



BUSHFIRE RISK ASSESSMENT AND MANAGEMENT STRATEGY BYFORD RAIL EXTENSION

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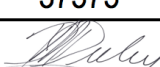
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I hereby declare that I am a BPAD Accredited bushfire practitioner.		
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Disclaimer

The recommendations and measures contained in this assessment report are based on the requirements of the Australian Standards 3959 – Building in Bushfire prone Areas, WAPC / DFES Guidelines for Building in Bushfire Prone areas (State Planning Policy 3.7) and CSIRO's research into Bushfire behaviour. These are considered the minimum standards required to balance the protection of the proposed dwelling and occupants with the aesthetic and environmental conditions required by local, state and federal government authorities. They DO NOT guarantee that a building will not be destroyed or damaged by a bushfire. All surveys and forecasts, projections and recommendations made in this assessment report and associated with this proposed dwelling are made in good faith on the basis of the information available to the fire protection consultant at the time of assessment. The achievement of the level of implementation of fire precautions will depend amongst other things on actions of the landowner or occupiers of the land, over which the fire protection consultant has no control. Notwithstanding anything contained within, the fire consultant/s or local government authority will not, except as the law may require, be liable for any loss or other consequences (whether or not due to negligence of the fire consultant/s and the local government authority, their servants or agents) arising out of the services rendered by the fire consultant/s or local government authority.

1 Executive summary

This Bushfire Risk Assessment and Management Strategy (BRAMS) was prepared for the Byford Rail Extension (BRE) for the Public Transport Authority. The proposed 9 km alignment from Armadale to Byford passes through urban and semi-rural areas that contain vegetation assemblages of conservation significance.

In order to identify possible risks from bushfires on rail assets, or from fires starting with rail assets on adjoining environmental or cultural assets or human settlements, both a Bushfire Hazard Level (BHL) assessment and a Bushfire Attack Level (BAL) contour assessment as specified in State Planning Policy (SPP) 3.7 (DPLH 2015), were determined. Vegetation within 150 m of both sides of the rail alignment was classified for its potential fuel load, and hence bushfire potential. Prevailing weather conditions during the fire season, possible points of ignition, fuel loads and fire-run potential were assessed, in order to determine risks and possible mitigation strategies.

The risk assessment methodology used here determined risk ratings of ‘high’ for fires emanating from rail assets or for fires emanating from adjoining areas and potentially impacting adversely on rail assets. Although there were areas within the corridor that were classified as moderate to low BHL because of the existing fuel loads and separation distances, the corridor must be treated in its entirety as ‘high risk’ because of the likely potential impacts of bushfires on rail assets and public rail patrons.

A series of recommendations was developed to mitigate the identified bushfire risks which included: partnerships with land owners, managers, Department of Fire and Emergency Services (DFES) and Department of Biodiversity, Conservation and Attractions (DBCA), to establish and maintain strategic firebreaks around valuable stands of vegetation; mowing and slashing of vegetation in close proximity to the rail alignment itself and mechanical mulching and other non-burn fuel-reduction techniques on adjoining Forest and Woodlands in close proximity to the rail alignment.

Recommendations were also made for operational, construction and maintenance activities occurring along the rail line, which would serve to reduce the risks of bushfire ignitions and spread of fires to adjoining vulnerable and valuable assets.

2 Introduction

This BRAMS document is based upon the objectives of the Public Transport Authority’s (PTA) Bushfire Management Strategy (PTA, 2018). Important considerations spelt out in the PTA’s guidance strategy have been incorporated into this BRAMS, and are summarised below in Section 2.1.

2.1 Objectives of the PTA’s bushfire management strategy

The PTA owns, leases and manages linear rail corridors and other land parcels which occupy or pass through a variety of landscapes throughout WA. Concerns about bushfire ignition arising from construction, operational or ongoing maintenance activities, or damage caused to rail assets by bushfires emanating on adjoining land, have seen bushfire risk assessment and management procedures incorporated into all aspects of the PTA’s business.

The overall aim of the PTA’s bushfire risk management strategy (PTA, 2018), is to reduce threats posed by bushfires to human settlements, economic, environmental and cultural assets on, or adjoining PTA land. It applies to all activities and operations undertaken by the PTA.

2.1.1 Objectives

Specific objectives of the strategy (PTA 2018), are to:

- a) mitigate bushfire risks to people as well as human settlement, economic, environmental and cultural assets on PTA Land;
- b) preserve cultural and conservation values on PTA Land; and,
- c) integrate bushfire mitigation measures at a landscape scale.

2.1.2 Strategic actions

The PTA’s BMS (2018), requires that the following strategic actions be implemented on PTA owned or managed lands including:

- Provide input and contribute to bushfire risk assessments undertaken by local governments, fire authorities and brigades and other land managers;
- Ensure that risk and treatment (mitigation) action plans for which the PTA is responsible for implementing, are documented in the PTA’s risk management system;
- Implement strategies for fuel reduction on PTA Land, taking into account conservation, infrastructure, cultural and other surrounding land values;
- Contribute to long-term bushfire mitigation strategies in conjunction with local governments and other land managers on PTA Land;
- Implement bushfire preparedness actions to address the threat of bushfire, including:
 - ensuring controlled access to PTA land;
 - requiring safe operating procedures for high risk activities (e.g. hot works);
 - designating asset protection zones on a specific risk and site basis;
 - implementing best practice in land management activities; and,
 - ensuring adherence to the PTA’s fire emergency response procedures described in its emergency management manual.
- Contribute to bushfire hazard reduction on PTA land; and,
- Liaise with key stakeholders to ensure that up to date data are used to inform bushfire hazard reduction activities.

2.1.3 Performance review

The PTA (2018) strategy also addresses appropriate record keeping, performance monitoring and review processes. As an example, bushfires on PTA land, or fires associated with rail assets that may have posed a bushfire risk, have been recorded and investigated. The PTA's Bushfire Management Strategy has been regularly reviewed to determine whether the strategic actions have been implemented and are achieving the stated objectives.

2.2 Application of this bushfire risk assessment and management strategy

2.2.1 Overall scope:

The overall scope of this BRAMS is to provide a high level bushfire risk assessment and management strategy for the BRE project area, based on available vegetation mapping for the project and publicly available bushfire risk information.

2.2.2 Spatial extent:

The spatial extent of this BRAMS is Armadale to Byford (BRE) development envelope plus a surrounding 150 m bushfire survey area, extending out from the development envelope (Figure 1, 5). For the purposes of this BRAMS, this bushfire risk assessment area has been termed throughout as the BRAMS 'survey envelope' which is 551.8 ha in area.

2.2.3 Inputs:

Inputs to the risk assessment process have included:

- Ground truthing as appropriate, selected vegetation assemblages within rail sections as to their bushfire classification and indicative fuel loads, so as to inform the available mapped ecologically-based vegetation categories;
- Identification of Bushfire Hazard Levels associated with vegetation assemblages along the corridor using the specifications of SPP3.7 and Australian Standard (AS) 3959:2018 Construction of buildings in bushfire-prone areas, and the Western Australian Planning Commission's (WAPC) Guidelines V1.3 (WAPC, 2017);
- Risk assessment of bushfire hazards informed by AS31000:2009 Risk management principles and guidelines, AS4360:2004 Risk management standards; and,
- Identification of key aspects of construction and operational phases of the rail corridor's management that may require certain risk management actions.

2.2.4 Outputs:

Outputs from the BRAMS process include:

- Hard copy and digital maps and digital data as ArcView .shp files, that describe the range of bushfire hazard and risk classes along the corridor;
- High-level recommendations to guide the implementation of on-ground management procedures by the Construction Contractor, and to inform the later operations of the rail corridor; and,
- A succinct report describing the risk assessment process, its findings and relevant risk mitigation and management strategies for construction and operational phases for the survey envelope directly and adjoining areas indirectly.



Figure 1 Armadale to Byford development envelope

3 Bushfire risk assessment methodology used

There are a number of interacting factors that contribute to the frequency, severity and damage caused by uncontrolled bushfires including: available fuel loads, points of ignition, weather variables such as temperature, wind, and humidity and moisture levels, topographic slope, fire-run potential and the bushfire preparedness of assets and communities in the bushfire's path.

Bushfire risk assessment and management is a complex process, that needs to consider the range of interacting causal factors listed above. A comprehensive bushfire risk assessment process is beyond the scope of this investigation however, a reasonable first approximation of the nature of bushfire risks can be undertaken using fuel load-based measures such as Bushfire Hazard Level (BHL), or estimation of radiant heat or Bushfire Attack Level (BAL) contours. BHL assessments are normally applied earlier in the development cycle at larger scales when the layout of the project is only generally understood. BAL contours are normally applied later in the development cycle at smaller scales, when project specifics have been consolidated and addressing potential impact on built assets is paramount. Both these risk assessment methodologies have been recently used in BRAMS projects (Eco Logical Australia 2019, WAPC, 2019) and both are provided here for consistency. Section 6 of this report describes these bushfire hazard issues in more detail.

The accepted methodology for risk assessment and management (SANZ 2019), includes the following steps:

1. Establish the context;
2. Identify risks;
3. Analyse risks as to their likelihood and consequence;
4. Evaluate risks; and
5. Treat risks

In addressing AS/NZS ISO 31000:2009, the risk assessment methodology used herein, was based on a combination of risk assessment elements which included:

1. ESTABLISHING CONTEXT: a qualitative assessment of weather variables to establish context, including long-term temperature (Table 1), long-term wind strength and direction (Figure 2), and long-term relative humidity (Figure 3);
2. IDENTIFY RISKS: semi-quantitative assessment of topographic slope (Figure 4) and vegetative fuel loads (Figure 6), as represented by the vegetation classes described in AS3959:2018;
3. ANALYSE RISKS: a semi-quantitative Bushfire Hazard Level (BHL) assessment (Figure 7), and a BAL contour assessment (Figure 8), as per SPP3.7;
4. EVALUATE RISKS: A qualitative assessment of potential points of ignition (Table 2); and fire-run potential (Figure 10), under the influence of (any) slope, fuel load and prevailing wind and weather conditions, together with a qualitative assessment of potentially impacted assets (Figure 10) and communities (Figure 11); and,
5. TREAT RISKS: A range of risk management options have been presented in Section 7 following.

3.1 Aims and outcomes of the risk assessment process

It is well understood that mitigating fuel loads broadly, and in particular establishing low-fuel Asset Protection Zones (APZ), and fire breaks along and around valuable assets reduces the occurrence and intensity of bushfires.

Implementation of mitigation measures along the rail alignment in the areas of highest risk of bushfire ignition and spread will reduce both the impacts of any fires either ignited by rail assets or works, or of occurring within bushland adjoining rail assets.

This BRAMS considers both external and internal bushfire risks, which means addressing both the impacts of fires being ignited by the operation, construction and maintenance of rail assets on adjoining bushland and communities and secondly, the impact of fires ignited elsewhere on rail assets.

The aim and outcome of this BRAMS is to identify where and when bushfire mitigation measures and improved operational, construction and maintenance procedures should be focussed. This BRAMS presents a range of measures that when implemented operationally, will reduce the potential adverse impacts of bushfires.

While the bushfire mitigation and operational measures presented here are to be implemented to prevent bushfires, the PTA's existing emergency management procedures will ensure rail service clients are not adversely impacted during bushfire events occurring adjacent to the BRE corridor.

3.2 Step 1 establishing the context for the risk assessment

In order to establish the context for this BRAMS, a focussed assessment of relevant long-term weather variables was undertaken. Perth airport data were used because of the extensive length (76 years), of this record. A weather station is also available at Jandakot which is closer to the BRE but the length of the record is considerably less than for Perth Airport. In the context of describing bushfire behaviour, longer term records are preferable even if they are a little further away.

- The long-term average daily temperature data (Table 1), clearly demonstrate the timing of the fire season from late spring to early autumn, where median daily temperatures averaged by month are close to or above 30°C.
- Long-term wind strength and direction data (Figure 2), reveal a pattern of strong morning east winds followed by strong afternoon south-west winds with this effect being most pronounced over summer.
- The long-term relative humidity data (Figure 3), demonstrate much drier conditions from late spring to early autumn, with the effect being more pronounced in the afternoon.

It is important to understand the synergistic effect of these three weather variables in combination. The averaged data presented here help establish the longer term context and pattern of increased fire risk during warmer, drier and windier periods but, averaged longer-term data tend to mask the occurrence and effect of natural variability and extremes. Extreme and catastrophic Fire Danger Ratings (FDR) are usually associated with extreme values of these variables in combination.

Table 1 Daily temperature for Perth airport from 1944 to 2020, averaged by month coloured by season

Station: Perth Airport **Number:** 9021 **Opened:** 1944 **Now:** Open
Lat: 31.93° S **Long:** 115.98° E **Elevation:** 15 m

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	31.8	32.0	29.7	25.6	21.8	19.0	18.0	18.6	20.2	22.8	26.1	29.1	24.5
Lowest	28.2	28.7	26.1	21.2	19.4	16.8	16.2	16.3	18.1	19.7	22.1	24.7	22.4
5th %ile	29.0	29.5	27.7	23.4	20.0	17.3	16.7	17.3	18.3	20.3	23.4	26.0	23.4
10th %ile	29.5	29.8	28.0	23.8	20.5	17.8	16.9	17.5	18.8	20.6	23.9	26.9	23.5
Median	31.8	32.0	29.9	25.7	21.6	19.2	18.0	18.5	20.1	22.9	26.0	28.9	24.5
90th %ile	33.8	33.8	31.6	27.7	23.6	20.0	19.1	19.8	21.4	24.6	28.2	31.4	25.6
95th %ile	34.0	34.9	31.8	28.0	24.2	20.5	19.3	20.2	22.1	24.9	29.1	31.6	25.8
Highest	35.6	36.3	32.8	29.0	24.4	21.5	19.7	21.5	23.1	27.0	30.3	33.9	26.1

Note: Red = Summer, Yellow = Autumn, Green = Spring.

Rose of Wind direction versus Wind speed in km/h (01 May 1944 to 09 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%.

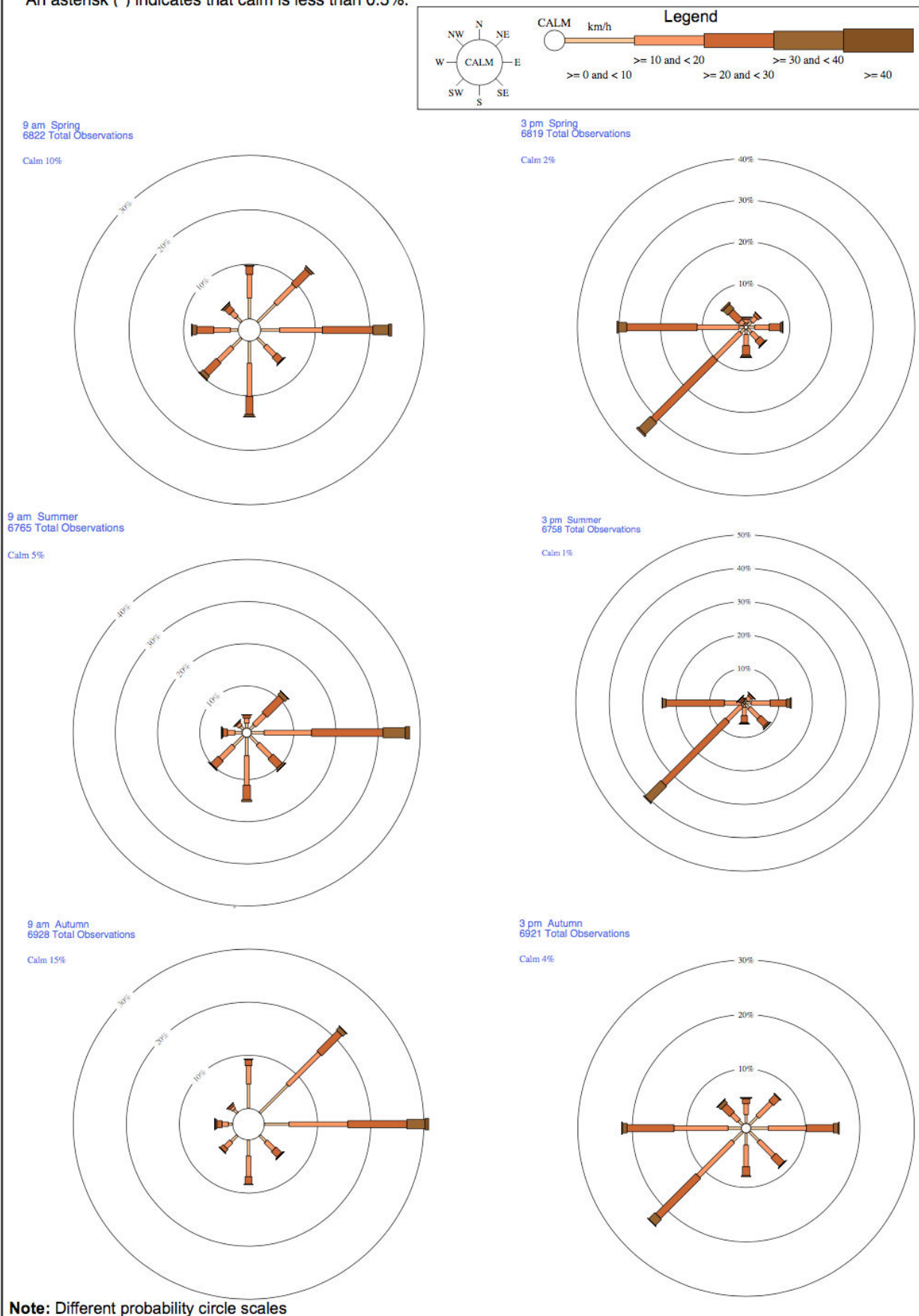


Figure 2 Wind direction and speed at 9am and 3pm for Perth airport from 1944 to 2019

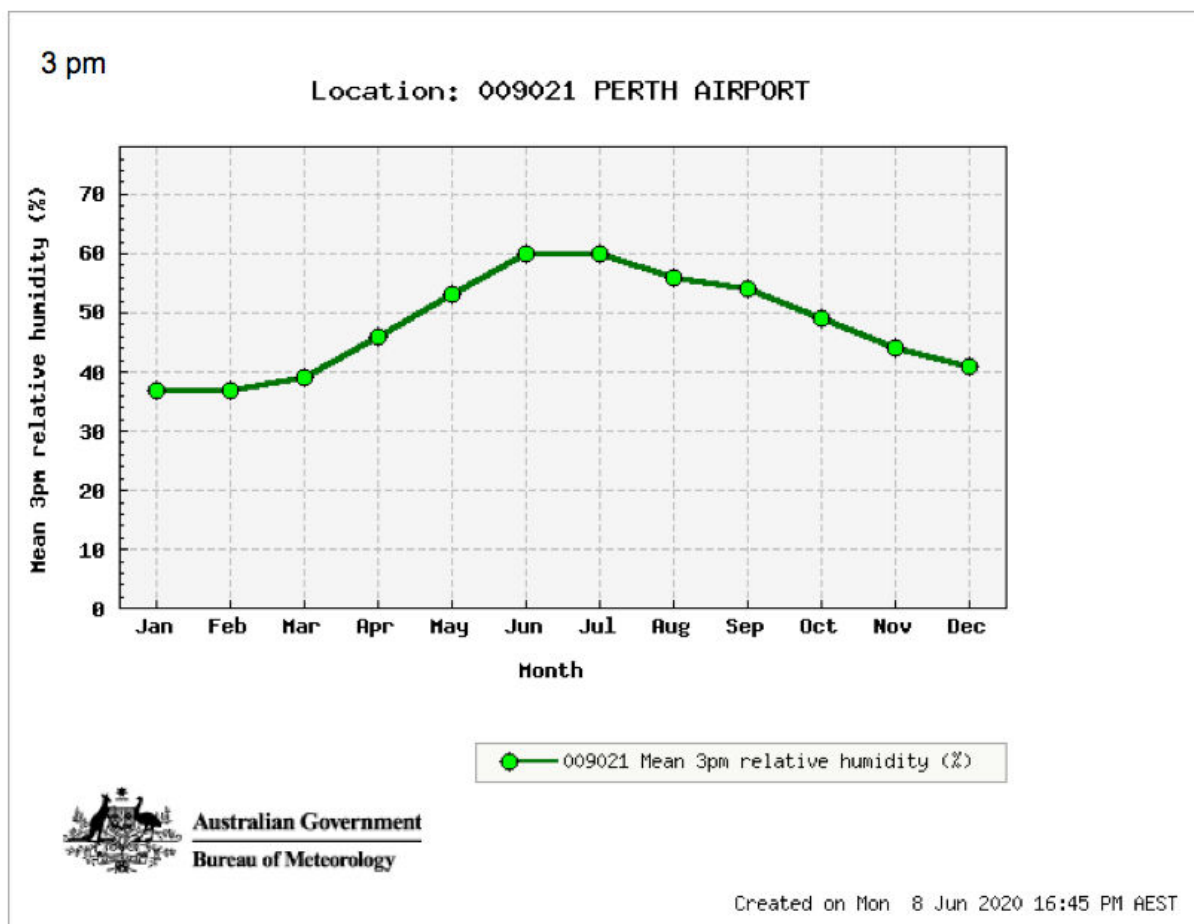
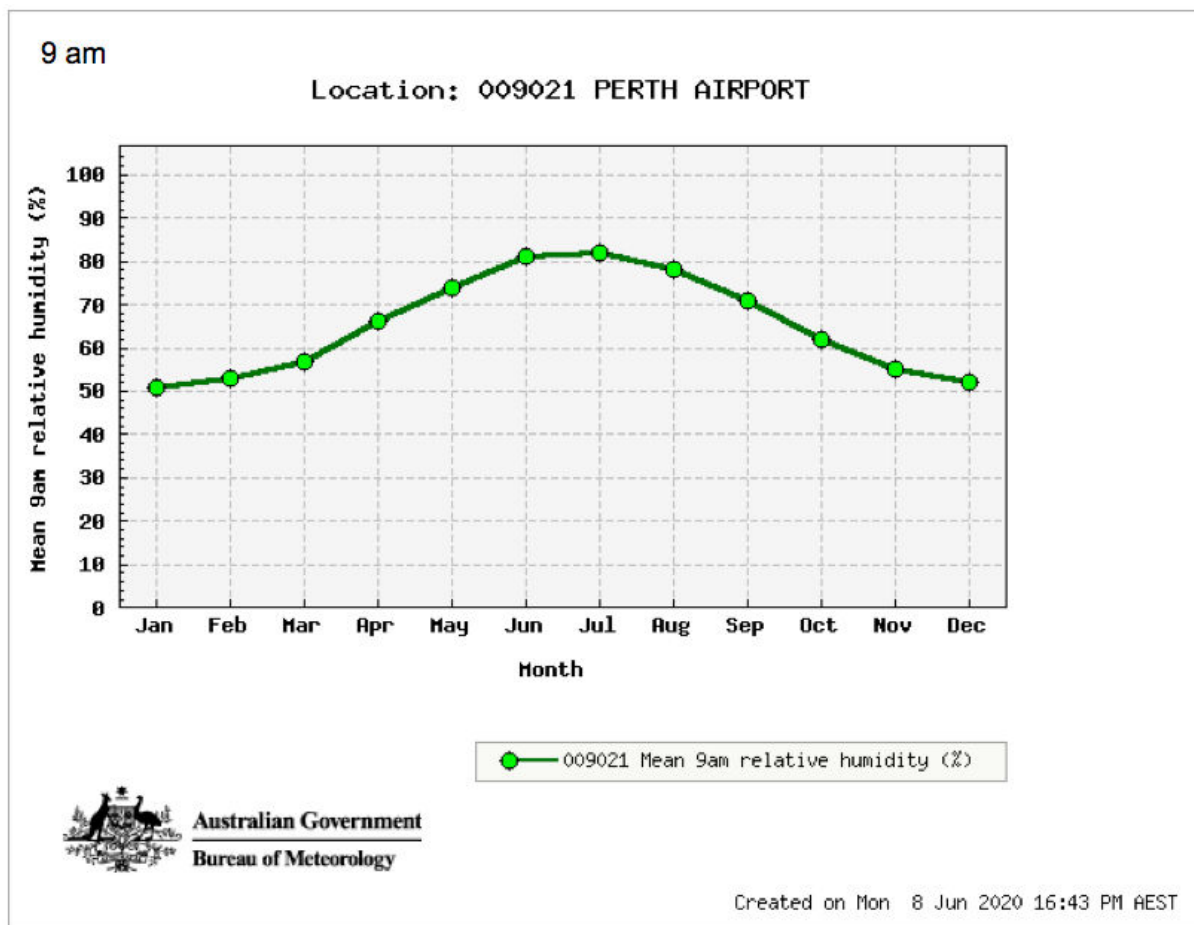


Figure 3 Average monthly relative humidity at 9 am and 3 pm for Perth airport from 1944 to 2010

4 Step 2 environmental and cultural considerations

A detailed assessment of environmental and cultural considerations has been undertaken elsewhere (GHD, 2020).

5 Step 3 identifying bushfire risks

This section comprises part of the third step of the risk assessment process in identifying the location and magnitude of bushfire risks. It uses inputs like slope and vegetative fuel-loads as inputs and BHL and BAL contour analyses as outputs.

5.1 Assessment inputs

5.1.1 BRAMS survey envelope project area

The BRE has a development envelope that varies in width along its length because it is influenced partly by cadastral boundaries, the occurrence of vegetation complexes and land tenure. To provide a more uniform assessment area for this bushfire risk assessment and considering the minimum 150 m survey area required by SPP3.7 for statutory assessment of bushfire risks the development envelope has been combined with a 150 m buffer each side to provide an area which is referred to in this report as the survey envelope (Figure 1, 5).

5.1.2 Slope effects

Slope has a significant influence on bushfire rate of spread. Vegetation that is downslope of a receiving asset can accelerate and intensify a bushfire depending amongst other things, on vegetative fuel load and the degree of downslope. As part of this BRAMS, an assessment of slopes using DAFWA 2 m contours was undertaken. There is a range of elevation of 20 m along the 9 km of the rail alignment, from a minimum of 36 m AHD at 7.5 km from Armadale Station, to a maximum elevation of 56 m AHD at 1.8 km from Armadale Station. The elevation changes (rise), were relatively small when compared to the total length (run), of the rail corridor.

To further determine any impact of slope on the bushfire risk assessment, an analysis of elevation changes perpendicular to the rail alignment was also undertaken (upper panel Figure 4). Five slope transects across the survey alignment were established. These showed that there was an approximate 2-3° downslope from east to west along the 9 km length of the BRE. The slopes were relatively consistent and were not of sufficient magnitude in a relative sense to cause local variations in bushfire behaviour, so slope effects have not been considered further in this analysis.

5.1.3 Vegetation classification

The provided linework for the project vegetation mapping (GHD 2020), was reclassified into the bushfire vegetation classes required by AS3959:2018, based upon experience with the vegetation in the area, previous site visits and google street view. For bushfire risk assessment, eight classes of vegetation (Table 5), were used to define the range of vegetative fuel loads including: Forest, Woodland, Shrubland, Scrub, Mallee/Mulga, Rainforest, Grassland and Low threat areas that are excluded. Figure 6 shows the range of bushfire vegetation classes along the BRE corridor. This classification scheme presents a range of suspended vegetative fuel load for each class (Table 2). These range from an upper limit of 35 t/ha of suspended or available fuel load for Class A Forest down to <4.5 t/ha for unmanaged Class G Grassland.

Non-vegetated or low-threat vegetation constituted the largest class covering 359.0 ha or 65.1% of the area. Class G Grassland at 101.0 ha within the survey corridor was the second largest class, and covered 18.3% of the area. The highly degraded nature of wooded areas in the locality, is demonstrated by the occurrence of Class B Woodland covering 0.03 ha compared to Class A Forest covering 51.5 ha or only 9.3% of the total. There is generally little significant difference between Class A Forest and Class B Woodland other than are much reduced understorey biomass in Woodland usually associated with degraded or parkland-cleared grazing areas.

Table 2 Area of vegetation classes and indicative fuel loads along the rail survey envelope

Vegetation class	Area ha	Area % of total of rail survey area	Indicative available fuel load tonnes/ha
Class A Forest	51.5	9.3	25-35
Class B Woodland	0.03	0.0	15-26
Class C Shrubland	31.0	5.6	<15
Class D Scrub	0.08	0.0	<25
Class G Grassland	101.0	18.3	<4.5
Exclusion clause 2.2.3.2e,f	359.0	65.1	<2
TOTAL	551.8		

Note: Indicative fuel loads for each vegetation class are from AS3959:2007.

5.2 Assessment outputs

As part of identifying which areas of the BRE may present the greatest potential bushfire risks, a Bushfire Hazard Level (BHL) assessment was prepared. For more detail on potential radiant heat levels that may occur under conditions of a Fire Danger Index (FDI) of 80, a BAL contour analysis was also undertaken.

5.2.1 BHL assessment

A BHL assessment is a simple method for identifying potential threatening vegetation and indicative bushfire risks. This is based on the bushfire vegetation classes described above. A BHL for the BRE survey envelope (Figure 7), identifies those areas that present the greatest potential bushfire risks (Table 5).

A BHL rating of 'moderate' is the dominant BHL class (Table 3), extending over 402.0 ha, or 72.8% of the survey envelope. An 'extreme' BHL rating covers 51.6 ha of the survey envelope or 9.3% of the total area. A BHL rating of 'low' makes up the remainder (17.8%).

Table 3 Area of BHL classes along the rail survey envelope

BHL rating	Area ha	% of total
Extreme	51.6	9.3
Moderate	402	72.8
Low	98.45	17.8
TOTAL	551.8	

Table 4 Area of BAL contour classes along the rail survey envelope

BAL rating	Area ha	% of total
BAL-FZ	214	38.8
BAL-40	11.4	2.1
BAL-29	20.2	3.7
BAL-19	21.8	4.0
BAL-12.5	98.8	17.9
BAL-Low	58.6	10.5
TOTAL	551.8	

Note: BAL ratings represent radiant heat levels of exposure for receiving assets in kW/m² as per AS3959

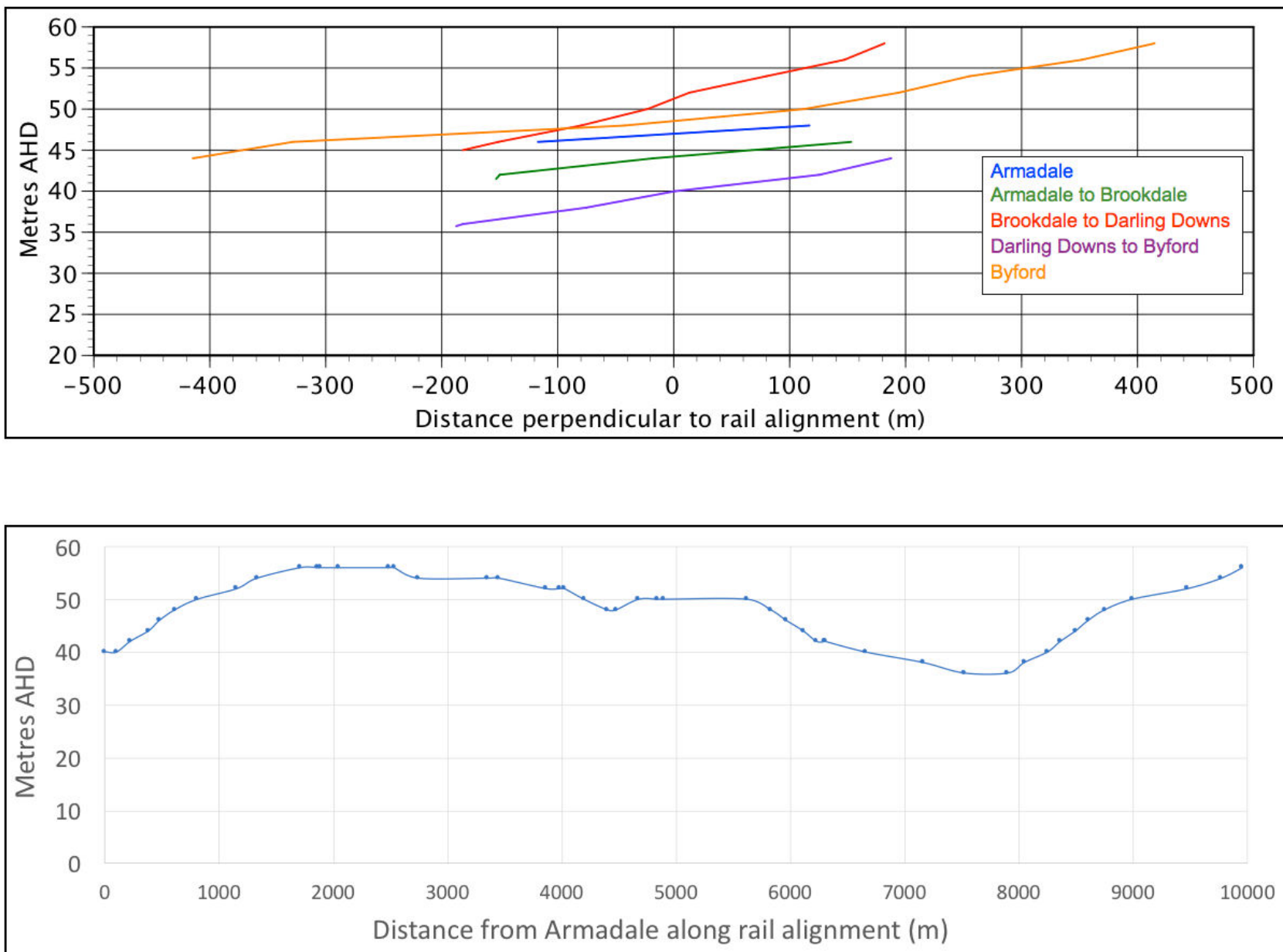


Figure 4 Slope profile transects across and along the rail corridor



Figure 5 Air photo for the bushfire survey area

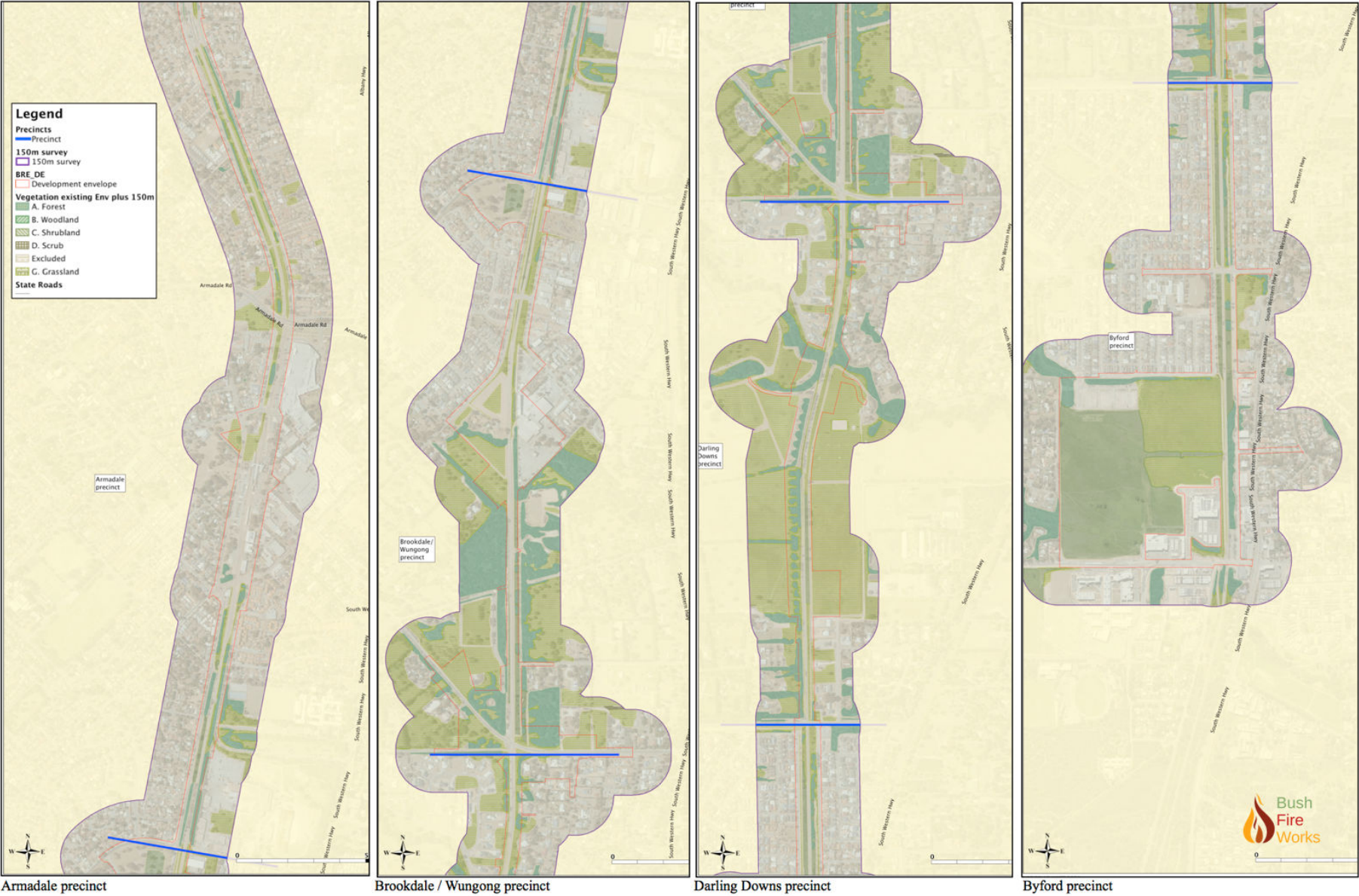


Figure 6 Bushfire vegetation classification for the survey envelope based on existing vegetation

From this assessment, BHL ratings of extreme represent the worst bushfire risks (Table 5), because they are associated with the greatest fuel loads of ≥ 25 t/ha. It should be pointed out, that even though unmanaged Class G Grasslands associated with fuel loads < 4.5 t/ha, and have BHL ratings of moderate, these areas are still of concern because they can act as bridging areas and serve to assist a severe bushfire move between areas of greater fuel loads. Areas of Class G Grassland are also important in that they can assist in providing lower-fuel breaks for suppression activities to extinguish severe bushfires.

5.2.2 BAL contour assessment

A BAL contour assessment (Figure 8), was undertaken as per the requirements of SPP3.7. This assessment was also based on the vegetation classes described earlier (Figure 6). As mentioned previously, a BAL contour assessment is more applicable for determining the nature of bushfire risks (Table 6), as they relate to the separation distances between built assets and a particular stand of vegetation. Table 4 summarises areas for each BAL rating with BAL-FZ or 'flame zone' at 38.8% of the survey envelope.

6 Step 4 bushfire hazard and risk profile

This section represents the fourth section of the risk assessment to evaluate risks, and includes part of the third step in discussing the likelihood and consequence of bushfire occurrence.

Bushfire ignitions can occur from a number of different sources. These include natural phenomena such as lightning, and many are the result of human activity including non-extinguished cigarette butts, escapes from camp-fires or prescribed burning operations, hot works such as welding or metal grinding, from failures along power transmission lines, mechanical mishaps through industrial, farming or mining activities, and wilful or deliberate ignitions by arsonists (DBCA 2019; DFES 2019).

A qualitative assessment of potential points of ignition associated with rail corridor assets and operations was undertaken using the past decade of available PTA situation reports (Table 7). It should be recognised that the 17 incidents recorded over a decade, represent all southwest rail assets including older diesel-powered, and heavy haulage rolling stock. It is conceivable that modern light, high-speed and electrified suburban rail assets may be associated with a lower risk profile than was identified during this assessment.

Table 5 Bushfire vegetation classes and BHL rating as an expression of risk

Vegetation class	Indicative suspended fuel load (t/ha)	BHL Rating
Forest	25-35	Extreme
Woodland (05)	15-26	Extreme
Scrub	Up to 25	Extreme
Any vegetation $> 10^\circ$ downslope	-	Extreme
Woodland 06, 07, 08	< 4.5	Moderate
Shrubland and shrubland 09	< 15	Moderate
Mallee/Mulga	< 8	Moderate
Low hazard vegetation < 100 m from moderate or extreme-rated classes	-	Moderate
Grassland	< 4.5	Moderate
Urban form, managed grassland eg. mown, irrigated turf	≤ 2	Low



Figure 7 Bushfire Hazard Level (BHL) for the survey envelope based on existing vegetation

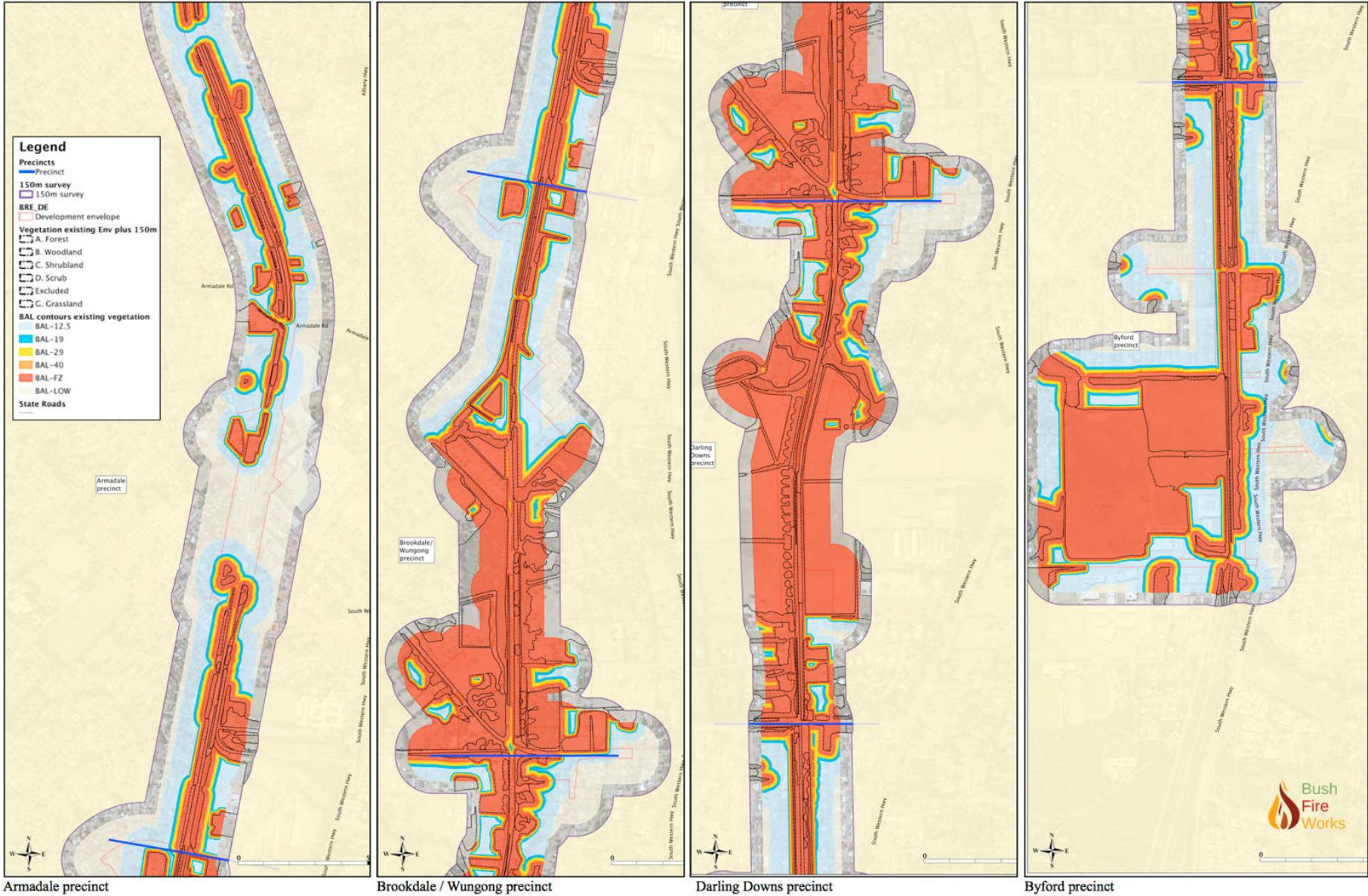


Figure 8 Bushfire Attack Level (BAL) contours for the survey envelope based on existing vegetation

Table 6 BAL contours as an expression of risk for flat land

BAL rating	Risk level ¹	Example
BAL-Low	Very low	Low threat vegetation eg. irrigated mown turf Grassland ≥50 m from receiver Class A Forest ≥100 m from receiver
BAL-12.5	Low	Grassland ≥17 m - <50 m from receiver Class A Forest ≥42 m - <100 m from receiver
BAL-19	Moderate	Grassland ≥12 m – <17 m from receiver Class A Forest ≥31 m - <42 m from receiver
BAL-29	High	Grassland ≥8 m – <12 m from receiver Class A Forest ≥21 m - <31 m from receiver
BAL-40	Very high	Grassland ≥6 m – <8 m from receiver Class A Forest ≥16 m - <21 m from receiver
BAL-FZ	Extreme	Grassland <6 m from receiver Class A Forest <16 m from receiver

Risk level¹ = After WAPC 2019 pp 28.

Table 7 Fire incidents reported from January 2009 to December 2019

Phase	Number	Consequence
Operating	1	Rolling stock fire - Minor lineside fires – easily extinguished
	8	Rolling stock fire- no lineside fire
	1	Engine fire - no lineside fire
	1	Alleged minor lineside fire – easily extinguished
	3	Overhead transformer/battery fire – easily extinguished
Construction and maintenance	2	Hot works - Minor lineside fires – easily extinguished
	1	Hot works – Fire alarm triggered no fire
TOTAL for decade	17	

6.1.1 Internal likelihood

Given the somewhat subjective nature of determining 'likelihood of occurrence' (Table 8), based upon few data points (Table 7), it has been determined that over an 80 year lifespan for the rail assets, that the occurrence of fire emanating from rail assets (internal likelihood), along the BRE alignment is 'Likely'.

6.1.2 External likelihood

There is a range of factors described above and which include weather-related events and arson, that have the potential to ignite fires outside the rail corridor, that may impact adversely on it. Populations associated with the development of residential areas along the rail corridor mean that the potential for the ignition of fires external to the rail corridor by arson, will increase over time.

The determination of 'likelihood of occurrence' of bushfires igniting outside the BRE alignment, is considered 'Almost certain'.

Table 8 Risk matrix showing occurrence and consequence

LIKELIHOOD OF OCCURENCE	CONSEQUENCES				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	High	High	Extreme	Extreme	Extreme
Likely	Medium	High	High	Extreme	Extreme
Possible	Low	Medium	High	Extreme	Extreme
Unlikely	Low	Low	Medium	High	Extreme
Rare	Low	Low	Medium	High	High
RISK LEVEL	RISK RESPONSE				
Extreme	Highly unacceptable risk. Site-specific mitigation and comprehensive management measures will be required to lower risk levels and urgent mitigation is required.				
High	Unacceptable risk. Application of site-specific management measures will lower the risk level that requires immediate action.				
Medium	Potentially unacceptable risk. Application of site-specific management measures to lower the risk level. Risk should be reduced as soon as practicable.				
Low	Acceptable risk. Application of management measures will ensure risk level remains low and risk eliminated or reduced over time.				

(Source: DFES 2015)

6.1.3 Consequences of internal and externally sourced fires

Typical and minimum track widths observed for the Perth to Mandurah suburban rail line (Figure 9), show separation distances of from 4 to 9 m. For fuel loads associated with Class A Forest, this means the rail tracks, overhead electrical gear and rolling stock could be exposed to ratings of BAL-FZ under an FDI of 80 (AS3959).

The PTA's current fire emergency response procedures described in its emergency management manual ensure that trains halt and do not pass through unsafe bushfire conditions, under any circumstances. This means that the potential for loss of life or serious injury to rail patrons or serious damage to expensive rolling stock from bushfires is minimal. It does however present the possibility of damage to tracks or overhead gear where separation distances are small. This may occur in situations where important conservation-category vegetation is being protected through minimal clearing and disturbance.

Potential fire run paths have been determined for morning ignition and east winds, or afternoon ignition and southwest winds during the fire season (Figure 10). This analysis shows that there is the potential for morning ignition occurring at locations along the north-south alignment of the rail corridor, to spread to grasslands to the west, particularly in the Darling Downs precinct (Figure 10). Even though the greatest risk of accelerating fire fronts might be associated with the 'Extreme' BHL classes (Figure 7, Table 5), the extensive grasslands between Forest, Woodland and Scrub vegetation (Figure 6), could serve to spread the fire rapidly toward the west and into islands of higher fuel loads. By similar logic, any fire igniting in the dense bushland to the east, could threaten the rail corridor under conditions of strong morning east winds, especially if firebreaks and grassland fuel loads associated with the intervening semi-rural properties have not been managed effectively.

The converse situation for afternoon ignition with strong southwest winds has the potential for fires emanating from rail assets spreading through semi-rural grassland to the hills bushland and beyond. There is less opportunity for fires emanating along the Byford, Brookdale and Armadale sections of the rail corridor to adversely impact on urban residential and commercial areas to the east under afternoon strong south west winds conditions, because of extensive areas of non-vegetated and low-threat vegetated areas (Figure 11).

From the above, it has been determined that the consequences of internally-derived fires on the surroundings is 'Moderate', and the consequences of externally derived fires on the rail corridor and associated assets is 'Minor'.

6.1.4 Risk ratings for internal and externally sourced fires

Table 7 shows that of the 17 events from 2009 to 2019, 4 triggered minor lineside fires which were easily extinguished by rail staff and local brigades which averted any serious consequences associated with the observed internal fires associated with southwest rail assets over the recent reporting decade. The fire-run analysis presented above, suggests that there is reduced opportunity for fires emanating within the rail corridor to directly impact urban settlements. There are lengthy fire-runs to the west with ample opportunity for suppression should fires escape into semi-rural grasslands under strong east wind conditions.

This means that internally-sourced fires although 'likely' will in all probability present only a 'Moderate' consequence on the surrounds if caught early, which translates (Table 8), to a bushfire risk rating of 'High'.

While the determination of a 'likelihood of occurrence' for bushfires emanating outside the BRE is considered 'Almost certain', the consequences of these fires ***on the rail assets themselves***, is considered to be 'Minor'. This translates for externally-derived fires (Table 8), as a bushfire risk rating of 'High'.

The required risk response for ratings of 'High' considers it (Table 8), to be an 'Unacceptable risk', and the 'application of site-specific management measures will (be required) to lower the risk level and that it requires immediate action'.



Figure 9 a) Typical 9 m, and b) minimum 4 m separations from vegetation on the Perth to Mandurah line

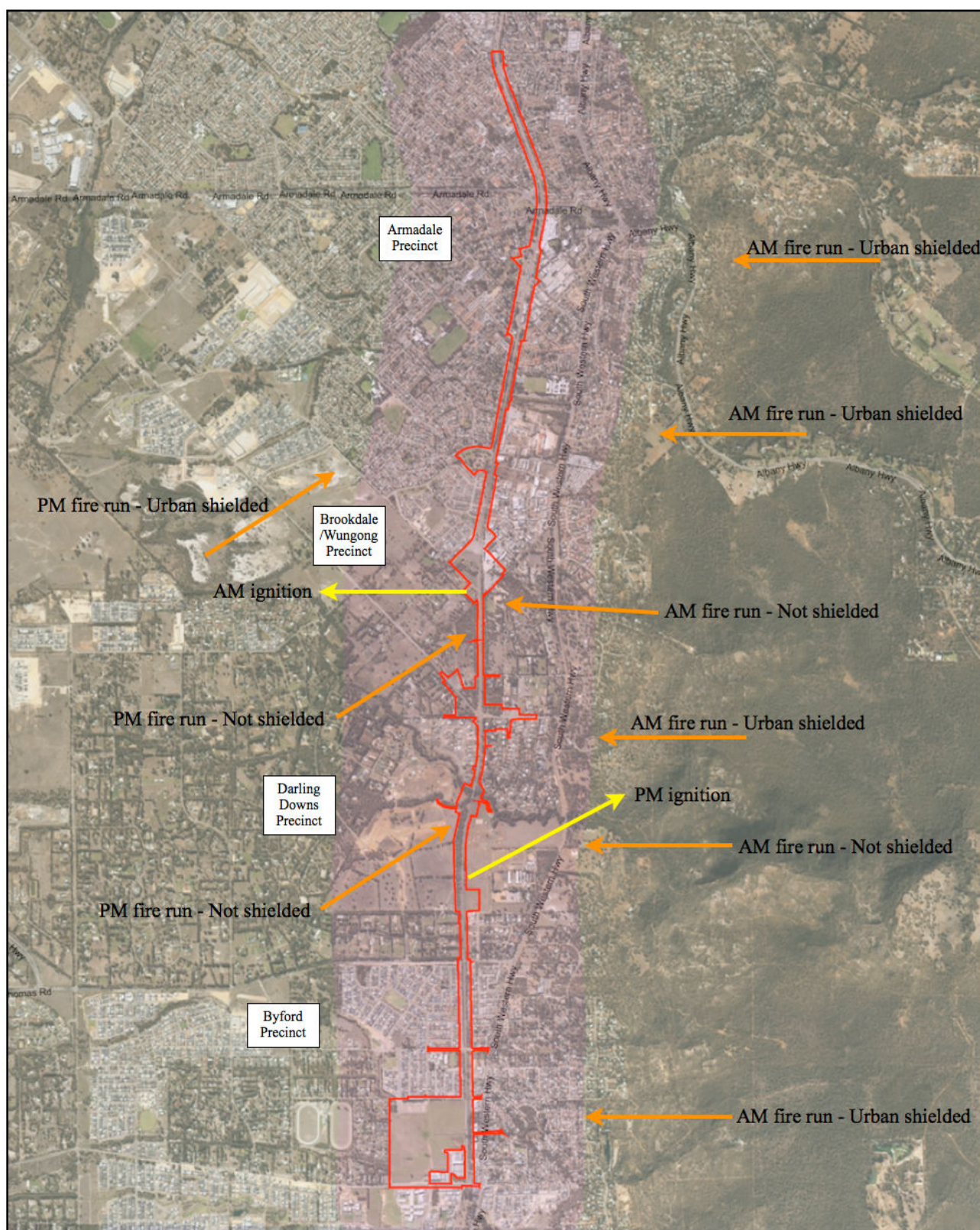


Figure 10 Fire run potential with dominant morning and afternoon winds related to possible ignition points

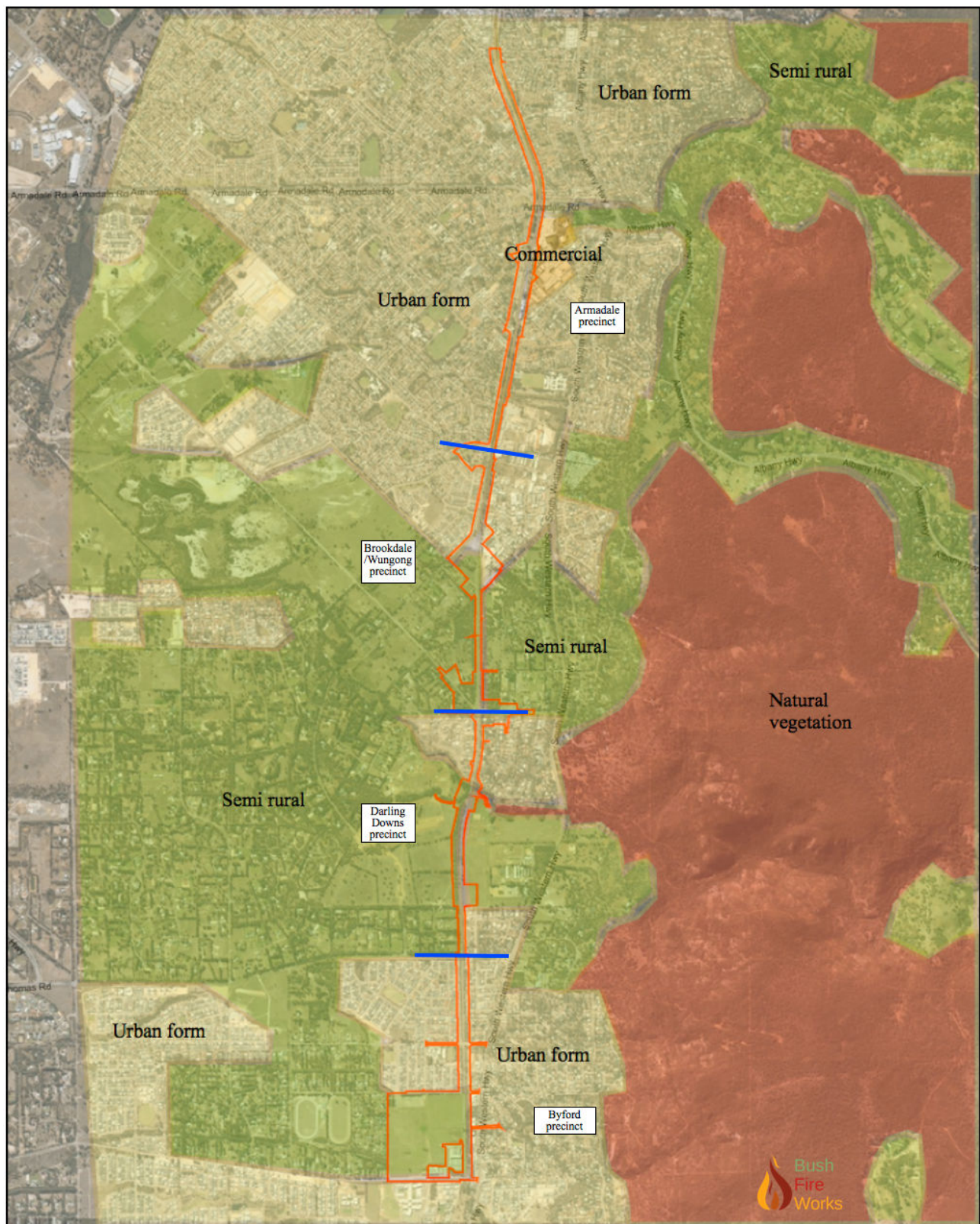


Figure 11 Communities and assets adjoining the Byford rail extension corridor

6.2 Bushfire threats and mitigation options for assets within rail section

A summary of threats and mitigation options is presented in Table 9.

Table 9 Potential threats and mitigation actions for the zone within 1 km of the BRE survey area

Asset class	Threats	Mitigation
Armadale precinct		
Urban	The potential for catastrophic bushfire impacts in this precinct is low. There are only small, narrow patches of planted trees and shrubs along the road and rail corridor (Figure 7). The natural vegetation associated with Albany Highway east of Southwestern Highway present a real risk under the influence of strong winds in the morning. Grasslands along the landscaped areas of the rail corridor present a Moderate BHL. Extensive stands of natural vegetation on uplands to the east present a very real risk of catastrophic bushfires but are some distance and well separated from the rail alignment	Grassland fuel loads should be managed to <2 t/ha along the rail alignment during the fire season to reduce risks. There are many roads and paths across the rail alignment, which present excellent natural breaks and opportunities for bushfire suppression. DBCA and the City of Armadale to continue to manage fuel loads in the bushland along Albany highway east and in the adjacent hills. Early surveillance and reporting of any bushfires would improve the success of suppression activities in this section.
Commercial		
Semi-rural		
Natural vegetation		
Brookdale/Wungong precinct		
Semi-rural	The northern Brookdale section of this precinct presents a low risk of catastrophic bushfires. There are few, narrow patches of planted trees and shrubs along the road and rail corridor (Figure 7). The southern Wungong portion of this precinct is mostly larger-lot semi-rural pastures (Moderate BHL), and associated stands of shrubs and trees (Extreme BHL). Larger stands of natural vegetation south of the Armadale Reptile Centre and on Lambert Lane Nature Reserve present an Extreme bushfire risk during adverse weather conditions. AM ignition and subsequent fire run under the influence of AM easterlies from Bungendore Park could spread across a relatively-narrow band of semi-rural grasslands and adversely impact rail assets and larger lot developments in this precinct.	Grassland fuel loads should be managed to <2 t/ha along the rail alignment during the fire season to reduce risks. Appropriate perimeter firebreaks on semi-rural properties should be enforced during the fire season, particularly adjacent to the rail corridor. There are many roads and paths across the rail alignment, which present excellent natural breaks and opportunities for bushfire suppression. DBCA and the City of Armadale to continue to manage fuel loads in Bungendore Park and large upland areas of dense natural vegetation to the east of the rail alignment. Early surveillance and reporting of any bushfires would improve the success of suppression activities in this section.
Urban		
Natural vegetation		

Asset class	Threats	Mitigation
Darling Downs Precinct		
Semi-rural Urban Natural vegetation	<p>The northern Darling Downs suburban section of this precinct presents a low risk of catastrophic bushfires. There are few, narrow patches of planted trees and shrubs along the road and rail corridor (Figure 7). The southern portion of this precinct is mostly larger-lot semi-rural pastures (Moderate BHL), and associated stands of shrubs and trees (Extreme BHL). There are very large areas of grassland (Moderate BHL) to the west of Oscar Bruns Reserve that will need to be maintained in a low-fuel condition during the fire season, particularly adjacent to the rail alignment.</p> <p>AM ignition and subsequent fire run under the influence of AM easterlies from Wungong Regional Park could spread across a relatively-narrow band of semi-rural grasslands and adversely impact rail assets and larger lot developments in this precinct.</p>	<p>Grassland fuel loads should be managed to <2 t/ha along the rail alignment during the fire season to reduce risks. Appropriate perimeter firebreaks on semi-rural properties should be enforced during the fire season, particularly adjacent to the rail corridor. There are many roads and paths across the rail alignment, which present excellent natural breaks and opportunities for bushfire suppression. DBCA and the City of Armadale to continue to manage fuel loads in Wungong Regional Park and large upland areas of dense natural vegetation to the east of the rail alignment. Early surveillance and reporting of any bushfires would improve the success of suppression activities in this section.</p>
Byford precinct		
	<p>The northern Byford section of this precinct presents a low risk of catastrophic bushfires. There are few, narrow patches of planted trees, shrubs and grasslands along the road and rail corridor (Figure 7). There are extensive shrubland/grassland areas north of Abernathy Road. Dense natural forests are found on the uplands to the east.</p>	<p>Fuel loads in larger lot properties with grasslands, shrubs and trees to the west, south and east of the main Byford suburban area will need to be managed in a low-threat status during the fire season. DBCA and the City of Armadale to continue to manage fuel loads in large upland areas of dense natural vegetation to the east of the rail alignment. Early surveillance and reporting of any bushfires would improve the success of suppression activities in this section.</p>

7 Step 5 bushfire mitigation measures

This section constitutes the final stage of the risk assessment and management process namely, to treat risks. It follows from the previous stages described above, which have determined risk ratings of 'High' for both internal and externally-derived fires on rail assets, and on surrounding bushland to the east and urban settlements and their associated assets to the west and northeast. It should be stressed that in order to maintain public confidence, the potential impacts of bushfires on rail assets or on rail users, an upwardly conservative level of risk mitigation should be assumed for the entire rail corridor. Fuel management and preparedness strategies have been determined to be the primary mechanisms to protect people and assets in this locality (WAPC, 2019).

Mechanical and chemical methods together with prescribed burning are used to achieve fuel reduction where is required. Mechanical and chemical methods are generally less cost-effective than prescribed burning to implement and are not without potential adverse impacts on valuable vegetation stands. Regular buffer burning around assets to maintain lower fuel loads and a mosaic burn program to create low fuel zones would be more appropriate than broad landscape-scale fixed rotation burning, which may reduce the hazard in the short term but may damage biodiversity values and degrade areas of vegetation in the medium to longer term (WAPC, 2019).

The WAPC (2019), provided the following directive when considering prescribed burning for fuel reduction in valuable conservation-category vegetation:

Intense or out-of-control fires can cause significant damage to native flora and fauna. Fuel reduction burning to reduce bushfire hazards should only be conducted by suitably qualified people through a specific prescriptive plan that takes into account all variables, including environmental considerations, fuel loads, safety, resources and weather.

It is recommended that a multi-agency effort be provided for any fuel-reduction activities associated with vegetation adjacent to the BRE. This would need to include asset managers working with bushfire and environmental specialists.

A range of potential measures for mitigation and preparedness are presented below for construction and maintenance stages and the rail corridor operational stage. The recommended suite of mitigation measures are triggered by Bushfire Warnings, Total fire bans and Fire Danger Ratings.

7.1 Construction and maintenance

The following mitigation measures should be implemented for all bushfire prone sections of the BRE. Areas that are non-vegetated or contain low-threat vegetation associated with urban residential areas are not included here.

Worker safety and site safety preparedness for **all** conditions during the fire season from 1st October to 31st May, should include:

- Site induction, basic fire-fighting training, familiarity with muster points, evacuation triggers and procedures;
- Egress track 6 m width alongside entire section where works are being undertaken with appropriate turn around areas for Type 3.4 fire appliances, gated to prevent unauthorised access;
- Appropriate PPE, fire extinguishers, basic fire-fighting equipment including rakes, knapsack, shovel in all vehicles which are to be diesel fueled only; and
- Fast-attack light tanker ≥450 l capacity available at all times.

Total fire ban and vehicle movement in paddock ban controls should additionally consider:

- Ongoing surveillance of DFES website;
- No clearing of vegetation;
- Consider self-evacuation if fire within 6 km of the development envelope; and,
- No hot works to be undertaken (eg grinding, welding, metal cutting, metal heating).

Catastrophic FDR controls should consider:

- No works on site; and,
- Gates locked and all construction and maintenance personnel prevented from entering site.

Extreme and severe FDRs should consider:

- Continual surveillance of DFES website;
- Consider self-evacuation if fire within 6 km of development envelope; and,
- No hot works within 15 m of vegetation.

Very high FDR should consider:

- Continual surveillance of DFES website;
- Consider self-evacuation if fire within 6 km of development envelope; and,
- No hot works within 15 m of vegetation unless specifically approved by an authorised PTA representative or delegate.

7.2 Operations

The following actions should be implemented on an ongoing basis on PTA owned or managed lands along the BRE, including:

- designating and maintaining asset protection zones on a specific risk and site basis particularly guided by the Extreme-rated BHL areas designated at Figure 7 herein;
- Implement strategies for bushfire hazard reduction through mechanical and chemical fuel reduction together with prescribed burning, well-maintained strategic firebreaks surrounding valuable assets or other means, taking into account conservation, infrastructure, cultural and other surrounding land values;
- Contribute to long-term bushfire risk assessments and bushfire mitigation strategies in conjunction with local government, DFES, brigades, DBCA and other land managers; and,
- Implement bushfire preparedness actions to address the threat of bushfire, including:
 - ensuring adherence with the PTA's current fire emergency response procedures described in its emergency management manual
 - ensuring controlled access to PTA land; and,
 - requiring safe operating procedures for high-risk activities (*e.g.* construction and maintenance works, and their management described in 7.1 above).

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