FINAL REPORT ON – "INVESTIGATION OF THE HOUSE LOSSES IN THE ROLEYSTONE/ KELMSCOTT BUSHFIRE 6 FEBRUARY 2011"

BUSHFIRE & ENVIRONMENTAL PROTECTION BRANCH

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The contribution of the staff from NSW Rural Fire Service - Simon Heemstra and Tasmanian Fire Service – Mark Chladil, Mark Klop is acknowledged. These staff provided expert assistance in the completion of the house damage survey undertaken following the bushfire in the Roleystone and Kelmscott areas.

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1. **Executive summary**

On the 6 February 2011 at around 12.30 pm a bushfire occurred on private property adjacent to the Brookton Highway. The fire occurred on a day that had been declared as a total fire ban day[1]. The initial suppression response was partially successful, but the fire continued to grow, quickly escalating to a significant destructive event.

This report is based on the post event surveys on the damage, destruction or no damage that occurred to houses within the fire affected area and an adjacent area. The surveys were undertaken by the FESA's Bushfire & Environmental Protection Branch (BF&EPB) staff, with support from Tasmanian Fire Service and NSW Rural Fire Service expert staff. The survey only considered houses and attachments to the house such as carports and patios (items that are covered by 'Australian Standard 3959 Construction of buildings in bushfire-prone areas') in its assessment. It is acknowledged that 'Australian Standard 3959 Construction of buildings in bushfire-prone areas' did not apply in this area as it was not formally declared as being bushfire prone (and therefore had no legal status as being bushfire prone), but the Standard is the most appropriate reference tool to assess the houses against as it specifically relate to construction standards and distance from vegetation associated with bushfires. During the post fire assessments and interviews it became apparent that there are some variations between the results of the FESA Urban Search and Rescue (USAR) staff assessments conducted during the fire and the BF & EPB assessments conducted after the fire due to the building classification variations and also that some homes from the outside appeared to have suffered no obvious damage were in fact uninhabitable as a consequence of the fire being in the ceiling and extinguished by firefighters.

There were a total of 72 homes destroyed, 37 homes damaged and within the survey area 32 that suffered no damage. This is the single biggest house loss in Western Australia to a single bushfire event.

The bushfire ran though some very steep and difficult to traverse terrain. There were very few tracks on the north side of the fire from which to conduct fire suppression operations. The fuels were consistent in nature in that they were 100% cured if a grassland type fuel and the total fine fuel profile was available in the forests and woodland vegetation. The Bureau of Meteorology (BoM) registered users web page showed that the drought factor for Bickley was 10. The Keetch-Byram Drought Index (KBDI) for Bickley was very close to 180 out of a possible total of 200. The KBDI was significantly higher than the five year average. Bickley is the nearest hills based AWS to the fire that is also surrounded by forest.

[1] This declaration of a total fire ban was later found to have not been applied appropriately through the administrative processes.

The fire started close to and ran through a range of different subdivision types, house construction standards (and eras) and vegetation types. The firefighters had to deal with saving lives and property as well as the environment. The fire ran through a range of different subdivision types, such as the larger lifestyle blocks adjacent to and parallel with Buckingham Road (including the Brookton Highway) until it ran into the suburb on the western end of the fire, and then up over Canning Mills Road to impact onto Clifton Hills suburb, with also a tongue travelling up the Bromfield Drive locality. There was also the more complete and intact bushland area to the north of the subdivisions and west of the Roleystone townsite area.

None of the subdivisions affected by this fire were legally declared as being a bushfire prone area. There also appears to be some correlation between home loss and damage, and to the direction of the headfire. Homes down wind and directly in-line with the severest section of the headfire appear to have been the ones damaged or destroyed. Those on the edge of the headfire or primary shoulder of the flank do not appear to have the same impact as houses downwind of the fire.

The Clifton Hills area is a standard suburb with a forest/urban interface that ultimately backs onto the intact bushland that was subject to very intense fire behaviour. There were homes destroyed or damaged from the fire on the direct interface. Similarly there are homes in this area that suffered no damage. There were also home destroyed as a direct consequence of the ember attack onto the homes. Generally these homes were older style construction standard as applied in the 1950-1960s era, and certainly prior to the current standards that would be applied today. The building protection zone (BPZ) and hazard separation zone (HSZ) for the homes within the forest/urban interface was generally not to the prescribed fuel levels of 2 t/ha for the BPZ and 5 - 8 t/ha HSZ respectively.

To the south of the Brookton Highway was a subdivision that was constructed on a hill and contained significant areas of vegetation within the HSZ. There were significant house numbers destroyed by the fire in this area.

The larger lifestyle blocks adjacent to and parallel with Buckingham Road (including the Brookton Highway) which also ran into an established suburb to the west had houses scattered through the bushland area suffered significant losses and damage. There was a range of impacts of the houses in this zone with some destroyed, some damaged and most undamaged. There were also homes lost in the suburban area.

There were a number of locations where for a variety of reasons the whole area was not evacuated. In these areas the intervention by those not evacuated resulted in a number of houses being saved by the active intervention. The intervention by firefighters also resulted in a number of homes being saved. There is research that indicates a well prepared house, with a well prepared occupier will more likely survive a bushfire than a house that has no occupier present. The difficulty for fire managers is to determine whether a house and its occupier are well prepared and should remain. It is appropriate for a safety first policy to be applied where protection of life takes precedence.

2. Objectives of the study (scope of work)

- To analyse the impact or non-impact of the “Roleystone / Kelmscott” fire on homes in the fire area
- To analyse the fire behavior, particularly the rate of spread, including the fire direction and intensity

1. Environmental conditions

The environmental conditions at the time of the fire were very dry, drier than the five year average when considering the Keetch-Byram Drought Index (KBDI). The KBDI is a good indicative tool to apply as it is utilised across Australia by most fire agencies which facilitates comparisons of bulk fuel dryness and community impacts. This is clearly indicated with the two KBDI graphs for Bickley (the closest hills based Automatic Weather Station (AWS)) and Perth Metro. Perth Metro was chosen as it is on the Swan Coastal Plain and indicative of the potential KBDI for the Champion Lakes site.

The drought factor for both sites at the time of the fire was 10. This effectively indicates that all of the forest and woodland fire fuel, the fuel less than 6cm diameter, was available for the fire to consume. The grass was also 100% cured and therefore it to was also totally available.

The weather conditions were relatively warm, dry and very windy. Table 1 indicates the hourly weather conditions. Linked to the total fuel load which was all available, strong winds with the significant wind gusts, steep slopes with very limited access made bushfire fighting very difficult.

The construction standard of the houses, the absence or presence of effective building protection zones, hazard separation zones and the fuel load and structure in the landscape zone were also contributing factors to the impact of the fire on the community assets.

Table 1 – Average weather conditions from the Bickley AWS

Time	Wind (km/hr)	Temp	Dew Pt	RH
1200	43	23.2	5.1	30.9
1300	39	24.2	5.1	29.1
1400	37	26.1	5.7	27.1
1500	33	26.4	4.8	25
1600	30	26.7	5.1	25.1
1604	35	26.6	4.4	24
1700	31	26.3	4.7	25
1800	33	25.1	4.3	26.1
1900	30	24.2	4.6	28.1
2000	30	23.3	4.8	30.1
2046	33	22.9	4.4	30
2100	35	23	5	31.1
2200	37	22.1	5.1	33
2300	33	21.5	5.8	36

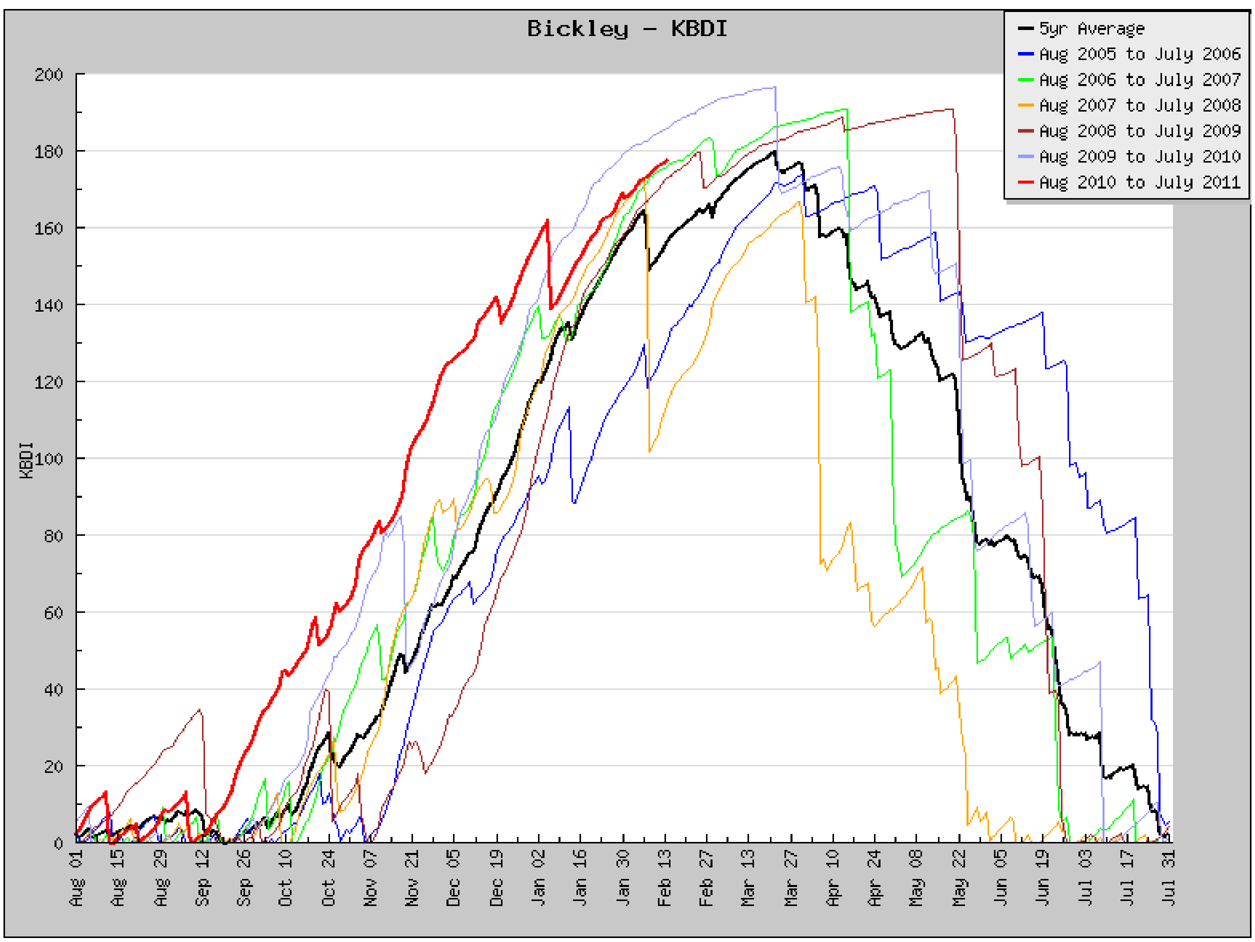

Figure 1 – KBDI graph for Bickley

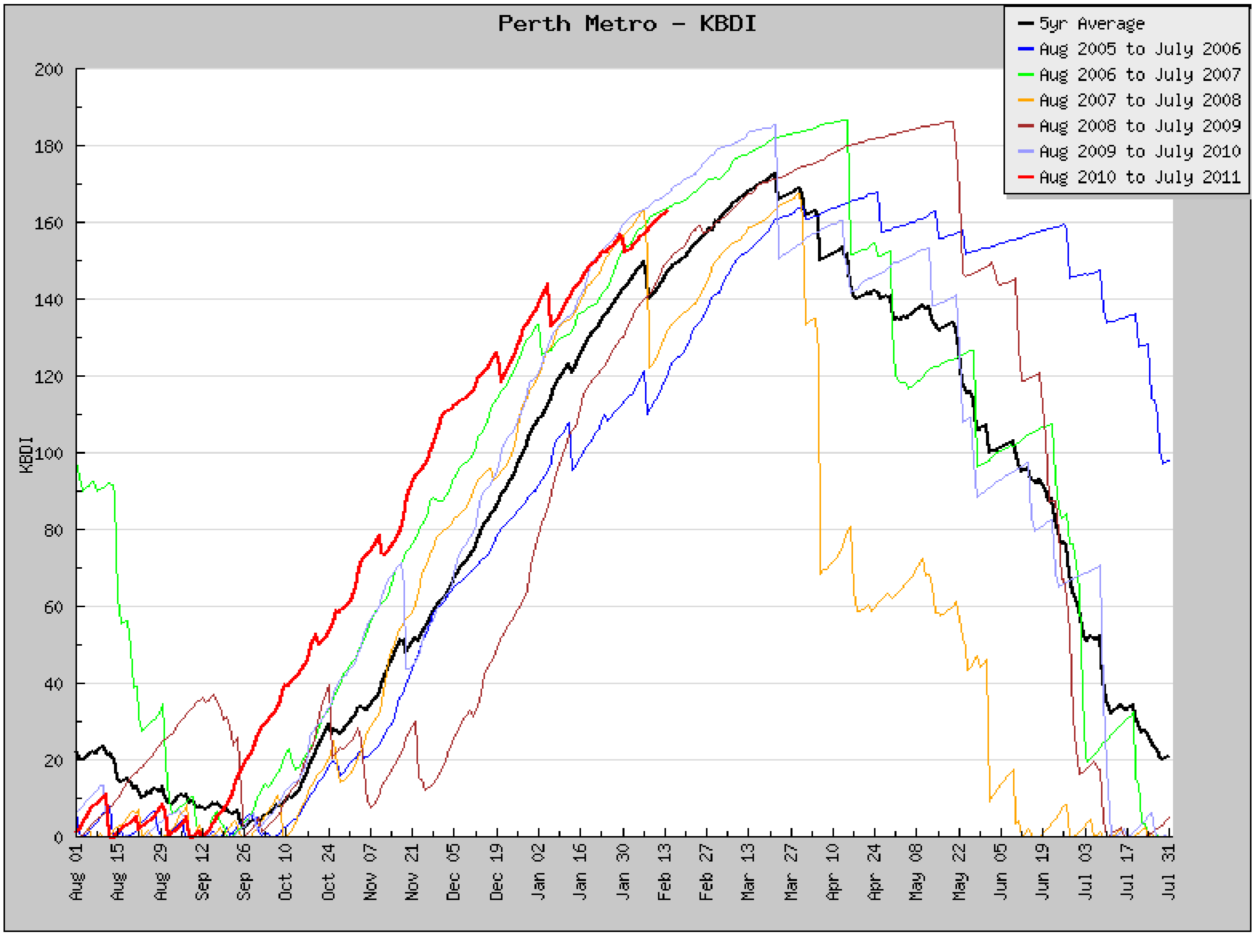

Figure 2 – KBDI graph for Perth Metro

2. Fire behaviour

On the 6 February 2011 at around 12.00 pm (the first 000 call was received at 11.42 hours) a bushfire occurred on private property adjacent to the Brookton Highway and was operational until the 14 February 2011 (at 07.35 hours). The vast majority of the house destruction or damage occurred in the first five or so hours of the fire starting. The Highway runs in a gully and then goes upslope from the vicinity of the ignition point and is surrounded by hills to the north and south. In a number of locations these hills have slopes up to 20 degrees.

The fire traversed through a range of vegetation types, from open grassland that was around 45 – 50 cm tall, scattered scrub with a tree overstorey to an intact continuous scrub layer with a tree overstorey. Contained within these zones were a range of periods since last burnt and therefore significant fuel loads. The wind direction was fairly consistent with the wind blowing the fire basically across the slope. The slope, fuel type and structure and the wind resulted in the fire creating several tongues with a variety of fire intensities. The variety of intensities assessment was based on the visual effect of the crown scorching or defoliation. The wind also gusted to significant strengths with gusts of 69km/hr and 85km/hr recorded at Champion Lakes and Bickley respectively. These wind gusts have not been factored into the fire behaviour analysis because of their very short duration, but they were consistent enough to consider.

Tables 1 and 2 give an indication of the average weather conditions based on the automatic weather station for both Bickley and Champion Lakes. These two AWS have been chosen as the default for the fire area because they are the nearest Bureau of Meteorology (BoM) sites. The two sites are also chosen because the Champion lakes site is closest to the fire but on the flats of the Swan Coastal Plain and the Bickley site has been chosen because it is a hills site and provides some compatibility to the potential conditions at Roleystone / Kelmscott. It is known that there can be local weather variations and by choosing these two AWS it is hoped to minimise the potential inaccuracies of the weather conditions and also the impact on fire behaviour.

For the fire spread analysis an available fuel load on 4.5 tonne per hectare in the natural grassland and 15 tonne per hectare within the forest overstorey areas has been applied. In table 2 the assumption has been for an undulating landscape, but it is also known that the headfire rate of spread will increase by up to four times on the steep upslopes of 20º.

The bushfire intensity for the bulk of the fire was significant, in the vicinity of 8,000 kW/m and 10,000 kW/m. The fire was very fast moving, intense, on very steep country with very few roads and therefore very difficult to suppress. The fire was directly attacking homes and properties with flames and radiant heat very early in its development and this was exacerbated by the atmospheric, fuel load and slope conditions where, within around two hours major community assets and a large number of homes were being attacked by the bushfire. This attack was initially from embers but for homes in the direct interface with the bush this became direct flame contact and radiant heat attack, particularly in the Bromfield Road area. The ember attack in the Clifton Hills area was significant with homes destroyed or damaged many hundreds of metres from the direct interface with the bush.

The fire behaviour was not consistent across the landscape as the wind direction and strength, slope, fuel load and structure were not consistent. There were general patterns that remained fairly consistent for the duration of the main fire run. The fire appears to have broken into a number of fire tongues where the main fire ran along parallel to Buckingham Road (including the Brookton Highway) and then up over Canning Mills Road to impact onto Clifton Hills suburb, with also a tongue travelling up the Bromfield Drive locality. The nature of the vegetation, construction standard and therefore fire behaviour and impact on the homes was also not consistent. The locality adjacent to Buckingham Road, particularly the eastern end was primarily larger lifestyle lots, where-as Clifton Hills was a standard type suburb with a bush frontage and Bromfield Drive locality was a more recent development that contained pockets of remnant bush amongst the houses.

Uitilising the fire's impact on the crowns of the tree overstorey it is possible to determine the fire intensity variations. The tree crowns were defoliated in the Canning Mills Road area (figures 3 and 4) where the landscape fire behaviour was very intense, compared to that in the vicinity of the homes in Clifton Hills bushland (figure 6) and near Buckingham Road (figure 7) and also Bromfield Drive (figure 8). With the exception of the Clifton Hills bushland (figure 6) all of the other areas close to homes, including the Martin Road section of Clifton Hills (figure 5) show the tree crowns as primarily scorched rather than defoliated.

A further complicating factor in the fire behaviour and the subsequent impact on the homes was the volume and distance associated with the spotting. There was significant long distance spotting that assisted in spreading the fire across the landscape very quickly. Coupled with the difficulty of access, as a consequence of very few tracks and the steep terrain, this exacerbated the difficulty of the fire suppression effort.

Figure 3: A general indication of the vegetation, slope and fire intensity

Figure 4: An overview of the vegetation and slope

Figure 5: View of the fire's impact on the vegetation from Canning Mills Road looking east – south-east

Figure 6: View of the fire's impact on the vegetation from Canning Mills Road looking east

Figure 7: View of the fire's impact on the vegetation near Martin Street, Clifton Hills


Figure 8: View of the fire's impact on the vegetation near Mundanup Close, Clifton Hills


Figure 9: View of the fire's impact on the vegetation near Buckingham Road

Figure 10: View of the fire's impact on the vegetation near Bromfield Road area

By applying the relationship between the fire's impact on the tree crown and fire behaviour it is possible to make a number of estimations on the fire behaviour and draw a number of conclusions. These are that the fire was most intense on the steep slopes in the landscape zone of the fire. The defoliation of the trees adjacent to Canning Mills Road is an indicator of the high flame heights and destructive fire behaviour. Figure 6 is indicative of the fire behaviour as it has come across the landscape towards the homes in the northern portion of the Clifton Hills suburb. This is indicative of the fire behaviour in the building protection zone and hazard separation zone. It is the fire behaviour that is linked to the fire moving over the Canning Mills Road area.

Figure 11: The view of the intact and defoliated crowns across the fire affected valley

Table 2 – Average weather conditions from the Bickley AWS and head fire rate of spread calculations[2]

Time	Wind (km/hr)	Temp	Dew Pt	RH	HFRoS Forest (m/hr)	HFRoS Grassland (km/hr)
1200	43	23.2	5.1	30.9	1414	5.7
1300	39	24.2	5.1	29.1	1423	5.1
1400	37	26.1	5.7	27.1	1552	5
1500	33	26.4	4.8	25	1511	4.3
1600	30	26.7	5.1	25.1	1456	3.9
1604	35	26.6	4.4	24	1692	4.8
1700	31	26.3	4.7	25	1442	4
1800	33	25.1	4.3	26.1	1413	4.2
1900	30	24.2	4.6	28.1	1192	3.6
2000	30	23.3	4.8	30.1	1079	3.4
2046	33	22.9	4.4	30	1157	3.8
2100	35	23	5	31.1	1173	4.1
2200	37	22.1	5.1	33	1112	4.3
2300	33	21.5	5.8	36	916	3.5

[2] Weather data was supplied by the Bureau of Meteorology

Table 3 – Average weather conditions from the Champion Lakes AWS and head fire rate of spread calculations

Time	Wind (km/hr)	Temp	Dew Pt	RH	HFRoS Forest (m/hr)	HFRoS Grassland (km/hr)
1100	28	23	5.9	33.1	931	3
1200	31	24.7	6.4	30.9	1142	3.7
1202	30	24.8	5.6	29.1	1192	3.6
1300	28	26	6.1	28	1216	3.4
1328	31	26.3	5.8	27	1349	3.9
1346	43	26.5	5.5	26.1	1909	6.5
1352	35	27.2	6	25.9	1583	4.7
1400	28	27	5.9	26	1344	3.6
1417	28	26.7	5.6	26	1344	3.6
1500	30	28	6.2	25.1	1505	4
1554	37	28.5	6	24	1895	5.4
1558	28	28.7	6.1	23.9	1535	3.7
1600	22	28.7	6.1	23.9	1334	2.9
1604	28	28.6	5.5	23.1	1587	3.8
1700	26	29.1	5.9	23.1	1515	3.5
1800	15	28.9	5.1	22.1	1530	2.3
1825	28	28.5	5.4	23.1	1587	3.8
1846	39	28.2	5.1	23	1986	5.8
1900	35	28.1	5.6	23.9	1749	4.9
2000	22	27.4	5.6	24.9	1207	2.8
2100	15	26.5	6	27	1212	2.1
2200	24	26.1	6.2	28	1107	2.9
2300	24	25.5	6.7	30.1	1036	2.9

Fire Line intensity

Bushfire line intensity is a factor of the fuel heat yield, the fuel weight consumed and the linear rate of advance of the fire. For the purposes of these calculations below it has been assumed a forest or woodland fuel load of 15 tonnes per hectare oven dried weight (t/ha) and the grass fuels at 4 t/ha. It is acknowledged that the entire site did not have this level of fuel load and it therefore an assumed, post fire estimation. The heat yield has been estimated for the forest and woodland fuels at 18,600 kJ/kg[3] and 16,890 kJ/kg[4] for the grass fuels.

[3] N D Burrows, 1984, "Describing forest fires in Western Australia. A guide for fire managers", Forests Department, WA

A further factor in the rate of spread of the fire was the variations in the slope which varied from undulating to around 20 degrees. A 20 degree upslope will result in a rate of spread multiplication of four times that on the standard undulating topography. As the rate of spread is a factor in the intensity equation this will also correspondingly increase the fire intensity.

Table 4 provides an estimation of the fire's intensity based on the AWS data for both Bickley and Champion Lakes and the fuel availability assumptions.

Table 4 – Estimated fire intensities on undulating ground with average weather conditions

Time	Bickley HFRoS Forest[5] (m/hr)	Bickley Forest kW/m	Bickley HFRoS Grassland[6] (km/hr)	Bickley Grassland kW/m	Champion HFRoS Forest (m/hr)	Champion Forest[7] kW/m
1200	1414	10,652	5.7	12,034	1142	8,602
1300	1423	10,720	5.1	10,767	1216	9,160
1400	1552	11,692	5	10,556	1344	10,124
1500	1511	11,382	4.3	9,078	1505	11,337
1600	1456	10,968	3.9	8,234	1334	10,049
1700	1442	10,863	4	8,445	1515	11,412
1800	1413	10,644	4.2	8,867	1530	11,525
1900	1192	8,979	3.6	7,600	1749	13,173
2000	1079	8,128	3.4	7,178	1207	9,092
2100	1173	8,836	4.1	8,656	1212	9,130
2200	1112	8,376	4.3	9,078	1107	8,339
2300	916	6,900	3.5	7,389	1036	7,804

FESA in partnership with the Department of Environment and Conservation (DEC) and the Commonwealth Government funded a tenure blind Bushfire Threat Analysis (BFTA) process that was published in 2008. A component of the BFTA report was an analysis of the headfire bushfire behavior classes and the intensity limits for various suppression options. Also considered was a technical report completed in 1984 by Dr Neil Burrows where he also nominated intensity limits for the various suppression options.

As can be seen in table 3 and in table 4 the fire intensity of the bushfire exceeded the category where even the "Indirect attack likely to fail".

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[4] Byram (1959) in Gill, King & Moore, "Australian grassland fire danger using inputs from the GRAZPLAN grassland simulation model," International Journal of Wildland Fire 2010, 19, 338-345, CSIRO Publishing

[4] Higgins et al, 2008, "Physically motivated empirical models for the spread and intensity of grass fires",

[5] Based on the assumption of a forest and woodland fuel load of 15 t/ha

[6] Based on the assumption of a grass fuel load of 4 t/ha

[7] Based on the assumption of a forest and woodland fuel load of 15 t/ha

Table 4: Intensity limits for various suppression options

Headfire Behaviour Classes (Modified)[8]

Indirect attack likely to fail
Intensity > 4000 kW/m (5,000[9] kW/m) and/or ROS > 800 m/hr in forest/woodland
Intensity > 8000 kW/m and/or ROS > 2000 m/hr in shrubland and/or
ROS > 10000 m/hr in grassland

Direct attack not possible/unlikely to succeed
Intensity > 2000 kW/m and/or ROS > 400 m/hr in forest/woodland
Intensity > 2000 kW/m and/or ROS > 1000 m/hr in shrubland
Intensity > 5000 kW/m and/or ROS > 6500 m/hr in grassland

Direct machine and tanker attack possible
Intensity < 2000 kW/m and/or ROS < 400 m/hr in forest/woodland
Intensity < 2000 kW/m and/or ROS < 1000 m/hr in shrubland
Intensity < 5000 kW/m and/or ROS < 6500 m/hr in grassland

Hand tool attack possible
Intensity < 800 kW/m and/or ROS < 140 m/hr in forest/woodland and shrubland
Intensity < 800 kW/m and/or ROS < 300 m/hr in grassland

Readily suppressed
Intensity < 800 kW/m (350[10] kW/m) and/or ROS < 60 m/hr in all fuels

Note: That in the forest fuels '**Readily suppressed'** and '**Indirect attack likely to fail'** categories there is some variation between references

Investigation of the Roleystone / Kelmscott area house loss and damage

The investigation of the houses destroyed and damaged in the Roleystone / Kelmscott fire utilised the "FESA House Loss Fire Assessment" form which covers basic building construction standards, building protection zone and hazard separation zone fuel loads, vegetation structure, type and health and a modified form to capture additional data on fire suppression intervention.

The methodology applied was to inspect all the available homes destroyed in the fire (two homes had security fences in place which prevented entry), a quantity that had suffered partial damage and also a number that had suffered no damage. The basis of

[8] C Muller, 2008, "Report on a Bush Fire Analysis for Western Australia", Chris Muller Consulting, Perth.
[9] N. D. Burrows, 1984, "Describing forest fires in Western Australia A guide for fire managers. Technical paper No9", Forests Department, WA

the assessment was on the initial data collected by the Urban Search and Rescue (USAR) team. As a consequence of the variation of assessment between buildings being assessed by USAR and the house loss/damage team there is a different figure being reported. The house loss/damage team concentrated our assessment on the homes, and excluded sheds, outbuildings and other structures.

The components of the house loss/damage team assessment included:

- Construction standards
- Building protection zone
- Hazard separation zone
- Fire suppression intervention
- Fuel or vegetation
- Land use
- Fire behaviour.

Construction standards

Anecdotal information indicates that the area subject to the fire and its effects is basically made up of three differing zones. These are:

- The Clifton Hills area which was basically a standard suburb, with a section abutting native bushland to the east. The bushland was a continuous forest or woodland for a number of kilometres.
- The semi-rural area where the lots size was generally larger, around the 2 hectare plus size. This is the general area near to Mount Street and Buckingham Road (and adjacent to the Brookton Highway)
- The subdivision south of the Brookton Highway (Bromfield Way)which was a more recent development on fairly steep slopes.

There appears to be a range of construction standards and ages within each of the three zones, but the Clifton Hills area appears to have been generally constructed prior to the other two zones.

Most homes that have been affected by the bushfire were constructed prior to the current construction standards being developed. That is they were constructed to the general standard that was applicable and this did not consider the potential bushfire attack level. In the case of the Clifton Hills area a number of the homes affected by the ember attack would be outside the separation distance applicable even today. That is they were greater than 100 metres from the bush. FESA identified that the standard distance of 100 metres was inadequate for the complete protection of homes from embers and published in 'Planning for Bushfire Protection' guidelines edition 2 (table 3 on page 24) the need to consider ember protection features be incorporated in design where practicable.

‘Australian Standard 3959 – 1999 (incorporating Amendments Nos. 1 and 2) Construction of buildings in bushfire-prone areas’ identified in section3.9.1.6 that ‘roof-mounted evaporative cooling units shall only be used if the openings to the cooling unit are encased in corrosion-resistant steel of bronze with a maximum aperture size of 1.8mm’. For AS 3959 to take effect under the Building Codes of Australia (BCA) required a formal declaration of an area to be bushfire prone. This area affected by the fire has not been declared as bushfire prone.

Effectively none of the homes had been formally constructed to comply with AS 3959 within the fire affected area. In many instances such as within Clifton Hills only a small percentage of the homes were constructed after AS 3959-1999 was published and there is no retrospectivity where non-compliant homes are required to be upgraded to the new or current standard. It is also important to note that the this area, as with most areas in Western Australia, have not been declared as bushfire-prone with the subsequence consequence of there being no formal process for AS 3959 to be applied as required in the Building Code of Australia.

Of the total homes destroyed by the fire, 35 had evaporative air conditioners and of the house damaged seven had evaporative air conditioners. A reasonable number of these homes were in the Clifton Hills area. The evaporative air conditioner issue is a little more complex than simply ‘did the house have an evaporative air condition and did it burn down, then it must have been the evaporative air conditioner that caused it’. Many of the older style homes did not have boxed eaves nor wire insect screens. They had open eaves which allowed air and then embers to circulate into the roof cavity. Many also had fibreglass insect screens which when attacked by ember melted and then any subsequent ember attack permitted entry into the home if the window was left partially open. Windows are frequently locked partially open to facilitate the evaporative air conditioner which draws air through the wet pads on the roof through the home and out through the open window.

Figure 12: A home destroyed by ember attack. This home was 421 metres from the fire. This home also had a roof mounted evaporative air conditioner

This home (in figure 12) is believed to have been constructed prior to 1999. Another feature of this home was that it was constructed to the basic standard for the era with an elevated wooden floor about 30cm to 45 cm above the ground, and then with limestone blocks around the base of the home. This home was quite some distance (estimated at 421 metres) from the forest or woodland vegetation and could only have ben ignited by ember attack.

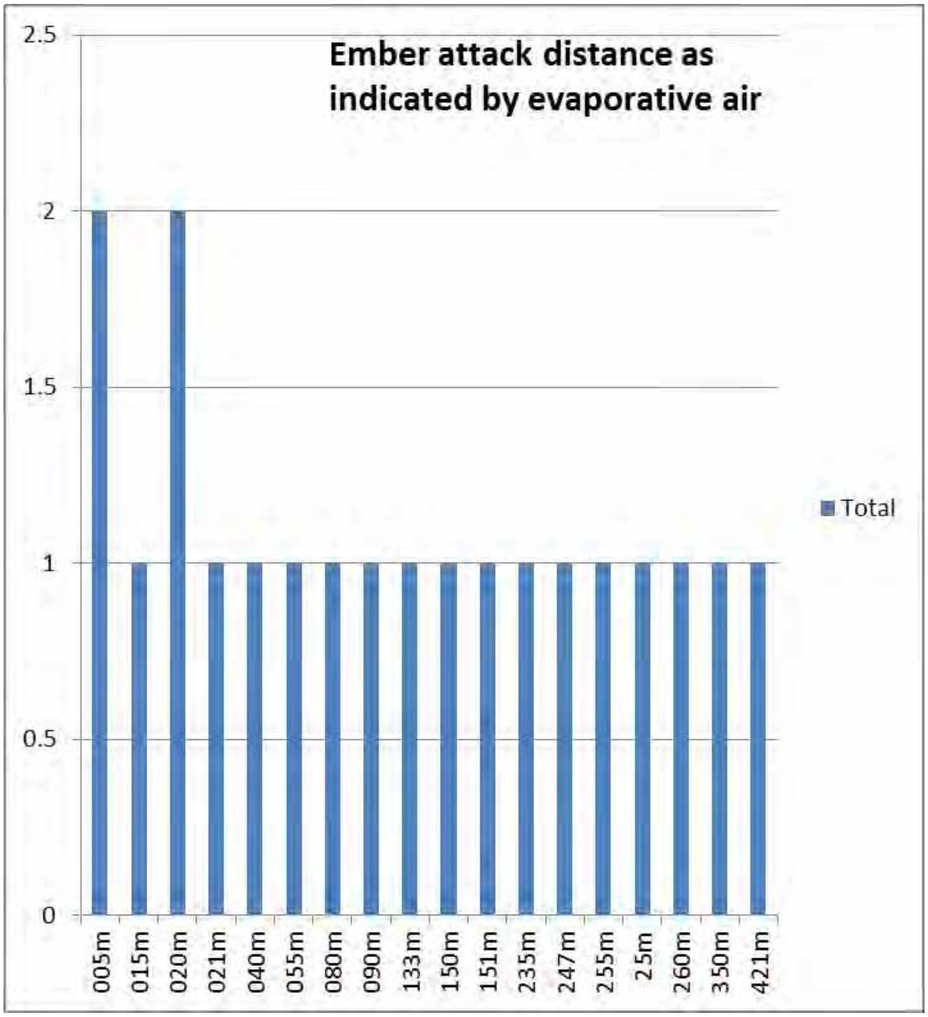


Figure 13 : Ember attack distance as indicated by evaporative air conditioners and destroyed houses

While AS 3959 considers a separation distance of 100 metres between the predominant vegetation and the building, the experience from this fire is that a house was destroyed 421 metres from the vegetation edge. There were 10 houses destroyed a greater distance than 100 metres from the vegetation edge. The houses greater than 100 metres would not be picked up through a declaration of bushfire prone and therefore would still be at risk from an ember attack.

Figure 14: Two further homes with evaporative air conditioners and fire affected

Figures 14 and 15 are indicative of the type of construction for evaporative air conditioners. They are positioned so that air can circulate through wet pads and have the moist air drawn into the house. The method of operation requires air to circulate through the house requiring windows or doors to be partially open during the operation of the unit. By having the unit on top of the house roof exposes the unit to ember attack. Screening the roof mounted units would result in increased protection of the house. This screening should be greater than the minimum 100 metres currently prescribed to optimise the protection of the house.

Figure 15: This is indicative of the flooring structure where the floor was wooden and supported around 30-45 cm off the ground

Figure 16 : This home was constructed without ember proofing. This house was on Martin Road and was subject to ember attack.

Figure 17: Further examples of the openings between the roof and the ceiling

As previously discussed, this is type of construction, where the roof space is not enclosed, is indicative of the type of construction that facilitated air movement within the space between the roof and the ceiling. It also facilitated the entry of embers into the same space. When coupled together with the evaporative air conditioner it is a potentially catastrophic outcome when a bushfire occurs.

It is not possible to determine with certainty whether the homes destroyed by ember attack were constructed to this standard or not. It is highly probable that only the Clifton

Hills area and some isolated homes in the Buckingham Road area were constructed to this standard, because of the age of the homes.

Linked into this destructive effect is the need to leave a window partially open to facilitate the functioning of the evaporative air conditioner. Where this occurs and the window insect screen is not wire it provides an opportunity for embers to breach the insect screen and to enter the home. A non-wire insect screen and open window adjacent to tall shrubs, particularly if the shrubs contain fine, dead aerated material may provide a further entry point into the house. A combination of unscreened evaporative air conditioner, open eaves into the roof space, non-wire insect screens and tall shrubs adjacent to the house provide multiple potential entry points for a bushfire to attack and enter the house.

Figure 18 : This is the ember attack on the car parked in the carport on Martin Road

Martin Road is adjacent to the bush and the house is separated from the bush by the road and the set back from the front of the block.

Figure 19 : This is the ember attack on a swing at the rear of a destroyed home in the Clifton Hills area.

Figures 18 and 19 are indicative of the number of embers that were falling in the Clifton Hills area. As can be clearly identified by the individual burn marks on the car roof and swing, the embers per square metre were very numerous and with sufficient size and ignition potential to cause damage to both items.

Figure 20: A cedar timber home destroyed following an ember attack

Figure 21: The cedar timber shed on similar construction style and materials adjacent to the destroyed cedar timber home.

Homes constructed of dry timber are also at risk of being destroyed from flame contact, radiant heat or ember attack. The home in the above photographs (figure 17 and 18) was destroyed, even though the neighbours had tried to suppress the fire and defend the house. It was attacked by embers and burnt to the ground. Figures 17 and 18 provide a pictorial indication of the construction materials and the final outcome for the timber home.

The construction standard of the home is a critical component in determining its ability to successfully withstand the impact from a bushfire, particularly embers. There is some evidence that as the bushfire fuel ages increase, particularly in the northern jarrah forest fuels, the quantity and distance of embers increases. This means that a long unburnt jarrah forest will result in more embers travelling greater distances and have the potential to ignite fine, aerated fuels. It must be noted that not all embers will have the potential to ignite the potential fuels. By ensuring that a home has increased construction standard above the basic level, to at least the level of ember protection (BAL – 12.5) will certainly facilitate greater survivability of that home. The ember attack impact of this fire has highlighted that embers produced under the conditions found at this fire have the propensity to ignite homes not constructed to the appropriate standard as specified in AS 3959, further than the 100 metres as prescribed in the AS 3959.

Figures 20 and 21 clearly indicate the effect that ember attacks can have on homes that are set back from the forest/woodland interface, with a reasonable BPZ but not constructed to the appropriate standard to prevent ember attack successfully penetrating the building.

Figure 22: The building protection zone (BPZ) of a home destroyed as consequence of the ember attack

Figure 23: The BPZ closer to the house and the house featured in photograph 19.

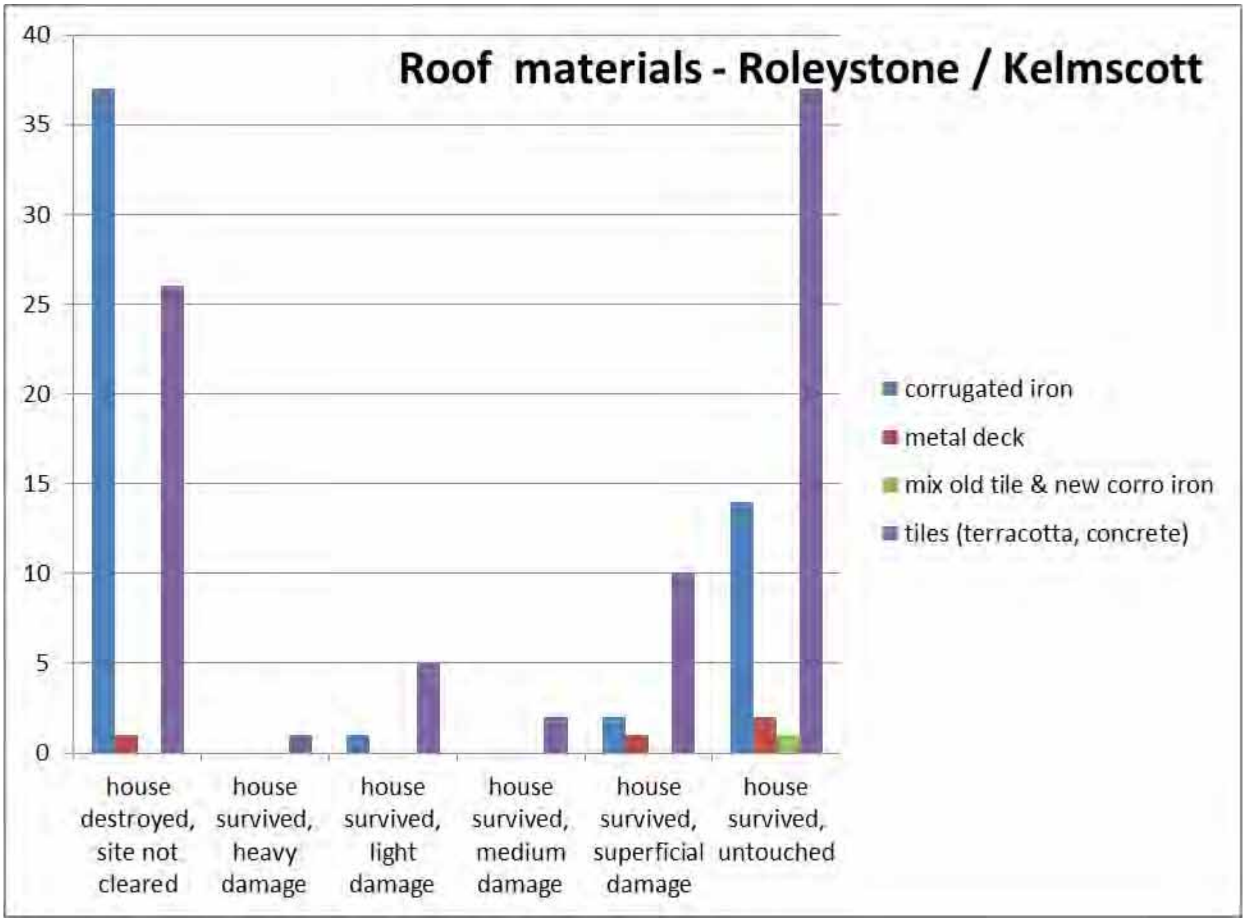


Figure 24 : Roof construction materials

There is no clear indication of which of the roof materials was the least or greatest risk as it was not possible after the fire to determine the level of construction. The type of roof construction was easy to assess, but the quality of the work completed to fix that roofing material could not be assessed. As an example it is not possible to determine if the roof tiling had been undertaken to the required standard to be certain that embers did not enter into the roof space via gaps in the roof tiling. In many instances it was not possible to definitely determine whether the tin roof had been appropriately sarked (to the current standards) or not.

There were also other roof mounted items such as skylights which have been identified in AS 3959 as requiring special attention. This skylight in figure 19 shows some minor damage as a consequence of the embers that fell onto the roof. This home was several streets back from bush interface.

Figure 25: Ember caused damage to a sky light

Most homes that are unattended during a bushfire are lost to ember attack from the bushfire. These burning embers get into gaps within the building, such as into the roof space, and ignite the material within the space. It can take a number of hours before the burning can be observed and by that time the building may not be able to be saved. It is recommended that all homes that may be affected by embers be made ember proof. If a bushfire occurs in the general area then the roof space and other crevices should be inspected to ensure that no embers have caused a fire. Be aware that there are electricity cables in the roof area and the introduction of water will be a safety issue.

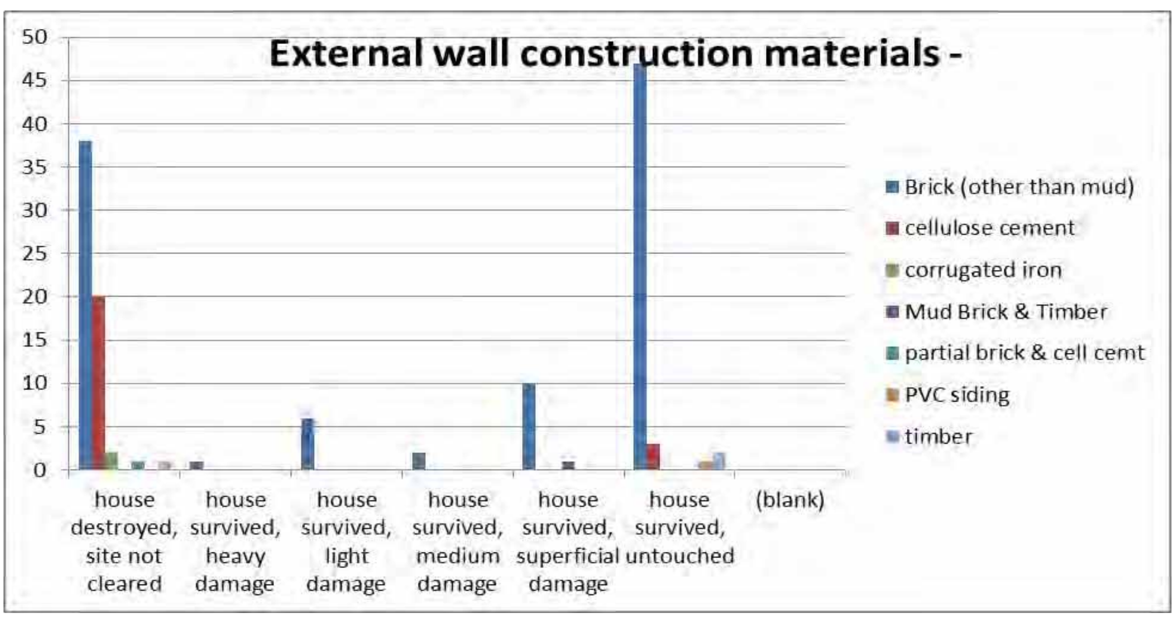


Figure 26: External wall construction materials

The external wall construction materials appear to be a significant contributor as to whether the house was destroyed if the walls were constructed of cellulose cement. The cellulose cement walls appear to be susceptible to direct flame contact and radiant heat. AS 3959 prescribes that the fibre-cement external cladding should be a minimum of 6mm for BAL -12.5 upwards. This fire's destruction associated with the direct flame contact and radiant heat on cellulose cement walls appears to be a problem.

Figure 27: House constructed with cellulose cement cladding

Building protection zone (BPZ)

The BPZ is the defined as the 20 metres out from the home. Within the BPZ, FESA prescribes a range of considerations for the vegetation. In general the aim of the building protection zone is to ensure that there will be no direct flame contact on the building from a bushfire. By utilising the fuel management options it will also be possible to reduce the potential radiant heat impact on the building. FESA advocates maintaining an available fuel load of 2t/ha. This figure is chosen as in most instances where a fire is burning in a forest fuel load of 2 t/ha or less the fire front intensity will be in the range that it is easily suppressed with water, that is less than 8ookW/m.
By coupling the fuel load and the vegetation structure it is possible to minimise the direct flame contact, radiant heat attack on the building whilst making it possible for fire to be suppressed with nothing more than an active person with a water hose.

The vegetation structure recommended is:

- Maintain a minimum 2-metre gap between trees and the building. Have no trees overhanging the house

- Keep the grass short and prune the scrub so that it is not dense, nor does it have fine, dead aerated material in the crown of the scrub
- Rake up leaf litter and twigs under trees and remove trailing bark
- Prune lower branches (up to 2 metres off the ground) to stop a surface fire spreading to the canopy of the trees
- Create a mineral earth firebreak
- Do not clump shrubs or trees, ensure that there is a gap
- Have your paths adjacent to the building and driveway placed so that it maximises the protection to the house
- Keep firewood away from the building
- Ensure fences that are combustible will not burn down and break the integrity of the building by breaking windows
- Keep your gutters free of leaves and other combustible material
- Ensure that your gas bottle will vent away from the building if it is subject to flame contact or radiant heat

There were 61 homes that were destroyed with tall vegetation within 20 metres of the home. There were also 20 homes damaged to varying degrees within the BPZ and tall vegetation. Therefore there were 81 homes damaged or destroyed with a fuel load or fuel structure that was not within the criteria advocated by FESA.

There were 58 homes that were destroyed with tree crowns within 2 metres of the house. There were also 20 homes damaged to varying degrees within the BPZ and had tall trees within 2 metres of the house.

There were 60 homes that had tall plants adjacent to the windows and the homes were destroyed. There were also 20 homes damaged to varying degrees within the BPZ and had tall plants adjacent to the windows.

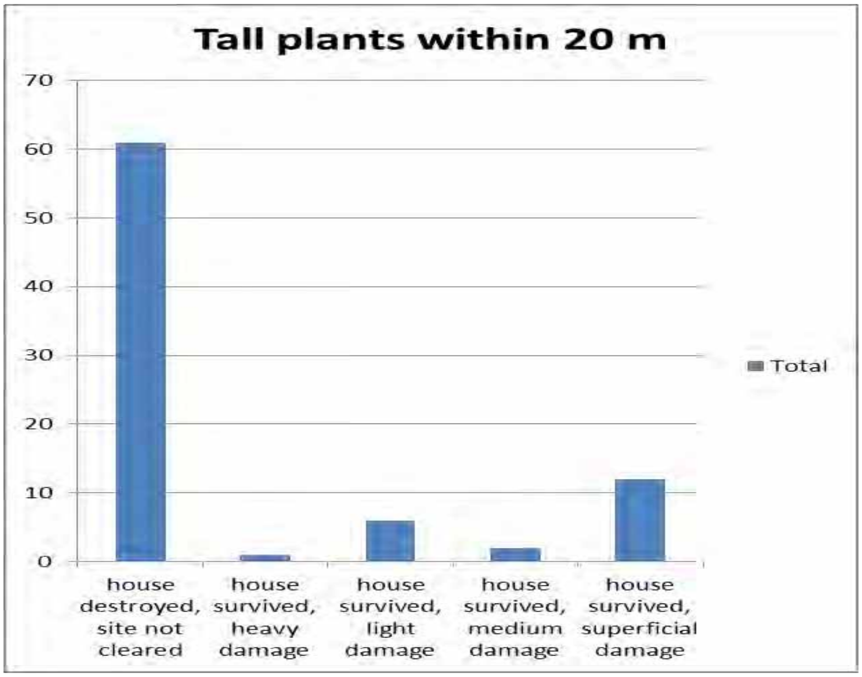


Figure 28: Houses with tall plants within 20 metres of the building

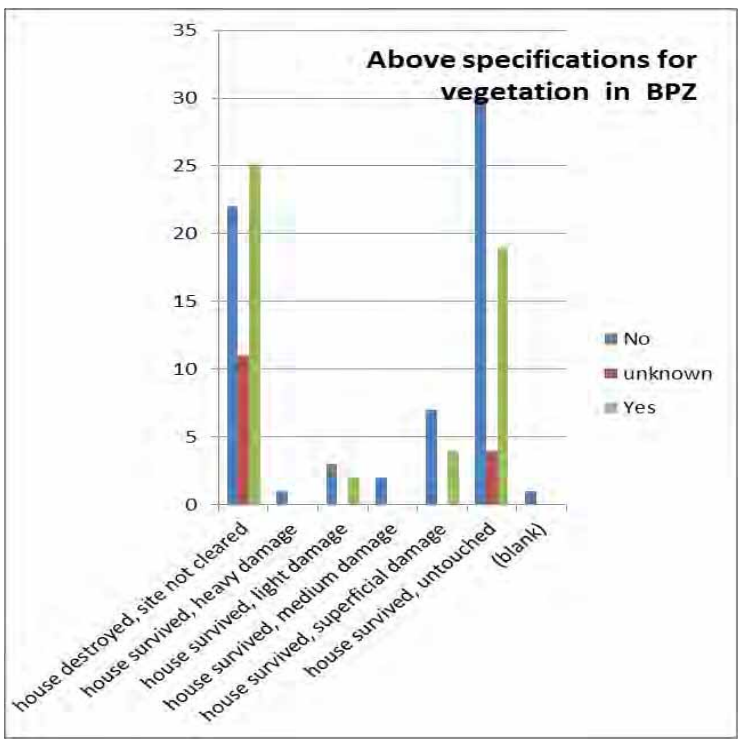


Figure 29: Locations within BPZ with vegetation above the level recommended by FESA

A fairly common theme is that a significant number of homes did not have an appropriate BPZ as prescribed by FESA and these homes suffered either destruction or damage.

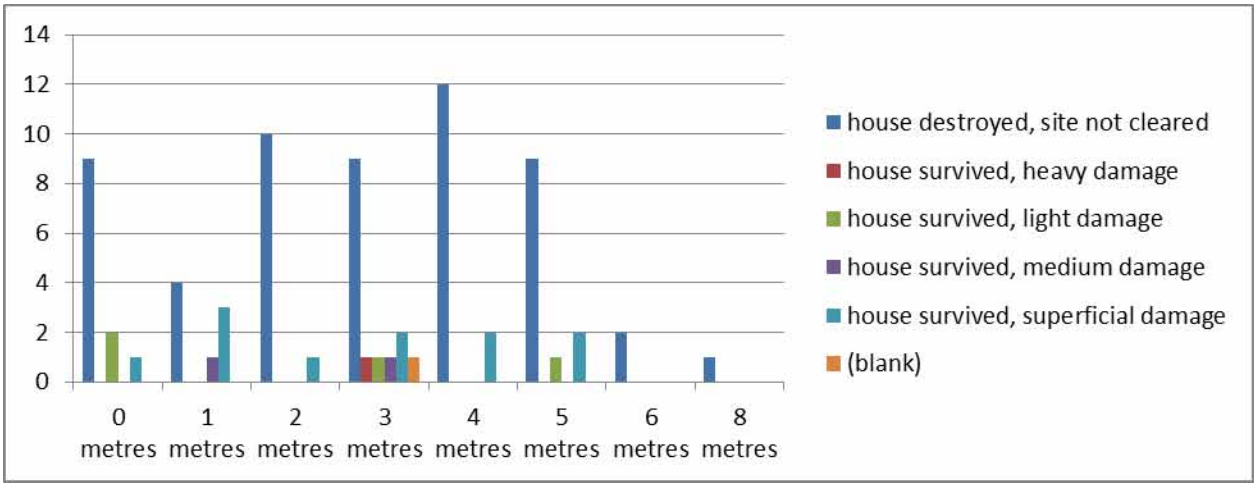


Figure 30 : Vegetation distance from the house

The distance between the house and the vegetation, and the amount of vegetation were significant contributors as to whether the house was destroyed, damaged or suffered no damage.

Figure 31 is indicative of some of the damage that resulted from having tall plants adjacent to the building. In a number of cases as a consequence of the plant location the bushfire caused direct flame contact onto the home.

Figure 31: House damage following the tall plants igniting and putting direct flame contact onto the house

The following group of photographs (figures 30 to 35) are indicative of the potential impact of a bushfire on a home. The first photograph(figure 30) shows the damage that was caused by the fire igniting the vegetation beneath the wooden deck. It should be noted that this fire was suppressed by the actions of firefighters. Even with the intervention of the firefighters the photographs indicate the potential impact on the homes in the interface zone. This impact can range from the burning of the wooden deck, to the melting damage to the seals around the windows and air vents, through to the cracked and broken cement sheet and exposure of the sarking.

Figure 32: Shows the deck damage

Figure 33: Shows the deck damage and BPZ vegetation structure

These photographs (photographs 32 and 33) show the impact of the flame and heat induced from the burning deck and subsequent impact on the cement sheet. The cement sheet has cracked and then broken, exposing a portion of gap in the roof space. This gap then creates an opening for embers, radiant heat or direct flame contact to enter the roof space and ignite any suitable fuels. The cracking and braking of narrow cement sheets appears to be a fairly consistent outcome when these products are exposed to reasonable levels of radiant heat or direct flame contact.

Figure 34: Shows the broken cement sheet

Figure 35: Shows the sarking through the broken cement sheet

The fire ran towards the house from the right of the photograph in figure 31. There are no fences or barriers to prevent the radiant heat or direct flame contact impacting directly onto the home. The fuel load was partially managed with some owner intervention immediately adjacent to the home, but diminishing further out from the home. This type of fuel load management in many areas of the fire affected locations was fairly consistent as a theoretical approach, but not uniformly applied to the level as recommended by FESA. This home backed onto the landscape zone that was subject to the defoliation near Canning Mills Road as indicated in photographs 3 and 4.

As can be seen in the series of photographs the home was constructed to a reasonable standard, although not as prescribed by AS 3959 - 1999. The home survived the fire, possibly as a combined result of the firefighter intervention and the level of construction standard, such as boxed eaves. This home definitely had active firefighter intervention.

In the photographs below (photograph 27 and 28) you can see the impact of the radiant heat with the melting of the air vent, the reduced fuel load near the retaining wall and the benefits of having the patch between the home and the bush.

Photograph 36: The view along the home adjacent to the bush.

Photograph 37: The melted air vent and smoke staining on the eaves.

Most of the homes that suffered direct flame contact or radiant heat damage as a consequence of the bushfire did so because the BPZ was not appropriate. The hazard separation zone was also not at the prescribed level for a number of locations. If the BPZ was 20 metres deep and contained 2t/ha the bushfire attack level would be 2.3kW/m², for the same BPZ depth but an increase of fuel load to 15t/ha it would increase the bushfire attack level to 17kW/m².

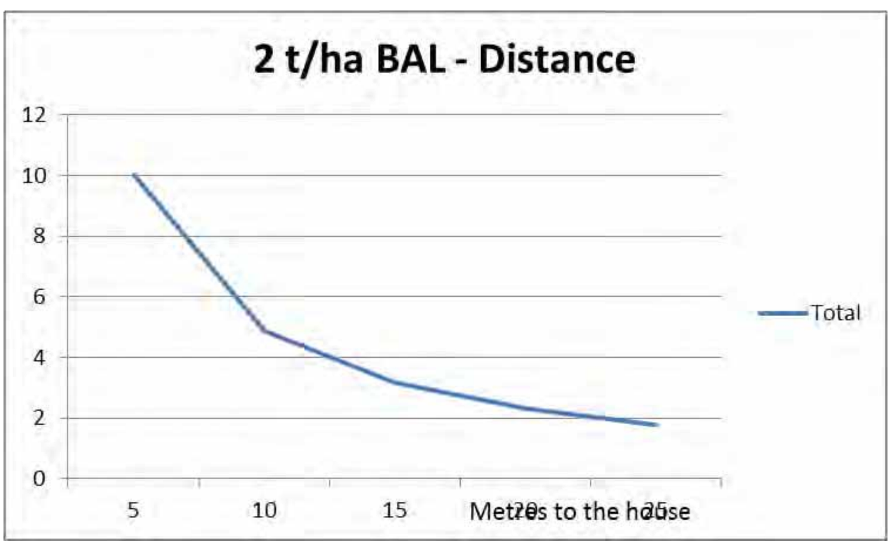


Figure 38 : Relationship between BAL and the distance to the house with a 2t/ha fuel load

This increase in bushfire attack level is critical in the survivability of the house. As can be seen from the following photographs the fuel load and fuel structure in the BPZ was continuous and at a fuel load that posed a risk to the survivability of the house. Across the fire zone the fuel loads were generally excessive for the level of standard for the houses that were constructed.

Photograph 39: This is the view of the BPZ and HSZ from near to the house

Hazard separation zone (HSZ)

The HSZ is the zone up to 100 metres out from the building. The HSZ may be reduced in accordance with 'Planning for Bushfire Protection' and AS 3959. For a reduction to occur the construction standards of the home should increase to compensate for the increased potential bushfire attack level onto the home. As this fire affected areas was not declared as bushfire prone, yet for much of the area was adjacent to a forest or woodland vegetation type. This would require these areas to have a HSZ of 100 metres with a fuel load of less than 8t/ha.

The impact of the fuel load on the bushfire attack level onto the house is demonstrated in the table. As is clearly demonstrated a high fuel load within the HSZ and close to the building will have a significant impact on the survivability of a standard construction homes in a bushfire risk area. FESA advocates that the fuel load should be less than or equal to 8t/ha in the HSZ. When coupled to a fuel load of 2t/ha in the BPZ it ensures that the fire is losing intensity and the bushfire attack level is reducing as the fire gets closer to the house. The standard construction home survivability is increasing as the appropriate fuel management is occurring in the BPZ and HSZ.

Photograph 40: This is the view of the BPZ and HSZ from near to the deck

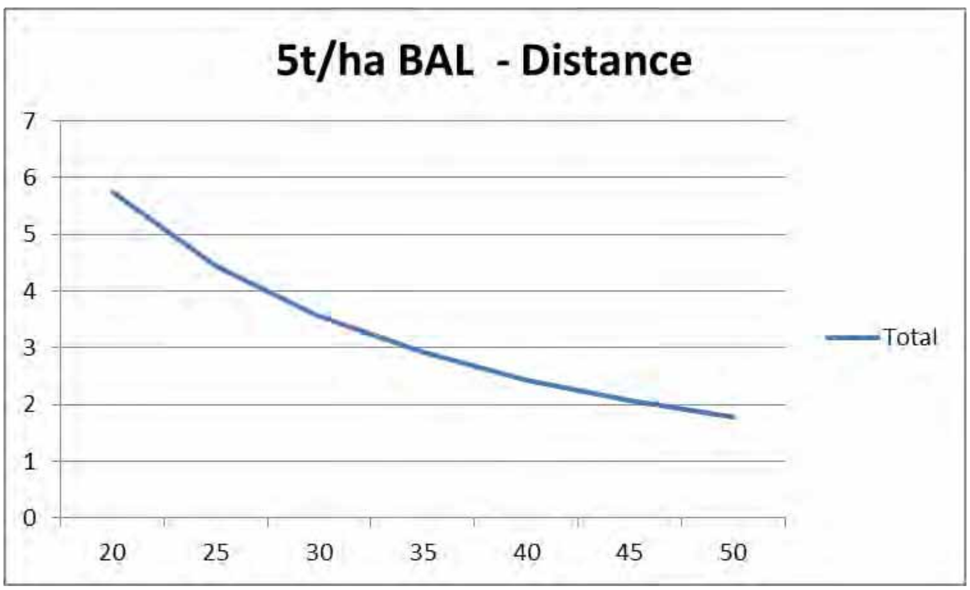


Figure 41: Relationship between BAL and the distance to the house with a 5t/ha fuel load

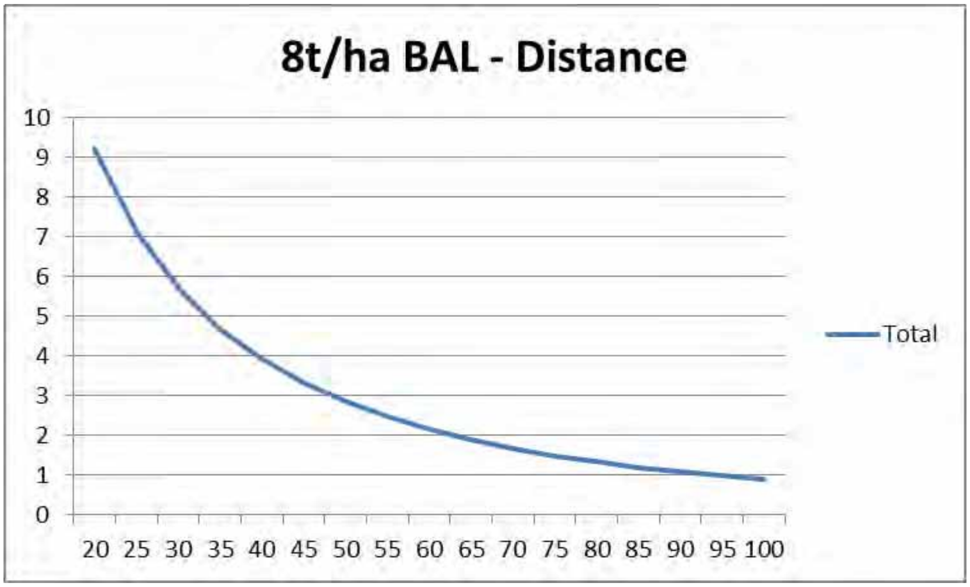


Figure 42: Relationship between BAL and the distance to the house with a 8t/ha fuel load

As can be seen in the two graphs (figures 39 and 40) where the fuel load increases the bushfire attack level increases and the level of construction must be enhanced if the house is to survive a bushfire. The area subject to this bushfire was not declared as a bushfire prone area and consequently houses were not constructed to the standard that would be applicable today if such a declaration had been made.

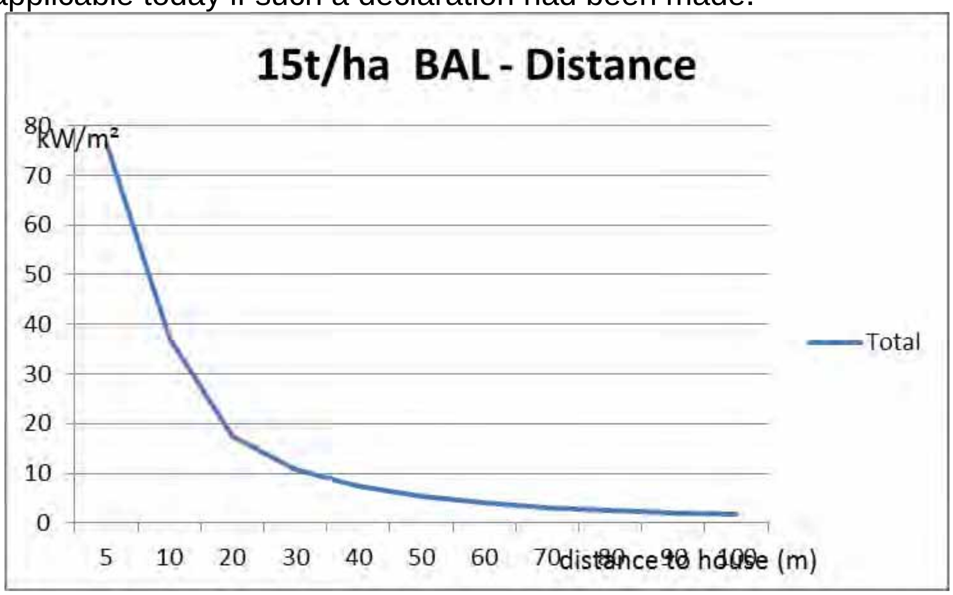


Figure 43: Relationship between BAL and the distance to the house with a 25t/ha fuel load

The above graph clearly reinforces the relationship between BAL and the distance to the house with a 15t/ha fuel load. The general estimated fuel load was 15t/ha in the landscape zone and also within the HSZ. At around 25 metres from the house the BAL would exceed BAL-12.5 construction standard. As these homes were generally not constructed to an elevated standard they would have been at an exceeded threat level from a bushfire at distances around 50 metres.

Table 5: Indicative BAL, distance from the vegetation and the fuel load.

Fuel load **15t/ha** **Distance to the building**	**BAL** **Intensity** **kW/m²**
100 m	1.69
80	2.52
60	4.06
40	7.38
20	17.4
10	37.11
5	76.03
Fuel load **8t/ha**	
100 m	0.9
80	1.34
60	2.15
40	3.92
20	9.21
10	19.57
5	40.31

Utilising the tree crown scorch height and defoliation levels as an indicator of the fire behaviour it is possible to analyse the fire behaviour in the HSZ. As can be seen in the following photographs, which have been taken at various locations across the fire zone, the fire intensity varied significantly.

Figure 44 shows a high intensity fire has travelled through the landscape. The trees have either been defoliated or suffered significant crown scorch for the entire height of the tree which are in the vicinity of 12 – 15 metres.

Figures 44 and 45 are indicative of the fire behaviour as the fire has got close to the HSZ. This indicates that fire was at a bushfire attack level that would have resulted in a standard construction home being attacked at a level above its constructed standard and therefore unlikely to survive undamaged or being destroyed.

Figure 44: Shows the indicative fuel structure in the HSZ

The flame length for forest and woodlands are calculated using the formulae $L_f = (13 R_{slope} + 0.24W) / 2$[11]

Where:

L_f = flame length
R_{slope} = forward rate of spread adjusted for effective slope (km/hr)
W = overall fuel load (t/ha)

By applying this formula it is estimated that the headfire flame lengths would have been in the vicinity of 7.8 to 11 metres. This greatly exceeds the flame lengths that firefighters can directly attack. These fire line intensity levels, flame heights and restricted access options forced the firefighters to attack the flanks of the fire.

[11] Standards Australia, 2009, "AS 3959 – 2009 Australian Standard Construction of buildings in bushfire-prone areas," Standards Australia, Sydney

Table 6 – Flame length for forest and woodland fuels on undulating ground with average weather conditions

Time	Bickley HFRoS Forest[12] (m/hr)	Bickley Forest kW/m	Bickley HFRoS Grassland[13] (km/hr)	Bickley Grassland kW/m	Champion HFRoS Forest (m/hr)	Champion Forest[14] kW/m	Flame length based on Bickley forest (m)
1200	1414	10,652	5.7	12,034	1142	8,602	11
1300	1423	10,720	5.1	10,767	1216	9,160	11
1400	1552	11,692	5	10,556	1344	10,124	11.6
1500	1511	11,382	4.3	9,078	1505	11,337	11.6
1600	1456	10,968	3.9	8,234	1334	10,049	11.3
1700	1442	10,863	4	8,445	1515	11,412	11.2
1800	1413	10,644	4.2	8,867	1530	11,525	11
1900	1192	8,979	3.6	7,600	1749	13,173	9.5
2000	1079	8,128	3.4	7,178	1207	9,092	8.8
2100	1173	8,836	4.1	8,656	1212	9,130	9.4
2200	1112	8,376	4.3	9,078	1107	8,339	9
2300	916	6,900	3.5	7,389	1036	7,804	7.8

Figure 45: Shows the indicative fuel structure in the HSZ and adjacent to the landscape zone

[12] Based on the assumption of a forest and woodland fuel load of 15 t/ha
[13] Based on the assumption of a grass fuel load of 4 t/ha
[14] Based on the assumption of a forest and woodland fuel load of 15 t/ha

Figure 46 is lower in the profile and close to the gully associated with the Brookton Highway zone which also contained the river and riparian vegetation. As can be seen the crowns of the vegetation are still intact and therefore attacked with a relatively low intensity fire.

Figure 46: Indicative fuel structure in the HSZ adjacent to a home that was destroyed

Figure 47 shows the impact of the fire on a home with a corrugated iron roof. The entire home is destroyed and burnt to the ground. The tree crowns are intact and only partially scorched indicating that the fire rate of spread and intensity was not great. As the site has not been burnt for a number of years the volume of embers would have been significant. Research conducted by Ellis[15] and presented in 2003 indicates that for an older jarrah forest fuel there can be a marked increase in the number of viable embers being generated and these embers may travel further than for a younger fuel in the jarrah forest fuel type.

Figure 48 is indicative of the fire rate of spread and intensity adjacent to a home that was destroyed by the fire. This indicates that managing the construction standard, BPZ and HSZ are essentially in ensuring that a bushfire's impact on the house is minimised.

[15] P Ellis, 2003, Presentation at the Wildland Fire Conference, Sydney, 2003.


Figure 47: Indicative fire impact in the HSZ adjacent to a home that was destroyed


Figure 48: Indicative fuel structure in the HSZ adjacent to home that was destroyed

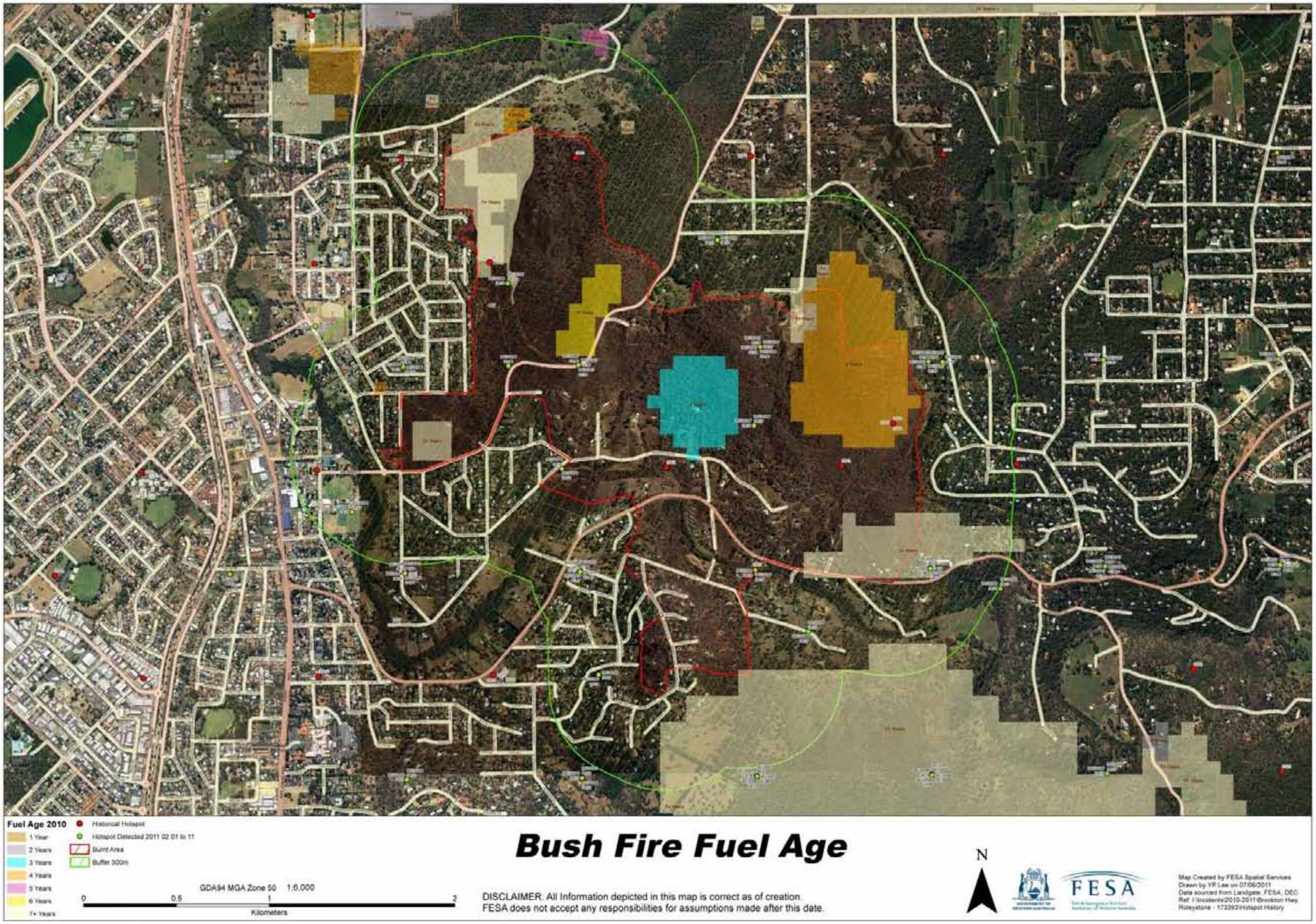
A further consideration during the field assessment was whether there was any land management practices that could have been used to mitigate against the rapid spread of the fire. There were no properties that were destroyed by direct flame contact or radiant heat where it was possible to identify (either through owner/occupier advice or visual inspection) that they had developed an appropriate BPZ and HSZ or increased the construction of the home to align t the current AS 3959.

3. Impact of the fire on the buildings and surrounds

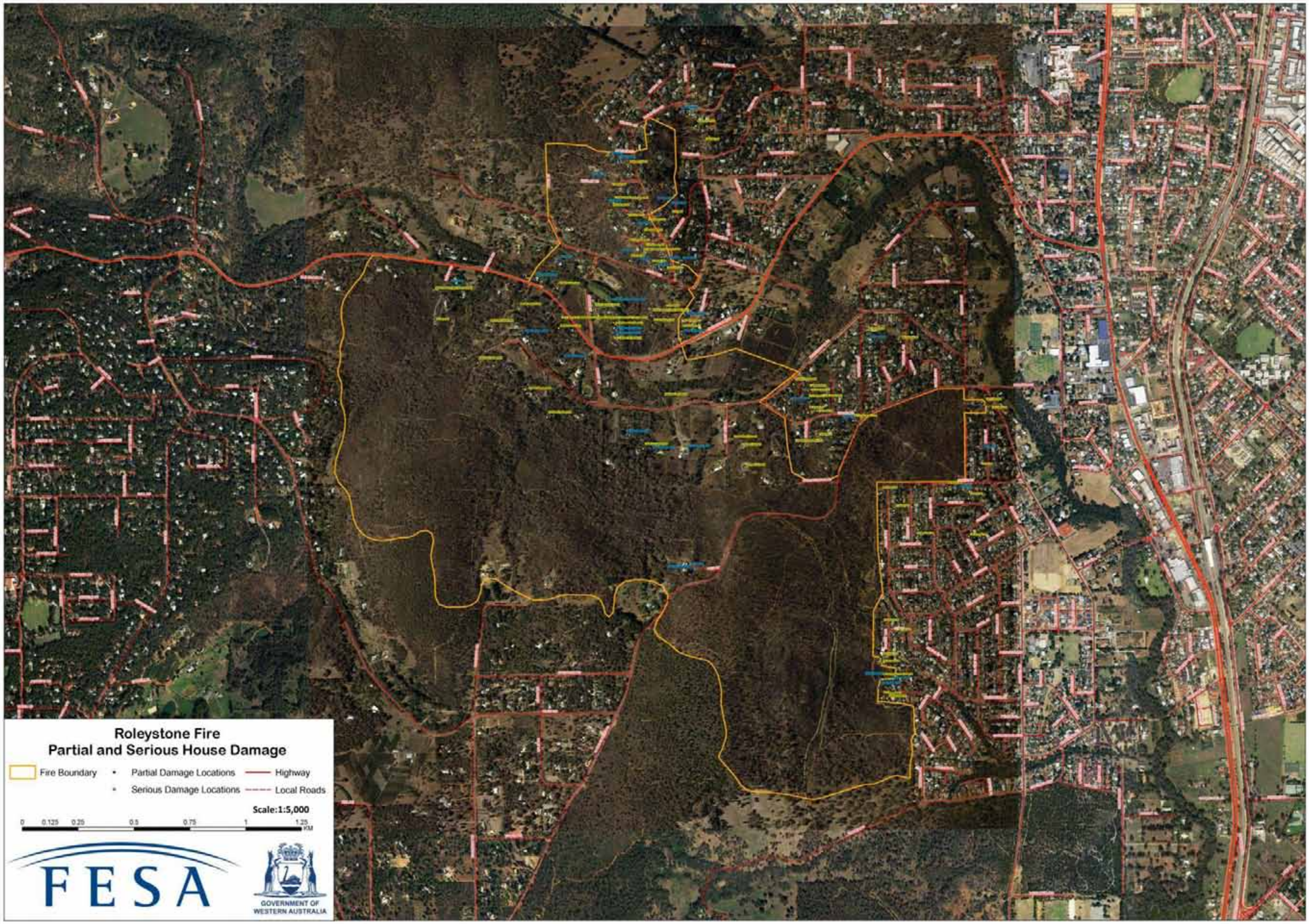
The fire had a significant impact on a range of houses primarily because the homes were not constructed to the current standard applicable today. The housing construction standards are not retrospective so as new knowledge and technology changes occur, homes that are already constructed will not be increased in construction standards. This potentially exposes these homes to a bushfire threat.

From the survey it was found that 12 homes suffered some fire damage but the home survived, and 48 homes suffered no damage and all had the benefit of some intervention whether by a firefighter or others. Historically it has been considered that a house is more likely to survive a bushfire if the house is well prepared, the occupier is well prepared and knowledgeable of the consequences and knows what is required. The historical position has been based on research. However it is very difficult to determine if the house or occupier is well prepared during the management of a significant running bushfire and it is therefore important to apply a conservative policy of ensuring protection of life.

Appendix 1


Fuel Age 2010
1 Year
2 Years
3 Years
4 Years
5 Years
6 Years
7+ Years
Historical Hotspot
Hotspot Detected 2011 02 01 to 11
Burnt Area
Buffer 500m
GDA94 MGA Zone 50 1:6,000
0 0.5 1 2
Kilometers
Bush Fire Fuel Age
DISCLAIMER: All information depicted in this map is correct as of creation.
FESA does not accept any responsibilities for assumptions made after this date.
N
FESA
Map Created by FESA Spatial Services
Drawn by YP Lee on 07/06/2011
Data sourced from Landgate, FESA, DEC
Ref: I:\Incidents\2010-2011\Brookton Hwy, Roleystone - 173393\Hotspot History

Appendix 2


Roleystone Fire
Partial and Serious House Damage
Fire Boundary
Partial Damage Locations
Serious Damage Locations
Highway
Local Roads
Scale:1:5,000
0 0.125 0.25 0.5 0.75 1 1.25 KM
FESA
GOVERNMENT OF WESTERN AUSTRALIA

Appendix 3

FESA

Fire & Emergency Services Authority of Western Australia

BUSHFIRE & ENVIRONMENTAL PROTECTION BRANCH

BUSHFIRE BUILDING DAMAGE SURVEY

Date (of fire): ____________________

House address / location: ____

Owned by: _______________________ Phone number: __________________

Date (of assessment): _____________________ GPS: ____________________

☐ House Survived – untouched

☐ House survived – superficial damage

☐ House survived - light damage (still habitable)

☐ House survived - medium damage (marginally habitable)

☐ House survived - heavy damage (unlikely to be habitable)

☐ House destroyed, site not cleared

☐ House destroyed, site cleared

Building Details

Number of functional areas

- ☐ One level
- ☐ Split single level
- ☐ Two levels
- ☐ More than two full levels
- ☐ Other (illustrate) ……………………………………………………………..
- ☐ Unknown

Distance from the edge of the floor to the ground

Side nearest to the ground		Side furthest from the ground
☐	☐	Contacting the ground
☐	☐	<600 mm
☐	☐	600mm to 1.6m
☐	☐	>1.6 m
☐	☐	Unknown

Major material supporting the floor

- ☐ Jarrah
- ☐ Other timber
- ☐ Concrete stumps
- ☐ Steel posts
- ☐ Bick piers, walls
- ☐ Slab on the ground
- ☐ Unknown
- ☐ Other …………………………

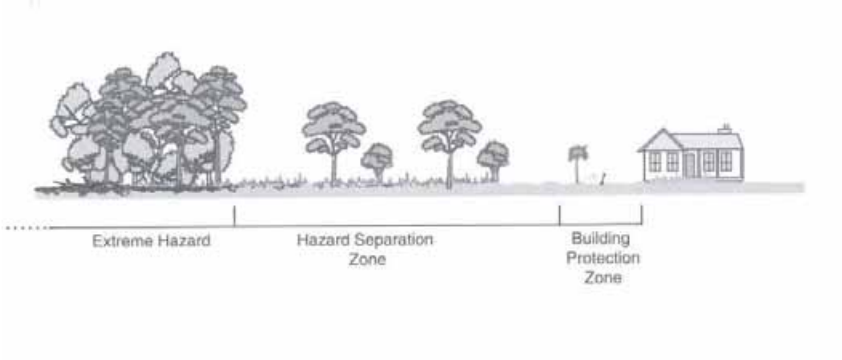
External walls

- ☐ Brick (other than mud brick)
- ☐ Cellulose cement
- ☐ Corrugated iron
- ☐ Unknown
- ☐ Mud Brick
- ☐ Timber
- ☐ PVC siding
- ☐ Other ……………………………

Roof material

- ☐ Metal deck
- ☐ Corrugated iron
- ☐ Corrugated cement sheet
- ☐ Tiles (terracotta, concrete)
- ☐ metal pseudo tiles
- ☐ Unknown
- ☐ Other ……………………………..

Construction standard		YES	NO	Unknown
1	Was the property enhanced above the standard construction standards?			
2a	Did the house have a patio on the side of the house from which the fire attacked?			
b	If yes, what were the supports constructed from? (list)			
c	If yes, what was the roof constructed from? (list)			
3a	Did the house have a deck?			
b	If yes, was it constructed of wood or other flammable material?			
c	If yes, what were the supports constructed from? (list)			
4	Did the house have boxed eaves?			
5	Did the house have sarking under the roof?			
6	Did the house have gaps in which embers could enter the roof, walls or under the house?			
7	Were there skylights in the roof?			
9	If yes, were they	Plastic	Plain wire	Wired glass
10	What was the size of the home?	<80m²	80-150	>150 m²
11	Did the house have shutters over the windows?			
12	Did the house have fly wire (not fibreglass) on doors and windows?			
13	Were the window frames wood or aluminium?	Wood	Alum	
14	Were there door mats adjacent to areas that may trap embers?			
15	Did/does the house have evaporative air conditioning?			
16	Did/does the evaporative air conditioning have a protective cover and was it applied?			
17	Is/was the house permanently occupied?			
18a	Were there gutters?			
b	If yes, were the gutters clear of leaves and litter?			



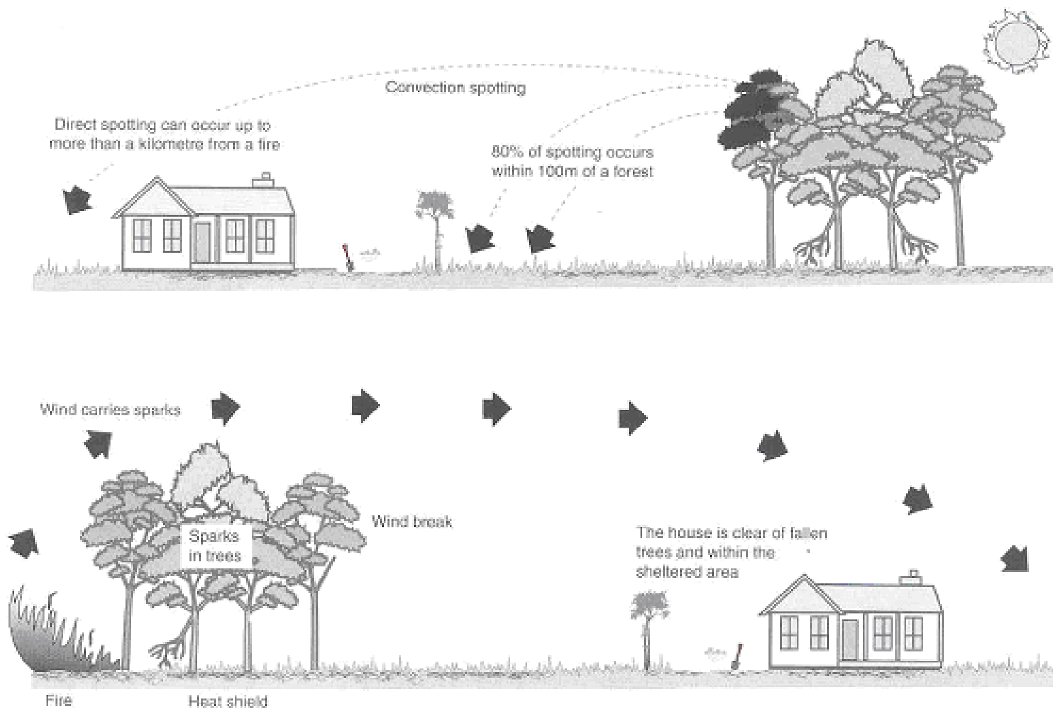
Building Protection Zone : 20 metres 'Circle of Safety'		**YES**	**NO**	**?**
1	Was there tall (> 10 cm high) vegetation (grass) within 20 meters of the house, other than the odd shrub (not clumped)?			
2	Were there (tall) plants adjacent (within 2 metres) to windows?			
3	How close were the shrubs to the building?			metres
4	Were the shrubs adjacent to the fire entry into the building?			
5	Was there dead material in the crown of the vegetation?			
6	Were there tree crowns within 2 metres of the house?			
7	Were there tree crowns over hanging the house?			
8	Were the tree crowns less than 10 – 15 metres apart?			
9	Was the wood heap close to the house (within the BPZ)?			
10	Was there more than 2 t/ha of available fuel in the BPZ?			
11	Is/was there a fence close to the house (< 5m)?			
12	If Yes, was it of combustible material?			
13	Did it burn or lose rigidity and impact onto the integrity of the house?			
14	Was /are there flammable liquids stored in the house or surroundings?			
15	Was / are the gas cylinders appropriately placed and protected from radiant heat?			
16	Did the gas bottles vent?			

17	Was / is there anything obvious that exposes the house to an unreasonable level of threat? If yes describe: …………………………………………………………………… …………………………………………………………………… …………………………………………………………………… ……………………………………………………………………			

Hazard Separation Zone (HSZ)				
1	What is the distance between the house and the principal vegetation - <16m, 16 – <21m, 21 - <31, 31 - <42m, 42 – 100m, >100m in the direction of the head fire travel?			
2	What was the principal vegetation type? F, W, S, MM, G			
		YES	**NO**	**?**
3	Is the site sloped?			
4	If Yes is the home upslope from the predominant vegetation?			
5	What is the slope (degrees)?			
6	Was / is there more that 5t/ha of available fuel in the HSZ? If yes what was the estimated tonnage?			
7	Did the fire run up the slope or down the slope to the home?			

Vegetation code - F = Forest, W = Woodland, S = Shrubland,

MM = Mallee/mulga G = Grassland/pasture T = Tropical savanna woodland



Building protection zones must be maintained around all buildings.

Fuel (Vegetation)		
1	How long it had been prior to this fire since the native vegetation in the immediate vicinity of the home was burnt (within 1 km)?	……………………………………………………………. ………………………………………………Unknown
2	How much litter (depth) was present on the ground before the fire (HSZ)?	……………………………………………… Unknown
3	Was the area grazed in the vicinity of the house? If yes, was it heavily grazed (HSZ)?	……………………………………………………………. ……………………………………………… Unknown

Within the HSZ what was the:

Fuel Load prior to the fire ~ scrub / leaf………/…………t/ha

Topography ……………………………………

Leaf litter percentage consumed ……………………% of total

Scrub fuel (≤1.5 m high) percentage consumed……………………% of total

Height of scrub scorch (m) - …………………..

Percentage of scrub crown scorch - ……………%

Percentage of scrub crown defoliation - …………..%

Height of average tree crown scorch (to the highest point)- ……….. (m)

Percentage of tree crown scorch - …………..%

Percentage of tree crowns defoliated - ………%

Describe the native vegetation (see guide below)

Tree structure Total = 27, 12, 3

Scrub structure rating – Young / Growing / Mature / Over mature / Unknown

Land Use		
1	What is the main use of the land on the property, e.g grazing, lifestyle, conservation?	G / L / C
2	Other than perimeter firebreaks were there any fire breaks or tracks intersecting the property?	Yes / No / Unknown
3	Are there any land management practices that could have been used to mitigate against the rapid spread of the fire? Describe: ……………………………………………………… ………………………………………………………………….. …………………………………………………………………..	
4	Is the property rented or owned by occupier?	Rented / owned / Unknown
5	Is the home permanently occupied?	Yes / No / Unknown
6	Are the residents mentally and physically confident of staying and defending the house?	Yes / No / Unknown
7	Have the residents undertaken bushfire preparedness measures and have a bushfire plan?	Yes / No / Unknown

Fire behaviour		
1	Was anyone present during the fire? If so are they able to provide any information regarding fire behaviour, e.g. direction of fire, speed (rate of spread) of the fire, spotting?	Yes / No / Unknown
	………………………………………………………………………………… ………………………………………………………………………………… ………………	

Residents Feedback	
1. Did you or others (including fire fighters) stay and defend your house? a) Who undertook the intervention? b) What was the intervention? ……………………………………………………………… ………………………………………………………………..	Yes / No / Unknown Self/ neighbour/ fire fighters / unknown
2. Were there many sparks (embers) that fell onto your house and yard?	Yes / No / Unknown
3. From which way was the wind blowing? a) How strong was the wind?	

Further Comments

(if the property owner/occupier has any further comments please provide them here)

………
………
………
………
……………………………………………

If required sketch the area of interest

Sketch Plan
Approximate scale 1: 0.25 m 1: 0.5 m 1: 1 m 1: 2m 1: 5m

Legend:

Running head fire direction (Red)	⟶	Backing fire direction (Black)	➢
Road, track or firebreak (Black)	------	Building or structure (Black)	☐
Tree (Black)	☼	Clumps of shrubs	☾
Photograph and direction of shot (Blue)	♂	Impact zone on the house	⚡

Vegetation Type

Forest Woodland with scrub Tropical savanna woodland Grassland (crop / pasture)

Tree structure

	1. Crown is around 1/3 the height of the tree 2. Crown is equal height and width 3. Crown is dense with many leaves covering all limbs Each component is rated up to 3 eg Crown is around 1/3 the height of the tree – Yes = 3 Crown is equal height and width - Yes = 3, No = 2 or 1 Crown is dense with many leaves covering all limb – Yes = 3, No = 2 or 1 **Total 3x3x3 = 27**

	1. Crown is less than 1/3 the height of the tree 2. Crown is less than the height and width ratio 3 Crown is dense with many leaves Each component is rated up to 3 eg Crown is less than 1/3 the height of the tree Yes = 3 Crown is less than the height and width ratio – Yes =2 Crown is dense with many leaves Yes = 3, No = 2 **Total 3x2x2 = 12**
	1. Crown is significantly less than 1/3 the height of the tree 2. Crown is not equal height and width 3. Crown is sparse with many limbs exposed and few leaves Each component is rated up to 3 eg Crown is significantly less than 1/3 the height of the tree - Yes = 1 Crown is not equal height and width – Yes = 1 Crown is sparse with many limbs exposed and few leaves – Yes = 1 **Total 1x1x1 = 3**

Scrub structure

  	1. Young & growing 2. Green 3. Foliage is sparse & generally low 4. Easy to walk through **Rating = Young**
	1. Still growing, but may have flowered and set seed 2. Basically green foliage but up to 20% may be dead 3. Foliage is moderately fine in structure 4. Mixed size classes of scrub vegetation 5. Medium density 6. Moderately easy to walk through

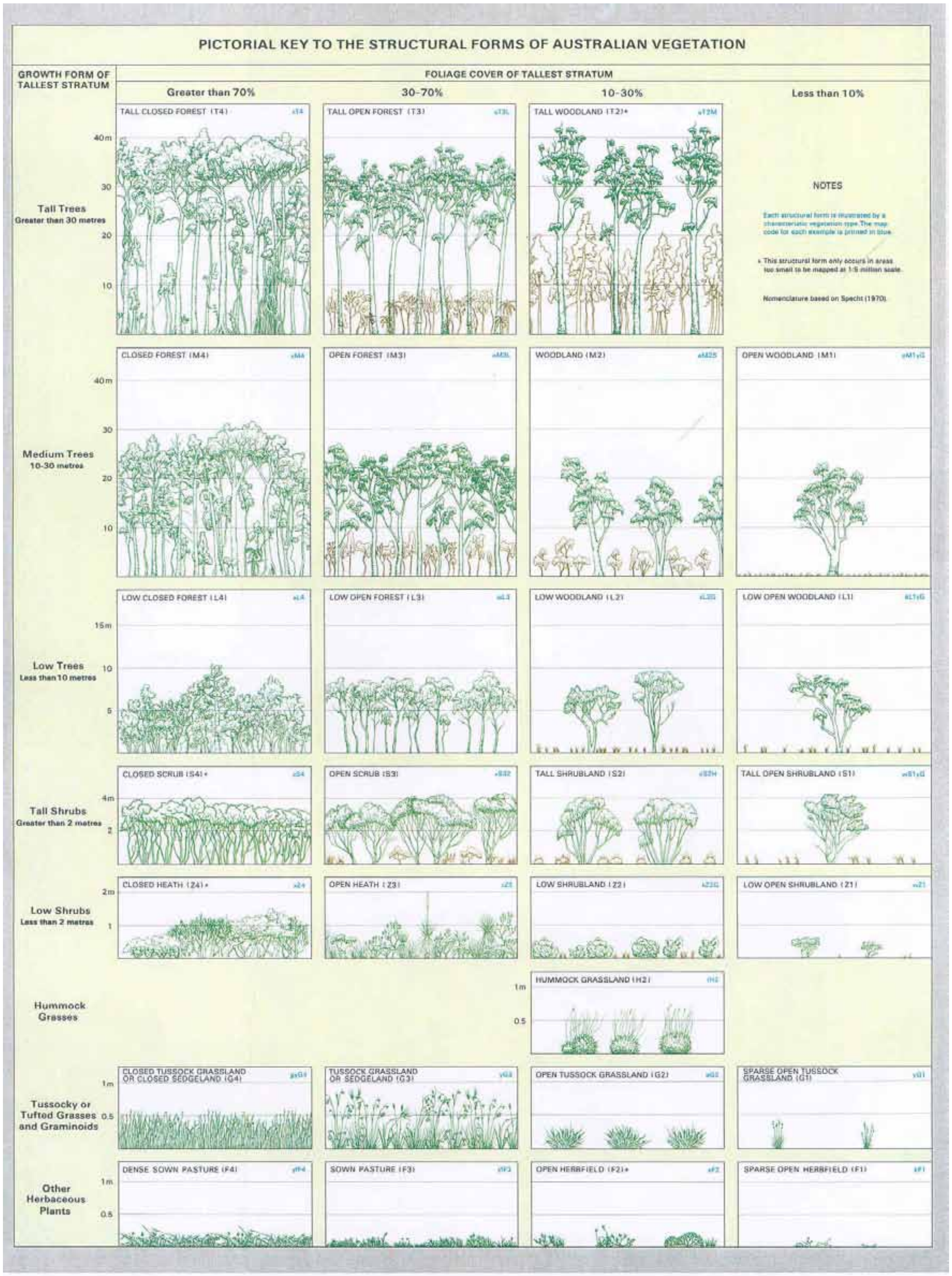
 	**Rating = Growing**
	1. Many plants starting to mature 2. Foliage may be up to 50% dead 3. Foliage is moderately fine with some coarse material 4. Mixed size classes of scrub vegetation 5. Dense and/r continuous vegetation layer 6. Difficult to walk through **Rating = Mature**

	
	1.Many plants mature and commencing senescence 2. Foliage over 50% dead 3. Foliage is moderately coarse with some fine material 4. Mixed size classes of scrub vegetation 5. Dense continuous vegetation 6. Difficult to walk through **Rating = Over mature**

Vegetation of Western Australia

Name	Description	Height	Foliage cover	Comment
Tall Closed forest	Trees	>30 m	>70%	Rainforest
Tall Open forest	Trees	>30 m	30-70%	Karri forest
Medium Closed forest	Trees	10-30 m	>70%	Rainforest
Medium Open forest	Trees	10-30 m	30-70%	Eucalypts predominant
Woodland	Trees	10-30 m	10-30%	Transitional zone between higher rainfall forest margins and arid interior
Woodland Open	Trees	10-30 m	<10%	Euc studded grasslands
Low Trees Closed forest	Trees	<10 m	>70%	Widespread but patchy across nth Australia
Low Trees Open forest	Trees	<10 m	30-70%	Acacia forest of NT & Qld
Low woodland	Trees	<10 m	10-30%	Floristically very diverse
Open woodland	Trees	<10 m	<10%	Throughout much of inland Aust. Scarce water & poor soils
Tall Shrubs Open scrub	Shrubs	>2 m	30-70%	
Tall shrubland	Shrubs	>2 m	10-30%	Mallee & Mulga
Open shrubland	Shrubs	>2 m	<10%	Most widespread structural form of vegetation
Low Shrubs Open heath	Shrubs	<2 m	30-70%	
Low shrubland	Shrubs	<2 m	10-30%	Saltbush & bluebush
Low open shrubland	Shrubs	<2 m	<10%	Extreme environment – rocky ranges or skeleton soils
Hummock grasses			10-30%	Grass steppe
Tussocky or tufted grasses	Closed tussock grassland or sedgeland		>70%	
Tussock grasses				
	Open tussock grassland		10-30%	Mitchell grass
	Sparse open tussock grassland		<10%	Mainly on clay plains

Source: "Atlas of Australian Resources Vegetation", 1990, AUSLIG, Australian Government Publishing Service, Canberra



PICTORIAL KEY TO THE STRUCTURAL FORMS OF AUSTRALIAN VEGETATION
GROWTH FORM OF TALLEST STRATUM
FOLIAGE COVER OF TALLEST STRATUM
Greater than 70%
30-70%
10-30%
Less than 10%
Tall Trees
Greater than 30 metres
TALL CLOSED FOREST (T4)
TALL OPEN FOREST (T3)
TALL WOODLAND (T2)*
NOTES
Each structural form is illustrated by a characteristic vegetation type. The map code for each example is printed in blue.
* This structural form only occurs in areas too small to be mapped at 1:5 million scale.
Nomenclature based on Specht (1970).
Medium Trees
10-30 metres
CLOSED FOREST (M4)
OPEN FOREST (M3)
WOODLAND (M2)
OPEN WOODLAND (M1)
Low Trees
Less than 10 metres
LOW CLOSED FOREST (L4)
LOW OPEN FOREST (L3)
LOW WOODLAND (L2)
LOW OPEN WOODLAND (L1)
Tall Shrubs
Greater than 2 metres
CLOSED SCRUB (S4)*
OPEN SCRUB (S3)
TALL SHRUBLAND (S2)
TALL OPEN SHRUBLAND (S1)
Low Shrubs
Less than 2 metres
CLOSED HEATH (Z4)*
OPEN HEATH (Z3)
LOW SHRUBLAND (Z2)
LOW OPEN SHRUBLAND (Z1)
Hummock Grasses
HUMMOCK GRASSLAND (H2)
Tussocky or Tufted Grasses and Graminoids
CLOSED TUSSOCK GRASSLAND OR CLOSED SEDGELAND (G4)
TUSSOCK GRASSLAND OR SEDGELAND (G3)
OPEN TUSSOCK GRASSLAND (G2)
SPARSE OPEN TUSSOCK GRASSLAND (G1)
Other Herbaceous Plants
DENSE SOWN PASTURE (F4)
SOWN PASTURE (F3)
OPEN HERBFIELD (F2)*
SPARSE OPEN HERBFIELD (F1)