WATER•3 – FIRE PROTECTION
3•56 Understanding and Designing for Fire Protection

UNDERSTANDING WILDFIRE DYNAMICS and how to assess, minimise and manage risk before, during and after fire attack is essential when designing living spaces and landscapes in fire-prone areas. The devastating destruction caused by wildfires has led to the development of standards, principles and guidelines to help planners, fire authorities, developers and home owners better design and prepare properties to withstand fire.

The main objectives of planning for wildfire are to:

- Integrate wildfire prevention, protection and management strategies into the property planning process.
- Site elements and features in a way that increases setback from, and improves survivability during, fire attack and the passing of the fire front.
- Design safe vehicle passage.
- Use terrain, earthworks, structures and vegetation for breaking, halting and resisting fire attacks.
- Ensure sufficient water storages are available for fire fighting.
- Factor in power outage, pump and pipe failures and emergency service unavailability.
- Manage fuel (any combustible material) loads within and around habitable buildings.
- Develop landuse and household management and maintenance regimes.

FIRE ATTACK

There are five forms of fire attack to be aware of and plan for:

1. **Embers** and **burning debris** can be propelled for long distances at speed from the fire front, breaking windows, damaging infrastructure and starting fires on the land, in gutters, inside structures and anywhere they contact combustible material.
2. **Radiant heat** at great intensity is generated at the fire front and increases with upslope movement and wind. This is the most dangerous aspect of wildfire for people and livestock. The fire front will be up to six times hotter than the fire's rear. This type of heat does not easily penetrate solid objects and travels in straight lines, so taking shelter is the first form of defence.
3. **Flame contact** is the most obvious form of attack. Direct exposure to flames typically occurs where fuel loads are allowed to accumulate in close proximity to structures.
4. **Smoke** is often unaccounted for in wildfire assessment. It can be a deadly when with exposure in confined spaces and can result in serious respiratory issues, disorientation or loss of consciousness. It also considerably reduces visibility.
5. **Wind**. Wildfires can create their own violent hot winds (more than 120kph/75mph) which facilitate rapid fire advancement, intense heat, propelling of embers to long distances and high speeds and preheating of materials making them more easily combustible. The kinetic energy of the wind can cause direct damage, e.g., through impact, structural damage (unroofing, breaking windows, toppling fences and power lines, etc.), uprooting trees, and affecting people and animals.
6. See also **Appendix 3.11 – Fire Danger, Behaviour, Impacts and Actions to Take**, p. 305.

TABLE 3.49: Smoke Characteristics and their Indications.

Smoke Colour	Indication
Dense,White	Very moist fuels, mild fire behaviour.
Pale Grey/Blue	Moist fuels, mild-moderate fire.
Black/Dark Brown	Dry fuels, high fire behaviour.
Copper/Bronze	Very dry fuels, severe fire behaviour.
Smoke Column	**Indication**
Thin, slowly rising.	Small fire with slow speed.
Bent over, close to ground, and increasing in volume.	Wind-driven fire, spreading rapidly.

COMMON MYTHS AND MISCONCEPTIONS

1. *Fire does not burn through metal.* There is no material commonly used in construction that wildfire cannot burn through, given the right conditions and time.

2. *Metal and brick are safer building materials than wood.* Research suggests the

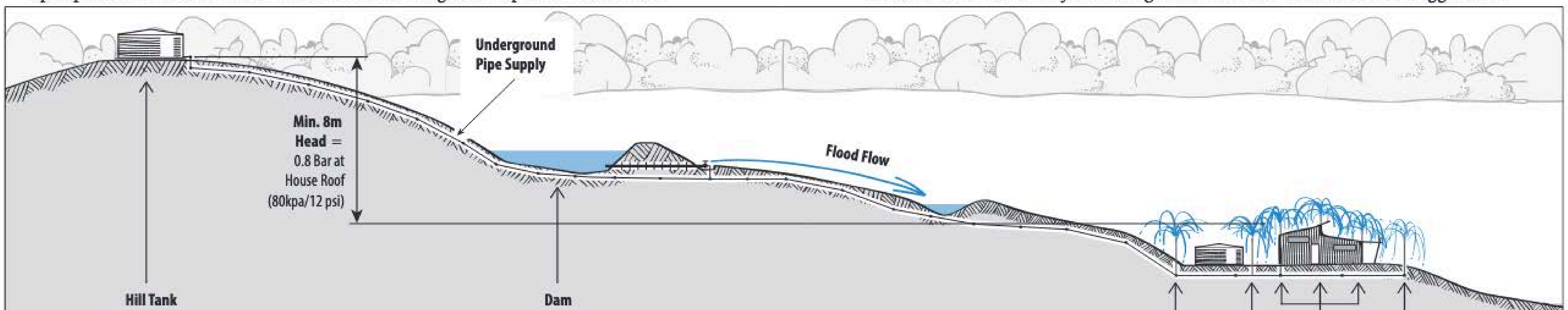

Fig. 3.50: Schematic Arrangement of Fire Protection Water Systems in this Case all Gravity-fed (hill tank or turkey nest dam must be pumped up to).

opposite. Both brick and metal structurally deteriorate when exposed to certain temperatures for a period of time, whereas wood can remain structurally sound until completely burnt through.

3. *Having large water storages is all we need to be safe*. Studies of past wildfire events demonstrate that water storage is worthless if it cannot be utilised. People have had to be evacuated and lose their houses because they did not factor in the severity of the fire, power outages (electric pumps), mains water shortages, and pipe and pump failures.

4. *Evacuation is always the best thing to do*. Not necessarily. People, property and housing that have been prepared for wildfire are usually the safest place to be.

5. *It is safe because the fire is far away.* Fire can move unpredictably and with extreme velocity, especially upslope and when there is a strong, hot wind (fire can create its own wind). Burning embers and debris can be launched for many kilometres ahead of the fire front, breaking windows and infrastructure, and causing pocket fires to start in unexpected locations where combustible material is present. Many houses are lost due to ember attack.

6. *Fire passes slowly/quickly*. In most cases the front of a fire will pass within 10–30 minutes. However, once the front of the fire has passed through, a property may be at risk from ember attacks and smoldering fuel for hours, days or even weeks.

7. *The government/fire brigade/neighbours will save us*. It has been consistently recorded that during widespread fire hazard, emergency services are either busy or unavailable. Hving the ability to deal with fire on your own, being able to draw on your own strengths and survival capacities, is a key to psychological and physical preparedness or failure.

ASSESSMENT

Prior to designing for wildfire, assess the land and land owners for:

1. Education and knowledge;
2. Psychological preparedness and holistic context;
3. Legal developmental allowances, building codes and control plans;
4. Climatic factors, sector analysis and fuel load analysis and historical wildfire events and patterns;
5. Geography, including topography, aspect, demographics;
6. Water resources, including mains water, dams, wetlands, tanks, pumps, pipes, fire hydrants, sprinklers and features; standard fire-service fittings on tanks (e.g., 'Storz').
7. Access for fire-fighting, water storages;
8. Vegetation, types, flammability and risks to these;
9. Livestock safe places;
10. Buildings, including houses, workshop, garage, barns, livestock and animal sheds;
11. Fences, material suitability and risk per placement and gate size;
12. Soils and grazing/cropping management practices (include) adjoining landholders;
13. Budget; and
14. Sources of power, electricity and gas, location of power lines.

1. CLIMATE

Education & Knowledge

Bushfire Attack Level (BAL)

An Australian system for measuring a property's exposure to bushfire attack. The

BAL relates to construction codes and other standards to ensure buildings can withstand fire attacks. To define the BAL, we must also assess land slope, vegetation type, and Fire Danger Index. [See also **Appendix 3.8**, p. 301, **Appendix 3.10**, p. 303, **Appendix 3.11**, p. 305].

TABLE 3.50: Bushfire Attack Levels (Aust. Standard 3959-2009).

Bushfire Attack Level (BAL)	Description of Predicted Bushfire Attack and Levels of Exposure
BAL – **LOW**	Insufficient risk to warrant specific construction requirements.
BAL – **12.5**	Ember attack.
BAL – **19**	Increasing ember attack and burnng debris. Heat flux: 12.5–19 kW/m².
BAL – **29**	Increasing ember attack and burnng debris. Heat flux: 19–29 kW/m².
BAL – **40**	Increasing ember attack and burnng debris. Increased likelihood of exposure to flames. Heat flux: 29–40 kW/m².
BAL – **FZ**	Direct exposure to flames from fire front in addition to radiant heat and ember attack. Heat flux >40 kW/m².

Fire Danger Index (FDI) and Fire Danger Rating (FDR) are measurements used by the various Australian State Fire Services during the bushfire season. The FDI and FDR work together, the former measuring the climatic factors and likelihood of fire to occur, the latter measuring the anticipated fire behaviour. These ratings are updated daily by State Fire Services and indicated on signs prominent in all rural towns and villages.

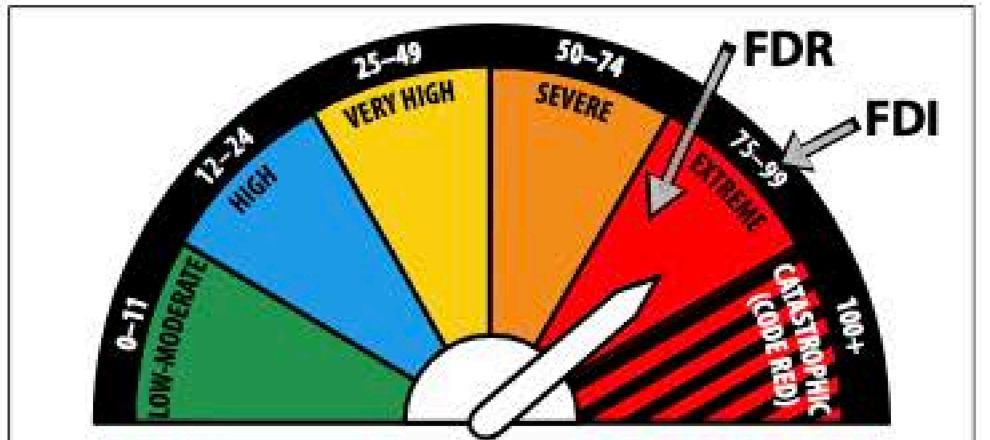

Fig. 3.51: Fire Danger Rating (FDR) and Fire Danger Index (FDI) Model used in Australia.

GIS analysis can be used to streamline the process of assessing the risk level of a property by the extraction and overlay of various maps from available survey data. For example, areas of high potential for wildfire—based on slope, aspect, vegetation and other criteria—and low availability/proximity of fire suppression agencies are in high risk areas.

Psychological Preparedness and Holistic Context

This involves Anticipation, Identification, and Management (AIM):

- The *Anticipation* stage is about setting expectations in advance as to what you are likely to face, and how you are likely to react, when in a crisis situation, so as not to be caught off guard (or not as much) by feelings, emotions and sensations that can cause panic.
- The *Identification* stage is about coming to terms with your broad psychological and physical reactions to stress, identifying what they are and understanding why they occur.
- The *Management* stage is about learning how to control or respond to your stress induced reactions.

Physical and practical preparedness should be managed in conjunction with psychological preparedness because they reinforce one another.

Holistic context analysis should be carried out to determine the decision makers, resource base, quality of life, actions and behaviours, indicators of success, weak

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links, and specific management steps for the enterprise or household [see: **CLIMATE•1.10 Holistic Context Development**, p. 26].

Legislation surrounding bushfire is an important factor. In places notorious for bushfire (such as most of Australia and regions with Mediterranean climates e.g, Greece and California—although, fanned by climate change and systemic corruption, wildfires are becoming an increasingly dangerous phenomenon everywhere from Portugal to Siberia), regulatory frameworks that govern development in fire-prone areas have changed in the last 20 years. It has become obligatory to follow developmental and building codes, as well as land management practises. Government agencies produce extensive guidelines for general preparedness, as well as policies and protocol to be followed before, during and after a bushfire event. Draw on an understanding of policies and procedures to serve as a basis for the formulation of a site-specific household and property management plan.

Climate History
Climatic factors should be closely considered at this stage. It is important to look for patterns by examining the past (up to 100 years), since patterns can inform strategic decisions more effectively than isolated data like precipitation, temperature, wind speeds, etc. can on their own.

2. GEOGRAPHY

Topography greatly influences the direction and velocity of air flow and fuel distribution having a direct effect on fire behaviour:

- *Slope* – the intensity and velocity of fire increases moving uphill, with radiant heat reaching farther ahead from the fire front, thus preheating and drying unburnt fuel in advance. For every 10˚of uphill slope, the fire will double its speed. Conversely, for every 10˚of downhill slope, the fire will halve its speed.
- *Orientation* – sun-facing slopes (north in the southern hemisphere and v.v.) carry much greater risk of bushfire.

Psychographics
Unprepared communities – wild fires can cover large areas. Risks to individual properties increase with lack of preparation in the wider commuity. Examples of community preparations include (many of these exist in areas prone to wild fire):

- Preventative reduction of fuel loads especially in the main fire sector (sun-side and continental interior) using cool burns in the off season where appropriate.
- Creation of and participation in local volunteer fire brigade service.
- ‘Phone trees’ and messaging services to maintain community emergency communication.
- Individual and settlement-wide emergency fire plans with effective trigger points for evacuation or action.
- Monitoring of fire danger conditions.
- Government inter-agency cooperation in fire emergencies.

Emergency services – locations and distance from emergency fire services, police, and hospitals, and their history of past performance and availability during crisis.

3. WATER

Design

- Gravity is used preferentially in the irrigation and fire-protection systems since it is far less likely to fail than a pump.
- The fire-protection system should ideally be also part of the irrigation system.
- All pipes must be buried (any above-ground piping, risers etc should be metal rather plastic, e.g., galvanised iron piping).
- Dams, wetlands, tanks, pipes, sprinklers and emitters should be positioned in a such a way as to facilitate increased fire protection, assistance access during firefighting.

Mains Water

- Assume shortage/unavailability due to droughts or water restrictions.
- Water pressure likely to drop drastically during crisis due to power outages and/or demand on supply.
- Can be used to refill dedicated firefighting water storage tanks during fire season.

Dams

- Dams should be located so as to serve as a firebreak within the fire sector, provide gravity irrigation and as asource of water for pumping to a header tank.
- Dams should hold enough storage for fire prevention and for assistance during fighting, between 20,000–50,000 litres/ha during the fire/dry season.
- Whenever possible, as topography and other factors permit, dams should be designed for convenient access to fire fighting services.

Tanks
Contrary to popular belief and advertisement, no tanks are completely fire-proof, however concrete and steel tanks offer better fire-resistance than other materials. Bushfire exposure turns stainless steel tanks black, but prolonged exposure to extreme temperatures will eventually destroy any welded joins, depending on how much water is in the tank and the intensity of the fire. Plastic tanks can ignite when there is a sustained ignition source, such as a high-intensity bushfire. Plastic-coated steel tanks, contrary to what some tank manufacturers state, are sensitive to temperature. In an intense fire, the plastic coating inside the tank will separate and render the tank useless. During Australian Fire Impact research conducted by the CSIRO’s Sustainable Ecosystems Branch, Zincalume® (steel plastic-lined tanks) performed better than Aquaplate®, with the Zincalume® coating melting at about 200°C, Fibreglass tanks failing entirely.

- Storage tanks should be located near the housing, but not on the fire-prone side.
- Dedicated fire fighting tanks should be steel or concrete and preferably above ground.
- Poly tanks should be buried if possible.
- Tanks should provide the required dedicated water storage for fire-fighting [see **TABLE 3.51**, overleaf] during the fire season. In practice, however, all available water sources are likely to be used.
- Fire fighting water sources must be easily identifiable from the public road, including signs at the property frontage, and readily accessible by a driveway that is 4m

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wide and that extends less than 4m from the tank.

- Tank stands may need additional protection so as not to collapse.
- Dedicated fire-fighting outlet (typically 65mm Storz but varies with each jurisdiction) should be made available at the bottom of the tank, with a reserve of 20kL maintained.
- Valves, pipes and fittings should be metal.
- Underground tanks should allow for tankers to refill directly through a large enough access hole (>200 mm).
- If located on the fire-prone side, tanks should have shielding that provides additional protection from heat and direct flame contact.

Wetlands/Swales

- In conjunction with fire-retardant vegetation, swales can act as fire break.
- In arid regions, swales can rehydrate soils to some extent, thus lessening the likelihood of some fires occurring/proceeding.
- Swales should be designed to double as an emergency two-wheel drive or foot access, typically to a dam, public driveway or emergency firetrail.
- Wetlands, WET systems and wetland trenches can be created within the fire sector to serve as a firebreak, wastewater treatment and production features. They can be fed with greywater, stormwater and/or runoff.

TABLE 3.51: Minimum Water Storages for Dwellings for Fire-fighting Purposes.

Development	Water Storage
Residential Lots (<1,000m²)	5,000 litres per lot
Rural-residential Lots (1,000–10,000 m²)	10,000 litres per lot
Large Rural Lots (>10,000 m²)	20,000 litres per lot
Dual Occupancy	2,500 litres per unit
Townhouses/Flats	5,000–20,000 litres per house/flat

Pipes

- All pipes should be buried. Risers should be metal.
- Assume pipe failure/blockage will occur.
- Should be of sufficient size to facilitate adequate water flow (typically at least 25 mm/1" diameter).

Pumps

- Assume pump failures.
- Should be petrol or diesel driven.
- Should be able to pressurise water at a minimum of 3.7 kW (5 hp) power rating, or the recommended pressure to deliver adequate supply of water to sprinklers and tanks.
- Should not be located on fire-prone side. The pump must be protected from radiant heat.
- Should be located to be accessible to fire fighters as safely and conveniently as possible.
- Consider the use of portable pumps with tanks (e.g., IBC). These can also be used for stock water provisions and watering newly established trees.

- Where pumps are used and depended on, regularly test them (once per 7–14 days during the fire season).

Sprinklers/Emitters

- Outlets, risers, and pipes should be metal rather than plastic.
- Pipes should be buried at a depth of at least 300 mm.
- Roof sprinklers should be designed while factoring in that wildfire generated wind will tend to blow the spray away.
- Roof sprinkler sprays must have a sufficient overlap to adequately cover the sides of the house and the entire roof.
- The activation mechanism for the sprinkler system must be regularly checked and should ideally be indoors or near an access door on the non-fire sector side.

4. ACCESS

General

- Always plan at least one alternative emergency access.
- The emergency route should always be as short, straight and fast as possible.
- Roads should be designed following contour or ridge alignments to minimise erosion and construction and maintenance costs, whilst providing complete access to critical points on the property.
- Alignments should be designed to a density and spacing criteria such that the road network provides efficient coverage of the property.
- Roads should be located according to pipelines and water storage features so that they are readily accessible and serviceable.
- Plan looping alignments, avoid dead ends.
- Roads should be located so as to act as firebreaks whenever possible.
- Maintain as straight alignments as possible, avoid unnecessary curves.
- Where curves are necessary, they should be able to accommodate the turning radius of the largest design vehicle (e.g., a fire truck) at the highest design speed.
- Alignment grade should not exceed 10°.
- Whenever possible, avoid designing alignments through wetlands, flood plains, creeks and other locations subject to periodical flooding and requiring culverts and crossings.
- All roads should be sign-posted, specifying routes to emergency exits and dedicated firefighting water storages.

TABLE 3.52: Road Spacing Based on Slope (metric conversions rounded). Ref: Pavlov (2016).

Slope %	Road Spacing m/(ft)	Road Density m/(ft)/ha
0–15	800 (2,625)	27 (90)
15–30	600–800 (1,950–2,625)	37–27 (120 –90)
30–60	300–400 (1,000–1,300)	73–55 (240–180)

Public Roads/Bridges

- Alignment grade should not exceed 10° (17.5%).
- Vertical clearance to be maintained at 6m along the length of the road.
- Two-lane, 8m wide at minimum, with shoulders to facilitate emergency stopping and overtaking. If necessary, has to be wider or include widenings at sufficient

increments or strategic locations so that firetrucks can pullover and firefighters can work around the vehicle.
- Must be able to bear the load of a fully loaded fire truck.

Perimeter Access/Fire Trail
- Provides firefighting access to water sources.
- Serves as an emergency evacuation route.
- Hazard control line.
- Should be located and designed to act as a firebreak.
- Gradient should not exceed 8–12°.
- Must be usable for fire trucks year round.
- Must be maintained and have a setback of at least 20m from hazardous vegetation.
- Minimum vertical clearance should be maintained at 6 meters at all times.

Property Access
- Property access should link to a public road every 500m along property frontage.
- Provide access to dedicated water storages, up to at least 4m away from the storage.
- Minimum width of 4 meters or enough to accommodate fire trucks and emergency vehicles.
- Should maintain vegetation clearance of 3.5–7.0m from the edge of the cut and fill.
- The roads, as well as any crossings (bridges, fords) should be able to bear the weight of a fully loaded fire truck (30T) or emergency vehicle. Crossings should be sign posted indicating bearing capacity.
- Vertical clearance should be maintained at 6m at all times along the entire length of the road.
- Must have the appropriate drainage and erosion control features.

5. FORESTRY

[See also **Appendix 3.12, Fire – Classification of Vegetation**, p. 306; **Appendix 3.13, Fire – Species that Resist Fire (Australia)**, p. 308].

General Design and Selection
- Mostly deciduous and evergreen vegetation.
- Accumulates minimum amounts of combustible material (leaves, twigs, bark, certain fruits), i.e., eucalypts are contraindicated.
- Vegetation with ribbon-like barks, open crowns, fine leaves and high oil content are typically highly combustible.
- Plantings should not stretch continuously or form a string or ladder like pattern.
- Choose trees that remain stable in high winds.
- Prioritise native species, or ones adapted to local climatic and soil conditions, *but* only if they are not part of fire-promoting Mediterranean ecosystems.
- Drought-tolerant and hardy.
- Form dense crown foliage to trap debris and radiant heat; dissipate smoke clouds.
- Avoid species retaining dead leaves or bark for long periods within the crown.
- Avoid planting under or in close proximity to overhead power lines.

Firebreaks and Shelterbelts
- Whenever possible should also provide food, fodder, fuel, fibre and/or timber.

- Should act as erosion control, wastewater treatment and/or privacy screens.
- Should be designed to deflect heat, wind and embers in a desired direction.
- Should be designed to a height, density and spacing so as to to let through 50–60% of the wind in order to minimise turbulence. Must not, however, have gaps large enough to create a funnelling or 'venturi' effect.

Livestock

Evacuation and Fire Planning
- Clarify an evacuation 'trigger'—the point or factors which trigger the decision to evacuate. In Australian, e.g., – the evacuation plan may be triggered by Extreme, Severe or Catastrophic fire danger ratings.
- Be clear on how much time each step in your plan is likely to take in a major crisis situation. During Extreme, Severe or Catastrophic danger ratings e.g., plan to be able to quickly and safely evacuate your livestock or move them to a safety area.
- Plan well ahead for an evacuation to another property and make arrangements so that no time is lost in discussions during the move.
- Loading yards and equipment should be designed, prepared and maintained such that the loading/unloading of animals happens as efficiently and safely as possible.
- A safe location on the property should be designed carefully in case the animals cannot be evacuated and must be left behind. This location should take advantage of its terrain to provide increased safety, and should be sheltered from fire attacks from the fire sector through the use of shelterbelts, firebreaks, heat barriers or earthworks. Maintain minimal fuel loads during the fire season, through clearing, planned grazing, cultivation or possibly green manure. At least 20m (ideally more) of setback from any hazardous vegetation material should be left around the perimeter of the safety area. If possible, this safe area must be large enough to allow animals to manoeuvre away from fire attacks. Enough drinking water should be available for stock to be able to remain in the area for a few days to a week.
- Plan a scenario: abandoning the property with the animals still on it. In such a case you must know how much time it takes for all internal gates to be opened, or fences cut, in case it seems best that that animals are not left trapped, if it appears likely that the safety area will be compromised. Boundary fences should not be cut, since it is much less safe for livestock and people if animals are allowed on a public road.
- If applicable, factor in how much time it will take to turn on sprinklers or open valves for flood irrigation within the safety paddock.
- Remove all combustible and metal materials from livestock (collars, saddles, rugs).
- Under no circumstances should animals be left enclosed in a stable, shed or barn.
- Practise and review the plan annually with all people involved.

6. STRUCTURES

Housing

Siting
- Should not be located at hill tops, steep slopes, ridge crests, above or within woodlots (especially those consisting of highly combustible species) or at the top of valleys and gully heads (which act as fire tunnels).
- Avoid building on slopes exposed to the fire sector.

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- Position near a well serviced public road and two way access that is located and leading away from the fire sector.
- Locate near alternative emergency access.
- Locate on level ground if possible.
- Locate away from trees at a distance at least 1–3 times the height of the highest tree.

Design and Construction

Structure and General Considerations:

- Buildings should be long and narrow, with the narrow side oriented to the windward or fire sector direction (typically east-west axis), at a ratio of depth to length 1 : 1.5.
- The shape of the building should not collect and accumulate debris.
- Buildings should be low as possible, with grading maximising on cut and minimising on fill.
- Concrete slabs should be used as a base, while raised floors should be avoided.
- Fire-resistant hardwood construction for the stud frame and trusses is preferable to soft wood.
- Any columns should be steel, masonry or concrete.
- Fireplace and chimney is made of dark-coloured brick within the house and light-coloured brick for the outside.
- Timber should be painted white.
- The use of plastics and highly combustible materials within and without the house should be minimised.
- Roof timber framing can be protected, eg., with a thick layer (6 mm) of cement.

Services:

- Power and gas lines should be buried, and their locations marked.

Roof:

- Low hip and gable type roofs are preferable against wind.
- Avoid flat or steep roofs.
- Roof tiles must be non-combustible.
- No gaps between roof sheets, or roof and walls. Any gaps should be sealed with corrosion resistant mesh, mineral wool or other non-combustible material.
- Additional roof guards can be fitted over any ventilation points.
- Fascias should be of non-combustible material such as galvanised steel.

Windows:

- External screens or bushfire shutters can be installed on the fire-prone side as an effective measure against ember attack. Metal blinds can provide safety against radiant heat, wind, solar exposure, cold and theft.
- Screens should be made with a corrosion-resistant, perforated steel, bronze or aluminium mesh. The mesh is attached to a frame made of metal or fire-resistant hardwood.
- Window frames and doors should be made of fire-resistant hardwood, steel or power-coated aluminium.
- Hardware required to open the windows should be metal.

External Doors:

- Doors should not face the fire sector.
- Combustible side-hung doors can be protected with external screens or bushfire shutters.
- Hardwood doors should be at least 35mm thick for a height of 400mm above the threshold.
- Hardware required to open the door should be metal.
- Sliding doors can be protected with external screens or bushfire shutters, and fitted with Grade A safety glass.

Vents and Weepholes:

- If openings in external walls are greater than 3 mm, they should be sealed with corrosion-resistant steel, bronze or aluminium mesh.

Eaves, Gutters and Downpipe:

- Gutters should be installed with leaf guards to avoid the accumulation of wind-blown combustible material.
- Gutters, downpipes and any attached hardware such as screens and leaf guards should be of non-combustible material.
- Eaves should be designed to a 90° angle to the walls facing the fire sector.
- Gutters and downpipes should be metal.
- Any gaps in the eaves should be sealed with corrosion resistant mesh, mineral wool or other non-combustible material.

External Structures:

- Pergolas should be constructed from steel framing.
- Any roof penetrations in the veranda, carport and awning roofs should be sealed as per the roof recommendations.
- Overhead glazing should be Grade A safety glass.

Animal and Tool Sheds

- Animal sheds are usually high risk structures due to the commonly used softwood, plastics and other combustible materials, as well as dry fodder and bedding. They should be sited away from the fire-prone side and away from the habitable buildings.
- Tool sheds should be positioned on a slab concrete base, with precast panel walls and slab roof. Junctions between walls and roofs should be sealed similar to that for the housing. The doors and windows should be tightly secured and protected against ember attacks and radiant heat through screens and shutters.

Fire Shelters can be constructed for use as a last resort strategy if all else fails and evacuation is not an option. They can be costly to construct properly and typically have to comply with performance requirements and building standards. They are not necessarily safe, especially if improperly designed and constructed. Consult with an accredited fire safety engineer before going ahead with a purchase.

7. FENCES

- Fences inevitably follow reticulation, access, forestry and building envelope lines to create asset protection zones, controlled grazing and 'safety' paddocks.

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- Fences should be designed and installed to resist high winds.
- If possible, fences should be designed so they do not collect debris and catch embers.
- Steel posts should be used instead of wood, for perimeter fences.
- If wood is used, fire-resistant hardwood is preferable to soft wood. Fire-treated softwood burns through quickly once it ignites. Electrical boundary fences should be stock-proof in case a power outage occurs.

TABLE 3.53: Fences – Experimental Fire Exposure and Response.

Level of Exposure	Steel	Hardwood	Treated Softwood
Litter Ignited. Leaf litter placed typically on fence rails and around fence posts and ignited to investigate and observe the influence of this ignition source.	No structural failure of fencing system.	No structural failure of fencing system.	Burning to completion in 1–2 hours during testing.
Litter Ignited + Pre-radiation Typical of an advancing bushfire occuring on a fire danger day with a Fire Danger Index of 40, but with sufficient clearing to avoid direct flame contact with the fence.	No structural failure of fencing system.	Structural failure of fencing system in sections.	Burning to completion in 1–2 hours during testing.
Simulation of Structural Fire Full continuous flame immersion for a period of 30 minutes. Designed to simulate a worst-case structural fire where the fencing system may increase or decrease the risk of adjacent house ignition.	No structural failure of fencing system.	Structural failure of fencing system in sections.	Not tested because exposure levels: 1. Ignited litter; 2. Litter ignited + pre-radiation; & 3. Simulation of bushfire passage... burnt down the fencing system to completion.
Note: Ember attack can occur before, during and after the main fire event. Hence this structural impact can create risk for the occupants in a number of direct ways.			

***Source**: http://www.bushfirecrc.com/sites/default/files/managed/resource/_6baf_bluescope_fence_report_final.pdf*

8. SOILS

Before the fire

- As part of holistic planned grazing, consider heavily grazing perimeter strips and other areas close to valuable infrastructure.
- Consider irrigating areas close to valuable structures to keep green vegetation buffers.

After the fire

- Deep tillage.
- Sow cover crops undersown with perennial pasture species.
- Use bale-grazing on any areas where soils are very thin and in riparian areas prone to erosion.
- In areas under high risk of erosion consider installing a range of erosion control measures [refer to **3.30 Silt Traps**, p. 209 and **3.58 Valley Erosion**, p. 284].

9. ECONOMY

- Maintain an adequate reserve for fire management and infrastructure maintenance within the property's financial plan.

- Insurance:
  - Review insurance policies and product disclosure agreements to ensure you have appropriate cover.
  - Liaise with neighbours, the larger community and local fire services to gain an understanding as to fire plans and insurance policies in case you can get information on better deals.

10. ENERGY

Electricity

- Assume and prepare for complete power outage.
- Power lines should be underground.

Gas

- Gas cylinders are located away from the fire-prone side and protected with an additional shielding or heat barrier.
- Cylinders to be located away from combustible materials and should not be fully enclosed.
- Release valves must face away from the housing and any combustible materials.
- Ideally should be located and housed in such a way that they can be easily be moved or rolled away in a fire.

APPENDIX 3.8 (see 3.56) – WATER•3
Bushfire Attack Levels (BAL) Details

Determination of category of bushfire attack for a site (NSW, Australia).

Distance from Vegetation	<20m	20m but not greater than 30m			>30m but not greater than 50m			>50m but not greater than 80m			>80m but not greater than 100m		
Slope	All slopes	>15°	>5° & <15°	0–5°	>15°	>5° & <15°	0–5°	>15°	>5° & <15°	0–5°	>15°	>5° & <15°	0–5°
Vegetation	**Category of Bushfire Attack**												
Forest	FZ	FZ	FZ	EXT	FZ	EXT	High	EXT	EXT	Med	EXT	High	Low
Woodland	FZ	FZ	EXT	Med	Ext	High	Low	EXT	Low	Low	Med	Med	Low
Shrub/Heath	FZ	FZ	FZ	EXT	FZ	EXT	High	EXT	High	Med	High	High	Low
Mallee/Mulga	FZ	Med	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Rainforest	FZ	High	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Grassland	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Non-vegetated	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Bushfire Attack Category:	Low Low		Med Medium			High High		EXT Extreme			FZ Fire Zone		

1. Categories of Bushfire Attack based upon Fire Danger Index (FDI) of 80 and fuel loads for NSW vegetation. Table provided by NSW Rural Fire Service (Australia). Fire behaviour models described in Appendix E to Aust. Standard 3959. Forest includes pine plantations but not rainforest.

2. The expected fire behaviour for each category is:

Category	Description	Radiation Levels
Low	Minimal attack from radiant heat and flame due to the distance of the site from the vegetation, although some attack by burning debris is possible. There is insufficient threat to warrant specific construction requirements.	No greater than 14.5 kW/m or >100m from all woody vegetation.
Medium	Attack by burning debris is significant with radiant heat & flame attack insufficient to threaten building elements (unscreened glass). Specific construction requirements are warranted.	>14.5 kW/m & <16 kW/m. (Level 1 AS3959–1999).
High	Attack by burning debris is significant with radiant heat levels and flame threatening some building elements (screened glass). Specific construction requirements are therefore warranted.	Significant ember attack, possible flame contact, radiation >16kW/m & <21 kW/m. (Level 2 AS3959–1999).
Extreme EXT	Attack by burning debris is significant and radiant heat levels and flame could threaten building integrity. Specific construction requirements are warranted.	Significant ember attack, possible flame contact, radiation heat >21kW/m & <31 kW/m. (Level 3 AS3959–1999).
Flame Zone FZ	Flames and radiant heat levels likely to significantly threaten building integrity and result in significant risk to residents who will not be adequately protected.	Within the Flame Zone and/or >31 kW/m, therefore construction outside the scope of AS3959–1999.

NOTE: Attack from burning debris increases as the category of bushfire attack becomes more severe. ***SOURCE***: *Planning for Bushfire Protection: A guide for councils, planners, fire authorities, developers and home owners*. NSW Rural Fire Service in collaboration with Planning NSW, 2001. www.bushfiresafe.com.au/Planning%20for%20bushfire%20protection.pdfw

WATER•3 APPENDIX 3.9 – (see 3.56)
Fire: Characteristics of Vegetation Types at FDI 80

Comparative structural characteristics for vegetation types on flat ground for an FDI of 80.

Vegetation Classification	W (T/ha)	R (km/hr)	I (kW/m x 1,000	Lf (m)	Vegetation Group	Vegetation Structure §
Forests	25–40	3.84	48–77	30	1	2, 3, 5, 9
Woodland	15–25	2.4	18–30	20	2	6
Tall Heath (scrub)	25	2.4	28	20	2	12
Open Shrub	15	1.44	14	10	2	13
Closed Heath	15	1.44	11	10	2	16, 17
Shrubland (Chenopod)	12	1.44	8.6	10	3	14, 18
Rainforest (closed forests)	10	0.96	5	10	3	1, 4, 8
Mallee/Mulga Scrub*	18 (5)	0.45	4	6	3	14, 15
Open Woodland *	8	0.77	–	6	3	7, 10, 11
Grassland (pasture) *	6	10	–	6	3	19, 21, 22
Grassland (native) *	5	5	–	3	3	19–28

§ See: **Appendix 13**, p. 308–309 for vegetation structure descriptions.

* These vegetation types are dominated by fuels characterterised as grasses which are consumerd within 5–20 seconds and as such peak values will approximate average (**I**) intensities. Rate of spread determined on understorey fuels in brackets.

KEY: Value using modified MacArthur Meter Mark V:
Fuel Weight (**W**),
Rate of Spread (**R**),
Intensity (**I**),
Length of Flame (**Lf**)

SOURCE: *Planning for Bushfire Protection: A guide for councils, planners, fire authorities, developers and home owners*. NSW Rural Fire Service

APPENDIX 3.10 (see 3.56) – WATER•3
NSW Rural Fire Service Fire Danger Index Calculations

NSW RURAL FIRE SERVICE McARTHUR METER (MARK V)
FIRE DANGER INDEX (FDI) CALULATION

FDI = 2e^(-0.45 + 0.987 ln(DF) - 0.0345RH + 0.0338T + 0.0234WS)

Where: **DF** = Drought Factor (0–10)
RH = Relative Humidity (0–100%)
T = Temperature (0–45°C)
WS = Wind Speed (0–70 kph)

Excel spreadsheet formula, for example (cells may obviously be different):

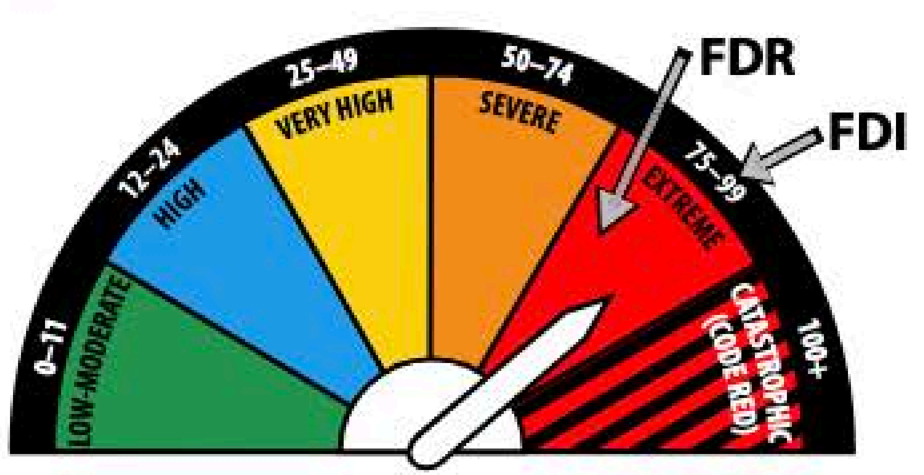
=2*EXP(-0.45+(0.987*LN(E7))-(0.0345*C7)+(0.0338*B7)+(0.0234*D7))

Where: Cell **E7** = DF or Drought Factor (0–10)
Cell **C7** = RH or Relative Humidity (0–100%)
Cell **B7** = T or Temperature (0–45°C)
Cell **D7** = WS or Wind Speed (0–70 kph)

AFTER: *Dowdy, Mills, Finkele & de Groot (2009)*, Australian fire weather as represented by the McArthur Forest Fire Danger Index and the Canadian Forest Fire Weather Index, *CAWCR Technical report No.10, Centre for Australian Weather and Climate Research (CSIRO/BOM). www.bushfirecrc.com/sites/default/files/managed/resource/ctr_010_0.pdf*

Automatic online FDI calculator examples:
www.windellama.bushfirebrigade.com.au/windellama_rfs_simple_fdi.php
www.cfa4wd.org/information/Forest_FDI.htm

Fire Danger Rating	Fire Danger Index
CATASTROPHIC	> 100
EXTREME	75–99
SEVERE	50–74
VERY HIGH	25–49
HIGH	12–24
LOW-MODERATE	0–11



Relative Humidity	Temp °C (°F)	Wind Speed (kph)	FDI	Fire Danger Rating FDR	Ember Spotting Dist. (km)	Fire Spread Rate on Flat Ground (kph)	Fire Front Flame Height (m.)
10%	35 (95)	30	58	Severe	4.4	1.9	24
		35	65		5.1	2.2	27
		40	73		5.8	2.4	30
		45	82	Extreme	6.6	2.8	34
		50	92		7.4	3.1	38
		55	104	Catastrophic	8.4	3.5	42
		60	116		9.5	3.9	47
	38 (100.4)	30	64	Severe	5.0	2.1	26
		35	72		5.7	2.4	29
		40	81	Extreme	6.4	2.7	33
		45	91	Catastrophic	7.2	3.0	37
		50	102		8.3	3.4	42
		55	115		9.4	3.9	47
		60	129*		10.6	4.3	52
	40 (104)	30	68	Severe	5.4	2.3	28
		35	77	Extreme	6.1	2.6	31
		40	86	Catastrophic	6.9	2.9	35
		45	97		7.8	3.3	40
		50	109		8.9	3.7	45
		55	123		10.0	4.1	50
		60	138*		11.4	4.6	56
	43 (109.4)	30	76	Extreme	6.0	2.5	31
		35	85		6.8	2.9	35
		40	96	Catastrophic	7.7	3.2	39
		45	107		8.7	3.6	44
		50	121		9.9	4.1	49
		55	136*		11.3	4.6	55
		60	153*		12.8	5.2	62
5%	35 (95)	30	69	Severe	5.4	2.3	28
		35	77	Extreme	6.2	2.6	32
		40	87		6.9	2.9	35
		45	97		7.8	3.3	40
		50	110	Catastrophic	8.9	3.7	45
		55	123		10.2	4.2	50
		60	138*		11.5	4.7	56
	38 (100.4)	30	76	Extreme	6.0	2.5	31
		35	85		6.8	2.9	35
		40	40		7.7	3.2	39
		45	108	Catastrophic	8.7	3.6	44
		50	121		10.0	4.1	49
		55	136*		11.3	4.6	55
		60	153*		12.9	5.2	62
	40 (104)	30	81	Extreme	6.5	2.7	33
		35	91		7.3	3.1	37
		40	103	Catastrophic	8.3	3.4	42
		45	115		9.5	3.9	47
		50	130*		10.7	4.4	53
		55	146*		12.2	4.9	59
		60	164*		13.8	5.5	66
	43 (109.4)	30	90	Extreme	7.1	3.0	37
		35	101	Catastrophic	8.2	3.4	41
		40	114		9.3	3.8	46
		45	128*		10.5	4.3	52
		50	144*		12.0	4.8	58
		55	161*		13.6	5.5	65
		60	181*		15.4	6.1	73
NOTE:	125*	WARNING: Once FDR>125, fire characteristics cannot be accurately calculated, but will be CATASTROPHIC!					

WATER•3 – APPENDIX 3.15 (see 3.56)
Fire: Some Species that Resist Fire

The following Australian shrubs and trees are recommended in bushfire prone areas. The dimensions shown here are only a guide, they can vary considerably depending on local conditions. (***AFTER***: *Landscaping for bushfire-prone areas*, Dept. of Education & Early Childhood Development, www.education.vic.gov.au/Documents/school/principals/infrastructure/bfpronelandsc.pdf).

SHRUBS

	Botanical name	Common name	Average height & width
	Acacia boormanii	Snowy River Wattle	3m x 2m
	Acacia cyclops	W.A. Coast Wattle	3m x 3m
	Acacia flexifolia	Bent-Leaf Wattle	1m x 1m
	Acacia glandulicarpa	Hairy-pod Wattle	1m x 3 m
	Acacia howittii	Sticky Wattle	5m x 3.5m
	Acacia pravissima	Owens Wattle	4 m x 2.5m
	Acacia iteaphylla	Gawler Range Wattle	3m x 3m
	Acacia myrtifolia	Myrtle Wattle	1.5m x 1.5m
	Acacia vestita	Hairy Wattle	3.5m x 2m
	Agonis juniperina	Juniper Myrtle	4.5m x 2m
	Atriplex nummularia	Old Man Saltbush	2.5m x 2m
	Banksia marginata	Silver Banksia	3 m x 3 m
*	*Buxus sempervirens*	English Box	2 m x 2 m
	Chaenomales japonica	Japonica	1m x 1.5m
*	*Cistus spp.*	Rock Rose	1.5m x 1m
*	*Correa alba*	Coastal Correa	1.5m x 2m
*	*Duranta plumieri*	Sky Flower	2.5 m x 2m
*	*Dais cotinifolia*	Pompom Tree	3m x 2.5m
*	*Elaegnus pungens variegata*	Variegated Oleaster	3m x 2.5m
	Erythrina crista-galli	Coral Tree	3m x 3m
*	*Escallonia macrantha*	Escallonia	2.5m x 2 5m
	Eupomatia laurina	Bolwarra (Copper Laurel)	3m x 2.5 m
	Grevillea rosmarinifolia	Rosmary Grevillea	2m x 2.5m
*	*Hebe spp*	Veronica	1–2m x l–2m
*	*Lagerstroemia indica*	Crepe Myrtle	3m x 3m
*	*Lonicera nitida*	Box-Leaf Honey Suckle	1–2m x 1–5m
	Myoporum Insulare	Boobialla	4m x 4m
	Myoporum montanum	Waterbush	1.5m x 1.5 m
*	*Myrtus penunculata*	Myrtle	3m x 3m
*	*Osmanthus heterophyllus*	Osmanthus	3m x 2m
*	*Photinia glabra "Rubens'*	Chinese Firebush	2m x 2m
*	*Photinia glabra "Robusta"*	Chinese Firebush	4m x 3m
*	*Pieris japonica*	Japanese Pearl Flower	2.5m x 2m
	Rhagodia parabolica	Saltbush	2m x 2m
*	*Rhapilolepis delacouri*	Indian Hawthorn	2m x 2.5m
*	*Rhododendron spp*	Rhododendron	3m x 3.5m
	Telopea oreades	Victorian Waratah	3m x 3m
	Telopea truncata	Tasmanian Waratah	2m x 2.5m
*	*Viburnum tinus*	Laurustinus	3m x 3m
	Westringia fruticosa	Native Rosemary	2m x 3m
	Westringia glabra	Violet Westringia	1.5m x 1.5m

* Introduced exotic species

TREES

	Botanical name	Common name	Average height & width
	Acacia Melanoxylon	Blackwood	12m x5m
*D	*Acer campestre*	Common Maple	14m x 7m
*D	*Acer negundo*	Box Elder Maple	12m x 6m
*D	*Acer platanoides*	Norway Maple	18m x 8m

TREES (Cont'd)

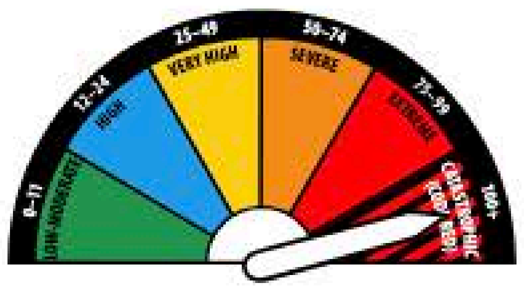
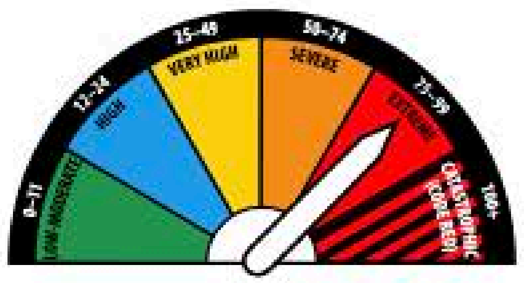
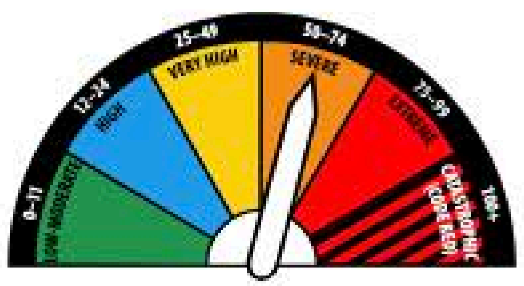
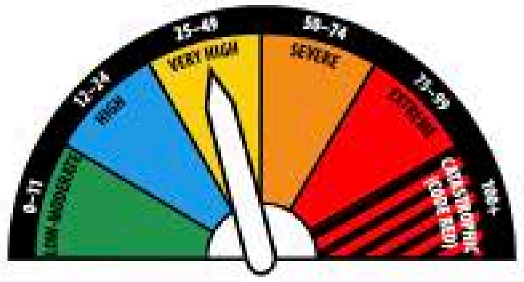
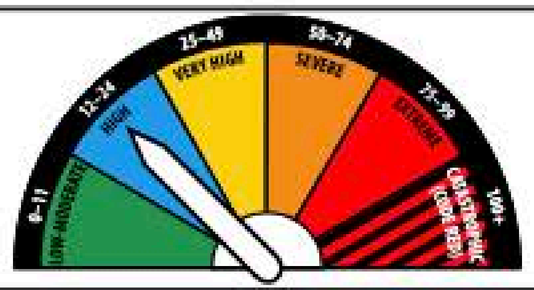
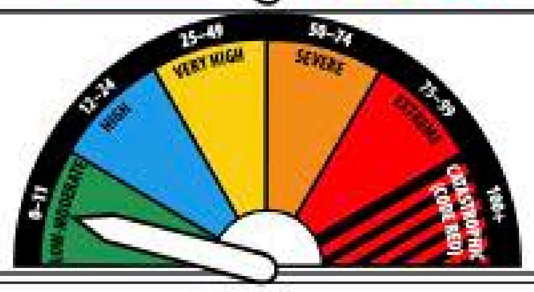
	Botanical name	Common name	Average height & width
*	*Azales, Camelias, Rhododendrons*		
*D	*Acer pseudoplatanus*	Sycamore	15m x 7m
R	*Acmena smithii*	Lilly Pilly	10m x 3.5m
*D	*Aesculus carnea*	Pink Flowered Chestnut	16m x 8m
*D	*Alnus glutinosa*	Common Alder	5m x 6m
*	*Alnus jorullensis*	Evergreen Alder	12m x 5m
	Angophora costata	Rusty Gum Myrtle	14m x 8m
	Brachychiton populneus	Kurrajong	11m x 5m
	Buckinghamia celsissima	Ivory Curl Flower	10m x 7m
*	*Calodendron capense*	Cape Chestnut	13m x 8m
	Casuarina cunninghamiana	River She-Oak	18m x 7m
*	*Celtis australis*	Hack Berry	16m x 7 m
*	*Ceratonia siliqua*	Carob	12m x 8m
	Ceratopetalum apetalum	Coachwood	19m x Sm
*R	*Cornus capitata*	Evergreen Dogwood	6m x 4m
R	*Elaeocarpus reticulatus*	Blue Oliveberry	6m x 2.5m
	Eucalyptus gummifera	Bloodwood	20m x 9m
	Eucalyptus maculata	Spotted Gum	22m x 9m
	Eucryphia moorei	Leatherwood	10m x 7m
*D	*Fraxinus species*	Ash Trees	10–15m x 7–9m
*R	*Gordonia axillaris*	Cordonia	6m x 4m
*R	*Griselina littoralis*	N.Z. Broadleaf	5m x 3m
	Lagunaria patersonii	Pyramid Tree	11m x 5m
*D	*Lagerstroemia indica*	Crepe Myrtle	6m x 5m
*R	*Laurus nobilis*	Laurel (Sweet Bay)	10m x 5m
R	*Ligustrum lucidum*	Privet	7m x S m
	Liriodendron tulipifera	Tulip Tree	25m x10m
R	*Metrosideros excelsa*	N.Z. Xmas Tree	10m x 4m
	Nothofagus cunninghamii	Myrtle Beech	15m x 5m
	Oreocallis wickhamii (syn. Embothrium w.)	Tree Waratah	15m x 6m
*	*Olea europaea*	Olive	10m x 9m
R	*Photinia serrulata*	Chinese Hawthorn	8m x 7m
R	*Pittosporum eugenioides*	Tarata	6m x 3.5m
*D	*Platanus acerifolia*	London Plane Tree	16m x 10m
*D	*Populus simenii*	Simons Poplar	10m x 4m
*R	*Prunus laurocerasus*	Cherry Laurel	6m x 4m
*R	*Prunus Lusitanica*	Portugal Laurel	5m x 4m
	Quercus canariensis	Algerian Oak	15m x 10m
*D	*Quercus cerris*	Turkey Oak	20m x 11m
*	*Quercus suber*	Cork Oak	11m x 9m
*	*Quercus virginiana*	Live Oak	10m x 8m
*D	*Salix alba sspp. vitellina*	Golden Willow	10 m x 7m
*	*Schinus molle*	Peppercorn Tree	7 m x 6m
	Stenocarpus sinuatus	Firewheel Tree	14m x 6m
R	*Syzygium coolminianum*	Lilly Pilly	10m x 4m
	Syzygium floribundum	Weeping Lilly Pilly	18m x 6m
*D	*Tilla vulgaris*	Linden	12m x 5m
	Tristania conferta	Brisbane Brush Box	10m x 6m
R	*Tristania laurina*	Kanooka	6m x 3m
*D	*Ulmus glabra*	Scotch Elm	12m x 6m
*	*Ulmus parvifolia*	Chinese Elm	9m x 8m
*D	*Ulmus pumila*	Siberian Elm	11m x 5m
*	*Zelkova carpinifolia*	European Zelkova	15m x 7m

***** = Introduced Species, **D** = Deciduous Species, **R** = Suitable for Radiant Shields

CLIMATE•1 GEOGRAPHY•2 WATER•3 ACCESS•4 FORESTRY•5 BUILDING•6 FENCING•7 SOILS•8 ECONOMY•9 ENERGY•10 INDEX

WATER•3 – APPENDIX 3.12 (see 3.56)
Fire Danger, Behaviour, Impacts and Actions to Take

Based on: Australian Rural Fire Service (NSW/ACT) &/or Country Fire Authority (VIC) System.
SOURCE: http://cdn.esa.act.gov.au/wp-content/uploads/fire-danger-ratings.pdf

Fire Danger Rating		F. D. Index	Fire Behaviour	Impact Potential	What Should I Do?	
CATASTROPHIC		↑ 100	• If a fire starts, some fires will be uncontrollable, unpredictable & very fast moving with highly aggressive flames extending high above tree tops and buildings. • A thick river of embers will attack homes violently causing other fires to start rapidly & spread quickly up to **20km** ahead of the main fire.	• Fire will threaten suddenly, without warning & be incredibly hot & windy making it difficult to see, hear or breathe. • Lives will be lost, people injured & homes & business destroyed or damaged. • Even well-prepared & constructed homes will not be safe. • Expect power, water & phone networks to fail as severe winds bring down trees, power lines & blow roofs off buildings well ahead of the fire.	• Ensure that survival is the primary consideration in any decision. • The safest option is for you & your family to leave early, hours or days before a fire occurs. • Under no circumstances will it be safe to Stay & Defend. • Ensure you stay well informed of current fire activity by monitoring local media & regularly checking for updates on appropriate websites or by calling authorities.	CATASTROPHIC
EXTREME		99 ↑ 75	• If a fire starts, fires will be uncontrollable, unpredictable & fast moving with flames in the tree tops & higher than roof tops. • Thousands of embers will be blown into & around homes causing other fires to start & spread quickly up to **6km** ahead of the main fire.	• Fire will threaten suddenly, without warning & be very hot & windy making it difficult to see, hear & breathe. • Lives may be lost & people injured & expect homes & business to be destroyed or damaged. • Only very well prepared, constructed & actively defended homes are likely to offer any degree of safety. • Power, water & phone networks are likely to fail because severe winds will bring down trees, power lines & blow roofs off buildings well ahead of the fire.	• Ensure that survival is the primary consideration in any decision. • Leaving early (hours before) will always be the safest option for you & your family. • Implement your Bush Fire Survival Plan. • If your Bush Fire Survival Plan includes the decision to Stay & Defend, only do so if your home is well prepared, well constructed & you are currently capable of actively defending it. • Stay well informed of current fire activity by monitoring local media & regularly checking for updates on appropriate websites or by calling authorities.	EXTREME
SEVERE		74 ↑ 50	• Fires will be difficult to control, unpredictable & fast moving with flames that may reach the tops of the trees & be higher than roof tops. • Expect embers to be blown into and around homes causing other fires to start and spread up to **4km** ahead of the main fire.	• Fire can threaten suddenly, without warning & be hot & windy which will make it difficult to see, hear & breathe. • There is a chance lives may be lost, people injured & some homes & business will be destroyed or damaged. • Well-prepared, constructed & actively defended homes are likely to offer safety during a fire. • Power, water & phone networks may fail as winds may bring down trees, power lines & blow roofs off buildings ahead of the fire.	• Ensure that survival is the primary consideration in any decision. • Leaving early (hours before) is the safest option for you & your family. • Follow your Bush Fire Survival Plan. • Staying & defending is an option if your home is well prepared, well constructed & you can actively defend it. • Stay informed of current fire activity by monitoring local media & regularly checking for updates on appropriate websites or by calling authorities.	SEVERE
VERY HIGH		49 ↑ 25	• Fires can be difficult to control quickly and may be fast moving. • Embers may be blown into and around homes causing other fires to occur up to **2km** ahead of the main fire.	• Fire can threaten suddenly, without warning & it may be hot & windy and at times difficult to see, hear & breathe. • Loss of life & homes is unlikely. • Well-prepared & constructed homes that are actively defended can offer safety during a fire. • Power, water & phone networks may fail.	• Ensure that survival is the primary consideration in any decision. • Leaving early (hours before) is the safest option for you & your family. • Activate your Bush Fire Survival Plan. • Stay informed of current fire activity by monitoring local media & regularly checking for updates on appropriate websites or by calling authorities.	VERY HIGH
HIGH		24 ↑ 12	• Fires can be controlled but can still present a threat. • Embers may be blown ahead of the fire and into and around homes causing other fires to occur close to the main fire.	• A fire may threaten suddenly & without warning. • Loss of life & homes is highly unlikely & well prepared homes that are actively defended can offer safety during a fire.	• Ensure your family & home is well prepared for the risk of bush fire. • Review & practice your Bush Fire Survival Plan. • Monitor local media for fire activity & regularly check appropriate websites or by calling authorities.	HIGH
LOW-MOD.		11 ↑ 0	• Fires can be easily controlled and are slow moving with low flame heights.	• Little or no risk to life or homes	• Ensure you have a current Bush Fire Survival Plan. • Ensure your family, home & property is well prepared for the risk of bush fire. Refer to appropriate websites or by calling authorities.	LOW-MOD.

ANDREW JEEVES, ILLUSTRATOR AND PRODUCER of this book, as a volunteer fire fighter, experienced fires over the summer of 2019/2020, Australia's worst fire season on record: 18.6 million ha burnt (42.3 million acres), 5,900 buildings destroyed, more than 1 billion animals killed, 34 human lives lost.

To put that into perspective, 18.6 million ha equals 26.1 million football (soccer) fields, which end-to-end, is a distance 194.3 times around the equator and which, if walked at an average pace, would take 62.5 years nonstop without sleep, meals or toilet breaks.

In his village on the far south coast of NSW, which largely escaped the ravages of the "Border Fire"—the fire split to each side of the village but nevertheless burnt about 200,000 ha/508,000 acres—one house on the edge of the village survived direct fire attack which burnt all vegetation in its way (amongst the worst and hottest fires of that summer, as commented by a National Parks' staffer). This house, built by retired academic biologists, was built on 4ha of land where the native, mostly pyrophytic* forest, was intentionally cleared to the minimal extent possible.

The building survived with only PVC downpipes melted, a plastic septic tank burnt and the 100KL roof-collection rain tank damaged by a fallen tree. The insurance assessor also decided that the metal roof had been heat-affected and needed replacing.

Site Selection/Context

- The owners chose a site and orientation of the house to both minimise the number of trees needing removal and to maximise passive solar access.
- A total of 37 trees were removed to comply with asset protection zone building requirements, and to reduce the risk of trees and/or large limbs falling onto the house.
- Only 10 trees needed to be removed roots-and-all; they left the rest as stumps. Some timber was milled on-site and was used in landscaping/building projects including the vegetable garden enclosure. The remainder is used for winter heating.

Design fundamentals

- Favour a house that was as inconspicuous as possible.
- House would be no larger than necessary to comfortably accommodate them, reducing the use of materials and therefore the embodied energy involved, and reducing the cost. Smaller house footprint also meant fewer trees had to be removed.
- Design a fire-safe house: the possibility of bushfire is part of living in the Australian bush. Their village is in an extremely high bushfire danger zone, being remote and with extensive pyrophytic* surrounding forests. Building to a high bushfire construction standard reduces the need to remove vegetation around the house.
- In a bushfire, houses generally burn as a result of ember attack. A simple house shape minimises the risk of embers lodging against the building. Building approval was sought and obtained at BAL-40 level for bushfire attack. The construction method used exceeded the BAL-40 level. At the time of building, construction standards for the highest defined attack level, BL-FZ (flame zone) had not been defined.[18]
- Design an energy-efficient home—they desired to live as sustainably as possible—

incorporating features such as good insulation, high levels of thermal mass, flow-through ventilation and both good solar access in winter and shading in summer.

House Layout

- An open plan living area with ample views in all directions including a large kitchen.
- A simple outside deck with removable shading in summer.
- A study area which would feel part of, and yet distinct from, the main living area.
- Two bedrooms.
- A small bathroom, but with a reasonably spacious shower (no bath) and a toilet.
- A spacious laundry which would double as a serviceable entry/mud room.
- An additional toilet readily accessible from outside the house.

To minimise the energy needed for heating, they created a 3-thermal zone layout. *Zone 1* – The open plan living area heated by slow-combustion wood heater, separated from the rest of the house by an internal door. *Zone 2* – bathroom and bedroom areas are unheated, although often the door to these rooms is opened to allow excess heat from the living area to flow through. *Zone 3* – another door separates the laundry to allow entry while preventing cold outside air from flowing into the rest of the house. In summer, they leave the internal doors open encouraging ventilation.

The wood heater in the living area has a wetback coupled to the solar hot water system which means that the electric booster in the solar water tank is only used for a short period in Autumn, when solar input is low and it is still too warm to use the wood heater.

To make the most of winter sun, the home's long-axis faces the north. Rooms not requiring direct solar access—study, second bedroom, laundry and toilet—are on the south side. The size of the house for one couple and guests is 150m^2 (about 1,600 ft^2).

Sustainable Construction Systems

To achieve their goal of an energy-efficient house providing a safe refuge in a bushfire, they selected the following construction systems/materials:

- External walls using AAC (autoclaved aerated concrete), Hebel® blocks.
- Timber framing only for internal walls.
- Polished concrete slab floor.
- Colorbond® corrugated steel roofing (anti-corrosion coated, baked-on lead-free paint).
- Double-glazed aluminium windows.
- Fire-rated, roll-down shutters on all doors and windows.
- External fire sprinkler system.
- They sought to reduce their environmental impact by designing a long-lasting building with low-energy requirements for living and maintenance. Given their construction system, using recycled building materials was not an option. After a couple of years researching/designing, they contracted a 'sustainability-savvy' draftsman who pulled together all ideas into detailed house plans and oversaw the full development application process. They felt no need to employ an architect.

**Pyrophytic plants are those which have adapted to tolerate fire. Fire acts to favour some species more than others (most Myrtaceae). Some species' seeds are reliant on fire/smoke to germinate. Many have epicormic buds under their bark which are dormant whilst leaves send hormones to the roots, but awaken to form new branches as hormone flow stops, e.g., after fires kill leaves.*

PLEASE ALSO SEE: *https://southernforestlife.net/* for before & after fire photos, and information about the biodiversity and ecology of the Australian bush and its regeneration after fires.

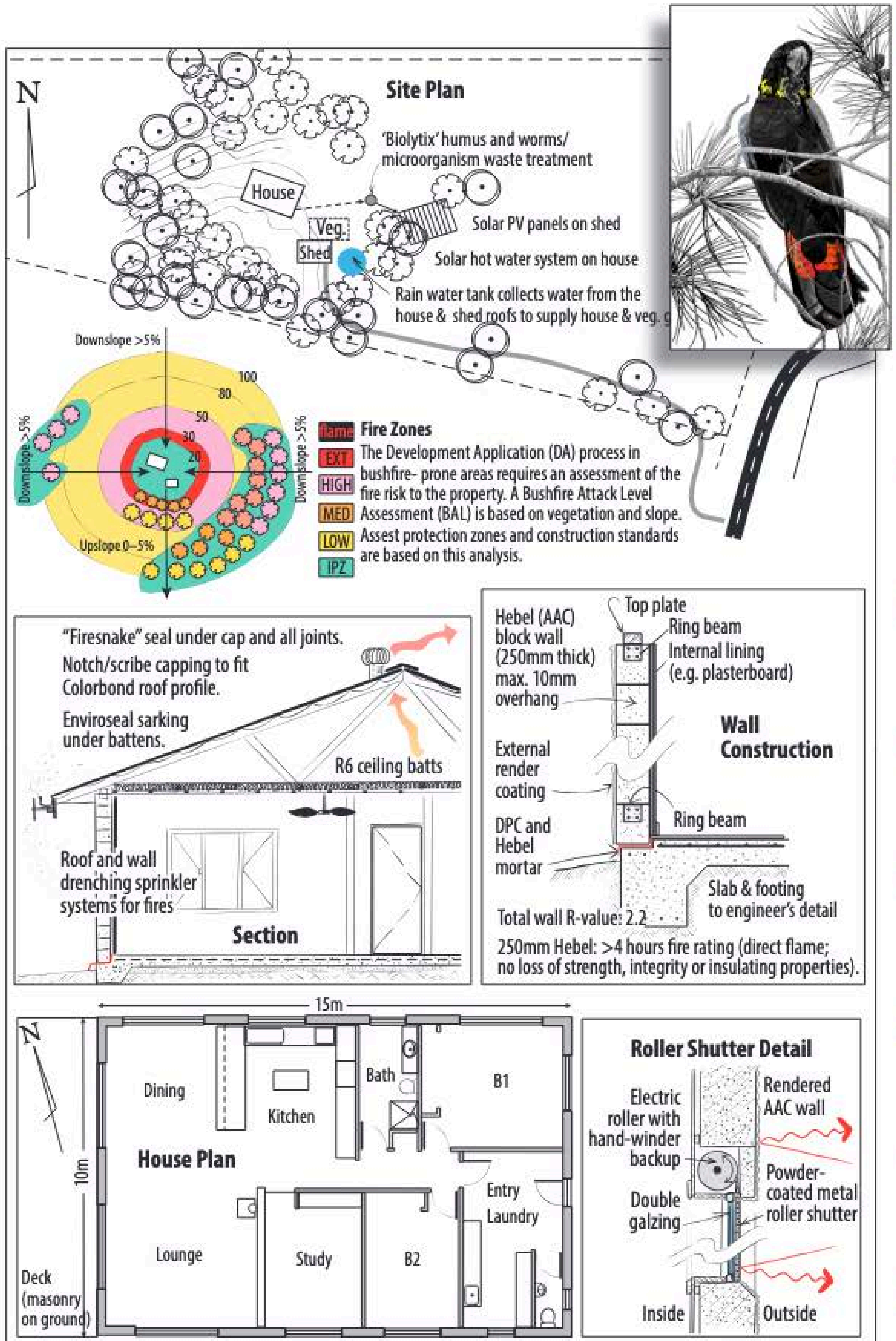


Fig 6.34: Design and construction of an Australian house that survived direct impact by a high-intentsity bushfire in January 2020 with virtually no damage. The owners had evacuated before the fire attack and the house survived despite the purpose-built drenching sprinklers not being deployed.[19]