Bushfire Management Plan

Pickering Brook and Surrounds Bushfire Risk Assessment

Project No: EP9-138(04)

Prepared for Department of Planning, Lands and Heritage
July 2020

Document Control

Doc name:	Bushfire Management Plan Pickering Brook and Surrounds Bushfire Risk Assessment				
Doc no.:	EP19-138(04)--004				
Version	**Date**	**Author**		**Reviewer**	
1	June 2020	Anthony Rowe	AJR	Dana Elphinstone	DAE
A	16 July 2020	Anthony Rowe	AJR	Dana Elphinstone	DAE
B	30 July 2020-	Anthony Rowe	AJR	Dana Elphinstone	DAE

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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

This strategic bushfire risk assessment has been prepared for the area of the Perth Hills between Paulls Valley in the north and Roleystone in the south (Study Area).

The State Government has formed a Project Taskforce and multi-agency Project Working Group to develop a strategy for economic development initiatives within the study area, including the growth of tourism activities in the Hills rural areas.

Topic-specific studies have been commissioned to inform the decision-making process. The report addresses one of these topics involving an assessment of the bushfire risk within the Study Area for further land-use intensification, and tourism development having regard to the outcomes of the Tourism WA commissioned *Pickering Brook and Surrounds Perth Hills Tourism Product Gap Analysis* January 2020.

Whilst the study area does not include the townships of Roleystone or Kalamunda, the study area adjoins the township of Kalamunda and the township of Roleystone to its west, north, and east. Actions taken in the study area potentially affect the bushfire security of the townships of Roleystone and Kalamunda and, therefore, have been an underlying consideration in this assessment.

Landscape Context

The study area is located east of the Darling escarpment and the Kalamunda township and extends south to encompass, but not include, the Roleystone township. The study area incorporates the township of Pickering Brook and is characterised by open valley floors with agriculture use and National Parks with extensive contiguous vegetation (Forest) on slopes of 5-10°, extending northeast and south. Located immediately to the east and south of the study area are riverine valleys that run in a north-west direction, notable for the Mundaring Reservoir (east of the study area) and the Canning Reservoir (south of the study area). The study area is a saddle between the riverine slopes of 5-10° adjoining valleys that run in a north-west direction. The valley floors have been historically cleared of native vegetation and utilised for orchards and viticulture.

The study area, is in a broader context, bordered by extensive areas of forest bushfire fuel, that extend for 43 km northeast and around to the south of the study area. The study area is separated from the Perth urban area located to its southwest and west (500 m and 3 km, respectively) by forest on steep land that is the Darling Escarpment. Relatively few roads (six) provide access to Perth through the escarpment and of these only Brookton Highway (southwest), Welshpool Road East (central west), and Kalamunda Road (northwest) are considered high volume roads.

Reticulated water services are available near the townships of Kalamunda and Roleystone, adjoining the study area and the township of Pickering Brook within the study area. Telecommunication coverage is stronger (complete) in the west of the study area and dissipates to the east; isolated black spots occur due to the varying landform throughout the area.

Both the City of Armadale and City of Kalamunda have identified in their draft Bushfire Risk Management Plans an average of 145 ignitions each per year. The Parks and Wildlife Service is

engaged in mosaic fuel reduction across public lands, which serves to reduce fire intensity but cannot eliminate the potential for a bushfire to be life-threatening or destructive.

Figure 1 illustrates the study area and the area within 20 km, showing the surrounding vegetation, the Darling Escarpment, and the location of the study area relative to the City of Perth urban area.

Figure 2 illustrates the study area enlarged to illustrate the cleared valley floor compared to retained native vegetation.

Figure 3 illustrates the topography, the steepness of the slopes (5˚-10˚), and the valleys running northeast. The steepness of slopes affects the intensity of a fire.

Figure 4 illustrates the vegetation complexes within the study area. Excluding the modified valley floors, the hills which retain native vegetation are generally uniform and support Jarrah forest.

Figure 5 Illustrates the National Parks within the study area that are subject to management by the DBCA.

Figure 6 illustrates the primary road network within the study area. Aldersyde Road, Glenisla Road, and Pickering Brook Road being a contiguous tourist route through the Pickering Brook Valley to Piesse Brook.

Figure 7 illustrates the extent of the reticulated water supply network through the study area.

Risk Assessment

> *"The great lesson of the examination of Black Saturday 2009 is that hard decisions have to be made. And those decisions must address systemic problems. They must limit individual freedoms where to pursue them will repeat the path of danger and expose the State and its personnel to unreasonable risk. Until Australians face up to the necessary tough decisions, they will be condemned, on a regular cycle, to witness further Ash Wednesdays, Black Saturdays and flames, floods and tempests on every other day."*[1]

A Bushfire Hazard Level assessment has been undertaken covering the study area. It 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, and upon a Generalised Extreme Value (GEV) 1:50, rounded up to an FFDI of 100, and is illustrated in **Figure 10**.

The BHL represents an unmanaged state. It does not represent the fuel reduction activities by the Parks and Wildlife Service – DBCA.

> *fuel load is (defined as) the amount of fuel available to burn, as determined by the type of vegetation, how much of it there is, its "fineness" and its moisture content. Fuel management is defined as the manipulation of this fuel load across the landscape for the purpose of minimising the size and intensity of bushfires.*[2]

Fuel reduction is undertaken in a cycle and in a mosaic (separated patches). Fuel loads and potential fire intensity builds until the cycle is repeated. Localised areas will, therefore, be exposed to varying

[1] AFAC *After the Fires Die Down and The Lawyers Depart* Australasian Fire & Emergency Service Authorities Council Annual Conference, Darwin Thursday 9 September 2010
[2] M. Keelty, *A Shared Responsibility the Report of the Perth Hills Bushfire February 2011*

degrees of available bushfire fuels depending upon their proximity to the activity and the time within the reduction cycle.

Efforts are also being made to coordinate public land fuel reduction in unison with private landowner fuel reduction, (referred to as tenure blind) but is difficult, and often unreliable, due to the ownership fragmentation and the varying interests and capacities of the private landowners which interferes with collective effort.

These activities, therefore, cannot eliminate a bushfire risk, and whilst past fire history is useful in identifying the direction of past fires and the routes for escape, it is the presence of fuels, their continuity, and climate that makes the risk every year.

M.Keelty commenting on the 2011 Roleystone Kelmscott fire observed:

> *The Special Inquiry heard that some residents had unrealistic expectations of the fire response – believing fire trucks would be available to protect every property, and aerial fire fighting could quickly contain a fire. This led to a sense of complacency and a lack of preparation.* [3]

As identified by Keelty, there is an expectation widely held in communities that the State can control a bushfire, and this sense of complacency can also lead to conflicting policies.

A bushfire risk can only be reliably reduced by eliminating the threat beyond a distance that can cause harm or damage to the potential receiver. (80% of houses lost to fire occurs within the first 100 m of a forest and the total loss of houses (effectively) occurs within 700 m of a forest[4]).

The ability to create sufficient separation within the study area is constrained by the presence of National Parks and forest on private land now regulated under various State and Federal biodiversity conservation legislation.[5]

Planning Framework

The study area is within a bushfire prone area, and strategic planning decisions[6] are guided by *State Planning Policy 3.7, Planning in Bushfire Prone Areas* and in particular, clauses 6.2 and 6.7

> ***"6.2 Strategic planning proposals, subdivision and development applications***
>
> *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*

[3] M. Keelty, *A Shared Responsibility the Report of the Perth Hills Bushfire February 2011*

[4] The Primary Impact area is 100 m from classified vegetation which represent a distance equivalent to 80% of the loss off all buildings having occurred, a secondary impact area has been identified as 700 m representing 100% (Leonard and Blanchi 2012)

[5] Commonwealth Environment protection and Biodiversity Conservation Act 1999, WA Environment Protection Act 1986, WA Biodiversity Conservation Act 2016

[6] Planning and Development Act 2005, s.162., LPS (2015) Regulation Deemed Provisions, cl.67

> ***"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* (Bushfire Hazard Level) *BHL and/or BAL-40 or BAL-FZ will not be supported."*

In regard to the above, clauses 5.4 of SPP 3.7 and 2.3 of the *Guidelines Planning in Bushfire Prone Areas* provide the following limitation:

> *In instances where biodiversity management conflicts with bushfire risk management measures and significant clearing of native vegetation is the only means of managing bushfire risk the proposal should generally not be supported*

Clause 6.7 has also been clarified in the WAPC Position Statement: *Planning in bushfire prone areas – Demonstrating Element 1: Location and Element 2: Siting and design November 2019.* It includes consideration of 'area' being external to the site and the potential for interaction with classified vegetation retained, and the developable area (less than BAL -29) on the site.

These policies are subordinate to the Policy Intent (SPP 3.7 clause 2) *risk-based land use planning and development to preserve life and reduce the impact of bushfire on property and infrastructure* (SPP cl.6.1) the *high-level consideration of relevant bushfire hazards when identifying land for future development*.

The strategic 'area' considerations, therefore, is to include more things than just achieving BAL-29 (29 kWm^2); as the satisfaction that a development can ameliorate the bushfire impacts affecting the site[7]. This is because physical human harm is incurred at levels exceeding 2 $kW^{2,}$ and BAL-29 is not a guarantee of a building survival; there is an expected 10% probability of failure.

Simplistically, people survive if the building they shelter in survives. Building survival is reduced markedly in extreme conditions when the building is closer than 30 m to a forest[8].

It is also acknowledged that AS3959:2018 separation distances can be underestimate when the fuel source is expansive. For this reason, risk-based planning, no longer reflects 'stay and defend' but early evacuation to minimise a person to exposure to bushfire. Higher standards apply to a building that is to be used as a shelter in a bushfire, i.e., a separation equivalent to BAL-10, based upon a 1 in 200 year event and provided with a requirement to submit annual Fire Engineering Certification to the planning authority[9].

The Australian Institute for Disaster Resilience 2020, *Land Use Planning for Disaster Resilient Communities* 2020 provides:

[7] The Primary Impact area is 100 m from classified vegetation which represent a distance equivalent to 80% of the loss off all buildings having occurred, a secondary impact area has been identified as 700 m representing 100% (Leonard and Blanchi 2012)

[8] Ibid.

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

> *From a strictly land use planning perspective, whilst evacuation is an emergency management process, risk-based land-use planning must deliver route network options and design that facilitate safe and efficient evacuation but acknowledging the scale of unknown and unforeseeable situations which may translate on the day a fire event might occur*.[10]

In addition to the potential for physical harm, *high-level consideration of relevant bushfire hazards* now also recognise emotional consequences, living with the anxiety of bushfire risk, the trauma of surviving exposure to bushfire, and property loss.

The addition of isolated development *high-level consideration of relevant bushfire hazards* also considers the depletion of existing resources and efficient defense. Isolated development, where assets are expected to be defended, diffuses the destinations able to be attended by emergency services to assist with suppression, or recovery for others in the community.

The productive use of regional areas is a *high-level consideration of relevant bushfire hazards*. Tourism is a productive use of land where the experience offered at the place, is the product that is consumed by the visitor. Other industries, by comparison, distribute their products[11]. Subject to the assurance of human safety, the acceptable level of risk associated is set higher than the loss of a home to an individual, and not insignificantly, this difference is partly based on emotional consequence as well as avoiding homelessness.

This is recognised in the WAPC *Position Statement Tourism Landuses in Bushfire Prone* Areas November 2019. It explains that the social and economic importance of tourism is recognised in the State Planning Strategy and developing tourism land uses within remote and/or heavily vegetated areas comes with an inherent risk of bushfire, which can be reduced but never fully eliminated. And:

> *"if human safety can be satisfied the asset may be considered replaceable, and its bushfire construction determined to the degree necessary."*

Further guidance is required to develop a strategy for economic development initiatives within the study area, to inform the 'area' considerations that should apply *high-level consideration of relevant bushfire hazard* where development may be facilitated.

Contextual compliance criteria for the application of 'area' used in clause 6.7

Following the above considerations, and having regard to interstate practice, an Extreme risk may be reduced to support clause 6.2 of SPP 3.7, in addition to ameliorating the bushfire impacts affecting the site where:

- A fully formed bushfire (fire line) can only arrive from one direction (single aspect).
- An early alert to maximise time for evacuation or preparation for the arrival of the bushfire impact, is available;
  - Telecommunication is available and reliable; or
  - The ability to observe an approaching fire is greater than 2 km:

[10] Australian Institute for Disaster Resilience 2020, *Land Use Planning for Disaster Resilient Communities* 2020
[11] International Centre for Responsible Tourism – Australia Encouraging Rural Tourism to embrace Bush Fire Risk Management 2013.

- Access is safe for evacuation to a place outside of the effect of a bushfire or to an appropriate place of shelter[12];
- Safe access[13] and egress is available for firefighting; and
- Suppression resources are available; adequate water volumes, and extraction pressure.

This criteria is herein referred to as the 'contextual compliance criteria'. It builds upon the overall study area bushfire hazard level assessment and the expected bushfire behaviour to identify and analyse individual precincts for closer analysis of their characteristics; for the purpose of informing the Taskforce consideration of various economic development initiatives within the study area.

Precinct risk evaluation

The seven Precincts were identified[14] for their potential for further land-use intensification having regard to context compliance criteria and anticipation of tourism potential having regard to the opportunities identified in the *Perth Hills Tourism Product Gap Analysis* and the landscape features present that support those opportunities.

The Precinct boundaries were determined because they represent one of the following characteristics; Future development within them may affect the bushfire risk for the adjacent town centres; It contained a concentration of activity/opportunity identified in the *Pickering Brook and Surrounds Perth Hills Tourism Product Gap analysis* January 2020; or a consistent land feature; largely public land, or forest over private land.

Figure 11 illustrates the study precinct areas.

Figure 12 illustrates an enlarged image of precinct north tourist attractions.

Figure 13 illustrates an enlarged image of precincts south tourist attractions.

The following table identifies the Precinct and summarises the assessment of the context compliance further to SPP 3.7 clause 6.7, and the landscape features present that support the tourism product opportunities identified in the *Perth Hills Tourism Product Gap Analysis*.

[12] The ability to complete the journey to a place that will not be affected by the bushfire and the ability to receive attendance immediately after the peak fire passing.
[13] The ability to safely leave before the fire arrival and the ability to safely attend immediately after the peak fire passing.
[14] Based on geographic features affecting suburb boundaries.

Precinct	Assessment Recommendation
Paulls Valley Piesse Brook (pt), Hackett's Gully [Figures 12 & 14]	The precinct is predominantly National Park with isolated rural living estates. Beyond the present subdivision policy, contextual compliance is not demonstrated in this area. The area is a focus area for walking trails and mountain biking, potentially exposing visitors to bushfire impact throughout the bushfire season, not just those periods that may trigger a National Park closure. Telecommunications for those using the trails is recognised as the primary bushfire protection measure for managing the safety of visitors to the area and promotion of bushfire awareness.
Carmel Walliston, Bickley (pt) [Figures 15 & 17]	The township of Kalamunda is in an elevated position to Aldersyde Road (tourist trail), and the Victoria Reservoir. Areas immediate to the township of Kalamunda are characterised as mixed-use on a variety of lot sizes. This area (contextual compliance) may have the opportunity through selective infill to reduce the bushfire intensity at the township boundary, a net benefit. Future development would be subject to contemporary bushfire construction and low threat land management to break the fuel continuity into the township. Historically cleared areas, orchards, and rural living south of Canning Road area are isolated from the township and retain a risk of multiple bush fire approaches through contiguous 'extreme' fuels in the adjacent National Park. It does not demonstrate contextual compliance.
Pickering Book Carmel (pt), Bickley [Figures 18 & 20]	Limited land-use intensification within the township has been addressed in a separate study. This precinct encompasses the 'natural grouping of tourism uses' identified in the Perth Hills Tourism Product Gap Analysis. The area has an opportunity for intensified tourism development with an emphasis upon evacuation into the township of Kalamunda. Multiple left-turn access opportunities are available traveling in a northerly direction to enter the township and retreat space. The township of Pickering Brook has been provided with the contingency of a potential safer place at the Primary School because it is an existing isolated township separated from the township of Kalamunda by a forest. The safer place has capacity for residents and visitors, but only if safe evacuation cannot be achieved.
Canning Mills Pickering Brook (pt) [Figures 21 & 22]	National Park – Public Land. Nature-based tourist attraction largely unstructured with high potential to expose visitors to bushfire. The walking trail infrastructure is not developed outside of the Victoria Reservoir walking trail. Walks from Canning Road have low-level infrastructure, and telecommunication coverage is progressively patchier moving eastward of Canning Road. Self-drive off bitumen and off-road activity, a desire for challenge and isolation, is promoted through various media, interest groups, and social media. This presents seasonal bushfire safety exposure to risk as well as an ignition risk.

The following Precincts were selected due to their proximity to the township of Roleystone, and the effect that future development in these areas may have upon the bushfire risk to the township.

It is a feature of the Roleystone township that access to it is only available from three roads that run through landscapes classed as extreme BHL and may be closed by bushfire.

A broader analysis of network capacity for the evacuation of the township of Roleystone is required before other areas, also dependent upon the same routes, can be considered.

Until an analysis of the network capacity has been undertaken, as a precautionary measure, further intensification in these precincts is not considered to meet contextual compliance with SPP 3.7, cl. 6.7.

Precinct	Assessment Recommendation
Karragullen [Figures 24 & 26]	The area northeast of Roleystone, Karragullen is in a direction a fire could arrive from through the National Park. The precinct includes areas historically cleared for orchards in locations along Brookton Highway and at the nexus with Canning Road. It is an isolated area, and beyond the present subdivision policy, contextual compliance is not demonstrated. It is currently a low threat and provides a break in fuel continuity to Roleystone. It offers no distinct landscape features for attracting tourist development but may be attractive for experiencing local produce/production if developed. Future development, within the current policy setting, should retain its low threat characteristic for the benefit of the Roleystone township. Within the precinct, the valley and orchards north of Chevin Road up to Canning Mills Road provide extended open views and are in close proximity to the Roleystone population centre. It is in an area not within a historic fire approach direction to the township of Roleystone.
Roleystone West [Figures 27 & 29]	This area is at the brow of the Darling Escarpment and has a complex land arrangement. It has a range of lot sizes whilst retaining a central area in larger holdings as orchards (low threat) with steeply undulating land and areas retained as forest. This makes for unpredictable fire behaviour The Precinct may have opportunity for contextual compliance at the northeast corner, and with infill opportunities where adequate separation from the Darling Escarpment is available and where it can retain a low threat land condition; to benefit the protection of the Roleystone township. Tourism development located on the east of the valley floor can have the advantage of landscape features with immediate access (convenience) to the Roleystone township.
Roleystone East [Figures 30 & 32]	With the exception of the southern extent (the residential area west of Hawkstone Road), the rural living area is indistinguishable, by aerial photo, from contiguous forest canopy notwithstanding it is private rural living land. The area is a complex landform with steep slopes, an arrangement that makes for unpredictable fire behaviour. The road network within the rural living area is a loop arrangement with limited access only to Brookman Highway. Beyond the present subdivision policy, contextual compliance is not demonstrated in this area. The precinct offers tourism development in the southern section potentially clustered along Croyden Road attracted to Araluen Botanic Park, access to Araluen Golf Resort outside the study area, and scenic tourist drives through to Canning Reservoir (outside the study area).

Conclusion and Recommendations

These recommendations are for the purpose of informing the Taskforce regarding the suitability, or otherwise, for further land-use intensification and tourism development as part of a strategy for economic development initiatives within the study area.

These recommendations should be read in conjunction with the Risk Register (NERAG 2015-2020) in **Appendix C** of this report, and the treatments identified as a basis for communication across stakeholders at the local level of the State Emergency Framework.

The study area is classified as an extreme bushfire hazard level (Guidelines Appendix 2), but mostly due to the extent and continuity of forest bushfire fuels in line with the historic directions that bushfires have come, driven by the prevailing winds typical of the bushfire season.

The assessment has found that other than opportunities to reduce vegetation and bushfire intensity for some areas located adjacent to the main population centres (the township of Kalamunda and the township of Roleystone) the 'area' considerations that should apply to the *high-level consideration of relevant bushfire hazards*[15]*,* cannot be satisfied due to limited safe road access availability, and the enduring proximity of forest and bushfire impacts within the study area.

Bushfires in this area cannot be eliminated despite measures to reduce the rate of ignition, and fuel reduction measures to reduce the intensity of a bushfire. A bushfire can occur in the area on any day throughout the bushfire season and not just in severe fire-rated day conditions.

The following recommendations acknowledge the important contribution made by existing bushfire risk management controls for the existing residents in the study area and township of Kalamunda, the township of Roleystone, and the township of Pickering Brook.

This includes:

- Continued policing and community education to minimise the ignition of bushfire fuels that may lead to an uncontrollable bushfire.
- The continuation of fuel reduction programs (Parks and Wildlife DBCA) with coordinated efforts across public land and private land (tenure blind).
- Effective implementation of the State Emergency Framework through to the local level by the Local Emergency Management Committee (LEMC) and Local Emergency Management Arrangements (LEMA) and the integration of the Bushfire Risk Management Plans.
- An integration of environmental enhancement programs and bushfire management programs within local government.
- The community alert systems and operational policy such as the Department of Parks and Wildlife *Closure of Parks and/or Recreation Sites Due to Very High or Above Fire Danger Ratings.*

[15] For the purpose of SPP 3.7, clause 6.7.

General Recommendations -

The following recommendations are provided for further action or study by stakeholder agencies

Recommendation 1

It is noted through the course of this assessment that the State Emergency Framework, through to local government, is multi-layered with numerous stakeholders, and as such, is complicated.

As a matter of good practice, it is recommended that an independent and critical review, from local government up, is periodically taken.

Recommendation 2

Access is a primary determinant for the satisfaction of SPP 3.7 cl. 6.7 and, in this regard, further analysis of the road network supporting the Roleystone township is required to ensure any further intensification does not impair the safety of the existing community in an emergency. Until this is addressed, further consideration of the land immediately adjacent to the township of Roleystone is not in context compliance with SPP 3.7 cl. 6.7.

Recommendation 3

The effectiveness of bushfire risk reduction measures, including tenure blind initiatives [16], and the application and enforcement of the *Bushfires Act 1954*, would be assisted by guidance that demonstrates landscaping arrangement that can achieve the urban forest benefits with a reduced bushfire intensity outcome.

This may include examples of horizontal and vertical separation of bushfire fuels using space or identifying and utilising low threat high moisture endemic vegetation varieties. It should be easy to follow to provide landowner certainty and effective compliance.

Tourism

Self -drive and self-ride visitors

Many of the tourism product experiences within the study area are self-drive, with visitors typically unfamiliar with the area. A bushfire can occur at any time during the bushfire season, and efficient direction to safe areas outside of the bushfire threat would minimise public exposure to bushfire as well as avoid a potential conflict with firefighting operations.

Recommendation 4

As a joint initiative between Local Government and Tourism WA, ensure that partnered websites include bushfire awareness and trip planners, including vehicle survival information. This could include promoting drive trails with evacuation routes.

[16] The coordination of bushfire fuel reduction measures across public and private land ownership (tenure)

Recommendation 5

As a joint initiative between Local Government and Tourism WA, for the benefit of visitors and the general public, the installation road signage that includes emergency direction, location code, and emergency alert information sites (radio channel or phone app).

Tourism development on public lands

Tourism development on public lands includes outdoor activities promoted within public land such as walking trails, mountain bike trails, and off-bitumen and off-road activity.

These activities often involve dispersed individuals who are in the open and isolated. Bushfires can occur outside of the DBCA park closure conditions and anytime during the bushfire season.

Telecommunication is an important tool to alert to changes in conditions and advise those who may be on the trail at any time and should be prominently promoted at least across all Department of Parks and Wildlife partners.

Telecommunication availability was found in this assessment to be less reliable on the east side of the study area, better closer to the townships, but isolated patches can still occur.

Recommendation 6

All trails would benefit from an audit of black spots and infrastructure.

It is recommended as part of the DBCA Operational Policy *Closure of Parks and/or Recreation Sites Due to Very High or Above Fire Danger Ratings,* a mapping of trails and telecommunication blackspots be undertaken.

There is a wide range of material on the internet partnered website and special independent interest website that promotes walking, mountain biking, and off-road adventure within the study area. Bushfire awareness, particularly in trip planning, is largely non-existent or obscure.

Recommendation 7

As a joint initiative between Local Government Tourism WA and DBCA, promote bushfire awareness and trip planning maps, across DBCA partnered sites, and 'keyword' internet search (SEO), that may include:

- telecommunications – existence/and blackspots
- Alert apps
- Availability of hydration stations
- Availability of coded locations for extraction by vehicle
- A voluntary registration process (to assist DBCA to know who is in the park)
- Bushfire survival information

Seasonal Tourism development

The *Pickering Brook and Surrounds Perth Hills Tourism Product Gap Analysis* January 2020 has advocated an enhanced focus on events outside of the bushfire season.

The Position Statement*: Tourism land uses in bushfire prone areas* November 2019 has identified that avoidance of the fire season is a potentially acceptable risk avoidance measure. This option, however, still involves a full planning application in accordance with SPP 3.7.

It is recommended consideration be given to a relaxation (by SPP 3.7) from the requirements of the SPP 3.7 bushfire protection policy, where a development is located within a bushfire prone area but will not operate within a period prescribed as the bushfire season. This would support the small-scale activities as an incubator for business development.

These land uses would still be subject to development approval, and must have an explicit undertaking of restricted operation, to provide compliance certainty for local government through section 214 of the *Planning and Development Act* 2005.

Recommendation 8

Amend SPP 3.7 to exempt certain requirements from clause 6.5 *Information to accompany a development application* where the development proposed will not operate during the nominated bushfire season.

This matter should be referred to the Western Australian Planning Commission for its consideration.

Tourism development on private lands

A key findings of the Tourism WA commissioned *Pickering Brook and Surrounds Perth Hills Tourism Product Gap Analysis* January 2020 (Gap Analysis), was a lack of certainty and facilitation in the administration of the SPP 3.7.

The Gap Analysis found:

> *Bushfire control is a key consideration in new tourism development, and issues that arise relate to road access and capability to support increased visitor numbers. A reduction in bushfire risk for land use and development may be aided by leveraging new planning scheme aims, objectives, local planning policies, and mapping tools to support tourism development.*[17]

The Position Statement *Tourism land uses in bushfire prone areas* November 2019 has only been recently introduced, and it is expected to gain efficiency as planning authorities become more familiar with it. It provides specific Acceptable Solutions for a range of tourism circumstances, and a risk assessment option where the Acceptable Solution in the *Guidelines for Planning in Bushfire Prone Areas* V1.3 is not met. The BAL analysis for each Precinct contained in this report has identified that development proposals will rely upon the Position Statement *Tourism land uses in bushfire prone areas* November 2019.

[17] Pickering Brook and Surrounds Perth Hills Tourism Product Gap Analysis January 2020 page 11

To assist the efficient administration of the Position Statement *Tourism land uses in bushfire prone areas* November 2019*,* the following recommendations are provided*.*

Recommendation 9

This bushfire risk assessment, undertaken as part of this bushfire management plan can be used to inform the Bushfire Risk Assessment option in the Tourism Position Statement, freeing the applicant to identify the measures that respond to the risk, which may be incorporated in their development proposal. The following list can assist applicants and planning authorities with the information required for the consideration of an application within the Study Area and the requirements of the Tourism Position Statement.

Assessment Summary

Each development application is required to demonstrate an understanding of the risk that is applicable to its circumstance and the merit of the solution proposed.

Likelihood or probability (Bushfire Management Plan - BMP)

Acknowledgment of the hazard by the applicant that the location is subject to frequent and potentially destructive bushfire.

Consequences of a bushfire event (Bushfire Emergency Evacuation Plan- BEEP)

An acknowledgment that the 'degree necessary' asset protection is acceptable to the applicant.

An acknowledgment by the applicant that the location is within an extreme bushfire hazard area.

An assessment of the land use and potential for the exposure of patrons at the site to bushfire impact (i.e., out in the open or capacity if within a building, day, or overnight).

Identification of operating times; full time, or restricted operation, block annual periods, daily restriction, or a combination.

Evaluates the risk

A demonstrated consideration of bushfire protection measures that can be used to reduce the impact of bushfire on the asset.

Evaluate the bushfire risk to access routes between the site and the safer place/destination.

Determine the Available Safe Egress Time (ASET) [18] and determine Required Safe Egress Time (RSET) [19].

Fire can be expected from directions in the northeast through to the west (late afternoon wind change); to be anticipated in evacuation route planning.

FFDI 50+ occurs from mid-December to mid-March annually, but isolated days can occur up to May.

Risk treatment measures to reduce the risk to an acceptable level

[18] Time available before the fires arrival or closure of the evacuation route (ASET).

[19] Allowing for human behaviour and practicality it is the time required to leave the site and complete the journey to the nominated safer place (RESET).

The BMP – demonstrates bushfire construction standards equivalence to the Determined BAL level plus As Low as Reasonably Practical (ALARP) measures to be complemented by the BEEP[20].

The BEEP – Demonstrates the ability to separate visitors from the impact of bushfire by:

- Evacuation - Alert, routes (ASET> RSET = Evacuation), interim accommodation, recovery and return.
- Separation by barrier Shelter[21] – When only a single site single access is provided (ASET < RSET = Survival – refuge last resort procedure), monitoring conditions, have suppression facilities and instructions available, evacuate when safe.

Process for ongoing monitoring

The annual review of the BEEP (by owner).

The annual Fire Engineer Certificate Shelter fit for purpose (by the owner to Local Government).

The enforcement of the development authorisation through Section 214 *Planning and Development Act* 2005 (Local Government).

Conditioned – notification to be placed upon the title that a BMP and BEEP applies to the use of the land (to transfer responsibility to future landowners). Evidence of application for Notice provided prior to the occupation (by the landowner).

Conditioned - Prior to the operation, the landowner should provide by a statutory declaration that the bushfire protection measures have been implemented prior to occupation - *not to be delegated to an agent/bushfire consultant* (by the landowner).

Strategic consideration – the periodic review of development policy, every five years, should include a review of the risk and the interaction of community to it, the environment and the effectiveness of land use policy (Local Government) and the Local Emergency Management Arrangement (LEMA) as complementary risk mitigation measures.

[20] Australian Building Codes Board, *Handbook: Bushfire Verification Method* 2019, the final 10% failure probability is to be addressed bry ALARP.

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

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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
FFDI	Forest Fire Danger Index
FDI	Fire Danger Index
FZ	Flame Zone

Table A2: Abbreviations – Organisations

Organisations	
DBCA	Department of Biodiversity Conservation and Attractions
DFES	Department of Fire and Emergency Services
OBRM	Office of Bushfire Risk Management
WAPC	Western Australian Planning Commission
BoM	Australian Bureau of Meteorology

Table A3: Abbreviations –Legislation and policies

Legislation	
AS 3959	*Australian Standard 3959-2018 Construction of buildings in bushfire-prone areas*
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)

1 Introduction

This strategic bushfire risk assessment has been prepared for the area of the Perth Hills between Paulls Valley in the north and Roleystone in the south (Study Area). The Study Area, shown in **Plate 1**, adjoins the townships of Roleystone and Kalamunda, and incorporates the township of Pickering Brook.

The State Government has formed a Project Taskforce and multi-agency Project Working Group to develop a strategy for economic development initiatives within the study area, including the growth of tourism activities in the Perth Hills rural areas.

The Project Working Group, on behalf of the Taskforce, is undertaking a comprehensive strategic analysis to align a diverse range of regulatory and service delivery agencies within the Study Area. Topic-specific studies are being undertaken to inform the decision-making process; one of these topics is an assessment of the bushfire risk within the Study Area.

Specific outputs requested of the bushfire risk assessment for this task include:

- Identify precincts within the Pickering Brook and Surrounds study area and make recommendations regarding the suitability or otherwise for further land-use intensification, and tourism development having regard to the outcomes of the Tourism WA commissioned Pickering Brook and Surrounds Perth Hills Tourism Product Gap Analysis January 2020.

Specific tasks include:

- Investigate the bushfire history of the study area, including date, severity, extent of the damage.
- Undertake a bushfire hazard level assessment for the study area as a whole.
- Investigate the suitability of each of the precincts within the study area for more intensive landuse and tourism development
    - identify potential access and egress solutions, including recommendations for upgrade or provision of new roads or emergency access ways to ensure compliance with the Guidelines, Element 3;
    - Investigate and identify any requirements relating to water availability, and any other required infrastructure upgrades, within each precinct of the study area for firefighting and management purposes, in accordance with the Guidelines Element 4.

Whilst the study area does not include the township of Roleystone or Kalamunda, the study area does join the township of Roleystone to its west, north and east, and joins the township of Kalamunda to its east and south. The risk assessment has acknowledged that development within the study area can affect positively or negatively the bush fire risk to the township of Roleystone and the Township of Kalamunda.

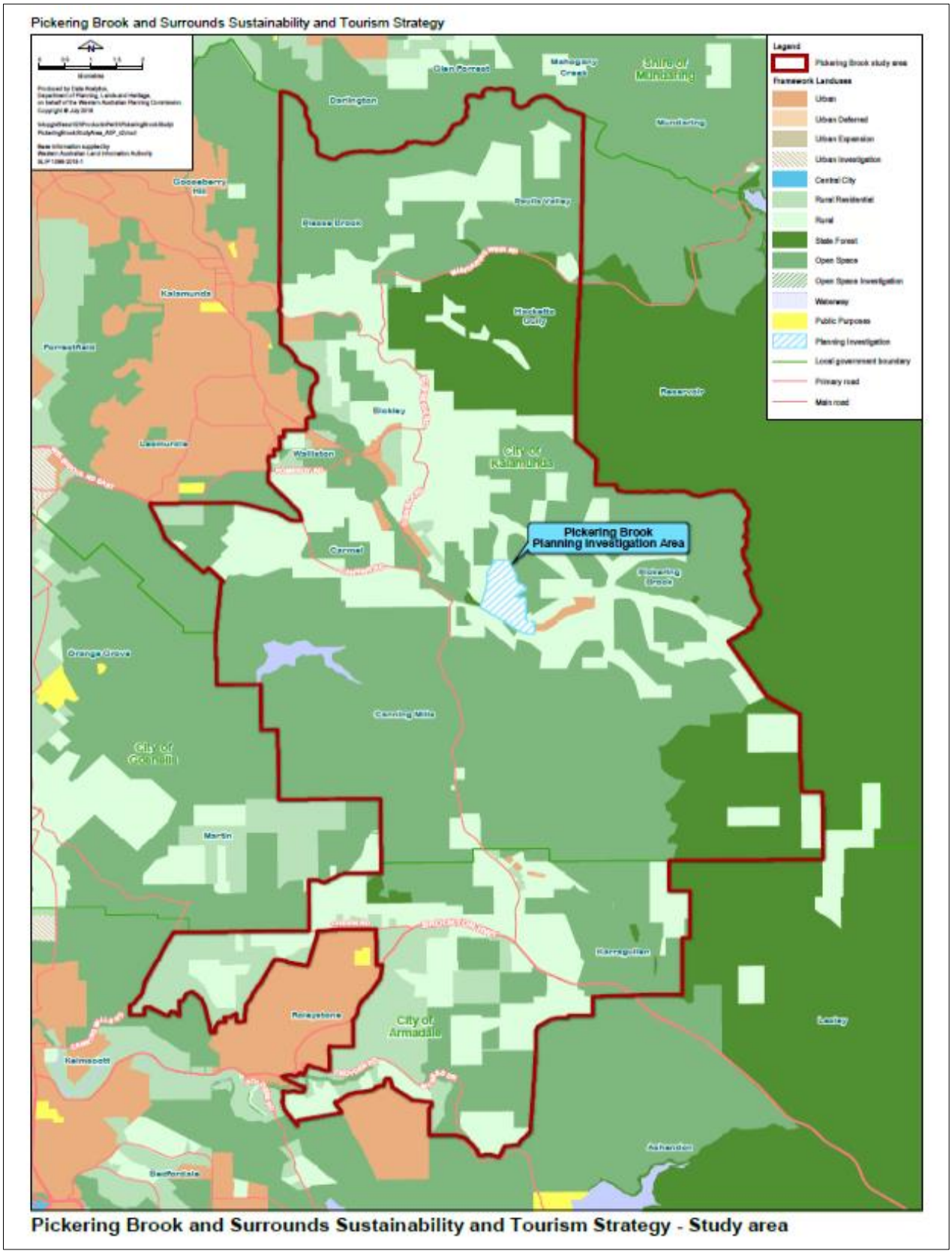

Plate 1: Pickering Brook and Surrounds Sustainability and Tourism Strategy Study Area. Note the townships of Kalamunda and Roleystone adjacent west of the study area

1.1 Pickering Brook and Surrounds Perth Hills Tourism Product Gap Analysis

A key objective of the Project Taskforce and multi-agency Project Working Group is to enhance the opportunity for tourism development to safely occur within the study area. This includes the preparation of an efficient risk-based assessment process following the Tourism WA commissioned Pickering Brook and Surrounds Perth Hills Tourism Product Gap Analysis January 2020 (Gap Analysis).

The Gap Analysis found:

Bushfire control is a key consideration in new tourism development, and issues that arise relate to road access and capability to support increased visitor numbers. A reduction in bushfire risk for land use and development may be aided by leveraging new planning scheme aims, objectives, local planning policies, and mapping tools to support tourism development.[22]

The Gap Analysis has identified 34 products across the cities of Kalamunda and Armadale, including nine accommodation places and 16 attractions, wineries, and food producers, which include Core Cider, La Fattoria, Myattsfield Winery, Raebourne Orchards and the Araluen Botanic Park.

The distribution of Tourism uses from the Gap Analysis is illustrated in **Plate 3.** The plate reflects a coalesced activity occurring in the northern section of the study area from Mundaring Weir Road to Pickering Brook. Broadly the accommodation and attractions have aligned along the valley floor from Mundaring Weir Road, along Aldersyde Road, Glenisla Road, Pickering Brook Road, and ending at Merrivale Road (dead end).

The Gap Analysis has identified products predominantly in the northern section of the study area, but there is strong tourism product immediately south of the study area, and the connection to those has been identified in this study with the prospect of developing tourism product in the southern section and through the study area.

The north sector has the potential to build upon the present concentration of tourist product development, including value-adding of primary production and high visual amenity accommodation and mountain bike trails. There is a natural road loop in the northern sector that links the features of Pickering Brook through to Carmel and Paulls Valley up to Mundaring Weir Road. Mundaring Weir Road is noted as a popular drive route.

Tourism product development opportunities identified in the Gap Analysis includes:

1. Road cycling routes: Canning, Pickering Brook, Pattersons, Walnut, Aldersyde.
2. Walking trails: Victoria Reservoir, Bickley Reservoir, Whistlepipe Gully, Rocky Pool, Bibbulmun Track (overnight section walks).
3. Mountain biking trails (Three Bears, Alchemy, Goldilocks) and the Canning Contour Channel and Munda Biddi Trail (overnight sections).
4. Perth Observatory, Astro tourism (Walnut Road east boundary of the study area).
5. Araluen Botanic Park.

[22] Pickering Brook and Surrounds Perth Hills Tourism Product Gap Analysis January 2020 page 11

6. Food and beverage trail development.
7. Enhanced focus on events in spring and autumn and the promotion of the winter months for amenity and strategic views (acknowledged to avoid bushfire season).

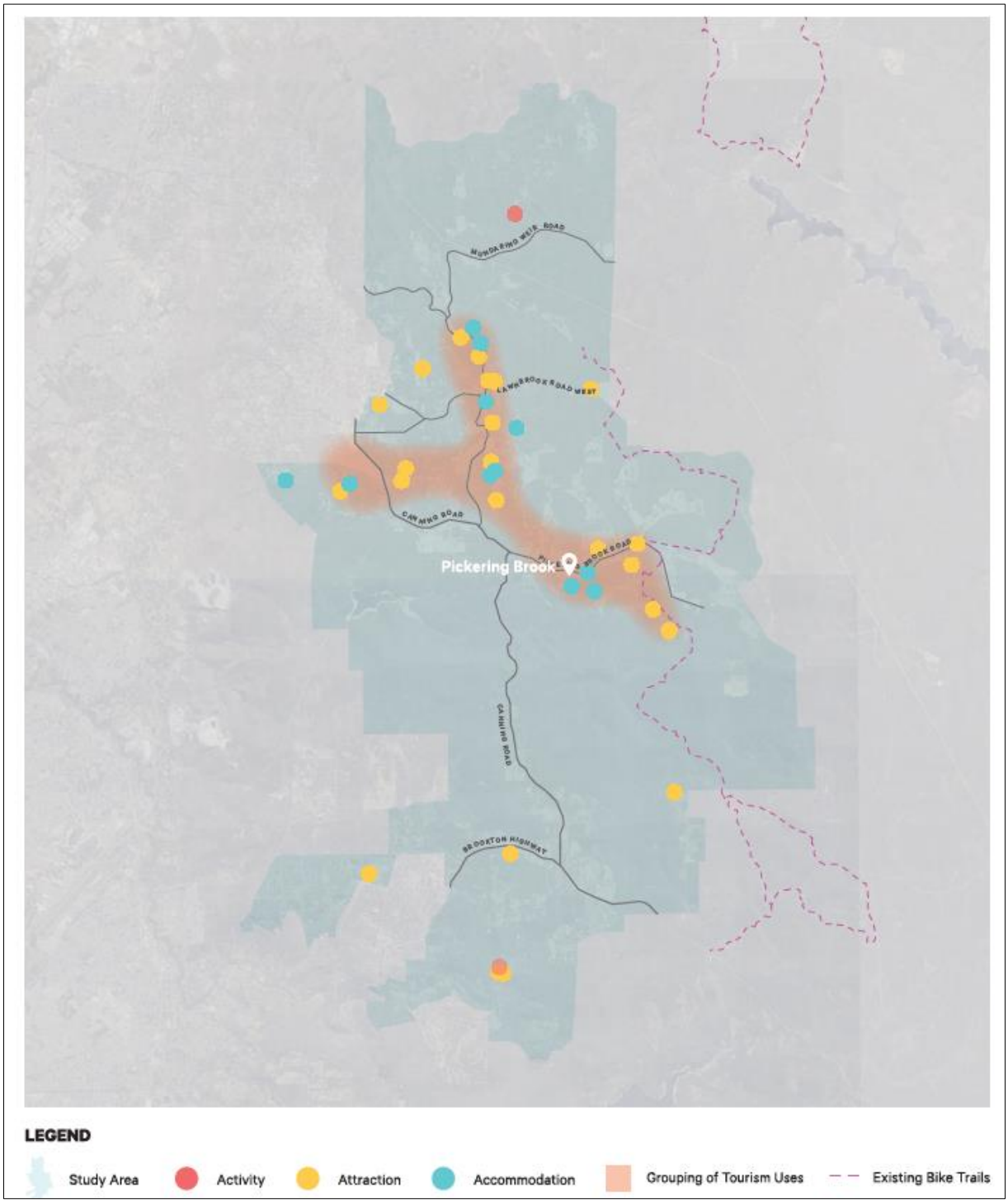

Plate 2: Pickering Brook and Surrounds Perth Hills Tourism Product Gap Analysis January 2020

1.2 Legislative Framework

The Study 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). *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (SPP 3.7) (WAPC 2015), (cl.4) applies to all higher-order strategic planning documents within the areas identified in the *Map of Bush Fire Prone Area*. The State policy is in turn informed by various guidelines, relevant to this strategic planning that includes the Guidelines for *Planning in Bushfire Prone Areas* V1.3, and appendices, and informed by Western Australian Position Statements and the Position Statement: *Planning in bushfire prone areas – Demonstrating Element 1: Location and Element 2: Siting and design*

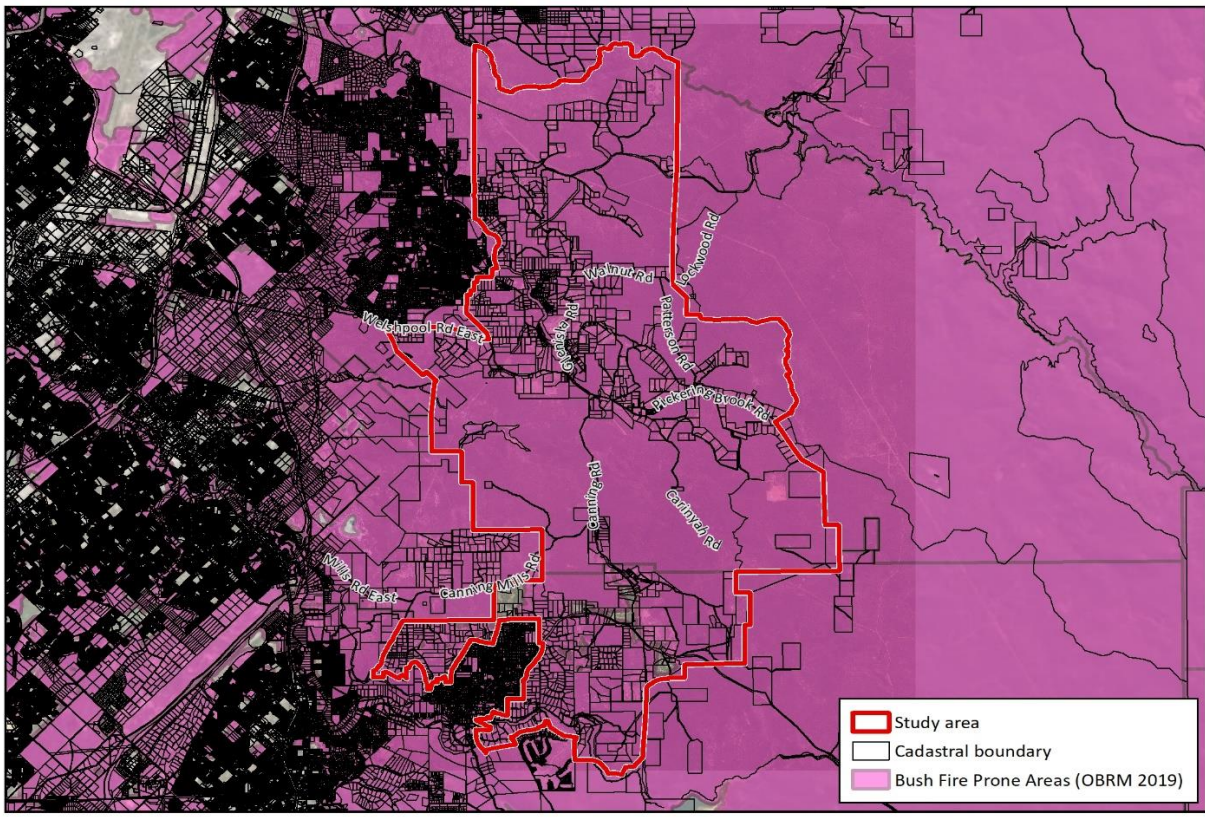

Plate 3: Areas within and surrounding the site identified as 'bushfire prone areas' (as indicated in pink) under the state-wide Map of Bush Fire Prone Areas (OBRM 2019)

In order to address the strategic considerations of SPP 3.7, an orderly and methodical approach is to be applied to this assessment following the *high-level consideration of relevant bushfire hazards* in order to make recommendations regarding the suitability or otherwise for further land-use intensification and tourism development.

1.2.1 Assessing Bushfire Risk in the Planning Context

Section 4 of the Guidelines for *Planning in Bushfire Prone Areas* V1.3 (Guidelines V1.3) provides that a starting point to considering a strategic planning proposal within an area mapped as bushfire prone is to first establish the bushfire risk, being the Bushfire Hazard level (BHL)

Before a strategic planning proposal, subdivision or development application can be considered, it is necessary to understand the extent of the bushfire hazard and its potential to affect people, property and infrastructure

The method for preparing a BHL is provided at Appendix 2 in the (Guidelines V1.3). It states that a BHL assessment is "a pre-development decision-making tool used to inform the suitability of strategic planning proposals for future subdivision and development" and "should be undertaken for any area identified for intensification of land use in a strategic planning proposal where lot layout is not yet known.

Appendix 2 provides for three classifications of BHL; Low; Moderate; and Extreme. It is based upon a broad application of vegetation following the classifications used in AS3959:2018. The vegetation classification of forest is classed within an Extreme BHL. Orchards and other vegetation normally classified as low threat and Low BHL, are classed as moderate if it is within 100 m of Extreme BHL.

Due to the extensive area of forest the Study Area, it is classified as Extreme BHL. Given the BHL is recognised as a broad brush, more detailed analysis and bushfire protection measures can reduce the risk at a particular site, but also within the broad brush, there are variations upon the intensity of the bushfire behaviour that may occur. Bushfire intensity is increased by the steepness of the slope and the relative effect is dependant position of the receiver in relation to the slope (aspect). A receiver at the top of a slope will receive a greater fire intensity than a receiver that is downhill/downslope from a fire. This Assessment will therefore identify the relative intensity within the BHL to assist in informing the planning decision. For example, a road at the top of a hill will experience a higher fire intensity than a road in a valley.

1.2.2 Applying the Bushfire Protection Policy

The following list identifies the key policy measures applicable to strategic planning within an Extreme BHL area.

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.

The 'Policy intent' is the principal measure of compliance for strategic policy guiding development within a bushfire prone area. It is important to note that the SPP 3.7 lies within the conventions applicable under the *Planning and Development Act 2005* and is a practical guide for practical purposes. Where there is conflict with between policies in SPP 3.7 these can be resolved by the purpose established by the policy intent.

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.*

(Note this objective is not to be read that the only solution is avoidance (prohibition), because on reasoning that it is impossible to avoid any increase of threat if further development occurs in a bushfire prone area. To apply this objective as a prohibition would be contrary to the application of the bushfire protection criteria (solutions) contained in the Guidelines)

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.*

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**

b) Any strategic planning proposal, subdivision or development application in an area to which policy measure 6.2 a) applies[23], 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

6.7 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 (Bushfire Hazard Level) BHL and/or BAL-40 or BAL-FZ will not be supported.

Guidelines for *Planning in Bushfire Prone Areas* V1.3

2.3 BUSHFIRE RISK MANAGEMENT AND ENVIRONMENTAL CONSERVATION

Section 2.3, following SPP 3.7 Objective 5.4, establishes a limitation bushfire protection measures that may otherwise achieve an acceptable outcome. It recognises the removal of regulated native vegetation to achieve an acceptable bushfire outcome is in conflict with

[23] SPP 3.7 cl.6.2a – Development application above BHL low are to comply with the policy measure.

biodiversity conservation principles and relevant Federal and State legislation. Where there is conflict the environment considerations will prevail, and the proposal will not be supported.

Whilst limited exemptions from clearing approval applies for subdivision and development applications it does not apply to strategic consideration.

> *In instances where biodiversity management conflicts with bushfire risk management measures and significant clearing of native vegetation is the only means of managing bushfire risk the proposal should generally not be supported.*

Clearing approval from Federal and State authorities would need to be achieved before strategic consideration for bushfire could be supported.

5.1 HIGHER ORDER STRATEGIC PLANNING DOCUMENTS IN BUSHFIRE PRONE AREAS

Section 5.1 of the Guidelines provides that higher order strategic planning documents should include high level consideration of bushfire risk when identifying land for future investigation and/or potential development. Strategic planning documents are typically prepared at a regional scale and provide a coordinated direction for application of land uses, reserves and infrastructure over more than one local government area.

The application of the BHL, and Section 5.1, provides guidance to achieving intent of the State Planning 3.7 Planning in bushfire Prone Areas.

WAPC Position Statement: *Planning in bushfire prone areas – Demonstrating Element 1: Location and Element 2: Siting and design November 2019*

Clause 6.7 has also been clarified in the WAPC Position Statement: *Planning in bushfire prone areas – Demonstrating Element 1: Location and Element 2: Siting and design November 2019.* It includes consideration of 'area' being external to the site and the potential for interaction with classified vegetation retained, and the developable area (less than BAL -29) on the site.

1.3 Strategic Planning for Bushfire Approach

Clause 6.7 in SPP 3.7 most specifically addresses the *Strategic planning proposals in areas where an extreme BHL but despite* WAPC Position Statement: *Planning in bushfire prone areas –Demonstrating Element 1: Location and Element 2: Siting and design November 2019,* the consideration of 'area' remains unclear other than a high level consideration of bushfire risk and satisfaction of the Policy Intent is greater than just achieving BAL 29 at the site.

This is because physical human harm is incurred at levels exceeding 2 $kW^{2,}$ and BAL-29 is not a guarantee of a building survival; there is an expected 10% probability of failure.

It is also acknowledged that AS3959:2018, as a risk measure alone, can underestimate a required separation distance when the fuel source is expansive. For this reason, risk-based planning, no longer reflects 'stay and defend' but early evacuation to minimise a persons to exposure to bushfire.

The Australian Institute for Disaster Resilience 2020, *Land Use Planning for Disaster Resilient Communities* 2020 provides:

> *From a strictly land use planning perspective, whilst evacuation is an emergency management process, risk-based land-use planning must deliver route network options and design that facilitate safe and efficient evacuation but acknowledging the scale of unknown and unforeseeable situations which may translate on the day a fire event might occur*.[24]

Higher standards therefore apply if a building that is to be used as a shelter in a bushfire, i.e., BAL-10 with annual Fire Engineering Certification[25].

In addition to the potential for physical harm, *high-level consideration of relevant bushfire hazards* now also recognise emotional consequences, living with the anxiety of bushfire risk, the trauma of surviving exposure to bushfire, and property loss.

A *high-level consideration of relevant bushfire hazards* also considers avoiding additional isolated development that will increase destinations to be attended by emergency services but which can conversely reduce the services available to the established community.

A review of national approaches was undertaken to identify the approaches taken for circumstances similar to the Study Area. Generally, they discourage further intensification of development except where a proposal would assist in strengthening existing communities 'resilience to bushfire' (urban edge)[26]. This may include a better-defined settlement edge, eliminating narrow settlement fingers, and armouring the urban extent with resistant construction standards and reduced fuels, in other words, where a developer can demonstrate a net benefit.

From the review of interstate policy[27], and to further guide the 'area' consideration of cl. 6.7 SPP 3.7, , the following guidance is recommended.

Further land-use intensification may be supported where:

- A fully formed bushfire (fire line) can only arrive from one direction (single aspect);
- An early alert to maximise time for evacuation or preparation for the arrival of the bushfire impact, is available;
  - Telecommunication is available and reliable; or
  - The ability to observe an approaching fire is greater than 2 km:
- Access is safe for evacuation to a place outside of the effect of a bushfire or to an appropriate place of shelter[28];
- Safe access[29] and egress is available for firefighting; and
- Suppression resources are available; adequate water volumes, and extraction pressure.

[24] Australian Institute for Disaster Resilience 2020, *Land Use Planning for Disaster Resilient Communities* 2020

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

[26] https://www.cfa.vic.gov.au/documents/20143/69382/Strategic_Planning_for_Bushfire_-_CFA_Approach_Presentation_for_Internet_250713.pdf/c8520719-5197-755d-e28c-9b0bfa209170

[27] https://www.cfa.vic.gov.au/documents/20143/69382/Strategic_Planning_for_Bushfire_-_CFA_Approach_Presentation_for_Internet_250713.pdf/c8520719-5197-755d-e28c-9b0bfa209170

[28] The ability to complete the journey to a place that will not be affected by the bushfire and the ability to receive attendance immediately after the peak fire passing.

[29] The ability to safely leave before the fire arrival and the ability to safely attend immediately after the peak fire passing.

2 Landscape Context

The study area is bordered by extensive areas of contiguous forest that extends for 43 km northeast around to the south of the study area, and by a narrow separation of steep forest land being the Darling Escarpment that separates it (500 m -3 km) from the Perth urban area to the west. Contiguous forest provides bushfire fuel in the event of a bushfire. Relatively few roads (six) provide access to Perth through the escarpment, including Brookton Highway (southwest), Welshpool Road East (central west), and Kalamunda Road (northwest).

Figure 1 illustrates the study area and the area within 20 km, showing the surrounding vegetation, the Darling Escarpment, and the location of the study area relative to the City of Perth urban area.

The proximity to the Perth urban area makes the study area popular as a day trip destination but is also within a commuting range offering 'lifestyle' large lot residential living. The proximity also means that with increased exposure to human activity, the risk of bushfire ignition by human activity is increased.

The study area is characterised by open valley floors historically cleared for agriculture (horticulture), much of which remains or is used for rural living. Outside the valley floor, remnant vegetation has largely been retained, mostly in National Parks or on Crown land, with the exception of the southern extent of the study area.

Figure 2 illustrates the study area enlarged to illustrate the cleared valley floor compared to retained native vegetation.

The Study Area is a saddle of undulating land slopes of 5-10° between the riverine valleys that run in a north-west direction. This includes Mundaring Reservoir (east of the study area) and the Victoria Reservoir (west of the study area) and the Canning Reservoir (south of the study area). The Study Area mostly comprises forest vegetation on public and private land, but within the wider valley floors the forest has been cleared and orchards and viticulture had been established.

Note: The urban canopy of trees at Roleystone makes it difficult to distinguish the township from the surrounding area, and the township is located upslope (on an elevated ridge to valleys that surround it).

Figure 3 illustrates the topography, the steepness of the slopes (5°-10°), and the valleys running northeast. The steepness of slopes affects the intensity of a fire.

Figure 4 illustrates the vegetation complexes within the study area. The hills which retain native vegetation are generally uniform and support Jarrah forest, excluding the modified valley floors.

Figure 5 illustrates the National Parks within the study area that are subject to management by the DBCA.

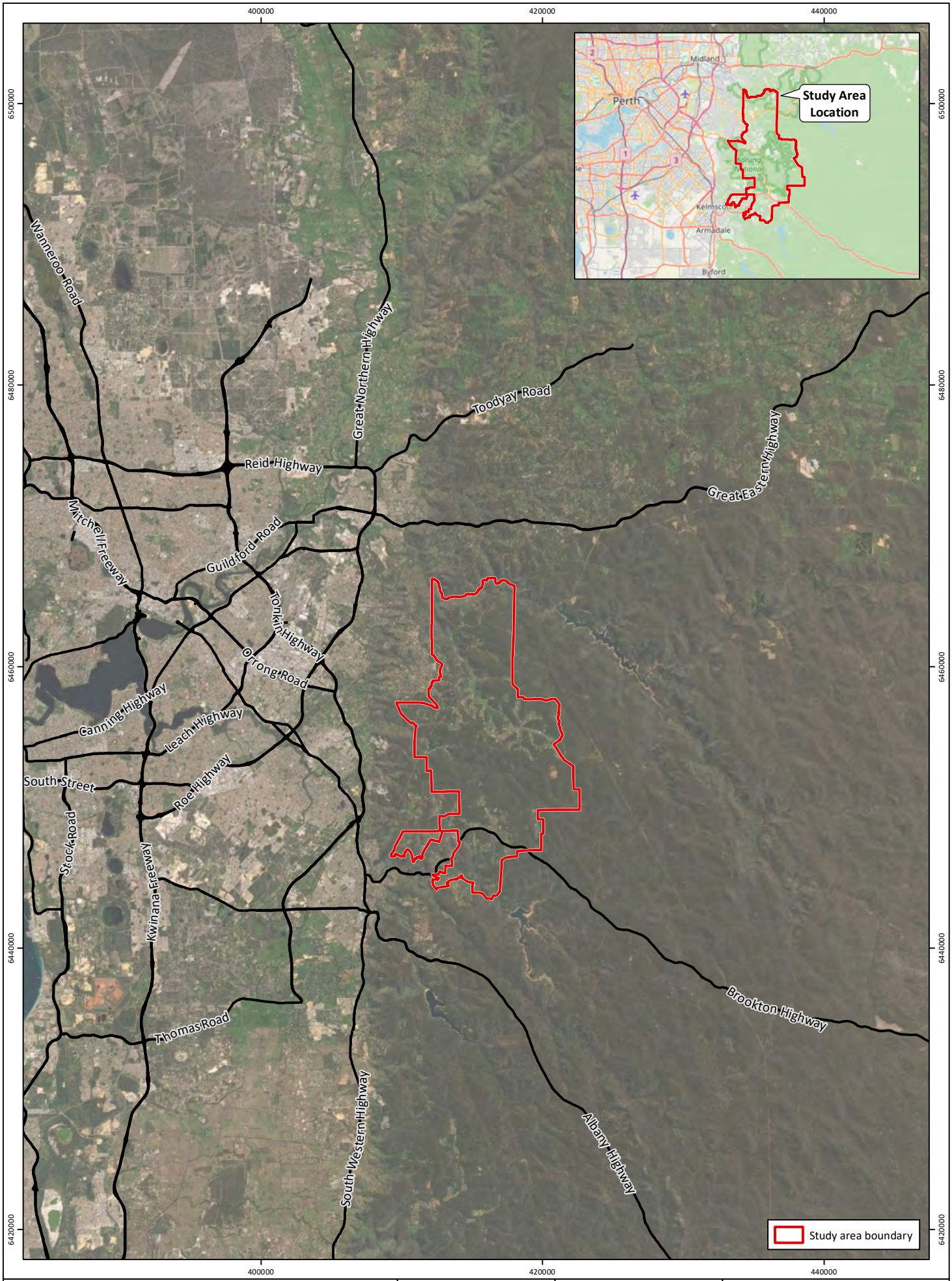

Figure 1: **Study Area Location**

Project: Bushfire Management Plan
Pickering Brook and Surrounds Bushfire Risk Assessment

Client: Department of Planning, Lands and Heritage

Plan Number:
EP19-138(04)--F41

Drawn:	SCM
Date:	13/05/2020
Checked:	DAE
Approved:	AJR
Date:	19/05/2020

N

0 5 10
Kilometers

Scale: 1:350,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

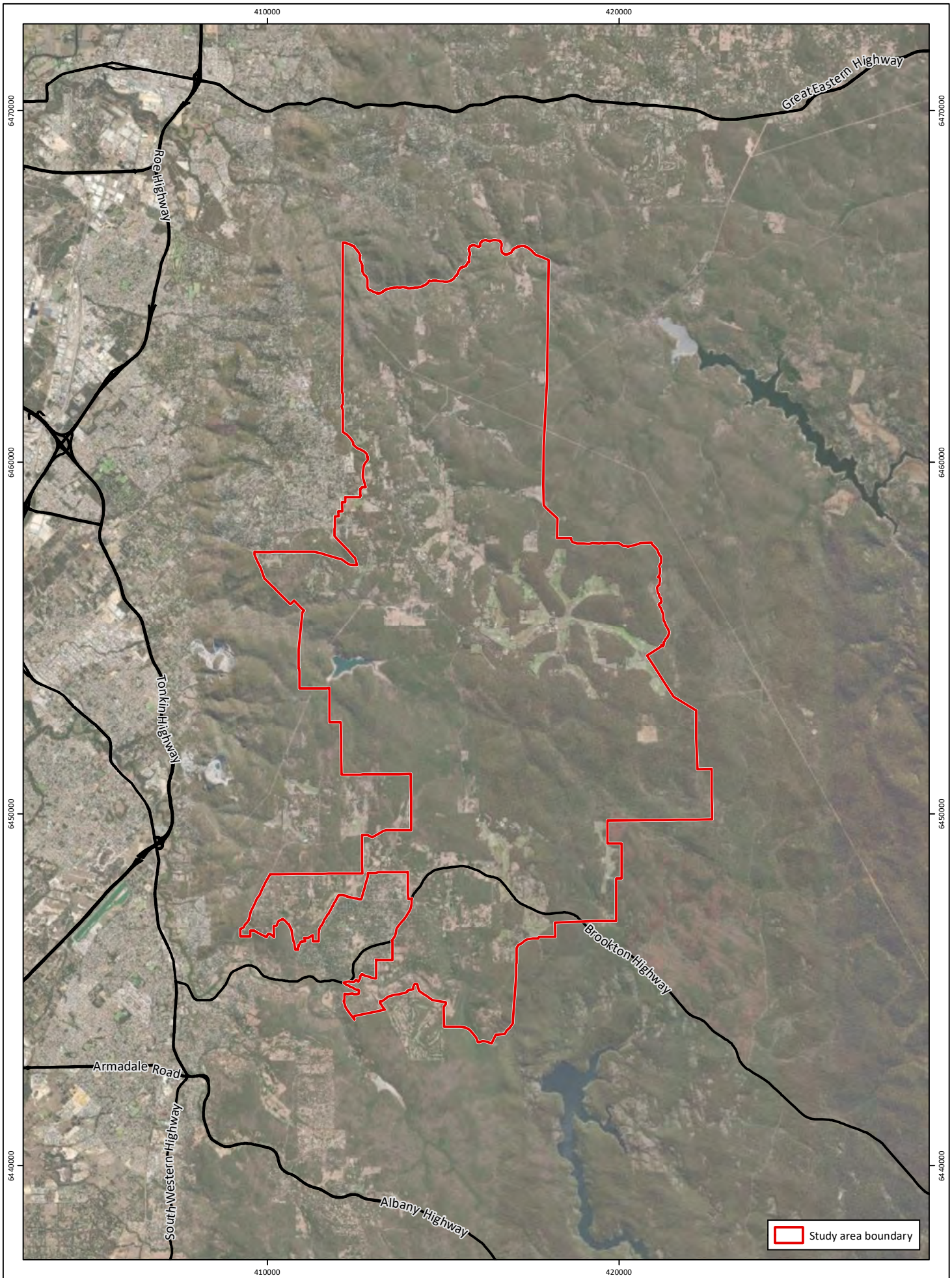

Figure 2: Study Area Surrounds

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

Plan Number:
EP19-138(04)--F42

Drawn:	SCM
Date:	15/05/2020
Checked:	DAE
Approved:	AJR
Date:	19/05/2020

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Scale: 1:140,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

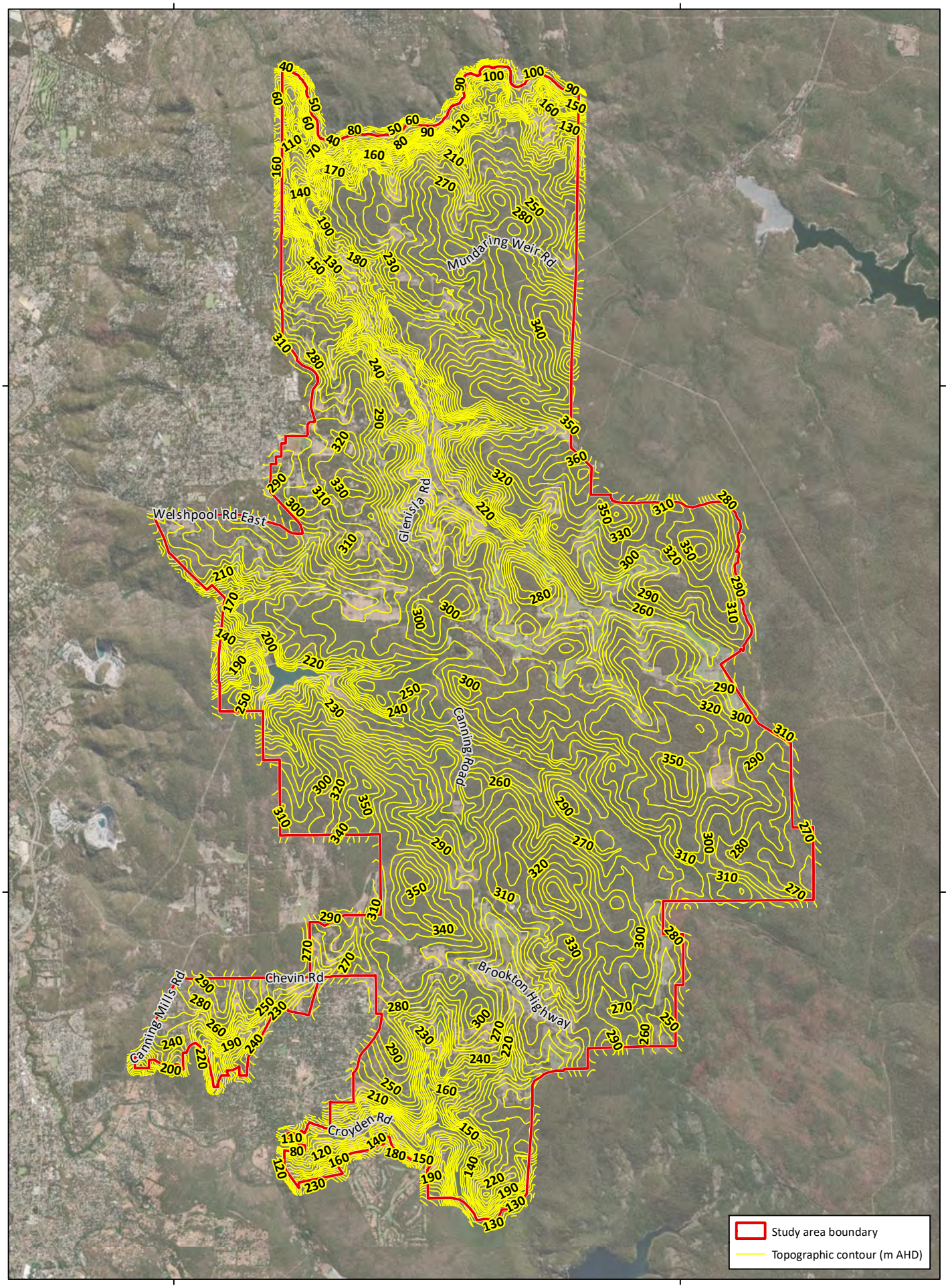

Figure 3: **Topographic Contours**

Project: Bushfire Management Plan
Pickering Brook and Surrounds Bushfire Risk Assessment

Client: Department of Planning, Lands and Heritage

Plan Number: EP19-138(04)--F43

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Date:	15/05/2020
Checked:	DAE
Approved:	AJR
Date:	19/05/2020

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Kilometers

Scale: 1:100,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

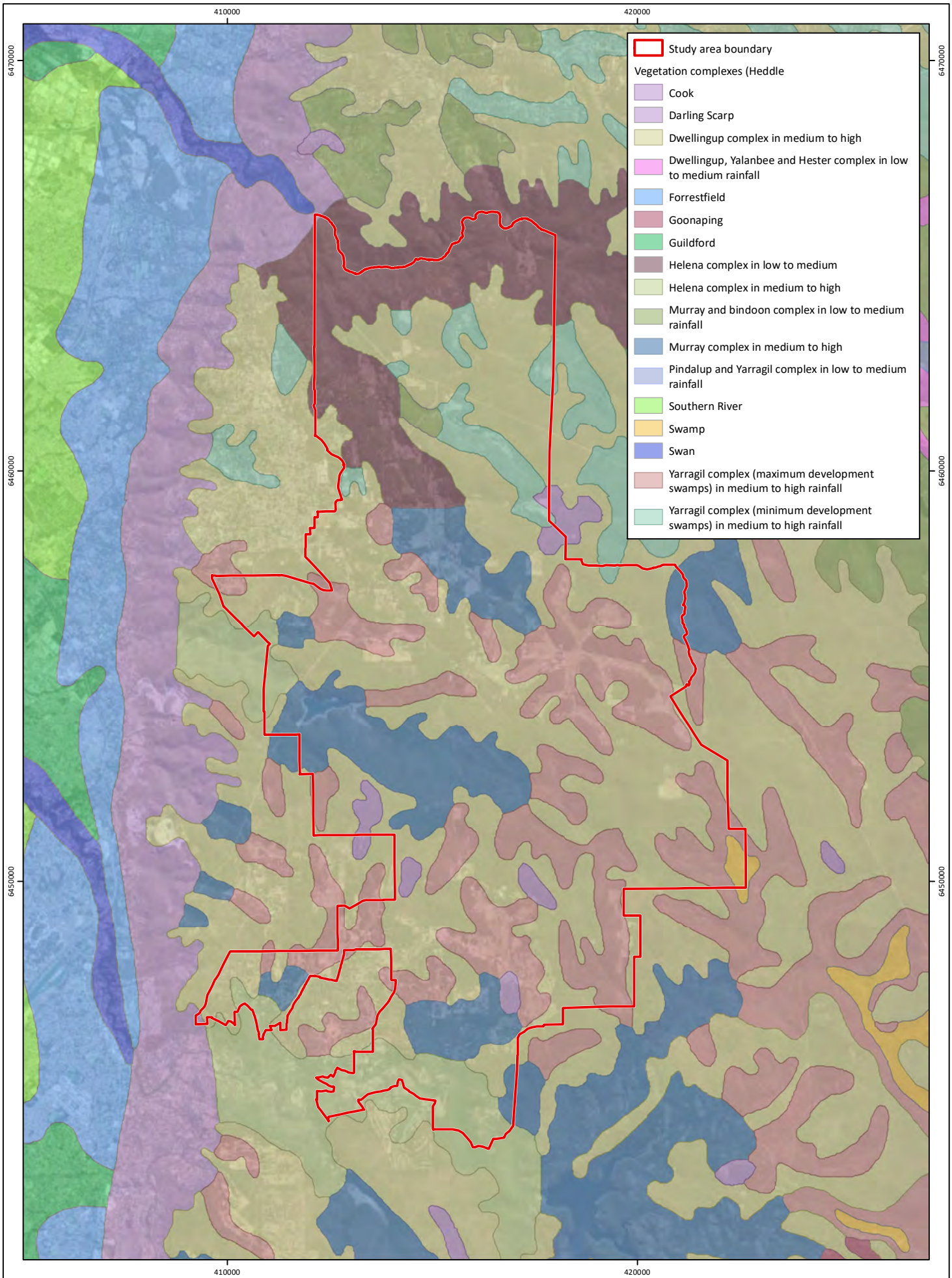

Figure 4: **Vegetation Complexes**

Project: Bushfire Management Plan
Pickering Brook and Surrounds Bushfire Risk Assessment

Client: Department of Planning, Lands and Heritage

Plan Number:
EP19-138(04)--F44

Drawn:	SCM
Date:	15/05/2020
Checked:	DAE
Approved:	AJR
Date:	19/05/2020

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Kilometers

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GDA 1994 MGA Zone 50

emerge ASSOCIATES

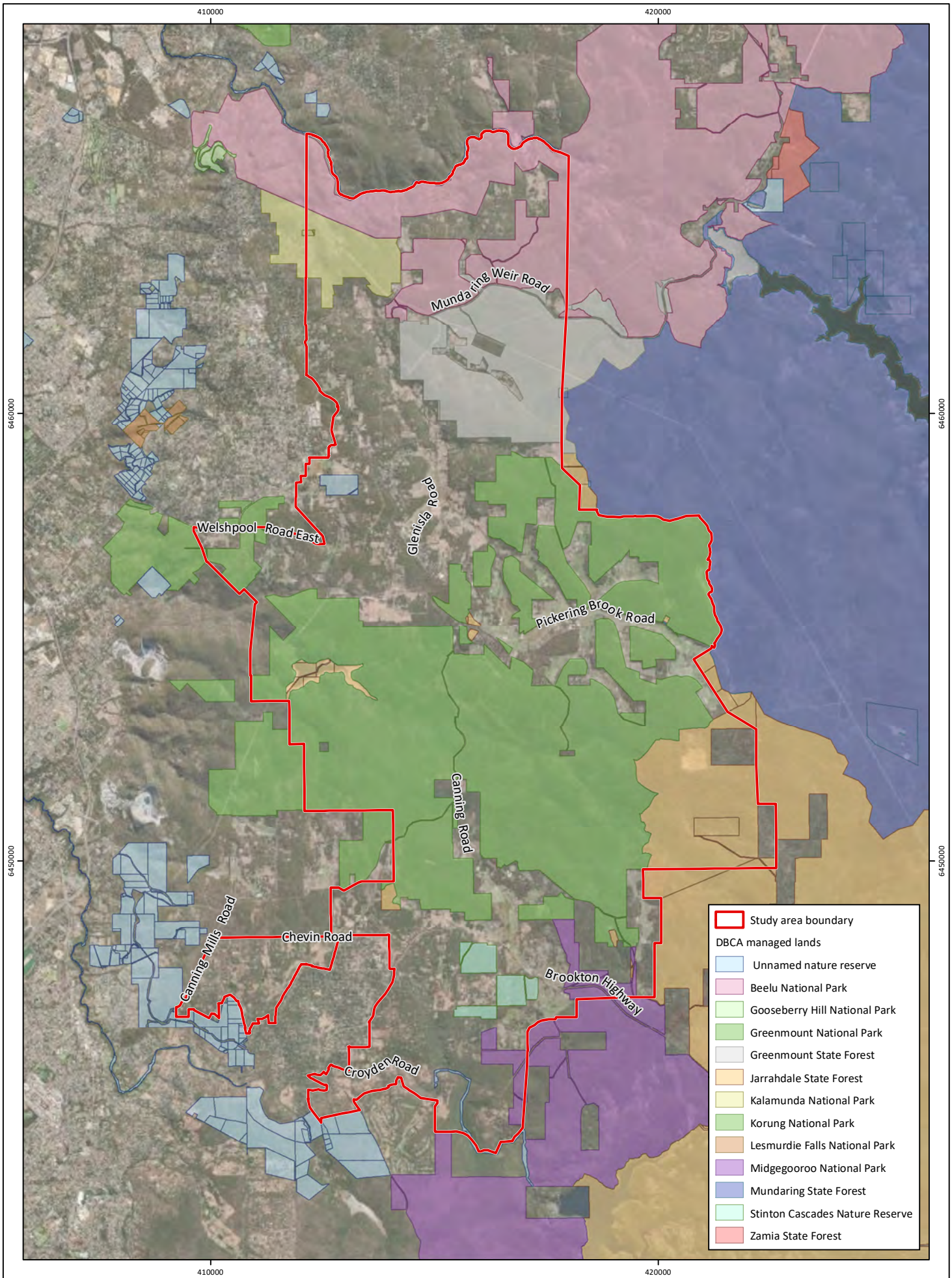

Figure 5: **Department of Biodiversity, Conservation and Attractions Managed Lands**

Project: Bushfire Management Plan
Pickering Brook and Surrounds Bushfire Risk Assessment

Client: Department of Planning, Lands and Heritage

Plan Number:
EP19-138(04)--F45

Drawn:	SCM
Date:	15/05/2020
Checked:	DAE
Approved:	AJR
Date:	19/05/2020

N

0 1 2 3
Kilometers

Scale: 1:110,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

2.1 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 and should not expose a driver to radiant heat through the windows above 3 kW/m^2. Vehicles do not offer effective protection from radiant heat above 10 kW/m^2.

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 traveling on roads during a fire; to close the road before a fire arrives or when firefighting operations are taking place.

An audit of roads, primarily guided by the Gap Analysis (Element January 2020) identified the majority of the tourist product (90%) is located along roads within the valley extending from Piesse Brook at Mundaring Weir Road by Aldersyde Road, Glenisla Road, to Pickering Brook Road and through to Merryville Road (dead end).

Canning Road links the north of the study area to the south through the National Park, connecting to Brookton Highway. Canning Mills Road, Chevin Road, and Croyden Road were assessed as a potential contribution to the tourist network.

These roads were audited using a methodology adapted from the VicRoads, *Road Bushfire Risk Assessment Guideline and Risk Mapping Methodology Report* April 2013, and achieve compliance with the access technical requirements in the *Guidelines for planning in bushfire-prone areas* (the 6m horizontal clearance is an internal dimension as applied interstate and consistent with E3.2 of the Guidelines). The Audit results are recorded in **Appendix A.**

Table 1: Road network

Road	Horizontal width	Surface condition	Through road
Mundaring Weir Road	>6 m	Unbroken bitumen seal	Yes
Aldersyde Road	>6 m	unbroken bitumen seal	Yes
Glenisla Road	>6 m	unbroken bitumen seal	Yes
Pickering Brook Road	>6m	unbroken bitumen seal	Patterson Walnut Pickering Brook road terminates east of the townsite.
Merrivale Road	>6m	unbroken bitumen seal	No
Patterson Road	>6m, 5.5 m seal	unbroken bitumen seal	Yes
Walnut Road	>6m	unbroken bitumen seal	No -Terminates at the Perth Observatory (at the eastern boundary of the study area)
Canning Road	>6m	unbroken bitumen seal	Yes

For the most part, Aldersyde Road and Glenisla Road run parallel to the township of Kalamunda separated by an eastern valley face (escarpment) of 800 m. The tourist roads provide a west and north exit with left-hand turns (reducing intersection delays and promoting continuous flow).

It is a State Emergency Management Procedure [30] to close roads to prevent access to an incident area, i.e., impingement by fire and when suppression operations are taking place. Section 14B(2)(c) of the *Bushfires Act 1954* authorises the police, WAPOL, 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

No suitable public areas were identified outside of the townships for refuge along the main routes within the study area.

The northern section of the study area has access to the Perth urban area from Welshpool Road East, and Kalamunda Road. Evacuation from the area is considered convenient and the safest option. It would, however, be assisted by 'emergency' directional signage.

The southern section of the study area has access to the Perth urban area from Canning Road/Brookton Highway. Mills Road East provides southern and western exits to the Perth Urban area from Roleystone.

Canning Road links the Kalamunda township and the Roleystone township to one another, although the circumstance where it would benefit an evacuation for either township is extremely limited as there is potential for it to be cut across its length.

Figure 6 illustrates the major road network within the study area from Mundaring Weir Road through to Brookton Highway.

2.2 Water supply

The local reticulated water supply is limited to the extent of the township areas of Kalamunda, Pickering Brook, and Roleystone. No strategic water tankage was observed from the roads within the area or appeared on the National Maps data set.

It has been reported that reticulated supplies may not be reliable in a bushfire event:

> *The first being the fire in Pickering Brook / Karragullen in 2005, where the amount of water being used by first responders caused an airlock and water had to be trucked in from a hydrant tapped into the pipeline near Pomeroy Road*. (City of Kalamunda 25 June 2020)

Within the study area, access to a reticulated water supply for firefighting is limited to close by to the main townships. A number of orchardists have dam/soaks on their properties that could be used as a source of water in the event of a bushfire. Many orchardists also have potable firefighting tanks (400 L).

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

The Study Area is also located near the Mundaring Reservoir and the Canning Reservoir, and the Victoria Reservoir is located within the study area. These may support rotating wing aerial firefighting appliances.

Figure 7 illustrates the extent of the reticulated water supply network through the study area.

2.3 Electricity supply

The residential and rural area is serviced by a reticulated power supply managed by Western Power (this excludes National Parks). The power supply is distributed by overhead wires located predominantly within the road verges. In extreme conditions, power may be cut to reduce the likelihood of ignition. The power supply can otherwise be disrupted by trees collapsing over power lines or infrastructure, and transformer or poles being impacted by bushfire. 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. Onsite suppression systems should not rely upon the reticulated power supply.

2.4 Telecommunication coverage

Telecommunications is an important innovation that has become available in the past twenty years to speed reporting of a fire, and importantly it provides early alert and directions to safety. An early alert increases the time to enact safe actions that can be taken with accurate information.

Telstra maps show the study area is under 4G coverage with some areas to the eastern extent of the Study Area, between Pickering Brook and Karragullen, not covered.

Undulations in the landform may create isolated shadows where coverage is not available, which may affect some of the walking and mountain bike trails. This is a matter recommended for further assessment, to identify the location of the blackspots.

2.5 Community infrastructure

Community infrastructure within the Study area Includes:

- Pickering Brook Primary School (parking for 248 vehicles, school oval and Pickering Brook Road reserve).
- George Spriggs Reserve (oval) (Pickering Brook township).
- Kalamunda Volunteer Bushfire Brigade, 20 Raymond Road Walliston
- Kalamunda Volunteer Fire and Rescue Service, 38 Central Rd, Kalamunda
- Roleystone Fire Station, 48 Jarrah Rd, Roleystone
- Bedfordale Volunteer Bush Fire Brigade, 2 Waterwheel Rd, Bedfordale.
- Evacuation Centre Armadale Arena, Townley St. Armadale
- Evacuation Centre Kalamunda (four), the address to be withheld at the request of the City of Kalamunda

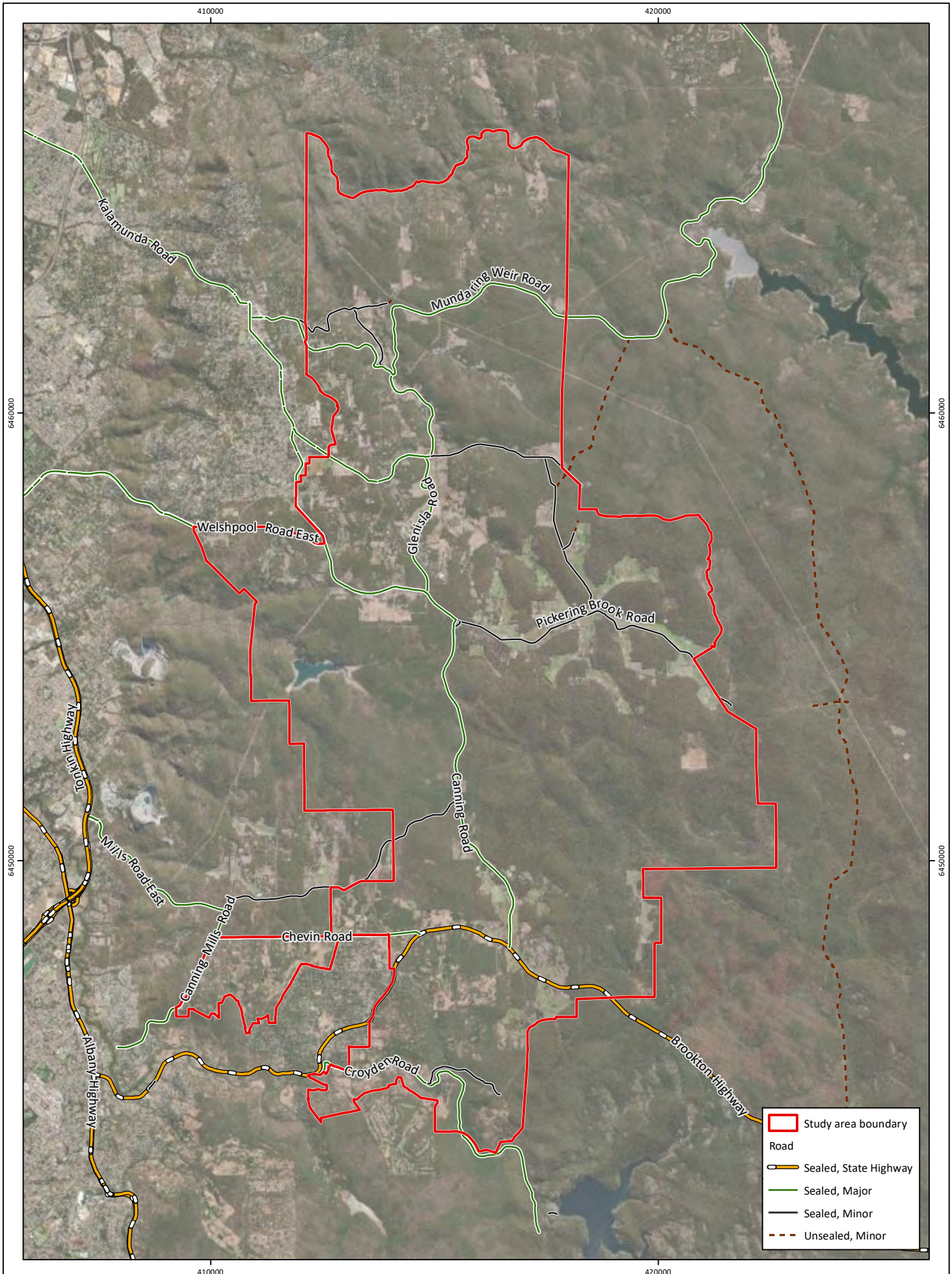

Figure 6: Major Road Network

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

Plan Number:
EP19-138(04)--F46

Drawn:	SCM
Date:	15/05/2020
Checked:	DAE
Approved:	AJR
Date:	19/05/2020

N

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Kilometers

Scale: 1:110,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

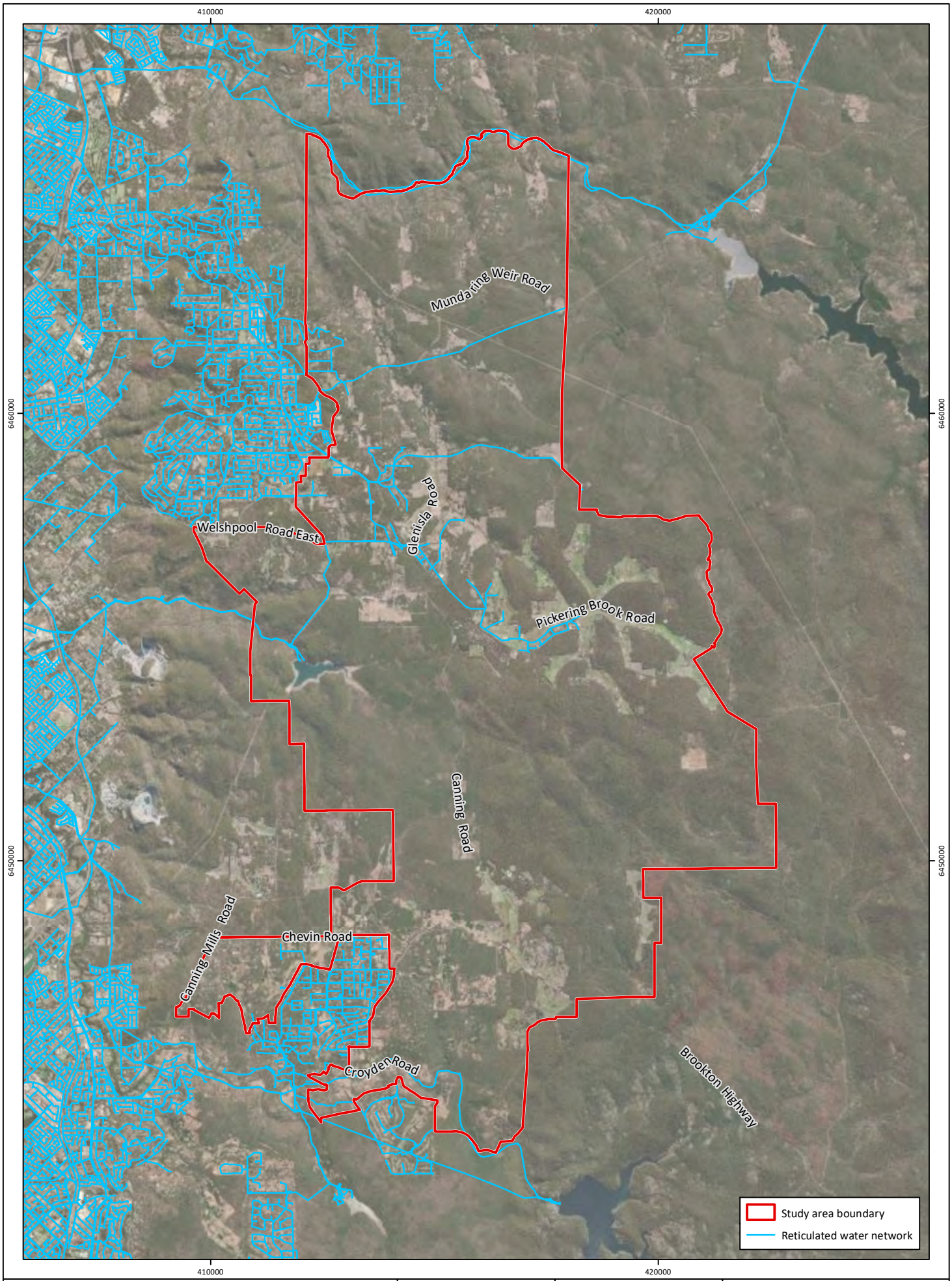

Figure 7: **Reticulated Water Network**

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

Plan Number:
EP19-138(04)--F47

Drawn:	SCM
Date:	15/05/2020
Checked:	DAE
Approved:	AJR
Date:	19/05/2020

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Kilometers

Scale: 1:110,000@A4

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3 Bushfire Behavior

The 2009 Victorian Bushfires Royal Commission explained:

> *Bushfires obtain their energy from fuel and their speed and direction from the weather, topography, and the fire itself. These factors affect fire behaviour, including the rate of spread, flame height and angle, persistence in the area, and the way firebrands travel. The only element that can be controlled by humans is the management of fuel*

Bushfire behaviour is primarily affected by three factors;

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

Bushfires take time and distance to fully develop to a steady-state and onto maximum intensity. Fires of sufficient size create strong convective updrafts that can create localised gale-force winds and lift heavy fuels into the atmosphere, which in turn can be spread downwind, contributing to advanced spotting and multiple ignitions up to 9 km ahead of the fire front.

Ember attack driven by localised effects created by the fire and carried on the prevailing wind direction driving the fire contributes most to building loss. AS 3959:2018 uses 100 m from the fire front, which reflects 80%[31] of dwellings severely damaged or destroyed (an acceptable level of risk) although the ratio of loss is proportionate to the separation from the hazard; the closer to the hazard the higher the loss[32]. Ember density is proportionate to the distance from the fire, most dense immediate to the fire front but potentially destructive up to 700 m which is the distance accepted to account for all dwelling loss[33].

The intensity of a bushfire impact is the greatest downwind of the advancing fire front. It experiences the greatest concentration of ember attack and flame lean, which advances the speed of the fire. A fire follows an elliptical shape. The rate of spread and intensity of a fire is lower in its sides, flanks and as a backing fire from the rear

Bushfire behaviour is affected by the slope under the vegetation. The intensity of bushfire doubles with every 10% increase in slope, and flame length and rate of spread also increase. The increased intensity is experienced by a receiver located upslope from the bushfire. For a receiver that is downslope of a bushfire, the intensity of the bushfire is mapped by AS 3959:2018 as if it is level land.

A fire's intensity and behaviour are affected by the mass and availability of fuel. Availability is determined by the surface area and access to oxygen. The most intense fires are forest fires that

[31] This reference addresses dwelling mostly constructed prior to bushfire construction standards although it is still expected that depending on the intensity of the fire the design standards can be exceeded. It is also acknowledged that the evacuation policy removes the attendance of the owners to attend to small fires, before they envelope the building after the fireront's passing, which had been significant is saving may buildings.

[32] 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

[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

engage the tree canopies. These require a vertical involvement of all available fuels from the ground to the canopy. Loosely arranged fuels have a higher exposure to oxygen (availability) and promote a faster and more intense fire. Heavy fuels such as tree trunks have a surface availability of barks but otherwise are slow to engage and will burn slower over a longer period of time. Prescribed burns, as a means of fuel reduction, attempt to remove the available fuels and the vertical fuel structure that can lead from the ground to the canopy. A bushfire also requires continuity of fuel, horizontal structure, to be able to advance. Separations in the horizontal arrangement can, however, be bridged by ember attack.

Fire weather comprises various combinations of air temperature, relative humidity, wind speed, and the long and short-term drought effects, expressed as an FFDI. The FFDI is a determinant of the bushfire behaviour. When the FFDI is above 50, bushfires move faster and are more intense and have longer flame lengths. Spotting increases (small fires igniting ahead of the fire front and started by burning embers lifted by the convective heat and carried downwind), and suppression becomes progressively more difficult. House loss and fatalities increase as the FFDI increases above 50 and up to 120 + (Catastrophic).

Unlike vegetation and slope, which is comparably fixed, the FFDI can vary from day to day and during a day. The FFDI can be predicted, and an alert is issued by the BoM on the proceeding day. Tourist operators can, therefore, make arrangements for the following day, i.e., close the facility (not operate).

Property loss can occur at less than FFDI of 50, but suppression is more effective, and therefore the availability of suppression resources can reduce the risk.

3.1 Topography

The study area is located immediately east of the Darling Ranges escarpment. 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 3**.

Deep, steep-sided valleys run in a north-westerly direction either side of the study area. These valleys accommodate the Mundaring Weir-Reservoir, the Victoria Reservoir, the Canning Reservoir, and the Churchman Brook Dam.

The study area ranges from approximately 100 m Australian Height Datum (m AHD) and up to 350 m AHD (Landgate 5 m contours).

Both the Townships of Kalamunda and Roleystone are located adjacent west and upslope from the study area.

Roleystone ranges from 310 m AHD down to 175 m AHD east and west of the township. Kalamunda ranges from 310 m AHD down to 175 m AHD to the east and 180 m AHD to the south.

3.2 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, according to 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, and marri-wandoo (*E. calophylla – E. wandoo*) woodlands on loamy soils with sclerophyll understoreys (Beard 1990).

At a regional scale, the vegetation complex mapping by Heddle *et al.* (1980) indicates that two separate complexes occur within the study area, which is shown in **Figure 4** 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 mixtures 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 study area is largely occupied by public land within the administration of the Department of Biodiversity Conservation and Attractions. These areas are characterised as forest (AS 3959:2018).

3.3 Urban penetration

Urban penetration is the occurrence of house loss within a built-out area and is reflective of the availability of fuels within the urban environment that may initially be accessed by ember attack but may expose heavier materials to direct and prolonged flame contact that can create a cascade of ignitions between structures that are in close proximity to one another (herd behaviour).

Urban penetration can be largely eliminated by construction standards (improved after the Wye River fire experience), the separation of structures, and site management (gardens and avoidance of flammable items near a house). Vehicles and material stored under open carports or under the main roof of the house and storage of material in open building undersides contribute to house loss.

The study area adjoins the township of Kalamunda, and it surrounds the township of Roleystone. Both townships are characterised with having a high degree of retained and propagated native eucalypt trees[34] with varying degrees of land management but largely a notable continuity of vegetation arranged both vertically and horizontally. As such both present a continuity of bushfire fuel through their urban areas. Both townships also comprise a housing stock that predates contemporary bushfire construction standards.

> *Urban fire intrusion is created when natural vegetation – corridors or patches – are retained in and amongst the urban area. This is leveraged by ember attack, which creates spots fires in these locations whilst also attacking the vulnerabilities of each particular building, creating fires that can quickly grow out of control. House-to-house ignition then becomes an issue, wherein urban contexts, homes are generally more tightly located, which allows radiant heat*

[34] City of Armadale Urban Forest Strategy

exposure from a burning dwelling next door to impact upon doors and windows of surrounding dwelling, which eventually leads to their failure and thus, onset of sequential house loss.[35]

Within the study area residences can be found associated with orchards, land that has been historically cleared. Densely vegetated, isolated, rural living lot estates are found in Paulls Valley and in the area east of Roleystone. Due to the extent of National Parks, public land, and regulated vegetation (restricted from removal), there is little potential for an expansion of farming and rural living development outside of the existing areas.

The township of Pickering Brook has been the subject of a separate study with measures identified to avoid urban penetration that includes construction standards and site management for new development and community, such as a DFES Bushfire Ready Group, established to promote improved residential site management and seasonal preparation, and voluntary building improvements to increase existing building resistance to bushfire attack. Further consideration may be given to establishing a local brigade at Pickering Brook, to assist response time but also to promote community awareness.

The townships of Kalamunda and Roleystone are located adjacent to the study area, and the future activities within the Study Area can potentially expose them to either an elevated or reduced intensity of bushfire attack.

A continuity of native vegetation through the townships of Kalamunda and Roleystone is an immediately notable character and one cherished by the local community. Unfortunately this is also a continuity of bushfire fuel susceptible to development that may occur in the study area, to either increase or reduce the risk of bushfire initiation and spread. It is an important consideration to ensure land presently a low bushfire hazard level area, ie historically cleared, if re-forestated associated with tree change rural living, can change to an extreme bushfire hazard level area.

Whilst the merit of urban forest strategies is understood and multifaceted, many acknowledge bushfire as a parallel objective but, in fact, is the opposite because it increases bushfire risk and a potentially uncontrollable urban penetration.

Urban forest strategies are an encouragement with an attached species list. It does not need to be the case that the objectives of forestation and bushfire management should remain opposed. They can both be achieved through careful consideration of the vertical and horizontal arrangement of fuels and utilising high moisture, low flammability endemic species to provide a natural separation.

This study has concerned itself with the management of land leading up to the townships but suggests that further consideration to demonstrating urban forest strategies that can achieve both the ecological and amenity benefit and reduce the likely bushfire intensity to a controllable level.

3.4 Weather and climate

Weather and climate data have been obtained from weather stations at Bickley and Gosnells and at Perth Airport. These represent the closest stations to the Study area, with the Bickley station located

[35] Leonard, Justin; Opie, Kimberley; Blanchi, Raphaele; Newnham, Glenn; Holland, Mark. *Wye River / Separation Creek post bushfire building survey findings*. Australia: CSIRO; 2016.

at the northern extent and Gosnells at the southern extent. The Gosnells station it should be noted is more reflective of the Swan Plain altitude and more closely follows the Perth Airport, whereas Bickley reflects the higher altitude and east of the escarpment locations, notably cooler and with higher longer rainfall, lower wind speeds and more consistent directions.

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, being 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 December to March rainfall (216.2 mm in June). Annual rainfall is 1071.5 mm. Relative humidity at 9 am is 56% on average.

Records of wind information were obtained from the Bureau of Meteorology from the weather stations nearest the Assessment Area and include Bickley, Gosnells, and Perth Airport. Monthly climate statistics from 'Climate Data Online' (BoM, 2020[36]) were considered for the period 1994-2019 for Bickley, 1991-2019 Gosnells, and 1944-2019 for Perth Airport (18.3 km away). The mean wind speed and direction have 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.

Notable from the wind rose (BoM) comparisons 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 compared to Perth, which has a higher proportion of strong winds from the south-west during the summer months.

3.5 Landscape Bushfire History

The *Bushfire Cooperative Research Centre Fire Development, Transitions, and Suppression study 2014,* which studied urban and peri-urban areas around Perth, compared 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%[37] from natural causes. It was noted that during the study period, there was a 50% 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.

The draft City of Kalamunda Bushfire Risk Management Plan 2019-2024 identified that during the period starting 1 July 2007 to 30 June 2018, an average of 125 fire ignitions occurred per year, but the rate had declined consistent with the with increased policing efforts to stop arson in the area.[38]

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

[37] A L Sullivan et al *Bushfire Cooperative Research Centre Fire Development, Transition s and Suppression study CSIRO 2014 p 17*

[38] City of Kalamunda Bushfire Risk Management Plan Draft 2019-2024 p. 22

The City of Armadale (draft) *Bushfire Risk Management Plan* 2020-2025, currently before Council as a draft for consideration, has illustrated a similar profile with an average of 142 fire ignitions per year[39].

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 eight significant landscape fire events between January 2005 and June 2016, affecting the study area. Seven of these fires are believed to be suspicious/deliberate. All but one of the fires was less than 100 ha in total.

Table 2 details the significant bushfire events considered in this report, including, where available, the FFDI 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 2: 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
15/01/2005	Pickering Brook	35-37	Suspicious/ Deliberate	Easterly changing to north-easterly	27700	East to west	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	60	Hot Works (Grinder)		400	East to West	

[39] City of Armadale Bushfire Risk Management Plan 2020-2025.

Date/Time of Ignition	Location	FDI	Ignition Source	Prevailing Wind	Area Burnt (ha)	Fire Path	Termination Factors
12/01/2014	Parkerville Stoneville Mt Helena	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
16/05/2015	Merrivale Rd Pickering Brook		Suspicious/ Deliberate		100		

3.5.1 Fire case study Roleystone Kelmscott Red Hills

Extracts are taken from M. Keelty, *A Shared Responsibility the Report of the Perth Hills Bushfire February 2011.*

On 6 February 2011, the Roleystone Kelmscott Red Hills bushfire destroyed 71 homes in the Roleystone-Kelmscott area. The fire occurred on a Severe Fire Danger Rating of FFDI 60 and was, started by human activity using an angle grinder on Brookton Highway, immediately west from Roleystone, at approximately 11.30 am. The wind direction was south-east and east with estimated wind gusts between 70 and 80 kph. The fire concluded after 11 hours spreading to Kelmscott.

> *"The Kelmscott-Roleystone bushfire developed rapidly from about 12.10 pm on 6 February 2011 under conditions of Very High fire danger in forest and grassland fuels. Almost immediately, the fire began impacting residential areas adjoining the Brookton Highway. The direction of the fire spread was clearly dominated by the strong easterly winds, which were reinforced by the orientation of the topography along the valley of the Canning River. By 2.00 pm the fire was well established in the Lloyd Hughes Reserve and was impacting properties in the southern section of the Clifton Hills residential area. Reconstruction of fire spread indicates the Banyowla Regional Park was burnt by flanking spread upslope from Buckingham Road, and by a fire front that spread in a northwesterly direction across Canning Mills Road under the dominant influence of localised steep slopes…Spotting appears to have contributed significantly to the propagation of the fire and the ignition of buildings.[40]"*

The fire spread from the ignition point to the west. Post-fire aerial photography revealed that spotting had played an important role in the propagation of the fire as it spread westwards through the forest; the rate of spread was 1.5 -1.6 kph.

[40] M. Keelty, *A Shared Responsibility the Report of the Perth Hills Bushfire February 2011*

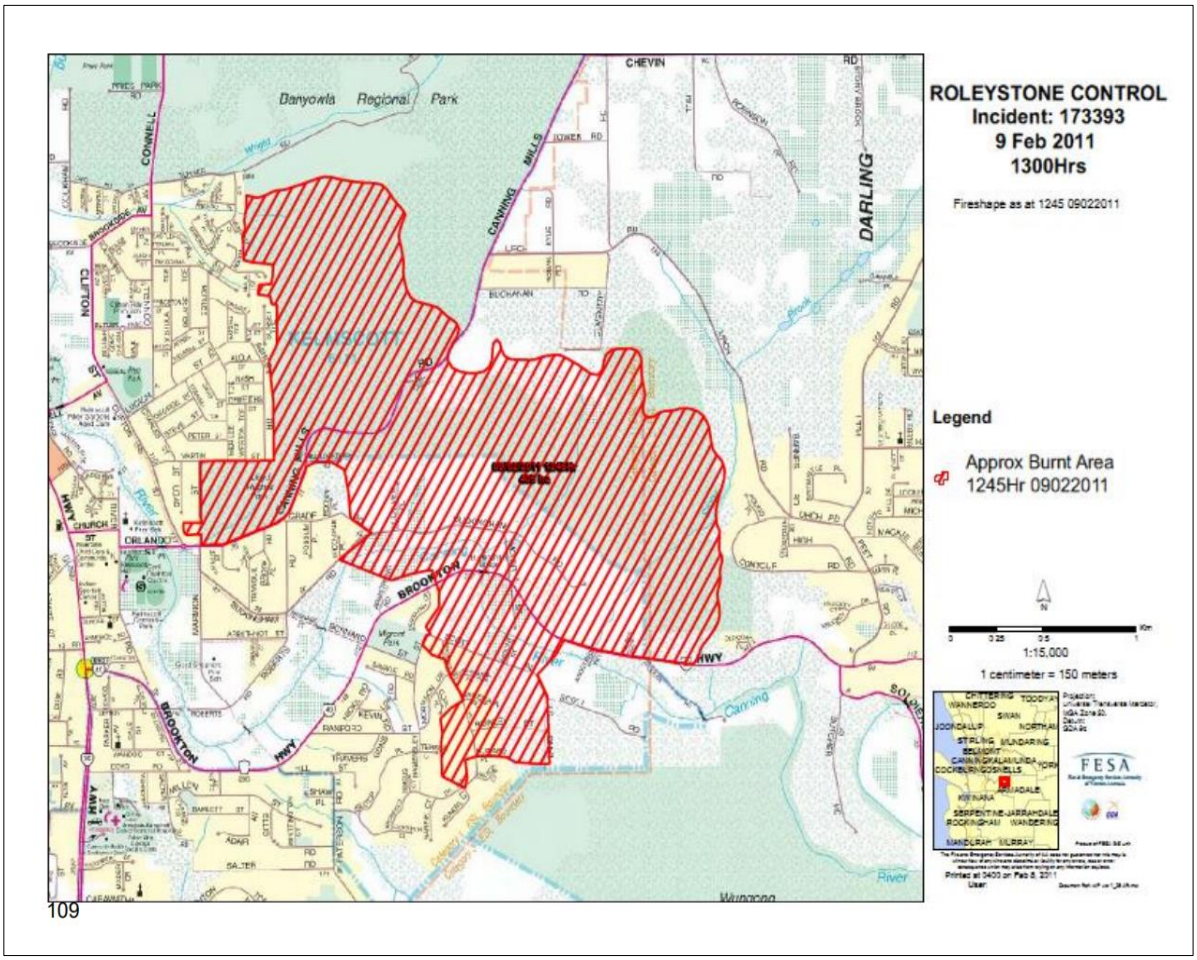

Plate 2: showing extent of the 2011 Roleystone Kelmscott fire

> *Recent studies conducted in WA concluded that hazard reduction by prescribed burning would reduce the rate of spread, flame height and intensity of a fire, as well as the number and distance of spot fires by changing the structure of the fuel bed and reducing the total fuel load. The reduced fire intensity and rate of spread observed when bushfires enter a reduced fuel area allows firefighters greater opportunity to effectively combat the fire and to limit its impact.*
>
> *It has also been demonstrated that prescribed burning will reduce the incidence of bushfires by maintaining areas of sparse fuel that are less likely to remain alight following ignition. This is supported by an analysis of fire statistics for forests in the south-west of WA between 2000 and 2006, which shows that lightning-caused fires, which should be randomly distributed at a landscape scale, are less likely to be sustained in areas where the fuel is less than five years old*[41] .

The Keelty review highlighted the difficulty in the 'preserve life and evacuation' policy, the lack of certainty to force the evacuation, and missed opportunity to suppress the progress of the fire to benefit property through the single focus upon evacuation. The evacuation centre nominated was Roleystone Town Hall but later changed to Armadale Arena at Forrest Road in Armadale, a larger facility outside the fire area.

[41] M Keelty a Shared Responsibility the Report of the Perth Hills Bushfire February 2011

3.5.2 2005 Perth Hills Fire (Pickering Brook)

Extracts taken from, *Fire behaviour during the Pickering Brook wildfire, January*

In January 2005, a wildfire burnt 27 700 ha of forest in the Pickering Brook area and was the subject of analysis by N.P. Cheney, in 2010.[42]

The analysis found the fire spread over 15–17 January 2005 to the southeast from deliberate and multiple ignitions and travelled in a south-west direction towards the Perth urban area under prevailing easterly winds. The spread was further influenced by spot fires and the confluence of individual fires into a single fire front.

The fire burnt over gently undulating terrain east of the Darling Escarpment and was stopped before it reached the steeper terrain west of the escarpment. The fire was stopped completely or checked to such a degree that suppression was effective when it ran into one or two-year-old fuels that were the outcome of recent fuel reduction burns.

The analysis found where fuel reduction had occurred in the last three years (instead of 20+year fuels), the reduced fuel load significantly reduced the rate of the fire spread and the intensity of the fire front (825 kWm^2 v 20645 kWm^2). Fire in the 3-year-old fuel spread six times slower and was 20 times less intense compared with the fire in 20-year-old fuel.

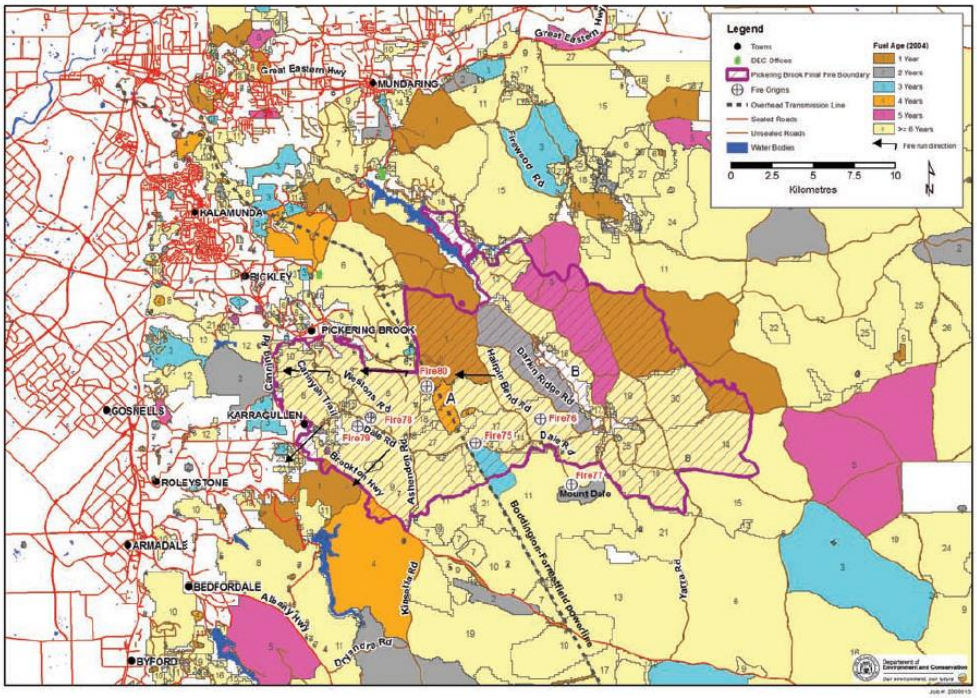

Plate 3: showing the extent of the 2005 Pickering Brook fire

The rates of spread observed in the 2005 fires were in relatively mild conditions with wind speeds up to 28 k/h: the rate of spread was up to 1.4 k/h.

[42] Cheney N.P. 2010, *Fire behaviour during the Pickering Brook wildfire, January 2005*

The fire lasted over three days traveling from the east, northeast on the morning winds of 17 January before settling east but then switching to the west with the arrival of a cold front at 3 pm.

This fire event illustrates the potential threat of fire to the peri-urban areas of the Perth Hills. This event highlights the need to manage fuels by prescribed burning to reduce rates of spread and make fire suppression easier.

Whilst in this instance the fire found fuels of less than three years old, had the fuel been 20 years old, and the winds extreme, 45 kph, the rate of spread would have been 4.3 kph, overwhelming resources and entering into Roleystone and Gosnells.

> *"If the fuel reduction burning program by the Department of Environment and Conservation had not been carried out, very little effective suppression would have been possible for several days until the weather moderated and indirect suppression could be carried out from established roads. The Pickering Brook fire would have burnt over the Darling escarpment and into the areas of Roleystone and Gosnells in less than 24 hours after ignition. In my opinion, this fire would have resulted in extensive damage to homes and the loss of life in the Perth Hills suburbs.*[43]"

[43] M Keelty, *A Shared Responsibility the Report of the Perth Hills Bushfire* February 2011

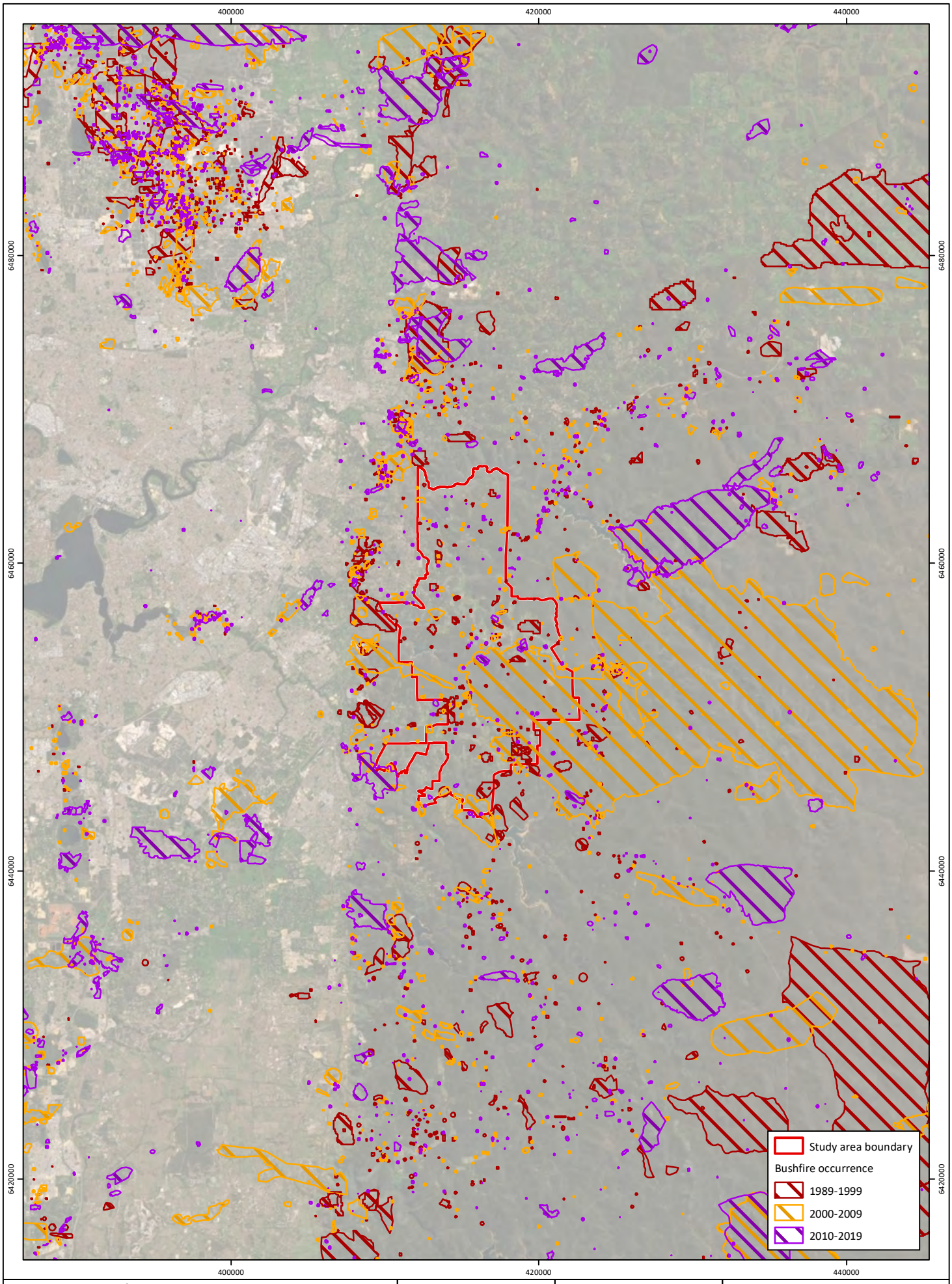

Figure 8: **Bushfire History Excluding Planned Burns - Landscape Context**

Project: Bushfire Management Plan
Pickering Brook and Surrounds Bushfire Risk Assessment

Client: Department of Planning, Lands and Heritage

Plan Number: EP19-138(04)--F48

Drawn:	SCM
Date:	15/05/2020
Checked:	DAE
Approved:	AJR
Date:	19/05/2020

N

0 3 6 9
Kilometers

Scale: 1:320,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

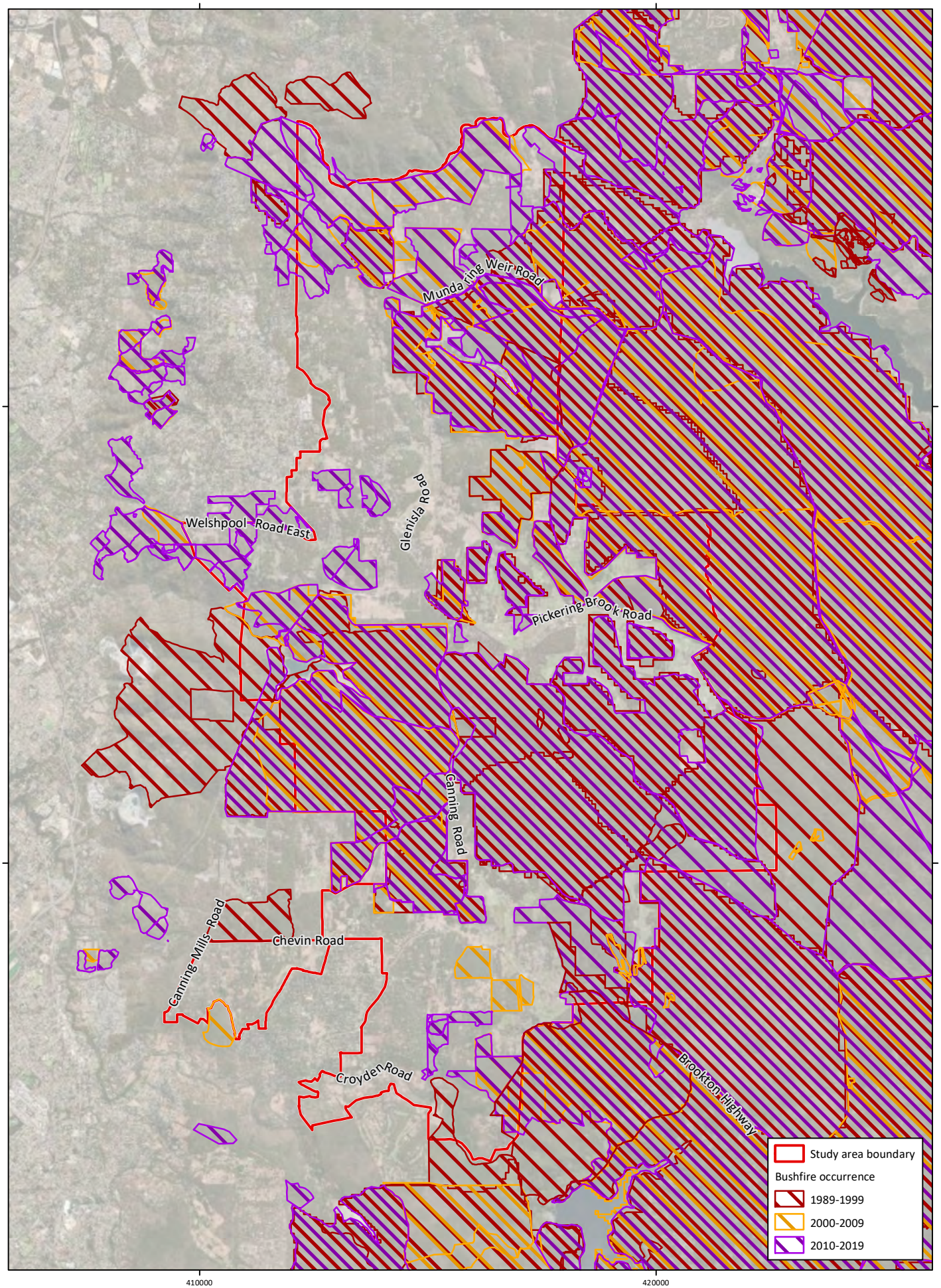

Figure 9: Planned Burns

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

Plan Number: EP19-138(04)--F49a

Drawn:	GAR
Date:	07/08/2020
Checked:	DAE
Approved:	AJR
Date:	07/08/2020

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Kilometers

Scale: 1:110,000@A4

GDA 1994 MGA Zone 50

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4 Landscape Bushfire Hazard Level assessment

4.1 Bushfire Hazard Level (BHL) 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.

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 classes of vegetation, as classified by AS 3959:2018 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.

The BHL assessment is provided in **Figure 10**.

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. **Figure 10** reflects the measure taken upslope from the fire, where it is most intense for the measured slope. For a forest, the minimum intensity in AS 3959:2018 is 44,000 kW/m^2, and the maximum shown in **Figure 10** is > 62000 kW/m^2 for a fire on a steeper slope (>10^0). All these values are increases upon an already 'extreme' bushfire hazard level.

Generally, throughout the area, the access routes, and the orchards are set downslope of the vegetation, the exception being a section of Canning Road between Pickering Brook Road and the townsite of Kalamunda which is located upslope from adjacent forest vegetation.

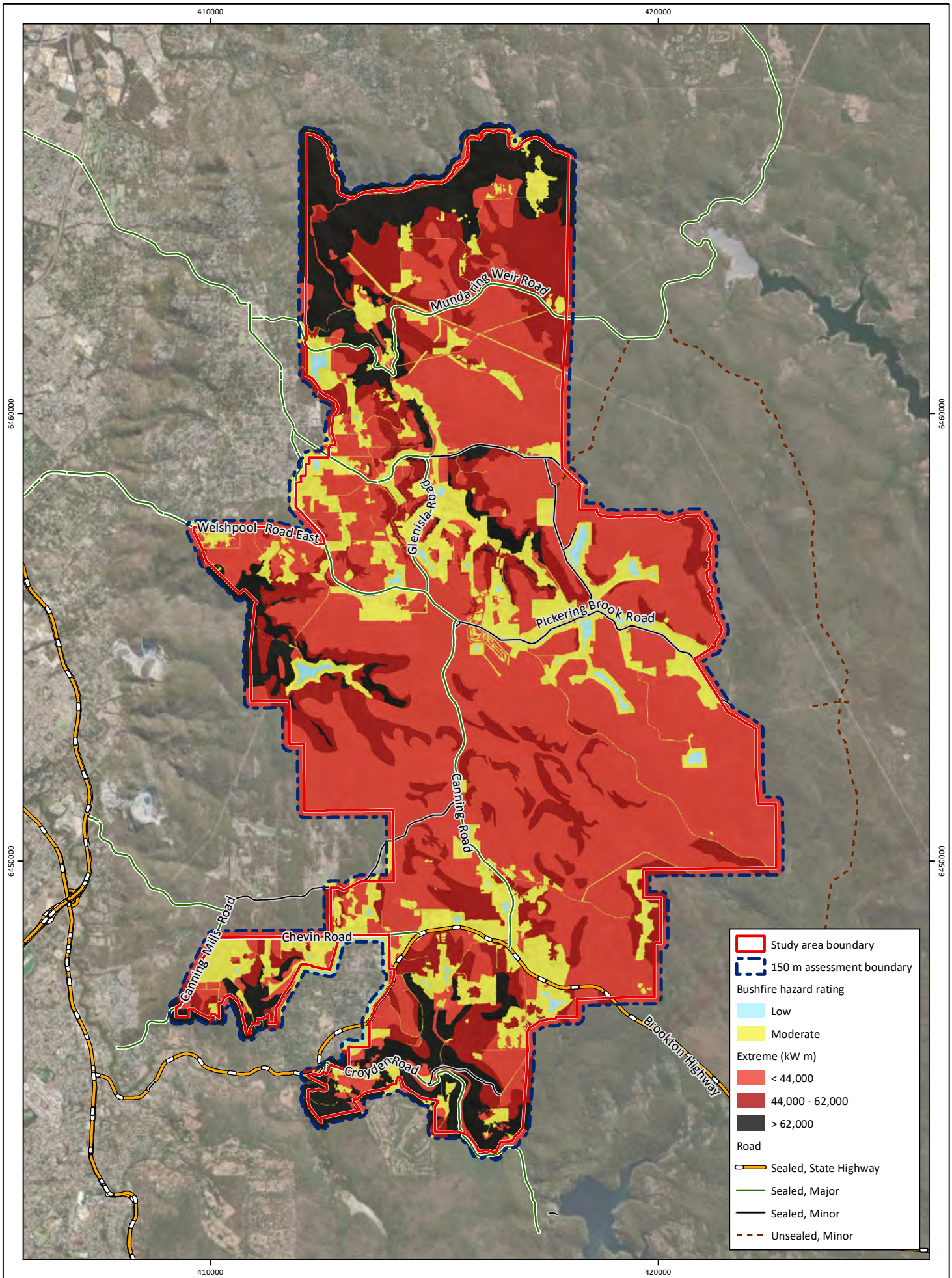

Figure 10: Landscape Bushfire Hazard Level Rating

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

Plan Number: EP19-138(04)--F53
Drawn: SCM
Date: 15/05/2020
Checked: DAE
Approved: AJR
Date: 19/05/2020

N

0 1 2 3
Kilometers
Scale: 1:110,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

5 Overall Study Area Risk Assessment

As part of addressing the bushfire management measures that may apply to the study area, a qualitative risk assessment for bushfire has been undertaken, following the risk management processes, as described in NERAG (2015, 2020) which evaluates the combination of likelihood and consequence to derive an appreciation of the risk, and the measures that can derive an acceptable level of risk. This perspective is taken from the promotion of the area for tourism, with people potentially found in the open, the location of tourism facilities, the potential impacts upon buildings, the opportunity for shelter, and land use intensification anticipating building for residential purposes.

The fire history has identified that fuel reduction measures in DBCA land and increased policing have reduced the rates of ignition and the intensity of bushfires enabling the arrest of bushfire before significant penetration into the Perth urban area.

Whilst these initiatives have been effective to date; they arguably have provided a false sense of security to the risks that are also increasing. The promoted emphasis upon extreme bushfire conditions can conversely create complacency outside these conditions during the bushfire season.

The examples of bushfires in 2005 at *Pickering Brook* and in 2011 at *Roleystone Kelmscott*, were not in extreme conditions. The apparent drying of the local climate is a recognised challenge to the orchard industry, and the conversion of low threat agricultural land to a classified threat is increasing the risk. Further intensification of activity in the area is exposing more people to the risk.

Conversely, knowledge of resilient building construction, land management, and building siting is improving. The knowledge of bushfire behaviour, whilst confounding, is improving as are the predictive models to undertake advanced preparations for bushfire management. Telecommunication has advanced significantly in the past 20 years, speeding the reporting of ignitions and alert times to increase the time available for people to make informed decisions to protect their safety.

The construction and siting standards reduce the dependency for individual attendance from emergency services to save individual property instead of freeing those resources to act strategically. However, there remains an existing stock of buildings that are reliant upon intervention and active fire suppression for protection.

5.1 The Primary Risk (Statement)

5.1.1 Scope

This risk assessment will assess the consequence of a landscape fire affecting the Study area either in part or over a substantial part, i.e., the 2005 bushfire.

The continuity of bushfire fuel to the east of the study area is sufficient for the development of a wide fire front directly affecting part or all of the study area, either from directly downwind of the firefront, or from a flanking fire as the front progresses (Cheney (2010) on the 2005 fire affecting Pickering Brook, was a flanking aspect).

Within the study area, all or part could be impacted by a bushfire from the northeast to the east, under the wind direction typical of severe weather during the fire season, with a southwest wind change late in the afternoon (Cheney 2010).

The extending distance of the forest to the east of the study area has the potential for a wide fire front, such as occurred in 2005, whereas to the west, southwest, the continuity of fuel is over a shorter distance, and as fires are elliptical, a narrower fire front would be expected to affect a part of the Study area. Fires typically follow the prevailing wind direction and, in turn, will travel from the direction of the wind and into available fuels as the wind direction may change during the course of a day and potentially over multiple days.

Areas directly downwind of the fire front, are likely to experience extreme ember attack and potentially neighbourhood-scale destruction of property in the townships of Kalamunda and Roleystone, and unprepared areas in Pickering Brook.

A high level of building loss can be expected if buildings are located closer than 30 m to classified vegetation and if the performance level of the building is exceeded by the bushfire conditions.

5.1.2 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.*

5.1.3 Defining an acceptable risk

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 immediate safety, including 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 a minimal disruption to the ongoing daily function of the community immediately following a bushfire event.

The Australian Institute for Disaster Resilience Handbook, *Land Use Planning for Disaster Resilient Communities* (AIDR 2017)('the Handbook'), has identified a recent study that explained the concept of risk applicable to bushfire.

It has described that consistent with other land use planning approaches to dealing with natural hazards, as a principle, the level of exposure can increase, but not the level of risk[44].

[44] Australian Institute for Disaster Resilience 2020, *Land Use Planning for Disaster Resilient Communities* 2020

The application of the bushfire protection criteria (solutions) contained in the Guidelines, establishes at FDI 80 that BAL 29 is an Acceptable Solution, but if a building is required for shelter the building should comply with the Australian Building Codes Board[45] *Design and Construction of Community Bushfire Refuges* and *Bushfire Verification Method,* which requires the building be exposed to less than 10 kWm2 derived using a flame temperature of 1200 K instead of 1090 K, and an FDI based upon a 1:200 AEP, instead of 80.

As an example, the number of dwellings exposed to a maximum BAL-29 (or 10% NCC verification alternative[46]) may be increased, but the risk level should not be greater than BAL-29.

The Handbook has also reintroduced the concept of ALARP (as low as reasonably practicable), specifically to address the uncertainty of bushfire, and in addition, recognise that other factors can contribute to a building's survival and bridge the 10% failure expectation of the NCC.

The productive use of regional areas is a high-level consideration of relevant bushfire hazards. Tourism is a productive use of land where the experience offered at a place, is the product that is consumed by the visitor.

Other industries, by comparison, distribute their products[47]. Subject to the assurance of human safety, the acceptable level of risk associated is set higher than the loss of a home to an individual, and not insignificantly, it is based on the difference of emotional consequence.

The WAPC Position Statement *Tourism Land uses in Bushfire Prone Areas* (DPLH 2019) recognises in the State Planning Strategy, the social and economic importance placed on developing tourism land uses within remote and/or heavily vegetated areas and that it comes with an inherent risk of bushfire, which can be reduced but never fully eliminated

In recognition that the inherent attraction may be in conflict with routine bushfire protection measures, it provides:

> ”if human safety can be satisfied the asset may be considered replaceable, and its bushfire construction determined to the degree necessary.”

[45] Australian Building Codes Board 2019, *Handbook: Bushfire Verification Method*, Commonwealth of Australia and States and Territories 2019, published by the Australian Building Codes Board, and
Australian Building Codes Board 2014, *Information Handbook: Design and Construction of Community Bushfire Refuges*, 2014

[46] The National Construction Code assumes the AS3959:2018 Deemed to Satisfy solutions have a 10% failure, based on assembly error. A verification method as an alternative to a DTS most also demonstrate a predicted failure of no greater than 10%. The remaining 10% to be addressed by ALARP.

[47] International Centre for Responsible Tourism – Australia Encouraging Rural Tourism to embrace Bush Fire Risk Management 2013

5.2 Risk Analysis

5.2.1 Likelihood

Two points of reference have been used to determine the likelihood of a bushfire event affecting the study area. This has included both a review of the bushfire history and 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.

From a review of the bushfire history, it is notable that ignitions frequently occur in the area but relatively few advance into a landscape-scale fire.

The frequency of ignition increases with human interaction. 90% of landscape fires are the result of unintentional ignitions, faulty equipment, and deliberate ignitions. Increased policing of arson has significantly reduced ignitions[48]. The rate of ignitions is sensitive to the policing efforts; if efforts are reduced, the probability of ignition will likely increase.

This risk assessment acknowledges the inherent risk that classified vegetation (AS 3959:2018) and slope presents, but the dynamic variable on the day that affects the fire behaviour is also the Forest Fire Danger Index (FFDI). The FFDI combines a record of dryness, based on rainfall and evaporation (drought factor), with meteorological variables for wind speed, temperature, and humidity.

From a land-use planning consideration, it is important to understand when the destructive conditions occur, when the fire intensity can be anticipated and how the building can be sited and designed to resist the fire intensity: to consider if the building can survive and provide a place of last resort for occupant survival if evacuation is not safe/possible.

The significance in the FFDI data, is to identify the extreme design condition using a 1:200 APE (return period standard) for refuge but also to identify when extreme conditions can be avoided, as one option for ensuring human safety.

The FFDI is a determinant of bushfire behaviour and a lead indicator for potential house loss and fatality. It is rare for houses to be destroyed when the FFDI is below 50, and civilian fatalities do not occur if the building survives, (excluding exertion causing heart attack). Building survival progressively deteriorates as the FFDI and the fire intensity increases, such that the building performance is exceeded. As the FFDI increases above FFDI 75 (Extreme) and 100+ (Catastrophic), the potential for house losses, and in turn, fatalities, significantly increases.

The seasonal period upon which the FFDI may exceed an FFDI 50 in mid-December to mid-March with days exceeding FFDI 60 is restricted to January and February, although a single FFDI 81 occurred on 14 April 2009.

An Extreme Value Analysis (EVA) (Douglas, G. et al, 2014) was performed on recorded historical FFDI data from Perth Airport (Lucas, 2010). The projected maximum FFDI to 2049 is approximately 89 at

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

Perth Airport (97 at 1:200 APE). The last 25 years of data is used for the purpose of projecting climate change.

The climate of Western Australia has changed over the past 100 years, with the average temperature increased by about 1°C[49]. 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.

A **landscape-scale** bushfire may affect the study area, either by a direct attack or by ember attack from a fire located up to 5 km away, at least once in 5 years, which is an annual exceedance probability of 20%.

By the NERAG classification, a Landscape-scale fire is Likely.

LIKELIHOOD	ANNUAL EXCEEDANCE PROBABILITY (AEP)	AVERAGE RECURRENCE INTERVAL (ARI) (INDICATIVE)	FREQUENCY (INDICATIVE)
Almost certain	63% per year or more	Less than 1 year	Once or more per year
Likely	10% to <63% per year	1 to <10 years	Once per 10 years
Unlikely	1% to <10% per year	10 to <100 years	Once per 100 years
Rare	0.1% to <1% per year	100 to <1000 years	Once per 1000 years
Very rare	0.01% to <0.1% per year	1000 to <10,000 years	Once per 10,000 years
Extremely rare	Less than 0.01% per year	10,000 years or more	Once per 100,000 years

Plate 4: NERAG 2020, Likelihood level

5.2.2 Consequence

The aspects of bushfire attack that affect human safety include:

- Burns from direct flame contact, 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.

[49] 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

5.2.2.1 Human harm

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[50] 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 are still to be determined, and it is acknowledged that forest fire does contain toxic gases. These include 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.[51]

The psychological impact of a bushfire should be a significant consideration in an overall perspective of planning for 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.[52]

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 been successful, but the intensity of the fire on Black Saturday was beyond their expectation, causing a fear for their lives a sense of a narrow escape and long-lasting trauma.[53]

An avoidance of fatalities and serious injury is important in determining the severity of consequence and an acceptable risk. Studies by the CSIRO[54] 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…."*[55]

A study by the CSIRO56 (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

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

51 Chemistry Centre of Western Australia

52 Florec V., and Pannell D J., (2016), *Economic assessment of bushfire risk management options in Western Australia*

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

54 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

55 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

56 Ibid

also found that for most fatalities, the victims were likely to have been aware of the fire nearby and had time to evacuate before the fire's arrival but instead had chosen to stay.

Simplistically, people survive if the building they shelter in survives. Building survival is reduced markedly over an FFDI of 100, early evacuation is, therefore, the preferred response to avoid fatalities and to avoid psychological trauma when the route and destination are safer than the location being evacuated. Otherwise, a safer place is required.[57]

LEVEL	CRITERIA	
	DEATH	INJURY OR ILLNESS
CATASTROPHIC	Deaths directly from emergency greater than 1 in 10,000 people for population of interest	Critical injuries with long-term or permanent inca-pacitation greater than 1 in 10,000 people for population of interest
MAJOR	Deaths directly from emergency greater than 1 in 100,000 people for population of interest	Critical injuries with long-term or permanent inca-pacitation greater than 1 in 100,000 people for population of interest, or Serious injuries greater than 1 in 10,000 people for population of interest
MODERATE	Deaths directly from emergency greater than 1 in 1,000,000 people for population of interest	Critical injuries with long-term or permanent inca-pacitation greater than 1 in 1,000,000 people for population of interest, or Serious injuries greater than 1 in 100,000 people for population of interest
MINOR	Deaths directly from emergency greater than 1 in 10,000,000 people for population of inter-est	Critical injuries with long-term or permanent inca-pacitation greater than 1 in 10,000,000 people for population of interest, or Serious injuries greater than 1 in 1,000,000 people for population of interest
INSIGNIFICANT	Deaths directly from emergency less than 1 in 10,000,000 people for population of interest	Critical injuries less than 1 in 10,000,000 people for population of interest, or Serious injuries less than 1 in 1,000,000 people for population of interest, or Minor injuries to any number of people

Plate 5: NERAG 2020 People consequence levels and criteria

[57] Ibid

5.2.2.2 Impact upon buildings and objects

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

- Direct flame contact from a bushfire front, (proximity of flammable vegetation or adjacent structures);
- Radiant heat from a bushfire front;
- A direct attack from airborne burning embers;
- Gale force winds generated by the convective forces of the bushfire front;

CSIRO[58] research and others[59] 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 retaining walls[60]. Changes were made in AS 3959:2018 to address the underside of building vulnerability.

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 providing a potential fuel source against the building or damaging the exterior and opening it to embers.

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

[59] 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

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

LEVEL	CRITERIA	
	LOSS IN ECONOMIC ACTIVITY AND/OR ASSET VALUE	IMPACT ON IMPORTANT INDUSTRY
CATASTROPHIC	Decline of economic activity, and/or Loss of asset value greater than 4% of gross product produced by the area of interest	Failure of a significant industry or sector in area of interest as a direct result of emergency event
MAJOR	Decline of economic activity, and/or Loss of asset value greater than 0.4% of gross product produced by area of interest	Significant structural adjustment required by identified industry to respond and recover from emergency event
MODERATE	Decline of economic activity, and/or Loss of asset value greater than 0.04% of gross product produced by area of interest	Significant industry or business sector is significantly impacted by the emergency event, resulting in medium-term (i.e. more than one year) profit reductions directly attributable to the event
MINOR	Decline of economic activity, and/or Loss of asset value greater than 0.004% of gross product produced by area of interest	Significant industry or business sector is impacted by the emergency event, resulting in short-term (i.e. less than one year) profit reductions directly attributable to the event
INSIGNIFICANT	Decline of economic activity, and/or Loss of asset value less than 0.004% of gross product produced by area of interest	Inconsequential business sector disruption due to emergency event

Plate 6: NERAG Economic consequence levels and criteria

5.2.3 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, the 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. The overall risk rating for the study area is achieved by matching the likelihood with the consequence, and because it is imagined that no controls are in place, it is classed as Extreme.

This is only the starting point that the controls are then laid upon, but some areas within the study area are more responsive to controls than others.

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 7: NERAG 2015- 2020 - Qualitative Risk Matrix. This table is used to evaluate the likelihood with a consequence, by aligning the assessed level of the row with the assessed consequence, the risk rating is shown. It can be noted that where an event is likely, then even extremely effective measures that may render the consequence as minor will still be classed a Medium risk.

5.3 Risk Evaluation

This perspective is taken from the promotion of the area for tourism, with people potentially found in the open, the location of tourism facilities, potential impacts upon buildings and opportunities for shelter, and land-use intensification for residential purposes.

A 'do nothing 'approach is a reflection of inherent risks. However, in regard to the study area, there are already in place a range of mitigation measures (herein 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 existing controls have been evaluated in **Appendix C Risk Register**.

5.4 Existing controls

5.4.1 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 effectiveness and importance of the fuel reduction program was recognised by M Keelty in the review of the Roleystone Kelmscott fire and proceeding fires (Keelty 2011).

> *Landscape-scale "mosaic" burns have been shown to slow the momentum of bushfires before they arrive at the urban interface, providing firefighters with a greater opportunity to control or extinguish the fire before it impacts on life or property. This approach was endorsed by the 2009 Victorian Royal Commission and is supported by extensive scientific research.*[61]

[61] M Keelty, *A Shared Responsibility the Report of the Perth Hills Bushfire* February 2011

> *PWS does not institute a specific prescribed burning program for the near-interface areas around the Perth Hills other than those developed under regional park fire preparedness and response plans. Instead, PWS takes a landscape-scale approach to its prescribed burning program that is designed to ensure that a "mosaic" of fuel reduced areas are maintained across DEC estate. This approach ensures that major fires are not allowed to develop and make significant, uninterrupted runs through high fuels loads towards the urban interface, where they would be near-impossible to stop. The Special Inquiry heard that smaller fuel reduction burns immediately adjacent to urban development do not provide adequate protection to life and property unless they are complemented by more significant landscape-scale burns.*[62]

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. **Figure 9** demonstrates the planned burns that have been carried out in the study area since 1989.

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.

5.4.2 Policing to reduce human ignitions

The Bushfire Cooperative Research Centre *Fire Development, Transitions and Suppression* study 2014, which studied urban and peri-urban areas around Perth compared 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. It was noted that during the study period, there was a 50% decline in the annual number of ignitions in deliberately lit fires, attributed to arson reduction programs and a range of public education and awareness programs[63].

5.4.3 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).

[62] M Keelty, *A Shared Responsibility the Report of the Perth Hills Bushfire*, February 2011
[63] A L Sullivan et al *Bushfire Cooperative Research Centre Fire Development, Transition s and Suppression study CSIRO 2014 p 17*

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 Emergency Management 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[64].

- 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 and the State Emergency Management plan. The LEMA addresses all emergencies, but special considerations within the LEMA include the bushfire season.

It addresses the roles and responsibilities of public authorities and persons involved in emergency management (stakeholders) and includes the Hazard Management Agency (comprising The City, WAPOL, and DBCA) in addressing the emergency management concepts of Prevention, Preparation, Response, and Recovery.

Prevention and Preparation typically includes coordinating stakeholders to undertake works to reduce the risk of bushfire and provide resilience to a bushfire event. This might include coordination of road reserve management with Western Power asset management to reduce vulnerability to bushfire. It is a challenge for all agencies to balance the cost of discretionary prevention with the cost (financial and reputational) imposed by reconstruction.

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

- Short term < 24 hrs (potentially isolated).
- Long term up to a week.

[64] State Emergency Management *A Strategic Framework for Emergency Management in Western Australia* October 2019

- State Evacuation Centre > 1 week.

The local government 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[65].

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.[66]

5.4.3.1 Local Government Fire Management Planning

Activities in which local government 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 clause 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 section 214 of the *Planning and Development Act* 2005.
- Administration of the *Building Act 2011* and the requirements of the *National Construction Code*, specifying 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 clause 78E (1) states bushfire construction standards provided in the *National Construction Code* can be applied by development approval if not in conflict with the *Building Act 2011*.

The LEMA is required to be updated every five years and is to be made publicly available. As at the May 2020 update of the *STATE EMERGENCY MANAGEMENT A Strategic Framework for Emergency Management in Western Australia Procedure*, with regard to LEMA, it is recognised that "*To ensure*

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

consistency of LEMA, the structure, and minimum content requirements are currently being reviewed; the model will be provided in due course."

5.4.3.2 Bushfire Risk Management Plans

Both the City of Kalamunda and City of Armadale has prepared (draft) Bush Fire Risk Management Plans (BRMP) following the OBRM *Bushfire Risk Management System and Bushfire Risk Management Plan template*.

The aim of the BRMP is to document a coordinated and efficient approach to the identification and treatment of assets exposed to bushfire.

The BRMP follows an Emergency management system approach, similar to NERAG, based upon AS 31000:2009. It breaks assets into four categories, Human Settlement, Economic, Environmental, and Cultural. It evaluates and ranks each asset based upon risk, following assessment criteria provided in the *Guidelines for Preparing the Bushfire Risk Management Plan* (OBRM 2017)

It includes a treatment schedule that sets out the multi-agency treatments by the identification and ranking of assets.

Key features are to guide tenure blind fuel reduction and multi-agency fuel reduction programs over a five-year period, a communications strategy, and integration of bushfire risk management into the City business.

The BRMP integrates with the LEMC and LEMA, with the LEMC being a stakeholder in the preparation of the BPMP.

With regard to the State Emergency Management framework, it is an orderly cascading framework of assigned responsibilities. It would be prudent to regularly and independently test the framework from bottom to top to ensure that the chain is complete and up to date.

5.5 Risk Register (Appendix C)

Following the methodology described in NERAG 2015 and 2020, a Risk Register has been prepared for the study area with regard to tourism opportunity.

It establishes a series of risk statements with each 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 requirements 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 judgment 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 for consideration in a LEMA.

For many of the treatments identified, they are presently underway, and the risk register may be used as an opportunity to refocus.

Key aspects not presently within the routine of the LEMA, will form the basis for the recommendations of this assessment.

6 Tourism Assessment

Consideration has been given to the *Pickering Brook and Surrounds Perth Hills Tourism Product Gap Analysis* (element 2019), and from this, two tourism precincts were identified. The Paulls Valley precinct includes the walking and mountain bike trails over public land and is notable as the terminus for the Bibbulmun Track, and the Pickering Brook Precinct which is the valley extending from Piesse Brook through to Merrivale Road at Pickering Brook. Whilst the Gap Analysis has mostly identified tourism products in the north of the study area, it is recognised that strong tourism opportunities are available to the south but overlooked by attractions immediately south of the study area within the Brookman Valley.

Within the Pickering Brook Study area, the valley that leads from Piesse Brook through to the town of Pickering Brook stands out as the tourism precinct due to the wider open valley, the extended views it affords and the ability to link value-added agriculture production/food and beverage manufacturers to the tourism experience and visual amenity. A similar amenity is provided in the valley immediately west of Roleystone township that extends to Canning Mill Road.

The area is attractive for activities that take in the views and includes boutique accommodation, restaurants, cellar door (wine, brewery, distillery, etc.). The area also lends itself to self-drive trails that string attractions together.

Events in the area create a concentration of activity and an awareness of a destination that supports the tourism operators as well as providing entertainment and opportunity for local residents. The concept of 'authenticity' summarises the product identified in the tourism gap analysis and can be described as a set of unique experiences that build upon the attributes, industry, and culture present in a location.

The Gap Analysis recognises the attraction for walking trails and mountain biking. A web search and review of social media identified a broad range of interest groups benefiting from the amenity of the National Parks and State Forest within the study area or accessed through the study area. This includes hiking, mountain biking, and off-bitumen and off-road enthusiasts. It suggests a wide dispersal of visitors may occur, in obscure places accessed from multiple formal and non-formal entry points. It presents a difficulty in knowing who is within the area and restricting entry.

6.1.1.1 Exposed tourism

The Gap Analysis recognises the potential to build upon the natural assets to include walking and mountain bike trails and self-drive trails, dirt road and off-road trails. These are self-guided and potentially expose the visitor to direct bushfire contact throughout the bushfire season.

The Department of Biodiversity Conservation and Attractions (DBCA) has an Operational Policy *Closure of Parks and/or Recreation Sites Due to Very High or Above Fire Danger Ratings.* This policy establishes a risk assessment identifying conditions when parks will be closed. It is understood DBCA has applied this policy to trails and recreation sites within the study area, which includes vehicle access to huts on the Munda Biddi Trail and Bibbulmun Track for evacuation if required.

The Parks Alert website expressly illustrates the Munda Biddi Trail and Bibbulmun Track, and otherwise, individual park closures are identified with a single icon.

This assessment has noted that there is a wide range of trail promotions on social media, and the trails have varying degrees of infrastructure and support. It was noted the trails within the Canning Mills precinct have a low level of infrastructure and offer poor visibility for alerting to an approaching fire. The Victoria Reservoir trail alternatively has a high level of infrastructure.

Social media sites, including for the Bibbulmun Track, do not directly promote in their route trip planners an awareness of bushfire safety conditions.

A concern recognised in this assessment is the messaging is becoming dispersed across websites and social media, undermining the control of the Parks and Wildlife to effectively close all its parks, and to date, these sites have understated the bushfire risk. Consideration may be given to utilising information technology to make prominent practical bushfire information for web-based platform searches upon the range of exposed tourism products in the Perth Hills, including utilising key word (SOE) technology.

Telecommunication is an important tool to keep people safe from bushfire. It is a facility not available 20 years ago and is improving going forward. It enables dispersed visitors to report bushfire ignitions, as well as to be informed and directed to safety.

Telecommunication availability was found in this assessment to be less reliable on the east side of the study area (Munda Biddi Trail), and better closer to the townships but with isolated patches of black spots in the telecommunication coverage. It is considered all trails would benefit from an audit and public documentation of black spots (where to expect no warnings).

In terms of protecting visitors from bushfire, the most effective risk mitigation is widely promoting trip planning with trail details that include the warning App to download, coded location points, identified evacuation points, blackspot areas (where to expect no warnings) and bushfire survival information.

6.1.1.2 Land-use change and associated building

As identified earlier, one of the key findings of the Tourism WA commissioned *Pickering Brook and Surrounds Perth Hills Tourism Product Gap Analysis* January 2020 (Gap Analysis), was a lack of certainty and facilitation in the administration of the SPP 3.7.

The Gap Analysis found:

> *Bushfire control is a key consideration in new tourism development, and issues that arise relate to road access and capability to support increased visitor numbers. A reduction in bushfire risk for land use and development may be aided by leveraging new planning scheme aims, objectives, local planning policies, and mapping tools to support tourism development.*[67]

[67] Pickering Brook and Surrounds Perth Hills Tourism Product Gap Analysis January 2020 page 11

In November, the Department of Planning, Lands, and Heritage released the Position Statement: *Tourism land uses in the bushfire-prone areas to provide guidance to the assessment of tourist development in bushfire prone areas* (Tourism Position Statement).

The Tourism Position Statement provides a framework for the development of performance principle-based solutions and acceptable solutions (policy measures) to guide the development of a variety of tourism land uses ranging from day activities to tourist accommodation (bed and breakfast through to resorts).

If a development proposal does not meet the Acceptable Solutions of the Bushfire Protection Criteria (Appendix 4, *Guidelines for Planning in Bushfire Prone Area* V1.3), it may be assessed as a performance principle.

Mapping undertaken as part of this risk assessment has identified that due to the proximity of forest vegetation, most development will exceed the Acceptable Solution for siting and design at a Bushfire Attack Level not exceeding BAL-29 calculated for extreme conditions.

This assessment has been made by broad categorisation of the vegetation and has not accounted for acceptable modifications that might be made (Native Vegetation Clearance Approval by the *Environment Protection Act* 1986)

Nonetheless, the WAPC Tourism Position Statement provides guidance for performance principle approaches that can meet its Acceptable Solution or follow a more detailed Risk Assessment Procedure (Tourism Position Statement cl.5.2).

Much of the background information applicable to the Risk Assessment Procedure has provided some of the considerations in applying the risk-based solution described in the Tourism Position Statement.

Further guidance, in terms of the information requirements, to accompany development applications (SPP3.7, cl.6.5) to assist the City of Kalamunda and City of Armadale can be provided as a summary from this assessment.

A feature of Tourism Position Statement is the requirement for an independent Peer Review where a Risk Assessment Procedure has been used. Regulation 49 of the *Planning and Development Regulations* 2009 facilitates that the Peer may be engaged by the planning authority to assist its investigations but charged on a prior agreement first to the applicant. Under this arrangement, the Peer (expert) reports to the planning authority (City) to protect the community interest. This feature may assist the confidence of the planning authority to resolve issues effectively.

The Tourism Position Statement, clarifies that a tourism asset can be replaceable, but it sets a higher standard of protection for visitors invited and unfamiliar with the bushfire risk, than compared to a landowner who may choose to live with the risk. This is reflected in a Bushfire Emergency Evacuation

Plan and the higher standards for onsite shelter[68] that may be applied as a contingency if safe evacuation cannot be assured at all times. The higher standards also require annual compliance, ensuring it is fit for function, by a Fire engineer if for a building, or Accredited Bushfire Practitioner if it is open space.

These requirements and the Risk Assessment Procedure are arguably unnecessary for development that is intended only to operate outside of the bushfire season. There is presently no exemption for tourism development located in a bushfire prone area, that is not operational during the bushfire season. For this reason, there may be benefit in amending the requirement at SPP 3.7, clause 6.5, to exclude requirements other than an enforceable commitment not to operate within a bushfire season, as nominated for the study area.

It is understood that planning authorities may be uncertain about the monitoring and compliance associated with some of the options provided by the Tourism Position Statement, where they may be management related, i.e., receipt of annual reports upon the *fit for the purpose* of the shelter, or monitoring time-restricted operating approvals.

Where there is a breach of a planning authorisation under a planning scheme the planning authority can issue a Notice under section 214(2) of the *Planning and Development Act* 2005 to stop, and not recommence the development or that part of the development that is undertaken in contravention of the authorisation.

A Notice under section 214(2) gives a right of appeal through the State Administrative Tribunal ('SAT') (28 days to appeal to SAT) but remains in force until considered by the SAT. Should the contravention continue, the relevant authority can pursue an offense under section 218 of the Act. The issuing of fines for an offense after a prosecution can be pursued under section 223.

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

7 Precinct Risk Assessment

An outcome of this project is to identify precincts within the Pickering Brook and Surrounds study area and make recommendations regarding the suitability or otherwise, for further land-use intensification for residential purposes and tourism development.

The study area exhibits three character areas:

- The open valleys of orchards and viticulture surrounded by national forest parks which is characteristic of the north section;
- A central section that is a contiguous national park from east to west; and
- A southern sector comprising land surrounding the township of Roleystone with mixed sized rural living lots, orchards, and forest retained on private landholdings.

It is also notable to the consideration that the township of Kalamunda is a continuous extension from the Perth urban area through to the northwest, whereas the township of Roleystone is separated from the Perth urban area by the steep and forested Darling Escarpment (around 500 m -3 km wide), and has only three access routes which all run through extreme BHL classified land. It relies mostly upon Brookton Highway as the high volume road.

Seven precincts have been identified within the Pickering Brook and Surrounds study area, to make recommendations regarding the suitability or otherwise for further land-use intensification, in addition to the three broad character areas discussed above. The seven precincts include Paulls Valley, Carmel, Pickering Brook, Canning Mills, Karragullen, Roleystone West and Roleystone East, as illustrated in **Figure 11**.

Each Precinct has been evaluated for 'contextual compliance' with SPP 3.7 clause 6.7, based upon the following features:

- A fully formed bushfire (fire line) can only arrive from one direction (single aspect);
- An early alert to maximise time for evacuation or preparation for the arrival of the bushfire impact, is available;
  - Telecommunication is available and reliable; or
  - The ability to observe an approaching fire is greater than 2 km:
- Access is safe for evacuation to a place outside of the effect of a bushfire or to an appropriate place of shelter[69];
- Safe access[70] and egress is available for firefighting; and
- Suppression resources are available; including adequate water volumes, and extraction pressure.

[69] The ability to complete the journey to a place that will not be affected by the bushfire and the ability to receive attendance immediately after the peak fire passing.
[70] The ability to safely leave before the fire arrival and the ability to safely attend immediately after the peak fire passing.

Four of the seven precincts, Carmel, Karragullen, Roleystone West, and Roleystone East were selected because of their proximity to the townships of Kalamunda and Roleystone in recognition that the future development in these areas may affect the bushfire risk to these townships.

Regard has also been given to the productive use of the region and the facilitation of tourism where an assurance of human safety can be provided. That aside, the acceptable level of risk associated with a tourism asset is set higher than the loss of a home to an individual, and the consequence of homelessness.

This has been reflected in the WAPC Position Statement Tourism Land uses in Bushfire Prone Areas November 2019.

> *if human safety can be satisfied the asset may be considered replaceable, and its bushfire construction determined to the degree necessary*

Table 3: Precinct land allocation

	Paulls Valley	Carmel	Pickering Brook	Canning Mills	Karragullen	Roleystone West	Roleystone East
Area (ha)	2500	2200	2970	4600	1400	484	1583
National Park (ha))	2072	331	1534	4262	560	0	332
Agriculture (ha)	142	262	829	29	550	81	177

The precincts have been informed by their relationship to the townships of Roleystone and Kalamunda, having regard to the bushfire history, overall risk assessment, tourism product development (from the Gap Analysis), and having regard to the availability of private land.

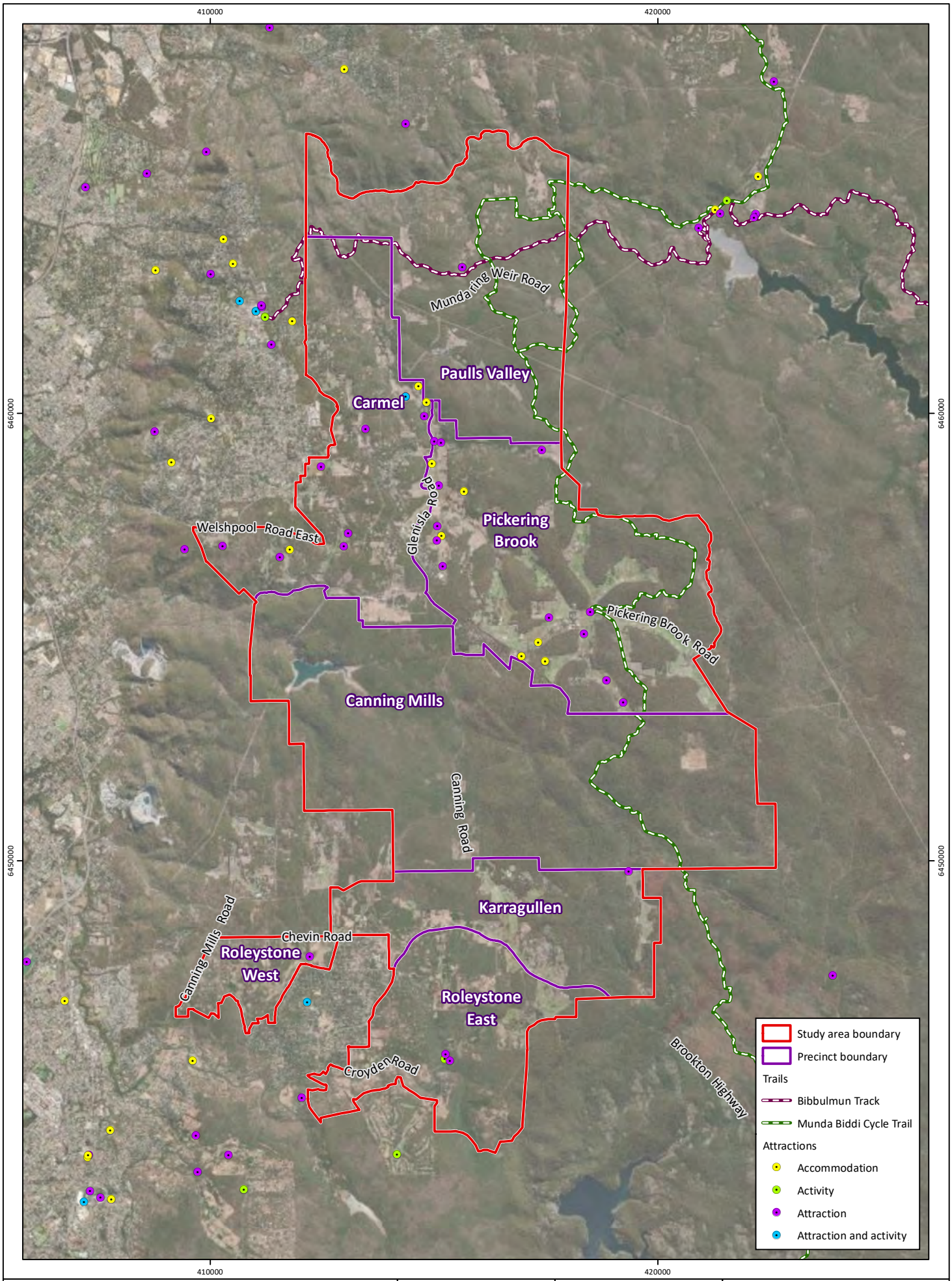

Figure 11: Precinct Map, Trails and Attractions

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

Plan Number:
EP19-138(04)--F50

Drawn:	SCM
Date:	15/05/2020
Checked:	DAE
Approved:	AJR
Date:	19/05/2020

N

0 1 2 3
Kilometers

Scale: 1:110,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

7.1 Assessment outputs

7.1.1 Precinct Bushfire Hazard Level Assessment

The Mapped Fireline intensity, following Figure 10, has been provided for each precinct.

In reading the maps, it should be noted that the Bushfire Hazard Level (BHL) is a result of the vegetation class and slope. This is different from the Bushfire Attack Level (BAL) map, which illustrates a projected radiant heat from the BHL parcels. A number of tourist projects identified in the Gap Analysis are to be located within low BHL, but due to proximity to classified vegetation may be assessed by AS3959:2018 as BAL-FZ. The merit for each will need to be addressed using the Tourism Position Statement.

7.1.2 Precinct Bushfire Attack Level Assessment

A BAL assessment has been undertaken, following the simplified procedure, Method 1 of AS3959 to determine the BAL ratings applicable within the Precincts to provide further detail on the bushfire risk.

The BAL Contour Plan has excluded 'orchards' and 'market garden' and 'grassland' as there is no restriction upon their clearance under the *Environment Protection Act* 1985 and the *Commonwealth Environment Protection and Biodiversity Conservation Act* 1999. The BAL contour is a representation of potential; however, future development will need to have regard to separation from unmanaged lands on-site or on adjoining land.

Table 4 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 precinct has been prepared and provides a visual representation of the distances determined in **Table 4**.

Table 4: Required setback distances from classified vegetation type and slope (from Table 2.4 of AS 3959:2018)

Post-development plot number	Vegetation classification	Effective slope	Distance to vegetation	BAL rating
Adjacent Vegetation 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 Vegetation 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 Vegetation Scenario	Grassland/Orchard	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 Vegetation Scenario	Grassland/Orchard	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

7.1.3 Paulls Valley

Figure 12-14
Area: 2500 ha
Public land National Park: 2072 ha
142 ha agricultural production orchards/cleared
Rural Living 268 ha (32 lots) north of Mundaring Weir Road.

Paulls Valley is primarily National Park and contains the Bibbulmun track, east-west linking Kalamunda to Mundaring Weir, and the Dell to South Ledge walk trail. It also includes the Mundi Biddi trail that leads south on the eastern side of the study area.

The Precinct contains a rural living area north of Mundaring Weir Road with lots ranging in size from 7 to 14 ha, surrounded by forest National Park (Beelu National Park - Extreme BHL) and is upslope of the highest category of extreme BHL to its north as part of an east-west long gully.

The area south of Mundaring Weir Road is the Greenmount State Forest, and within it is a narrow rural living orchard area on a valley floor accessed from Mundaring Weir Road by a 1.6 km long cul-de-sac called Bahan Road.

These rural living areas are isolated, with limited access, and contextually further subdivision, other than provided by the current policy, is not context compliant with clause 6.7 of SPP 3.7.

Paulls Valley has been promoted for mountain biking with trails straddling Mundaring Weir Road and is a target for walking with the Bibbulmun Track northern terminus in Kalamunda and the starting point for walkers heading to Mundaring Weir and south (outside study area)

Whilst the Bibbulmun Track is well developed with campsites huts and cleared areas, it is not well serviced for an emergency and walkers are unprotected from bushfire. Documentation is not available on the website or suggested in the trip planner.

Closure of the trails is routine during 'Extreme' Fire Danger Rating conditions or if a fire is nearby. Notification of closure is made on the Parks Alert System and Emergency WA. Telecommunications along the trails have not been tested.

Aside from exposure to an approaching fire, there is also a risk of creating an ignition from camp cooking, although areas are set aside.

Access to the trails is difficult to police.

Voluntary registration through a phone application may assist in minimising human exposure in a bushfire event.

The Bibbulmun Track does cross over roadways at various points, and it would be of assistance to publicly identify extraction locations, with coded extraction points to be used for trip planning and promoted on partnered websites.

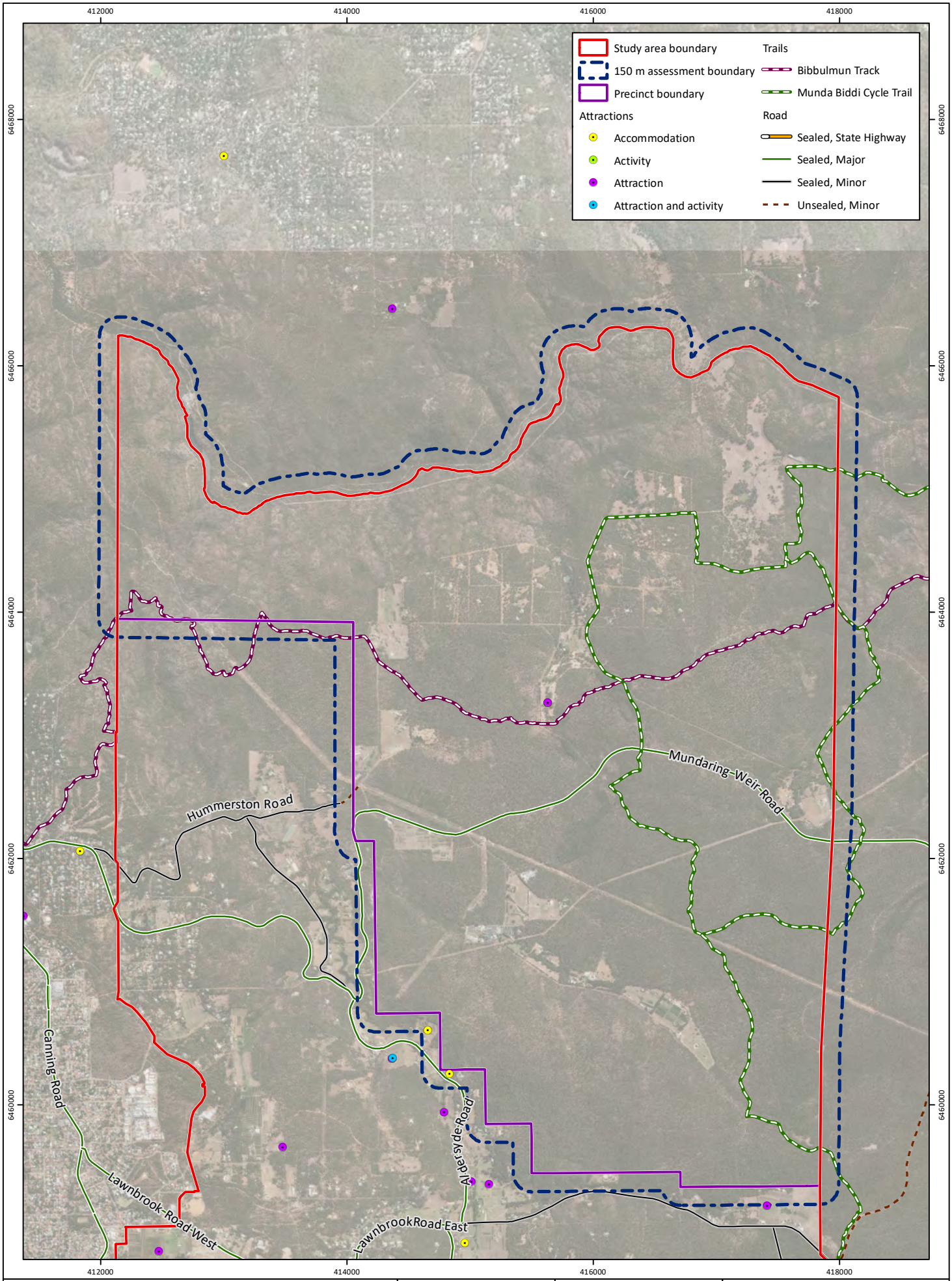

Figure 12: **Precinct Map, Trails and Attractions - Paulls Valley**

Project: Bushfire Management Plan
Pickering Brook and Surrounds Bushfire Risk Assessment

Client: Department of Planning, Lands and Heritage

Plan Number: EP19-138(04)--F69

Drawn:	SCM
Date:	27/05/2020
Checked:	DAE
Approved:	AJR
Date:	27/05/2020

N

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Meters

Scale: 1:40,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

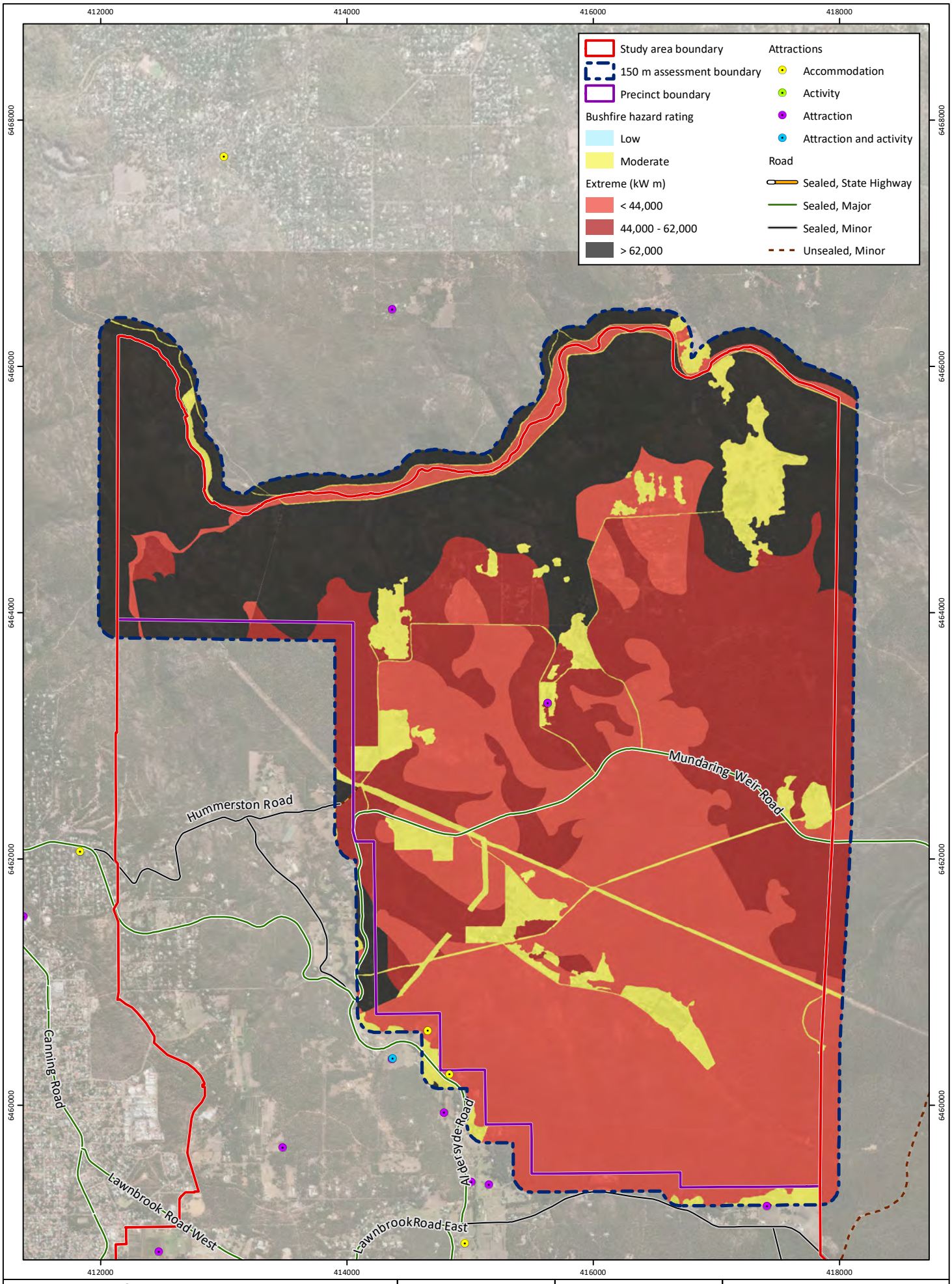

Figure 13: Bushfire Hazard Level Rating - Paulls Valley

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

Plan Number:
EP19-138(04)--F54

Drawn:	SCM
Date:	15/05/2020
Checked:	DAE
Approved:	AJR
Date:	19/05/2020

N

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Meters

Scale: 1:40,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

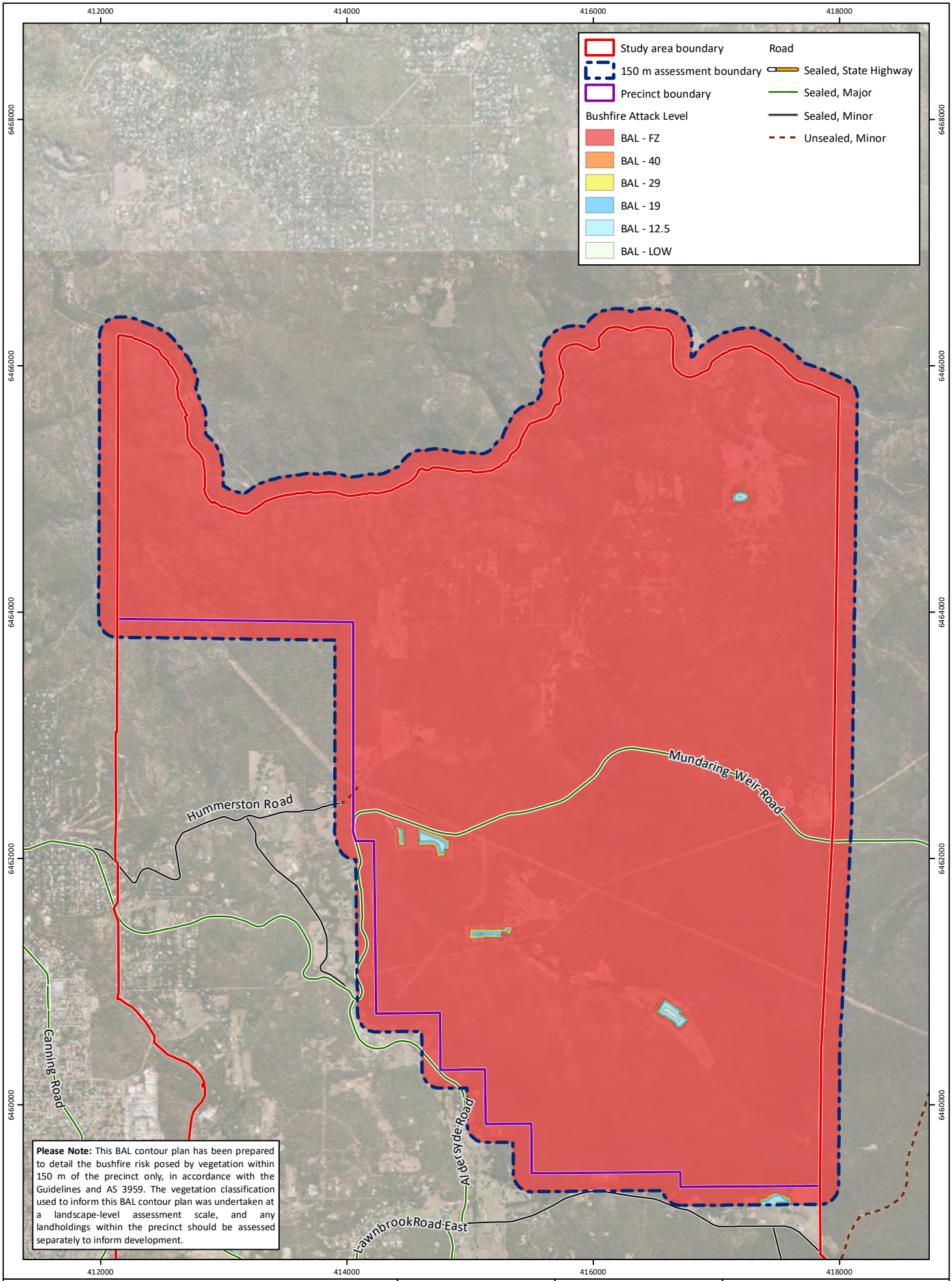

Figure 14: **Bushfire Attack Level Contour Plan (FDI 100) - Paulls Valley**

Project: Bushfire Management Plan
Pickering Brook and Surrounds Bushfire Risk Assessment

Client: Department of Planning, Lands and Heritage

Plan Number: EP19-138(04)--F62

Drawn:	SCM
Date:	24/05/2020
Checked:	DAE
Approved:	AJR
Date:	25/05/2020

N

0 490 980
Meters

Scale: 1:40,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

7.1.4 Carmel

Figure 15-17
Area: 2200 ha
Public land National Park: 331 ha
262 ha agricultural production orchards/cleared
Rural Living 1700 ha

Carmel was selected as a precinct because it adjoins the township of Kalamunda to its west. It has a mixed land use that slopes downwards to the east and south, which are potential aspects from which a bushfire may arrive.

Sections between Glenisla Road, Aldersyde Road, (east), and between Canning Road and Lawbrook Road (south) are predominantly large residential private holdings retaining a high proportion of native vegetation. Isolated vegetated crown land parcels are interspersed and create a complex tenure management and a ragged edge.

Areas in close proximity to the township, particularly at the west face, have multiple access options into the town and short extensions to township infrastructure, including reticulated water. The location is convenient to the Kalamunda volunteer brigade.

Net benefit opportunities may exist along the west boundary of the precinct aligning with the Kalamunda township, but the slope immediate to Aldersyde Road and the eastern section of Mundaring Roads is steep and has a high-end extreme BHL requiring substantial setback to achieve a moderate BHL.

The challenge with considering a net benefit intensification is, that it is difficult to better the protection of townships provided by the existing large cleared areas, historically or continuing to be used as orchards. These are commercially maintained low threat areas, and unless otherwise controlled, a change in land use may introduce an extreme BHL.

Cleared areas south of Welshpool Road east and Canning Road are bound by public land to the south and west, and are upslope of steep slopes, downwind of a fire from the southwest, isolated from the township and subject to multiple fire approach aspects west, south, and east.

The valley along Aldersyde Road is amongst the highest amenity in the study area. It has an open floor framed by forest on steeply sloping land 10˚. This section has the highest density of tourist attractions and accommodation.

No public safer places are presently provided along Glenisla Road (from Canning Road), and Aldersyde Road (to Mundaring Weir Road), but the travel route to the township of Kalamunda is comparatively short and available traveling north (historically the opposite to approaching fire) and by making left turns: which promotes the free flow of traffic.

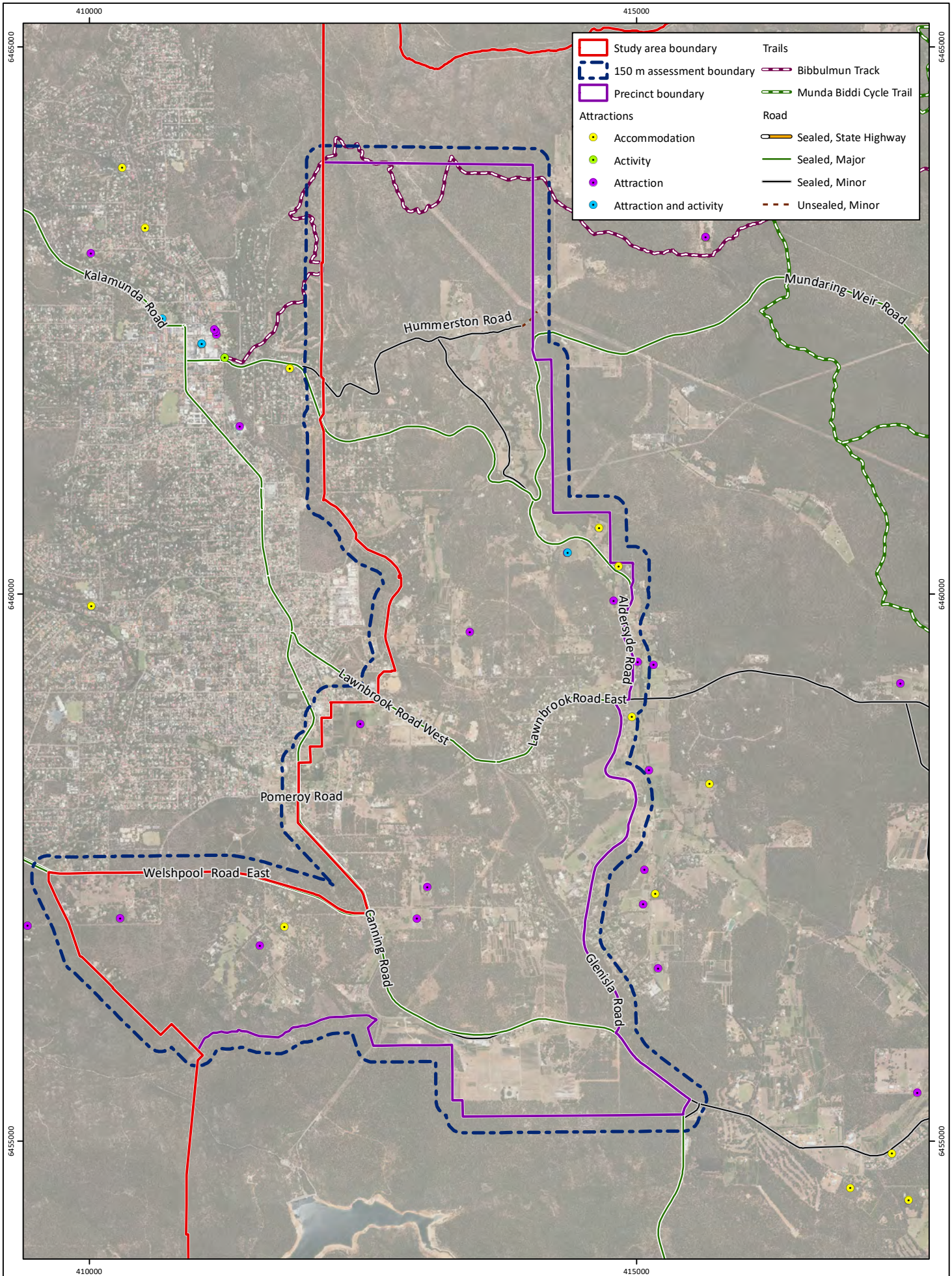

Figure 15: Precinct Map, Trails and Attractions - Carmel

Project: Bushfire Management Plan
Pickering Brook and Surrounds Bushfire Risk Assessment

Client: Department of Planning, Lands and Heritage

Plan Number: EP19-138(04)--F70

Drawn:	SCM
Date:	27/05/2020
Checked:	DAE
Approved:	AJR
Date:	27/05/2020

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Meters

Scale: 1:45,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

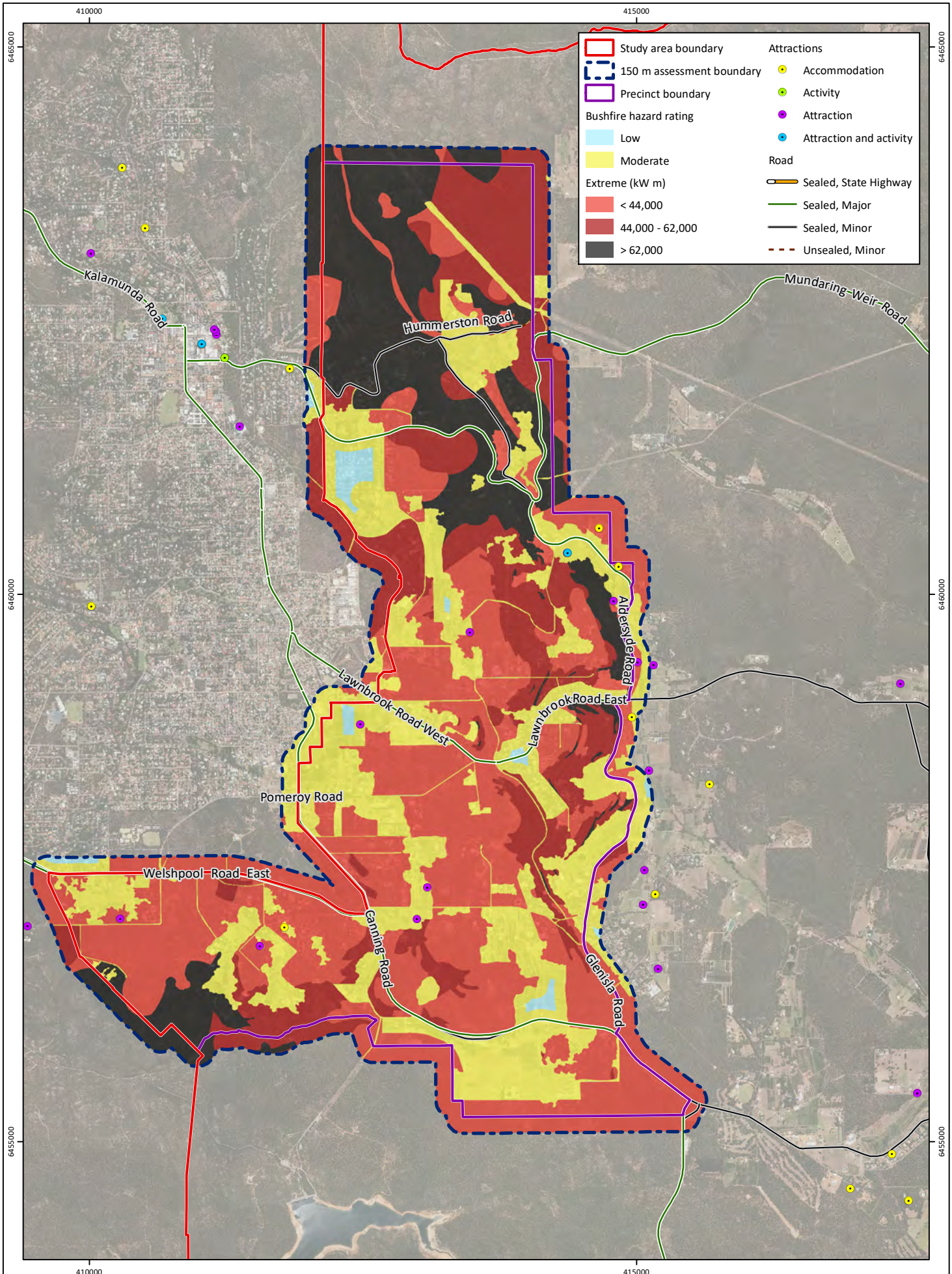

Figure 16: Bushfire Hazard Level Rating - Carmel

Project: Bushfire Management Plan
Pickering Brook and Surrounds Bushfire Risk Assessment

Client: Department of Planning, Lands and Heritage

Plan Number: EP19-138(04)--F55

Drawn:	SCM
Date:	15/05/2020
Checked:	DAE
Approved:	AJR
Date:	19/05/2020

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Meters

Scale: 1:45,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

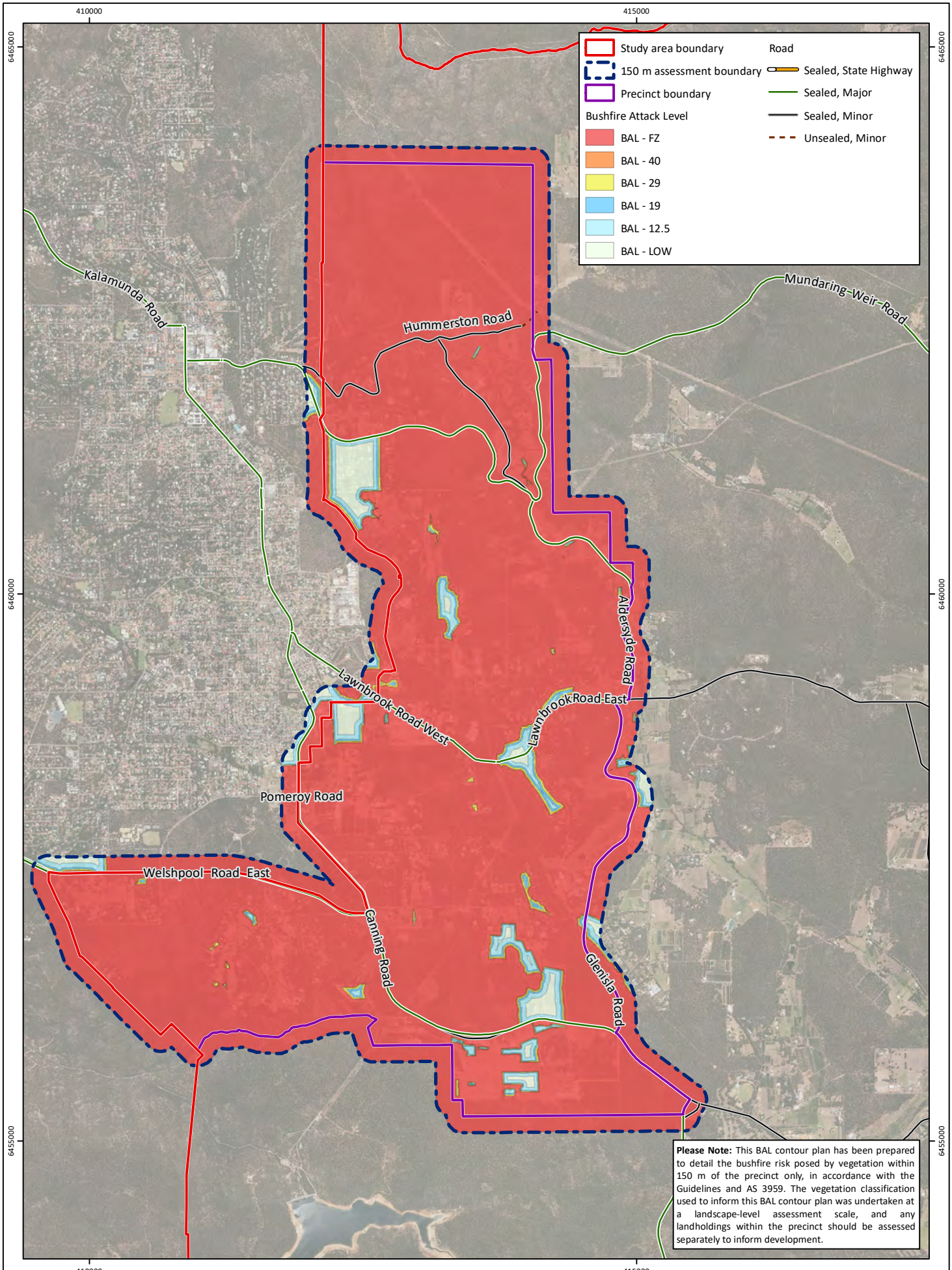

Figure 17: **Bushfire Attack Level Contour Plan (FDI 100) - Carmel**

Project: Bushfire Management Plan
Pickering Brook and Surrounds Bushfire Risk Assessment

Client: Department of Planning, Lands and Heritage

Plan Number: EP19-138(04)--F63

Drawn:	SCM
Date:	24/05/2020
Checked:	DAE
Approved:	AJR
Date:	25/05/2020

N

0 500 1,000
Meters

Scale: 1:45,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

7.1.5 Pickering Brook

Figures 18-20
Area: 2970 ha
Public land National Park: 1534 ha
829 ha agricultural production orchards/cleared
72 ha rural residential lots.

The Pickering Brook precinct is characterised by wide valleys adjoining by National Parks that extend from Carmel to the Mundaring State Forest to the east. The wide valley views and primary production provide opportunities to combine tourism with value-adding of primary production, recognised in the Gap Analysis as a natural grouping of tourism uses. The natural grouping is linked by Aldersyde Road (north of Walnut Road), Glenisla Road, Canning Road Pickering Brook Road and terminating at Merrivale Road. It is a sealed road network compliant with Table 6 of the Guidelines.

The township expansion assessed the Pickering Brook investigation Area (PIA) in a separate study (Emerge Associates 2020). The study examined the history of bushfire in the area and identified evacuation routes to the north by Paterson Road and west by Canning Road. The Pickering Brook Primary School was identified as a potential safer place should evacuation not be safe from the town. It was identified because it was central, located along Pickering Brook Road, and adjoined by low threat vegetation. Human behaviour was also anticipated. Children will remain at the school if safe evacuation from Pickering Brook is not possible, and parents will want to be close to their children. A separate refuge (for adults) was not advocated for this reason.

It was also recognised that Pickering Brook was a terminus rather than a through point, enabling the safer place to be determined upon a likely number of residents and visitors present. Subject to verge vegetation treatments and fuel reduction along the perimeter of the school oval, a BAL-LOW area can be established at the oval and along Pickering Brook Road with sufficient capacity to accommodate residents and visitors.

Evacuation from the tourism venues along Aldersyde Road (north of Walnut Road) and Glenisla Road, can be taken in a northerly direction, opposite to historic bushfire directions, with left-hand turns at Carmel Road, Lawnbrook Road East, Mitchell Road, Mundaring Weir Road and Hummerston Road, and a short distance into urban Kalamunda.

The evacuation from Pickering Brook is expected mostly west along Pickering Brook Road, Canning Road and into Kalamunda township. Should access to the west not be safe, then evacuation north along Patterson Road to Walnut Road and Lawnbrook Road East can be taken. As an additional contingency, the Pickering Brook Primary School has been identified as a potential safer place.

Reticulated water is available from extensions of the network in the township of Kalamunda, and Pickering Brook, including the length of Merrivale Road. The location is also convenient to the Kalamunda volunteer brigade, and a Pickering Brook Brigade is under consideration.

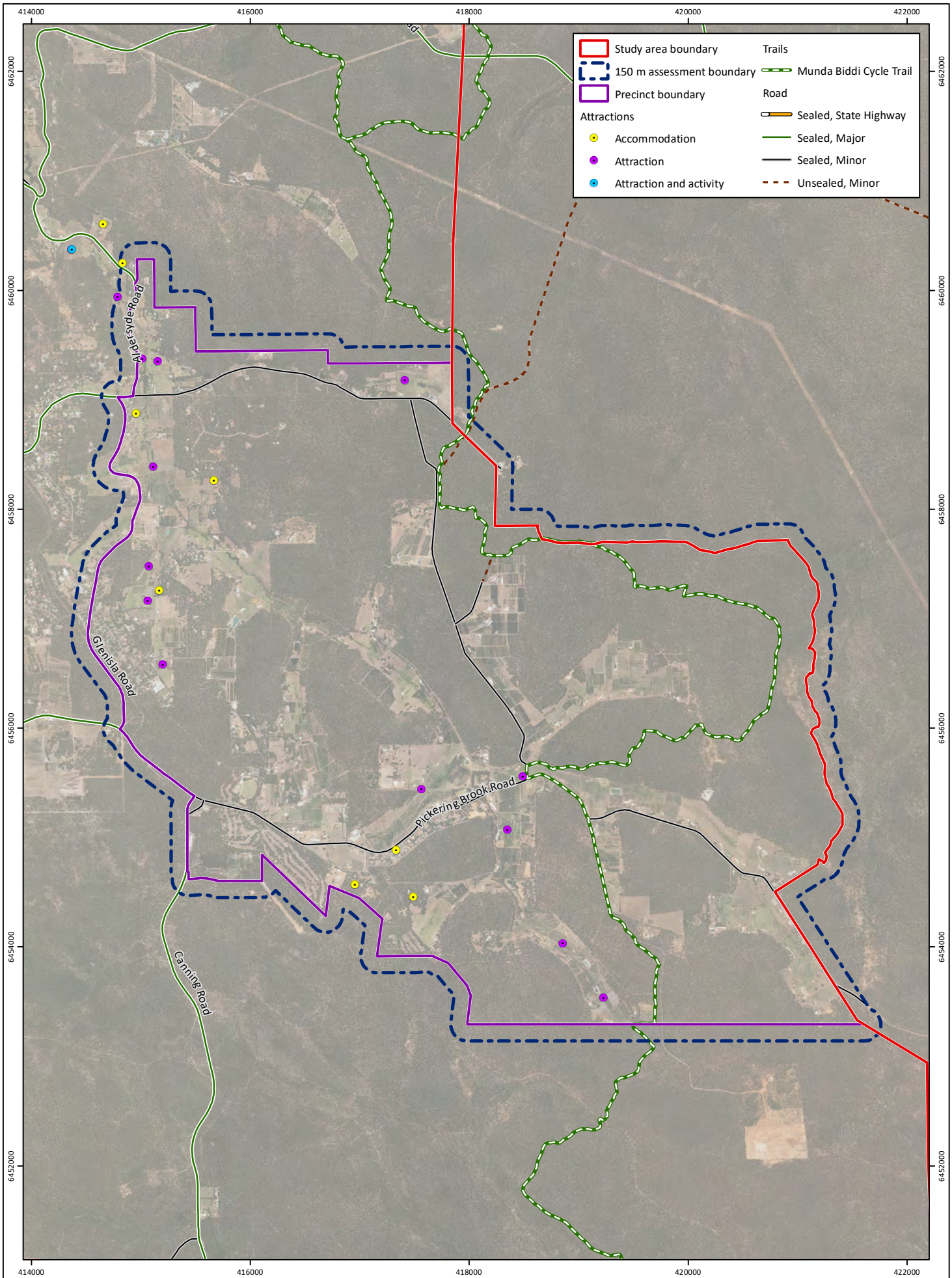

Figure 18: **Precinct Map, Trails and Attractions - Pikcering Brook**

Project: Bushfire Management Plan
Pickering Brook and Surrounds Bushfire Risk Assessment

Client: Department of Planning, Lands and Heritage

Plan Number: EP19-138(04)--F71

Drawn:	SCM
Date:	27/05/2020
Checked:	DAE
Approved:	AJR
Date:	27/05/2020

N

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Meters

Scale: 1:45,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

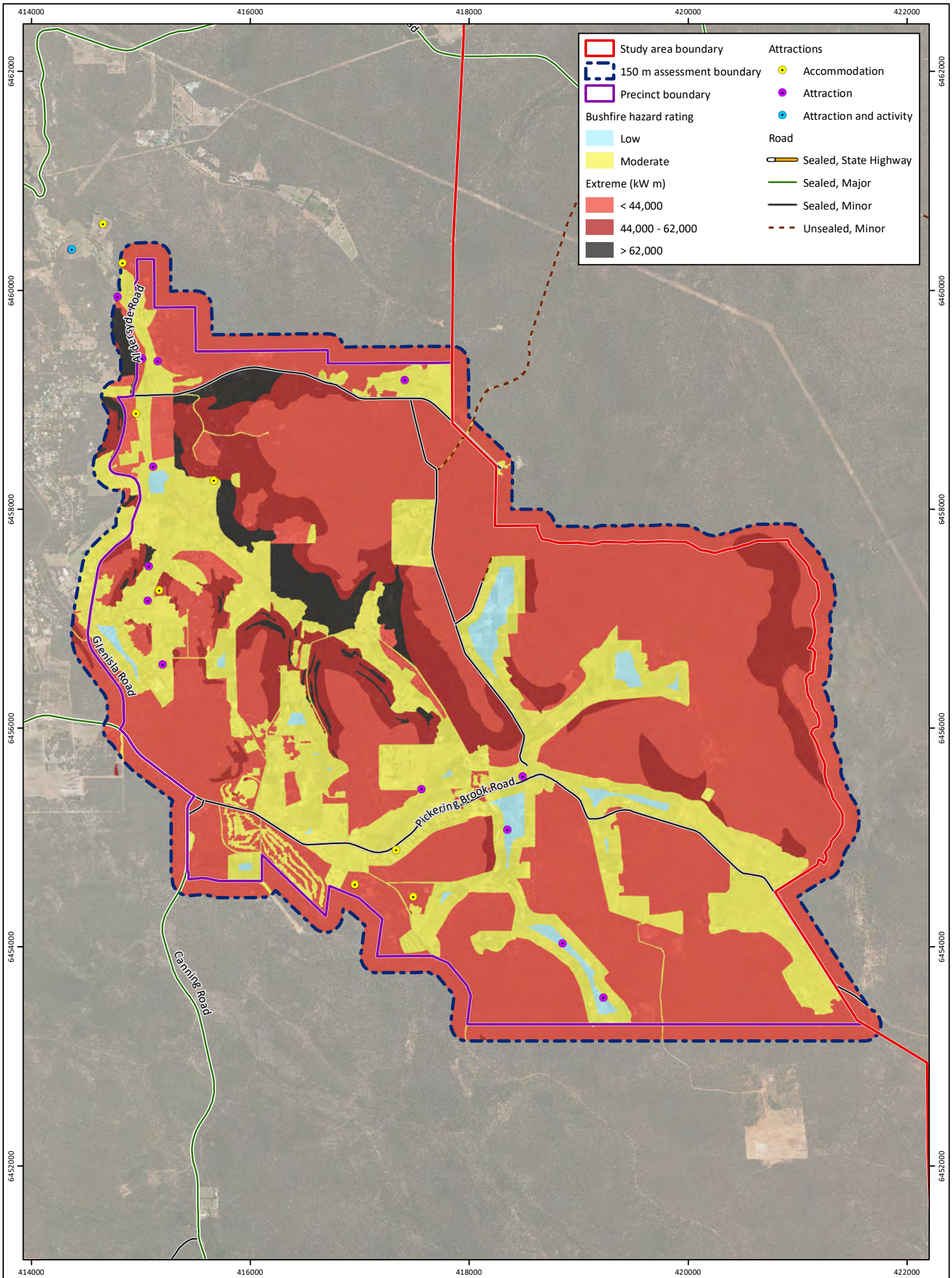

Figure 19: Bushfire Hazard Level Rating - Pickering Brook

Project: Bushfire Management Plan
Pickering Brook and Surrounds Bushfire Risk Assessment

Client: Department of Planning, Lands and Heritage

Plan Number: EP19-138(04)--F56

Drawn:	SCM
Date:	15/05/2020
Checked:	DAE
Approved:	AJR
Date:	19/05/2020

N

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Meters

Scale: 1:45,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

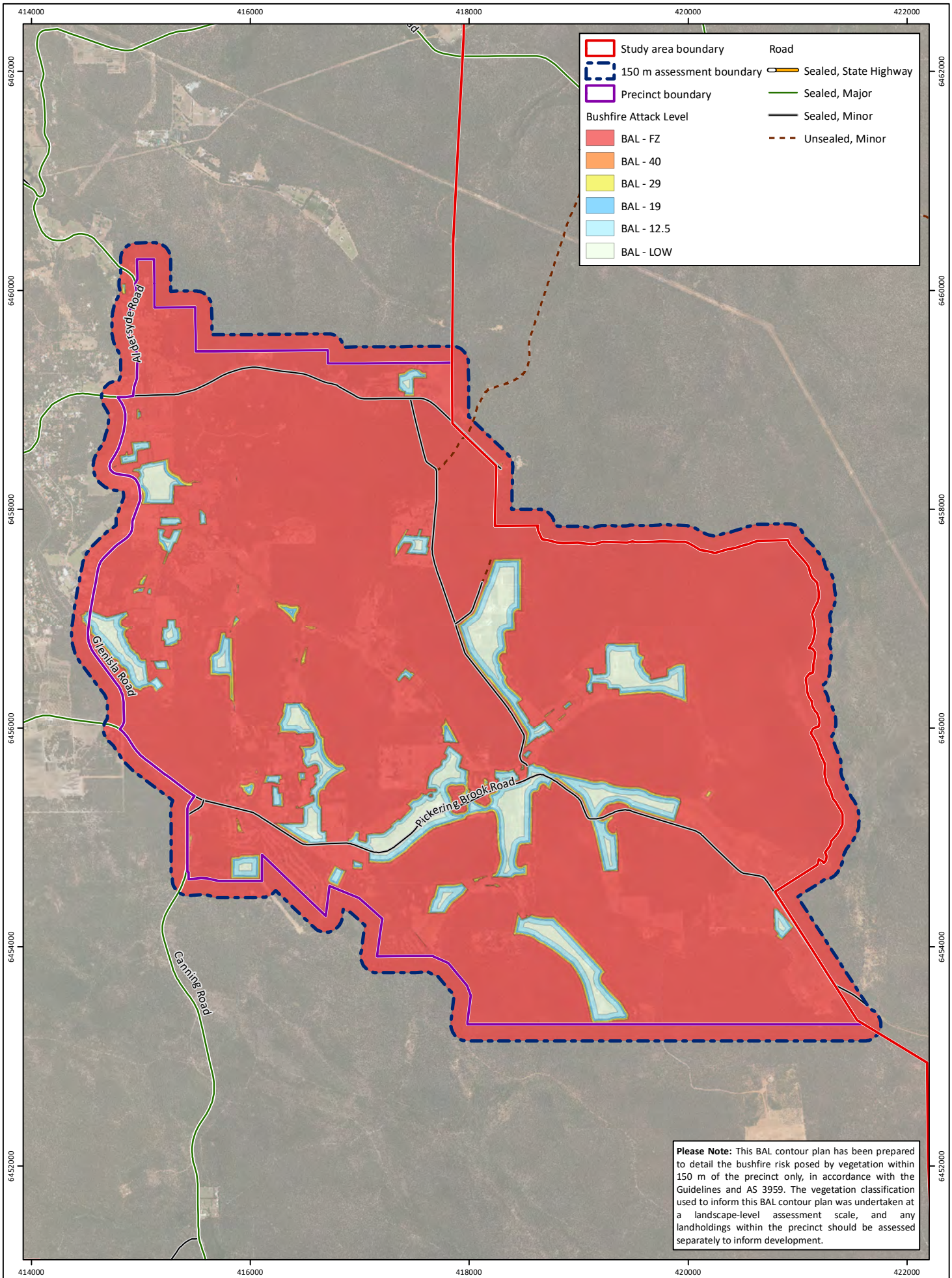

Figure 20: **Bushfire Attack Level Contour Plan (FDI 100) - Pikcering Brook**

Project: Bushfire Management Plan
Pickering Brook and Surrounds Bushfire Risk Assessment

Client: Department of Planning, Lands and Heritage

Plan Number: EP19-138(04)--F64

Drawn:	SCM
Date:	24/05/2020
Checked:	DAE
Approved:	AJR
Date:	25/05/2020

N

0 560 1,120
Meters

Scale: 1:45,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

7.1.6 Canning Mills

Figures 21-23
Area: 4600 ha
Public land National Park:4262 ha
29 ha agricultural production orchards/cleared

The central section study area Canning Mills is National Park.

Identified walking trails within this precinct include the Victoria Reservoir Walk (includes facilities) and the informal Munday Brook Walk.

Canning Mills is crossed by Canning Road which connects the townships of Roleystone and Kalamunda. The road runs through the forest and could be crossed by a fire. There is little supporting infrastructure, no reticulated water supply, and the Victoria Reservoir is the only identifiable water source. Telecommunication coverage to the east of Canning Road is incomplete, and not certain to the west of Canning Road.

The Victoria Reservoir is accessed from Canning Road south of Kalamunda, whereas trails such as the Munday Brook Walk are less conspicuous and may present difficulties in terms of alert and protection from exposure to bushfire. Telecommunication access has not been tested on the Munday Brook Walk and views are restricted by the tall trees aligning narrow fire access trails

There is no opportunity to create a safer place along the route without a substantial clearing of native vegetation.

The walking trails are poorly serviced in an emergency, and walkers and bike riders are unprotected from bushfires.

Closure of the trails is routine during Extreme Fire Danger conditions or if a fire is nearby, but a fire can start in moderate conditions that are not usually a trigger for park closure.

Notification of closure is made on the Parks Alert System, and Emergency WA. Telecommunications along the trails have not been tested.

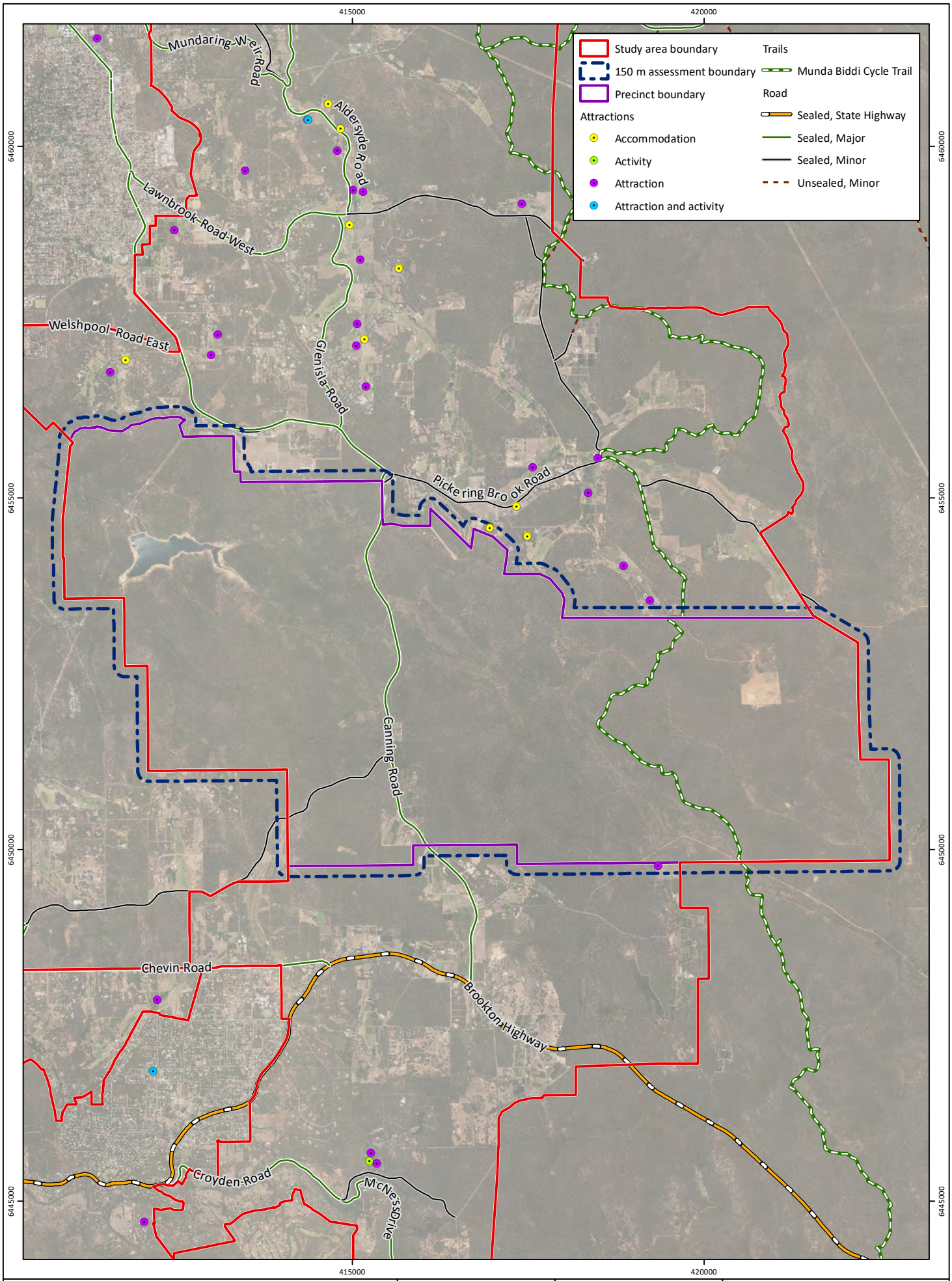

Figure 21: **Precinct Map, Trails and Attractions - Canning Mills**

Project: Bushfire Management Plan
Pickering Brook and Surrounds Bushfire Risk Assessment

Client: Department of Planning, Lands and Heritage

Plan Number: EP19-138(04)--F72

Drawn:	SCM
Date:	27/05/2020
Checked:	DAE
Approved:	AJR
Date:	27/05/2020

N

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Meters

Scale: 1:70,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

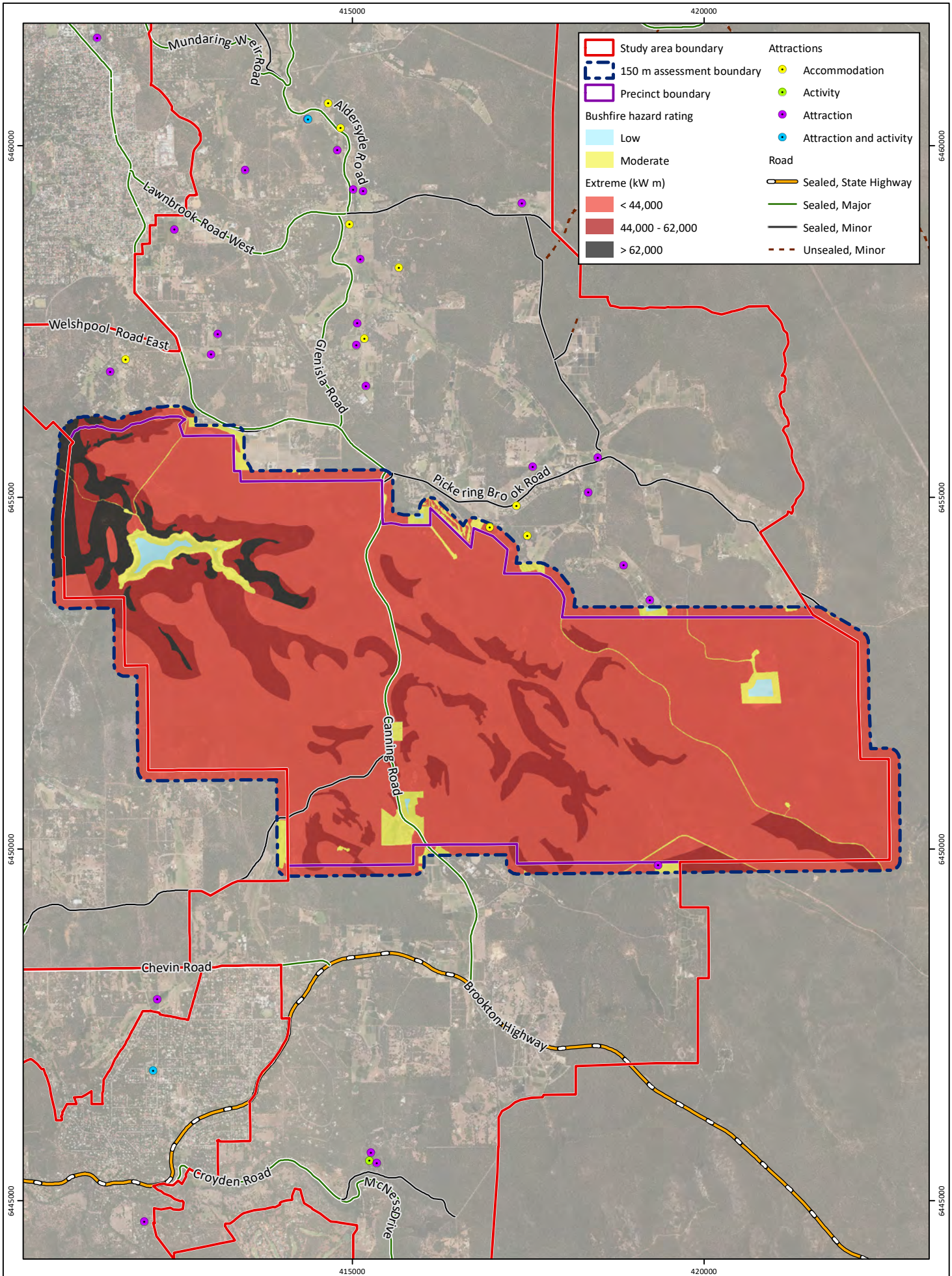

Figure 22: **Bushfire Hazard Level Rating - Canning Mills**

Project: Bushfire Management Plan
Pickering Brook and Surrounds Bushfire Risk Assessment

Client: Department of Planning, Lands and Heritage

Plan Number: EP19-138(04)--F57

Drawn:	SCM
Date:	15/05/2020
Checked:	DAE
Approved:	AJR
Date:	19/05/2020

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Meters

Scale: 1:70,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

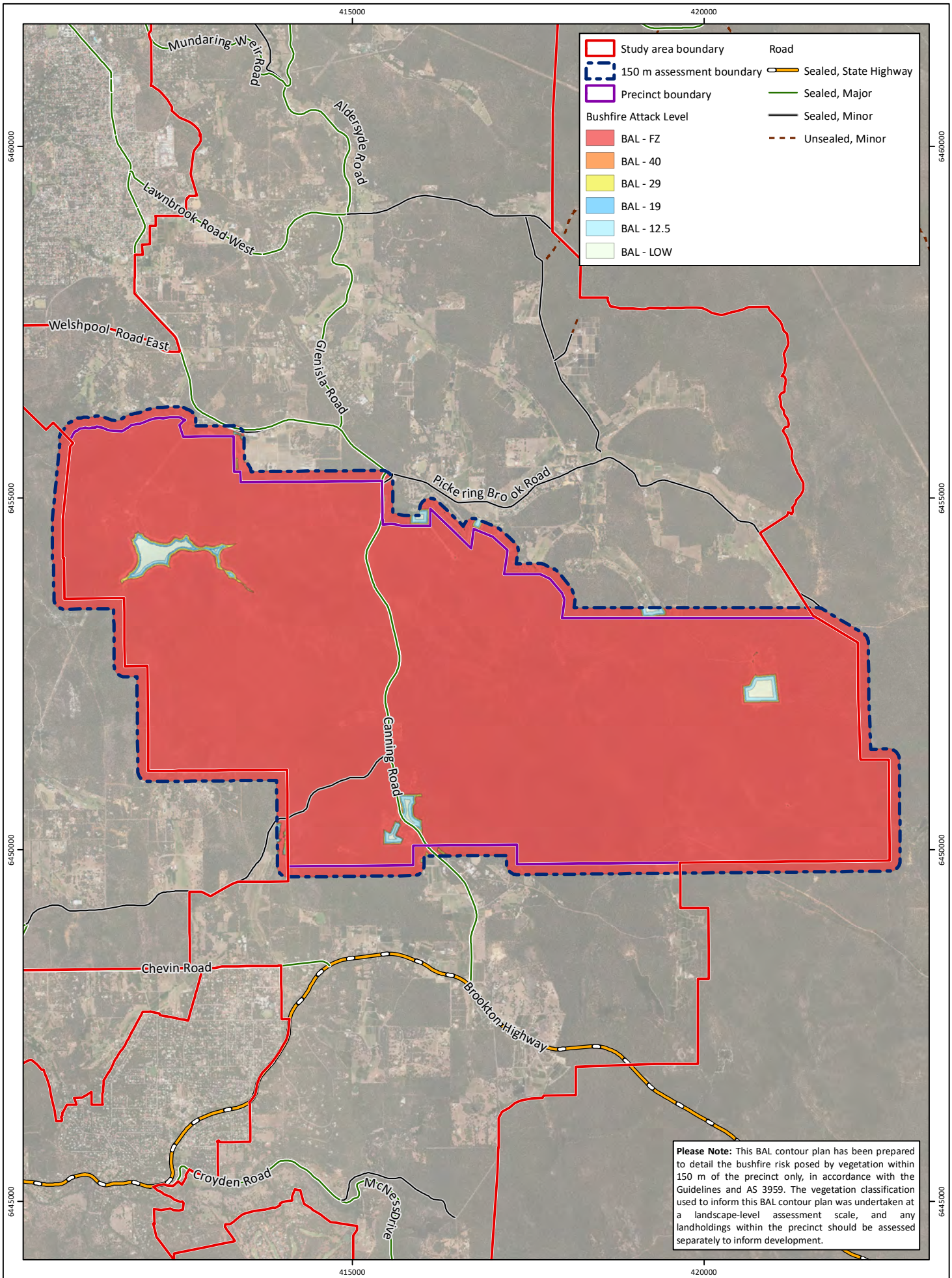

Figure 23: **Bushfire Attack Level Contour Plan (FDI 100) - Canning Mills**

Project: Bushfire Management Plan
Pickering Brook and Surrounds Bushfire Risk Assessment

Client: Department of Planning, Lands and Heritage

Plan Number: EP19-138(04)--F65

Drawn:	SCM
Date:	24/05/2020
Checked:	DAE
Approved:	AJR
Date:	25/05/2020

N

0 500 1,000 1,500
Meters

Scale: 1:70,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

7.1.7 Karragullen

Figures 24 -26
Area: 1400 ha
Public land: National Park 560 ha
550 ha agricultural production orchards/cleared (north and immediate to Brookton Highway.
93 ha rural living lots.

Karragullen was selected as a precinct because it is a mixed land use area east of the township of Roleystone and has a low slope rise to the township of Roleystone.

Karragullen is characterised by a large area (550 ha) of historically cleared land, traditionally used for orchards, but now includes a mix of orchards and rural living land use located along Brookton Highway. It is presently zoned as General Rural. Isolated pockets of native vegetation within the area cast a broad BAL, but large areas within orchards and on some rural living lots identify as BAL-LOW.

Karragullen presents a break in the continuity of bushfire fuels leading from the east towards the township of Roleystone and should retain a low threat condition for the benefit of the township of Roleystone.

This area is adjacent to a contiguous run of forest from the east but could also experience a fully formed fire from the west and the south; being isolated, it is not context compliant with clause 6.7 of SPP 3.7.

Further intensification, including for tourism, other than low-frequency opportunities, may place further pressure upon on Brookton Highway to the west, and the evacuation capacity of the road network, including the coincidence that evacuation from this area and the township of Roleystone is uncertain.

The valley and orchards, north of Chevin Road up to Canning Mills Road, have extended views, along the valley, potentially attractive for tourist accommodation, restaurant, cellar door opportunities. It adjoins the township of Roleystone population centre with ready access and service response and may be suitable for further consideration as it is potentially bushfire context compliant.

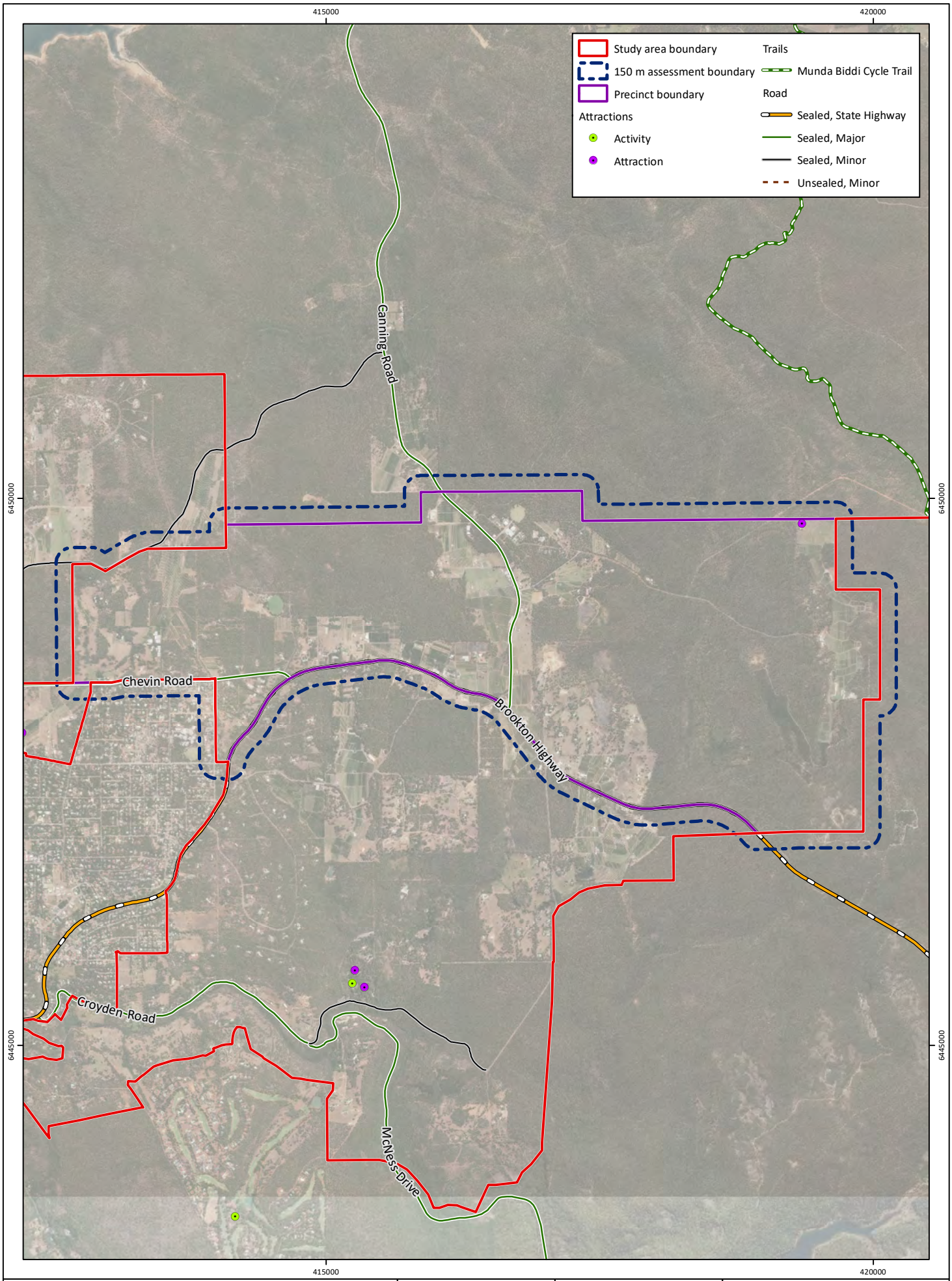

Figure 24: **Precinct Map, Trails and Attractions - Karragullen**

Project: Bushfire Management Plan
Pickering Brook and Surrounds Bushfire Risk Assessment

Client: Department of Planning, Lands and Heritage

Plan Number: EP19-138(04)--F73

Drawn:	SCM
Date:	27/05/2020
Checked:	DAE
Approved:	AJR
Date:	27/05/2020

N

0 500 1,000
Meters

Scale: 1:45,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

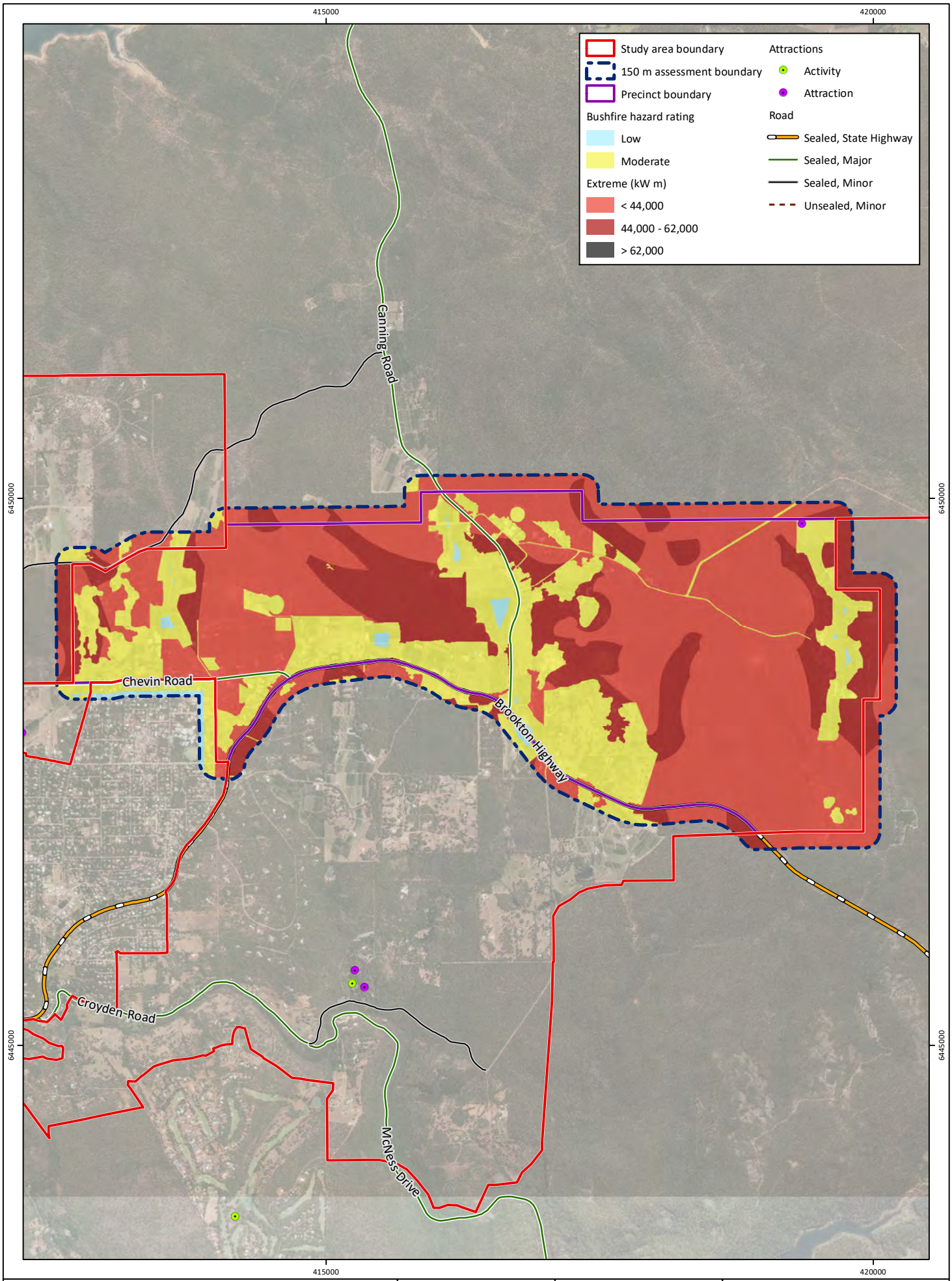

Figure 25: Bushfire Hazard Level Rating - Karragullen

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

Plan Number:
EP19-138(04)--F58

Drawn:	SCM
Date:	15/05/2020
Checked:	DAE
Approved:	AJR
Date:	19/05/2020

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Meters

Scale: 1:45,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

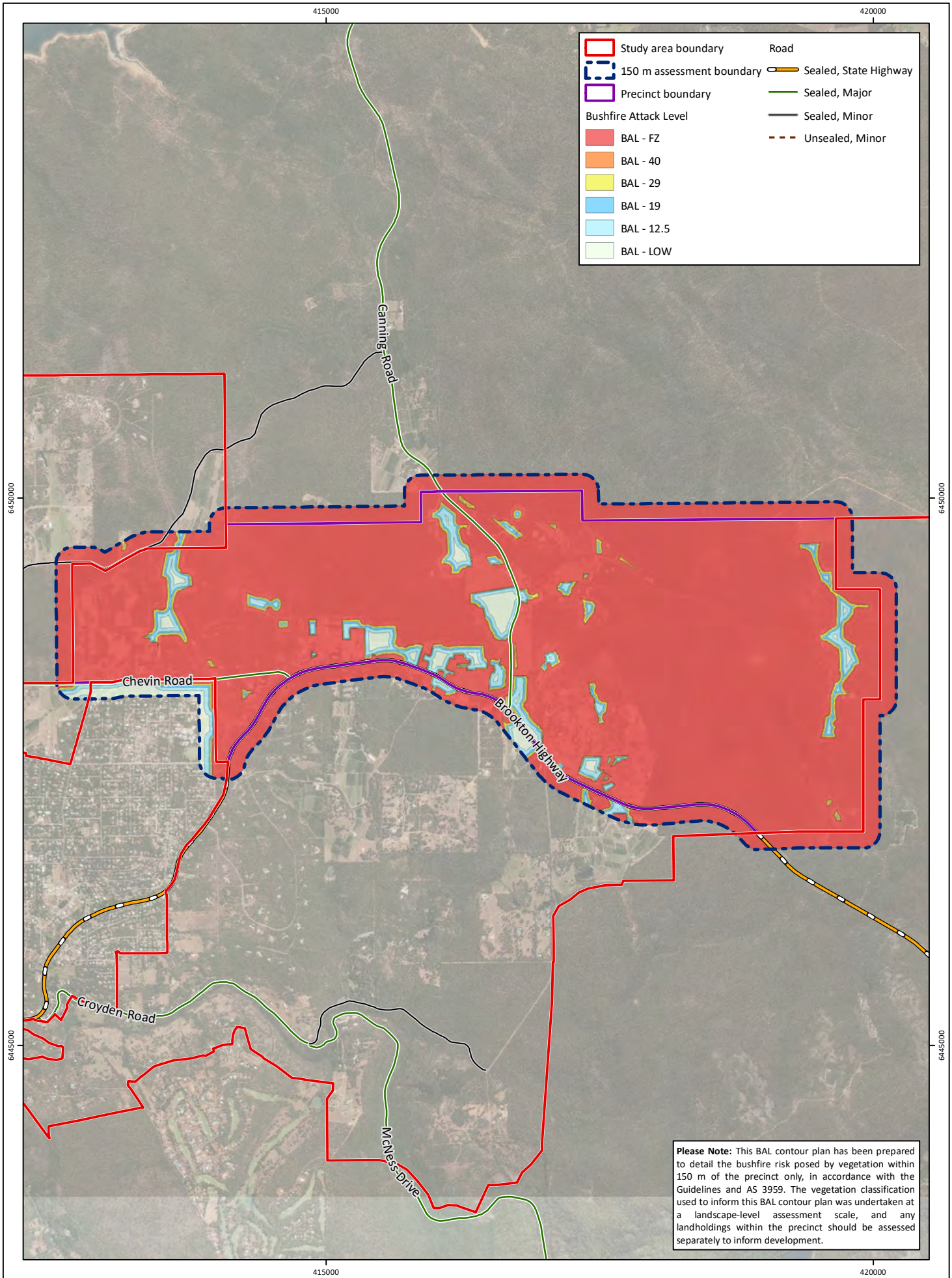

Figure 26: Bushfire Attack Level Contour Plan (FDI 100) - Karragullen

Project: Bushfire Management Plan
Pickering Brook and Surrounds Bushfire Risk Assessment

Client: Department of Planning, Lands and Heritage

Plan Number: EP19-138(04)--F66

Drawn:	SCM
Date:	24/05/2020
Checked:	DAE
Approved:	AJR
Date:	25/05/2020

N

0 500 1,000
Meters

Scale: 1:45,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

7.1.8 Roleystone West

Figures 27-29
Area: 484 ha
Public land National Park: 0 ha.
81 ha agricultural production orchards/cleared.
310 ha rural living lots.

This precinct is a mixed-use area with rural living at the perimeter, which adjoins the forested Darling Escarpment to the west and south.

The rural living lots range in size from 0.4 ha to 1 0 ha and are densely vegetated and capable of carrying a fire. They are located around a central area comprising larger lots 3 ha to 10 ha, and irregular in shape, with a mixture of remnant vegetation and orchard.

The southern portion is an extension of the Darling Escarpment, characterised as steep slopes and high-end Extreme BHL in a valley that runs northeast. It has a high property to surface exposure[71], and while the fire run to the township is comparatively short (500 m -1 km), a fire ignited to the southwest of Roleystone could quickly penetrate the township.

The steep, irregular slopes, even under the orchards to the south of the precinct, (normally orchards would be classed as low threat but because of the land slope are classed extreme BHL) and the forest fuels provide an overall extreme BHL and may contribute to unpredictable bushfire behaviour. The intensity of a fire in this area would be further increased if the remaining open area were forested. Future development of the open areas for the benefit of Roleystone should, therefore, retain a low threat land management.

The Precinct may have limited opportunity for contextual compliance at the northeast corner, and individual opportunities within the Precinct with separation from the Darling Escarpment and where a low threat land condition, to benefit the protection of the Roleystone township, can be achieved.

[71] An urban edge with a high number of properties facing a wide fire front, potentially more houses will be affected than the same area with large lots.

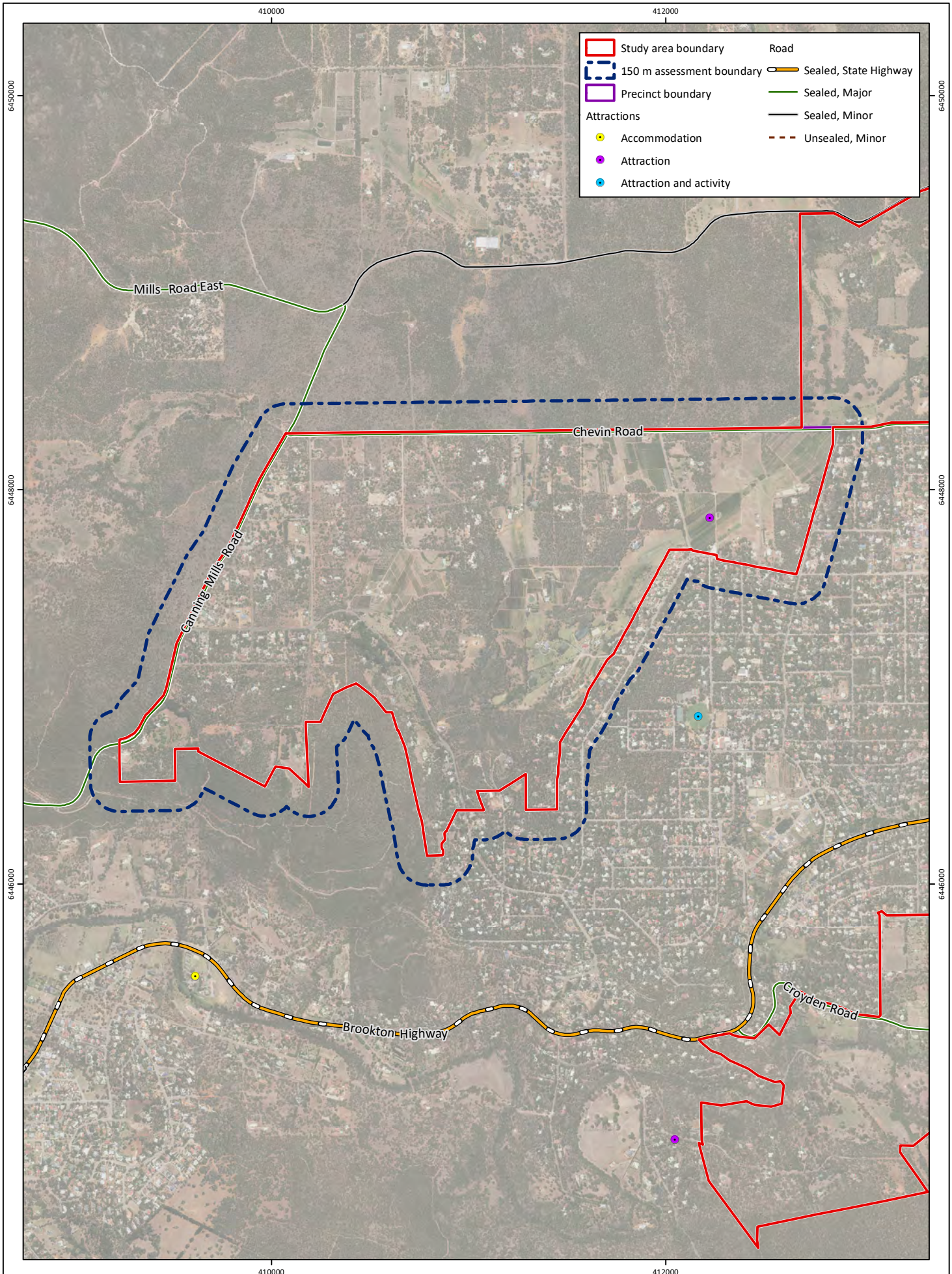

Figure 27: **Precinct Map, Trails and Attractions - Roleystone West**

Project: Bushfire Management Plan
Pickering Brook and Surrounds Bushfire Risk Assessment

Client: Department of Planning, Lands and Heritage

Plan Number: EP19-138(04)--F74

Drawn:	SCM
Date:	27/05/2020
Checked:	DAE
Approved:	AJR
Date:	27/05/2020

N

0 200 400 600
Meters

Scale: 1:25,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

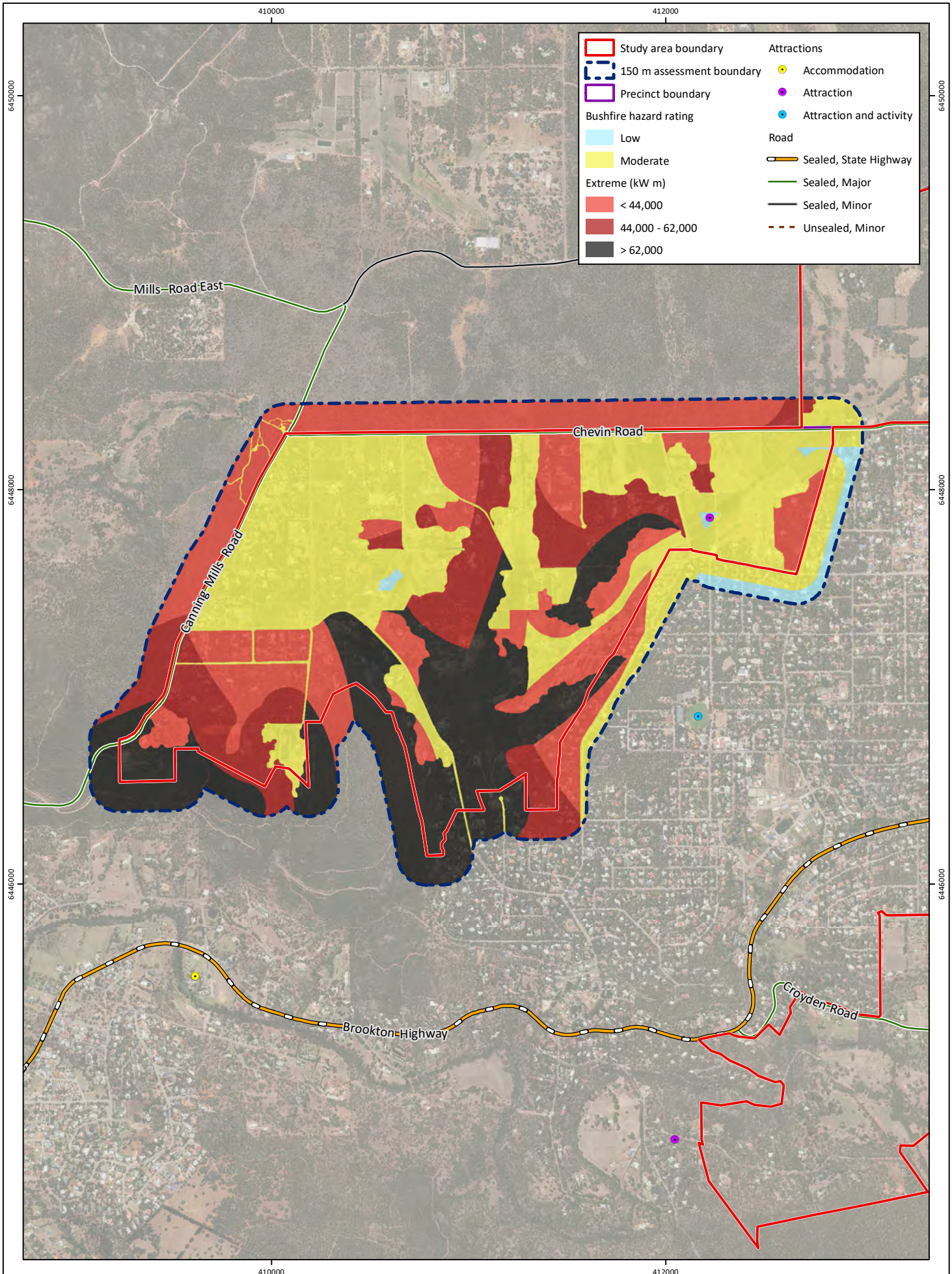

Figure 28: **Bushfire Hazard Level Rating - Roleystone West**

Project: Bushfire Management Plan
Pickering Brook and Surrounds Bushfire Risk Assessment

Client: Department of Planning, Lands and Heritage

Plan Number: EP19-138(04)--F59

Drawn:	SCM
Date:	15/05/2020
Checked:	DAE
Approved:	AJR
Date:	19/05/2020

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Meters

Scale: 1:25,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

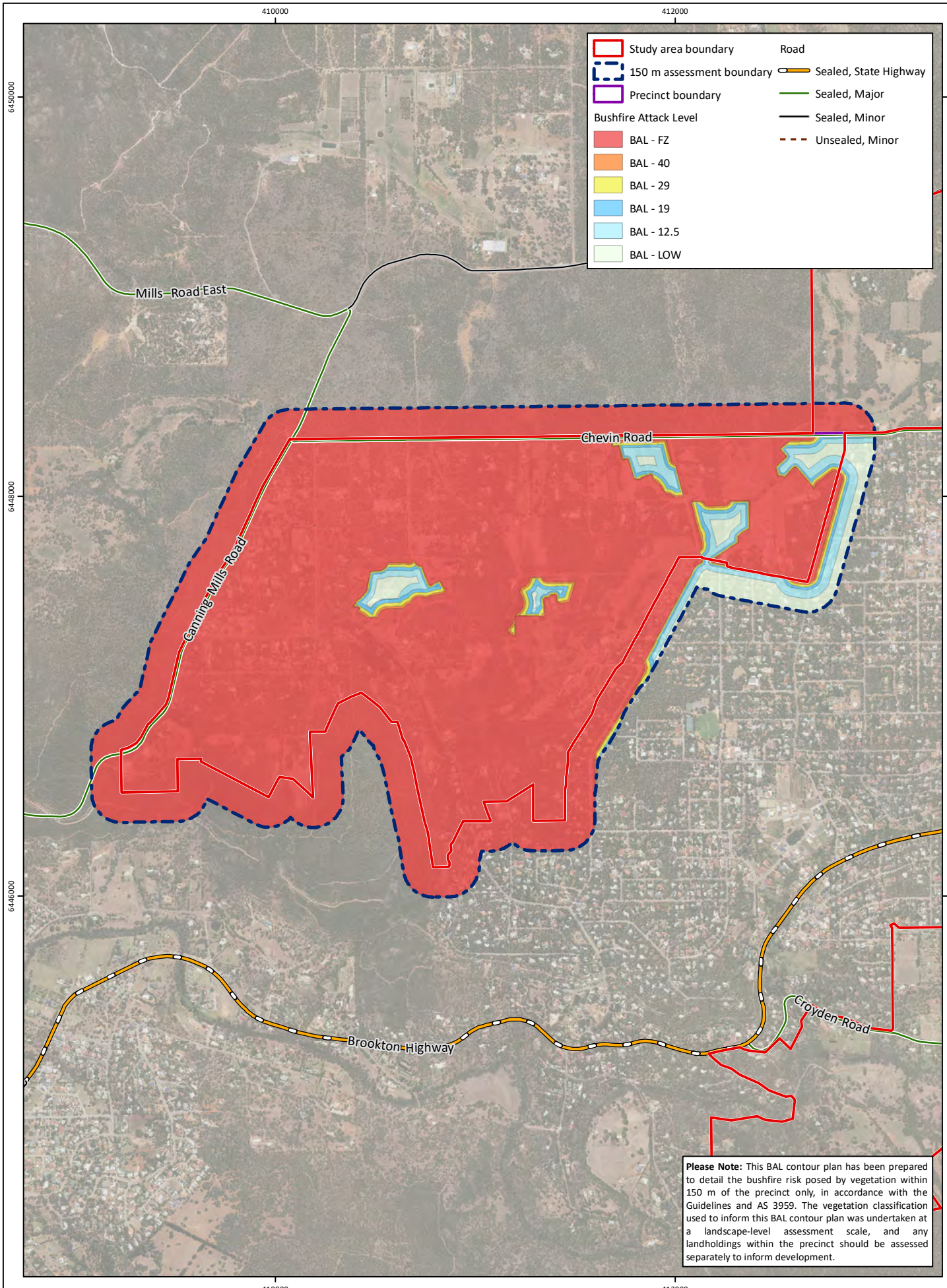

Figure 29: **Bushfire Attack Level Contour Plan (FDI 100) - Roleystone West**

Project: Bushfire Management Plan
Pickering Brook and Surrounds Bushfire Risk Assessment

Client: Department of Planning, Lands and Heritage

Plan Number: EP19-138(04)--F67

Drawn:	SCM
Date:	24/05/2020
Checked:	DAE
Approved:	AJR
Date:	25/05/2020

N

0 200 400 600
Meters

Scale: 1:25,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

7.1.9 Roleystone East

Figure 30-32
Area 1583 ha
Public land National Park 332 ha
177 ha agricultural production orchards/cleared.
680 ha rural living lots.

This Precinct joins Brookton Highway and the Roleystone township, which is upslope to the west. With the exception of the southern extent residential area west of Hawkstone Road, the Precinct is characterised by Rural living lots of around 2 ha, aligned along Brookman Road at the western section of the Precinct. These rural living lots are characterised by dense vegetation presenting a continuous fuel run and upslope from land to the east. They are indistinguishable, by aerial photo, from a contiguous forest canopy.

The area in this precinct is a complex landform with steep slopes, that makes for unpredictable fire behaviour. An orchard area of 68 ha, held in 8 large lots, is centrally located in the precinct and serves to break the continuity of bushfire fuels leading to the rural living lots, aligned on Brookton Highway and in turn the Roleystone township, from a fire travelling from the east. If further subdivision and development was to occur in this section, typical of the present forested rural living development, it would infill the present gap in the continuity of fuel and would extend the potential fuel run east from the Roleystone township.

The road network within the precinct is a loop arrangement with limited access only to Brookman Highway.

Beyond the present subdivision policy, contextual compliance is not demonstrated in this area.

The southern section comprises the valley extending from the Canning Dam. The valley is steep-sided and has a high-end Extreme BHL. Croyden Road runs along the valley and is the spine to the Araluen Botanic Garden, Araluen Golf Course, and the Canning Reservoir - by connection to McNess Drive. McNess Drive continues to connect to Brookton Highway further south and forms a scenic drive. Croyden Road also connects to Gardiner Road to provide a loop from the south end at Brookton Highway through to Brookton Highway at the east of the Precinct.

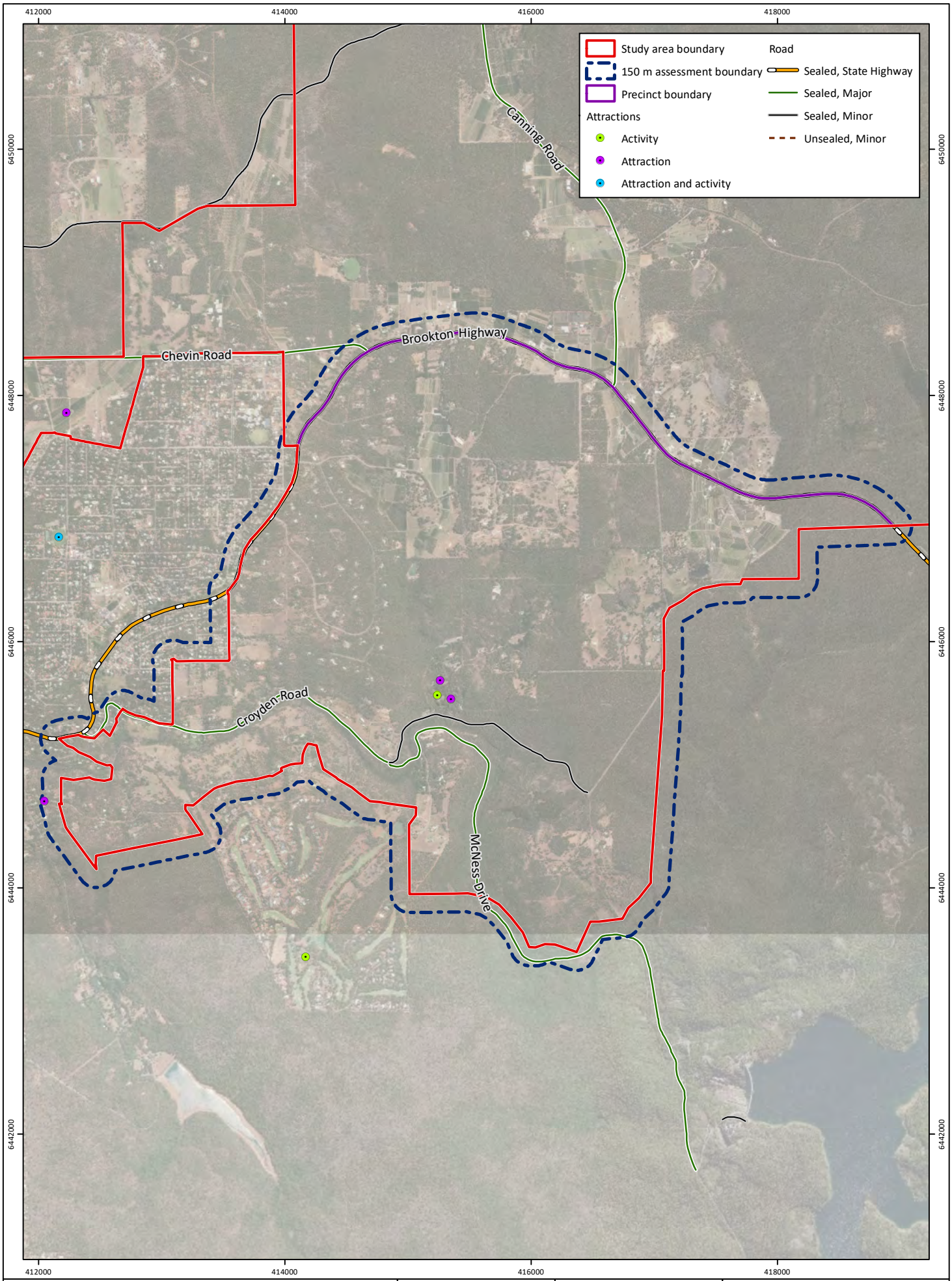

Figure 30: Precinct Map, Trails and Attractions - Roleystone East

Project: Bushfire Management Plan
Pickering Brook and Surrounds Bushfire Risk Assessment

Client: Department of Planning, Lands and Heritage

Plan Number: EP19-138(04)--F75

Drawn:	SCM
Date:	27/05/2020
Checked:	DAE
Approved:	AJR
Date:	27/05/2020

N

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Meters

Scale: 1:40,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

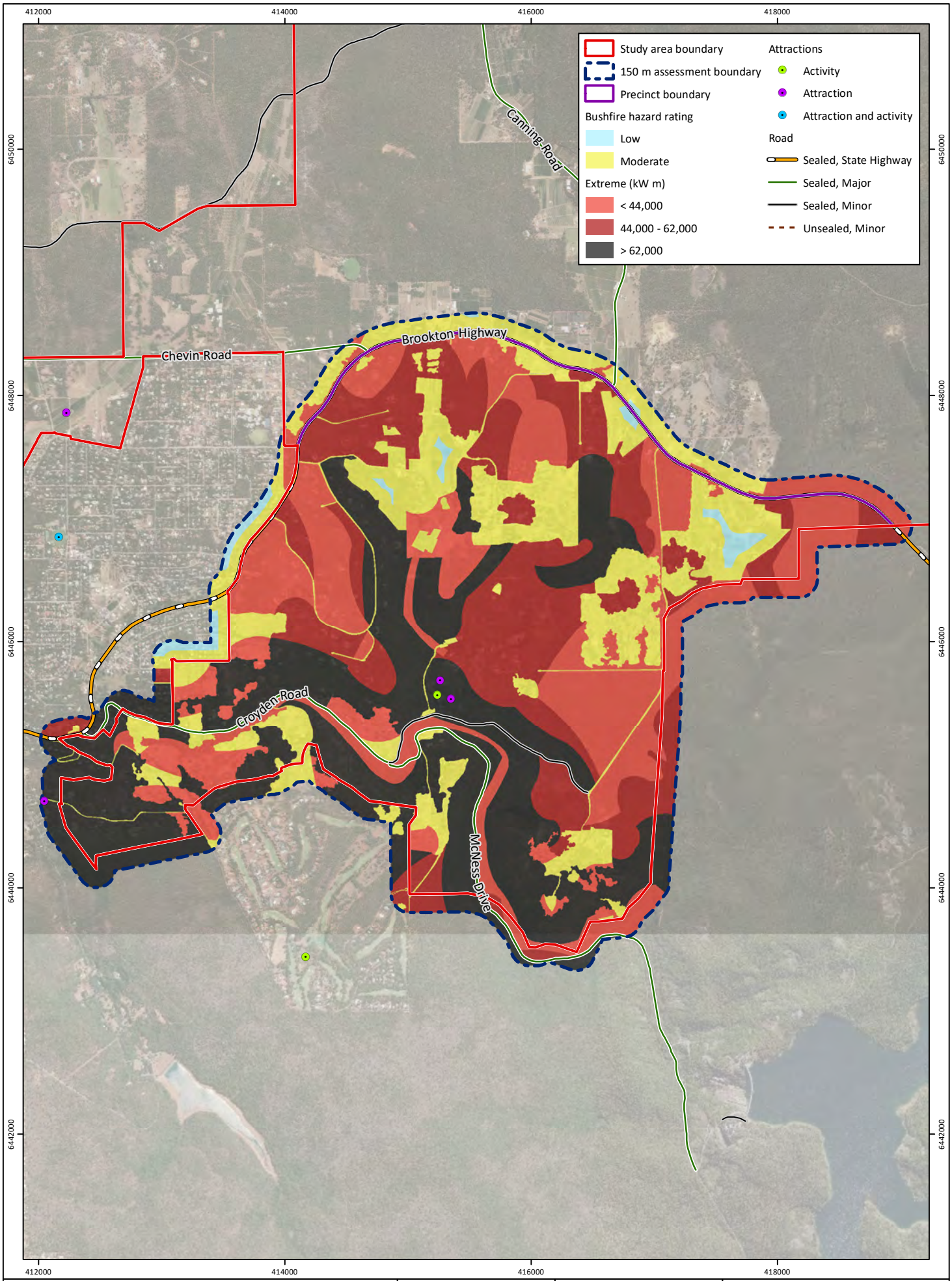

Figure 31: **Bushfire Hazard Level Rating - Roleystone East**

Project: Bushfire Management Plan
Pickering Brook and Surrounds Bushfire Risk Assessment

Client: Department of Planning, Lands and Heritage

Plan Number: EP19-138(04)--F60

Drawn:	SCM
Date:	15/05/2020
Checked:	DAE
Approved:	AJR
Date:	19/05/2020

N

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Meters

Scale: 1:40,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

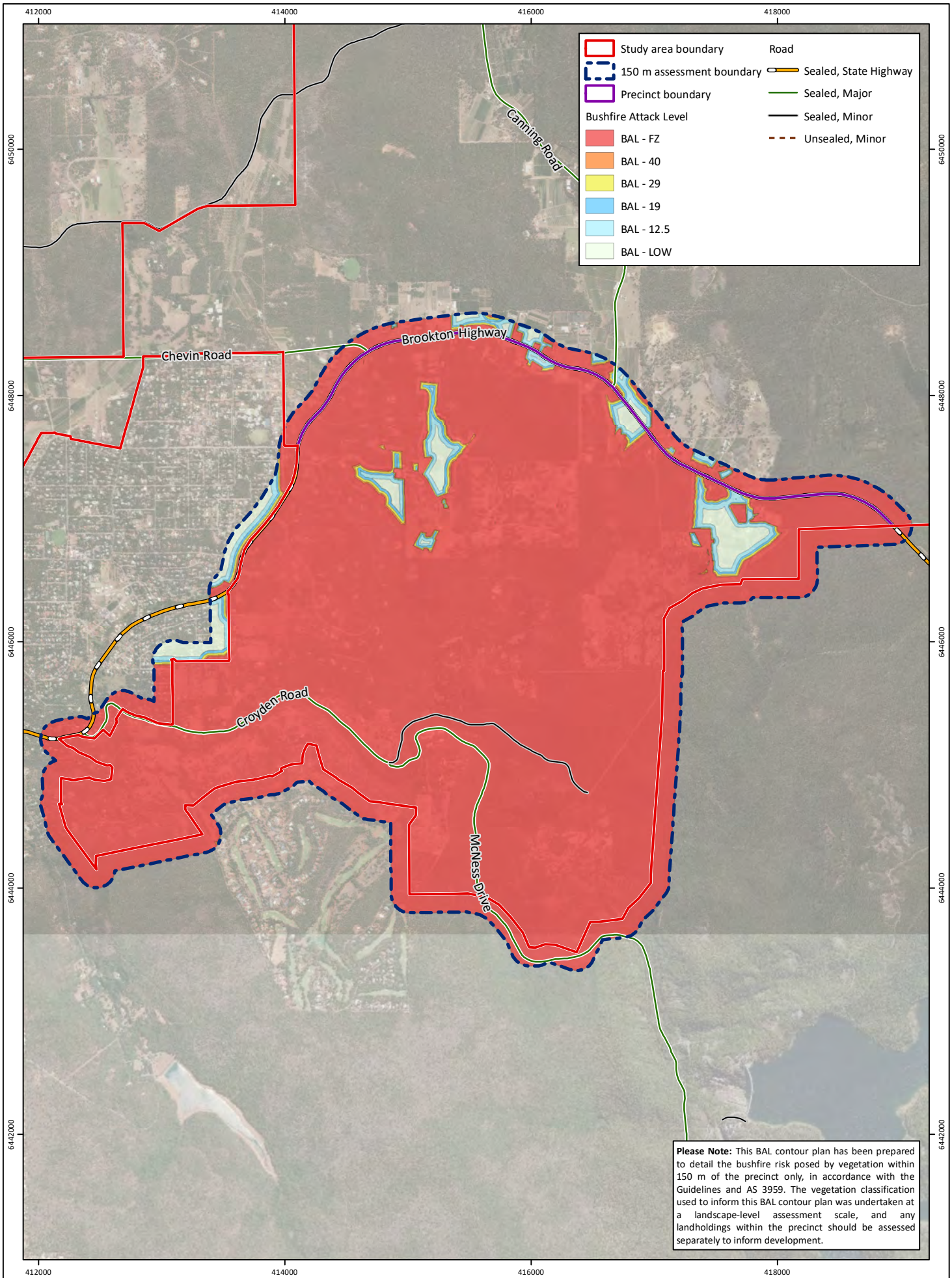

Figure 32: **Bushfire Attack Level Contour Plan (FDI 100) - Roleystone East**

Project: Bushfire Management Plan
Pickering Brook and Surrounds Bushfire Risk Assessment

Client: Department of Planning, Lands and Heritage

Plan Number: EP19-138(04)--F68

Drawn:	SCM
Date:	24/05/2020
Checked:	DAE
Approved:	AJR
Date:	25/05/2020

N

0 500 1,000
Meters

Scale: 1:40,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

8 Applicant Declaration

8.1 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.

8.2 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: 14 July 2020

BPAD Accreditation: Level 3 BPAD no. 36690

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Appendix A

Audit of major routes entering and leaving the study area

Table 5 - Audit of major routes entering and leaving the study area

	Brookton Hwy	Canning Mills Road	Chevin Road	Croyden Road Gardiner Road	Canning Rd towards PB from south	Canning Rd west from PB	Pickering Brook Rd towards PB	Merrivale Road	Patterson Rd, Walnut Road.	Glenisla Road	Aldersyde Road	Mundaring Weir Rd heading North-east from Lockwood Rd
Is the carriageway sealed	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
If sealed, what is the carriage width	>6 m	>6 m	>6 m	>6 m	>6 m	>6 m	>6 m	5.5-6 m	5.5-6 m	5.5-6 m	>6 m	>6 m
If sealed what is the shoulder width	<1 m	<1 m	1 m	1	1 m	1 m	1 m	1m	1m	1 m	1	<1 m
If sealed is the carriageway surface unbroken	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
If sealed is the surface clearly marked	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y
If not sealed what is the overall width	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
If not sealed what is the estimated carriage width	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
If not sealed is the surface	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

	Brookton Hwy	Canning Mills Road	Chevin Road	Croyden Road Gardiner Road	Canning Rd towards PB from south	Canning Rd west from PB	Pickering Brook Rd towards PB	Merrivale Road	Patterson Rd, Walnut Road.	Glenisla Road	Aldersyde Road	Mundaring Weir Rd heading North-east from Lockwood Rd
free of loose material												
Is the road surface smooth	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Is the road traversable by 2WD	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Does the maximum grade exceed 1 in 10, for any length >50m	N	N	N	N	N	N	N	N	N	N	N	N
Does the cross fall exceed 1 in 33 at any point	N	N	N	N	N	N	N	N	N	N	N	N
Is the alignment of the roadway clearly defined	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y
Is the presence of intersections clearly visible	Y	Y	Y	Y	Y	N	N	N/A	y	Y	Y	N
Are reflective delineators provided on	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y

	Brookton Hwy	Canning Mills Road	Chevin Road	Croyden Road Gardiner Road	Canning Rd towards PB from south	Canning Rd west from PB	Pickering Brook Rd towards PB	Merrivale Road	Patterson Rd, Walnut Road.	Glenisla Road	Aldersyde Road	Mundaring Weir Rd heading North-east from Lockwood Rd
guideposts, crash barriers and bridge railings												
What is the percentage of the 'line of sight' < 200 m	0.9	0.9	0.9	0.3	0.9	0.9	0.9	0.9	0.8	0.8	0.7	0.3
Is the road illuminated	N	N	N	N	N	N	N	N	N	N	N	N
Are intersections illuminated	N	N	N	N	N	N	N	N	N	N	N	Y
Are barriers provided to prevent access to dropping embankments	N	N	N	N	N	N	N	N	N	Y	Y	Y
Is the carriageway clear of vertical obstruction	Y	N	N	N	N	N	N	N	Y	Y	Y	N
Is the shoulder traversable,	N	N	N	N	N	N	N D	N/A	N	N	N	Y/N

	Brookton Hwy	Canning Mills Road	Chevin Road	Croyden Road Gardiner Road	Canning Rd towards PB from south	Canning Rd west from PB	Pickering Brook Rd towards PB	Merrivale Road	Patterson Rd, Walnut Road.	Glenisla Road	Aldersyde Road	Mundaring Weir Rd heading North-east from Lockwood Rd
clear of obstruction, signs, drains, and trees												
Are overtaking opportunities provided	Y	N	N	N	Irregular	N	Limited	N	N	N	N	N
Are areas clear of vegetation, safer places, available along the road	Y	N	N	N	N	N	Y	N	N	N	N	N
Are bridges narrower than the shoulder and carriageway	same	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NA	N/A	N/A	same
Are all road signs conspicuous and clear	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Are road markings consistent along the route	N	N	N	Y	Y	Y	Y	N	N	N	N	Y

	Brookton Hwy	Canning Mills Road	Chevin Road	Croyden Road Gardiner Road	Canning Rd towards PB from south	Canning Rd west from PB	Pickering Brook Rd towards PB	Merrivale Road	Patterson Rd, Walnut Road.	Glenisla Road	Aldersyde Road	Mundaring Weir Rd heading North-east from Lockwood Rd
Is emergency advice provided along the road	N	N	N	N	N	N	N	N	N	N	N	N
Do restrictions apply to any class of vehicle using the road	N	N	N	Y E	N	N	N	Probably		Y E	Y E	N
Does the route rely on electronic traffic signalling	N	N	N	N	N	N	N	N	N	N	N	N
Is the route likely to be free from large animals	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
What is the adjoining vegetation	Forest	Forest	Forest	Forest	Forest, Scrub	Forest	Forest, Grassland	Forest Orchards	Forest	Forest Orchards	Forest Orchards	Forest

Appendix B

Fire Weather Data

Forest Fire Danger Index (FFDI)

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[72]. The closest BoM historic record for FFDI and GFDI is Perth Airport.

The station at Bickley records consistently lower maximum daily temperature than Perth Airport, while Gosnells generally achieves the same peaks as Perth Airport as demonstrated in **Plate 5**. It is noted that this difference is slight and follows the same overall pattern as Perth Airport. Daily rainfall and relative humidity (3pm) are consistently higher at Gosnells and Bickley than Perth Airport as seen in **Plate 6** and **Plate 7**. Daily windspeed (recorded at 3pm) appears to be generally much lower at Bickley than at Perth Airport (refer to **Plate 8**). Daily windspeed records for Gosnells are inconsistently recorded. 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, while Roleystone would experience consistently higher relative humidity lowering the FFDI.

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 9).**

An 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 10).** Based on this, the present FFDI of 80 is appropriate but a 1:200 AEP should use an FFDI of 100.

Since 1990 the December FFDI (15 -31 December) is generally higher than that recorded for January, and since 2005 often over an FFDI of 50 **(Plate 11). It suggests the higher FFDI is moving to earlier in the bushfire season.**

FFDI data is not currently available for the Bickley or Gosnells weather stations. The key factors responsible for determining FFDI have been compared at Bickley, Gosnells and the Perth Airport weather stations for the period 1 December 2019 to 26 February 2019.

The study team attempted a range of approaches to get a better reflection for the study area on the basis of the lower temperature, windspeed and humidity. A key aspect not available is the drought factor (1 -10) and the Keetch Byram index (1-200). Utilising the Perth Values applied to Bickley data made little difference to the FFDI recorded for Perth, highlighting this factor is highly influential.

[72] 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

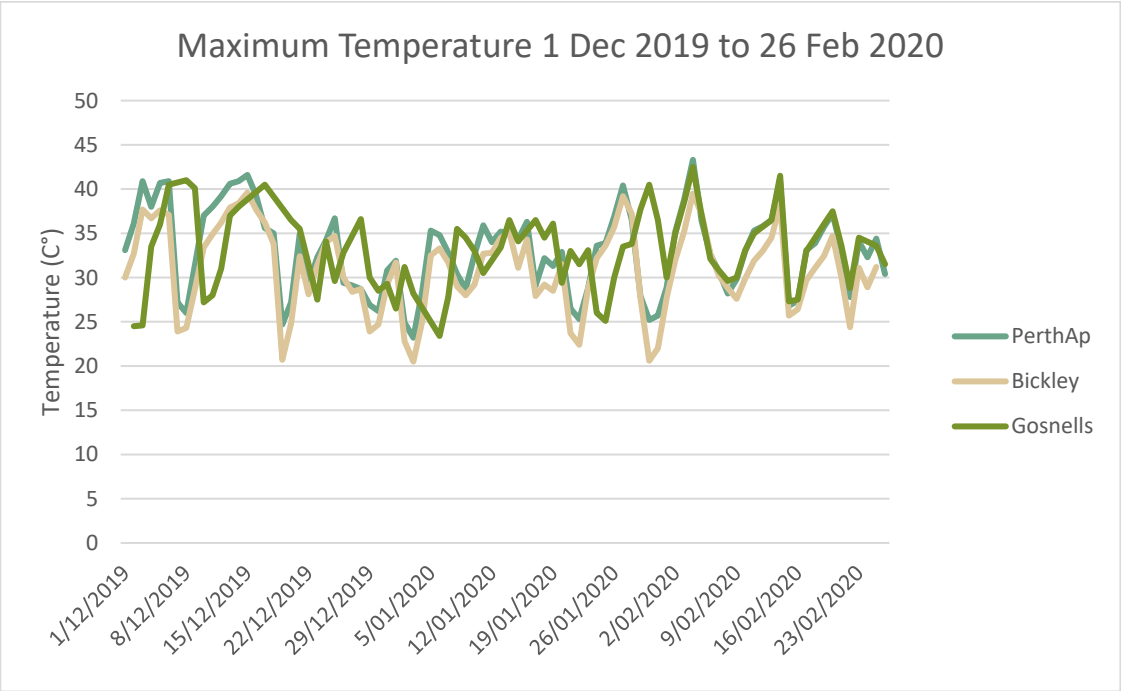


Plate 4: Maximum daily temperature at Perth Airport, Bickley and Gosnells Weather Stations over the period 1 December 2019 to 26 February 2020 (BoM, 2020).

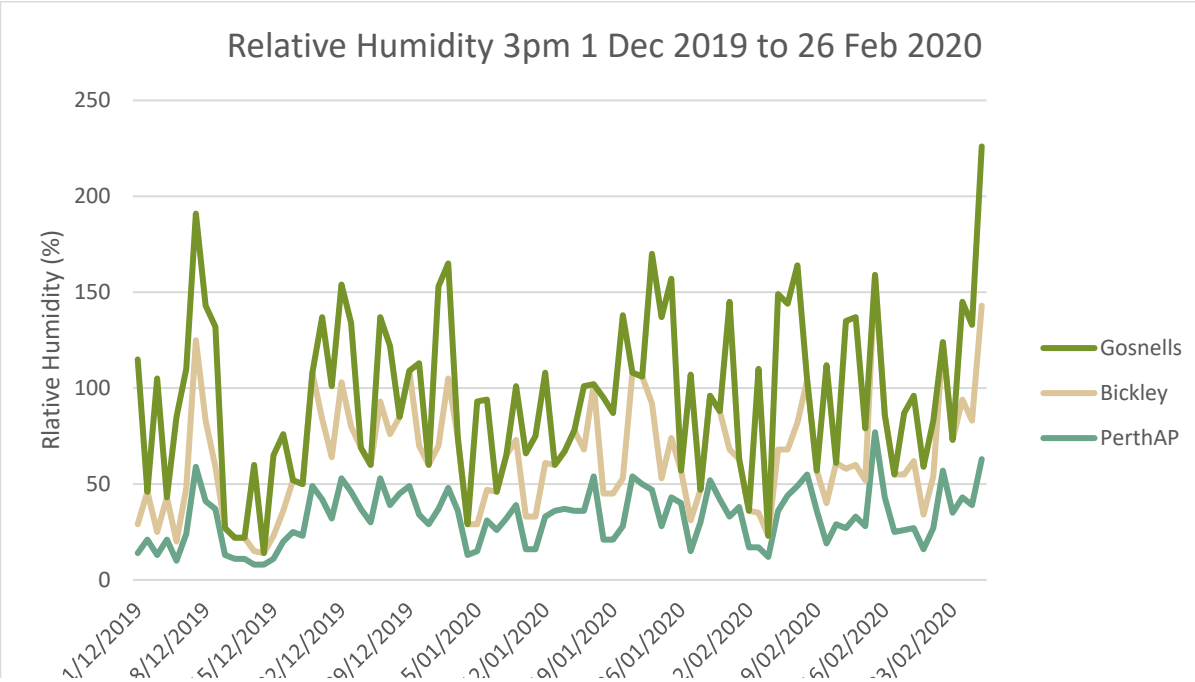


Plate 5: Daily Relative humidity at 3pm at Perth Airport, Bickley and Gosnells Weather Stations over the period 1 December 2019 to 26 February 2020 (BoM, 2020).

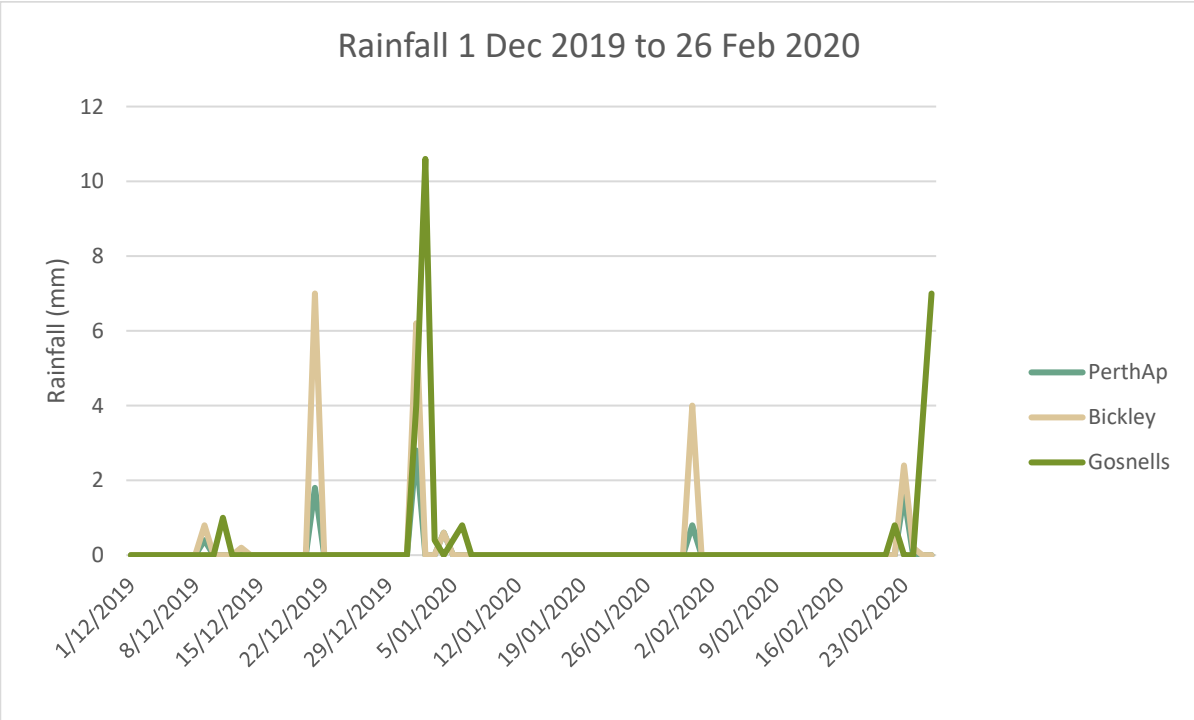


Plate 6: Daily Rainfall at Perth Airport, Bickley and Gosnells Weather Stations over the period 1 December 2019 to 26 February 2020 (BoM, 2020).

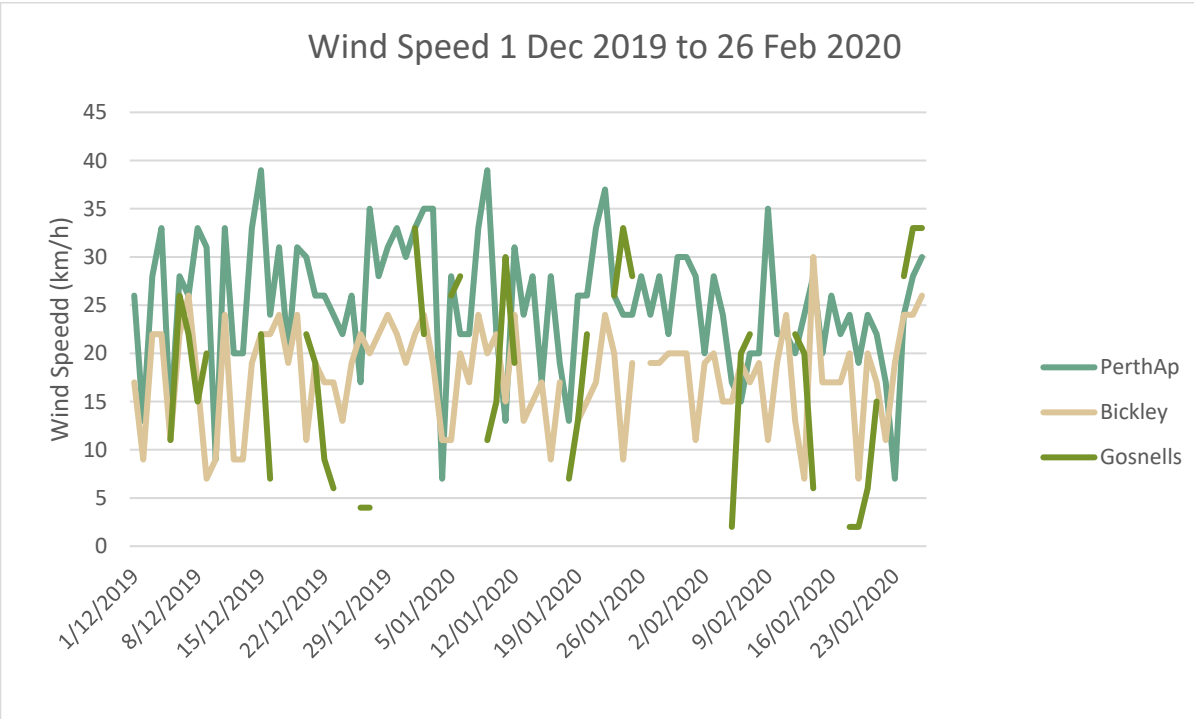


Plate 7: Daily Wind Speed at 3pm at Perth Airport, Bickley and Gosnells Weather Stations over the period 1 December 2019 to 26 February 2020 (BoM, 2020).

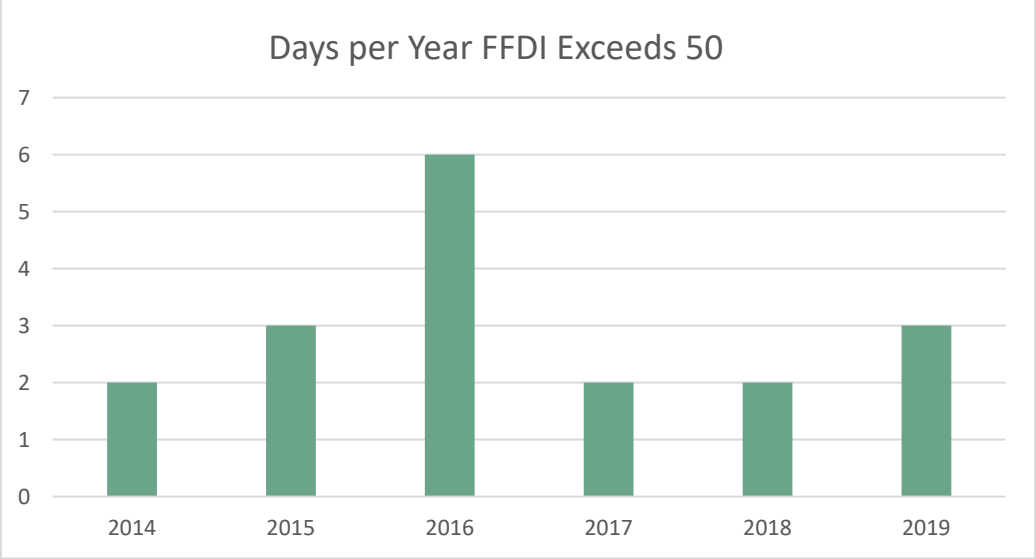


Plate 8: Number of days FFDI recorded as 50 or above at Perth Airport from 01/01/2014-31/08/2019 (BoM, 2020)

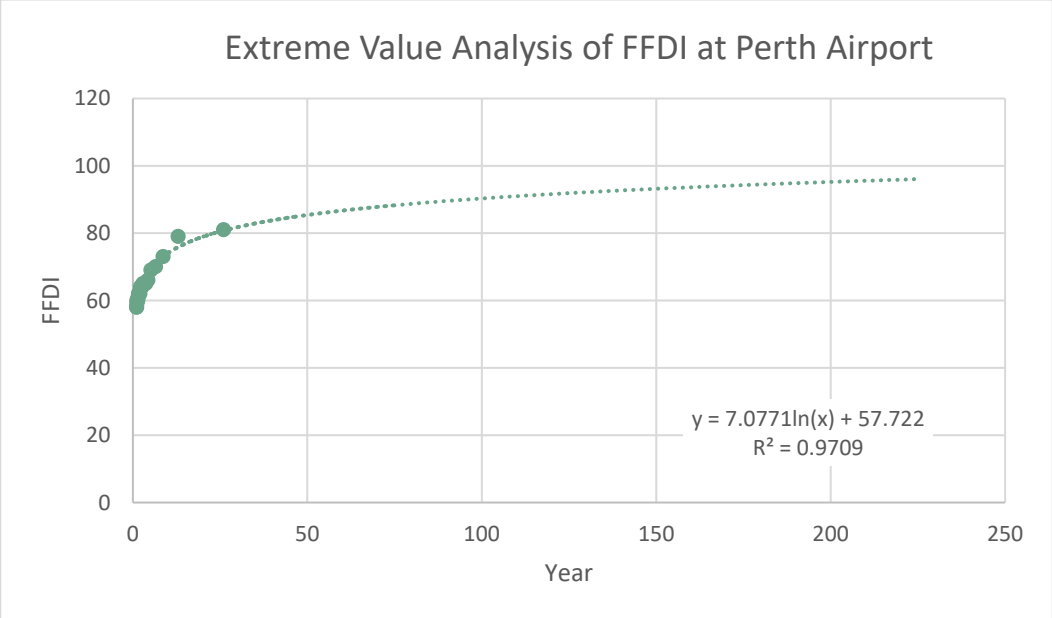


Plate 9: Extreme Value Analysis for FFDI for Perth Airport based on fire weather dataset using recorded FFDI values from 1994-2019 by Lucas (2010) received from BoM.

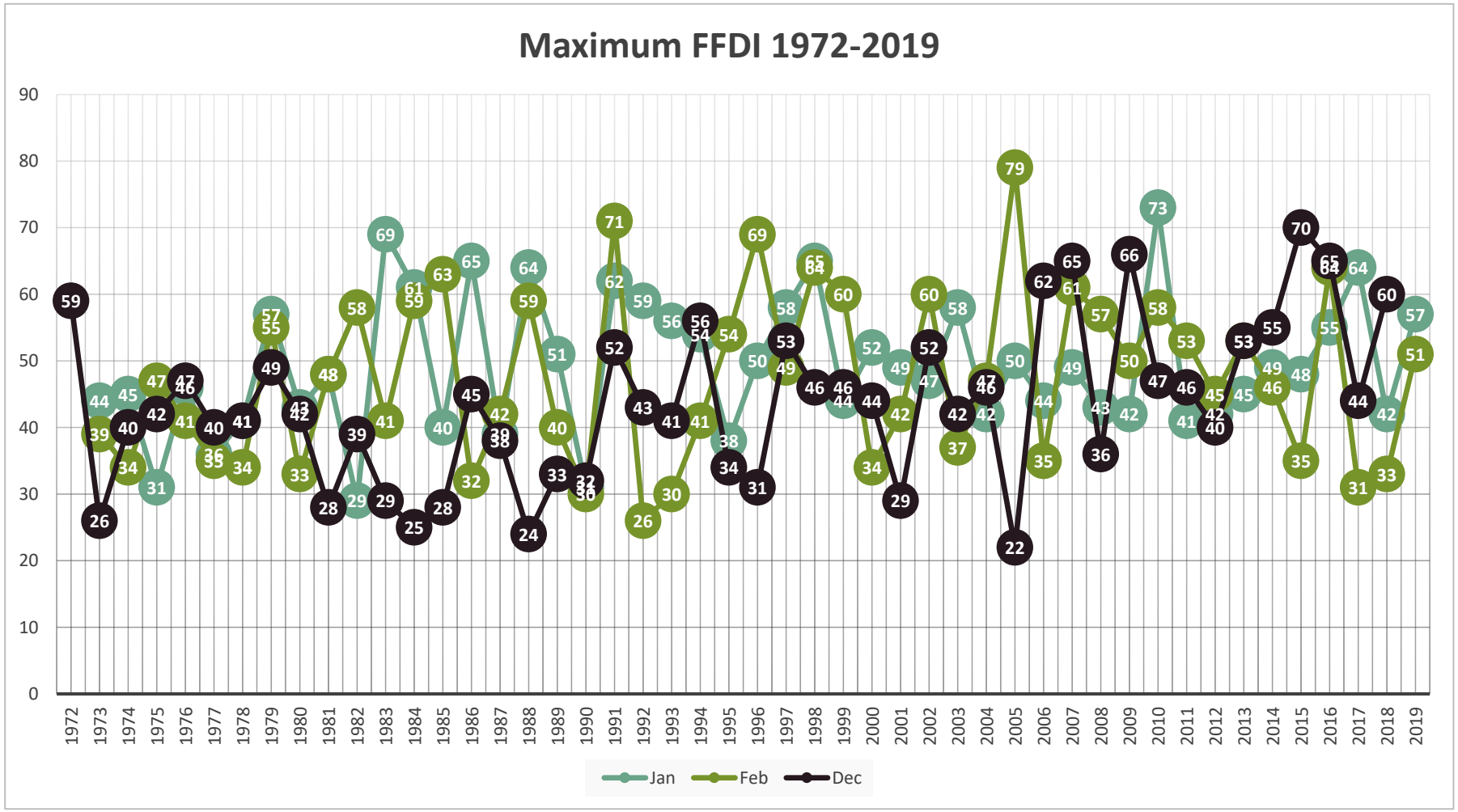


Plate 10: Maximum FFDI recorded at Perth Airport from 1972 to 2019 in January, February and December (BoM, 2020)

Bickley

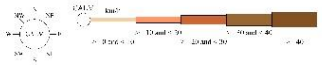
Rose of Wind direction versus Wind speed in km/h (11 Feb 1994 to 11 Aug 2019)

Custom times selected, refer to attached note for details

BICKLEY

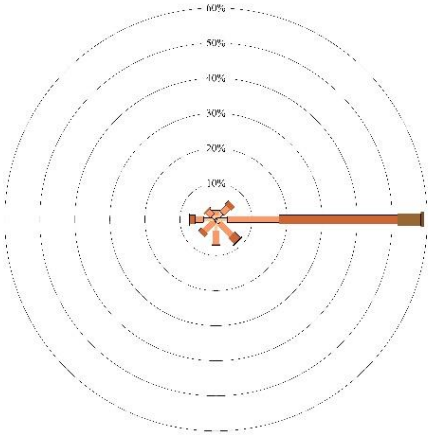
Site No: 009240 • Opened Jan 1989 • Still Open • Latitude: -32.2972° • Longitude: 116.1898° • Elevation 334m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



9 am Jan
711 Total Observations

Calm 1%



Perth Airport

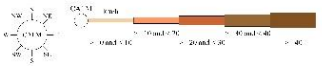
Rose of Wind direction versus Wind speed in km/h (01 May 1944 to 12 Aug 2019)

Custom times selected, refer to attached note for details

PERTH AIRPORT

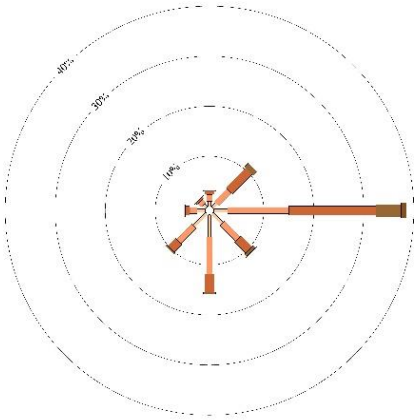
Site No: 009021 • Opened Jan 1944 • Still Open • Latitude: -31.9275° • Longitude: 115.9764° • Elevation 15 m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



9 am Jan
2324 Total Observations

Calm 4%



Gosnells

Rose of Wind direction versus Wind speed in km/h (17 Jul 1991 to 11 Aug 2019)

Custom times selected, refer to attached note for details

GOSNELLS CITY

Site No: 009106 • Opened Jan 1961 • Still Open • Latitude: -32.0481° • Longitude: 115.9844° • Elevation 10m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.

9 am Jan
824 Total Observations

Calm 3%

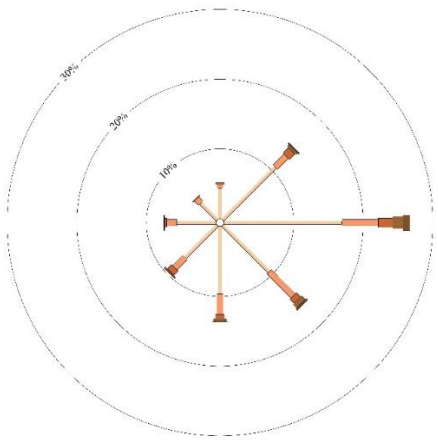


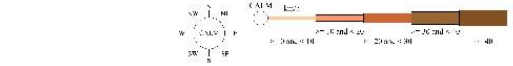
Plate 11: Windspeed and direction at Bickley, Perth Airport and Gosnells City (BoM, 2020) January (9am) observations

Bickley	Perth Airport	Gosnells

Rose of Wind direction versus Wind speed in km/h (11 Feb 1994 to 11 Aug 2019)

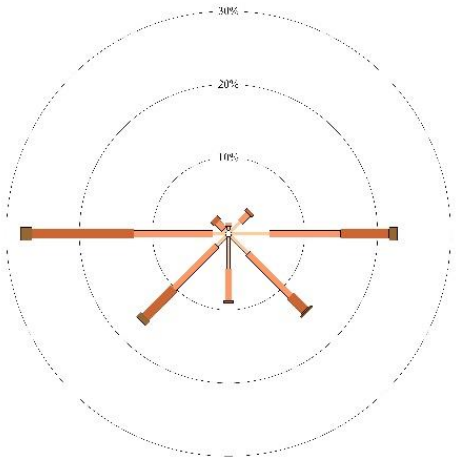
BICKLEY

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



3 pm Jan
711 Total Observations

Calm 2%



TCZMONTH Page

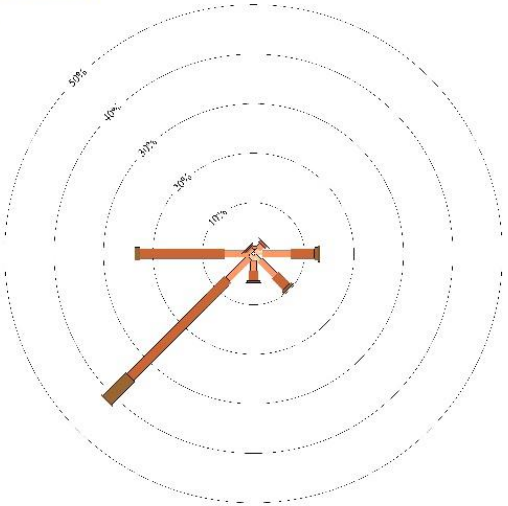
Rose of Wind direction versus Wind speed in km/h (01 May 1944 to 12 Aug 2019)

PERTH AIRPORT

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.

3 pm Jan
2320 Total Observations

Calm 1%

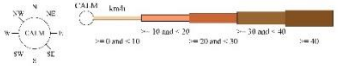


TCZMONTH Page

Rose of Wind direction versus Wind speed in km/h (17 Jul 1991 to 11 Aug 2019)

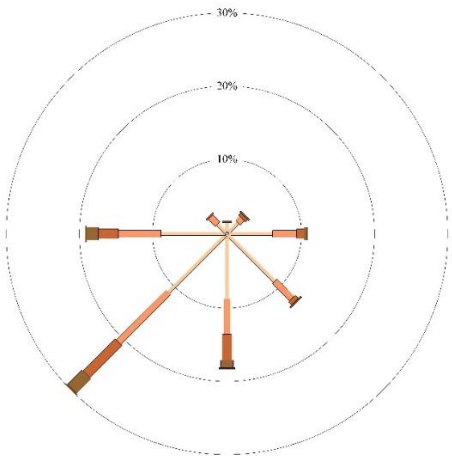
GOSNELLS CITY

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



3 pm Jan
499 Total Observations

Calm 1%



TCZMONTH Page

Plate 12: Windspeed and direction at Bickley, Perth Airport and Gosnells City (BoM, 2020) January (3pm) observations

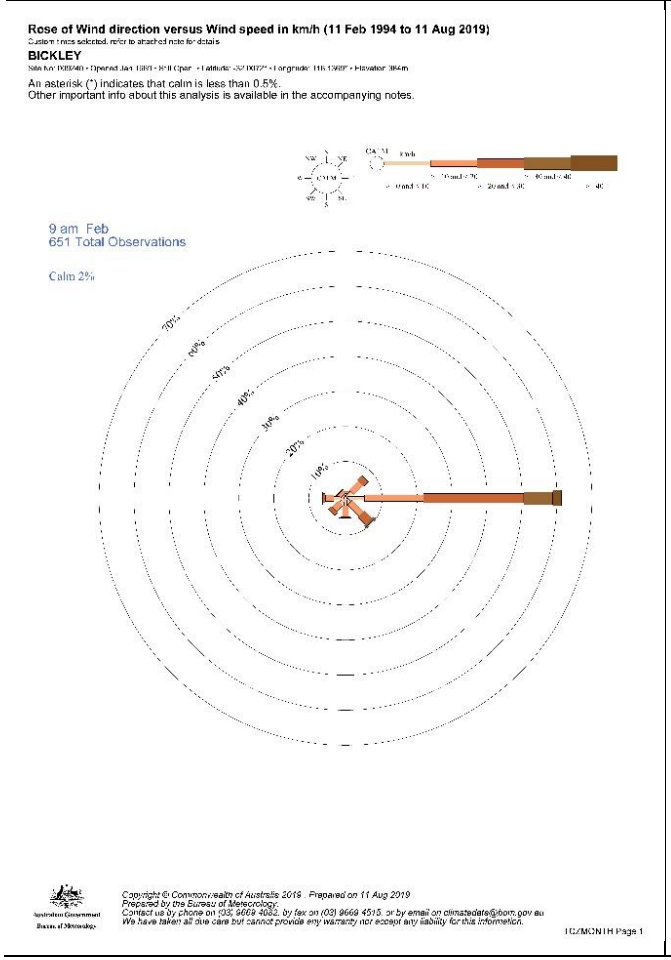
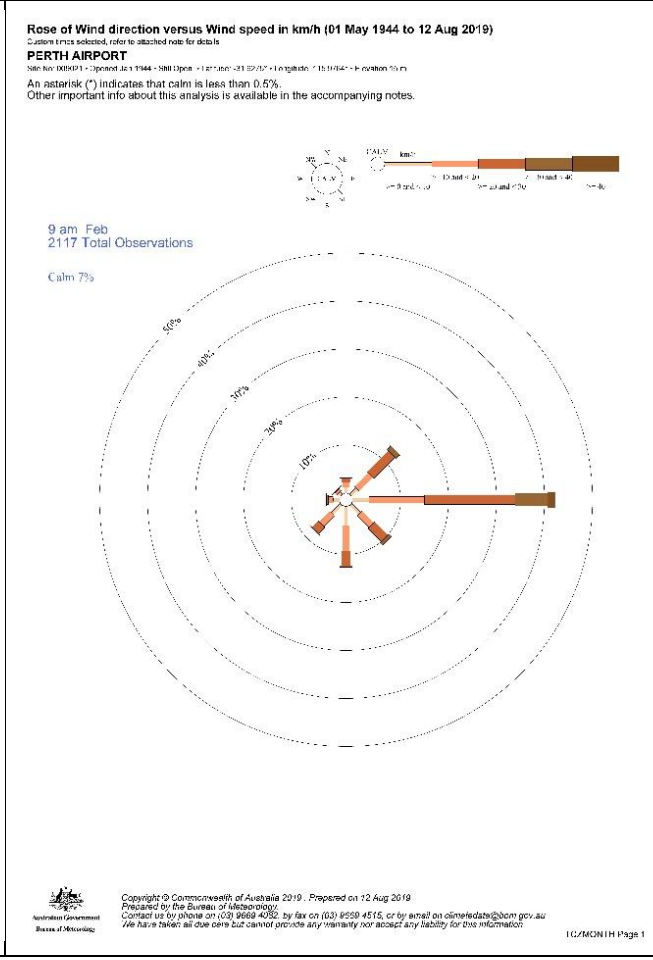
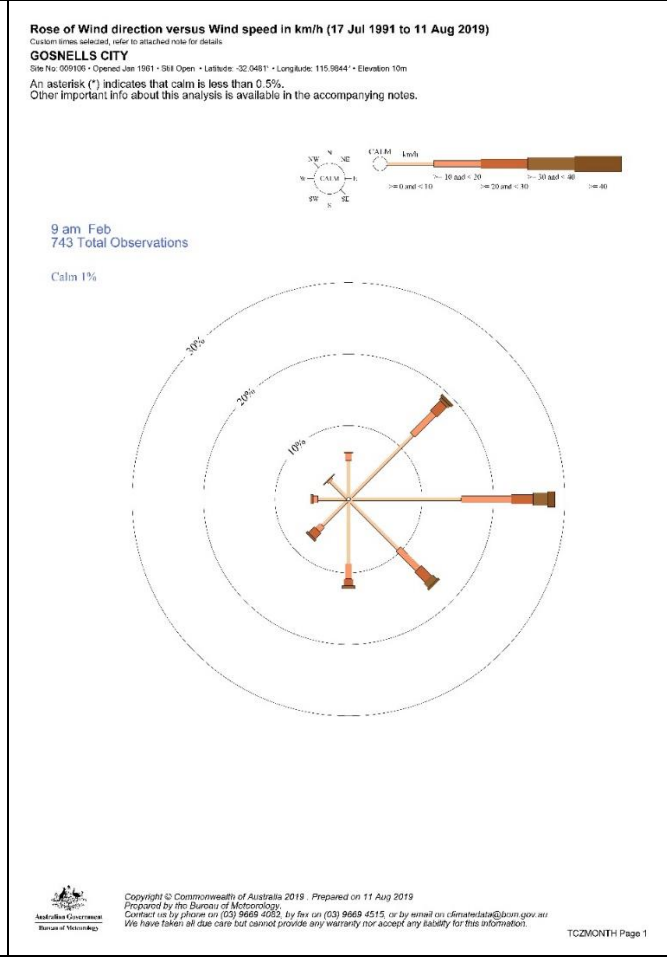
Bickley	Perth Airport	Gosnells
		

Plate 13: Windspeed and direction at Bickley, Perth Airport and Gosnells City (BoM, 2020) February (9am) observations

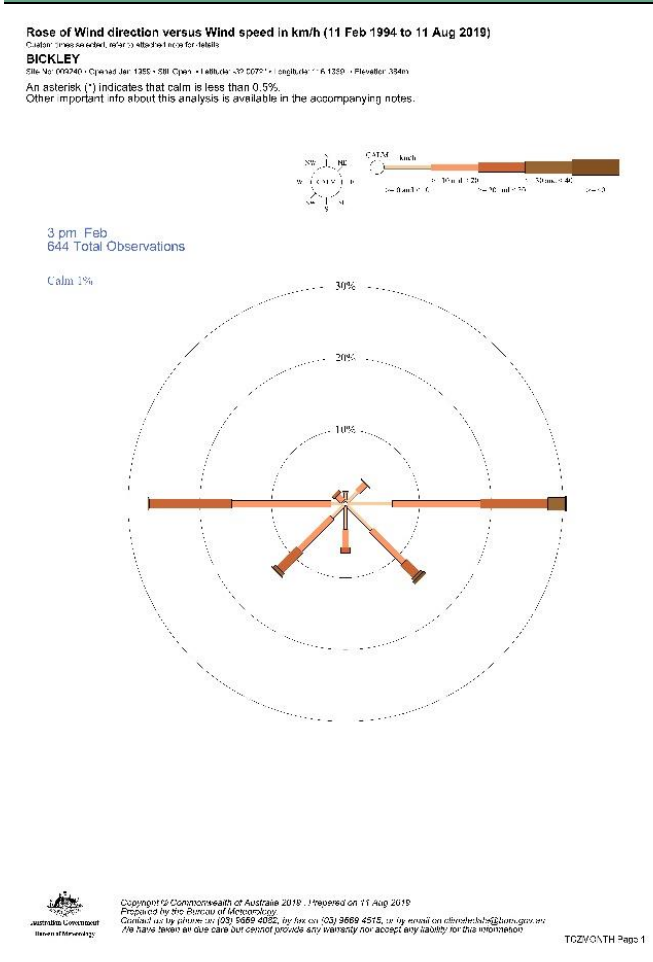
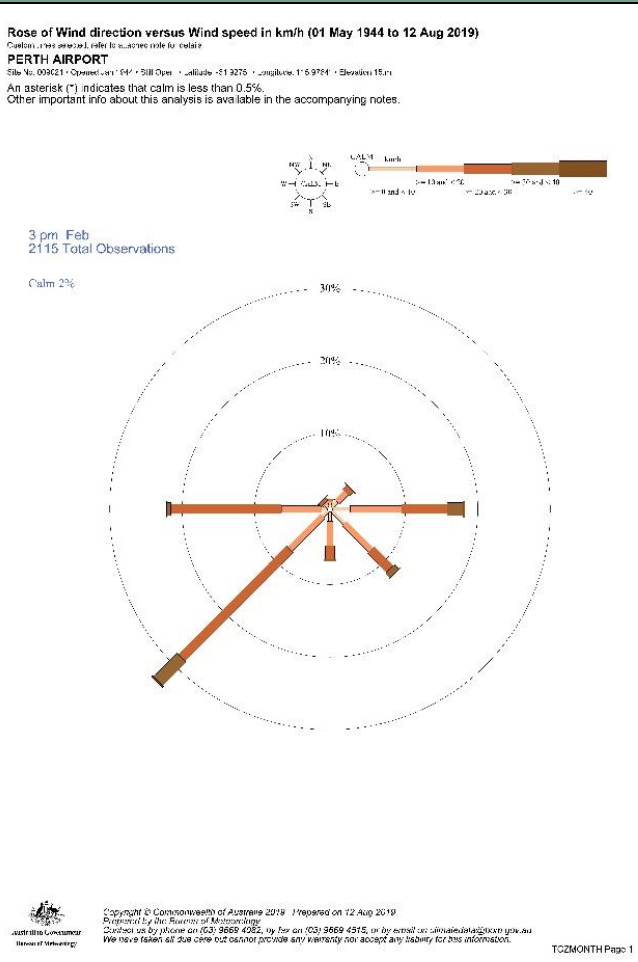
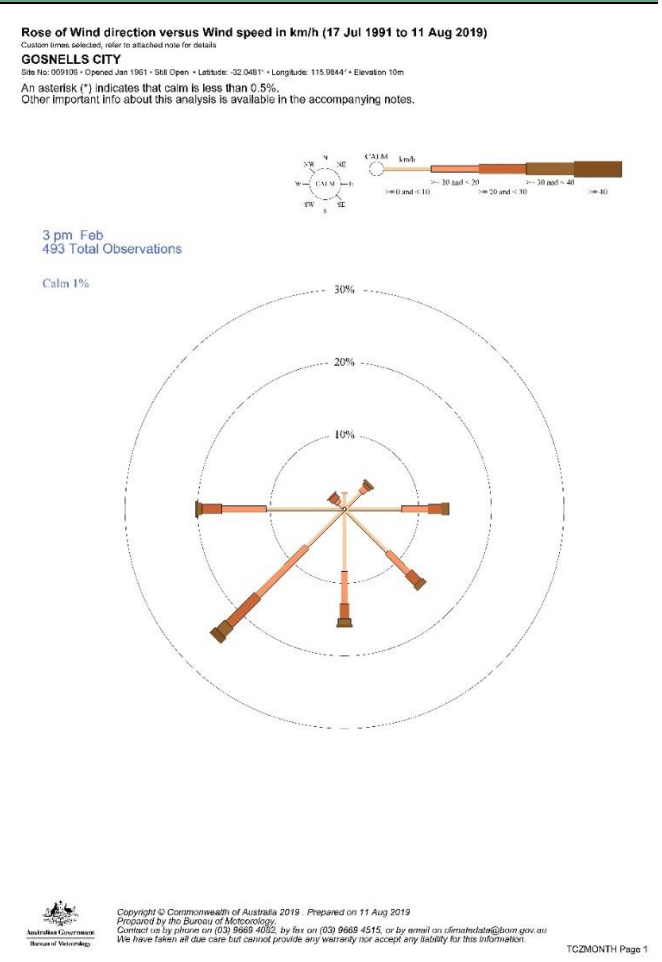
Bickley	Perth Airport	Gosnells
		

Plate 14: Windspeed and direction at Bickley, Perth Airport and Gosnells City (BoM, 2020) February (3pm) observations

Appendix C

Study Area Risk Register

Risk Register (NERAG 2020)

The following has used a NERAG approach to identify a risk, evaluate the existing controls and examine the expediency of identified mitigation measures. Regard has been given to fire safety concept *NFPA 550: Guide to the fire safety concepts tree*, adapted for bushfire and illustrated in the ABCB bushfire verification method handbook July 2019[73].

It is important to note that the National Construction Standards, assumes a 10% failure in constructions following the Deemed to Satisfy Solutions in AS3959:2018. This is reflected in the alternative approach using the verification method which accepts no less than an anticipated construction failure of 10%. This is a hypothetical assumption that in turn asks the consideration of as low as reasonably practical (ALARP) approach measures to bridge the final 10%. These need not be confined to construction alone but can include a broad range of measures that may reduce the risk.

As a strategic document the considerations are made for broader level public arrangements that may be followed through subsequent levels to site specific development, and administrative arrangements under the State Emergency Management Framework, that can be considered in bridging the final 10%.

As an analogy with advances to inundation risk, the premiums charged to an individual householder is based upon an assessed risk that includes the location and the risk at the site and expected damage, but also regional initiatives, such as planned levees and regional flood controls. A similar approach is expected to be taken to bushfire risk based on location, building construction, site management and regional mitigation measures.

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
- **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
- **Minimising the exposure** of the community to the effects of bushfire
    - Early evacuation, detection, alarm
    - Evacuation facilitation
    - Safer places

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

Table 6: Study Area Risk Register (colours are from NERAG 2015)

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 endeavors 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,	Local government Maintain road reserves under infrastructure as low threat	Medium: Sparse grasses exceeding 100 mm evident adjoining carriageway (shoulder) to dense grass	34 in 11 years rare	Catastrophic	High	Frequency and coordination between stakeholders	Medium	Medium	Medium	Medium
	Western Power Grid management Vegetation management around audited risks, poles, powerlines transformers	Medium: Grasses and elevated vegetation leading to 30 % of power poles. Clearing vegetation from powerlines Bundling cables in high risk area	rare	Catastrophic	High	Frequency and coordination between stakeholders	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	Promote landholder awareness Power corp Local Government observance of Bushfire's Act 1954 if known.	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										

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
A bushfire can be ignited by unintentional human actions cigarettes, metal grinding, fireworks	State and Local Government Community education Fire ban days announcements.	Low: Complacency despite awareness.	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
Many Bushfires are deliberately ignited (including suspicious fires)	WAPOL Arson prevention	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
MANAGING THE FIRE										
The spread and intensity of a bushfire is influenced by the vertical and horizontal continuity of native vegetation and cured grasses.	DBCA/ Parks and Wildlife Management of Government land (National Parks:) • fuel reduction	Medium: Mosaic pattern provides for overall reduction, but localised fires and property exposure can occur.	Likely	catastrophic	Extreme	Ensure a frequency consistent with the 3-5-year fuel cycle. Investigate cultural efficacy with indigenous traditional bushfire practices at a higher frequency activity.	Medium	High	High	High
	DBCA/ Parks and Wildlife Management of Government land (National Parks:) • strategic firebreaks	Strategic firebreaks are effective for managing fuel reductions activity but can be breached by spotting.				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
	Private land management Maintain fuels not conducive to the spread of fire and install fire breaks	Low Local government enforcement resources are limited, but wide spread observable failure is evident from aerial photography. Due to, landowner capability, and conflicting objectives of amenity and bushfire protection.				Illustrate methods that achieve amenity and bushfire protection Increase the frequency of inspection to verify aerial imagery Determine the cost-effectiveness, hardship programs to assist those without the capability to undertake works.	Medium			Medium
Land Management										

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
The proximity of buildings to the bushfire front affects their vulnerability to damage from direct flame attack from and radiant heat.	For new development, SPP 3.7 and AS3959:2018. Subdivision in the area of extreme bushfire hazard is to be avoided cl. 6.7 SPP 3.7	High Applies to development since 8 December 2015, if within 100 m from classified vegetation.	Rare	Minor	Low	Apply AS3959:2018 Subdivision only where the impacts of bushfire can be ameliorated on site.	Low	High	High	High
Townships (outside of study area)vulnerable to bushfire attack due to continuity of bushfire fuels on adjacent public and private land (within the study area)	*Bushfires Act 1954*, land management by fire break notice Bushfire Risk Management Plan tenure blind fuel reduction initiatives. Community ignition reduction initiatives WAPOL.	Low The fragmentation of smaller rural living lots with contrary expectations of land management (the desire to place a house within a forest) and encouraging an urban forest is contradictory to bushfire risk. The *Bushfires Act 1954* is lightly applied in practice. The Notice and policing are unable to balance owner amenity aspirations with effective bushfire management. Broadscale land management, i.e., reduction burns are not practical with dispersed assets across rural living lots. Changes to the intensity of development within the study area will affect the continuity of bushfire fuels affecting townships adjacent to the study area.	Likely	Catastrophic	Extremer	The 2011 Kelmscott fire illustrated the vulnerability of Roleystone and Kelmscott from a fire initiated from within the study area. Kalamunda is similarly affected but is adjoined by larger areas of public land, the management of which proved decisive in 2005. Strategic land intensification to consider the consequence upon adjacent townships. Further community guidance on bushfire resistant landscaping techniques, as a compendium to urban forest initiatives, a demonstrated achievement of both. To be used as a reference for the satisfaction of requirements under the *Bushfires Act.1954*.	High	Medium	Medium	High
Detection										
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. Dependency on telecommunications is increasing.	High: Telecommunication towers are set within compounds	Unlikely	Major	High	Maintain separation of vegetation, and ensure any equipment is shielded from radiant heat and bushfire attack and potential falling trees Ensure public walking trails through National Parks can receive telecommunications, or where it is lacking avoid use during fire season.	Medium	Medium	Medium	Medium
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

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
	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 traveling 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
Suppression										
Emergency services are unable to access land to undertake suppression operation	Public Road Network *Bushfires Act 1954*, Fire breaks Notice, traversable tracks	Low: Land management, long narrow internal driveways, and a lack of turn around areas and defendable spaces around buildings, is unsafe for brigade attendance and may trap a unit denying its participation in saving other properties. Enforcement of the firebreak notice, traversable firebreaks is unreliable - apparent from aerial photography	Likely	Major	Extreme	Investigate owner self-certification with aerial varication undertaken by the City and random verification inspections to expand the effectiveness of limited City resources. Advise landowners whose properties are not safe, for City inspection.	Medium	Medium	Medium	Low
Emergency Service Personnel is unable to safely undertake operations due to road traffic.	Evacuation response LEMC and LEMA.	Low: Uncertainty can create a coincidence of evacuating traffic, or property owner land management back and forward attending animals, potentially conflicting with roadside firefighting preparations and operation Community is not aware of road closure procedure in an emergency event	Likely	Major	Extreme	Evacuate the community early and decisively and close roads during brigade operations. The road is unsafe due to potential exposure to bushfire when the brigade is present. Educate the community to understand road closures Close roads during suppression operations, too late to leave Assist residents living along the roads to have an early evacuation or survival plan	Medium	High	High	High
Emergency Service Personnel is unable to access after the fires passing	Public Road network LEMC and LEMA.	Low Individual stakeholder responsibilities within the roadway	Likely	Major	Extreme	Coordinate stakeholders to review the road network, coordinate their works with consideration to avoiding falling trees, power pole, powerlines that may block a road or warrant a delay in the opening after the passing of the fire.				

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An unreliable water supply restricts effective fire suppression leading to building loss	Reliance upon reticulated water supply or private landholder reserves, tanks, and dams. Reservoirs nearby may support aerial operations	Low Previous experience suggests that water pressure (Pickering Brook area) was insufficient for firefighting purposes causing uncertainty in establishing an alternative	Likely	Major	High	To be addressed in pre-incident planning, to provide certainty, alternative sources, and identify gaps in the overall network (reticulation and strategic tankage) for augmentation May also include encouraging interface properties in the reticulated network to have a stand-alone capacity for fire fighting	Medium	High	High	High
MINIMISING EXPOSURE										
Hikers and mountain biker riders are unprotected from the effects of a bushfire	Park closure, Operational Policy closure of parks and/or recreation sites due to very high or above fire danger ratings Telecommunication Electronic Alert system Parks Alert System	Very Low A bushfire can occur outside of park closure Park closure is difficult to police Alerts system relies on no blackspot, monitoring, accuracy, and timeliness. Promoted sites (partnered by DBCA do not directly address bushfire). Trip planners not promoted that include bushfire survival. Bush fire survival on individual trails, evacuation points, survival instructions is not publicly available.	Likely	Catastrophic	Extreme	Encourage DBCA partners to elevate bushfire awareness and encourage inclusion on trip planners. DBCA to audit popular trails (many have been) and **make publicly available** bushfire protection assets, i.e., coded evacuation points to assist trip planning, and impart bushfire survival techniques.	High	High	Medium	High
Visiting drivers not familiar with the road network or the locality may be exposed to the effects of a bushfire	Vehicles provide limited protection from bushfire, driving 5kWm2, Sheltering 10kWm2. General community alert to daily fire danger rating. Many dirt roads through the forests to explore – isolated Promoted off-road destinations around Mundaring Weir	Very Low – No direct control No bushfire guidance found on self-drive promotions of the Perth Hills No emergency road directional road signage observed through the study area	Likely	Catastrophic	Extreme	Promotions of Perth Hill drives, and off-road sites should include seasonal bushfire awareness. Include in trip planning Sealed public network Emergency road signage with coded location, directional advice, and alert radio channel and website information. Investigate active signage, that provides a visual alert to evacuate. Investigate telecommunications network coverage.	Medium	High	High	High
People not familiar with bushfire risk not familiar with **Venues** may be exposed to the effects of a bushfire.	Planning and Development Act 2005, SPP 3.7 Planning in Bushfire Prone Areas and Position Statement Tourism Land Uses in Bushfire Prone Areas. Shelter to provide for those attending as a contingency to evacuation	High Primacy placed upon human life, early evacuation or shelter on-site within constructed shelter standards Australian Building Codes Board 2014, Information Handbook: Design and Construction of Community Bushfire Refuges, 2014	Likely	Moderate	High	Planning and Development Act 2005, SPP 3.7 Planning in Bushfire Prone Areas and Position Statement Tourism Land Uses in Bushfire Prone Areas.	High	High	High	High

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People not familiar with bushfire risk not familiar with **Venues** may be exposed to the effects of a bushfire.	Planning and Development Act 2005, SPP 3.7 Planning in Bushfire Prone Areas and Position Statement Tourism Land Uses in Bushfire Prone Areas Insufficient shelter for those attending as a contingency to evacuation	Low For tourism events, the required construction compliance may be prohibitive: the event, i.e., receptions or association with food festivals, may not warrant the expense. Some activities, notwithstanding they are located in a bushfire prone area, may be able to avoid the bushfire season.	Likely	Catastrophic	Extreme	Avoid operation during the bushfire season Rare (likelihood) of a bushfire outside of the bush fire season	Medium	High	High	High
Early Evacuation										
A lack of certainty restricts the likelihood of early Community evacuation	Evacuation response LEMC and LEMA.	Very Low: There is no promoted plan in place for evacuation It is subject to the judgment of magnitude. The Keelty Review 2011 reported a high level of community resistance. Information and road signage to direct evacuation is not evident in the study area	Likely	Catastrophic	Extreme	Develop an integrated emergency evacuation plan Promote certainty of procedures and responsibility between agencies and stakeholders LEMC and LEMA.	Medium	High	High	High
A lack of timely alarm restricts the likelihood of early community evacuation	Emergency WA - DFES	Low: The community is reliant upon public declaration of bushfire warnings, timeliness is unreliable. Up to 45 minutes	Likely	Catastrophic	Extreme	Notification of a watch and act upon the first brigade call out	Medium	Medium	Medium	Medium
Road access opportunity	Local Government Austroads standards Contingency for shelter Position Statement Tourism	High The audit of roads as part of the study identified the sealed roads were in good condition Roads throughout the area can be crossed by bushfire, and travel should be restricted when a road is expected to be unsafe. Evacuation of residents and visitors needs to be safely in advance of a fire, when visibility is high, and the risk of flame contact is unlikely.	Likely	Moderate	High	Coordinated maintenance of roads and regular auditing of their condition can maintain their function. Road signage to assist visitors in being orderly evacuate would reduce confusion and improve flow.	Medium	Medium	Medium	Medium