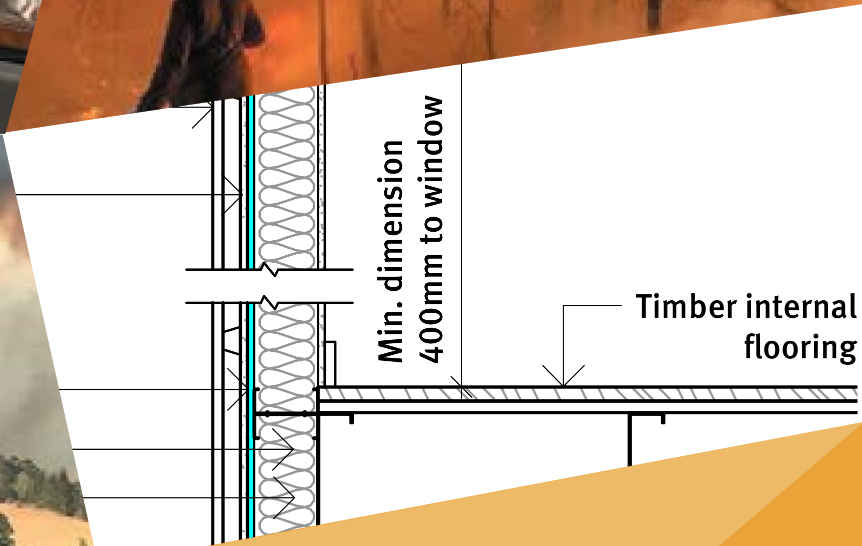

Bushfire Resilient Building Guidance for Queensland Homes

CSIRO
Queensland Government

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- Department of Housing and Public Works
- Queensland Fire and Emergency Services
- Queensland Treasury
- Local Government Association of Queensland
- Queensland Building and Construction Commission
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This guidance provides information about improving the bushfire resilience of new and existing Queensland homes.

Bushfire threat. Source: QFES

Contents

Bushfire Resilient Building Guidance for Queensland Homes

Bushfires are a natural part of the Australian landscape, but they can have devastating consequences on people and communities. The purpose of this guideline is to help the people of Queensland mitigate these effects. The guideline provides innovative, practical and affordable solutions for adapting homes and gardens to be more bushfire and heat resistant.

Preparing for bushfires is critical to minimising their associated risks. This is especially important for Queenslanders living in bushfire prone areas. Where and how we live and the way we organise our communities will determine the way we prepare and respond to bushfire threats. The guideline provides information about bushfire hazards and how they interact with buildings and landscapes. The guideline also describes the various measures that can be taken to improve the chances of both people and property surviving a bushfire.

The guideline identifies a suite of best practice building and landscaping measures, using tailored, site-specific solutions to adapt buildings for bushfire resilience. The guideline is based on extensive research into the attack mechanisms of bushfires and the different ways that buildings and gardens may be vulnerable to these attacks.[1]

This document provides guidance to stakeholders that can be used to design and build new homes or retrofit existing buildings. It can also be used to design or upgrade the landscape immediately surrounding the home, for better bushfire outcomes. It provides guidance on bushfire resilient design principles, constructions details, types of material, landscaping, and highlights the importance of maintenance and preparation.

1 See for example, Barrow, 1945; Ramsay et al. 1996; Leonard et al. 2006, 2009, 2016; Blanchi and Leonard, 2008; Arena et al., 2018.

Is this guideline for you?

The guideline was developed to support a state-wide effort in mitigating catastrophic impacts from bushfires, and to provide additional assistance in developing resilient communities throughout Queensland. The guideline provides information for homeowners and the building industry on how to develop more resilient housing in bushfire prone areas. As a best-practice document, and for the benefit of property owners, this guidance goes beyond the official building regulations.

The information presented here is not intended to replace existing regulations, legislation or expert advice on building in bushfire prone areas. It is still necessary to comply with existing building and urban planning regulations, and follow the advice and guidance provided by fire authorities and related agencies.

Bushfire resilience is multifaceted and requires attention at different scales. This guideline focuses on determining appropriate measures to increase bushfire resilience at individual property, neighbourhood and community scales.

Home under fire threat. Source: QFES

Understanding your bushfire risk

Understanding how bushfires behave and how buildings are typically impacted is essential for determining what measures can be taken to mitigate bushfire risks. Research has shown that house loss is a complex phenomenon that is dependent on a combination of factors, including fire severity, house design, and the type and arrangement of surrounding objects. For any bushfire event, it is important to assess the potential intensity of the fire and to know how to respond to the different types of bushfire attack.

Information on how bushfires spread, how to identify your own bushfire risk and who to contact for advice is provided in **Part 1: Bushfire essentials.**

Climate change

Climate change has led to longer and more intense periods of extreme weather and more elevated fire weather days. From a building perspective, this means an increase in the chance of bushfire and an increase in the potential severity of the bushfire itself.

Firefighter intervention. Source: Hugh Strong, QFES

Protecting yourself and your family

For all Queenslanders living in bushfire prone areas, it is vitally important to develop a bushfire survival plan and implement a routine of building and landscape maintenance (refer to **Part 6 Ongoing maintenance**). Bushfires are chaotic and dangerous for even the most experienced firefighters, and the consequences of failing to respond properly (both before and during the event) may be catastrophic.

A bushfire survival plan helps your household to make important and potentially life-saving decisions when threatened by bushfire. A well-thought-out plan will protect the lives of your family and will assist you in preparing your home to survive the event.

A bushfire survival plan must be completed well ahead of the bushfire season to allow time to prepare yourself, family and home. Each occupant should read and understand the plan, and a hard copy version should be kept in case digital systems are not working.

The plan should step through each decision the household needs to make and agree on the steps you will each take in the event of a bushfire. For example, will you stay and defend, or will you leave early, and if you leave, what will you take with you?

To develop and prepare a bushfire survival plan, refer to the online guide provided by the Queensland Rural Fire Service, available at: www.ruralfire.qld.gov.au/BushFire_Safety/Pages/Create-your-bushfire-survival-plan.aspx.

Benefits of bushfire resilient homes

Bushfire resilient homes and landscapes will help:

- reduce the loss of life from bushfires
- reduce the impact and number of homes and buildings lost to bushfire
- improve community resilience to bushfire events
- reduce the social and financial cost of recovering from bushfires
- conserve and enhance Australia's biodiversity and ecological value.

Bushfires and insurance

Most insurance plans cover your home and contents in the event of bushfire. However, it is common for homes to be underinsured, meaning that many residents face an unexpected financial hit post-bushfire. It is important to regularly check your policy to make sure you understand the coverage that your plan provides, and to update the value of your home and contents.

A bushfire resilient home will have an increased chance of surviving a bushfire. Consider discussing the measures you have taken (or propose to take) with your insurer and ask whether these measures may lower your insurance premiums.

Well-designed and well-maintained bushfire resilient home. Source: Andrew Halsall

Other benefits

Homes that are built to high bushfire resilient standards are also energy efficient. By necessity, a bushfire resilient home has fewer gaps and openings and better insulating properties, resulting in a home that requires less energy to heat and cool. Bushfire resilient homes also tend to be better built, meaning lower maintenance costs compared to traditional buildings. These economic and environmental benefits are magnified when considering future predicted climate changes.

Importantly, the cost of building a bushfire resilient home—or retrofitting an existing home to be bushfire resilient—need not be prohibitive. Depending on the size and complexity of your build, a local draftsman or designer can help, and there are many free resources available, this guideline included.

The benefits of a bushfire resilient design are far-reaching and support the economic, social and environmental recovery of a community in the aftermath of a bushfire.

Peregian bushfires October 2019. Source: QFES

Alignment with the regulatory guidelines

Various state and federal regulations specify the requirements of planning and building for bushfire resilience in order to avoid or mitigate the risk of bushfires, protect people and property, and enhance the community's resilience to bushfires. The best indicator of whether these regulations apply to your situation is to identify if you are in a bushfire prone area.

If you live within or plan to build in a bushfire prone area, additional (bushfire specific) building requirements will apply, including constructing to *Australian Standards, AS 3959 (2018) Construction of buildings in bushfire-prone areas*; or *NASH Standard (2014) Steel framed construction in bushfire areas*.

A bushfire prone area is land that is potentially affected by significant bushfires, including vegetation likely to support a significant bushfire, and adjacent land that could be subject to impacts from a significant bushfire.[2] These bushfire prone areas have been identified by local governments as part of their local planning activities, or are based on a localised bushfire study or determined via mapping products designed to support the *Queensland State Planning Policy* ' (refer to How to assess your bushfire hazards' for more information).

The guidance provided in this guideline is in addition to existing building and planning regulations and does not replace the mandatory requirements outlined in legislations, codes, Australian standards and other standards referenced in any of the codes[3] (see Appendix C for more information).

2 Department of State Development, Manufacturing, Infrastructure and Planning (2019) Natural, hazards, risks and resilience – Bushfire. dsdmipprd.blob.core.windows.net/general/spp-guidance-natural-hazards-risk-resilience-bushfire.pdf (accessed May 2020).

3 This includes Building Act 1975, Building Regulation 2006, the National Construction Code's (NCC) Building Code of Australia, Queensland Development Code, Australian Standards (e.g. AS3959 - 2018 Construction of buildings in bushfire prone areas) and other standards (National Association of Steel-Framed Housing Standard *Steel framed construction in bushfire areas*) referenced in any of the code (see Appendix C for more information). If you are unsure if you are located in a BPA you should contact your local government.

How to use this guideline

Bushfire resilient building and landscape designs should be tailored to different building types and environments. Identifying which strategies are suitable for which situations can be difficult, therefore we recommend following the step-by-step user guide below.

Step 1: Bushfire essentials (Part 1; pages 12–29)

Refer to pages 12-29 for an introduction to bushfires and their behaviour. An understanding of these fundamentals will facilitate a better appreciation of the various risks associated with bushfire.

Step 2: Bushfire survival plan

It is important to create and maintain a bushfire survival plan, so you and your family know how to respond when threatened by bushfire[4].

Step 3: Bushfire hazard assessment (Part 1; pages 30–31)

Assess the bushfire hazard at your location by following the guidance in Part 1 on pages 30 to 31 and referring to the external resources shown in Appendix F.

Step 4: Building category

Select your project category from the following list:

- Building a new house or fixed structure (go to step 5)
- Renovating or retrofitting an existing house or structure (go to step 6)
- Landscaping the area around a new or existing house or structure (go to step 9)

Step 5: Siting and site layout (Part 2; pages 34–43)

When building a new house or fixed structure, it is important to site the building in the best location possible on the available land. Considerations should be made for bushfire resilience, site access, and aesthetic values and preferences.

Step 6: Bushfire resilient design principles (Part 2; pages 44–69)

Refer to pages 44-69 for guidance related to a range of fundamental design principles. This guidance will help optimise the building response for specific situations.

Step 7: Bushfire resilient construction (Part 3; pages 70–91)

Refer to pages 70-91 for guidance related to a range of building design features. Review the associated information for best practice advice on mitigating risks and enhancing bushfire resilience.

Step 8: Bushfire resilient materials (Part 4; pages 92–99)

Identify required materials by referring to specific entries in the bushfire resilient materials table. Review the associated information for best practice guidance.

Step 9: Bushfire resilient landscaping (Part 5; pages 100–119)

Refer to Part 5 for guidance on landscaping principles aimed at eliminating local bushfire hazards and reducing the intensity of bushfire attacks. Review the landscaping design and plant selection information for best practice guidance.

Step 10: Maintenance (Part 6; pages 120–128)

Refer to Part 6 for guidance on maintaining the bushfire resilient properties of buildings and landscapes. A routine of regular maintenance and management is imperative for all Queenslanders living in bushfire prone areas.

4 www.ruralfire.qld.gov.au/BushFire_Safety/Pages/Create-your-bushfire-survival-plan.aspx

Part 1: Bushfire essentials

Introduction

Bushfires are common in many parts of both rural and urban Queensland and can pose significant challenges for people living in bushfire prone areas. Understanding how bushfires behave is essential when it comes to planning, designing, building and surviving in a bushfire resilient house.

It is important to understand:

- the environments in which bushfires occur
- the challenges faced by people living in bushfire prone areas
- the different types of bushfires, their potential impacts, and how buildings ignite
- how to assess bushfire hazards in and around your property
- myths and misconceptions about bushfires.

Fire and bushfire

Fire is a chemical reaction which occurs when flammable objects combust and produce heat. Three elements are necessary to ignite and sustain a fire:

- fuel to burn (any kind of combustible material)
- heat to ignite the fuel
- oxygen in the atmosphere to sustain the fire.

A bushfire is an unplanned fire burning in forest, woodland, grassland or scrub (vegetation dominated by shrubs, low woody plants). Bushfires are a defining feature of many of Australia's ecosystems and they play an important role in shaping the landscape and the biodiversity within it.

Bushfires vary in size and intensity depending on the type and availability of fuel. Different vegetation burns differently, influencing the spread of bushfire and how hot it burns. For example, a bushfire in grassland will burn differently than a bushfire in forest, typically spreading faster but at a lower intensity.

Example of surface fire with candling of the bark.

Example of consequential fires, retaining wall burnt. Source: CSIRO

House loss because of bushfire is a complex phenomenon that involves several mechanisms related to the ignition and propagation of fire. When bushfires spread into an urban (or built-up) area, bushfires will impact both houses and their surrounding elements (e.g. fences, retaining wall, cars and sheds). Some of these surrounding elements will ignite and present additional impacts to buildings beyond the bushfire itself. This burning of surrounding elements is called a **consequential fire**.

Research tells us that buildings are most commonly ignited by embers and burning objects around the house.

Peregian bushfires October 2019. Source: QFES

Bushfire risk

The risk from a natural hazard, such as a bushfire, is determined by the combination of three elements: hazard, exposure and vulnerability.[5]

A **hazard** is defined as an event or natural phenomenon that may cause loss of life, injury, house and infrastructure damage, and socio-economic and environmental disruption.

Exposure refers to the elements exposed to bushfire. This includes people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas.

Vulnerability is defined according to the responses of people, houses and assets in mitigating the impacts of a hazard. Specifically, it refers to the extent to which a community, building, services or location is likely to be damaged or disrupted by the impacts of a hazard, such as a bushfire.

This guideline focuses on the house as the exposed element, and refers to the likelihood of the house either burning down or failing to provide safe refuge for its occupants (if they happen to be present). Hazard refers to the combination of bushfire and consequential fires experienced at the house. Vulnerability is defined by the house's response to the hazard, which may lead to either a life threat to its occupants or to house loss.

When occupants are present during a bushfire, they are often proactive in monitoring the house's condition and addressing minor ignitions as they occur. The success of these actions depends on:

- the number of able-bodied occupants
- the number of ignitions that occur concurrently
- whether ignitions occur in areas that are not easily monitored (such as in the roof cavity or underfloor space).

This guideline aims to reduce the potential for such ignitions to occur, by either protecting or eliminating the combustible elements that could ignite. This means that the house is more likely to survive irrespective of whether it is occupied.

The risk of building loss depends on the building's vulnerability to the hazards it is exposed to.

Building vulnerability refers to the weak points in a building caused by its design, construction, use of materials and management (including maintenance). These weak points are identified in the context that they are not able to withstand the level of hazard they are exposed to.

House damage from garden bed burning. Source: CSIRO

Climate and weather may directly influence the building's vulnerability through several processes, including:

- moisture content of combustible elements around and within buildings
- gaps between materials that may shrink and expand due to changes in moisture content and temperature
- wind action causing damage or dislocation of elements
- moisture content of fine combustible debris that may enter or have already accumulated in and around the house.

The level of bushfire **hazard** that a building experiences is influenced by a combination of factors, including the weather and local-climate conditions, topography, and fuel load from unmanaged vegetation: as well as other consequential fire sources. These consequential fire sources could be either fixed or movable such as ornamental vegetation, cars, caravans, sheds, garden materials and gas cylinders.

Potential source of consequential fires. Source: Larissa Cordner

5 *United Nations* www.un-spider.org/risks-and-disasters/disaster-risk-management (accessed May 2020). See also Queensland emergency risk management framework – Risk assessment process handbook: www.disaster.qld.gov.au/dmg/st/Documents/H1102-QFES-Risk-Assessment-Process-Handbook.pdf (accessed May 2020).

The mechanics of fire propagation

Fire behaves differently depending on the:

- vegetation (and other fuels)
- weather
- topography.

These three factors influence the intensity, speed and spread of a bushfire. Together, fuel, weather and terrain are often described as the fire behaviour triangle.

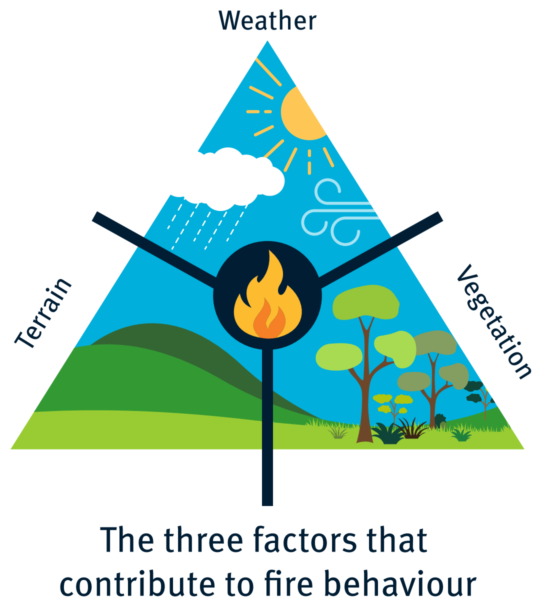


Figure 1 Fire behaviour triangle

Vegetation (and other fuels)

The behaviour of a fire will vary depending on the availability of fuel at a given location; it is therefore important to understand the characteristics of different vegetation types, as vegetation is a bushfire's main fuel source.

Different vegetation characteristics will have different impacts on a bushfire's behaviour.

Fuel size and shape—anything thinner than a pencil (e.g. grass and twigs) is considered a **fine fuel**, which ignites and burns very quickly, whereas **heavy fuels** (anything thicker than a pencil) like tree trunks and fallen logs take more time to ignite, but will burn for a long time. As a fire front moves through the landscape, it consumes the fine fuel only, leaving the heavy fuels to burn out over the hours that follow, resulting in the area remaining dangerous for people or vehicles over this time.

Fuel load—fuel quantity is also known as the 'fine fuel load', which is commonly used to estimate the likely size of a fire front as it moves through the landscape. It is measured in tonnes of fuel per hectare (t/ha), for example, a mature forest has a higher fine fuel load than a young forest or open woodland. Fuel load depends on vegetation type and accumulation time.

Type of vegetation providing the fuel—e.g. grassland, shrubland, scrub, woodland or forest.

Arrangement of the fuel can influence how it will burn. If densely packed, vegetation will burn slowly and with low intensity; if standing as a vertical fuel arrangement like a 'ladder', vegetation like shrubs and grasses can burn rapidly at higher intensity. If the fire intensity is high enough, then these flames can reach up to the tree canopies (crowns) further contributing to the overall fire intensity. Bushfire can also spread as a running crown fire when there is a high amount of surface and elevated fuels. Cypress hedges, for example form a continuous 'ladder' from the ground to the top of the tree. The presence of other 'ladder' fuels such as ribbon barks can also allow ground fires to climb into the tree canopies and increase fire intensity and risk of spread.

Figure 2 Fuel arrangement

Fuel moisture content—is a measurement of how much water is contained within the fuel source, e.g. wet fuel is more difficult to ignite while dry fuel ignites and burns quickly. Some vegetation systems such as tropical rainforest have a high moisture content because of their dense canopy. This canopy filters much of the sunlight from reaching the surface vegetation and prevents this surface vegetation from drying out, except during extreme drought conditions.

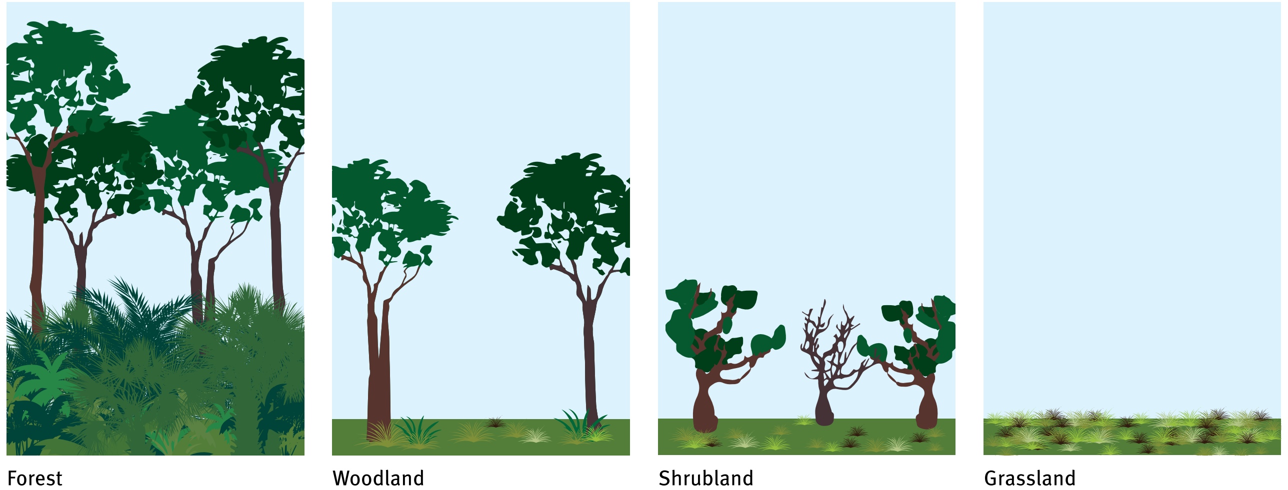


Figure 3 Vegetation type. For more detail on vegetation types see Australian Standard (2018) type of vegetation and Queensland vegetation hazard class (Neldner et al, 2015)

Weather

Weather plays an important role in bushfire behaviour. All of Australia's most devastating bushfires have occurred in the presence of:

- wind
- heat waves and drought
- high temperature, low relative humidity, and direct sun exposure
- climate change
- extreme fire danger rating (FDR).

The duration and peak of the bushfire season varies across Queensland. However, the greatest danger occurs from late winter to early summer, after 'the dry' in the tropical north Queensland, and the frosts and 'Ekka' westerly winds of winter. In general, the most dangerous bushfire conditions occur when strong, hot and dry westerly winds move towards the coastal districts. The Bureau of Meteorology provides further detail on bushfire weather.[6]

Just as the weather prefaces the start of the bushfire season, the weather can bring about an end to the season. This is typically brought about by the onset of wetter conditions, such as daily thunderstorms that roll from west to east (from the Darling Downs and across south-east Queensland to the coast) and the cyclone season in the north.

In certain circumstances, bushfires can create their own weather system, known as a firestorm. Firestorms can create unpredictable fire spotting ahead of the main fire, narrowing the window for a safe evacuation.

Fire plume. Source: QFES

6 www.bom.gov.au/weather-services/fire-weather-centre/bushfire-weather/index.shtml (accessed June 2020).

Weather can influence a bushfire in the following ways.

Wind

Wind can:

- push air into the bushfire—more air can increase the bushfire's intensity
- influence the fire's direction and push flames onto new fuel sources, increasing a bushfire's size, speed and intensity
- transport embers that can create new fire fronts—embers that are driven onto structural elements can enter gaps in the building, and can ignite fine fuels that have accumulated around buildings, which is the cause of most property damage and house losses
- increase the rate at which building elements lose moisture—building materials become drier and more flammable when exposed to persistent, hot, dry winds
- cause stress on vegetation, resulting in leaves dropping on the ground, increasing the fuel load.

Heatwaves and drought

Heatwaves and drought can lead to drier soils and lower moisture content in plants and dry fuels, which in turn can influence bushfire behaviour.

Temperature, relative humidity and sun exposure

Temperature, relative humidity and sun exposure will affect the moisture content of fuel, which will in turn influence how easily the fuel will ignite and burn. Vegetation and other combustible elements around the house (including wooden decks, woodpiles and fences) will more readily ignite and burn during hot, dry weather.

Temperature, relative humidity and sun exposure will also affect the moisture content of building elements, influencing the ease with which they may ignite.

Climate change

Climate observations and models indicate that there is an increasing likelihood of longer and hotter fire seasons, as well as longer and more severe droughts.

Fire danger rating

The Bureau of Meteorology provides daily fire danger ratings (FDRs) based on the forecasts of the likely fire danger index (FDI). The Bureau's FDI considers the temperature, relative humidity, wind speed and dryness of vegetation in calculating a measure of fire danger. The FDR provides an indication of the difficulty of suppression should a fire start.

The daily FDR and the anticipated FDR for Queensland climatic regions for the next three days are available on the Rural Fire Service website at www.ruralfire.qld.gov.au/Pages/FDR.aspx

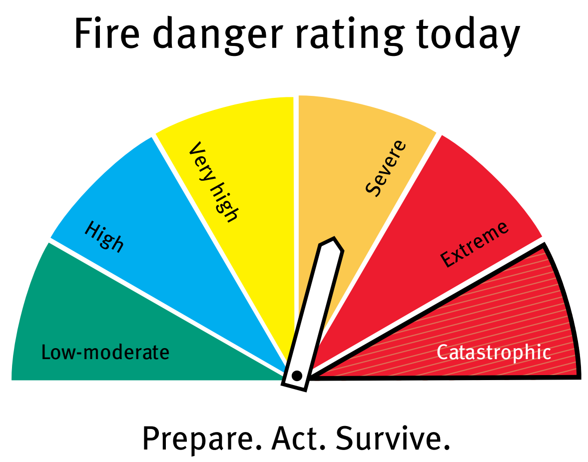


Figure 4 Fire danger rating

Fire in complex terrain. Source: QFES

Topography

Topography (also called terrain) describes the shape or lay of the earth's surface. This is usually expressed in terms of the elevation, slope and orientation of topographic features such as mountains, valleys and plains.

Topography can affect local weather conditions, such as how hot and windy it is, where rain falls, and the drainage, run-off and accumulation of both surface and ground water. For example, ground orientation and slope affect the amount of sunlight received, which in turn influences the moisture content of the fuel and vegetation characteristics.

Fire spreads much faster going uphill than downhill, and the slope' s alignment with local winds will influence how fast a bushfire spreads. The rule of thumb is that for every 10 degrees of slope, a fire will double its rate of spread if moving in the direction of the prevailing wind. Fire spreading uphill also has an increased flame length that can reach further exposed elements at the top of the hill.

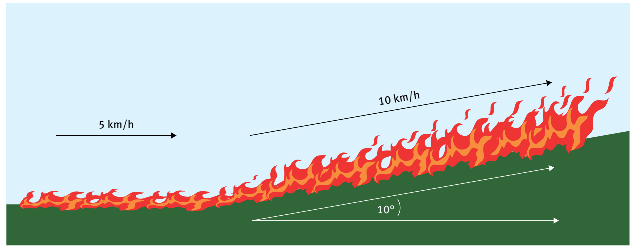


Figure 5 Influence of slope on fire propagation

How buildings ignite

There are eight ways that bushfires can damage or destroy buildings.

Direct attacks

- ember attack
- radiant heat attack
- flame front contact
- surface fire attack.

Indirect attacks

- debris accumulation
- consequential fire
- wind attack
- tree strike

These actions rarely occur in isolation, rather, they tend to work together in the way they contribute to to damaging the house.

Most building fires start with small ignitions. Under ideal fire conditions, these ignitions will accelerate and progressively involve the whole building. For example, small ignitions on timber decks or verandahs, if left unattended, can grow to a size where they will ignite or break building elements, such as combustible facades, eaves or windows, creating a potential point of entry for embers to ignite materials inside the house. Ignition can also occur from embers landing on external combustible elements or entering the house through gaps. If small ignitions can be prevented, the risk of larger more destructive fires is reduced.

Embers. Source: QFES

Ember attack

Ember attack is the most common way for buildings to ignite in a bushfire. An ember is a small particle of burning material that is moved around in the strong winds that accompany a bushfire.

Embers are usually made up of burning plant materials such as bark, leaves and twigs, the source of which is usually adjacent plants or loose plant materials that have fallen or have been deliberately placed on the ground (such as mulch). Of these plant materials, bark is the most prominent source of embers. To a lesser extent, built timber elements (e.g. decks) can also produce embers. Together, debris can be driven forward by winds and may land among dry fuels where it can ignite and spread fire.

- Embers often accumulate in or around vulnerable parts of the house, such as on rooftops, gutters, and in and around doors, vents, windows and against re-entrant corners where they can ignite the house.
- Burning debris can ignite surface materials such as walls, timber decks and verandahs.
- Embers can also enter through gaps in the building's envelope to reach the house's interior, such as wall cavities, roof spaces, subfloor spaces and the occupied regions within the house.

Scientific experiments have shown that embers smaller than two millimetres are not effective at igniting combustible materials.[7] So the use of fine metal mesh with openings of two millimetres or less is an effective way to address ember entry.

Embers can attack buildings at any time before, during or after a bushfire has passed, so it is important to be vigilant to ember attack.

7 Manzello, 2006, 2009.

Ember attack. Source: CSIRO

Building elements that are especially vulnerable to embers include:

- all small gaps larger than two millimetres
- re-entrant corners
- crevices
- exposed surfaces made of combustible materials (including both horizontal and vertical surfaces)
- inside the house, especially elements near windows and doors, such as curtains, rugs and carpets
- roof cavities
- wall cavities
- under the house (subfloor spaces).

Radiant heat attack

The intense heat produced by a bushfire can be felt hundreds of metres away. This radiant heat is given out in all directions from the flame. The amount of radiation that a flame produces is influenced by the flame size and temperature.

Radiation can dry and heat vegetation (and other fuels) to a temperature where it either ignites or is more readily ignited by existing flames or embers. Radiant heat can also further dry out and heat timber elements, making then more readily ignitable by other attack mechanisms. If the radiant heat is intense enough, it can cause the exposed timber to spontaneously ignite.

Radiant heat can damage or destroy other (non-timber) vulnerable building elements, such as PVC downpipes, window screens, windows, air-conditioning units, exposed (unshielded) generators, water pumps, plastic water tanks, pipes and hoses.

Radiant heat is also a significant threat to people and can threaten the safety of building occupants and firefighters during a bushfire.[8]

Bushfire flame front

When flames from a bushfire flame front physically contact the houses, they can flow over and wrap around the house, impacting the sides of the building not directly facing the bushfire. Flames can also flow into underfloor spaces and over roofs and are able to enter into small gaps and crevices.

Flame front contact is more common in areas surrounded by dense vegetation such as forests, shrubland or grasslands, where the bushfire consumes available fine fuels as it passes through. Flames are longer when fine fuel loads are higher: winds push the flames faster through the fine fuel when the flame front moves up slopes.

Flame fronts have two distinct parts or regions. The lower part is known as the solid body flame region, and the upper part is the transitory flame region where flames are intermittently present. Both flame regions can damage buildings. Flame length calculators such as those used in *Australian Standard AS3959 (2018)* provide an estimate of the solid body flame length.

8 Example of burns and impacts on people's health from radiant heat levels could be found in: www.dea.org.au/wp-content/uploads/2017/12/DEA-Bushfires-Fact-Sheet.pdf (accessed May 2020).

Surface fire

Surface fires are low intensity fires (less than 0.5 metres high) that burn along the ground consuming fine fuels and in some cases coarser fuels (such as woodchip or bark mulch). Surface fires are distinct from a bushfire flame front in that they involve intermittent low-lying fuels such as low-lying vegetation, ground litter, mulch and other debris. These fires are typically patchy and erratic in their direction. In the context of building loss, surface fires are a serious threat when they occur immediately adjacent to the house where they can give rise to direct flame contact, radiant heat exposure and ember attack. Surface fires involving fine fuels are short-lived (fewer than 40 seconds). Surface fires involving coarser fuels can persist for much longer.

Debris accumulation

The ignition of a building is made easier by the accumulation of debris on, under and within cavities of the house. During a bushfire, embers blow into these locations and ignite the accumulated debris.

Debris can accumulate against vertical surfaces (such as walls, fences and garden edgings), in re-entrant corners, in gutters, along roof valleys, under buildings, in the small gaps in roof spaces, and wall claddings, and on damaged, splintered or rough timber surfaces. Unburnt debris can build up in building cavities over many years where it can ignite during a bushfire.

Houses with overhanging or adjacent vegetation are likely to have significant levels of debris accumulation on and within their building cavities, which slowly build up over the life of the house. This can be readily observed by checking under roof tiles near eaves or under ridge cappings.

Debris accumulation.

Consequential fire

It is common for bushfires to impact both buildings and their surrounding elements. When ignited, these surrounding elements form a consequential fire, which presents potential additional impacts on the house.

Consequential fires spread from heavy fuel sources such as wood heaps, cars, boats, fences, decking, pergolas, sheds, outdoor furniture, rubbish bins, sporting equipment and neighbouring houses.

Consequential fires produce their own surface fire, radiant heat, flame and ember attacks beyond those produced by the bushfire. These modes of attack behave as described in the preceding sections, the only difference is their origin. A good rule of thumb is to assume that flames produced from a consequential fire source will be approximately twice as high as the object itself.

A consequential fire.

Wind attack

Given that bushfires require wind to build to a hazardous level, these same winds will act on houses and surrounding objects during the bushfire. Wind speeds are typically described by a direction (the direction they are blowing from), average speed and gusting speed. The gusting wind speed can be much higher than the average wind speed.

Wind can dislodge or break building elements, via direct pressure or by carrying debris (e.g. branches, roofing materials, tiles) which strike the building. Strong winds (gusting wind speeds above 75 kilometres per hour) can compromise the integrity of the building's envelope by lifting or dislodging part of the roof or cladding. This superficial damage can provide openings for other bushfire attack mechanisms to enter and ignite internal cavities. It is important to secure external objects that may be dislodged or moved about during an intense gust (e.g. trampolines).

In certain fire events, the fire front can create its own winds, which can produce wind gusts to a house in excess of the forecast wind gust speeds, and possibly from the opposite direction to the main fire front as air is 'drawn in' to a developing fire.

Tree strike

Trees and branches can fall and strike the house due to either wind or by the burning out of knots and hollows within the tree. Houses are not typically built in a way that can resist a direct tree strike without sustaining either superficial or major structural damage. Either outcome is likely to result in the exposure of internal cavities or the occupied space to other bushfire attack mechanisms.

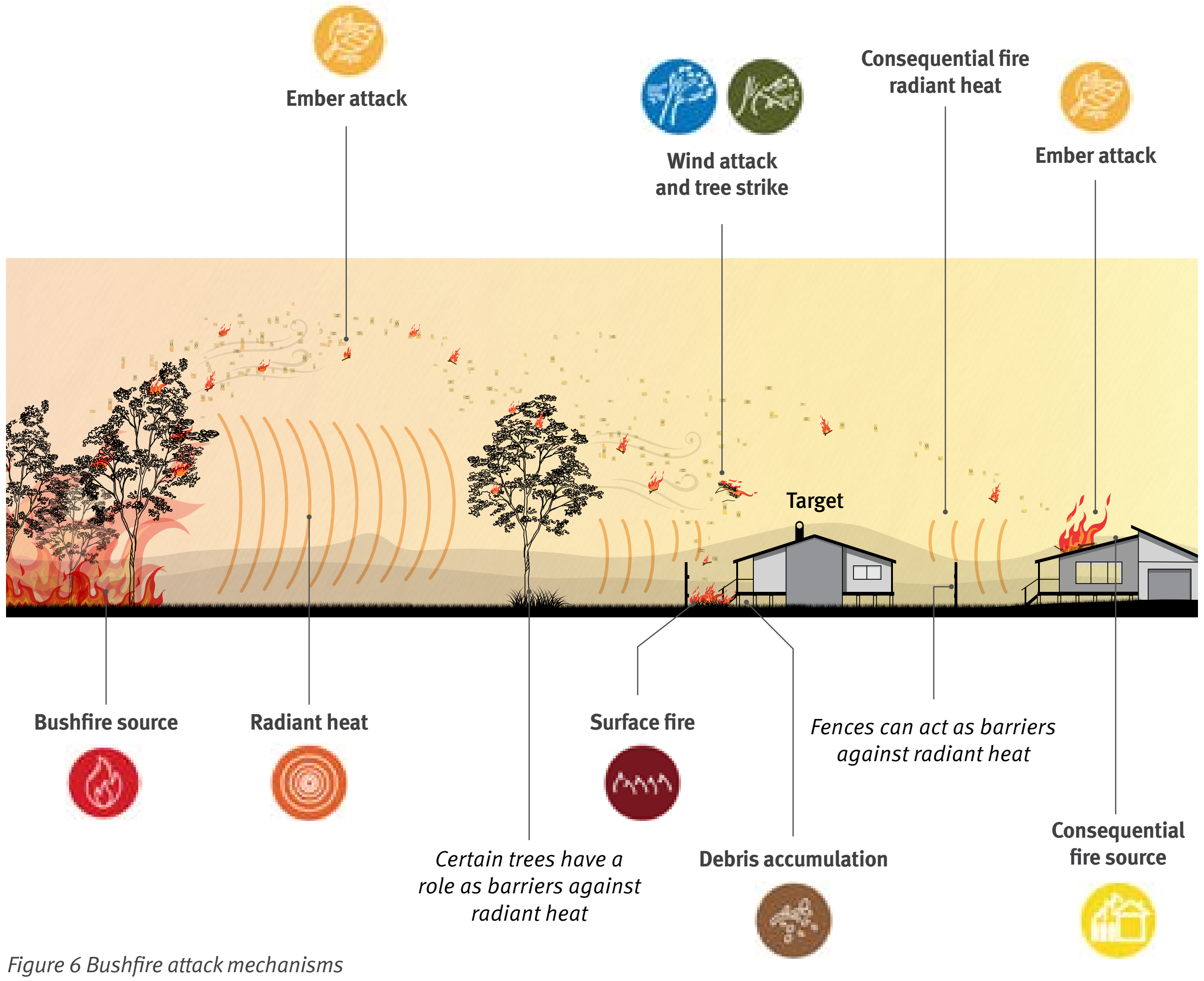
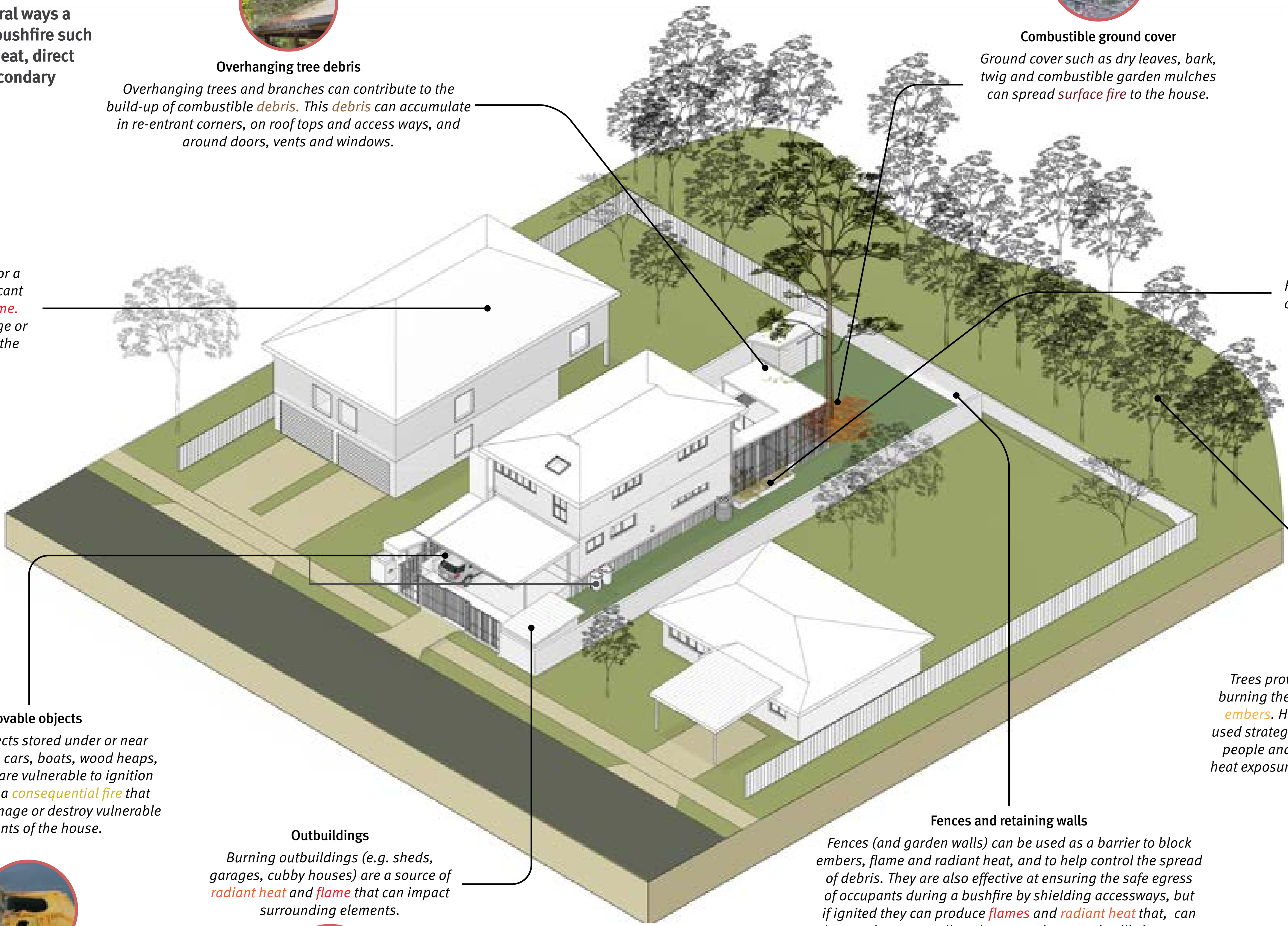


Figure 6 Bushfire attack mechanisms

Property vulnerabilities and hazards

This diagram illustrates several ways a building can ignite during a bushfire such as by ember attack, radiant heat, direct flame contact and various secondary sources.

- Debris
- Embers
- Radiant heat
- Direct flames
- Surface fire
- Wind
- Consequential fire



Overhanging tree debris

Overhanging trees and branches can contribute to the build-up of combustible debris. This debris can accumulate in re-entrant corners, on roof tops and access ways, and around doors, vents and windows.

Combustible ground cover

Ground cover such as dry leaves, bark, twig and combustible garden mulches can spread surface fire to the house.

Adjacent buildings

Adjacent house fires can burn for a long time and produce a significant amount of radiant heat and flame. These hazards can ignite, damage or destroy vulnerable elements of the neighbouring buildings.

Garden beds

Garden beds can present a bushfire hazard if they contain an abundance of overgrown plants (particularly dry or woody vegetation), are covered with a combustible mulch, lined with combustible timber edging, or contained within a raised timber or plastic garden bed. Each of these elements can ignite and spread flame, radiant heat and embers.

Movable objects

Movable objects stored under or near the house (e.g. cars, boats, wood heaps, wheelie bins) are vulnerable to ignition and can form a consequential fire that may ignite, damage or destroy vulnerable elements of the house.

Outbuildings

Burning outbuildings (e.g. sheds, garages, cubby houses) are a source of radiant heat and flame that can impact surrounding elements.

Fences and retaining walls

Fences (and garden walls) can be used as a barrier to block embers, flame and radiant heat, and to help control the spread of debris. They are also effective at ensuring the safe egress of occupants during a bushfire by shielding accessways, but if ignited they can produce flames and radiant heat that, can impact the surrounding elements. They are also likely to trap debris which can ignite and spread fire.

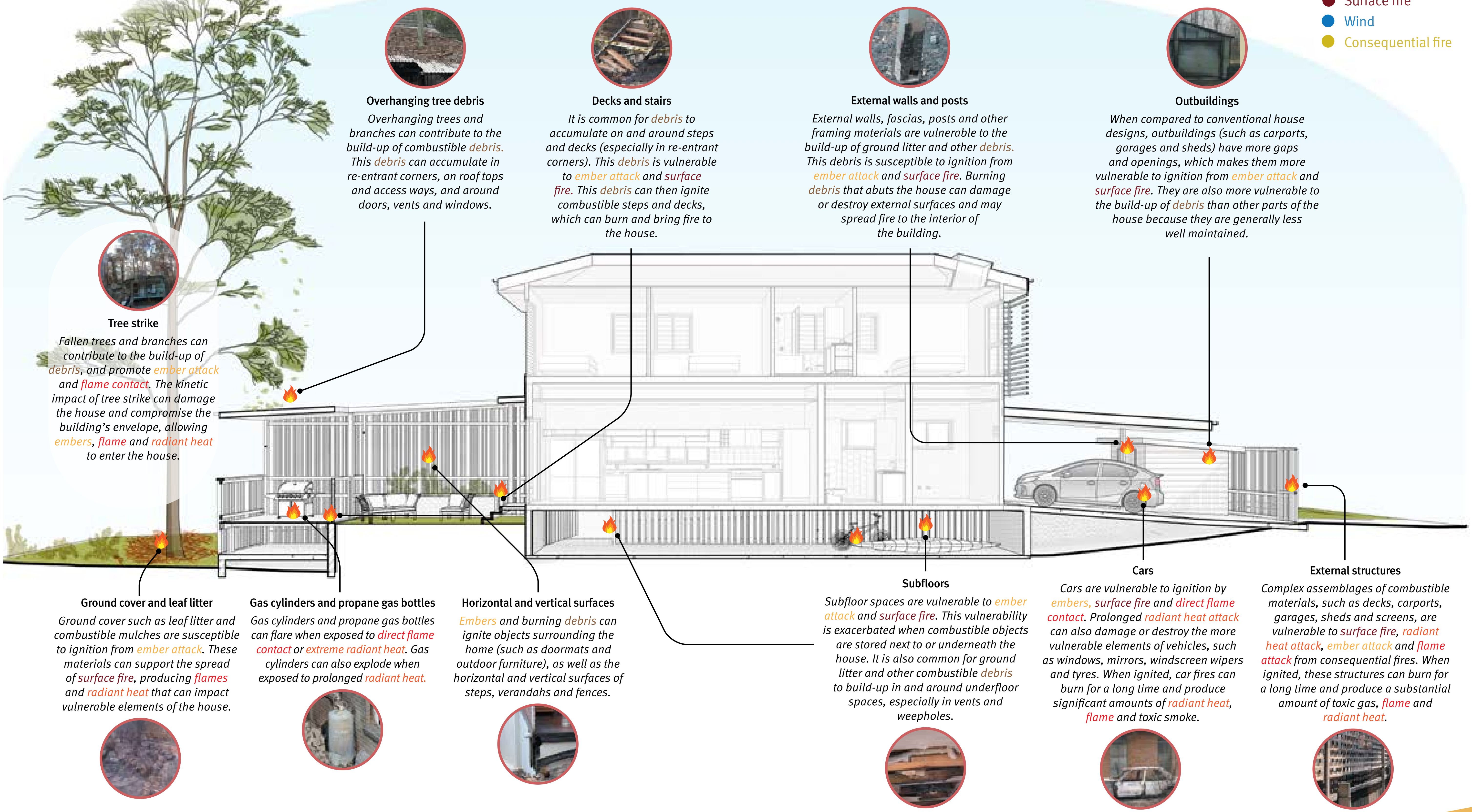
Trees

Trees provide fuel for bushfires, and when burning they produce flame, radiant heat and embers. However, many tree species can be used strategically as screening plants to protect people and buildings from wind and radiant heat exposure and to filter out embers and other flying debris.

Vulnerability of elements around the house

This diagram illustrates the vulnerabilities of elements surrounding the building and how they ignite and bring fire to the house.

- Debris
- Embers
- Radiant heat
- Direct flames
- Surface fire
- Wind
- Consequential fire



Overhanging tree debris

Overhanging trees and branches can contribute to the build-up of combustible debris. This debris can accumulate in re-entrant corners, on roof tops and access ways, and around doors, vents and windows.

Decks and stairs

It is common for debris to accumulate on and around steps and decks (especially in re-entrant corners). This debris is vulnerable to ember attack and surface fire. This debris can then ignite combustible steps and decks, which can burn and bring fire to the house.

External walls and posts

External walls, fascias, posts and other framing materials are vulnerable to the build-up of ground litter and other debris. This debris is susceptible to ignition from ember attack and surface fire. Burning debris that abuts the house can damage or destroy external surfaces and may spread fire to the interior of the building.

Outbuildings

When compared to conventional house designs, outbuildings (such as carports, garages and sheds) have more gaps and openings, which makes them more vulnerable to ignition from ember attack and surface fire. They are also more vulnerable to the build-up of debris than other parts of the house because they are generally less well maintained.

Tree strike

Fallen trees and branches can contribute to the build-up of debris, and promote ember attack and flame contact. The kinetic impact of tree strike can damage the house and compromise the building's envelope, allowing embers, flame and radiant heat to enter the house.

Ground cover and leaf litter

Ground cover such as leaf litter and combustible mulches are susceptible to ignition from ember attack. These materials can support the spread of surface fire, producing flames and radiant heat that can impact vulnerable elements of the house.

Gas cylinders and propane gas bottles

Gas cylinders and propane gas bottles can flare when exposed to direct flame contact or extreme radiant heat. Gas cylinders can also explode when exposed to prolonged radiant heat.

Horizontal and vertical surfaces

Embers and burning debris can ignite objects surrounding the home (such as doormats and outdoor furniture), as well as the horizontal and vertical surfaces of steps, verandahs and fences.

Subfloors

Subfloor spaces are vulnerable to ember attack and surface fire. This vulnerability is exacerbated when combustible objects are stored next to or underneath the house. It is also common for ground litter and other combustible debris to build-up in and around underfloor spaces, especially in vents and weepholes.

Cars

Cars are vulnerable to ignition by embers, surface fire and direct flame contact. Prolonged radiant heat attack can also damage or destroy the more vulnerable elements of vehicles, such as windows, mirrors, windscreen wipers and tyres. When ignited, car fires can burn for a long time and produce significant amounts of radiant heat, flame and toxic smoke.

External structures

Complex assemblages of combustible materials, such as decks, carports, garages, sheds and screens, are vulnerable to surface fire, radiant heat attack, ember attack and flame attack from consequential fires. When ignited, these structures can burn for a long time and produce a substantial amount of toxic gas, flame and radiant heat.

Vulnerability of the house

This diagram illustrates the vulnerabilities creating a breach in the building envelope that can let fire into the house.

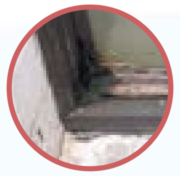
- Debris
- Embers
- Radiant heat
- Direct flames
- Surface fire
- Wind
- Consequential fire

Roofs, gutters, fascias and soffits

Gutters are vulnerable to ignition from ember attack when containing accumulated debris. Burning debris can spread fire to combustible fascias or combustible tracks underneath roof coverings. These fires can penetrate the building's envelope, igniting wall and roof cavities. Fires within roof and wall cavities are often hard to spot and can be very difficult to extinguish.

Re-entrant corners

Re-entrant corners (corners of door frames, windowsills, wall-and-floor joins) are vulnerable to the build-up of debris. This debris can ignite and spread fire to the adjoining surfaces.



Door and window gaps and openings

Embers can penetrate the building's envelope through open, damaged or broken windows and doors, or through small gaps (larger than 2 mm) in these systems.

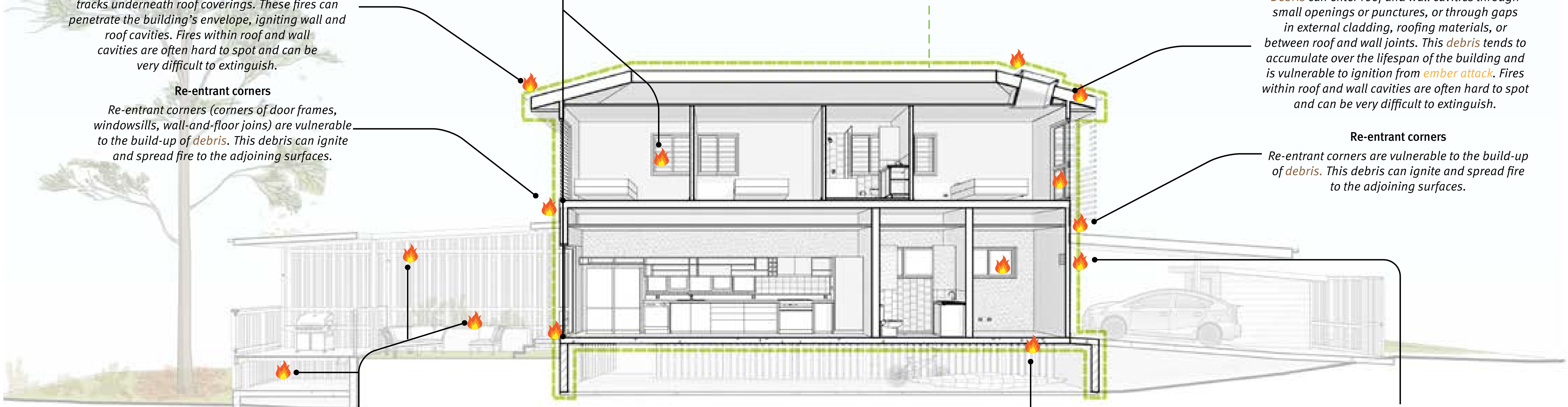
Any breach of the building envelope (dashed green) can result in fire and smoke penetrating to the inside of the house. Fire in the occupiable space is likely to result in the building's destruction.

Gaps in roof and wall sheeting

Debris can enter roof and wall cavities through small openings or punctures, or through gaps in external cladding, roofing materials, or between roof and wall joints. This debris tends to accumulate over the lifespan of the building and is vulnerable to ignition from ember attack. Fires within roof and wall cavities are often hard to spot and can be very difficult to extinguish.

Re-entrant corners

Re-entrant corners are vulnerable to the build-up of debris. This debris can ignite and spread fire to the adjoining surfaces.



Artificial objects surrounding the house (e.g. decks, fences, sheds, outdoor furniture) are a ready fuel source for consequential fires. These consequential fires produce radiant heat and flame that can damage vulnerable elements of the house envelope, such as window frames and screens, combustible cladding, air-conditioning units, door frames, post and poles. Radiant heat, flame and embers can then breach the building's envelope through gaps in damaged surfaces.

Subfloors

Subfloor spaces are vulnerable to ember attack and surface fire from debris and consequential fire (from combustible material stored underneath the floor).

Vents and weepholes

Vents, weepholes and other gaps larger than 2 mm in diameter are vulnerable to the build-up of debris. This debris can ignite and spread fire to internal wall cavities and underfloor spaces, which often burn unnoticed until it is too late the save the house.

How to assess your bushfire hazards

The potential bushfire hazards a house may experience are a combination of the:

- potential intensity of the bushfire including:[9]
  - the vegetation that can carry a fire front proximal to the house
  - weather and topography, which will influence the intensity of the bushfire and the potential impacts that the house could experience
  - separation of the house from vegetation
- vegetation and other combustible objects near the house.

Defining and mapping bushfire hazards (including other generic fire hazards such as neighbouring buildings and combustible material on your property) will help you to understand how a bushfire might impact your house or future house location. This information will help you determine the type of measures you might wish to employ in terms of bushfire resilient construction and landscaping to adequately address these hazards.

Table 1 Bushfire Attack Level

Bushfire Attack Level

The Bushfire Attack Level or BAL is a method for categorising local bushfire intensity the house may experience. BAL provides a local estimate of the potential radiant heat and flame exposure (from bushfire flame fronts travelling through unmanaged vegetation only) at the house location. Knowing the potential BAL can help owners better site new buildings or better manage existing ones (see table on BAL in Australian Standard AS3959).

Bushfire Attack Level (BAL)	Heat flux thresholds (kW/m^2)	Predicted bushfire attack and levels of exposure
BAL-12.5	≤ 12.5	Significant ember attack, burning debris and radiant heat up to a level of 12.5 kW/m^2.
BAL-19	12.5–19	Greater levels of ember attack, burning debris and radiant heat up to a level of 19 kW/m^2.
BAL-29	19–29	Greater levels of ember attack, burning debris and radiant heat up to a level of 29 kW/m^2.
BAL-40	29–40	Greater levels of ember attack, burning debris and radiant heat up to a level of 40 kW/m^2. Flames from the bushfire front may intermittently contact the house.
BAL-FZ	≥ 40	Greater levels of ember attack, burning debris and radiant heat in excess of 40 kW/m^2. Flames from the bushfire front are likely to engulf part or all of the house.

9 For more detail refer to p. 25 of the *Bushfire Resilient Communities* document published by Queensland Fire and Emergency Services: www.ruralfire.qld.gov.au/Bushfire_Planning/Documents/Bushfire-Resilient-Communities.pdf

Hazard assessment

The following steps will help you to identify and understand the bushfire (and non-bushfire) hazards on your property. It provides information on hazards to consider when choosing a design for your house and landscape or retrofitting your house. For more detail on undertaking a bushfire hazard assessment, see section 5 of the *Bushfire Resilient Communities* technical reference guide.[10]

Step 1: Gain a general understanding of the bushfire hazard at your location using the Rural Fire Service bushfire risk postcode checker, which identifies areas where bushfires have either a moderate or heightened potential to take hold, spread and damage houses. www.ruralfire.qld.gov.au/BushFire_PostCodeChecker

Step 2: Identify if you are located within a bushfire prone area (BPA) using the relevant local planning scheme Development Assessment Mapping System (DAMS) at dams.dsdip.esriaustraliaonline.com.au/damappingsystem[11].

Once the map portal is open click on 'SPP Assessment Benchmark Mapping', then click on 'Natural Hazard Risk and Resilience', then tick the box next to 'Bushfire hazard area – bushfire prone area'.

In addition to the BPA map, DAMS provides information on bushfire intensity class[10]:

- very high potential bushfire intensity
- high potential bushfire intensity
- medium potential bushfire intensity
- potential impact buffer.

Step 3: Calculate potential bushfire radiation levels and flame exposure using a BAL calculator if the location of the house is known (best-practices-assessment-tool.herokuapp.com/#calculator, see also Appendix D) or the Rural Fire Service SPP Bushfire Asset Protection Zone Width Calculator.[10] This tool considers:

- forest danger index
- vegetation type/s[12]
- effective slope under vegetation (degrees)
- site slope (between building and classified vegetation)
- horizontal distance between vegetation and house location (as physically measured on site).[13]

Step 4: Identify other hazards on and around your property.

It is important to understand how elements in the wider landscape might affect your building's survival in terms of slowing, stopping or promoting the spread of fire. As a first step, consider all existing structures on your own property or allotment and then work outwards to account for elements on neighbouring or nearby lands. For example, note the locations of the following elements:

- isolated trees
- fences
- retaining walls
- sheds
- neighbouring buildings
- movable objects, e.g. cars and caravans.

Also consider your property boundary, easements, street setbacks, the local road network and access.

10 Details on the bushfire hazard assessment, BPA mapping methodology and SPP Bushfire Asset Protection Zone Width Calculator can be found in the *Bushfire Resilient Communities* document published by Queensland Fire and Emergency Services in December 2019: www.ruralfire.qld.gov.au/Bushfire_Planning/Pages/Bushfire-Resilient-Communities.aspx (accessed May 2020) www.ruralfire.qld.gov.au/Bushfire_Planning/Documents/Bushfire-Resilient-Communities.pdf (accessed May 2020). See also Leonard et al. (2014).

11 Also accessible from State Planning Policy Interactive Mapping System (SPP IMS): spp.dsdip.esriaustraliaonline.com.au/geoviewer/map/planmaking (accessed May 2020).

12 In the DAMS, you can use the 'Basemaps' tab to turn on an aerial photographic/satellite image (Qld Imagery, Aerial or Hybrid Aerial) to better understand the vegetation near you that may be considered a bushfire hazard.

13 In the DAMS, the 'Measure' tab allows you to estimate the distance between an existing building and vegetation.

Bushfire myths and misconceptions

It is important to be aware of the misconceptions and common myths about bushfires that could endanger lives.

Myth 1: The spread of fire is best slowed by removing trees

Fire fronts move faster in thinned forests and open grasslands compared to thicker forests. This is because thick forest limits the wind speeds experienced below the forest canopy, causing the fire front speed to slow.

Reducing fine fuels in the environment has the greatest influence on slowing the spread of a conventional flame front-driven bushfire. Fine fuel is defined as dead material thinner than a pencil and live material thinner than a match.

Myth 2: Buildings not directly near bushfires are safe

Embers can travel hundreds of metres from their source. Many houses are lost due to embers lighting fine fuels, which then ignite nearby structures or combustible elements. For example, igniting timber retaining walls near a house can then ignite the house. Small parks, gardens and creek lines within urban areas can also be ignited by embers. These areas will burn at much lower intensity than larger areas, but are still able to generate new embers that may reach further into an urban area.

Research tells us that buildings are most commonly ignited by embers and other wind-driven burning debris, rather than bushfire flames. Spotting from ember attack has been known to occur up to 40 kilometres away from the main fire front, but most spotting (around 80 per cent) occurs within 100 metres of burning vegetation.

Prescribed burn. Source: QFES

Reducing fine fuels around the house has the greatest influence on slowing the spread of a conventional flame-front driven bushfire.

Bushfire on the Gold Coast.

Myth 3: Embers only arrive from the direction of the prevailing wind

Embers are wind driven. However, the wind direction experienced at ground level and out in the open is not a reliable indication of all possible wind directions an ember may experience. Wind strength and direction can change at any moment. Additionally, higher altitude winds can also affect where embers travel, with the wind sometimes moving in different directions at different altitudes. Multiple wind direction changes can be experienced during bushfire events, including moving in the opposite direction from the prevailing wind.

Myth 4: Leaves are the main source of embers

Leaves and other fine fuels, such as grass clippings and seed pods, can produce embers, but tree bark is by far the most common source.

Myth 5: Canopy fires start when trees self-combust from internally stored heat

Crown or canopy fires are usually ignited by flames reaching up into the canopy. These flames are produced by fine fuels on the ground, which then spread fire up into the canopy via a ladder of fine fuels, such as nearby shrubs. This crown fire can then spread as a running canopy fire (between trees) but only when there is a high amount of both surface and elevated fuels. The presence of surface fuel is essential for the spread of a canopy fire, as the fire will not spread if there are insufficient surface fuels to project flame into the crown. Crown fires in eucalypt forests are nearly always associated with an uphill (upslope) run of fire or fire runs driven by very strong winds.

Myth 6: Australia's bushfires are so severe, there is nothing we can do about them

This is false. Both buildings and their surrounding landscapes can be designed and managed in a way that improves their bushfire resilience. This can greatly improve the chances of people and buildings surviving a bushfire.

Part 2: Bushfire resilient design principles

Introduction to bushfire resilient design

Using design principles to mitigate the impacts of bushfire is called bushfire resilient design. The objective of bushfire resilient design is to reduce, eliminate or counter the effects of:

- **Ember attack**
- **Radiant heat**
- **Bushfire flame front contact**
- **Surface fire**
- **Consequential fire**
- **Tree strike**
- **Wind**
- **Debris accumulation**

These objectives should be achieved without the use of materials or designs that might present additional hazards (such as significant levels of toxic smoke) to occupants if they happen to be present or are attempting to leave the house.

A bushfire resilient design can be achieved via three complementary design strategies:

1. siting[14] (positioning buildings) the house in a way that minimises its exposure to multiple hazards that cannot be readily addressed by building design (see page 36 on how to recognise and optimise the trade-offs between siting and building design)
2. using bushfire resilient landscaping by planning, selecting and managing bushfire resilient plantings and other garden features in the area around the house to reduce bushfire attack.[15]
3. using design and construction materials appropriate for the combined bushfire hazards presented to each aspect or element of the house.

There are usually multiple ways to manage the risks presented by the same hazard(s). Some of these hazards are more easily addressed through siting and landscaping, while others are more easily addressed through construction (see design principles table on page 36). For example, to protect the house from flame front attack, it is more cost effective to locate the house away from the source of the flames (where possible) rather than construct the house to resist it. Conversely, constructing a house to resist ember attack is relatively cheap and effective compared to site relocation, or extensively clearing many hundreds of metres of vegetation.

The best level of protection for a given budget is often a measured combination of siting, landscaping and construction.

Designing new buildings

Queensland's building and planning regulations seek to ensure that new developments are designed and constructed with bushfire protection in mind. These regulations provide a minimum set of requirements aimed at improving the chances that occupants and properties will survive a bushfire. Note that some of the bushfire attack mechanisms described in this guide are not accounted for in the official regulations. For example, building regulations do not address the full range of consequential fire sources that present hazards to a house (e.g. neighbouring houses or boundary fences).

Some readers may find the level of house protections provided by the regulations acceptable, while others may wish to aim for a higher likelihood of survival by considering the widest range of hazards that a house may face during a bushfire.

Example of bushfire resistant building. Source: Paul Whitington

14 You may need to check with your local government to determine if there are any specific requirements relating to siting. Also see Bushfire Resilient Communities document: www.ruralfire.qld.gov.au/Bushfire_Planning/Documents/Bushfire-Resilient-Communities.pdf (accessed My 2020)

15 You may need to check with your local government to determine if there are any specific requirements relating to landscaping and vegetation.

Many of the design principles found in this guide go beyond what is required under current building and planning regulations, but in doing so they provide a higher level of bushfire resilience. In many cases, these principles can be incorporated with minimal additional cost.

Bushfire resilient home under construction, using flame resistant sarking. Source: Ian Weir

Renovations and retrofits for bushfire protection

Most measures available for a new build are also applicable to the renovation or retrofit of existing buildings. The bushfire resilience of a building is only as good as its weakest element. Therefore, when considering the benefits of retrofitting for bushfire resilience, especially when working with a limited budget, it is important to first address the weakest or most vulnerable aspects of the house and its surroundings.

Bushfire resilient measures can vary in cost, so it is important to consider the different options available for achieving the desired objective. For example, sealing small gaps around the building to resist ember entry has a relatively low cost, whereas replacing timber cladding with a less ignitable material can be expensive.

When retrofitting with a limited budget, it is worth considering the relative likelihood of the different bushfire attack mechanisms impacting the house. Fire can arrive with a wide range of intensities depending on the local weather conditions, climate, terrain and available fuel sources. For example, direct flame front contact will typically occur during extreme fire weather conditions, while ember attack and surface fire can be expected for all levels of fire arrival severity.

Hence, most of the time it is important to prioritise ember attack and surface fire resilience before moving onto radiation and flame front contact.

How to navigate your design:

Step 1
BUILDING DESIGN PRINCIPLES
(which solutions are best for my situation?)

Step 2
SITING
(measures to reduce the intensity of bushfire attack)

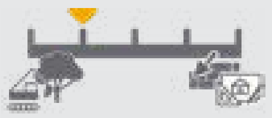
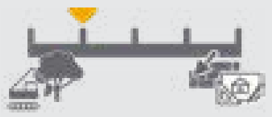
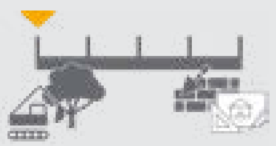
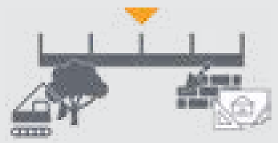
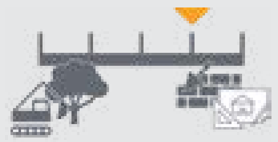
Step 3
CONSTRUCTION
(measures to reduce the vulnerability of the house)

Step 4
MATERIAL
(measures to reduce the vulnerability of the house)

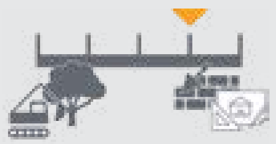
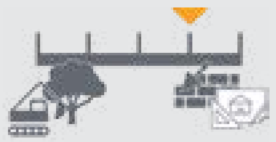
Step 5
LANDSCAPING
(measures to reduce the intensity of bushfire attack)

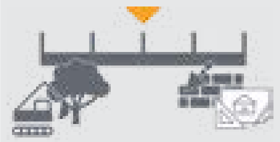
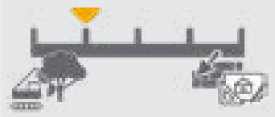
Bushfire resilient design principles

Design principles in response to each bushfire hazard (surface fire, consequential fire, wind, radiant heat, tree strike) are outlined in the following Design principles table. Bushfires have a range of impacts that vary in their difficulty to address. For each hazard, the preferred design response (siting, construction or landscaping) is outlined alongside comments in relation to the effort and financial costs required to implement them, and the response's effectiveness.

	Hazard	Design principles	Ease of mitigation Siting vs construction
	Bushfire flame front contact on the house from adjacent vegetation.	Site buildings away from vegetation (bush). Try to maximise the distance between the home and vegetation. Buildings can be constructed using non-combustible materials, or the building can be built partly or wholly underground; however, both options may be significantly expensive compared to other design approaches.	Siting Construction 
	When adjacent fixed structures (e.g. neighbouring buildings) burn, they can heat or ignite the house. Adjacent structures can burn for a long time, producing dangerous levels of heat and toxic smoke.	Site the home away from neighbouring buildings and other fixed structures. Ideally, you should provide a separation distance of at least 12 metres between vulnerable elements of the house and other structures.[16] Buildings can be constructed using non-combustible materials. Consider non-combustible barriers between the house and neighbouring buildings (e.g. fences and earthworks).	Siting Construction 
	When adjacent movable objects burn, they can heat or ignite the house. For example, vehicles can burn for a long time, producing moderate levels of heat and dangerous levels of toxic smoke.	Position vehicles away from the home. Consider how to design parking spaces (e.g. for vehicles, caravans and boats) away from the home. Constructing a house to resist flame and radiant heat from burning vehicles can have a high cost. Therefore, we recommend siting as the best design response (provided there is adequate space on the allotment).	Siting Construction 
	Reduce attack by **radiant heat** from burning vegetation.	Site the home away from vegetation. Buildings can be constructed using non-combustible materials. For lower intensity bushfires, appropriate construction materials and designs may be used to prevent damage to the home. Consider non-combustible barriers (e.g. fences) and earthworks (e.g. retaining walls) to reduce the impact from radiant heat.	Siting Construction 
	Wind can carry embers and burning debris that can ignite vehicles, buildings and vegetation. Strong **winds** (greater than 75 km/h) can damage buildings and impede the movement of people. Designing for bushfire-based wind resilience will also provide protection against severe wind events, such as tropical cyclones.	Site buildings in locations that have low wind exposure. Avoid the top or side of ridges – these locations are especially vulnerable to wind attack. Use landforms, hedges and trees to screen the house from the strong winds that may accompany a bushfire. Take advantage of any existing terrain features to minimise exposure to wind attack. Non-combustible barriers (e.g. fences and earthworks) can shield against wind exposure. Building codes related to wind are primarily focused on preventing the complete structural collapse of the house, rather than preventing superficial damage of the type that can lead to other ignitions during bushfire. Use construction measures to resist superficial damage from wind loading. Wind attack has a moderate-cost implication when building the house to resist wind exposure (remember that wind attack can directly damage buildings, promote the spread of fire, and spread wind-driven debris).	Siting Construction 

16 *Leonard et al, 2016.*

	Hazard	Design principles	Ease of mitigation Siting vs construction
	Ember attack and the accumulation of unburnt debris.	Ember protection is primarily achieved by limiting the ember's ability to ignite any aspect of the house or its surrounding features. These may be external features, such as cladding and building fascias, or internal features, such as building cavities and internal furnishings. To mitigate ember attack: – use non-combustible construction materials, both externally and within building cavities – use designs that limit the ability for embers and unburnt debris to enter the house or its cavities, such as cavity-less construction (e.g. slab on ground flooring, solid masonry walls, skillion roofs) and tight-fitting cladding on roof and subfloors. – use designs that limit accumulation points for unburnt debris and embers (e.g. use a simple house shape and simple roof lines). A secondary strategy is to reduce the total exposure of embers and unburnt debris on the building by: – using screening plants to filter embers and other wind-driven debris – using proximal plants with low bark hazard – using non-combustible barriers (e.g. fences and earthworks) to shield buildings from ember attack – removing overhanging trees that may drop debris onto or around the house.	Siting Construction 
	Smoke, including toxic gases, can exacerbate asthma and other respiratory conditions, as well as irritate the eyes, nose and throat and cause coughing, shortness of breath or suffocation. Fine particles can also penetrate deep into the lungs and cause long-term health problems.	Mitigating smoke exposure is best achieved through two approaches: – Build the house to be as airtight as possible; meaning that the rate of air exchange between the inside and outside of the house is as low as practical when all windows, doors and vents are closed. This approach is the same as those used to achieve a high level of energy efficiency. – Use appropriate construction materials that, when exposed to embers, radiant heat and flame, do not emit toxic smoke. Sources of smoke immediately adjacent to or within building cavities will contribute to the build-up of toxic smoke within the house more than sources further away.	Siting Construction 

	Hazard	Design principles	Ease of mitigation Siting vs construction
	Surface fires move through grasses, forest litter, mulch, bark and garden beds. These fires have short flame lengths (below knee height) and can impact buildings, vehicles and vegetation elements at that level. Surface fires can also produce significant levels of radiant heat, which can damage building elements at greater heights.	Create an open space (using non-combustible surfaces, such as non-combustible pathways, or ground cover) around the outside of the house. Avoid dense plantings of shrubs—plant individual or small clusters of shrubs, separated by breaks (e.g. open spaces, or non-combustible walls or fences). Use non-combustible mulches. Use non-combustible materials when building near combustible ground fuels.	Siting Construction 
	Tree strike can damage buildings, spread fire, and injure, kill or trap people. Trees can fall either due to strong winds or the burning of the tree.	Site the home away from trees—create a separation distance to 1.5 times the height of the tallest tree.[17] Buildings can be constructed to withstand tree strike using heavy construction materials; however, appropriate designs can be extremely expensive to build.	Siting Construction  (new house only)

17 dsdmipprd.blob.core.windows.net/general/clearing-vegetation-for-firebreaks-and-fire-management-lines.pdf

Siting

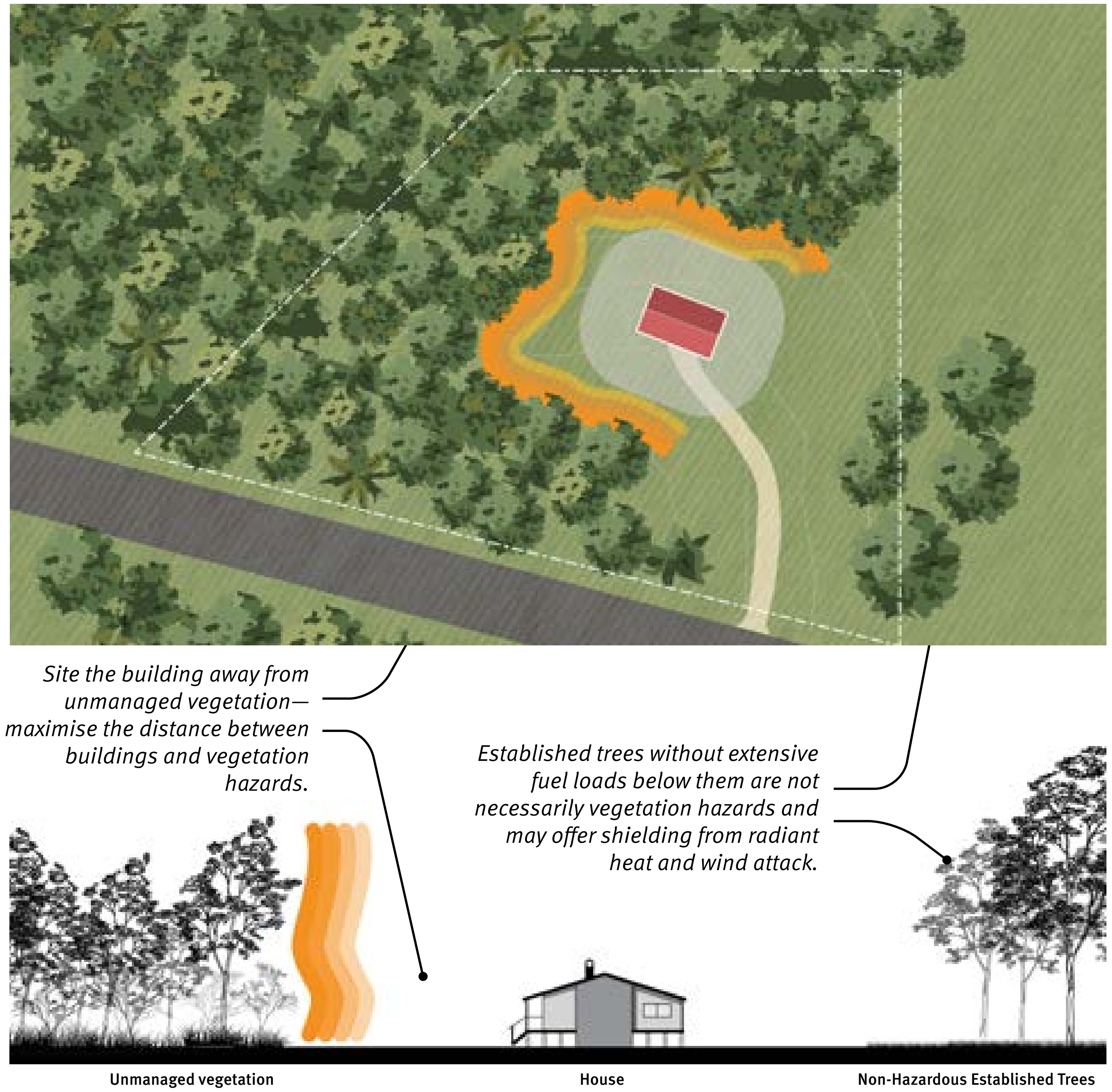
Siting can reduce the intensity of bushfire attack by reducing the building's exposure to vegetation and other bushfire fuels by maximising the distance between the house and vegetation, or by using barriers. This section provides advice to assist you in identifying the best location to site (position) your home or other buildings in relation to both bushfire and consequential fires hazards. Ideally, buildings should be located away from steep vegetated slopes, narrow ridges and dense vegetation. Buildings should also (ideally) be located close to public roads or open spaces that contain managed vegetation.

If you are retrofitting an existing house, some of these principles may not be relevant.

Siting for vegetation hazards

Design principle: Site to reduce exposure from vegetation hazards.

Figure 7 Siting for vegetation [18]

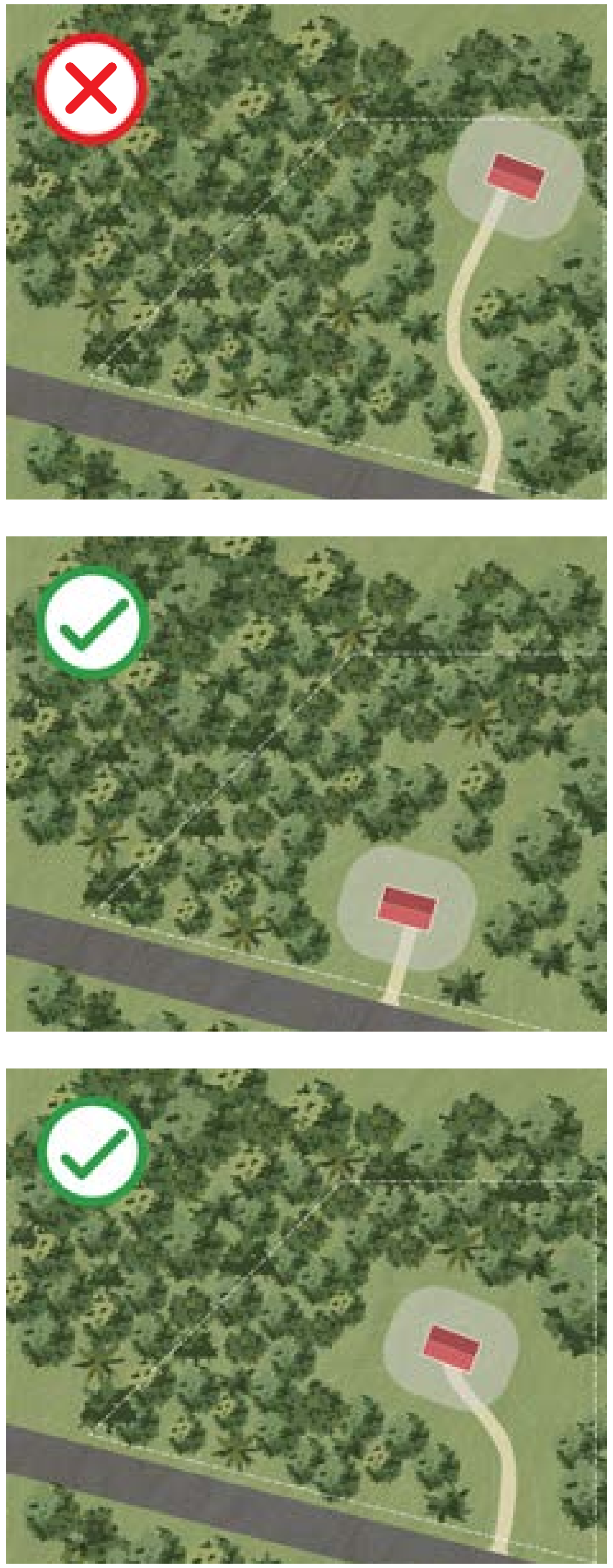


18 *You may need to check if there are any specific requirements relating to vegetation management, see:* www.qld.gov.au/environment/land/management/vegetation/disasters/fire (accessed May 2020).

Siting for best access

Design principle: Site driveways and pathways to provide access to and from the property. Consider positioning the house and other structures to minimise the risks associated with access and exit.

Figure 8 Siting for access



- Identify potential points of access to and from the property on your building plan to determine the best siting option or options.
- Consider the benefits of a short driveway close to a main public road versus the costs and benefits of a longer driveway.
- Identify any terrain features that might aid or hinder access.
- Reduce or eliminate nearby hazards, e.g. the possibility of trees or branches falling on driveways from adjacent or overhanging vegetation, or flame attack from adjacent vegetation or combustible objects.
- As a potential second exit, consider access through an adjacent block of land that has been cleared of surface and near-surface fuels.
- Determine whether the surrounding land (in the immediate vicinity of the house and further out) is accessible and has a large enough area to allow vehicles to turn (including a minimum 12 metres outer radius turning circle for medium rigid fire-fighting appliances), with clearance up to 4.8 metres in height and 4.0 metres in width.

Siting for existing structures (including neighbouring houses and outbuildings)

Design principle: Site to reduce exposure to combustible objects, such as existing fixed structures.

Figure 9 Siting for existing structures [19]

Prepare for contingency – siting for pathways and secondary places

Design principle: Identify both primary and alternative places of shelter and associated escape routes as part of a bushfire survival plan.

Bushfires can be unpredictable: changes in wind direction or an unforeseen hazard may block or obstruct the escape route to a place of shelter. Therefore, you should identify backup options for shelter and escape if the planned options are compromised (the more options the better).

Places of safe shelter or last resort may include (not in order of preference)[20]:

- a well-prepared bushfire resilient home (yours or a neighbour's house)
- a purpose made and approved bushfire shelter
- a stationary vehicle in an open area
- open spaces (e.g. ploughed paddock or reserve)
- bodies of water (e.g. beaches, pools, dams)
- community fire refuges.

19 Research has shown that houses could be damaged by a neighbourhood house burning down up to 12 metres away Leonard et al., 2016. Arena et al., 2018.
20 Blanchi et al., 2014, 2018.

Potential issue with exit path on fire damaged stairs. Source: CSIRO

Maintain a suitable escape route between your house and the alternative place(s) of shelter. Ensure that each occupant can safely exit the house (be mindful of children, the elderly and people with impaired mobility). Ensure that these exit routes do not involve passing over, through or next to combustible surfaces, substructures, retaining walls, fences and other buildings.

It is important to avoid the use of combustible decking or stairs along exit and access routes, as these combustible objects can create a bushfire hazard.

Siting for defendable space or asset protection zone

Depending on your location, you may be required to establish an asset protection zone (APZ) around your home to better facilitate its defence. [21]

An APZ is a specified area of land that enables emergency access and operational space for firefighting. Vegetation is modified and maintained within the APZ to reduce fuel load in a way that reduces the risk of flame contact and radiant heat attack.

Make the following considerations when siting a defendable space:

- Consider the local landscape and the actions required to create a defendable space.
- Create the defendable space in accordance with the guidance provided by the Queensland Fire and Emergency Services technical guide.[21]
- Consider integrating accessways in the design of the defendable space.
- Design the defendable space with aesthetic values in mind, consider how to make the space both functional and practical.

Think of yourself and your house as being at the centre of an onion; focus most attention on the innermost layers being the house's immediate surroundings. Each layer around you needs to be bushfire-ready.

21 For information on calculating the size of an APZ, see guidance provided by Queensland Fire and Emergency Services.

Building design principles

The use of bushfire resilient design and construction materials should be considered the last layer of bushfire defence. Buildings located in bushfire prone areas should be able to withstand attack from bushfire and other consequential fires, at the intensity expected at their location. However, prevention (preventing hazards from reaching the house) should be your primary goal.

Carefully review the hazards identified in your guided hazard assessment developed in 'How to assess bushfire hazards', paying attention to which hazards are relevant for each side of the house. When deciding which hazards are relevant for any given side, remember that some hazards, such as ember attack and flame contact, can involve sides of the house other than those facing the busfire front. Knowing which hazards are present will help you choose the most appropriate design solutions.

It is important to consider the design of all elements in proximity to the house (not only the design of the house itself). This includes the design and siting of parking spaces, decking, verandahs, stairs, retaining walls, water tanks, outbuildings and exit path strategies. Such elements may bring additional hazards to the home, for example, a parking space close to the house may require additional design and construction measures to protect the building in the event of the car burning. Consider the trade-off between different strategies, and experiment with different design configurations until you are satisfied with the result.

The design solutions outlined on the following pages are categorised according to four increasing levels of protection.

	Level of protection
Level 1*	Provides protection from ember attack, surface fire from burning debris, fine fuels (maintained to less than 50 mm height) and radiant heat up to 12.5 kW/m²(#), and a separation of at least 6 times the height^ of any consequential fire sources.
Level 2*	Provides protection from ember attack, burning debris, fine fuel surface fire (maintained to less than 150 mm), provides protection from radiant heat up to 29 kW/m² (#), or a separation of between four and six times the height^ of any consequential fire sources.
Level 3*	Provides protection from ember attack, burning debris, fine fuel surface fire of any height, provides protection from direct flame contact from a bushfire front, and from consequential fire for sources with a separation of between two and four times their height^.
Level 4	Provides protection from ember attack, burning debris, fine fuel surface fire of any height, direct flame contact from a bushfire front, and from consequential fire from sources with a separation of less than two times their height^.

* If large combustible elements (e.g. decks, vehicles) are present or preferred, then refer to level 4 house construction so that the house can be adequately designed to resist the additional fire load from consequential fire.

Where a radiation heat level is identified, this roughly corresponds to the recommended separation distance from unmanaged fuels identified in the BAL calculator.[22]

^ Where the consequential fire source is a structure, then the maximum eave height is a reasonable measure of maximum height.

22 best-practices-assessment-tool.herokuapp.com/#calculator *(see also Appendix D).*

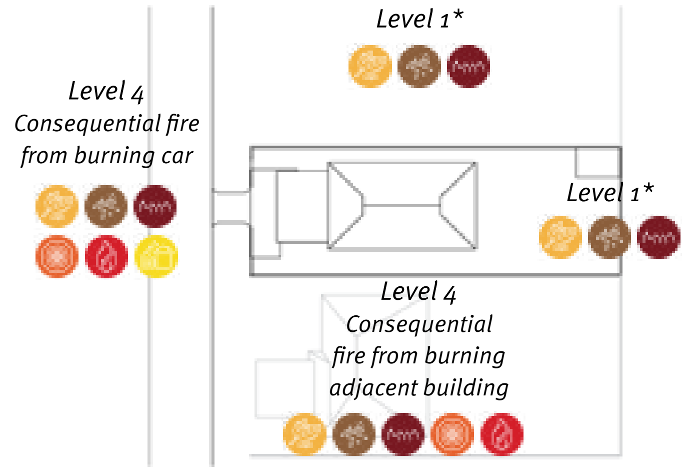


Figure 10 Consider hazard on 4 sides of the house

Choose designs and materials carefully:

- Consider **robust** design principles. Robust means that they are not easily damaged or compromised, and do not require manual operation or intervention to work. An example of this might be to choose non-combustible building elements rather than the combination of combustible elements and a water spray protection system.
- Consider design **redundancy**. This ensures that the fate of your house is not reliant on the effective performance of a single element. An example of this would be to secure metal screens over window glazing. Another would be to use a complete wall system that is non-combustible; this not only includes the facade, but all the materials used within the wall cavity like insulation, wall framing, and framing for windows and doors.
- Cost effective design solutions often involve **simple and practical strategies** that reduce or eliminate design details that can be problematic in a bushfire. An example of this could be to either enclose the subfloor area or build using a slab on the ground in order to prevent subfloor exposure. Another is to use simple roof layouts that avoid valleys and minimise the number of ridges that need protection details. Yet another is to use simple building footprints that avoid re-entrant corners where debris may accumulate and burn.
- Many design solutions can work **together** with other requirements. For example, window screens and shutters can also provide insect and solar protection.

Choosing a design

The following section describes design principles aimed at bushfire resilience. These principles are categorised according to their effective level of protection (level 1, 2, 3 or 4).[23] While using the recommended construction for a level is appropriate, construction solutions for higher levels will offer useful alternatives, with the added benefit of greater robustness and redundancy.

It is important to understand the strengths and weaknesses of your design. Some design decisions have implications for how well the rest of the building will perform. It is important to be aware of how each system may interact with adjacent elements and the building as a whole. A good example could be the choice of thick non-combustible wall cladding to protect the combustible framing elements underneath. This is a sound approach, but if the subfloor area is not fully enclosed, then flames may be able to reach the combustible wall framing elements and burn behind the thick cladding.

Your building (and the building's envelope—the physical separator between the internal space and the outside environment) is made up of walls, floors, roof sections and subfloors. Identify which elements of the building are vulnerable to ignition, and which parts may be difficult to extinguish once burning (e.g. roof cavities, wall cavities and subfloor spaces).

- Consider the merits of non-combustible framing and cladding versus combustible framing for walls, roofs and subfloors.
- Consider whether it is possible to remove cavities from the design (e.g. by building on a slab on the ground or using solid masonry).
- Avoid mixed solutions. For example, if you use a non-combustible cavity design for wall and floor systems, we recommend a similar non-combustible cavity approach for the design of the roof. The use of a combustible system may undermine the value of adjacent non-combustible systems. Remember that the resilience of a building in a bushfire is governed by the weakest link principle.

23 *Every effort has been made to ensure that this best practice guidance either meets or exceeds the minimum requirements in both AS3959, Australian Standards (2018) and the NASH construction standards (2014):, however, we recommend that you check the relevant standards to ensure that you meet or exceed these regulatory requirements.*

** If no other combustible object or vegetation is threatening the house.*

Steps to navigate the following guidance is outlined below.

Step 1

To help choose a general strategy, refer to the *building design house examples on pages 48-55* for an overview of different bushfire resilience strategies applicable to common building types in Queensland. Sectionals 1 and 2 provide examples of buildings with non-combustible framing and cladding. Sectionals 3 and 4 provide examples of homes with a combustible framing and cladding, respectively.

Step 2

Refer to the materials flow (pages 70-91). The flow chart outlines different design and material solutions and their associated levels of protection, for:

- wall systems (including insulation, framing and cladding)
- floor systems (including the floor, supporting floor system and enclosure)
- roof systems (including the internal insulation, framing and cladding)
- window and door systems
- vents
- verandahs, decks and carport systems.

Step 3

Refer to Part 3 for information about bushfire resilient construction systems.

For additional guidance on construction details at different level of exposure (e.g. wall system, roof and deck), refer to Australian Standard AS3959 and the NASH construction standard.

Step 4

Refer to bushfire resilient materials (Part 4, pages 92-99) for guidance on the use and performance of common material in bushfire.

Building design house examples

The following sectional house examples identify a few different residential types, systems of construction and materials to reduce bushfire attack vulnerabilities. The diagrams provide examples of bushfire resilient house designs and explain the strategies and principles applied for both new builds and retrofits. The strategies refer to the protection levels on page 44, as there are often multiple solutions depending on the level of protection your situation requires.

#1: Typical new two-storey slab on ground house

This house is a typical suburban two storey house, with a slab on the ground floor and a carport and backyard terrace.

See pages 48–49

#2: Building a new raised house on a sloped site

Houses on slopes are often partially or completely raised off the ground, and as such require care when it comes to protecting the floor structure. This design outlines principles that can be used to design raised houses.

See pages 50–51

#3: Retrofitting an existing Queenslander house

Typical Queenslander houses will likely have combustible timber framing, timber doors, timber window frames and timber cladding. This example illustrates an effective way to retrofit these and other timber houses for bushfire protection.

See pages 52–53

#4: Retrofitting an existing partly raised timber and slab-on-ground brick veneer house

This house highlights strategies used to retrofit an existing raised timber framed floor and tiled roof for bushfire protection. The sectional also describes how to retrofit an existing brick veneer wall.

See pages 54–55

Building design: Typical new house on a flat site or gentle slope (example house 1)

Example House 1 is a typical suburban double-storey up to level 3 protection.

Non-Combustible Framing and Cladding | Gentle Slope | Slab on Ground | 2-Storey.

Construction details

Refer to roof ridge details (pages 90–91)

Construction details

Refer to construction detail 1a for level 1 exposure (page 72) and 1b for level 3 exposure (page 73)

As a minimum for Level 1 protection, install an external metal mesh on all openable windows to protect against ember entry.

Use a non-combustible envelope to protect the occupied space from bushfire attack

Simple roof designs with no valleys and minimimal ridges reduce the need for complex protection details where debris can collect and embers can enter the cavity. Ensure the roof is constructed with a non-combustible frame, insulation and cladding to form an entirely non-combustible roof system.

Skylights are a great way to bring natural light deep into the house, but special care must be taken to ensure there are no small gaps (> 2 mm) that breach into the roof cavity. The glass must also comply with AS3959.

Protect window systems from ignitions, breakages and collapse. Choose materials and designs according to your exposure level (see page 62).

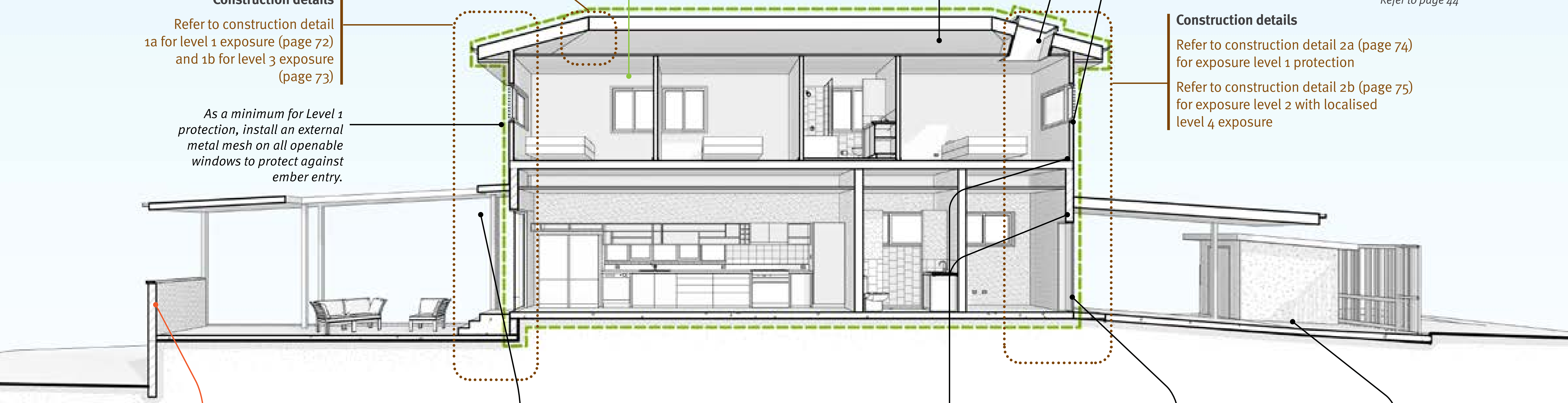
Protection levels*
Level 1
Level 2
Level 3
Level 4

*Refer to page 44

Construction details

Refer to construction detail 2a (page 74) for exposure level 1 protection

Refer to construction detail 2b (page 75) for exposure level 2 with localised level 4 exposure



Solid non-combustible balustrades such as brick or rendered block are excellent bushfire resilient choices if the fire is likely to come from the facing direction, as they also shield from radiant heat and low flying embers. Other non-combustible options such as stainless steel wire balustrades are also good choices where radiant heat is not a concern.

Use non-combustible systems (e.g. steel framing with metal roof sheeting) for external projections such as terrace roofs. Slab on ground floors and external areas such as patios and terraces prevent any chance of ignition that can occur to subfloor structures. Use solid non-combustible steps along exit and access paths.

Non-combustible framing (e.g. steel framing) and solid walls (e.g. masonry) for external walls protect the interior of the building and prevent ember-based ignition inside the wall.

Walls and doors adjacent to carports should be fire rated to protect from consequential fires (level 4 protection). See construction detail 2b (page 75).

Outbuildings such as sheds should be built to the same level of protection as the main house.

Building design: Building a new house on a sloped site (example house 2)

Example house 2 is built on a slope and partially raised of the ground. Simple building footprints and roof shapes reduce the number of areas where debris and embers can accumulate, and eliminate potential ignition points.

Non-Combustible Framing and Cladding | 1-Storey | Steep Slope | Partially Raised.

Protection levels*

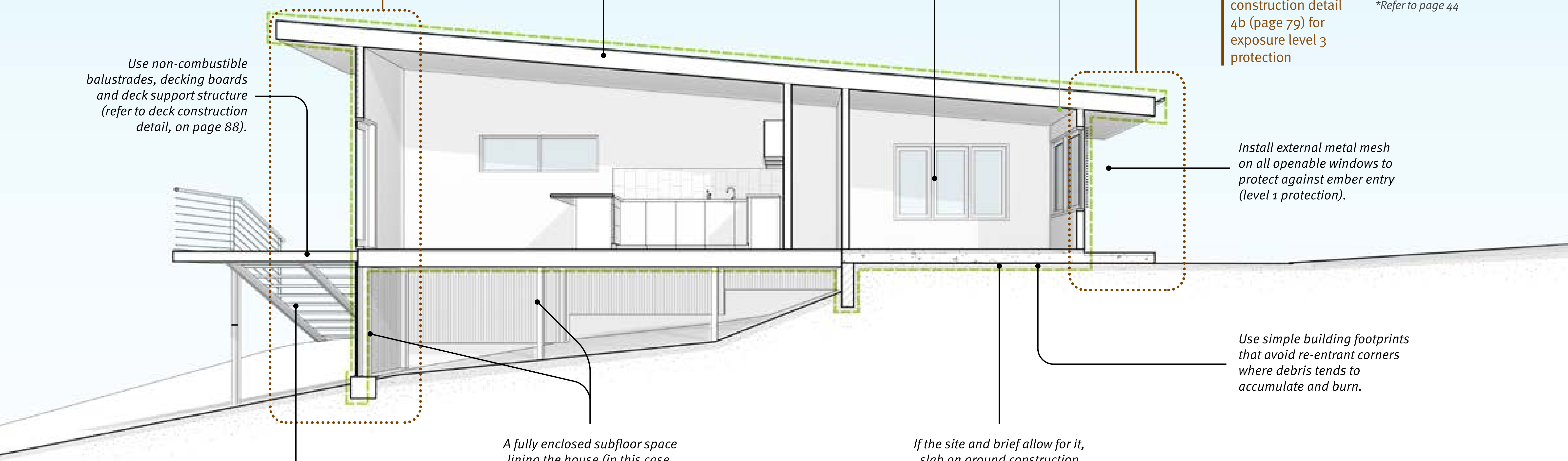
Level 1

Level 2

Level 3

Level 4

*Refer to page 44



Building design: Retrofitting an existing Queenslander house (example house 3)

Typical Queenslander houses will have combustible timber framing, doors and windows, and cladding. As such, sealing all small gaps larger than 2 mm is essential to prevent ember entry into wall cavities and the interior of the building.

Existing Combustible Frame | 2-Storey | Any Site | Slab on Ground.

Protect the roof system from igniting by replacing fascia and soffit with non-combustible lining.

construction details

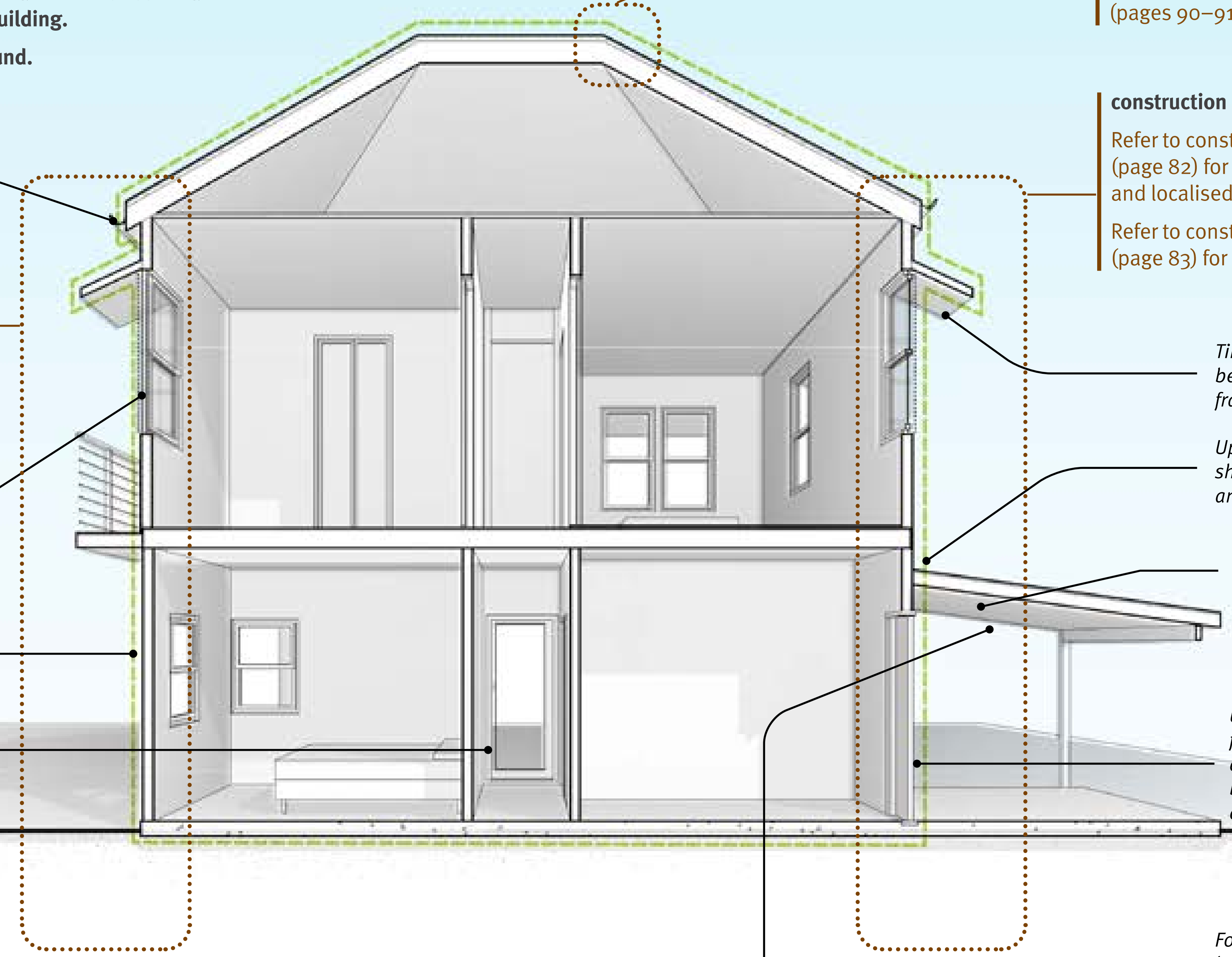
Refer to construction detail 5a (page 80) for exposure level 2 protection

Refer to construction detail 5b (page 81) for exposure level 3 protection

Install external metal mesh on all openable windows to protect against ember entry (level 1 protection).

For level 2 protection, any combustible cladding (e.g. timber weatherboards) should be replaced with non-combustible cladding.

Consider having at least one exit route that does not involve either a carport or combustible deck or stairs.



Check existing roof ventilation for small gaps (seal any gaps larger than 2 mm with non-combustible material), screen whirlybirds for level 1 and 2, remove for level 3 and 4.

construction details

Seal all ridge and valley intersections. Refer to roof details (pages 90–91)

construction details

Refer to construction detail 6a (page 82) for exposure level 1 and localised level 4

Refer to construction detail 6b (page 83) for exposure level 2

Protection levels*
Level 1
Level 2
Level 3
Level 4

*Refer to page 44

Timber-framed window hoods should be replaced with non-combustible framed alternatives.

Upper and lower non-combustible cladding should overlap to prevent any gaps into wall and floor cavities.

Any horizontal projection less than 18° requires non-combustible cladding 500mm above the horizontal projection. Refer to construction detail 5, page 80.

Use fire rated wall level 3/4 protection and fire rated door separating the main house and carport to provide protection from burning cars. Refer to construction detail 5, page 80.

Use non-combustible framing for the carport to limit exposure to upper level walls.

For level 1 protection, external doors should be made from non-combustible materials or class 1 durability timber with solid core doors, and be tight fitting with gaps smaller than 2 mm. For level 2 protection, doors should be non-combustible. Consider using a metal screen door which is self-closing (with apertures no larger than 2 mm) to protect against embers.

To prevent ember entry:
- seal any gaps larger than 2 mm
- protect vents and weepholes using metal mesh (less than 2 mm).
If possible, add flame resistant sarking to resist ember and flame penetration.

A combustible frame is not recommended, but is often unavoidable when retrofitting an existing Queenslander house due to the construction costs of replacing wall framing.

Building design: Retrofitting an existing partly raised timber and slab-on-ground brick veneer house (example house 4)

The following example house highlights strategies used to retrofit an existing house with a raised timber-framed floor and tiled roof for bushfire protection. The example house also shows how to retrofit an existing brick veneer wall.

Existing Combustible Framing | 1-Storey | Slab on Ground and Raised.

Construction details

Refer to construction detail 7a (page 84) for level 1 protection

Refer to construction detail 7b (page 85) for level 2 protection

Protect roof systems from igniting by replacing fascia and soffit with non-combustible lining.

Ensure existing tile roofs are tight fitting. Eliminate any gaps larger than 2 mm.

Construction details

Prevent the roof system from igniting by replacing eaves and soffit with non-combustible lining. Refer to roof valley details (refer to pages 90–91)

Construction details

Refer to construction detail 8a (page 86) for exposure level 1 protection

Refer to construction detail 8b (page 87) for exposure level 3 protection

Protection levels*

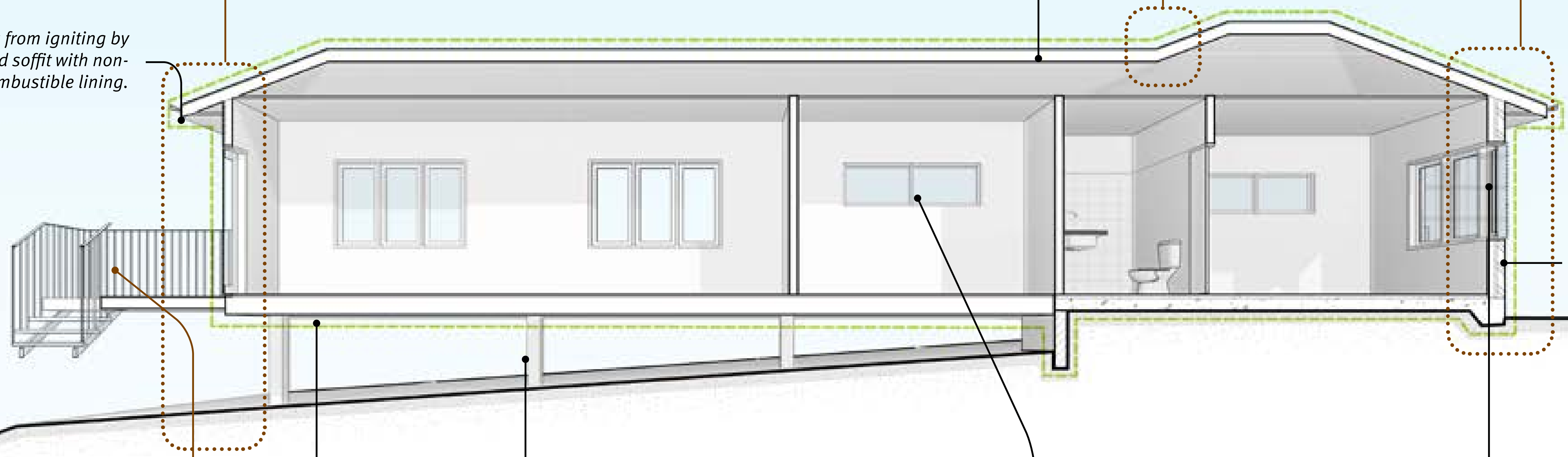
Level 1

Level 2

Level 3

Level 4

*Refer to page 44



Ensure any weepholes in bricks are covered with a metal mesh protection against embers entering the wall cavity.

Construction details

Replace combustible deck, balustrade and structure with non-combustible material if it is an exit path. Refer to deck construction detail (page 88)

For other exposures see how to protect your deck page 65

Do not store any combustible objects under the house (e.g. mower).

Protect window systems from ignitions, breakages and collapse. Choose materials and designs according to your exposure level (see window and glazing system section page 62).

Install external metal mesh on all openable windows to protect against ember entry (with aperture no larger than 2 mm).

Protect existing raised floor according to your level of exposure (see floor system section page 58-59).

For level 2 protection, any combustible cladding (e.g. timber weatherboards) should be replaced with non-combustible cladding.

Choose a wall system

Embers can ignite combustible wall cladding either by direct attachment to certain materials like rough sawed timber, or by accumulating against cladding, causing localised flame contact. This flame contact is especially prevalent in re-entrant corners. Localised flames can burn external facades or enter through small gaps in the facade and then burn the internal face of the facade, and adjacent framing.

Wind can assist this process by depositing additional debris onto the same locations where embers are likely to land. Radiation can promote ignition by drying out and heating facades increasing the likelihood and severity of flame spread from ember ignition. Wall cladding can be damaged by direct flame contact from surrounding burning objects.

Damaged wall from burning vegetation. Source: CSIRO

Design principles for external wall systems (including frames and wall claddings):

- Resist ember entry into wall cavities and the interior of the building, and prevent ember-based ignition of combustible debris, which have accumulated outside and inside the wall.
- Resist ignition by radiant heat flux and flame contact with both the exterior and interior of the building.
- Resist wind loads and wind-driven debris.
- Eliminate or reduce the use of wall junctions with other building elements which create re-entrant corners where embers can accumulate (e.g. a carport roof).
- Prevent wall systems from burning and producing toxic gases that may spread to the interior of the building and exit routes.
- Where the framing is combustible, multiple layers of non-combustible cladding should be used and great care should be taken around wall perforations and edge details in order to prevent flame contact.
- Consider a robust approach, using both non-combustible cladding and framing materials.

Example of house built using non-combustible framing material (steel frame). Source: KNK Builders

Avoid the following:

- Relying on external wall cladding to resist ember entry or flame contact from burning debris unless the framing material is non-combustible.
- Relying on conventional sarking (including flammability index 5 rated) to protect combustible framing. The typical building wraps (sarking) used under cladding offer little resistance to the spread of flame to the combustible framing underneath.
- Use combustible jointing strips.
- Seal gaps using timber beading strips.

Frame

Solid wall
E.g. concrete >90 mm masonry, rammed or packed earth

Steel frame
For detailed information on minimum compliance levels, please refer to the NASH Standard[24]

Cladding

No cladding or non-combustible cladding
(e.g. renders, paints, see material section)
Level 4 and wind

Use thick non-combustible cladding

Level 3
Non-combustible 30-minute fire rated system or higher cladding system (e.g. brick veneer, 50mm aerated concrete)

Level 4
Non-combustible 60-minute fire rated system or higher cladding system (e.g. brick veneer)

Use thin non-combustible cladding

Level 2
(e.g. steel, cement sheet, fibre cement sheet). Seal and cover all joints to prevent gaps larger than 2 mm in the external surface material

Level 3
As for Level 2 with the addition of an appropriate non-combustible fire barrier under cladding (e.g. plasterboard)

Construction detail

Refer to:
Construction detail 1a (page 72), 1b (page 73), 2a (page 74), 2b (page 75) lower level

Refer to:
Construction detail 1a (page 72), 1b (page 73), 2a (page 74), 2b (page 75) upper level

Frame

Timber frame
For detailed information on minimum compliance levels, please refer to AS3959[25]

Cladding

Use thick non-combustible cladding

Level 3
Non-combustible 30-minute fire rated system or higher cladding system (e.g. brick veneer, aerated concrete)

Level 4
Non-combustible 60-minute fire rated system or higher cladding system (e.g. brick veneer)

Prevent ember entry[28] (see section on sealing small gaps, page 64)[27]:
- seal any gaps larger than 2 mm
- protect vents and weepholes using metal mesh (<2 mm)

Use thin non-combustible cladding

Level 2
(e.g. steel, cement sheet, or fibre cement) with overlapped joints. The thicker the cladding, the more robust the system

Prevent ember entry[26] (see section on sealing small gaps, page 64):
- seal any gaps larger than 2 mm - protect vents and weepholes using metal mesh (<2 mm)
- use flame resistant sarking to resist ember and flame penetration

Level 3
As for level 2 with the addition of an appropriate non-combustible fire barrier under cladding and using steel hat section between the fire barrier and cladding (e.g. plasterboard)

Combustible cladding[26]
(Retrofit ONLY)
Level 1
Seal and cover any gaps larger than 2 mm[26] (see section on sealing small gaps, page 64)

Protect vents and weepholes using metal mesh (<2 mm). For re-entrant corners, non-combustible cladding for first 500 mm in any direction from corner. On flat surface, retrofit at least 500 mm from the bottom using non-combustible material or class 1 durability timber[27] with flame resistant sarking to prevent flame penetration

For rough sawn timber finishes, sand and paint to prevent embers from catching on and igniting the textured surface

Construction detail

Refer to:
Construction detail 8a (page 86), 8b (page 87)

Refer to:
Construction detail 5a (page 80), 5b (page 81), 6a (page 82), 6b (page 83)

24 NASH Standard (2014) Steel framed construction in bushfire areas.
25 Australian Standards, AS 3959 (2018) Construction of buildings in bushfire-prone areas.
26 If using for a new build or recladding the house, add fire resisting sarking and class 1 durability timber (level 1 only).
27 As specified in Australian Standard AS5604 (2005) Timber – Natural durability ratings.

Floor system

Embers and surface fire can ignite unprotected underfloor spaces, underfloor enclosures and combustible supporting posts. It is common for debris to build up in these areas and present a considerable fine fuel source. It is also common for people to store heavy fuels, such as firewood, building materials, sporting equipment and gardening equipment in their underfloor spaces. However, this practice should be avoided in unenclosed floor spaces, as these elements are vulnerable to ignition and the subsequent fire can threaten the floor and its support systems.[28]

Underfloor damage caused by burning garden bed, supressed by fire agency before it burnt into the house. Source: CSIRO

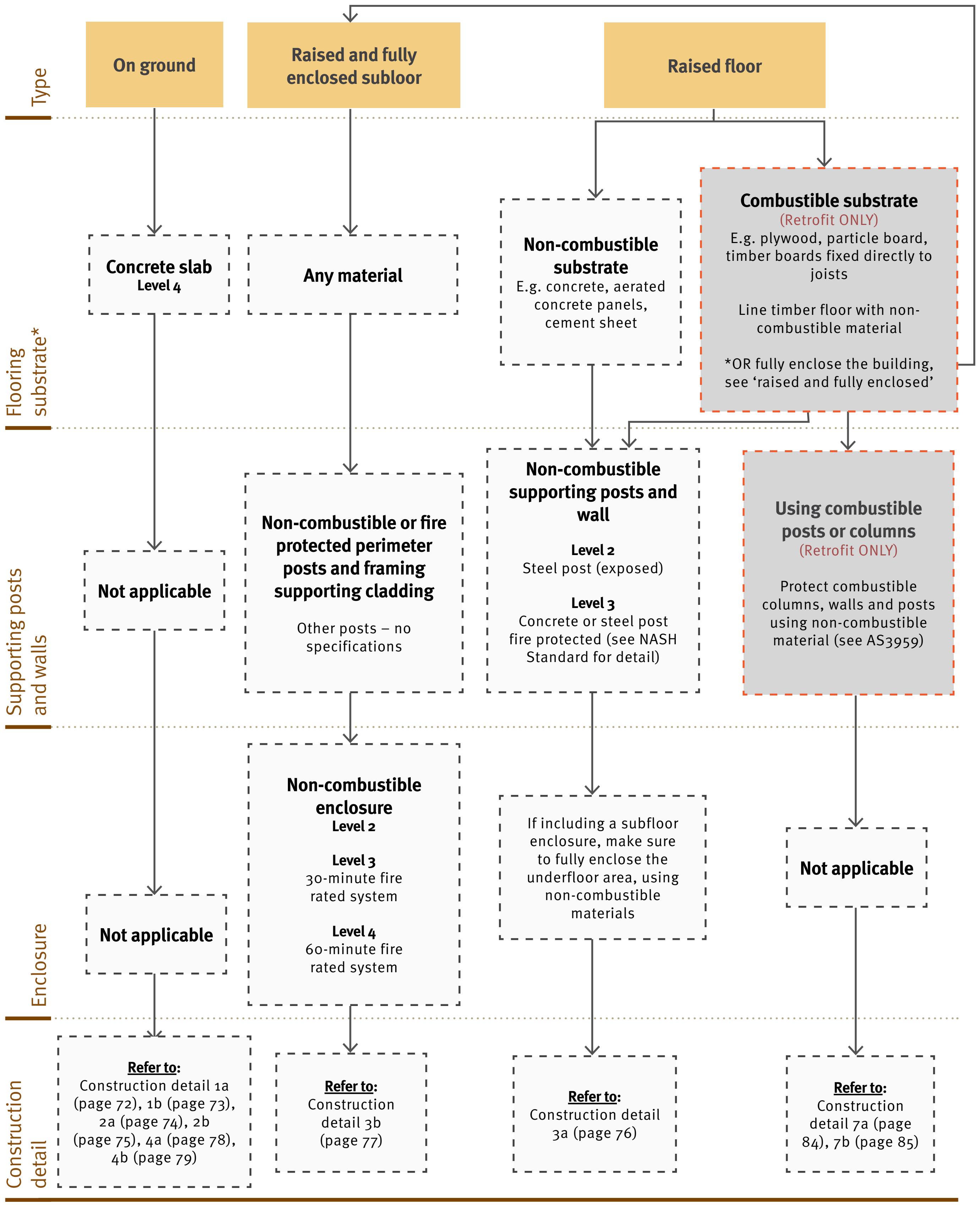
Design principles for flooring systems (including supporting posts and enclosures)

- Resist surface fire and ember attack from entering the underside of the building.
- Resist ignition from radiant heat flux and direct flame contact.
- Protect floors and subfloors from burning, collapse, displacement, breach and producing additional heat to:
  - the interior of the building
  - other building elements
  - exit routes.
- Prevent floor systems from burning and producing flames and toxic gases that may threaten the interior of the building and exit routes.

Avoid the following:

- Storing combustible objects in open underfloor spaces, if present.
- Installing a combustible access door in an enclosed underfloor space, if present.
- Using combustible support structures or framing behind thin cladding to enclose under floor spaces even if the cladding is non-combustible.
- Exposing combustible flooring, irrespective of the height of the floor above ground level unless underfloor volume is fully enclosed.

28 See, for example, Leonard et.al.,2016.



*Flooring substrate refers to the underside of your floor lining, e.g. timber floorboards on a concrete slab would be described as having anon-combustible flooring substrate.

Choose a roof system

Ember attack can ignite combustible eaves, fascia, and debris matter that has accumulated in gutters, along ridge lines, in roof valleys, against roof penetrations and inside the roof cavity. This debris is vulnerable to ignition and the subsequent fire can ignite surrounding elements if they are combustible such as the eaves, fascias, roof framing and roof battens. The sarking, including flammability index 5-rated sarking, does not offer a barrier to flames. Ember and potential flame entry into the roof cavity is often difficult to spot and is almost certain to result in total house destruction if the roof contains combustible framing or other combustible elements.

Debris accumulation in gutter.

Design principles for roof systems (including supporting posts and enclosures)

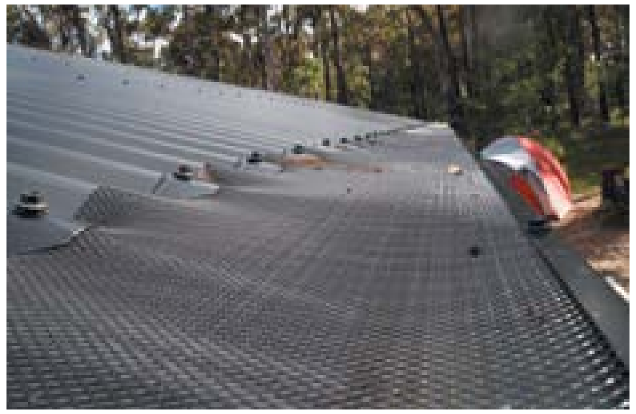
- Safeguard the roof system from igniting, collapse, displacement and breach.
- Prevent ember accumulation and entry into the roof cavity.
- Prevent roof systems from igniting, burning and producing additional heat to:
  - the interior of the building
  - other building elements
  - exit routes.

Choose a simple roof profile to avoid debris and ember accumulation but if a ridge or valley are present, refer to construction detail 10a and 10b.

Gutters and gutter guards

Accumulated debris and ember attack can build up in gutters and provide flames to adjacent roof elements:

- use non-combustible gutters and gutter guards
- avoid adjacent combustible elements such as fascias, roof framing and battens
- avoid using gutters (design out the risk).



Metallic gutter guard. Source: Paul Whitington

Avoid the following:

- Complex roof forms with many valleys and ridges as they require complex roof protection details to prevent ember entry.

Frame: **Non-combustible roof frame**
e.g. steel (for detailed information, refer to the NASH Standard)

Roof covering: **Steel roof** | **Tile roof**

Fascias, barge boards, eave linings and ridges:

Steel roof:

Use non-combustible fascias and eaves

Level 2
Seal ridges and eaves to resist ember attack and prevent debris from building up in the roof cavity

Level 3
As for level 2 and add noncombustible foil-backed blanket insulation (see construction detail 1b, 3b and NASH Standard)

Level 4
Use a 60-minute fire rated roof design that also has non-combustible framing, external finishes and insulation

Tile roof:

Use non-combustible fascias and eaves

Level 2
Seal ridges and eaves to resist ember attack and prevent debris from building up in the roof cavity

Level 3
Use a 30-minute fire rated roof design that also has non-combustible framing, external finishes and insulation

Level 4
Use a 60-minute fire rated roof design that also has non-combustible framing, external finishes and insulation

Construction detail:

Refer to:
Construction detail 1a (page 72), 1b (page 73), 3a (page 76), 3b (page 77)

Frame: **Combustible roof frame**
(e.g. timber)

Roof covering: **Steel roof** | **Tile roof** (assumed to be non-tight fitting)

Fascias, barge boards, eave linings and ridges:

Steel roof:

Use non-combustible fascias and eaves
Eliminate gaps larger than 2 mm

Level 1
Seal ridges and eaves with non-combustible insulation or flashings to resist ember and localised flame attack and prevent debris from building up in the roof cavity
(If installing new roof sheets: fully wrap framing trusses with flame resistant sarking and use steel roofing battens under roof sheets)

Level 2
As for level 1, fully wrap framing trusses with flame resisting sarking and use steel roofing battens under roof sheets

Level 3
Refer to AS3959 BAL FZ roof design solutions. In addition, consider using non-combustible fascia and eave finishes.

Level 4
Use a 60-minute fire rated roof design that also has non-combustible external finishes and insulation

Tile roof:

Use non-combustible fascias and eaves
Eliminate gaps larger than 2 mm

Level 2
Seal eaves with steel flashings to resist localised flame attack. Use steel roofing battens under tiles and fully wrap framing trusses with flame resistant sarking

Level 3
Refer to AS3959 BAL FZ roof design solutions. In addition, consider using non-combustible fascia and eave finishes.

Level 4
Use a 60-minute fire rated roof design that also has non-combustible external finishes and insulation

Construction detail:

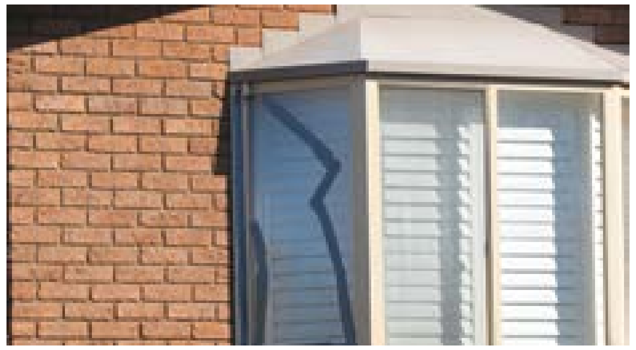
Steel roof: **Refer to:**
Construction detail for 5a (page 80), 6a (level 1, page 82), 5b (page 80), 6b (level 2, page 83)

Tile roof: **Refer to:**
Construction detail 7a (page 84), 7b (page 85)

Window and glazing systems

Combustible window components, such as frames and seals, can ignite when exposed to ember attack, flame contact or radiant heat attack.

Glazing can crack or shatter when exposed to radiant heat or flame, depending on the duration and intensity of the exposure. Damaged glazing can provide a point of entry for ember attack, which can ignite internal furnishings.



Cracked window from adjacent vegetation burning. Source: CSIRO

Design principles for window systems (including glazing, frames, screens and shutters)

- Safeguard window systems from ignitions, breakages and collapse.
- Prevent embers from accumulating and gaining entry through windowsills.
- Resist ignition burning, and production of additional heat.

Design strategies

Glazing

- Standard glass (annealed glass)–**level 1**
- Toughened glass–**level 2**
- Fire rated window–**Level 3 or 4**[29]
- Alternative is to use bushfire shutters–**level 4**[30]

Frame

Class 1 durability timber acceptable[32], non-combustible preferred–**level 1**

- Window frames, sills, reveal should be constructed using non-combustible materials–**level 4**

Openable section windows

Openable window sections[31]:

- install external metal mesh on all openable windows to protect against ember entry (with aperture no larger than 2mm) –**level 1 to 4.**

Windows that extend to the floor need to follow specific building requirements:

- toughened safety glass or glass blocks for all glazing within 400 mm of ground and screen (for additional details, please refer to AS 3959).

Avoid the following:

- Using combustible cladding around the window.
- Putting combustible objects close to the window.
- Relying on shutters alone to protect windows as they are often not in their closed position when the bushfire arrives.

29 *See manufacturer specifications.*
30 *See manufacturer specifications.*
31 *Any installation should be compliant with AS3959.*
32 *Australian Standard AS5604 (2005) Timber–Natural durability ratings.*

Door systems

Combustible parts of the door can ignite when exposed to ember attack, direct flame contact or radiant heat attack. These attacks may come from consequential fires (e.g. door mats) or from the bushfire itself. Glazing included in door systems can break when exposed to radiant heat or flame, depending on the duration and intensity of the exposure, the type of glass and type of seal. See Window and glazing systems for more information. Doors may form a key part of an exit pathway.

Embers attack in re-entrant corners. Source: CSIRO

Design principles for door systems (including materials, frames, screens and shutters)

- Prevent all doors (including thresholds, framing, door materials, fixtures and draft excluders) from collapse, displacement, and burning.
- Prevent embers from gaining entry through the door threshold sill.
- Prevent door systems from igniting, burning and producing toxic gases that may then threaten either the interior of the building or an exit route.

Avoid the following:

- Using combustible cladding on or around the door.

Design strategies

All exposed components should be made of non-combustible materials. Fixtures and materials should be durable and heat resistant. Fixtures and materials should be rated to withstand the extreme wind conditions and heat loads expected during a bushfire event. Doors should be self-closing and easily opened from the inside without the use of a key or deadlock. Also ensure there are no gaps between the door and the door frame (including the threshold).

Doors, framing and thresholds

- All doors should be tight fitting, with gaps smaller than 2 mm. If this is not possible, install weather draft strips and seals to ensure there are no gaps greater than 2 mm.
- Non-combustible, the use of class 1 durability timber solid core doors is acceptable–**level 1**
- Should be constructed using non-combustible materials–**level 2**
- Non-combustible fire rated 30 minutes –**level 3**[30]
- Non-combustible fire rated 60 minutes –**level 4**[30]

Door protection

Screens*

Install a non-combustible screened security door which is self-closing (with apertures no larger than 2 mm).

Glass sliding door

As for windows for the equivalent level.

** any installation should be compliant with AS3959*

Vents and other perforations

Design principles

- Prevent flames and embers from entering the building through vents and perforations in the building envelope.
- Safeguard individual vents from collapse, displacement and breach.

Vents

All components should be made of non-combustible materials. Vents should be tight fitting and secure, with a maximum aperture of 2 mm. Materials should be durable, and heat and corrosion resistant. Vents should have a minimum aperture of 2 mm and be made of:

- stainless steel or galvanised steel frames and mesh (galvanised steel requires more frequent replacement, this is the best option)
- bronze mesh as a reasonable alternative to steel mesh
- aluminium mesh.

Vents should not be in areas where flame contact is expected, as mesh screens may not prevent flames or flammable gas entry through the vent, (e.g. locate vents at least 500 mm from ground level to prevent surface fire interaction).

Perforation of the external envelope

Any penetrations in roof, wall or floor (e.g. chimney, flu, extraction vent, downlights, pipes) should be non-combustible and tightly fitted to avoid any gaps larger than 2 mm and sealed with non-combustible material.

Example of roof perforation and combustible elements on roof.

Perforation of internal lining (roof, wall and subfloor)

Any perforation of internal lining (e.g. internal light, pipes and extraction) should be sealed with non-combustible material to avoid any gaps greater than 2 mm.

Sealing small gaps

It is important to seal small gaps with appropriate joining strips. Silicone is recommended for sealing in areas with no direct flame attack, and fire rated sealants and steel flashings in areas where flames can contact the gap that was sealed (flame front, consequential fire, surface fire). No polymer joining strips should be used unless they are fire rated (no PVC).

Avoid the following:

- Using plastic coated glass fibre screening materials.
- Do not block or cover an existing vent before considering whether its removal will hamper the flow of ventilation.
- Using plastic or rubber beadings or clips to secure the vent and screening materials.
- Using slotted vents, or vents with gaps that are wider than 2 mm.
- Using whirlybirds.

Decks, verandahs and stairs

Decking and stair configurations can vary significantly in terms of materials used, size and relative location. Factors affecting both ignition and severity of burning include decking surface, bearer and stump materials, the height of the decking above ground level, where debris accumulates, and separation distance between decking elements and the house.[33] Small ignitions on timber decks, porches, patios or verandahs, if left unattended, can grow to a point where they ignite or break building elements such as combustible facades, windows, doors, eaves and subfloors.

Design principles

- Resist ignition from ember attack.
- Resist ignition from radiant heat attack and direct flame contact.
- Protect the deck and supporting posts and columns from burning, collapse, displacement, breach and producing additional heat and toxic gases to:
  - the interior of the building
  - other building elements
  - exit routes.

Design strategies for deck

- Use non-combustible material for the deck, supporting posts and bearers. If the deck is not used as an exit path, then consider using class 1 timber decking slates as an alternative –**level 1.**
- Use non-combustible materials for the deck, supporting posts and bearers–**level 4.**
- Separate direct attachments to the house that are combustible (e.g. carport pergolas, patio areas).

Examples of deck construction details are presented in construction detail 9a and 9b.

Ember attack in re-entrant corners. Source: CSIRO

Damaged deck by ember attack (potential issues withexit path).

Avoid the following:

- Attachment of combustible materials directly to parts of the house that are not level 4 rated.
- Use of combustible materials near parts of the house that are not level 4 rated.

33 Leonard, 2019.

Active protection systems

System	Design principle	Design strategies
Shutters	Tight fitting shutters offer protection to window systems by preventing embers from accumulating on windowsills and by blocking flame, radiant heat and, airborne debris from reaching the window glass, frame and seals.	• Shutters should be permanently fixed to the house and ideally incorporate a reliable means of automated deployment. • Shutters should be made of non-combustible materials. • Ensure the system is tight fitting to avoid gaps larger than 2 mm. • Bushfire shutter must comply with AS3959 and should be non-combustible.
External spray systems	External spray systems can wet down combustible external elements such as eaves, facades, decking and surface fuels. External spray systems are not effective in sealing gaps or preventing the spread of fire to parts of the house that are sheltered from the weather, such as the roof cavity, wall cavities, under floor areas and the occupied areas of the house.  Because of these limitations, external spray systems should be considered as one part of a wider holistic approach to bushfire resilience. External spray systems should be used in combination with other design measures to reduce the overall bushfire risk rather than expecting them to provide a complete solution.	• Maintain a supply of water, with adequate water pressure that can continue to operate if both mains water pressure and power supply are lost. • Consider using automatic activation using a combination of smoke or heat sensors.[34]

System	Design principle	Design strategies
Internal sprinkler systems	Internal sprinkler systems offer protection against internal ignition, and can control the spread of fire within buildings and increase the duration of time the building may remain tenable. In some situations, internal sprinkler systems may prevent the total loss of the building. In bushfires, the ignition can occur externally, in the building cavities or within the occupied space of the house. Domestic building sprinkler standards cover ignition and spread within the occupied spaces of the house and may be compromised by fire spread within building cavities that may either damage sprinkler pipework or lead to rapid entry into multiple rooms (e.g. a roof cavity fire leading to multiple ceiling collapse).	• Follow the relevant standards for domestic building sprinklers. • Consider using additional sprinkler heads in the roof cavity, and under floor spaces if they contain or are composed of combustible materials. • Consider linking the system with an external spray system if there are external combustible facades or adjacent features.

34 *For detailed information refer to regulation and product specifications, including Standards Australia (2012) AS 5414–Bushfire water spray systems. Sydney: SAI Global. (See also Leonard & Potter, 2006).*

Services

Service	Design principle	Design strategies
Water	Maintain a water supply to the house for both active and passive defence. A static water supply should be adequately sized for the combination of all possible uses in a bushfire and full to this level through a bushfire season. The tank and pipework should be able to remain viable throughout the bushfire event. Pumping systems should be designed to be able to continue to provide adequate water pressure for all uses assuming that both mains water pressure and mains power are lost. Systems that can automatically switch over are preferred.  *Combustible pipe fitting melted. Source: CSIRO*	• Water tanks should be constructed using non-combustible material, such as metal or concrete, or alternatively can be installed underground (as a subterranean tank). • Avoid plastic water tanks.[35] • Use non-combustible pipework. • Where possible, use static water pressure if there is suitable terrain to support this. • If an external water pump is required or desired, ensure the water pump is designed and protected to allow it to operate under extreme bushfire conditions. Electric, petrol and diesel pumps are susceptible to radiant heat and flame contact, while petrol and diesel pumps have the added susceptibility to ember attack and elevated air temperatures, which can cause fuel vaporisation or air inlet filter ignition. Careful consideration of the refuelling requirements of these pumps is also important. Having a fuel tank that is sized so as not to require refuel during a bushfire event is the preferred option. The logistics of accessing the pump and safely refuelling it in the middle of a bushfire event presents a range of life safety issues. • Size the water tank for all possible uses including firefighting and static water supply. • Use non-combustible tank and pipework for all elements that are less than 150 mm below the earth. • Ensure the water pump is designed and protected to allow it to operate under extreme bushfire conditions.

35 *Leonard et al. (2006)*

Service	Design principle	Design strategies
Electricity	Maintain an electricity supply and manage electrical infrastructure appropriately. Protect electrical infrastructure on the property in a way that does not exacerbate bushfire hazards or obstruct firefighting. Consider the merits of a backup electrical power supply.	• If possible, install electrical infrastructure underground. • Create a cleared, open space between vegetation and any exposed electrical infrastructure (such as poles and wires). • For a backup power supply, consider either a battery backup system linked to a solar power system, or a protected generator. In each case, an automatic switch over is prefered to a manual one as failure of electricity supply is most common during the peak of the fire event.
Gas (piped)	Protect gas lines from bushfire actions both external to the house and within the cavities within the house. Isolate gas supply prior to fire arrival and follow gas safety procedures when reactivating gas supply after an event.	• Install gas lines below ground to minimise the risk of explosion. • Use metal connections, pipes and fittings in all above ground locations, including within building cavities. • Avoid using PEX gas piping above ground and in building cavities, as it can lose integrity at at 80°C which could be achieved within building cavities during a bushfire.
Gas (cylinders)	When a gas bottle vents, it can ignite the house or any combustible materials in the path of the flare. Protect people from the hazards associated with gas cylinders. A gas tank that is not secure may fall and if the tank continues to be heated in this position it may violently explode. Such explosions are common in the period following the passage of the fire front and pose a significant threat to people and houses. Protect gas cylinders from falling by attaching them to a solid steel or masonry structure that cannot collapse even if the adjacent structure burns.	• Refer to local installation regulations. • Securely attached gas cylinders to a solid structure with a metal chain or cable. • Ensure the area around the cylinder is clear of vegetation and other combustible materials. • Use metal connections, pipes and fittings. • Direct the vent on the gas cylinder away from structures and exit pathways.

Part 3: Bushfire resilient construction

Introduction to bushfire resilient construction

This section provides information about bushfire resilient construction systems applicable to:

- wall systems
- floor systems
- roof systems
- verandahs and decks.

The details in this section refer to the **protection levels** on page 44 as there are often multiple solutions depending on the level of protection your situation requires.

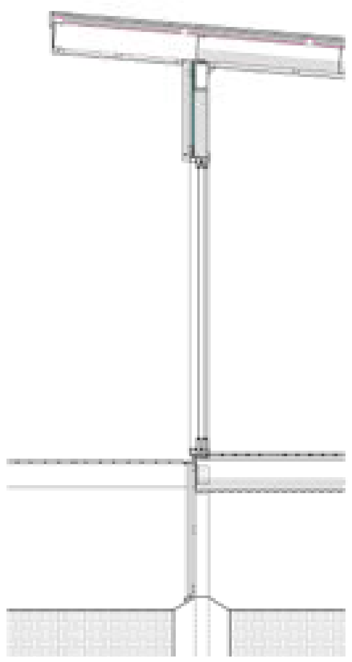
These are examples of construction designs, for complete information refer to the Australian Standards AS3959 and NASH Standard. Refer to the bushfire resilient materials table for information about the advantages and disadvantages of various material types.

Protection levels*
Level 1
Level 2
Level 3
Level 4

*Refer to page 44

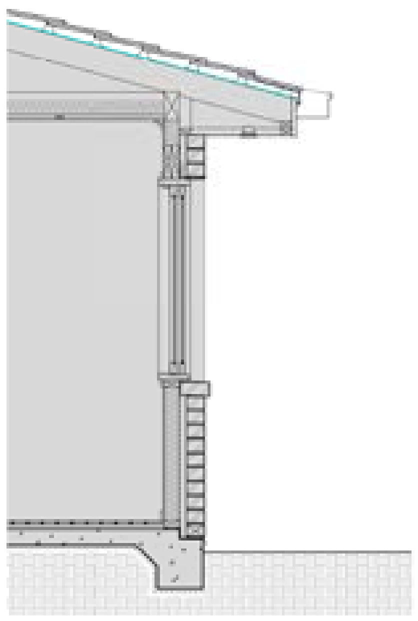
1. Complete wall detail section: new house

See details 1 - 4



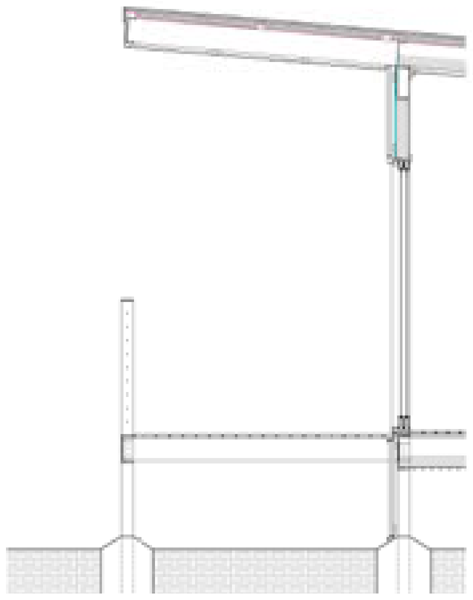
2. Complete wall detail section: retrofit existing house

See details 5–8



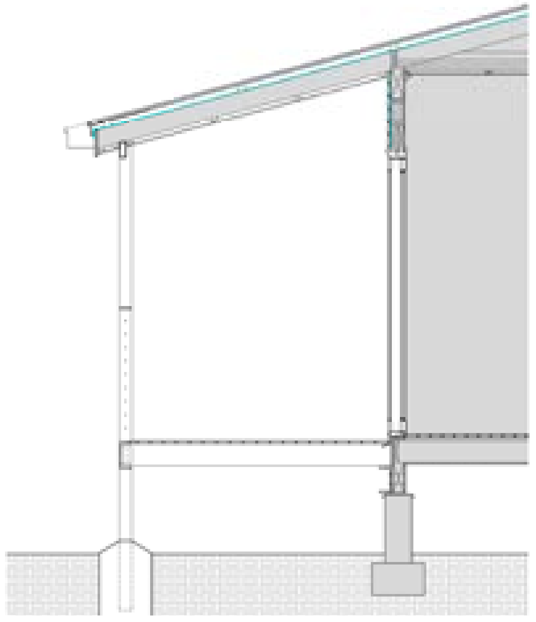
3. Deck construction: new deck

See detail 9



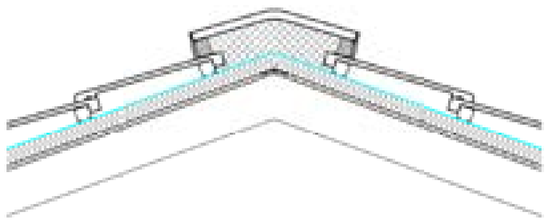
4. Deck construction: retrofit existing

See detail 10



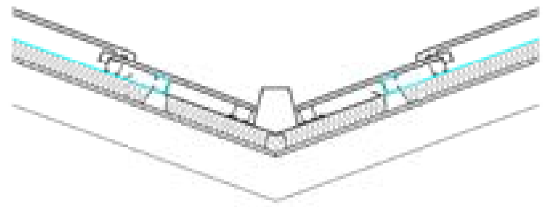
5. Roof ridges: new and retrofit

See details 9–10



6. Roof valleys: new and retrofit

See details 9–10

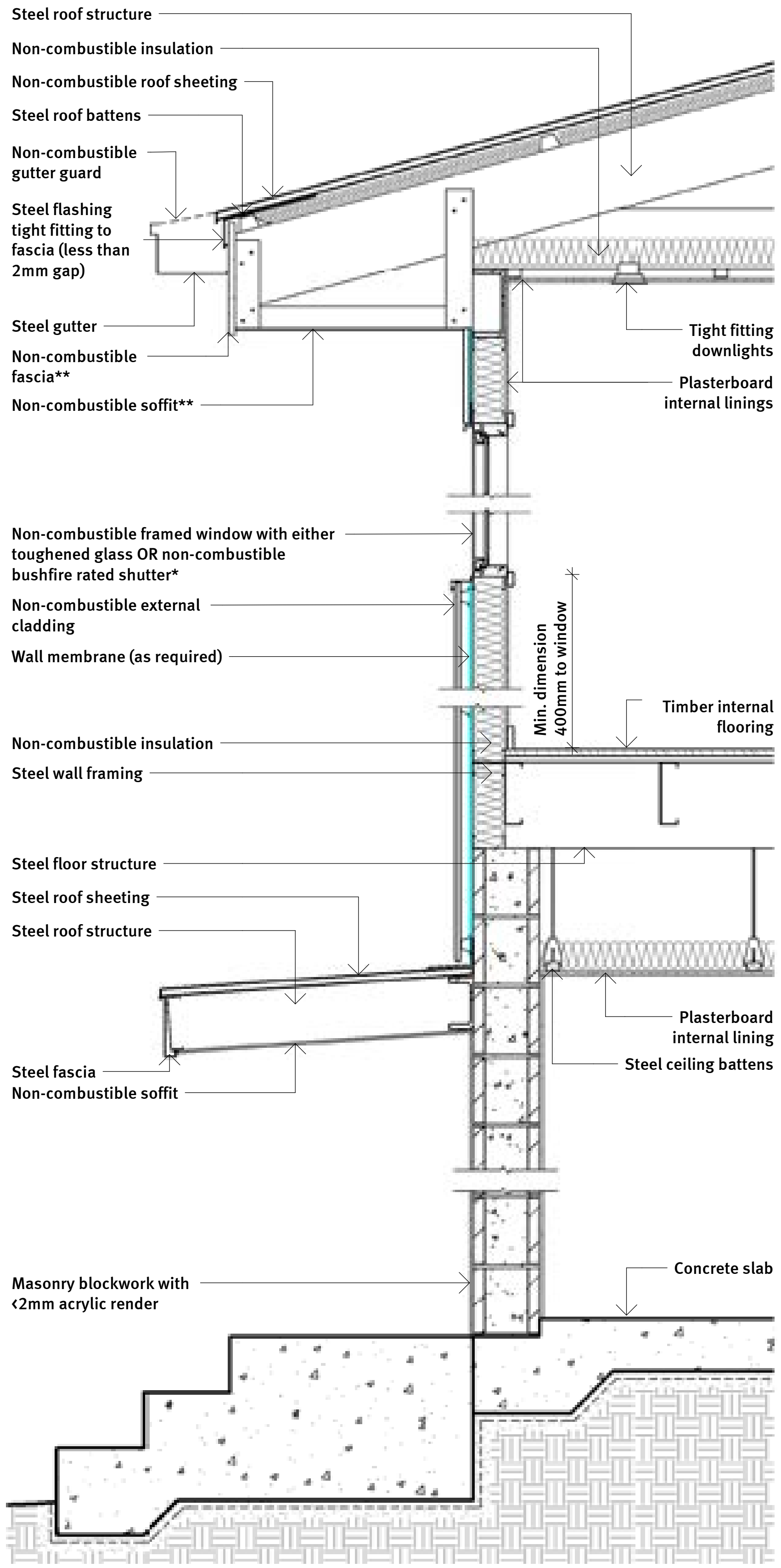


Construction examples

Construction detail example 1a

Non-combustible frame–level 2 exposure

The following scenario shows an example of a house with non-combustible external masonry walls on the lower level, non-combustible steel framed walls on the upper level, an external window and adjoining awning roof that is resilient up to a level 2 exposure.



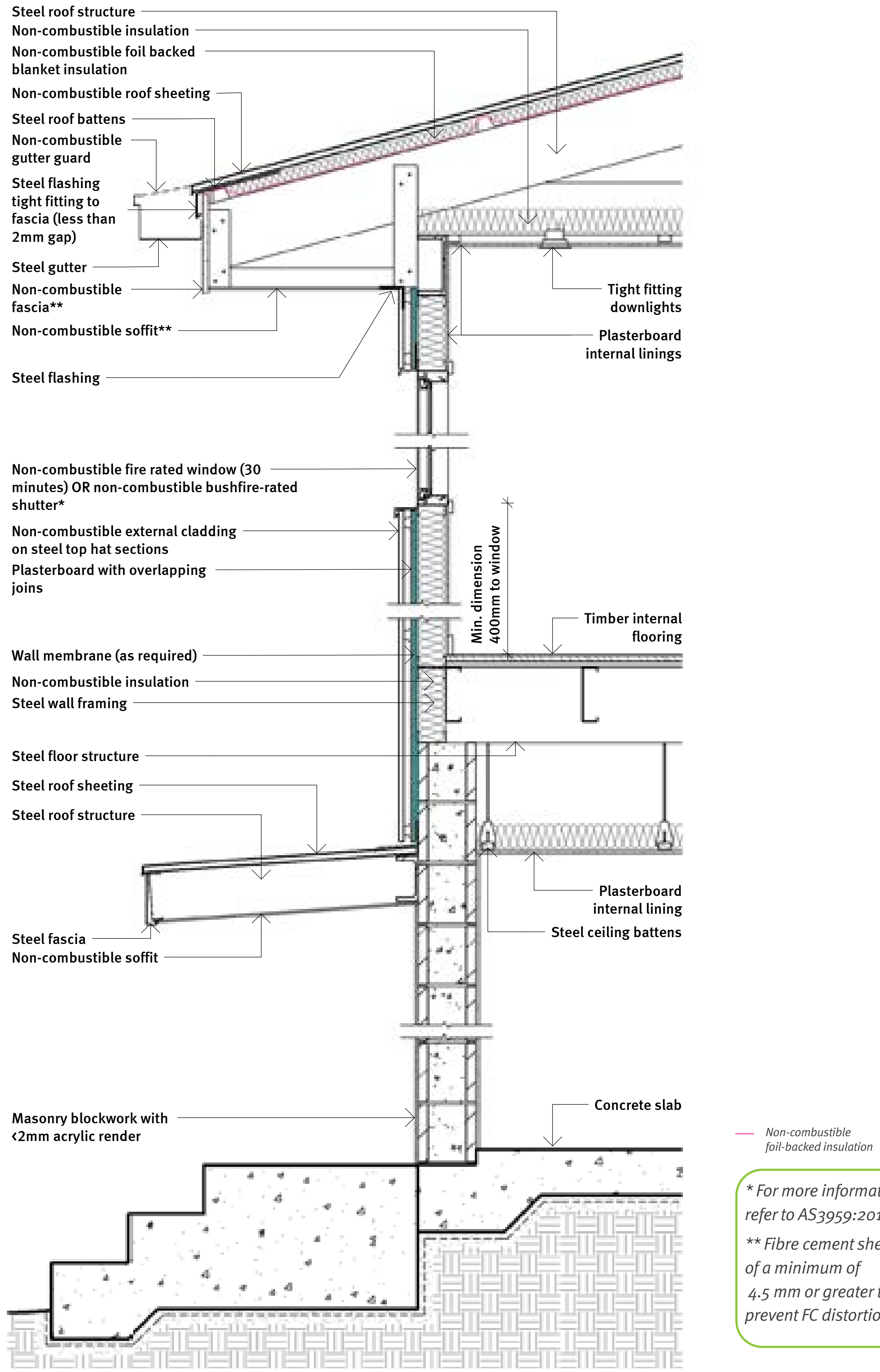
** For more information refer to AS3959:2018*

*** Fibre cement sheet of a minimum of 4.5mm or greater to prevent FC distortion*

Construction detail example 1b

Non-combustible frame–level 3 exposure

The following scenario shows an example of a house with non-combustible external masonry walls on the lower level, non-combustible steel framed walls on the upper level, an external window and adjoining awning roof that is resilient up to a level 3 exposure.



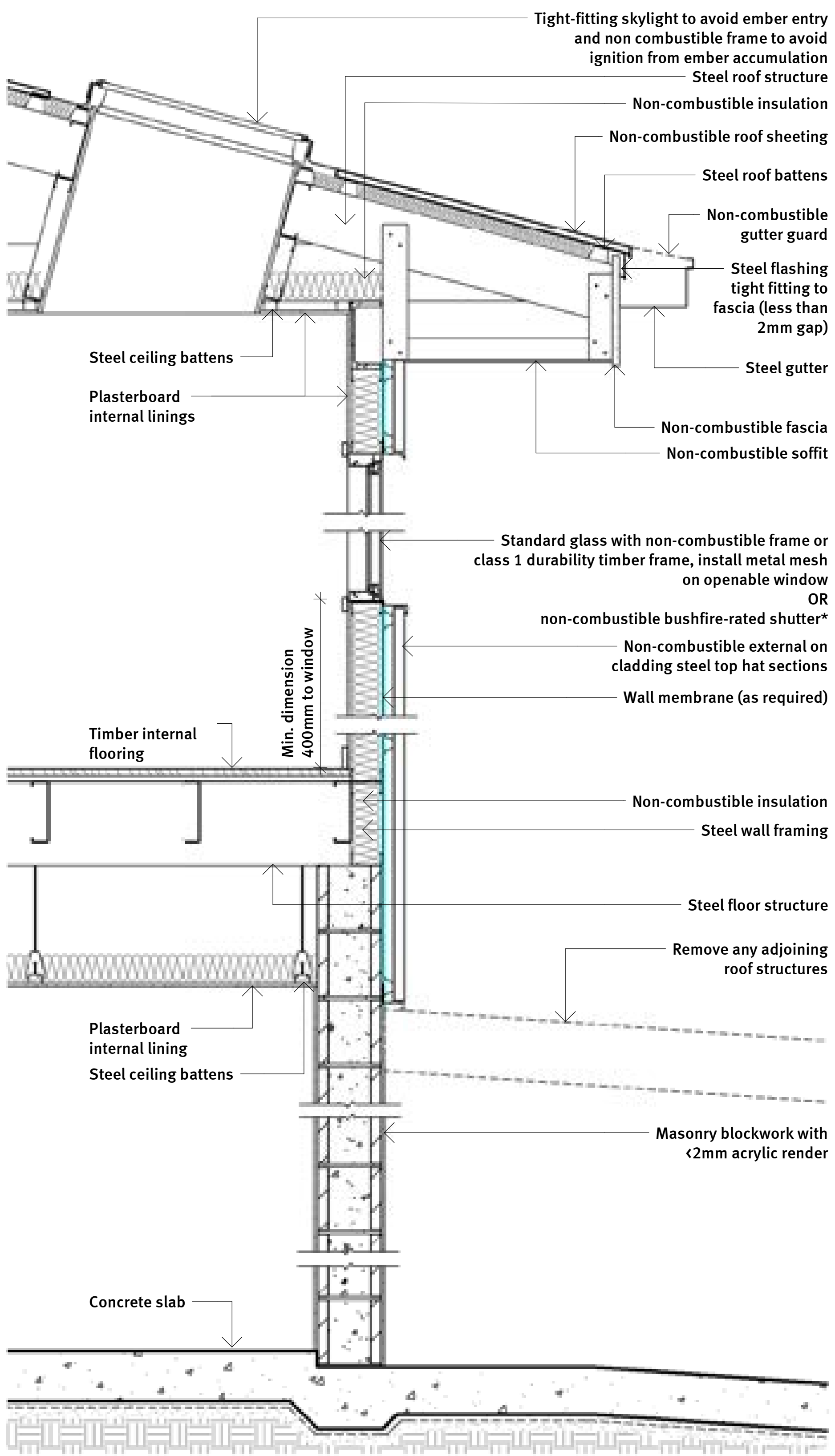
** For more information refer to AS3959:2018*

*** Fibre cement sheet of a minimum of 4.5 mm or greater to prevent FC distortion*

Construction detail example 2a

Non-combustible frame–level 1 exposure

The following scenario shows an example of a house with non-combustible external masonry walls on the lower level, non-combustible steel framed walls on the upper level, a skylight and external window that is resilient up to a level 1 exposure.

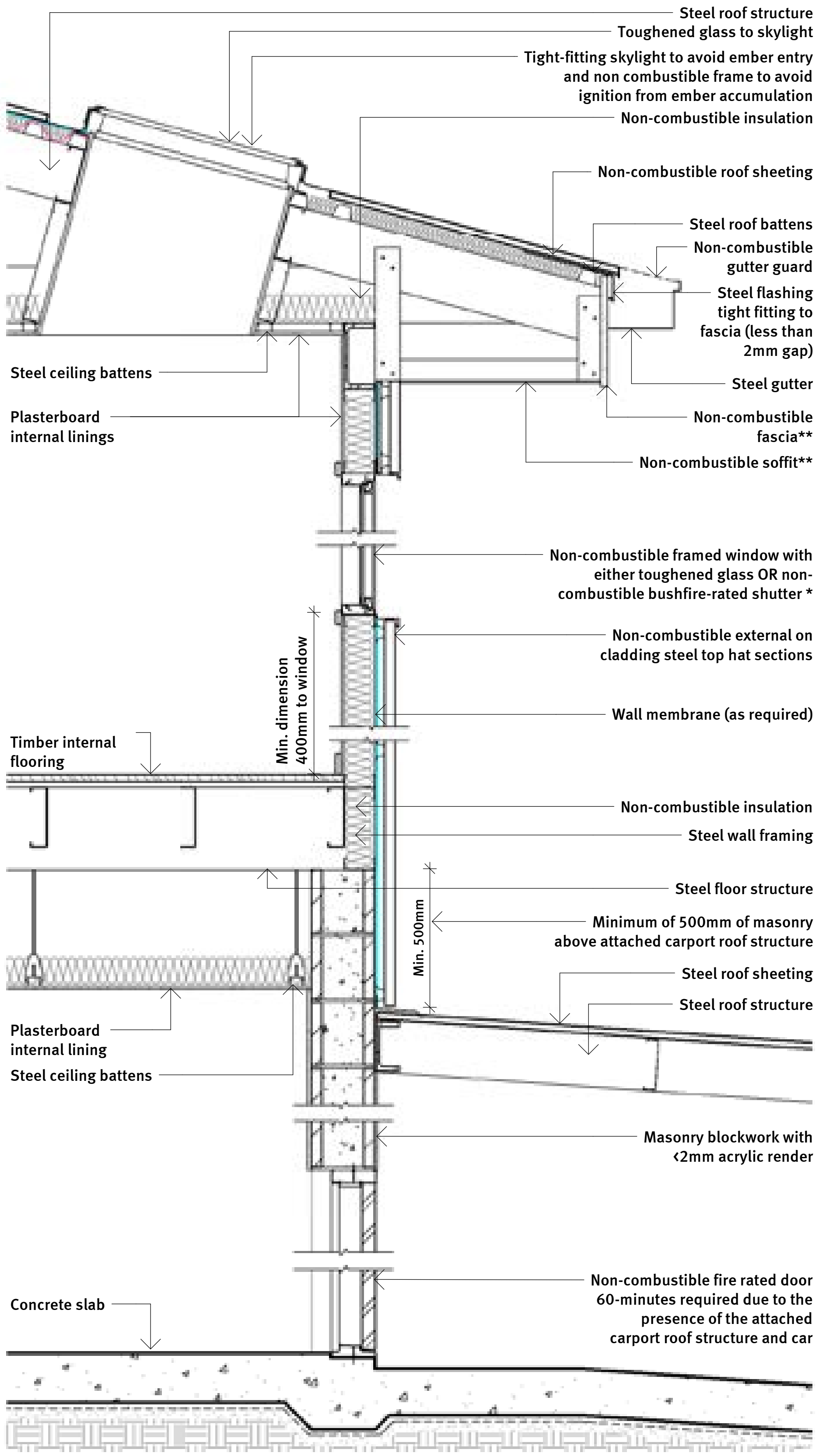


** For more information refer to AS3959:2018*

Construction detail example 2b

Non-combustible frame–level 2 with localised level 4 exposure

The following scenario shows an example of a house with non-combustible external masonry walls on the lower level, non-combustible steel framed walls on the upper level, a skylight, external window and adjoining carport roof that is resilient up to a Level 2 exposure. In this scenario, a fire rated door is required at the adjoining roof structure.



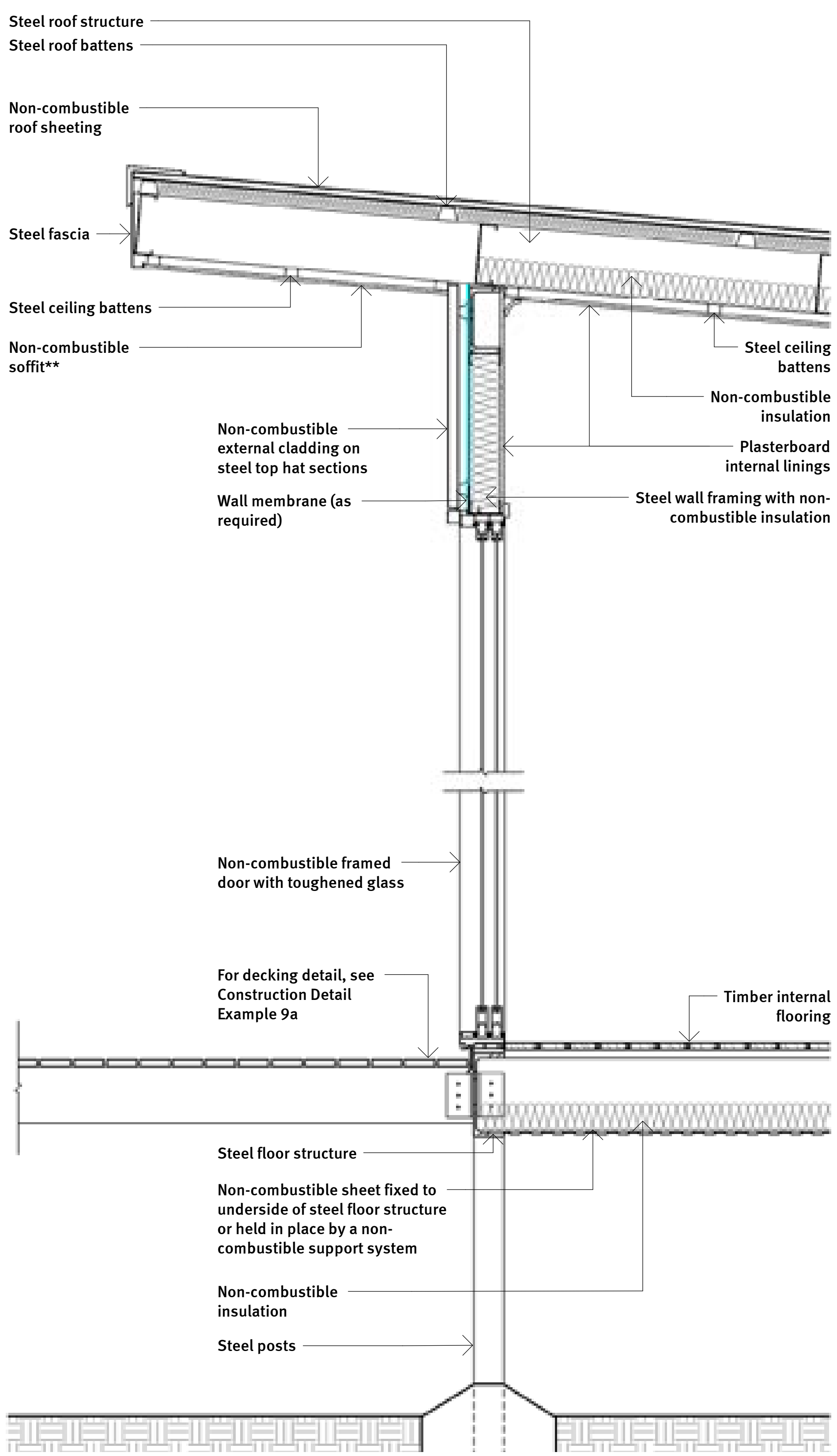
** For more information refer to AS3959:2018*

*** Fibre cement sheet of a minimum of 4.5 mm or greater to prevent FC distortion*

Construction detail example 3a

Non-combustible frame–level 2 exposure

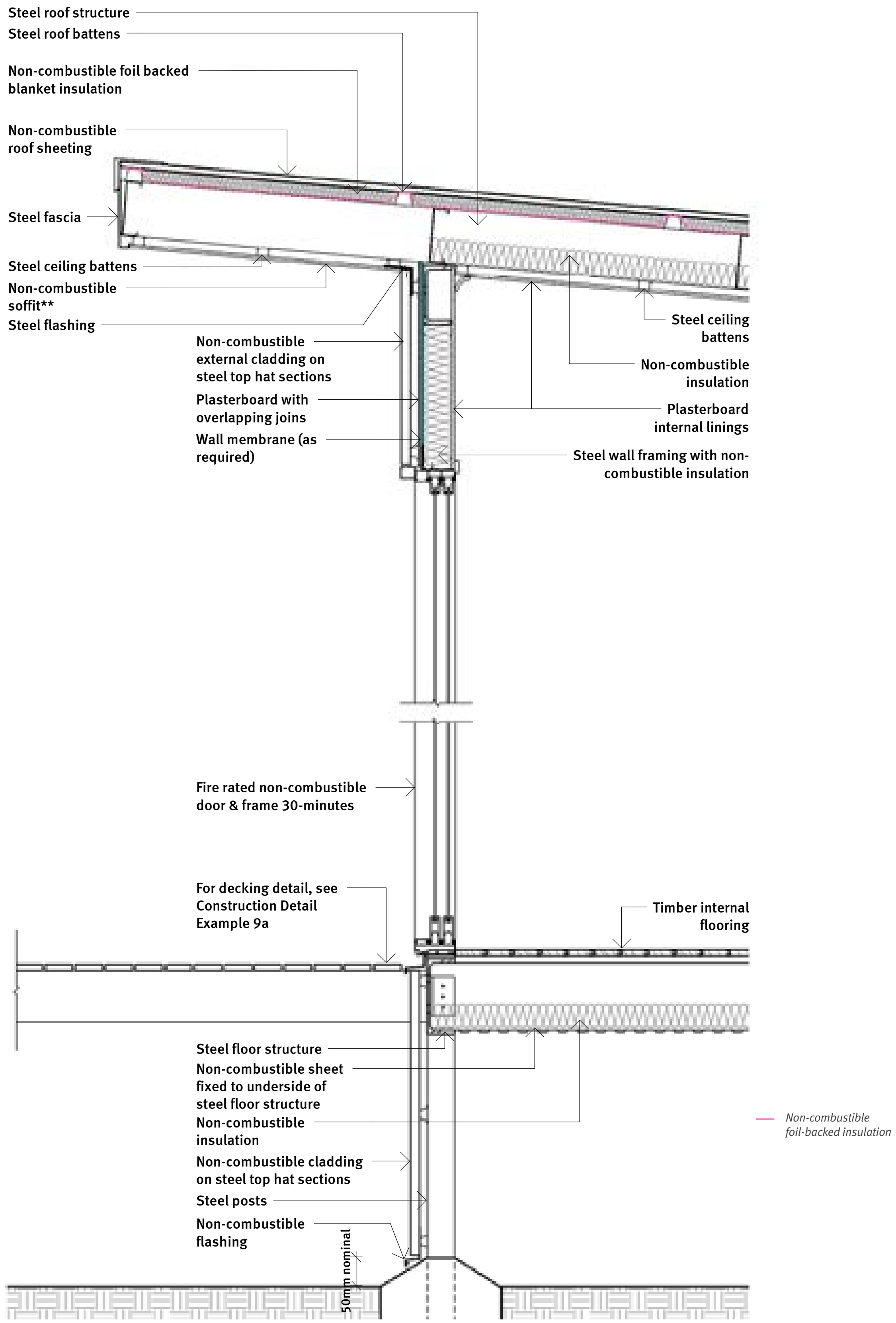
The following scenario shows an example of a raised, non-combustible framed house with a skillion roof, external door and adjoining deck that is resilient up to a level 2 exposure.



Construction detail example 3b

Non-combustible frame–level 3 exposure

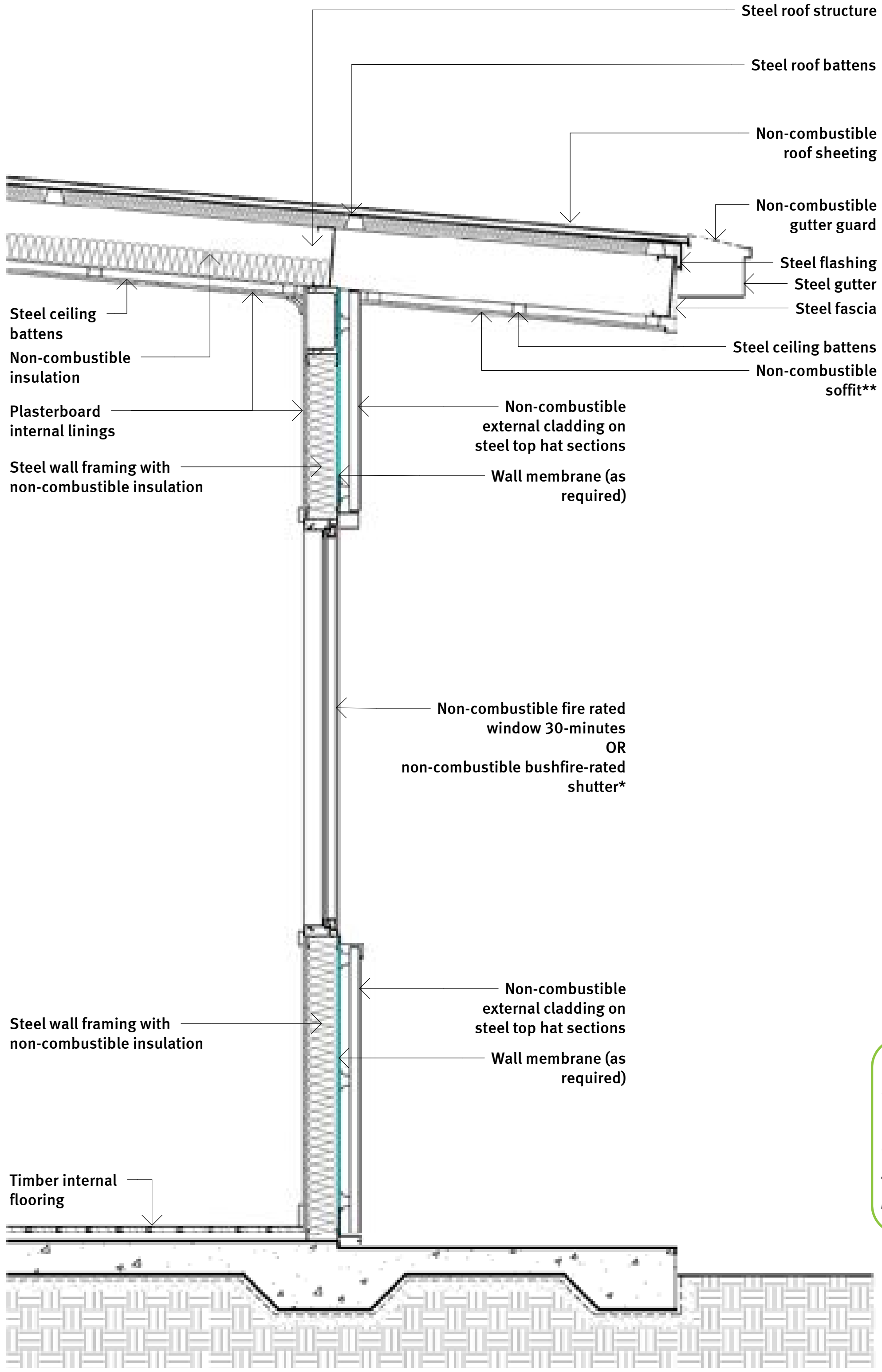
The following scenario shows an example of a raised, non-combustible framed house with a skillion roof, external door and adjoining deck that is resilient up to a level 3 exposure.



Construction detail example 4a

Non-combustible frame–level 2 exposure

The following scenario shows an example of a non-combustible framed house with a skillion roof that is resilient up to a level 2 exposure.



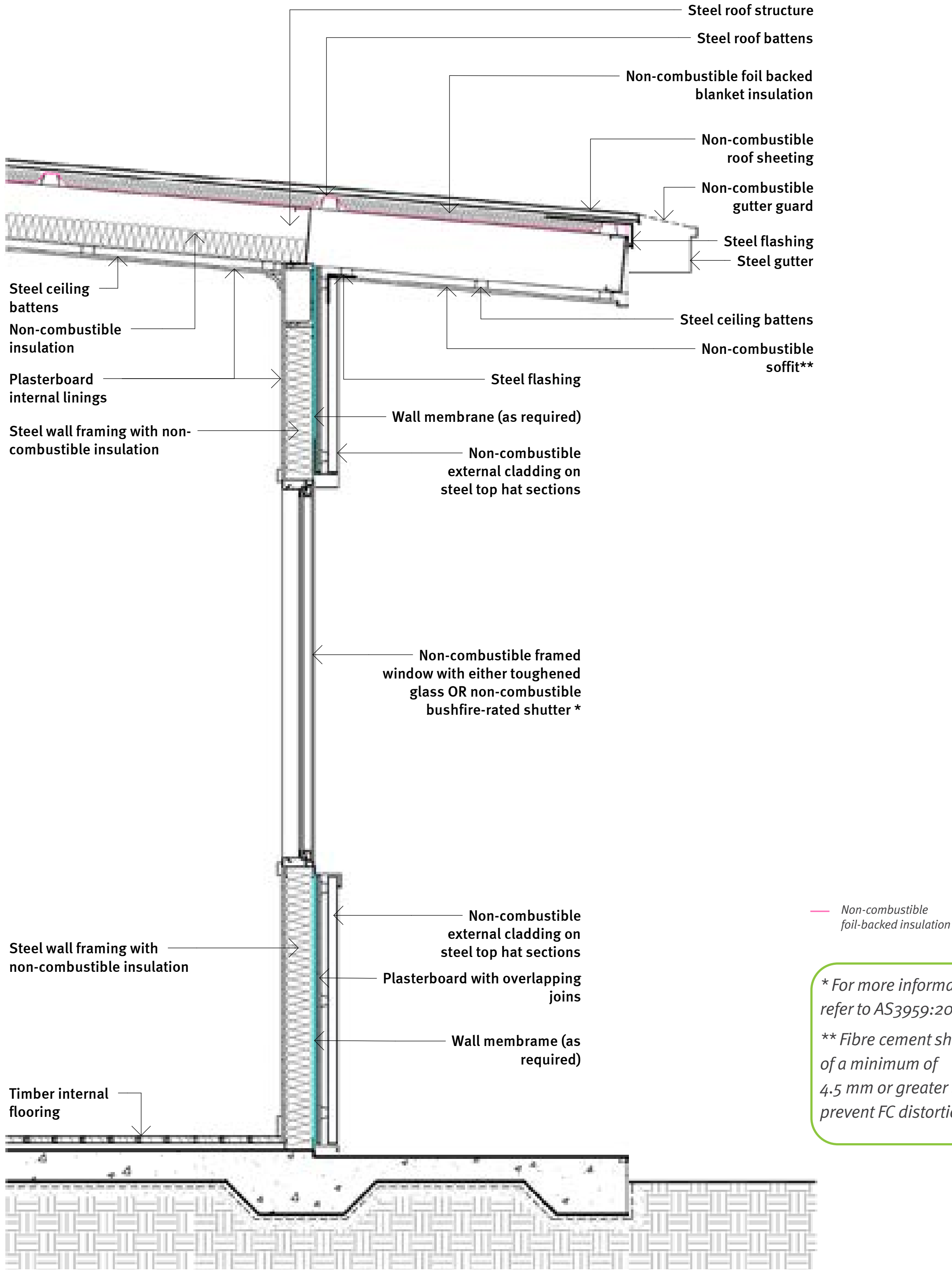
** For more information refer to AS3959:2018*

*** Fibre cement sheet of a minimum of 4.5 mm or greater to prevent FC distortion*

Construction detail example 4b

Non-combustible frame–level 3 exposure

The following scenario shows an example of a non-combustible framed house with a skillion roof that is resilient up to a level 3 exposure.



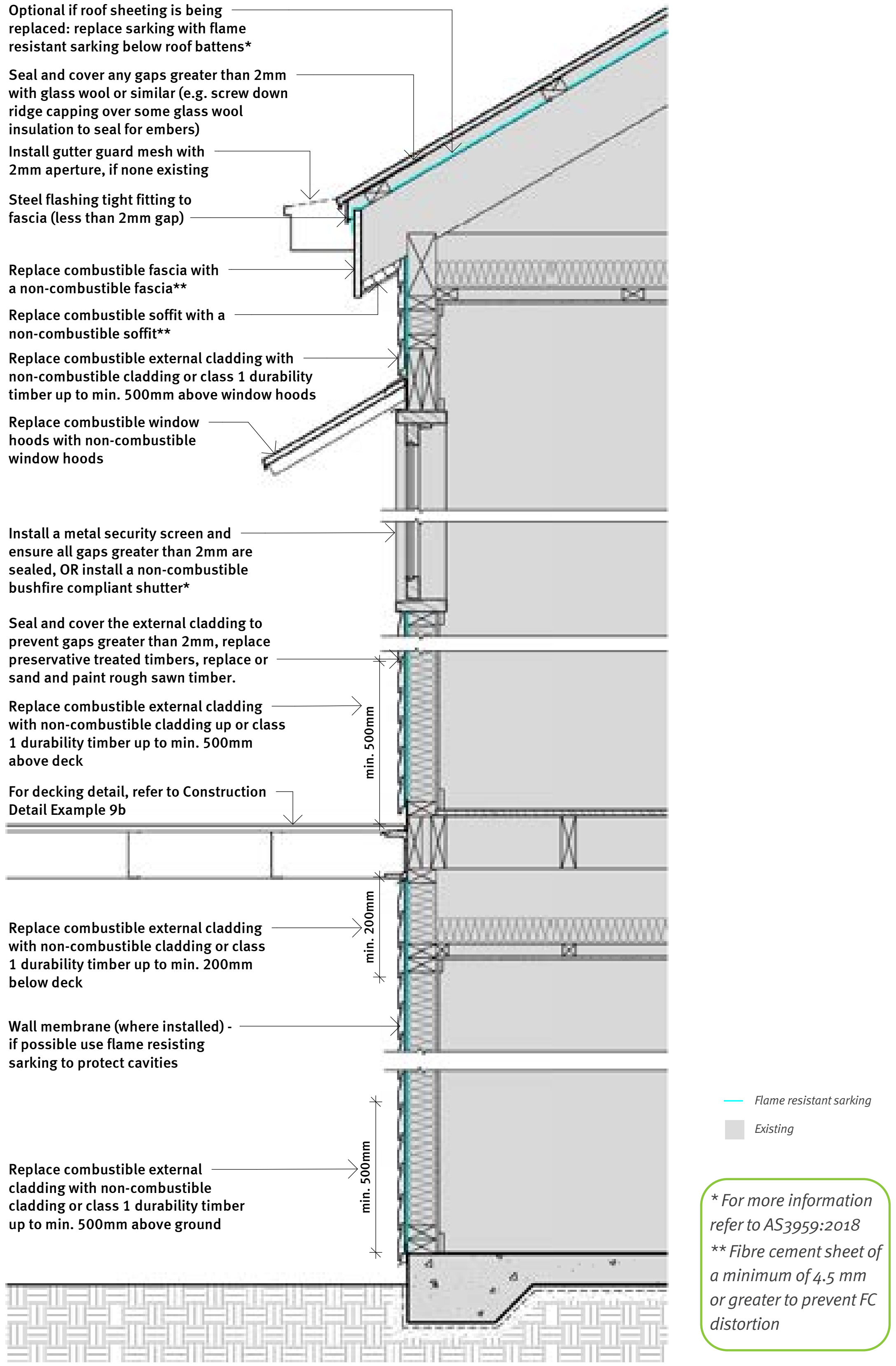
** For more information refer to AS3959:2018*

*** Fibre cement sheet of a minimum of 4.5 mm or greater to prevent FC distortion*

Construction detail example 5a

Timber frame retrotfit–lightweight wall–level 1 exposure

The following scenario explains how to retrofit a typical timber framed house with a steel roof, adjoining deck and an existing window to be resilient up to a level 1 exposure.

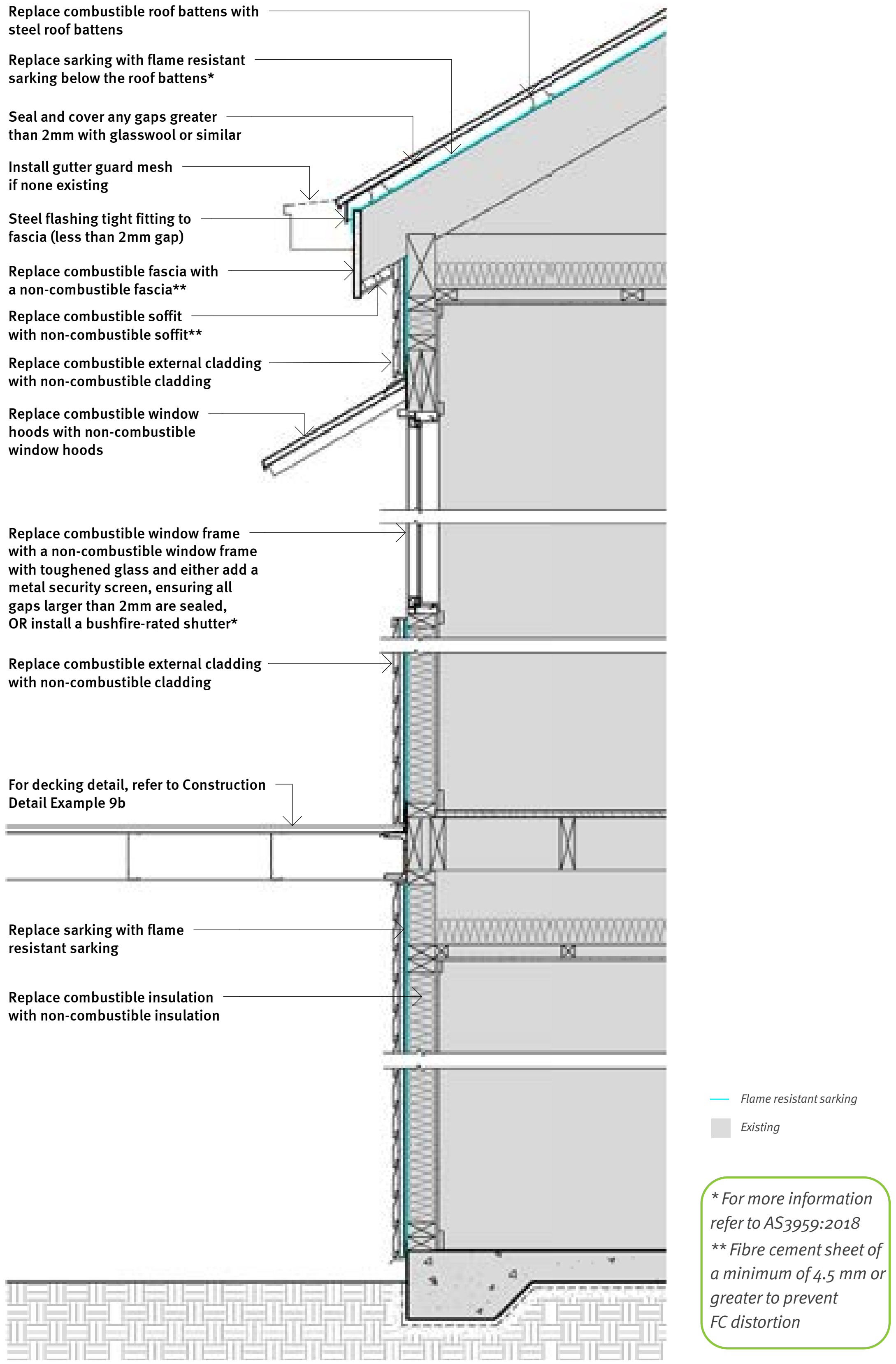


** For more information refer to AS3959:2018*
*** Fibre cement sheet of a minimum of 4.5 mm or greater to prevent FC distortion*

Construction detail example 5b

Timber frame retrotfit–lightweight wall–level 2 exposure

The following scenario explains how to retrofit a typical timber framed house with a steel roof, adjoining deck and an existing window to be resilient up to a level 2 exposure.

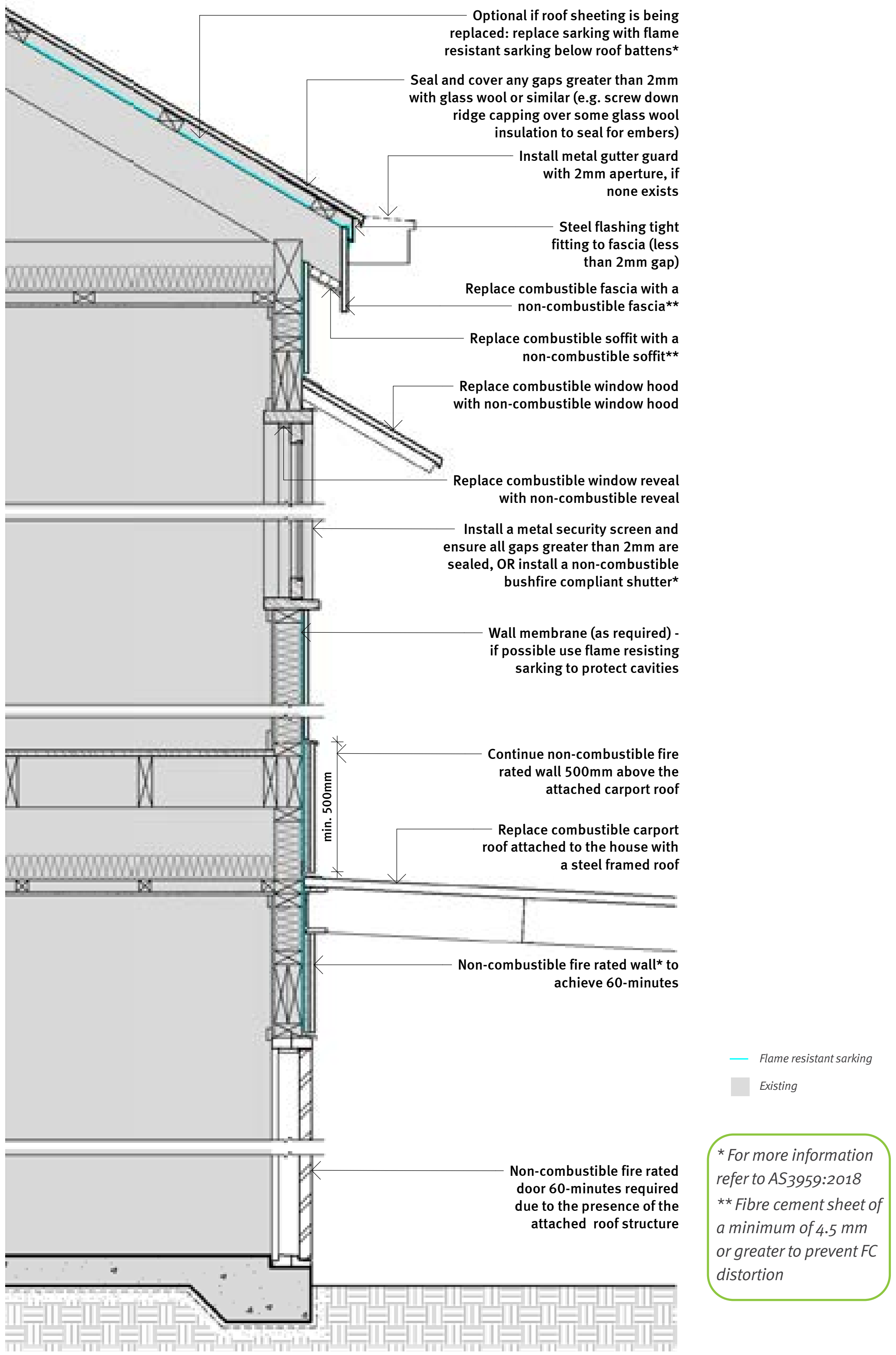


** For more information refer to AS3959:2018*
*** Fibre cement sheet of a minimum of 4.5 mm or greater to prevent FC distortion*

Construction detail example 6a

Timber frame–lightweight wall–level 1 exposure

The following scenario explains how to retrofit a typical timber framed house with a steel roof, adjoining carport roof and an existing window to be resilient up to a level 1 exposure. In this scenario, a fire rated door is required at the adjoining roof structure that is to be retained.

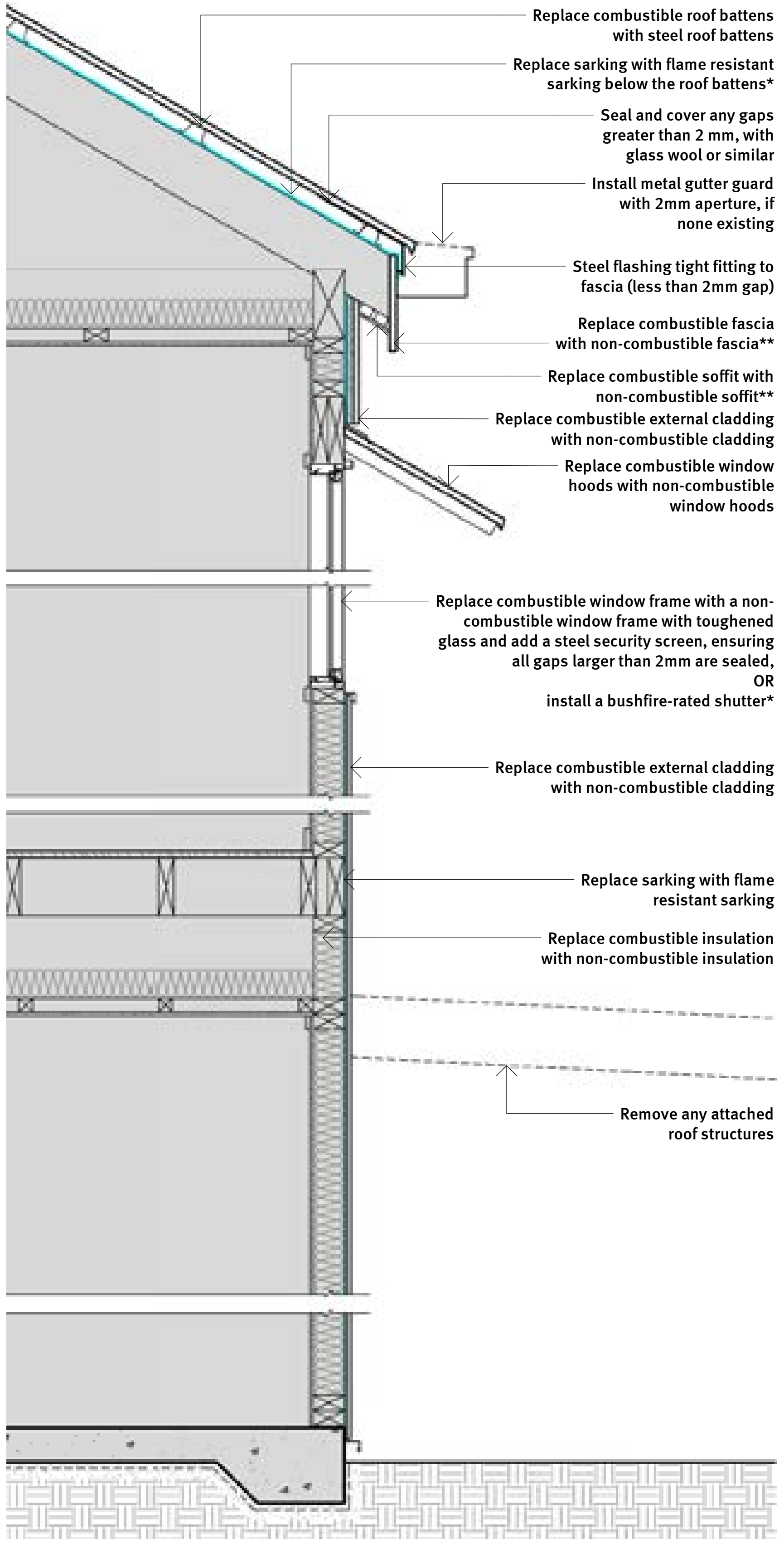


** For more information refer to AS3959:2018*
*** Fibre cement sheet of a minimum of 4.5 mm or greater to prevent FC distortion*

Construction detail example 6b

Timber frame–lightweight wall–level 2 exposure

The following scenario explains how to retrofit a typical timber framed house with a steel roof to be resilient up to a level 2 exposure. In this scenario, an existing timber framed wall is transformed into a fire rated wall and the adjoining roof structure is removed.

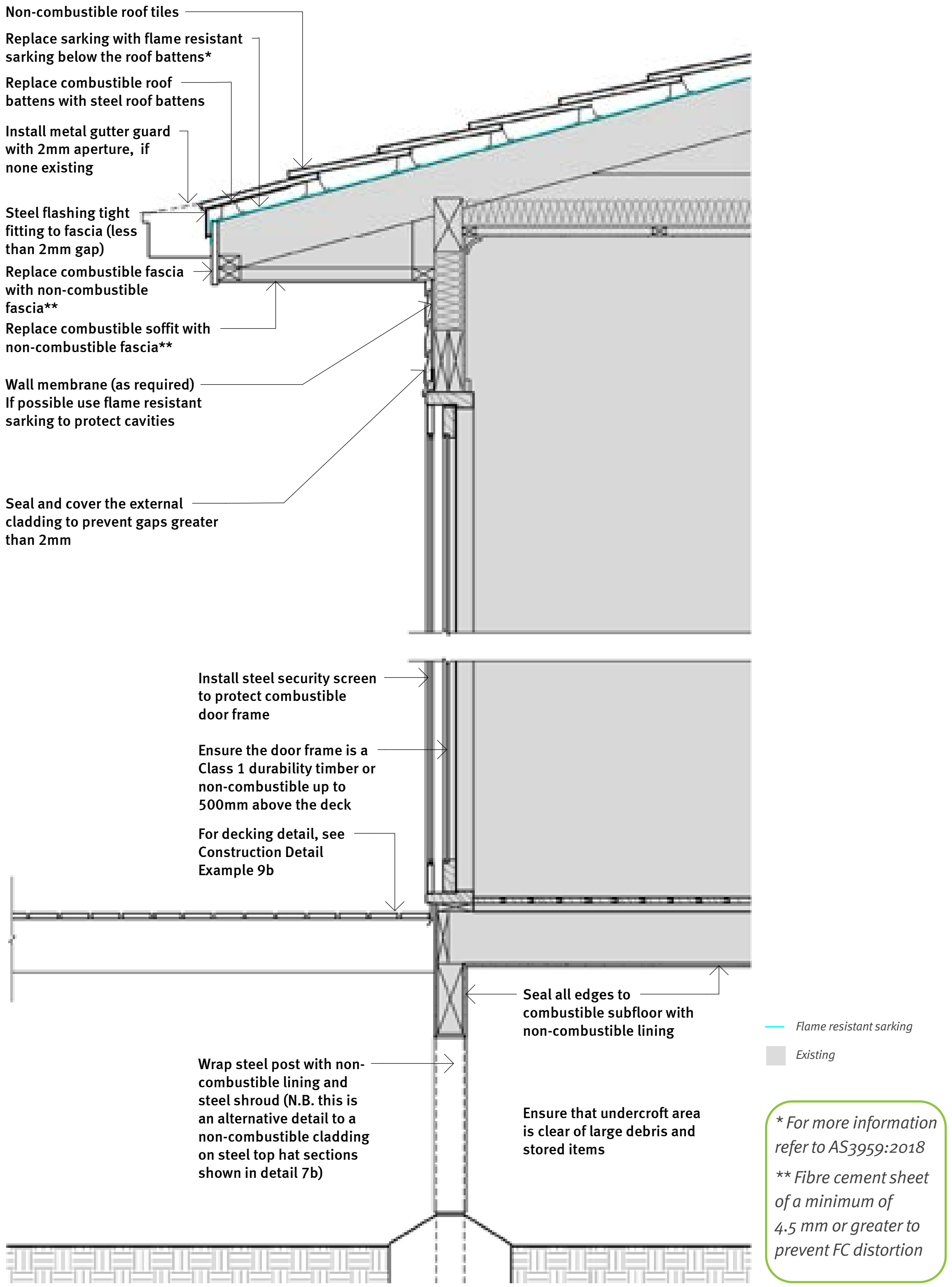


** For more information refer to AS3959:2018*
*** Fibre cement sheet of a minimum of 4.5 mm or greater to prevent FC distortion*

Construction detail example 7a

Timber frame retrofit–raised lightweight–level 1 exposure

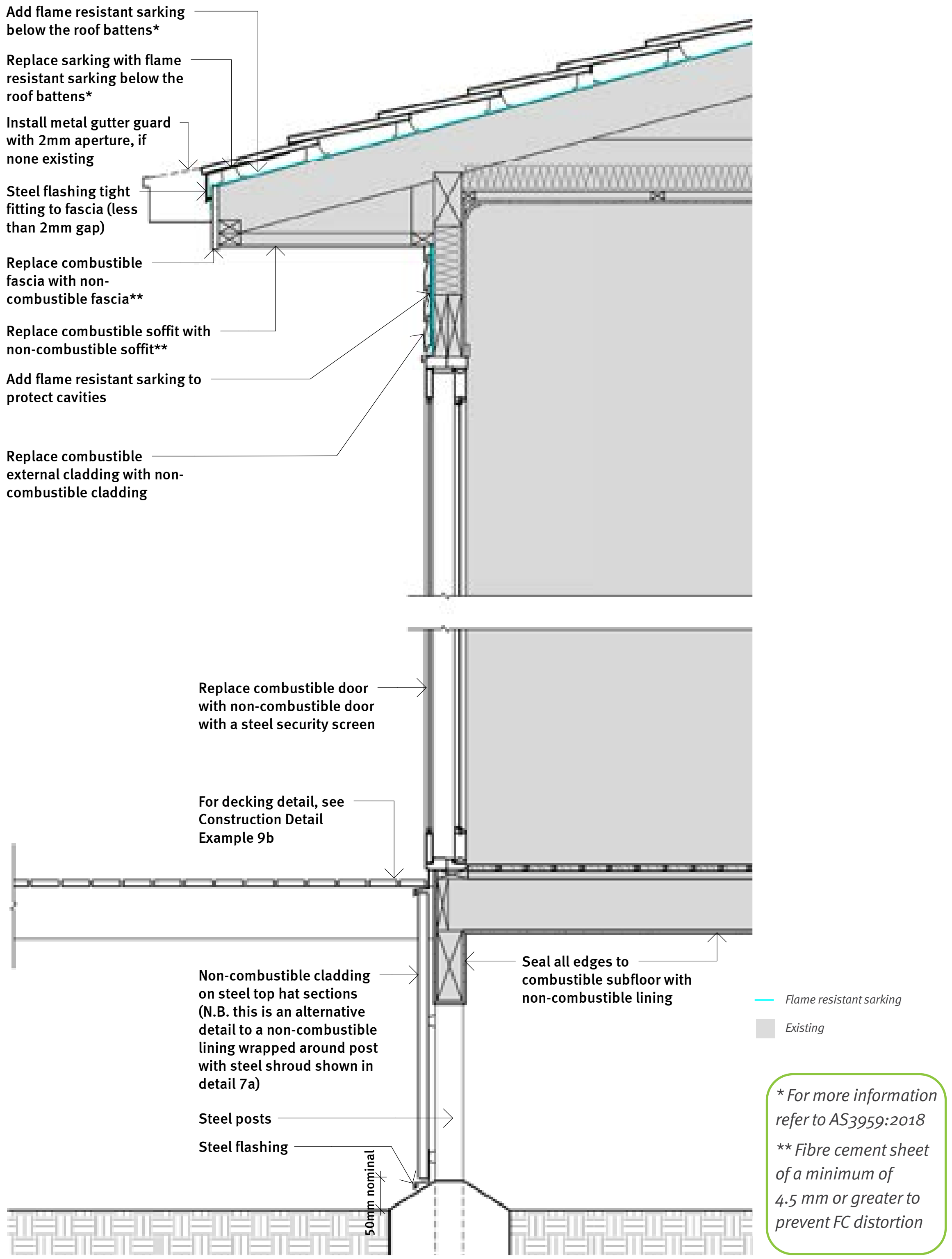
The following scenario explains how to retrofit a typical timber framed raised house with a tiled roof and an existing external door to be resilient up to a level 1 exposure.



Construction detail example 7b

Timber frame retrofit–raised lightweight–level 2 exposure

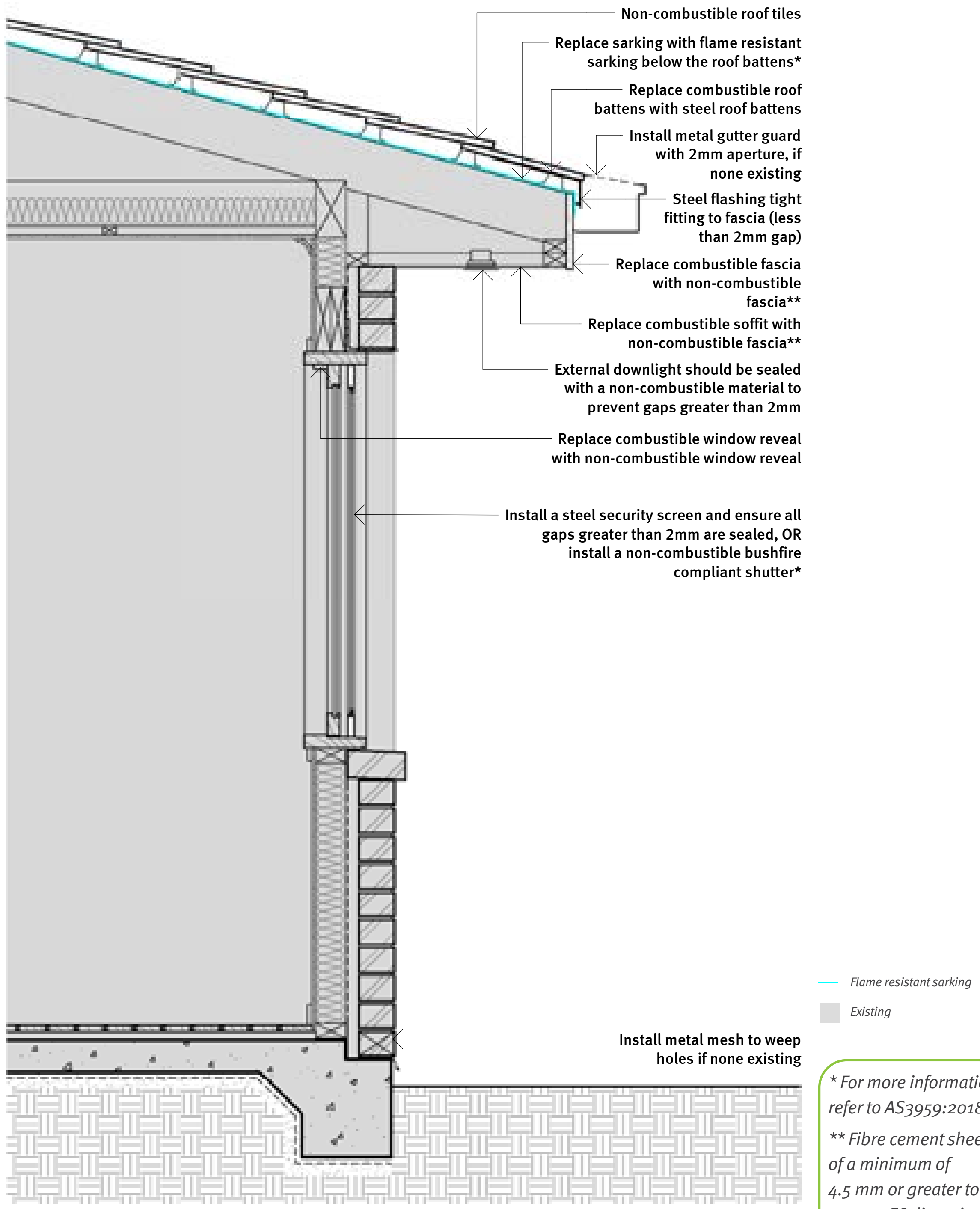
The following scenario explains how to retrofit a typical timber framed raised house with a tiled roof and an existing external door to be resilient up to a level 2 exposure.



Construction detail example 8a

Timber frame retrofit–brick veneer–level 1 exposure

The following scenario explains how to retrofit a typical timber framed brick veneer wall with a tiled roof and existing window opening to be resilient up to a level 1 exposure.



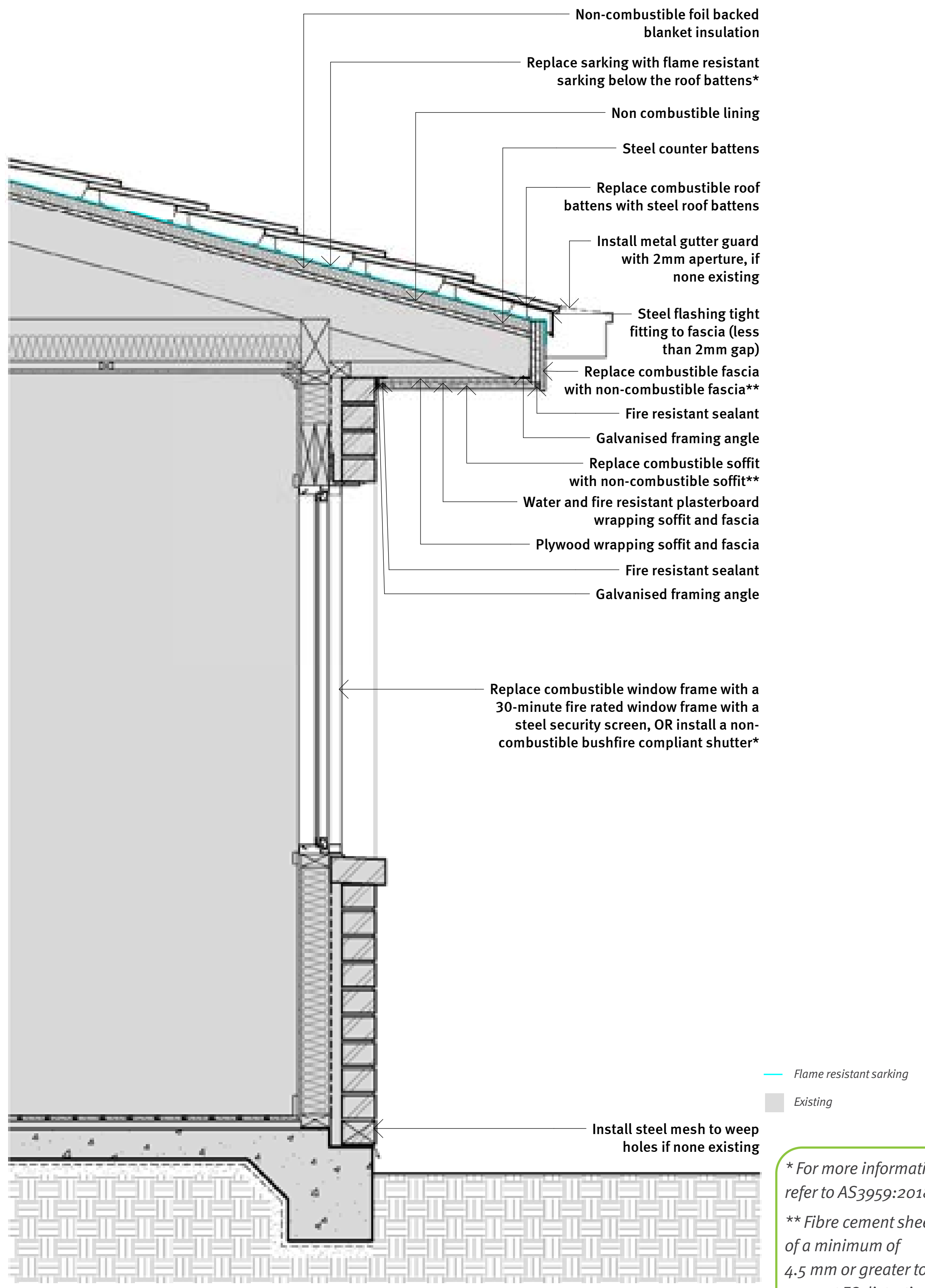
** For more information refer to AS3959:2018*

*** Fibre cement sheet of a minimum of 4.5 mm or greater to prevent FC distortion*

Construction detail example 8b

Timber frame retrofit–brick veneer–level 3 exposure

The following scenario explains how to retrofit a typical timber framed brick veneer wall with a tiled roof and existing window opening to be resilient up to a level 3 exposure.



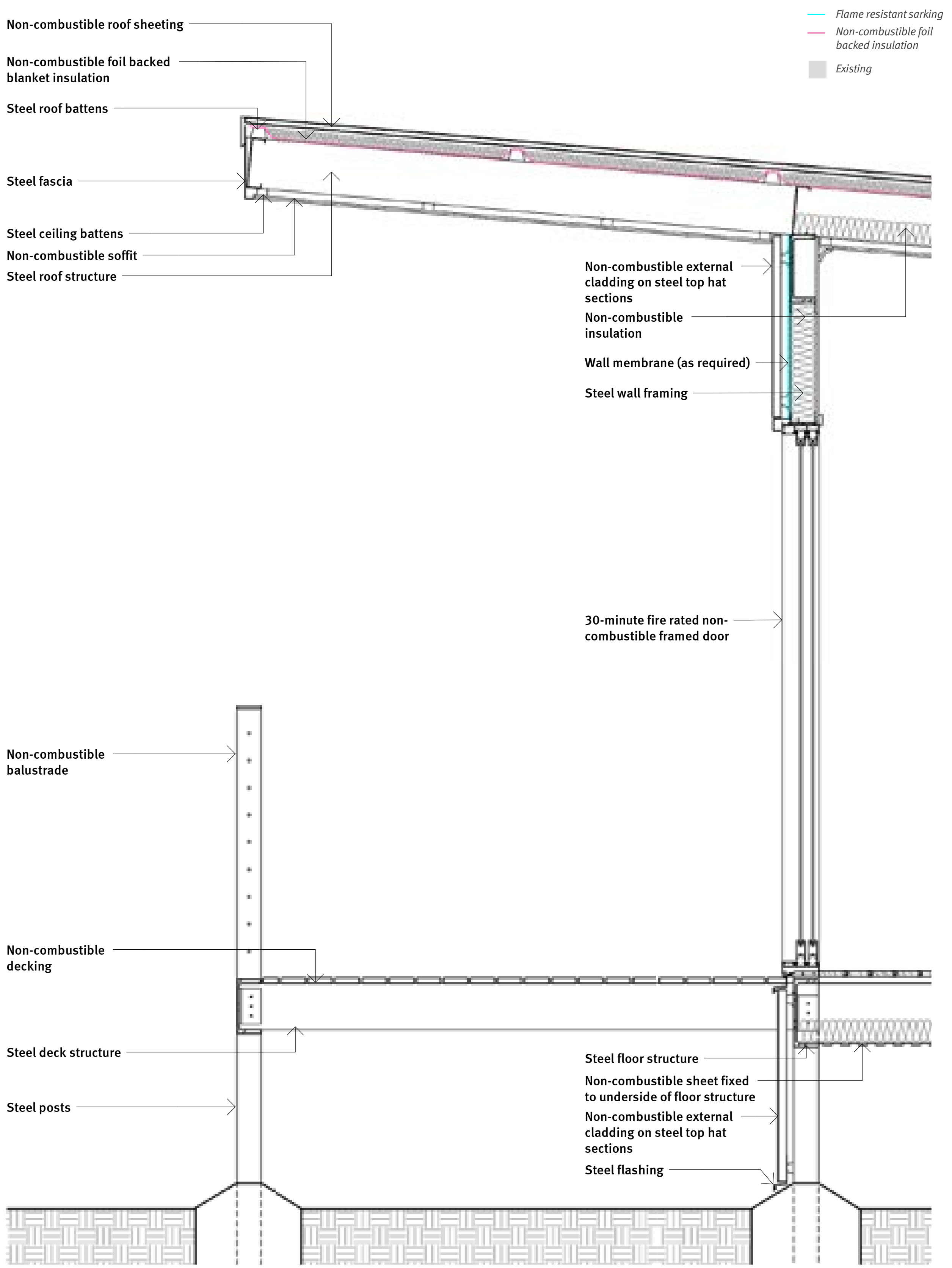
** For more information refer to AS3959:2018*

*** Fibre cement sheet of a minimum of 4.5 mm or greater to prevent FC distortion*

Construction detail example 9

Verandahs and decks–adjoining a combustible frame–level 2 exposure

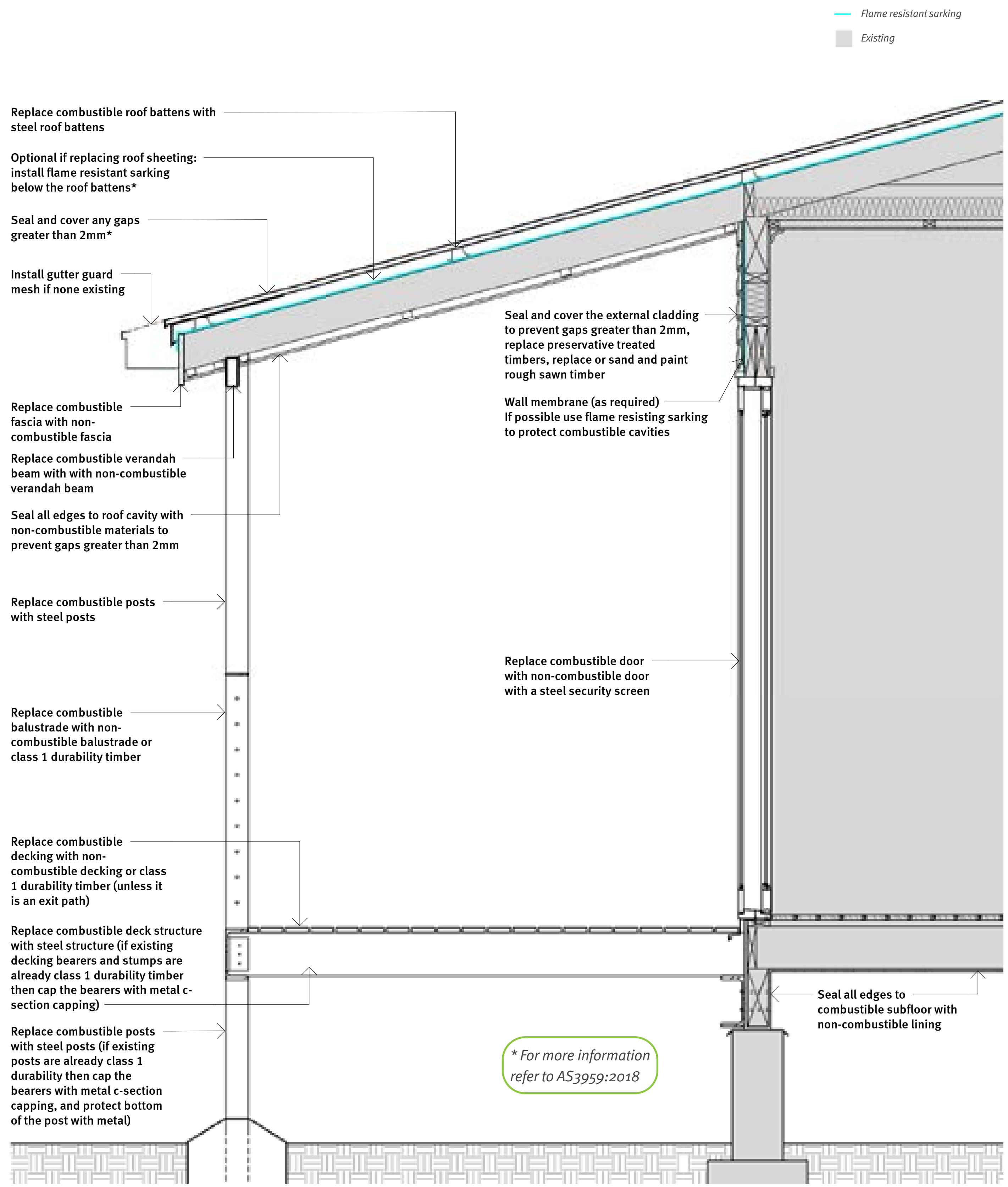
The following scenario explains how to retrofit an existing deck adjoining a raised steel framed house to be resilient up to a level 2 exposure.



Construction detail example 10

Verandahs and decks–adjoining a combustible frame–level 1 exposure

The following scenario explains how to retrofit an existing deck adjoining a typical raised timber framed house to be resilient up to a Level 1 exposure.



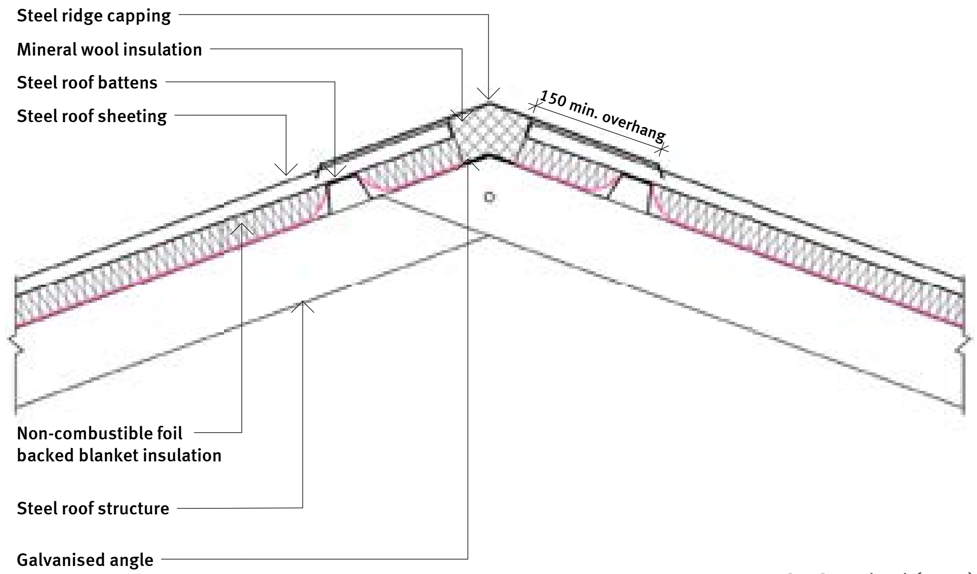
Construction detail example 11

Roof ridges

The following drawings show examples of steel and tile roof ridges resilient up to level 3.

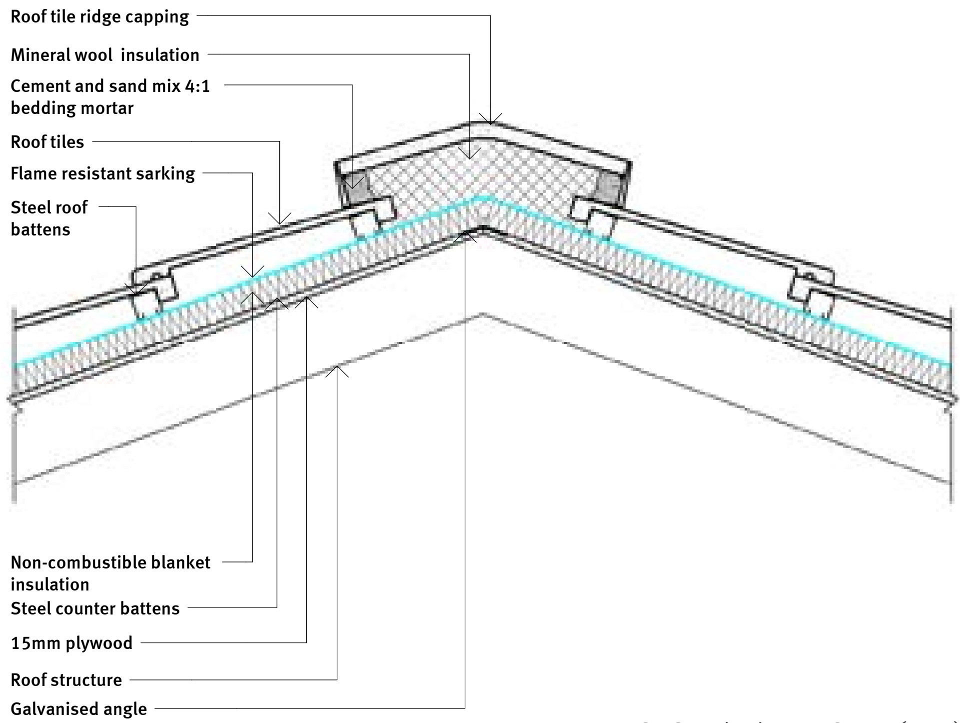
Flame resistant sarking
Non-combustible foil-backed insulation
Existing

Steel roof–level 3 exposure



From NASH Standard (2014)

Tile roof–level 3 exposure



From NASH StandardFrom AS3959 (2018)

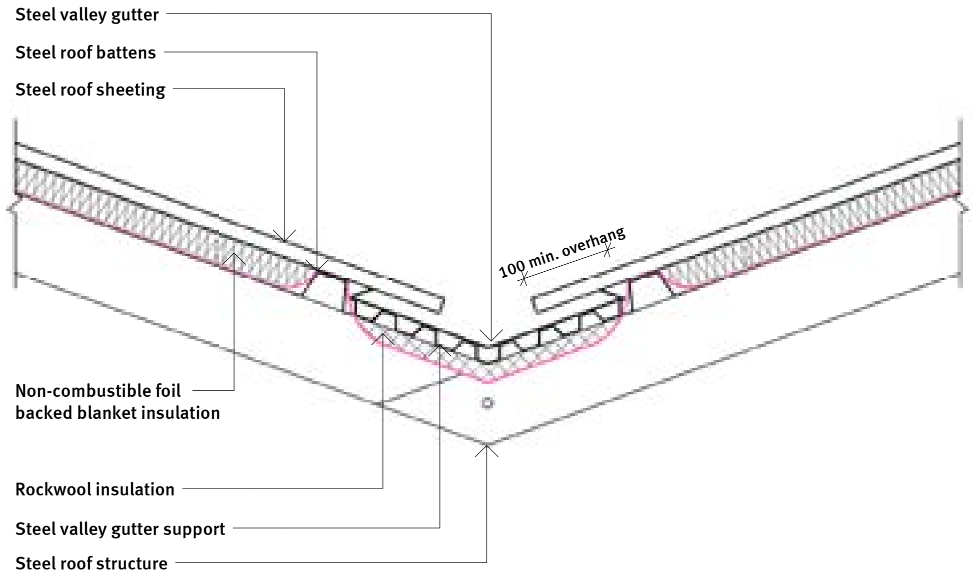
Construction detail example 12

Roof valleys

The following drawings show examples of steel and tile roof valleys resilient up to level 3.

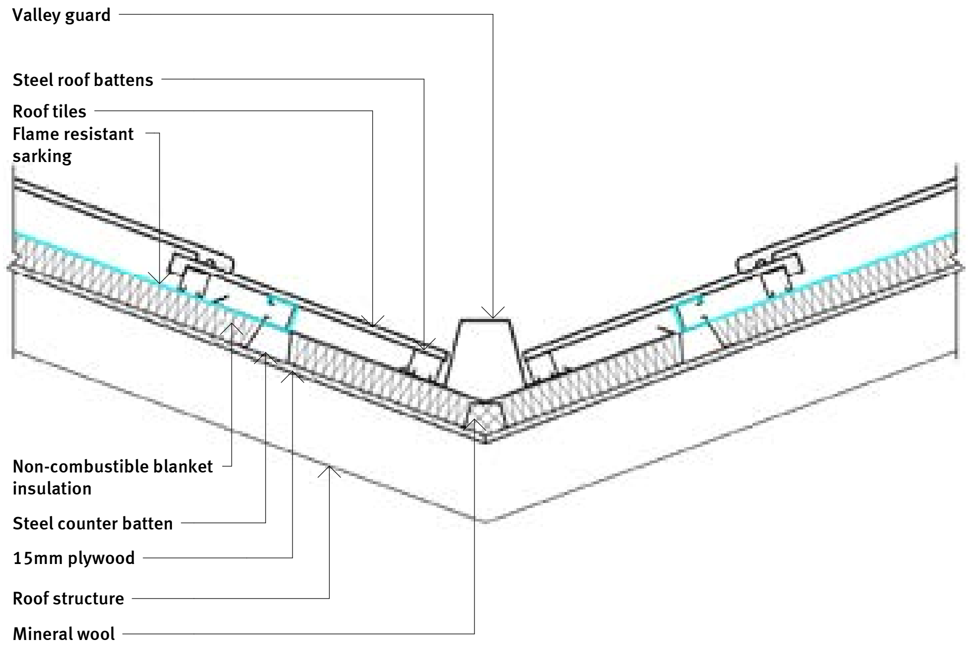
Flame resistant sarking
Non-combustible foil backed insulation
Existing

Steel roof–level 3 exposure



From NASH Standards (2014)

Tile roof–level 3 exposure



Part 4: Bushfire resilient materials

Introduction to bushfire resilient materials

This section describes the main materials used in common building types, including the advantages and disadvantages of the material to reduce ignition from embers, radiant heat and flame, and its resistance to damage by wind and objects carried by the wind. The material chosen should be considered in relation to other material used in the building (e.g. material used for cladding, material used for framing).

CONCRETE

Including slab, concrete cast in situ, precast, tilt up panels, aerated concrete

Uses and level of protection	Advantages	Disadvantages
Used for ground slabs for all levels. Used for wall systems for all levels, and in some cases it may have a minimum thickness or joint requirements for level 3 and 4. The thickness requirements for the various materials or products can be provided by the suppliers or builder, to achieve either a 30-minute fire rating for level 3 or a 60-minute fire rating for level 4. If used for roofing, the same applies.	• Strong non-combustible material resists all bushfire actions. • Offers a reasonable degree of branch strike protection (depending on thickness). • Dimensionally stable when heated. • High thermal mass. • Building fire rating test performance translates well to effective performance in bushfires. • In many cases, it would only receive minor cosmetic damage in a bushfire.	• No disadvantages from a bushfire exposure perspective, though in some cases it may be more expensive compared to lighter weight construction. • If polymer insulation such as extruded polystyrene or insulation is used, toxic gas may be produced in the house and surrounds during a bushfire and should be avoided for levels 2, 3 and 4.

MASONRY

Brick veneer, double brick, concrete block, stones, mudbrick

Uses and level of protection	Advantages	Disadvantages
Used for wall systems for all levels, and in some cases may have a minimum thickness or joint requirements for level 3 and 4. The thickness requirements for the various materials or products can be provided by the suppliers or builder, to achieve either a 30-minute fire rating for level 3, or a 60-minute fire rating for level 4.	• Strong non-combustible material resists all bushfire actions. • Offers a reasonable degree of branch strike protection (depending on thickness). • Dimensionally stable when heated. • High thermal mass. • Building fire rating test performance translates well to effective performance in bushfires. • In many cases would only receive minor cosmetic damage in a bushfire. • Effective in protecting framing elements underneath from direct flame. • Thick masonry has a high fire rating.	• Vents and weepholes need to be carefully designed and maintained, especially when there are combustible framing elements in the cavity behind the masonry cladding system.

RENDER

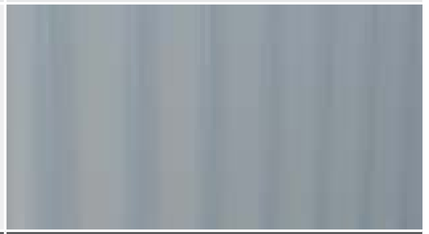
Heavy and acrylic renders

HEAVY MASONRY RENDER

Uses and level of protection	Advantages	Disadvantages
Heavy masonry render can provide a level of protection similar to masonry cladding. The thickness requirements for the various materials or products can be provided by the suppliers or builder, to achieve either a 30-minute fire rating for level 3, or a 60-minute fire rating for level 4. Can be used to completely enclose and seal structural strawbale construction to create a bushfire resistant wall system.	• Strong non-combustible material resists all bushfire actions. • Offers a reasonable degree of branch strike protection (depending on thickness). • Dimensionally stable when heated. • High thermal mass. • Building fire rating test performance translates well to effective performance in bushfires. • In many cases would only receive minor cosmetic damage in a bushfire.	• Requires a combination of good render formulation and skilled application to achieve uniformity and appropriate thickness and finish around building details.

ACRYLIC RENDERS, PAINTS, LACQUERS AND PRESERVATIVE TREATMENTS		
Uses and level of protection	**Advantages**	**Disadvantages**
These renders are generally not recommended in bushfire circumstances. If chosen, then use as sparingly as possible as they can form a combustible surface or contribute to the combustibility of an existing substrate.	• Provides a cost-effective finishing solution and can reduce the rate of weathering of certain materials such as timber.	• Could readily degrade and emit toxic fumes for levels 2 to 4, and for level 1 when adjacent to surfaces. • Could increase the likelihood of ignition and fire spread over the surface. This initial spread could lead to house loss.

STEEL WALL AND ROOF CLADDING

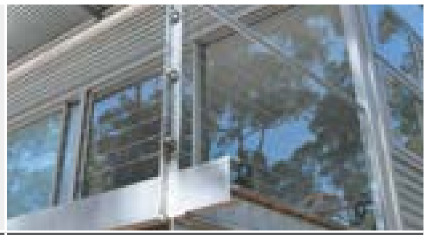


Uses and level of protection	Advantages	Disadvantages
Steel wall and roof cladding are a durable non-combustible cladding system that is most effectively used over a non-combustible framing system. Is dimensionally stable for levels 1 and 2. Some distortion is possible for levels 3 and 4, requiring additional wall design details to account for possible cladding distortion.	• Cost effective non-combustible and dimensionally stable for levels 1 and 2. • Cost effective replaceable cladding for levels 3 and 4. • Common material used by conventional trades.	• Cladding will suffer cosmetic impact and some distortion if subjected to direct flame contact. Its long-term durability may also be affected.

STEEL FRAMING

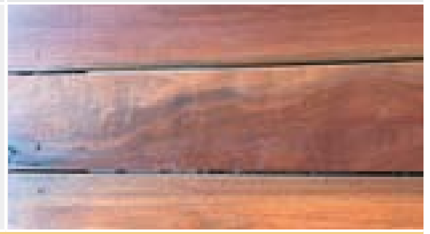
Uses and level of protection	Advantages	Disadvantages
Steel framing is a durable, cost effective way to achieve light weight construction outcomes with wall and roof cavities that are non-combustible. Is dimensionally stable in the use cases described in the guide for all levels. Is dimensionally stable for steel temperatures up to 400 degrees Celsius, which are highly unlikely to be reached in the construction methods for housing. Can tolerate a reasonable degree of damage or modification to the wall system, as a breach of both outer cladding and inner wall plaster would be required to cause potential house ignition.	• Cost effective non-combustible and dimensionally stable for levels 1 and 2. • Cost effective replaceable cladding for levels 3 and 4. • Common material used by conventional trades. • Framing elements unlikely to exceed 400 degrees, therefore will be dimensionally stable and durable for future use.	• Some builders have limited experience with steel framing.

STEEL FLOOR AND DECKING SUPPORT



Uses and level of protection	Advantages	Disadvantages
Steel floor is a durable, cost effective support structure that is effective for levels 1 and 2 and requires shielding for levels 3 and 4 where direct flame contact over a significant duration may be possible.	• Cost effective non-combustible and dimensionally stable for levels 1 and 2. • Cost effective replaceable cladding for level 3 and 4. • Common material used by conventional trades. • Framing elements unlikely to exceed 400 degrees and in these cases will be dimensionally stable and durable for future use.	• Limited decking board fixing option.

TIMBER CLADDING, DECKING AND FRAMING



CLASS 1 (ABOVE GROUND) DURABILITY HARDWOODS USED AS TIMBER CLADDING (THAT HAVE NOT BEEN PRESERVATIVE TREATED)		
Uses and level of protection	**Advantages**	**Disadvantages**
Is durable with a reasonable tolerance to ember attack and radiant heat appropriate to level 1. Timbers in this durability class tend to have higher resistance to ignition and lower tendency to support flame spread compared to lower durability timbers (compared at the same moisture content). Will degrade (emitting significant smoke) at temperatures in excess of 150 degrees Celsius and be at risk of spontaneous ignition at temperatures above 200 degrees Celsius.	• High durability timber will last longer than other timber species as a cladding. Fortunately, timber durability is also a good predictor of bushfire performance compared to other timbers (a significantly better metric for bushfire performance compared to other generalised metrics like timber density class).	• Dimensional stability is subject to moisture content. • Can still ignite and support fire spread at low moisture content levels that are possible in some bushfire circumstances. Will ignite if exposed to high radiation levels or direct flame contact. • Is commonly treated with oils or painted which is likely to increase its ignitability.

BUSHFIRE RESISTANT TIMBER (AS3959 DEFINITION)		
Uses and level of protection	**Advantages**	**Disadvantages**
Consists of a mix of class 1 durability timbers, timbers treated with a fire-retardant system and some other timber species that are deemed to meet this definition according to the performance and testing regime.	• Is a better indicator of bushfire performance compared to other generalised metrics like timber density class. • Offers a way to consider fire retardant coatings and impregnation treatments.	• Fire retardant system treatment systems may degrade over time when exposed to weathering.

PRESERVATIVE TREATED TIMBER		
Uses and level of protection	**Advantages**	**Disadvantages**
Not recommended for use in bushfire prone areas due to its ignitability, which can be significantly higher than the same timber in its untreated state.	• Inexpensive, durable for the price point.	• Dimensional stability is subject to moisture content. • Low moisture content during bushfires can lead to ignition and sustained ignition can lead to house loss. • The combustion process can release both toxic smoke and water-soluble metal salts, which can present a significant risk to people and the environment.

TIMBER FRAMING		
Uses and level of protection	**Advantages**	**Disadvantages**
Is a common and cost-effective framing system suitable as framing material, provided appropriate measures are taken to prevent ember, radiation and flame access to the framing. There are suitable cladding options to achieve this in the guide. Care should be taken not to compromise the protective cladding, either during the initial build or through modification during the life of the building. Framing can degrade at temperatures more than 180 degrees Celsius, leading to a build-up of combustible smoke within the building cavity.	• Familiar framing approach with majority of current trades.	Provides a combustible element to the region below the cladding. This places a greater onus on the cladding to prevent ember contact and heat transfer to the framing elements immediately behind the cladding layer(s). Burning framing in roof and wall cavities can be difficult to detect by building occupants. As the fire develops, it can reach a point where it rapidly breaches the occupiable space, risking entrapment.

OTHER CLADDING

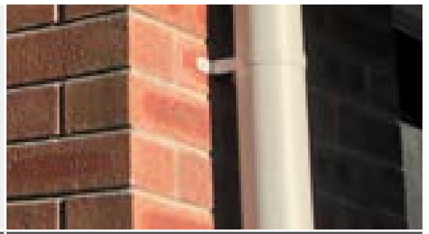
FIBRE CEMENT SHEET CLADDING		
Uses and level of protection	**Advantages**	**Disadvantages**
Is a durable and effective cladding material over non-combustible framing systems. Is dimensionally stable for levels 1 and 2. Some distortion is possible for levels 3 and 4, requiring specific thickness requirements in combination with joint finishing methods.	• Inexpensive.	• Is not as dimensionally stable as many other masonry claddings when exposed to flame.

ALUMINIUM WALL CLADDING		
Uses and level of protection	**Advantages**	**Disadvantages**
Level 1 and 2 wall cladding.	• Non-combustible, low distortion when exposed to radiant heat (level 1 and 2).	• May melt or fall away when exposed to direct flame, which is possible for construction exposed to levels 3 and 4.

Polycarbonate

Uses and level of protection	Advantages	Disadvantages
Not used as a barrier at any level. Commonly used for light access in open pergolas and carports. Not effective as a window or skylight glazing element that encloses a house.	• Does not support flame spread until heated to a molten state, so it tends to fall away from its installed location before it supports flame spread.	• Does not offer a barrier to radiant heat or flame. Will melt and fall away from current location when heated. If it falls to the ground and continues to be heated by adjacent sources, it can form a molten puddle on the ground which can burn. May hamper exit path in this situation.

PVC



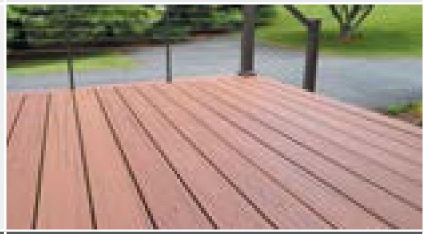
Uses and level of protection	Advantages	Disadvantages
For example, used for gutter and cladding.	• Like polycarbonate, it tends to melt and fall away before flaming begins.	• If it falls to the ground and continues to be heated by adjacent sources, it can form a molten puddle on the ground which can burn. May hamper egress in this situation. Smoke from burning PVC can be very toxic.

TILES FOR ROOF COVERING

Uses and level of protection	Advantages	Disadvantages
Used as a roof covering for all levels as it provides a non-combustible roof finish.	• Inexpensive, has thermal mass, dimensionally stable when heated. • Can be part of a high-performing roof at all levels when it is combined with non-combustible framing and tile battens.	• Difficult to form a tight-fitting roof with gaps less than 2 mm that will prevent ember entry and debris accumulation in the roof space. • Typically used with timber tile battens, which may be susceptible to ember and debris attack.

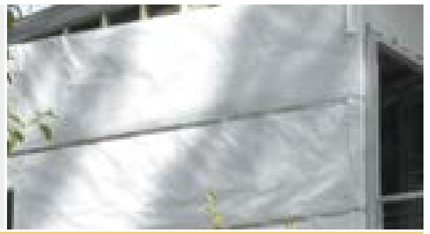
WOOD COMPOSITE DECKING

Typically a polyethylene plastic that is filled with wood dust and for bushfire specific products also includes fire retardants.



Uses and level of protection	Advantages	Disadvantages
For decking for level 1 and 2 provided it has been tested under bushfire conditions.	• Durable. Some bushfire specific products perform well in bushfire events.	Not all wood composite decking performs well in bushfires. Look for evidence of product testing and use a reputable brand.

INTERNAL WALL SYSTEM MATERIAL



Uses and level of protection	Advantages	Disadvantages
SARKING (UNRATED)		
Not recommended for any circumstances in bushfire construction.	• Inexpensive, provides a moisture barrier in typical wall systems	Sarking is combustible and may spread flames through building cavities even if adjacent elements are non-combustible.
SARKING WITH LEVEL 5 FLAMMABILITY (AS1530.2)[37]		
Used as a moisture barrier where needed. This sarking offers little to no protection to underlying combustible elements from the flame and smouldering debris that has accumulated against the sarking.	• Has a low tendency to support the spread of flame beyond the active area in which the flame occurred.	Does not offer a barrier to flame, a flame or smouldering debris may burn a hole through the sarking.
SARKING THAT IS FLAME RESISTANT		
Used to limit the spread of flame to underlying building elements.	• Offers an option to protect the underlying framing from flame and ember contact in certain retrofit and new building circumstances (refer to relevant construction details).	• More expensive than conventional sarking. • This category of sarking is not formally defined by a test method, but it is relatively easy to observe whether the sarking forms a hole when flame is applied to it.
INSULATION – NON-COMBUSTIBLE e.g. GLASS WOOL AND ROCKWOOL		
Used as thermal insulation and in some cases as a barrier to the passage of heat and flame.	• Low cost, reasonable high temperature performance for glass wool. • Excellent high temperature performance for rockwool.	Provides small amount of toxic gas if exposed to flame due to the binders used to hold the fibres together.
INSULATION – COMBUSTIBLE e.g. POLYESTER, POLYISOCYANURATE FOAM, EXPANDED OR EXTRUDED POLYSTYRENE		
Not recommended in bushfire applications.	• Inexpensive with good insulation properties.	Breaks down at temperatures that are readily achieved in bushfire events. This breakdown may result in toxic gas emission flame spread.

37 *AS1530.2 -1993 Methods for fire tests on building materials, components and structures Test for flammability of materials Sydney: Standards Australia*

Part 5: Bushfire resilient landscaping

Introduction to bushfire resilient landscaping

The design and management of the area surrounding the home plays an important role in bushfire resilience. **Part 1, Bushfire essentials**, explained how most buildings destroyed by bushfire are ignited by wind-driven embers. In many cases of house loss, embers were found to have ignited vegetation in the garden, which then spread fire to the home. Hence, bushfire resilience in the immediate vicinity of the home can be increased significantly through landscaping modifications that:

- plan a strategic garden layout
- minimise the use of combustible garden materials (such as combustible mulches and timber garden edging)
- choose appropriate plantings.

This section provides a comprehensive look at the most important landscaping principles that should be followed by people living in bushfire prone areas[38].

In the past, the common approach to designing bushfire resilient gardens tended towards elimination rather than adaptation. Homeowners would clear all vegetation around the home and replace it with lawn or a non-combustible surface, such as gravel or pavers. While this approach can improve bushfire resilience, it also reduces a home's liveability. Gardens should be designed to be used all year around, not just during bushfire season. By adopting the following design principles, you can create a beautiful, family-friendly garden that is also resilient to bushfire.

The design and management of the landscape surrounding the home plays an important role in bushfire resilience.

38 You may need to check with your local government to determine if there are any specific requirements relating to landscaping and vegetation.

Landscape design

An increasing number of people desire to live in closer contact with their natural environment. This often translates to gardens that emulate native bushland. While this style of garden brings about a certain level of hazard, it can (when managed appropriately) also shield the home from an advancing fire. Gardens also offer the opportunity to create a micro-climate for the house and its immediate surroundings, offering both amenity and resilience to a bushfire.

Broadly, the principles outlined on the following pages involve reducing the amount and continuity of surface and near-surface fuels in order to disrupt an advancing fire front and prevent isolated fires from developing to a size that could threaten the house. It is also important to consider continuity in a vertical sense by providing a substantial distance between surface fuels and tree canopies.

Reducing fuel continuity around the house also aligns with landscaping principles that limit soil subsidence in areas with reactive soils (like clay soil) and associated house damages and cracks.[39]

Some key guiding principles are:

- Use landscaping solutions to shield the home from embers, heat, flame and wind.
- Use landscaping to improve the ease with which buildings can be defended during a bushfire.
- Use landscaping to provide safe and effective egress from the house to an alternative place of shelter by considering the layout of the garden and how people might navigate around the house.
- Consider the aesthetics of the garden and how to incorporate a bushfire resilient design without compromising the intended look, feel and function of the garden.

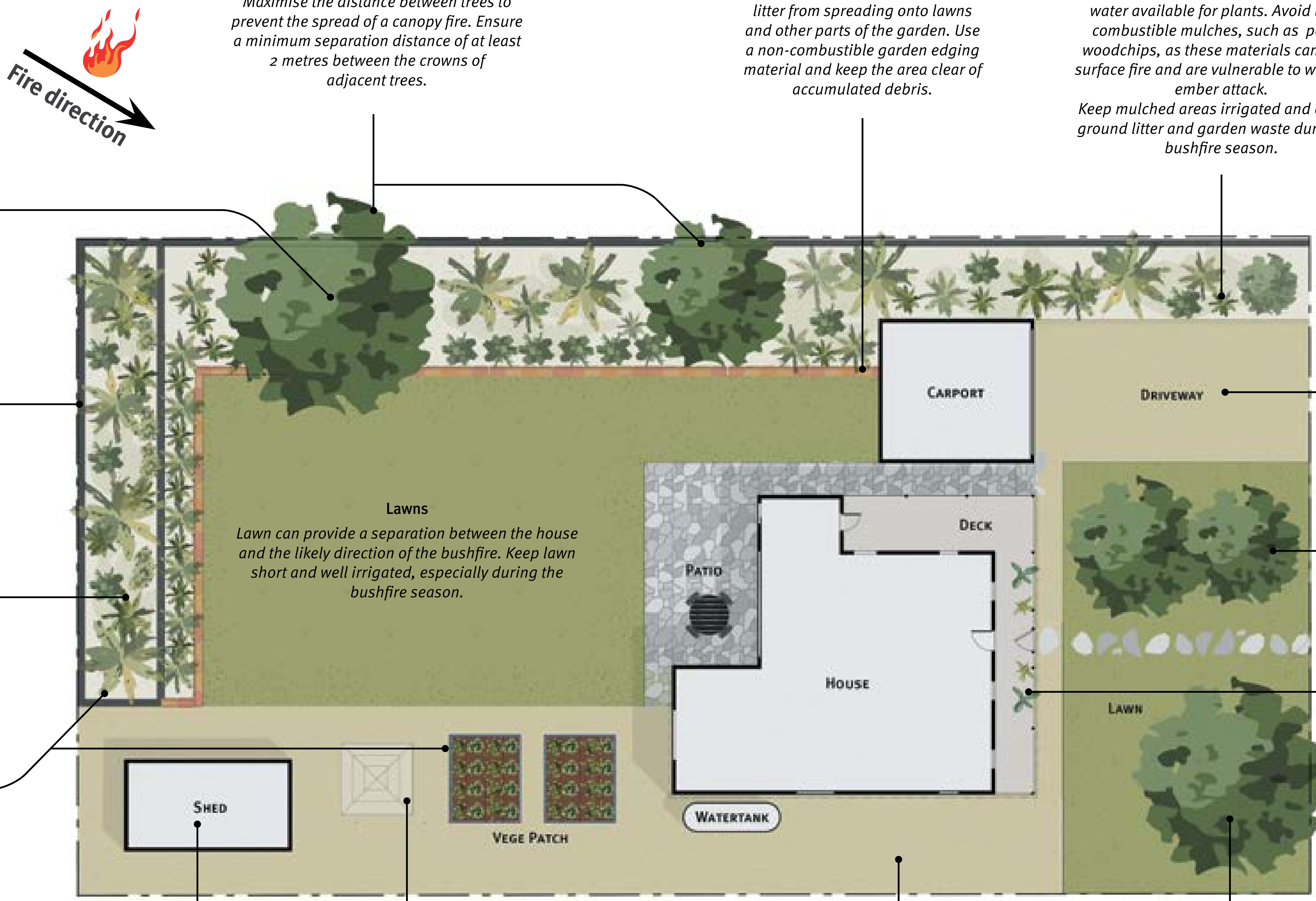
Landscaping should be thought of as a holistic process, where each design element impacts on the elements around it. A resilient landscape requires ongoing maintenance. Vegetation can quickly become overgrown, presenting an increasing bushfire hazard.

Landscaping can play an important role in a building's bushfire resilience.

39 Movement in clay soil by various moisture conditions around the house may lead to cracks greater than 2 mm, possibly allowing ember entry. For more information see a guide to prevent structural damage structural damage: www.qbcc.qld.gov.au/sites/default/files/A%20Simple%20how%20to%20Guide%20to%20Preventing%20Structural%20Damange%20to%20your%20Home.pdf

Landscape design

Suburban property



Small trees

A small tree positioned away from the house and access ways can reduce wind attack and catch embers and other wind-borne debris. Trees should be positioned between the house and the most likely direction of the bushfire.

Solid non-combustible fences

A solid non-combustible fence or retaining wall can form a barrier against radiant heat attack, flame contact, and ember and wind attack. For maximum utility, keep the area around the fence clear of unmanaged vegetation and free of combustible ground litter and other debris.

Shrubs and small plants

Depending on the mature size of the vegetation, either use individual shrubs or small clusters of two to three plants. Avoid planting dense or continuous areas of vegetation and keep the area between plantings clear of accumulated debris.

Garden beds

Separate raised garden beds to help slow or stop the spread of surface fire. Raised garden beds or boxes should be made of a non-combustible material to prevent ignition.

Tree spacing

Maximise the distance between trees to prevent the spread of a canopy fire. Ensure a minimum separation distance of at least 2 metres between the crowns of adjacent trees.

Lawns

Lawn can provide a separation between the house and the likely direction of the bushfire. Keep lawn short and well irrigated, especially during the bushfire season.

Garden edging

Garden edging can add visual appeal and stop mulch and ground litter from spreading onto lawns and other parts of the garden. Use a non-combustible garden edging material and keep the area clear of accumulated debris.

Mulches

Mulches help to retain moisture in the soil, reducing water wastage and making more water available for plants. Avoid using combustible mulches, such as poplar woodchips, as these materials can fuel a surface fire and are vulnerable to wind and ember attack. Keep mulched areas irrigated and clear of ground litter and garden waste during the bushfire season.

Driveways

Ensure that driveways are clear of any overhanging vegetation.

Tree branches

The lower branches of a tree should be pruned to prevent surface fire spreading to the canopy.

Potted plants

Potted plants can add visual appeal and extra productivity to small suburban gardens. When positioned close to the house, separate individual plantings and use non-combustible containers, such as stone or concrete pots.

Outbuildings

Sheds and other outbuildings should be positioned both away from the house and the likely direction of the bushfire.

Clotheslines

Positioning outbuildings, clotheslines and raised garden beds within a gravelled area (or on a similar non-combustible surface) can help stop the spread of fire.

Ground surfaces

Use a non-combustible surface, such as gravel, concrete or pavers to surround the house. A non-combustible buffer can help to slow or stop the spread of surface fire and will aid in identifying and extinguishing spot fires caused by ember attack.[40]

Tree maintenance

The area beneath a tree should be free of unmanaged vegetation and other combustible materials, such as dry fallen leaves, twigs and bark.

40 Non-combustible surfaces around the house align with the landscaping principles to limit soil subsidence in areas with reactive soils. See *A guide to preventing structural damage*: www.qbcc.qld.gov.au/sites/default/files/A%20Simple%20how%20to%20Guide%20to%20Preventing%20Structural%20Damange%20to%20your%20Home.pdf)

Landscape design

Rural property

Water tanks

Non-combustible water tanks can help shelter the house from radiant heat and provide water for irrigation and for defending the house in the event of a bushfire. Keep the area around the water tank free of flammable vegetation and other combustible objects.[41]

Food producing plants

Food producing plants can be used to break the continuity of other, more flammable vegetation. They are generally less flammable when compared to other types of vegetation. Plant in non-combustible raised garden beds and keep plants green and watered during hot, dry weather.

Vegetation around driveways

Keep driveways clear of overhanging vegetation, debris and other obstacles. Providing ample space for vehicles to turn may aid evacuation.

Exposed parking

Position exposed parking spaces away from the house, other combustible objects and the direction of the bushfire.

Sheds and outbuildings

Sheds and other outbuildings should be positioned away from the house. Positioning outbuildings within a gravelled area (or on a similar non-combustible surface) can help slow or stop the spread of fire.

Irrigated lawns

An irrigated lawn can provide a separation between the house and the likely direction of the bushfire. Keep lawn short and well irrigated, especially during the bushfire season.

Open areas

A fuel-reduced area between the house and the direction of the bushfire can help stop fire spreading to the home and reduce the impacts of bushfire attacks.

Water bodies

A farm dam, pond or other large water feature between the house and direction of the bushfire can help slow or stop the spread of fire.

Swimming pools

Swimming pools can provide a water supply. However, swimming pools, farm ponds and dams are not considered reliable sources of static water supply in Queensland due to regular drought events.

Screening plants

Moderately dense evergreen trees, orchards or hedges can be used as screening plants to filter embers and wind-born debris from spreading to the house. They also shield the house and occupants from wind attack.

Ground surfaces

Use a non-combustible surface, such as gravel, concrete or pavers to surround the house. A non-combustible area can help to slow or stop the spread of surface fire and will aid in identifying and extinguishing spot fires caused by ember attack.

Driveways

A driveway that provides access to a public road away from the likely direction of the bushfire is often ideal.

41 Where a planning scheme contains an assessment benchmark for the provision of an appropriate static water supply, a development condition may specify how this is to be provided. For more information see section 9 of *Bushfire Resilient Communities* document: www.ruralfire.qld.gov.au/Bushfire_Planning/Documents/Bushfire-Resilient-Communities.pdf (accessed May 2020).

Garden layout

Garden layout describes the general arrangement of garden beds, trees, pathways and other features in the area surrounding the home.

Before proceeding, try to decide on the overall style of garden (e.g. an exotic garden, a modified Australian landscape or park-like garden)[42] rather than designing one element at a time. This initial choice should consider the suitability of the garden in the given environment, its maintenance requirements, and how easy (or difficult) it will be to manage in terms of bushfire resilience.

It is also important to identify the hazards at both local and regional scales, and note any slopes, ridges or earthworks that may restrict access, promote the spread of fire or provide a barrier against bushfire attack. Think about how to incorporate existing elements into the design of the garden. If these elements represent a hazard, consider how to remove them or mitigate the risk.

Garden design and layout is often dictated by lot size. Large lots provide some great opportunities for developing highly resilient homes, while small lots may restrict the available options. In either case, consider how the available space (or lack thereof) will affect the occupant's ability to prepare for a bushfire. For example, small lots may limit opportunities to control for hazards in neighbouring properties. If this is the case, consider a cooperative approach that involves the owner of the neighbouring lot. If it is not possible to remove hazards in the adjoining land, consider installing a barrier to shield against attack, or using an area of open space as a buffer. Also, ensure the home is resilient to the risks that the hazard represents, such as increased ember attack.

- Provide easy access for firefighters and vehicles onto, or adjacent to the lot; prioritise access between buildings and the likely direction of the bushfire.
- Provide operational space (an area of open space) for occupants and firefighters to defend the main building.
- Provide a buffer between the main building and the direction of the bushfire hazard; this buffer could be an area of open space, or a swimming pool, pond or other water feature.[43]
- Include at least two accessways onto the property that are clear of any overhanging or adjacent vegetation (excluding lawn).
- Accessways should provide adequate access onto the site and safe evacuation.
- Create gaps in vegetation (e.g. between trees, shrubs and garden beds) to slow down or stop the spread of fire towards buildings.
- Use options that minimise maintenance requirements.
- Consider the long-term needs of occupants; remember that gardens should be used all year round.
- Create a fuel-reduction zone around the home.
- Position larger plantings (such as trees and shrubs) beyond flame contact distance from buildings and key access routes.
- Install water faucets on at least two sides of the house and ensure garden hoses can reach all areas of the garden.

42 See also *Landscape and building design for bushfire*, Ramsay & Rudolph, 2003.
43 Swimming pools, farm ponds and dams are not considered reliable sources of static water supply in Queensland due to regular drought events, but the space they occupy will still provide the open space buffer.

Open spaces and fuel-reduction zones

Both open spaces and fuel-reduction zones can be used to slow or stop the spread of fire. In addition to reducing fuel load, these areas provide a space where embers and burning debris can fall without the risk of fire spreading to other parts of the property. Fuel-reduction zones can also provide a safe refuge to defend buildings or to shelter in-place during a bushfire.

A fuel-reduction zone is an area of modified native vegetation or managed landscape that is partially cleared of fuel, while an open space is an area of open land with little or no vegetation, featuring an artificial or highly managed surface (e.g. lawns, paved areas, mown or grazed paddocks, sporting ovals, tennis courts or similar).

As a rule, buildings located in a BPA should incorporate an open space in the immediate vicinity of buildings, and if possible, an extended fuel-reduction zone between buildings and the direction of the bushfire hazard. The desired size of the fuel-reduction zone is largely dependent on the slope of the land, its aspect and the type of vegetation. The size and layout of the lot or subdivision may also dictate the size and position of fuel-reduced areas.[44]

- If possible, create an open space around buildings using a non-combustible surface, such as concrete, gravel or pavers.
- Create a fuel-reduction zone between the house and the likely direction of the bushfire. For more information, refer to the document on clearing for firebreaks and fire management lines.[45]
- Use open spaces to separate trees, garden beds and areas of dense vegetation.
- Lawns and pathways are suitable for creating 'mini' breaks in the continuity of vegetation.
- A fuel-reduction zone can be created by managing existing vegetation:
  - remove ground litter and undergrowth from around trees and shrubs either using mechanical means or via controlled burning (do not do this without authorisation)
  - thin trees to break the continuity of canopy vegetation
  - remove dead limbs and branches from individual trees and shrubs
  - and remove low hanging branches from trees.
- Keep the area clear of ground litter and other combustible materials.

44 For more information see *Bushfire Resilient Communities:* www.ruralfire.qld.gov.au/Bushfire_Planning/Documents/Bushfire-Resilient-Communities.pdf (accessed May 2020).
45 Department of State Development, Manufacturing, Infrastructure and Planning: dsdmipprd.blob.core.windows.net/general/clearing-vegetation-for-firebreaks-and-fire-management-lines.pdf (accessed May 2020).

Pathways

Pathways (like open spaces) play a critical role in bushfire resilience by improving the chances of buildings and occupants surviving a fire. Pathways can be used to separate areas of vegetation to slow or stop the spread of fire. They are also important in ensuring the safe movement of occupants and emergency responders during a bushfire.

As a rule, always keep pathways clear of trip hazards, overhanging vegetation and combustible materials. Moving around should be both practical and safe.

Keep pathways clear of trip hazards, overhanging vegetation and combustible debris.

- Use pathways to break the continuity of vegetation and to aid navigation.
- Consider how pathways can be integrated as part of the wider landscape system; pay attention to the interactions between pathways, garden beds, mulch, vegetation, open spaces, fuel-reduction zones and other features.
- Pathways, especially key exit routes, should be created using non-slip, non-combustible surfaces such as concrete, gravel, stone or hardpacked earth.
- Keep pathways clear of overhanging vegetation.
- Position key access routes away from unmanaged vegetation.
- Avoid or minimise the use of edging near or along pathways; these are a trip hazard and can accumulate debris.
- Do not rely on a single pathway for access onto and off the property; it is important to plan for multiple solutions.
- Ensure that pathways are safe to navigate during bushfire conditions; be mindful of strong winds and poor visibility.
- Consider using artificial lighting and non-combustible handrails to aid navigation.
- If possible, shield key access routes using non-combustible retaining walls.

Landforms and earthworks

Landforms and earthworks can be used to mitigate the hazards associated with bushfire. Landforms include naturally occurring features in the terrain, such as ridges, slopes and gullies, while earthworks are human-made, and include earth mounds, terraces and retaining walls. No matter the origin, earthworks and landforms can provide an effective barrier against all four bushfire attack mechanisms—embers, heat, flame and wind.

Consider how to use features in the terrain to block or deflect bushfire attack. Be aware that some landforms (particularly steep slopes and narrow ridges) can increase risk, so manage these appropriately.

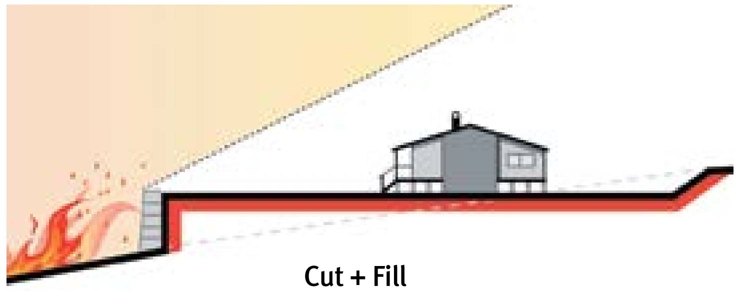


Figure 11 Terracing of sloping ground can block and deflect embers and radiant heat away from buildings (from Caird and Ramsay, 2003)

- Use earth mounds to block and deflect radiant heat, embers, flame and wind attack.
- Earth mounds need to be of an appropriate height and distance away from buildings to be effective.
- Be mindful of erosion and how newly established earthworks may interfere with natural surface drainage patterns. It may be necessary to create drainage ditches to divert the flow of run-off.
- While effective, earthworks can be expensive to construct and are likely to obstruct access, views and other activities, so weigh the costs and benefits carefully; it is often possible to obtain many of the same benefits using an appropriately designed fence, wall or row of screening plants.
- Manage the risks associated with building on existing landforms, such as hills and gullies.
- On sloping land, cut-and-fill or terrace the terrain in order to create a flat surface for buildings; if possible, create space for a flat, trafficable area around the building's perimeter.
- Cut-and-fill and terracing will likely result in the formation of retaining walls and earth embankments, which can also act as effective barriers against the spread of fire burning uphill; use these features to your advantage.
- Ensure that pathways that extend along slopes or narrow ridges are safe and easy to navigate. Consider installing artificial lighting and handrails along key access routes.

Retaining wall.

Non-combustible garden walls can protect against all modes of bushfire attack.

Fencing and garden walls

Fences and garden walls can be used as a barrier to block embers, flame, radiant heat and the spread of debris. They are also effective at ensuring the safe exit of occupants during a bushfire event, by shielding pathways and accessways.

Consider installing a non-combustible fence or garden wall between buildings and the likely direction of the bushfire hazard. Once installed, make sure to keep the surrounding area clear of combustible materials.

- Use non-combustible materials, such as concrete, stone, brick or metal.
- Avoid combustible materials, such as timber, bamboo or brushwood, close to vulnerable building elements.
- Use non-combustible fences or garden walls as heat shields between bushfire hazards, buildings and key access routes.
- Do not install combustible fences or garden walls close to buildings.
- For smaller lots (or where neighbouring buildings are located close together), a solid, non-combustible wall can reduce radiant heat (depending on the situation).
- Non-combustible walls can be used to enclose vulnerable objects, such as gas cylinders, electricity generators, water pumps and piles of garden waste.
- Set walls and fences into the ground (using concrete or deep-set posts) so they can withstand wind attack.
- Avoid permeable fence styles such as horizontal or vertical slatted fences, etched metal screens, picket fences, lattices, and wire fences—these styles can be visually appealing, but they offer little protection against bushfire attack and may trap occupants or otherwise restrict movement during a bushfire.
- Ensure boundary walls and fences have appropriately located and designed gates and accessways; ensure these features are clear of vegetation and other combustible elements.

Mulching

Mulching helps to retain moisture in the soil, meaning there is more water available for plants. Although they are important to plant health, mulches can be a significant fire hazard if used and managed incorrectly.

Ensure that mulched areas are clear of large amounts of combustible materials, such as ground litter. Non-combustible mulches, such as pebbles, shells and gravel, are the best option. These mulches will not burn, and many are heavy enough that they will not be scattered by the strong winds that accompany a bushfire.

Non-combustible mulches are resistant to ember attack and can help slow or stop the spread of surface fire.

Garden edging

Garden edging can add visual appeal to gardens and has the practical benefit of providing a barrier to stop mulch from straying onto lawns. Edging also helps to protect plants from lawnmowers and edging tools. Despite its benefits, garden edging can be a fire hazard if used and managed inappropriately.

Try to minimise the use of garden edging around pathways, especially near to key access routes. Garden edging is a potential trip hazard, and this risk can be compounded by the low visibility conditions that accompany a bushfire.

- Garden edging can trap embers and other debris (debris will accumulate during a bushfire); therefore, it is important to use non-combustible edging materials.
- Use non-combustible materials, such as brick, stone, concrete or weathering steel.
- Avoid using timber garden edging; these materials can ignite and spread fire to other parts of the garden.
- Ensure that garden edging is kept in good condition and is clear of accumulated debris.

Garden edging.

Plant selection and management

This section describes how to manage existing vegetation and choose and use new plantings[46]. As a rule, plant selection and management should be aimed at reducing the opportunities for vegetation to ignite, and slowing or stopping the spread of fire.

In the past, the advice on achieving bushfire resilience tended towards removing mature vegetation and replacing it with exotic species and foreign garden styles. Many contemporary approaches, however, opt for a nuanced solution that favours fuel reduction and intelligent design, over wholesale elimination and replacement.

For many Queenslanders, the imported garden approach can work, provided there is a suitable growing climate and an adequate water supply to sustain exotic species. Unfortunately, these requirements may be beyond the scope of some Queensland homes. But in either case, we recommend using native plants whenever possible, supplemented by the strategic use of imported species.

Despite its reputation, native vegetation is not wholly bad when it comes to bushfires. Many native plants have low flammability characteristics, which makes them suitable for growing in bushfire prone areas. Native species also have the added benefit of supporting local bird and insect life, and are generally better suited to local growing conditions, meaning they may require less water than imported plant species.

Regardless of the choice of vegetation, landscapes require ongoing maintenance to remain resilient. Vegetation can quickly become overgrown, presenting an increasing bushfire hazard. In all cases, a proactive approach of regular maintenance and enhancement should be adopted—you never know when the next bushfire will strike, so be prepared.

For additional information on plant selection, see section 8.5.2 Plant selection (in www.ruralfire.qld.gov.au/Bushfire_Planning/Documents/Bushfire-Resilient-Communities.pdf) and the plant selection key developed by the Country Fire Authority (www.cfa.vic.gov.au/plan-prepare/plant-selection-key).

The following section illustrates a variety of strategies that are applicable to buildings in Queensland, both historical and contemporary. Many of these strategies are specific to plant types, while others are more broadly relevant. In general:

- Keep plants and garden beds clear of ground litter and other combustible debris.
- Remove dead or dry leaves, twigs and branches.
- Dead plants should be removed immediately during the bushfire season.
- Avoid vegetation that regularly dries out during the bushfire season.
- Remove leaves and branches which overhang buildings and pathways.
- Avoid planting large areas of dense vegetation (unless used as a barrier).
- Remove or thin areas of unmanaged vegetation.[47]
- Separate large plantings using open spaces, pathways or non-combustible retaining walls.
- Do not plant anything against the house—it is very important to keep vegetation away from doors, vents and windows.
- Do not store large piles of garden waste next to buildings, trees, pathways or other vulnerable elements.
- Irrigate during periods of hot, dry weather.
- In the event of a bushfire, keep plants wet until after the fire front has passed; prioritise vegetation closest to and between buildings and the direction of the bushfire hazard.

46 You may need to check with your local government to determine if there are any specific requirements relating to landscaping and vegetation
47 Department of State Development, Manufacturing, Infrastructure and Planning: http://dsdmipprd.blob.core.windows.net/general/clearing-vegetation-for-firebreaks-and-fire-management-lines.pdf (accessed May 2020).

Plant selection 1: lawns and grasses

Lawns and grasses can be planted in strategic locations to break up areas of larger, more combustible vegetation. A well-irrigated and maintained lawn can be used as an effective firebreak, especially when combined with non-combustible features like a pathway, fence or stone wall.

Manage areas of lawn in a way that does not create an additional fire risk. For example, do not slash or mow during hot weather and do not store grass clippings in large exposed piles. Large stacks of garden waste are extremely vulnerable to ember and flame attack and can promote the spread of fire.

Design strategy

When selecting lawn and grass species:

- Choose species that have favourable flammability characteristics.
- Avoid species that contain an abundance of oils, waxes or resins.
- Avoid species that produce a lot of dead plant material.
- Avoid tall grasses, especially species which have fine foliage—these plants can ignite and burn very quickly.
- Choose species that remain green throughout the summer.

When planting lawns and grasses:

- Plant in strategic locations to provide breaks in fuel continuity.
- Separate larger, dense plantings with lawn or short-cut grasses.
- Plant lawn or short-cut grasses in the area surrounding buildings.
- Use lawn and grasses in the design of defendable spaces.
- Consider planting lawn in the area between the main building and the direction of the fire hazard.

When managing lawns and grasses:

- Keep lawn and grasses short, irrigated and clear of debris—this is very important for grasses near trees, shrubs, buildings and other combustible elements.
- Grass clippings should be disposed of appropriately.
- Do not store garden waste in large exposed piles close to buildings.
- Lawn and short-cut grasses are relatively safe; however, all plants (even moist green lawn) can burn under extreme bushfire conditions.
- Minimise risk by keeping grasses short and clear of accumulated debris.

Plant selection 2: ground covers and creeping plants

Ground covers and creeping plants should be used sparingly in bushfire prone areas. These plants can accumulate large amounts of fine fuels, and trap embers and other wind-driven debris.

All plants, including lush green creeping plants, can burn under the right conditions. Dry ground covers will burn almost instantaneously when in contact with an ignition source, and this fire can travel quickly along the ground. As a rule, aim to keep plants green and to a manageable size, and consider separating areas of vegetation with a non-combustible surface.

Design strategy

When selecting ground cover and creeping plant species:

- Select species with favourable flammability characteristics.
- Avoid species that contain an abundance of oils, waxes or resins.
- Avoid species that produce a lot of dead plant material.
- Choose species with lush, green foliage, and which remain green throughout the summer.
- See Appendix E for a selection of fire-resistant plants suitable for Queensland homes.

When planting ground covers and creeping plants:

- Avoid planting large, continuous areas of vegetation, especially near buildings (do not plant close to doors, windows or vents).
- Break up any large plantings with strategically placed pathways and open spaces.

When managing ground covers and creeping plants:

- Manage waste vegetation appropriately and do not store garden waste in large piles.
- Keep plants short, irrigated and clear of debris, especially during hot, dry weather.
- When under imminent threat of bushfire, keep any creeping plants wet until long after the fire front has passed.

Plant selection 3: shrubs

Shrubs may form a ‘ladder fuel’ that can spread fire along the ground to other parts of the garden. If this happens, the spreading fire may be difficult to control. To minimise this risk, ensure that plantings are positioned, maintained and irrigated appropriately.

Design strategy

When selecting shrub species:

- Choose species with favourable flammability characteristics.
- Avoid species that produce a lot of ground litter.
- Choose low growing species that remain green throughout the summer—this is very important for vegetation near buildings and accessways.
- See Appendix E for a selection of fire-resistant shrubs suitable for Queensland homes.

When planting shrubs:

- Do not plant against walls or near windows, vents or doorways.
- Avoid large or dense plantings—use individual or small clusters of plants.
- Plant away from any pathways leading to the secondary place of shelter or along key access routes burning shrubs are a hazard to people trying to escape or defend against bushfire.
- Some larger species of shrub can be used as a bushfire barrier—these species can shield people and buildings from embers, wind and radiant heat (see page 116 for more information).

When managing shrubs:

- Keep plants watered and clear of debris, especially during hot, dry weather.
- Regularly prune dead leaves and limbs and dispose of the waste appropriately.

Plant selection 4: screening plants

Screening plants include hedges and other windbreaking vegetation.

As well as providing privacy to occupants, appropriately selected and maintained screening plants can protect people and buildings from bushfire by:

- filtering out embers and wind-driven debris
- slowing the spread of fire
- protecting people and buildings from dangerous winds
- protecting people and buildings from radiant heat.

Windbreaks require a degree of permeability to prevent negative pressure on the house-facing side of the barrier. This negative pressure can cause dangerous turbulence during a bushfire.

The feasibility of using screening plants to improve bushfire resilience will depend on the size of the subdivision. Large land parcels in rural areas are generally more suited to this form of protection.

Design strategy

When selecting screening plant species:

- Choose species that have good barrier-forming characteristics.
- Avoid highly flammable species—plants that produce a lot of dead vegetation or which contain an abundance of an oils, waxes or resins in the leaves and stems should be avoided.
- Species that produce lush, fleshy foliage are the best option.

When planting screening plants:

- Screen plantings should consist of rows of closely packed shrubs or trees, either trimmed as a hedge or untrimmed as tightly grouped plantings. Include breaks in hedges to reduce vegetation continuity that could spread fire.
- Screen plantings should be placed in strategic locations to catch embers and other debris, and to shield against wind attack.
- If sited correctly, screening plants can filter out a large proportion of the burning debris that is carried by the wind during a bushfire.
- Screening plants should be positioned between the home and the most likely direction of a bushfire attack. A recommendation is that the planting should be located between 1.5 times the height of the tree and 5 times the height of the tree from the building.[48]
- Plan for the possibility that screening plants will ignite during the bushfire. Minimise risks associated with this burning by creating a separation distance of 10 metres between the home and the plantings.

When managing screening plants:

- Keep plants to a manageable size, noting that overgrown vegetation is more vulnerable to bushfire.
- Keep the area around the plants free of ground litter and other combustible materials.
- Keep vegetation green and moist, especially during hot weather.

48 Ramsay & Rudolph, 2003.

Plant selection 5: ornamental and food-producing plants

Ornamentals and food-producing plants provide variety and colour to the garden and are generally less flammable when compared to other types of vegetation. It is important to maintain ornamental and food-producing plants by clearing ground litter from around the plant and regularly pruning dead or dry leaves and limbs.

All plants, no matter how green or succulent, will burn if the fire is intense enough.

Design strategy

When selecting ornamental and food-producing plant species:

- Most ornamentals and food-producing plants are safe to use.
- Lush green plants are best because of their high moisture content.
- Most ornamental and food-producing plants are seasonal, so consider what this means for the design of your garden and its bushfire resilient properties.

When planting ornamental and food-producing plants:

- Larger species, such as orchard or flowering trees, can be used as screening plants (see section opposite).
- Plant smaller ornamental and food-producing plants in non-combustible tubs, pots or raised garden beds—separate individual garden beds using open spaces, retaining walls or pathways.
- Keep plants away from walls, windows, vents and doorways.
- Do not store on window ledges or in window-mounted pots.
- Lush green ornamental and food producing-plants can be used to break the continuity of other, more flammable vegetation.
- Prune regularly during the bushfire season to remove dead or dry plant material.

When managing ornamental and food-producing plants:

- Keep plants and garden beds clear of garden waste and other debris.
- Keep plants green and watered during hot, dry weather.
- In the event of a bushfire, keep plants wet until long after the fire front has passed.

Plant selection 6: trees

Trees have something of a dual nature when it comes to bushfires. Trees provide fuel for bushfires to burn, but when used strategically, trees can protect people and buildings from wind and radiant heat exposure and can filter out embers and other flying debris.

Trees are useful in the design of a bushfire resilient home, provided they are carefully selected, maintained and positioned at a safe distance from buildings.

For existing trees, make sure to be aware of how they might affect movement around the house during a bushfire. If a tree is likely to impact people's ability to move around safely, then it is recommended that the tree is removed or lopped. Be mindful of trees located close to buildings, roads and powerlines.

Design strategy

When selecting tree species:

- Avoid species that produce excessive amounts of leaf litter, fallen bark or woody debris.
- Avoid species that shed debris (e.g. leaves, bark) during bushfire season.
- Avoid species with loose, flaky, stringy or ribbon-like bark—these barks can spread fire to the canopy, and when dropped are a dangerous source of fine fuel.
- Select species with thick or reflective bark.
- Choose species that retain green leaves during bushfire season.
- See Appendix E for a selection of fire-resistant tree species suitable for Queensland homes.

When planting trees:

- Keep trees away from buildings, water supplies, powerlines, accessways, exit routes and defendable spaces—trees and tree limbs are vulnerable to strong winds.
- Trees should be at least 1.5 times their mature height away from buildings and other vulnerable elements, such as pathways and secondary places of shelter.
- Separate large trees to minimise the spread of fire (especially canopy-to-canopy fires).
- When building near established vegetation, fell individual trees (if possible) to create gaps between plantings to help slow or stop the spread of fire.

When managing trees:

- Remove low hanging and damaged branches—these are vulnerable to 'laddering' and wind damage.
- Remove loose bark, dead leaves, twigs and branches from the lower reaches of the tree.
- Keep the area under trees clear of ground litter and other combustible materials.
- Remove leaves, bark and other flammable materials from gutters, rooftops and around other parts of the house.
- Dispose of garden waste appropriately.

Part 6: Ongoing maintenance

Building maintenance

Buildings are dynamic systems that constantly change, meaning there is an ever present need to maintain their bushfire resilient properties. Even appropriately designed buildings can be compromised through a lack of routine maintenance. Remember that buildings follow a weakest link principle, where a single flaw in the design or management of the building can compromise the entire structure.

This section provides general guidance for the management of all new and existing buildings. The information below is intended to supplement the materials provided in **Part 2** and **Part 3, bushfire resilient design and construction.**

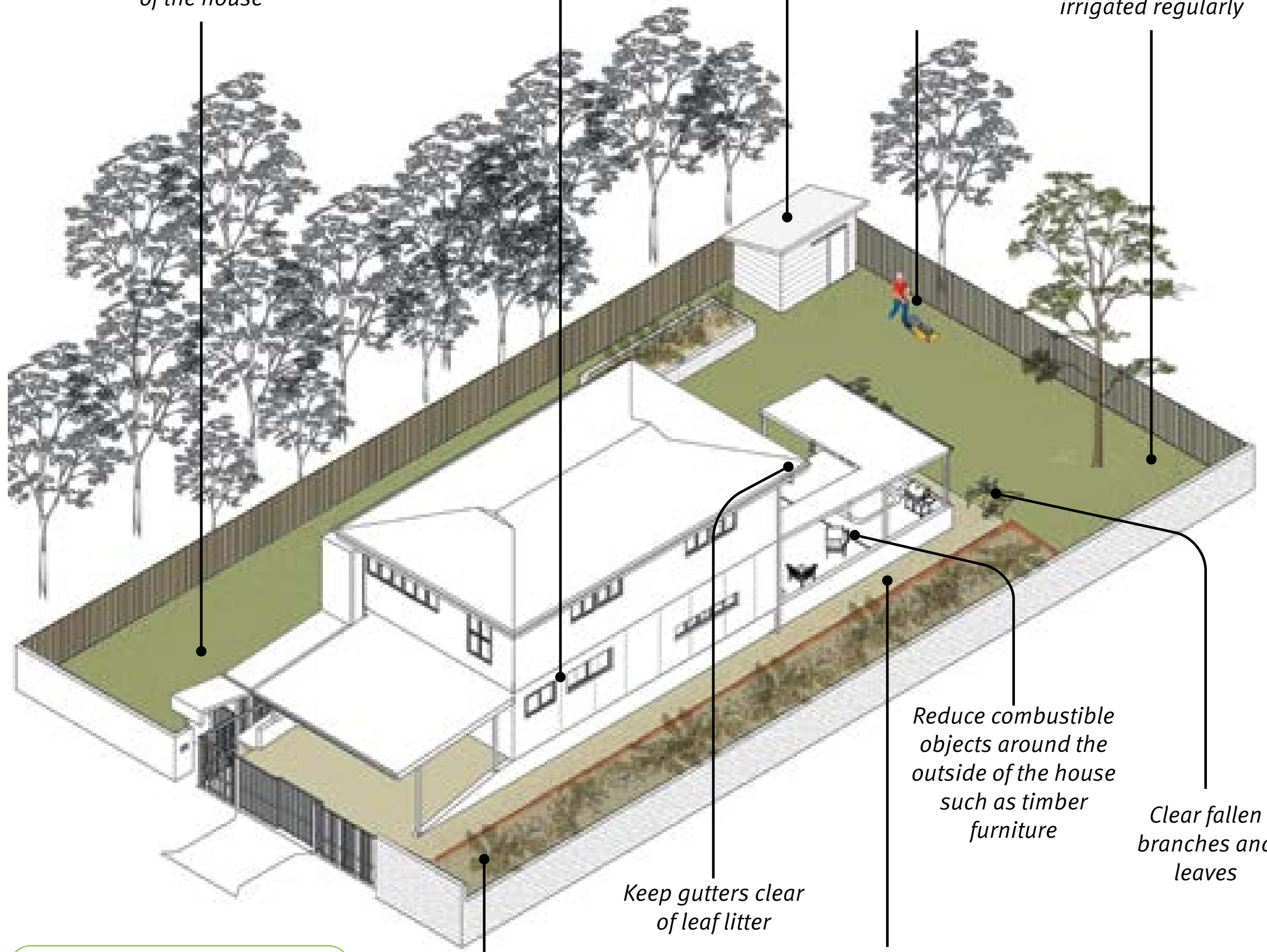
General management

Care should be taken to ensure the bushfire resilience of a building is maintained and reflects the changing nature of the landscape. Be aware that new hazards may develop which warrant additional design or construction responses. For example, vegetation in an adjacent property may become overgrown through the passage of time, creating a bushfire hazard not present when the building was initially designed.

General management actions include:

- Continue to update and refine your bushfire survival plan. Note and adjust for any changes in the building's condition, local bushfire hazards, road closures, accessibility (onto, through and adjacent to the property), access to water and equipment, and the health and mobility of occupants.
- Routinely check for any damage to vulnerable building elements. Pay close attention to the condition of doors, windows, vents, roof systems, building facades, stairs and steps.
- Routine maintenance should be carried out to remove dead leaves, twigs, bark, and other organic matter from around buildings, parking spaces and accessways. As a rule, aim to keep the area within 10 meters of the main building clear of loose, combustible materials. The frequency with which this maintenance is carried out will depend on your situation, for instance, more heavily vegetated gardens will require more frequent management.
- Routinely check that driveways are kept in good condition and are free from fire and trip hazards, or other obstacles which may prevent or obstruct access.
- New extensions, renovations, or retrofits should not compromise the resilience of the building.
- Regularly check for disruptions to local water services.
- Ensure that home water pumps and water supplies (including hoses and fittings) are available and in good working condition. We recommend routine testing of all hoses, pumps and fire suppression systems before and during the bushfire season.

Property maintenance in a bushfire prone area



Clear debris and any combustible elements stored under decks and subfloors.

Routine maintenance should be carried out to remove dead leaves, branches, and loose bark from trees. Also remove dead twigs, leaves and needles from shrubs and other smaller plants.

Walls and cladding

The integrity of wall systems must be maintained in order to retain their effectiveness as a barrier to radiant heat, wind, smoke, and ember attack. Regular maintenance actions include:

- Damaged or missing panels, sheeting, and cladding must be repaired or replaced as soon as possible.
- Monitor external walls for cracks, gaps, and holes. Damaged surfaces should be repaired as soon as possible.
- Closely monitor the condition of any exposed timber surfaces. Decaying timber is vulnerable to bushfire attack, as embers may become lodged within gaps. Gaps in the timber should be sealed and any fire-retardant treatments or coatings need to be reapplied.
- Monitor painted surfaces for damage. Flaking, cracked, or chipped surfaces need to be repainted and any fire-retardant treatments need to be reapplied. Loose, flaking paint can readily ignite and create fine fuels which may also spread as embers.
- When under imminent threat of bushfire, do not wet masonry or concrete walls. These surfaces perform better when dry.

Floors and underfloor spaces

Care should be taken to manage the integrity of floors and underfloor spaces – poorly managed underfloor spaces are vulnerable to bushfire attack. The following guidance on the maintenance of floor systems will help to retain their bushfire resilient properties:

- Where underfloor spaces are enclosed, cladding should be regularly checked for holes, gaps, or cracks. Any damage should be repaired.
- Routine maintenance should be carried out to clear vents and weepholes of debris.
- Avoid storing combustible materials in underfloor spaces.
- Floor surfaces should be kept in good condition. Repair or replace any damaged surfaces.
- When under imminent threat of bushfire, store any combustible rugs or mats in cupboards and ensure that walkways are clear of trip hazards.

Roofs and roof cavities

Damaged or poorly managed roof systems are vulnerable to all forms of bushfire attack: wind, heat, flame, and embers. As a rule, care should be taken to maintain watertight seals on all exposed surfaces to prevent embers from gaining entry to the roof cavity.

Regular management actions include:

- Routine maintenance should be carried out to remove leaves, twigs, bark, and other combustible materials from rooftops and gutters.
- Routinely check the integrity of gutters and gutter shielding. Damaged materials should be repaired or replaced.
- Check tiles and roof lines for broken or dislodged roofing materials.
- Maintain the integrity of sarking materials. Damaged materials should be repaired or replaced.
- Clear vents of debris.
- Maintain the seal between the roof and wall junctions. Damage should be repaired, and any gaps should be sealed.
- Avoid storing combustible materials in roof cavities.

Regularly clean debris from your gutters.

Windows and doors

Windows and doors can create problems in a bushfire, especially when under attack from embers and other burning debris. Most building losses can be attributed to failures in these systems, with faulty windows, doors, and vents providing a means of entry for embers or surface fire to ignite combustible materials inside the house or within wall, floor, or roof cavities.

Consider the following guidance:

- Maintain the integrity of door and window frames. Routinely check the materials for damage. Split, cracked, or broken frames should be repaired or replaced. Pay close attention to timber frames as they are particularly vulnerable to bushfire attack.

Damaged or decaying timber frames are vulnerable to ember attack.

- Check for gaps in window and door systems (e.g. between the door and doorframe). Gaps should be minimised using draught seals or close-fitting construction methods.
- Cracked or broken glazing should be repaired as soon as possible.
- Routinely check doors for damage and excessive wear and tear. Damaged surfaces should be repaired and repainted, and any fire-retardant treatments should be reapplied.
- Ensure that screens on windows and doors are kept in good condition. Tears or holes in screens need to be repaired.
- Where window shutters are installed, routinely check that they function as intended. Non-combustible shutters can enhance the bushfire resilience of buildings, so ensure shutters are properly maintained in order to retain their bushfire resilient properties. As a rule, shutters should be closed when the building is unattended, in case a bushfire occurs when occupants are away from home.
- If timber window shutters are installed, ensure that fire-retardant treatments or coatings are reapplied at regular intervals as specified by the manufacturer.
- Keep the area around doors and windows clear of vegetation and other combustible elements, such as free-standing timber structures, piles of garden waste, and outdoor furniture.
- Regularly check the condition of door mats. Damaged mats should be removed or replaced as they can create a trip hazard. Ensure that mats are made of a non-combustible material to minimise the chances of them igniting and spreading fire.

Verandahs and decks

Poorly managed verandahs and decks can ignite and spread fire to buildings or other parts of the property. We recommend using solid, non-combustible decking to partially 'design-out' this risk.

Damaged deck is vulnerable to ember attack. Source: CSIRO

Example of deck well maintained, clear of clutter. Source: Andrew Halsall

Regardless of the construction materials, attention should be paid to the following:

- Routine maintenance should be carried out to remove debris which may have accumulated around decks and its supporting elements.
- Monitor all materials for damage or excessive wear and tear. Pay close attention to holes, cracks or gaps in surface materials which may provide a point of entry for ember attack. Repair or replace materials as required.
- Check timber decking and support columns for damage. Cracks or gaps in the timber should be sealed, repainted or replaced. Fire-retardant treatments should also be reapplied on a regular basis as recommended by the manufacturer.
- Maintain artificial lighting or navigation aids for use during low visibility conditions. Be mindful of slip and fall hazards around the perimeter of decks and verandahs.
- Minimise the number of plants stored on decks and verandahs. Ensure that any plants are well-maintained and are potted in fire-resilient containers (such as ceramic or concrete pots). Plants should be positioned away from doors, windows, vents and stairs.
- Keep decks and verandahs clear of excessive clutter. Maintain clear, open spaces, especially near to doors, steps, and stairways where clutter may form a trip hazard. Clear debris accumulating in corner and close to combustible elements.
- Minimise the number of plants stored on decks and verandahs. Ensure that any plants are well-maintained and are potted in fire-resilient containers (such as ceramic or concrete pots). Plants should be positioned away from doors, windows, vents and stairs.
- Keep decks and verandahs clear of excessive clutter. Maintain clear, open spaces, especially near to doors, steps, and stairways where clutter may form a trip hazard.

Landscape and garden maintenance

Landscapes tend to require more attention compared to buildings. The need for building maintenance is often readily apparent, especially when the day-to-day use of the building is affected. For example, a leaking roof or broken window may demand immediate attention.

Landscapes, however, can quickly become overgrown or marred by the presence of ground litter, steadily increasing the fire hazard over time. Gardens are easily ignored when it comes to active use, especially as people are tending towards busier lives and may be away from home during daylight hours. Therefore, it is important to develop a routine of proactive garden maintenance.

If time management is an issue, we recommend choosing a garden style that is low maintenance. Make abundant use of lawn, large open spaces, and plants that require little direct management. These options can maintain reasonable levels of bushfire resilience without excessive labour —see **Part 5** for more information.

Low maintanance gardens can be interesting and attractive.

Retain the moisture content of plants by watering regularly, especially during periods of hot, dry weather.

Vegetation management

We recommend incorporating vegetation management into your bushfire survival plan. Areas of unmanaged vegetation can drastically increase the impacts of a bushfire and will reduce the chances of people and buildings surviving the event.

The information below is intended to supplement the guidance provided in **Part 5** and is broadly aimed at reducing fuel load and restricting the opportunities for vegetation to ignite. See plant selection and management section for advice relating to specific plant types.

Regular management actions include:

- Maintain a clear understorey around trees and shrubs. This will restrict the opportunities for a surface fire to ignite the lower branches.
- Routine maintenance should be carried out to remove dead leaves, branches and loose bark from trees. Also remove dead twigs, leaves and needles from shrubs and other smaller plants.
- Prune excess foliage (especially dead or dry foliage) from trees, shrubs and other woody plants.
- Remove the lower branches of trees. This reduces the opportunities for a surface fire to burn up into the canopy. It is usually recommended to remove branches up to 1.5 metres above the ground, but, specific heights will depend on the age of the tree and its species.
- Keep all lawn and grasses short to reduce fuel load and minimise the chances of surface fire.
- Retain the moisture content of plants by watering them regularly.
- Be mindful of the influence of seasonal weather patterns and how the garden will perform in summer when bushfires are most prevalent. In general, the maintenance requirements (in terms of bushfire) will be greatest in summer, and especially during periods of high temperature and low rainfall or periods of water restrictions.
- Trees and other vegetation in the vicinity of powerlines must be managed.
- Woodpiles and other combustible materials should be stored downslope (if possible) and well away from buildings.
- Replacement plantings will need to be considered as older plants die or the needs of the occupants change. Take this as an opportunity to improve the bushfire resilience of the garden.

Managing garden waste

Garden waste includes any dead plant material or organic plant matter. This includes lawn clippings, pruned leaves and branches, weeds, compost and whole plants that have been removed from the soil.

Garden waste, particularly lawn clippings and fine plant material (such as fallen leaves and bark), is a significant fire hazard. Inappropriately managed waste can ignite and spread fire and embers to buildings and other vegetation. Even when not burning, inappropriately managed garden waste is a significant hazard. Light waste is vulnerable to being spread by winds that accompany a bushfire. This wind-driven debris may then accumulate on rooftops or in and around other vulnerable elements of buildings. When ignited, this debris can threaten buildings and the safe escape of occupants.

Regularly clear garden waste from around the yard, including dry or dead plant material.

Regular management actions include:

- Do not store garden waste in exposed piles. If possible, dispose of waste using the greenwaste bins provided by your local council. If this is not an option, consider composting garden waste or disposing of it at an authorised recycling centre. In some cases, it may be necessary to burn garden waste, but, do not do this without the proper authorisation.
- Store garden waste in tubs or cover with a non-flammable material, such as hessian cloth or canvas. This will prevent the waste from being carried by wind and will offer some protection against spot fires.
- Keep all compost and piles of garden waste moist, especially during hot weather. Dry garden waste is a bushfire hazard.
- Store garden waste well away from buildings—never store compost or piles of garden waste near to doors, windows, vents or key access and exit routes.
- Routine maintenance should be carried out to remove garden waste from around the garden. Pay close attention to mulched garden beds, accessways, and the areas under trees and adjacent to fences.
- Routinely remove any organic material that might accumulate around buildings. Pay close attention to gutters, vents, weepholes, rooftops, window ledges and doorways.

Appendices

Appendix A–Acronyms and abbreviations

APZ	Asset Protection Zone
AS	Australian Standards
BAL	Bushfire Attack Level
BCA	Building Code of Australia
BPA	Bushfire Prone Area
CSIRO	Commonwealth Scientific and Industrial Research Organisation
FDI	Fire danger index
FDR	Fire Danger Rating
NASH	National Association of Steel-framed Housing
NCC	National Construction Code
QFES	Queensland Fire and Emergency Services
QRA	Queensland Reconstruction Authority
SPP	State Planning Policy
SPP DAMS	State Planning Policy Development Assessment Mapping System
SPP IMS	State Planning Policy Interactive Mapping System

Appendix B–Glossary

Access (and ingress and egress): to enter (ingress) or exit (egress) a site or location. This may include stairs, steps, walkways, traversable open spaces, driveways, and public and private roads.

Active (and passive) protection systems: in the context of bushfires, active protection systems (such as automatic sprinkler systems, fire extinguishers and smoke alarms) act in order to suppress, extinguish, or alert people to the presence of a fire. These systems require some amount of energy, action or motion to take effect. Passive protection systems (such as non-combustible retaining walls or breaks in the continuity of vegetation) are static building or landscaping features and are generally aimed at stopping or slowing the spread of fire or preventing an initial ignition.

AS 3959: regulatory construction standards applicable to residential developments in bushfire prone areas within Australia.

Aspect (of slopes): the compass direction that a slope faces. In the context of bushfires, aspect influences the amount of sunlight or solar radiation that a fuel source (vegetation growing on the slope) receives. This will also influence the moisture content of the fuel, making it easier (or more difficult) to ignite.

Asset protection zone (APZ): also referred to as a fire protection zone, an APZ is a fuel-reduced area surrounding a house or other asset of value. This can include any residential, commercial, industrial or heritage-listed building. Fuel-reduced means an active reduction in the available vegetation, which is sufficient to reduce the impacts of bushfire on the asset.

Bushfire: an unplanned fire burning in forest, woodland, grassland or scrub. Bushfires are a defining feature of many of Australia's ecosystems and play an important role in shaping the landscape and the biodiversity within it.

Bushfire attack: the method or mechanism by which a bushfire can damage, injure, kill or destroy. There are four main types of bushfire attack (embers, radiant heat, flame, wind), and each presents specific risks and may require specific measures to address.

Bushfire Attack Level (BAL): a means of measuring the severity of a building's potential exposure to bushfire attack. BAL is used as the basis for establishing the requirements for construction to improve protection of building elements in AS 3959.

Bushfire event: any occurrence of a significant, uncontrolled bushfire that threatens life or property.

Bushfire front (also called a fire front): the part of the bushfire within which continuous smouldering or flaming combustion is taking place. The bushfire front is the leading edge of the bushfire's perimeter.

Bushfire hazard: an event or natural phenomenon that may lead to or contribute to the loss of life, injury, infrastructure damage, or socio-economic or environmental disruption. Bushfire hazards include embers, radiant heat, flame, smoke, toxic gases and particles, winds, and the vegetation or other fuels that support bushfires.

Bushfire prone area (BPA): an area of land that can support a bushfire or is particularly vulnerable to bushfire attack. A statewide map that identifies areas at very high risk of bushfire. Properties that fall within an area identified by the Bushfire Prone Area require measures to protect against bushfire attack mechanisms.

Bushfire resilient design: the use of materials, construction methods and design principles that can withstand substantial bushfire attack by actively mitigating hazards and reducing or eliminating vulnerabilities.

Bushfire risk: the combination of one or more related hazards and exposure to these hazards. Includes an object's, person's or system's vulnerability to these hazards.

Bushfire survival plan: a bushfire survival plan outlines all the decisions that households must make when threatened by a bushfire, including whether to leave early or stay and defend the property, as well as plans for escape and defence, and many other important and potentially life-saving details. A bushfire survival plan should be completed well in advance of the bushfire season.

Canopy (or crown) fire: a fire burning in the upper foliage of a tree.

Appendix B–Glossary

Combustion: a chemical process where a material (a fuel source) reacts rapidly with oxygen and produces heat.

Consequential fire: defined as any fire supported by the burning of combustible elements surrounding a house, such as fences, wood heaps, cars and sheds.

Cut-and-fill: the process of moving earth from one place to another to make an area of land level for the construction of a new building. The 'cut' is performed when earth is removed from above the desired ground level and the 'fill' is performed when earth is used to fill in a depression up to the desired height.

Debris: fine bushfire fuels, such as dry leaves, bark, twigs, scattered mulch, grass clippings, paper and other light weight combustible materials. Debris can support surface fires and can form embers when spread by winds.

Embers (also called burning debris): any burning twigs, leaves, bark and other debris that are carried by the wind. Embers can land well ahead or away from the main bushfire front, and as such they represent an especially unpredictable hazard. Ember attack is the most common way that buildings catch fire during bushfires.

Exposure: the state of experiencing or being subjected to a hazard. In the context of bushfire resilience, the goal should be to limit or eliminate exposure to the harmful or damaging effects of bushfires.

Fire: chemical reaction that occurs when flammable objects combust and produce heat. Three components are necessary to ignite and sustain a fire: fuel to burn, heat to ignite the fuel and oxygen to sustain the chemical reaction.

Fire danger index (FDI): an index of relative fire danger, developed by CSIRO scientist AG McArthur, for Australian forests and grasslands. FDI is calculated as a function of a location's air temperature, relative humidity, wind speed and fuel-based moisture content on a given day. The higher the FDI, the greater the danger should a bushfire occur on a given day.

Fire danger rating (FDR): a descriptive indicator of relative fire danger based on the FDI. The FDR provides a six category (low-moderate, high, very high, severe, extreme, catastrophic) assessment of a fire's behaviour and its potential impacts on the community, should a bushfire occur on a given day.

Fire front: see bushfire front

Fine fuel: small pieces of vegetation or garden waste under six millimetres in diameter (e.g. twigs, leaves, wood chips and grass clippings). Fine fuels are easily ignited, burn quickly and can form embers, which may spread fire to new locations.

Fuel: a source of fuel is required to sustain and spread bushfires. The most common bushfire fuels include fallen bark, leaf litter, dry grasses and unmanaged vegetation (such as overgrown trees and shrubs).

Fuel load: describes the amount of fuel in a landscape. Generally, the greater the fuel load, the hotter and more intense the bushfire.

Fuel-reduction zone: an area of modified native vegetation or managed landscape that is partially cleared of fuel.

Hazard: see definition for bushfire hazard.

Hazard assessment: the process of hazard identification, analysis and evaluation.

Ignition: the process by which a fuel catches fire. In the context of bushfire resilience, the goal should be to reduce the chances of building and landscaping elements igniting.

Laddering: the process by which fire spreads from the ground layer to the crown of a tree, by burning along the surface of the trees' bark, up nearby shrubs, or up climbing plants.

Landforms (and earthworks): Landforms and earthworks can be used to mitigate the hazards associated with bushfire. Landforms are naturally occurring features in the terrain, such as ridges, slopes and gullies, while earthworks are human-made and include earth mounds, terraces and retaining walls.

Appendix B–Glossary

Managed vegetation: vegetation that has been modified or planned in such a way to reduce the opportunities for it to ignite and spread fire.

Mitigation (also called hazard reduction): actions taken to eliminate a hazard or reduce its harmful effects.

NASH Standard: the NASH Standard for Steel Framed Construction in Bushfire Areas, which provides constructions standards and guidance for new buildings located in bushfire affected regions. The standard provides two separate solutions, one covering lower BALs (BAL-12.5 to BAL-40) and another for BAL-FZ (buildings located in a flame zone).

Open space: an area of open land with little or no vegetation, featuring an artificial or highly managed surface (e.g. lawns, paved areas, mown or grazed paddocks, sporting ovals, tennis courts and other similar spaces).

Radiation (radiant heat): the heat produced from combustion, or the burning of a fuel source.

Re-entrant corner: the internal angle (or corner) formed at the junction of two vertical surfaces of a building.

Resilience: the ability of a building, environments or community to withstand and recover from the negative impacts of a hazard.

Sarking: a sheeting of waterproof material used beneath roofing materials or behind wall cladding.

Sarking (fire resistant): non-combustible sheeting.

Secondary place of shelter (secondary shelter): an alternative refuge where a person may shelter during the passage of a bushfire with some level of safety.

Site assessment: the process of hazard identification, analysis and evaluation at a site – usually at the location of a new build.

Site layout: the general arrangement of garden beds, trees, pathways and other features in the area surrounding the main building.

Site slope: the average slope (also called gradient or incline) of the ground between the building or proposed building site and the edge of the nearest bushfire hazard (e.g. an area of unmanaged vegetation).

Siting: the process of positioning a home and other fixed structures on a property in order to mitigate the risks or impacts of bushfires and any other potential hazards.

Surface fire: low to high intensity fire that burns horizontally along the ground, consuming low-lying vegetation, ground litter and other debris.

Temperature (ambient): the temperature of the air in an environment or in the space surrounding an object or structure.

Terracing: the process of grading or cultivating a slope into a series of level spaces (called benches or steps).

Topography: (also called terrain), describes the shape, arrangement or layout of the earth's surface.

Tree strike: the process by which a damaged tree or branch falls and causes damage to property or causes injuries or loss of life. Tree strike can occur at any time, as a result of prolonged or sudden damage from winds, disease, insect infestation or dry rot from drought. It is also a common occurrence during and proceeding a bushfire as significant fire and wind damage can weaken trunks and branches, which may lead to them falling.

Unmanaged vegetation: vegetation that results in a substantial bushfire hazard when ignited.

Vulnerability: the characteristic or property of a community, system or object that makes it susceptible to the damaging effects of a specific hazard.

Wind direction: the direction a wind is blowing from. For example, a north-westerly wind will be blowing from the north-west and will generally be pushing the fire front in a south-easterly direction.

Land-use planning-related bushfire risk assessment and management strategies are required to align with the Australian and New Zealand international standard for risk management (AS/NZS ISO 31000:2018). These risk control mechanisms are identified in Queensland's 2017 State Planning Policy (SPP). The SPP seeks to ensure that:

- development in bushfire prone areas:
    a. avoids the natural hazard area
    b. where it is not possible to avoid the natural hazard area, mitigates the risks to people and property to an acceptable or tolerable level
- further, development must:
    c. support, rather than hinder the community's disaster management capacity and capabilities
    d. directly, indirectly and cumulatively avoid an increase in the exposure or severity of the natural hazard and the potential for damage on the site or to other properties
    e. avoid risks to public safety and the environment caused by the storage of hazardous materials and the release of these materials as a result of a natural hazard
    f. maintain or enhance the protective function of existing landforms and vegetation that can mitigate the risks associated with the natural hazard.

Ideally, these risk assessments and management strategies are also consistent with the methodology set out in the Queensland Emergency Risk Management Framework, to the extent relevant.

In addition to the SPP, two non-statutory guidelines to assist in bushfire mitigation are available to help implement the measures outlined in the SPP. These include:

- Queensland SPP, natural hazards, risk and resilience bushfire guidance material, available at dsdmipprd.blob.core.windows.net/general/spp-guidance-natural-hazards-risk-resilience-bushfire.pdf
- QFES *Bushfire Resilient Communities* technical reference guide, available at www.ruralfire.qld.gov.au/Bushfire_Planning/Documents/Bushfire-Resilient-Communities.pdf
- These documents support the SPP in assisting local governments to develop or amend local planning instruments and to develop and apply local bushfire hazard assessment requirements.

Appendix C–Legislative framework for Queensland homes in bushfire prone areas

Building regulations

For building work, the following legislations codes, Australian standards and other standards apply:

Bushfire protection provisions in the National Construction Code (NCC) apply to class 1, 2 and 3 residential and commercial buildings and associated class 10a structures, such as garages, sheds and carports. Further, section 12 of the Queensland Government's 2006 Building Regulations specifies that a local government may, via a local planning instrument, designate all or part of its local governance area as a designated BPA[49] under the Building Code of Australia or the Queensland Development Code.

- Building Act 1975
- Building Regulation 2006
- NCC Building Code of Australia (BCA)
- Queensland Development Code
- Australian Standards referenced in any of the code
    - AS3959–Construction of buildings in bushfire prone areas (2018)
    - National Association of Steel-Framed Housing (2014) Standard: Steel framed construction in bushfire areas.

The designated building located within a designated BPA is required to meet the mandatory provisions outlined in the NCC BCA, constructed in accordance with AS 3959 or, where applicable, the NASH Standard.

The NCC stipulates that 'buildings constructed in a designated bushfire prone area must, to the degree necessary, be designed and constructed in order to reduce the risk of ignition from bushfire, appropriate to the potential for ignition caused by burning embers, radiant heat or flame generated by bushfire; and intensity of the bushfire attack on the building'. This performance requirement is regarded as satisfied if the building complies with either AS 3959 or the NASH Standard. These bushfire standards contain provisions that can be used to resist bushfires, reduce the risk to life and minimise the risk of property loss. The provisions include construction requirements for mitigating the risks of embers and burning debris, and controls to reduce the vulnerability of exterior materials and openings, including external cladding, fascia, doors and window systems.

49 In some cases, your land may still be in a bushfire prone area as identified in the state-wide SPP IMS mapping or planning scheme, but AS3959 (2018) has not been triggered. In these circumstances you may still voluntarily choose to build to AS3959 (2018) or NASH Standard (2014).
If you are doing assessable building work, your certifier will advise whether you are in a bushfire prone area for the purposes of the BCA. In which case you will need to design your building to meet NCC provisions that include AS3959 (2018).

Appendix D–Bushfire Attack Level calculator

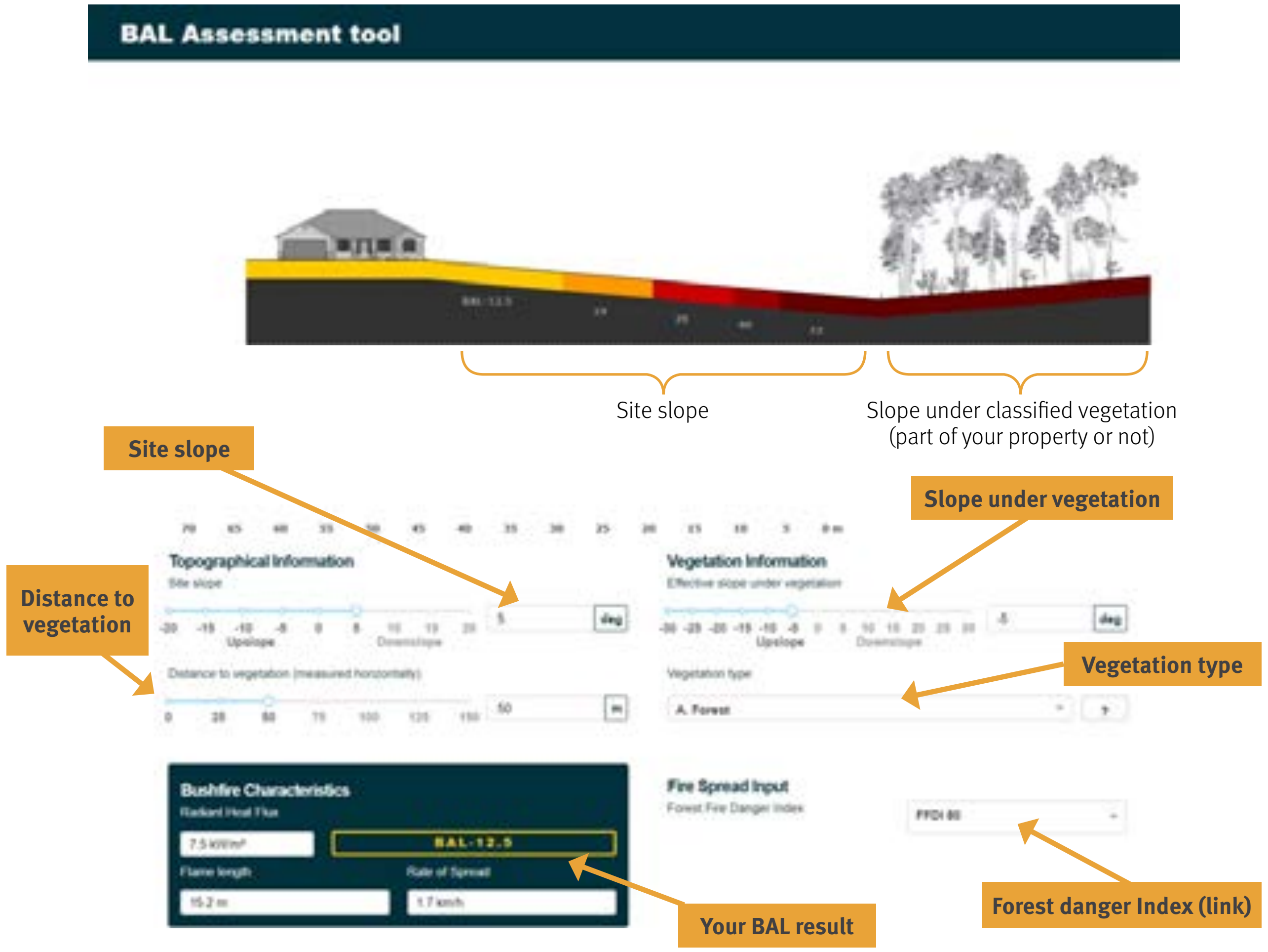
Bushfire Attack Level (BAL) contours (i.e. estimates of the bushfire attack level in the direction of any surrounding classified vegetation) form the basis of most planning and building regulations. Where different building controls are required for different BALs, BAL contours can aid in siting the house in order to reduce the impacts of bushfire and mitigate the surrounding hazards.

BAL contours can be determined using the CSIRO interactive BAL assessment tool and calculator, available at best-practices-assessment-tool.herokuapp.com/#calculator.

The BAL calculator requires the following inputs for each contour:

- an estimate of the location's fire danger index
- the majority classified vegetation type or types in the direction of the given BAL contour
- the average distance to the classified vegetation[46]
- an estimate of the effective slope underneath the classified vegetation
- an estimate of the site slope (the average slope between the site and the classified vegetation).

Guidance on how to estimate these inputs is available in AS 3959.



46 *Could be measured using DAMS at: dams.dsdip.esriaustraliaonline.com.au/damappingsystem/ (In the DAMS, the 'Measure' tab allows you to estimate the distance between an existing building and vegetation) or other mapping systemS (like Google Earth).*

Appendix E–Plant species lists

These lists are intended as a general guide. Independent research is required to determine which species are fire resistant in your location.

The suitability of individual species will vary across Queensland.

All plants, whether native or exotic, will burn when exposed to extreme heat or flame.

Ground covers and creeping plants

- *Casuarina glauca prostrate*, commonly known as grey she oak or marsh she oak
- *Anigozanthos*, commonly known as kangaroo paw
- *Carpobrotus glaucescens*, commonly known as pigface
- *Hardenbergia violacea*, commonly known as sarsparilla or purple coral pea
- *Liriope muscari*, commonly known as lilyturf
- *Lomandra longifolia*, commonly known as spiny-headed mat-rush
- *Lomandra hystrix*, commonly known as mat-rush
- Varieties of *Brachyscome*
- Varieties of *Dampiera*
- *Dianella caerulea*, commonly known as blue berry lily
- Varieties of *Dianella prunina*
- *Dianella revoluta*, commonly known as blue berry lily or spreading flax lily
- *Dichondra repens*, commonly known as kidney weed
- *Einadia nutans*, commonly known as climbing saltbush
- *Hardenbergia violacea*, commonly known as false sarsaparilla, purple coral pea, happy wanderer, native lilac or waraburra
- *Scaevola aemula*, commonly known as fairy fan flower
- *Scaevola humilis*, commonly known as sandplain fan flower
- Varieties of *Cotyledon*
- *Myoporum insulare*, commonly known as boobialla, native juniper or blueberry tree
- *Eremophila glabra*, commonly known as kalbarri carpet
- *Eremophila debilis*, commonly known as winter apple
- *Elaeocarpus eumundi*, commonly known as eumundi quandong
- *Elaeocarpus prima donna*, commonly known as blueberry ash
- *Kennedia rubicunda*, commonly known as Dusky coral pea or red kennedy pea
- *Rhododendron hybrid*, commonly known as azalea
- Varieties of *Arctotis*
- Varieties of *Photinia*
- *Westringia fruticosa*, commonly known as native rosemary

Shrubs

- All varieties of *Aloe*
- *Correa reflexa*, commonly known as nativefuchsia
- Varieties of *Acacia*
- *Nerium oleander*, commonly known as oleander
- Varieties of *Atriplex*, commonly known as saltbushes
- Varieties of *Escallonia*
- Varieties of *Maireana*, commonly known as cottonbush
- Varieties of *Eremophila*, commonly known as emu bushes or fuchsia bushes
- Varieties of *Grevillea*
- *Melaleuca nodosa*, commonly known as prickly leaf paperbark
- Varieties of *Syzygium*
- Varieties of *Photinia*
- Varieties of *Rhagodia*
- *Rhaphiolepis indica*, commonly known as india hawthorn
- *Strelitziacae hutch*
- *Strelitzia banks*
- *Srelizia nicolai*
- *Sambucus australasica*, commonly known as yellow elderberry or native elderberry
- Varieties of *Coprosma*
- Varieties of *Plectranthus*
- *Senna artemisioides*, commonly known as silver cassia

Deciduous trees

- *Brachychiton acerifolius*, commonly known as the flame kurrajong
- *Ulmus parvifolia*, commonly known as chinese elm
- *Morus alba*, commonly known as the mullberry tree
- *Eriobotrya japonica*, commonly known as loquot
- *Gleditsia triacanthos*, commonly known as honey locust
- Trees from the genus *Prunus*, including ornamental cherries, plums and peaches
- Trees from the genus *Malus*, including apples and crab apples

Appendix E–Plant species lists

Evergreen trees

- *Grevillea robusta*, commonly known as silky oak
- *Melia azedarach*, commonly known as cape lilac, white cedar, persian lilac or chinaberry
- *Lophostemon confertus*, commonly known as brush box, queensland box, brisbane box or pink box
- *Tristaniopsis laurina*, commonly known as water gum, kanooka or kanuka
- *Rapanea variabilis*, commonly known as muttonwood
- Varieties of *Acacia*
- Varieties of *Acmena*
- Varieties of *Magnolia*
- *Cupaniopsis anacardioides*, commonly known as tuckeroo or beach tamarind
- *Elaeocarpus reticulatus*, commonly known as blueberry ash
- *Alectryon subcinereus*, commonly known as native quince
- *Callicoma serratifolia*, commonly known as black wattle
- *Canthium coprosmoides*, commonly known as supple jack or sweet susie
- *Cassine australis*, commonly known as red olive berry or red olive plum
- *Croton insularis*, commonly known as Queensland cascarilla, native cascarilla bark or silver croton
- *Cuttsia viburnea*, commonly known as native elderberry
- Varieties of *Citrus*
- *Denhamia celastroides*, commonly known as denhamia or orange boxwood
- *Diospyros australis*, commonly known as black plum or yellow persimmon
- *Eupomatia laurina*, commonly known as bolwarra, grey beech or native guava
- *Glochidion ferdinandi*, commonly known as the cheese tree or buttonwood
- *Guioa semiglauca*, commonly known as guioa or wild quince
- *Hodgkinsonia ovatiflora*, commonly known as golden ash
- *Hymenosporum flavum*, commonly known as native frangipani or Queensland frangipani
- *Petalostigma triloculare*, commonly known as quinine berry, forest quinine or bitter bark
- *Podocarpus elatus*, commonly known as she pine
- *Rhodosphaera rhodanthema*, commonly known as yellow cedar, tulip satinwood or deep yellow wood
- *Sarcopteryx stipata*, commonly known as corduroy
- *Scolopia braunii*, commonly known as scolopia or brown birch
- *Stenocarpus sinuatus*, commonly known as white silky oak, tulip flower, white beefwood or wheel of flower tree
- *Streblus brunonianus*, commonly known as the whalebone tree, axehandle wood or white handlewood
- *Symplocos stawellii*, commonly known as white hazelwood
- *Symplocos thwaitesii*, commonly known as buff hazelwood
- Varieties of *Ficus* (fig trees)

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Appendix F–References and resources

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