ABCB

FIRE SERVICES COMMISSIONER VICTORIA

Design and Construction of Community Bushfire Refuges

2014

Handbook

NON-MANDATORY DOCUMENT

DESIGN AND CONSTRUCTION OF COMMUNITY BUSHFIRE REFUGES

INFORMATION HANDBOOK

2014

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Preface

The 2009 Victorian Bushfires Royal Commission (VBRC) investigated the cause and responses to *bushfires* that swept through parts of Victoria in late January and February 2009. The VBRC delivered a first Interim Report in August 2009, a second Interim Report in November 2009 and a Final Report in July 2010.

The Final Report included numerous recommendations, one of which (Recommendation 4) related to the need for a comprehensive approach to the provision of options for shelter from *bushfire*, including the development of technical Handbooks for local community refuges.

The (then) Victorian Building Commission, on behalf of the Victorian government, subsequently requested that the ABCB develop a technical Handbook for the design and construction of *Community Bushfire Refuges* (*refuges*) for potential use by all State and Territory governments. The ABCB agreed to undertake this task and initiated the project by establishing an expert industry-based Reference Group to assist.

In conjunction with the Building Commission's initiative, the Victorian Fire Service Commissioner was contributing to the Victorian Government's response to other components of Recommendation 4 and had established a Bushfire Construction Advisory Panel (BCAP), comprising expert industry practitioners, to assist its task. In particular, the Fire Service Commissioner was collaborating with other government agencies and private enterprise on the implementation of a pilot project to develop three Community Fire Refuges.

In recognition of the common components of the ABCB's task and the Fire Service Commissioner's task, it was agreed that a mutually beneficial outcome would be derived from collaboration between the two organisations. A major benefit of this collaboration was access to the expertise of the BCAP during the development of this co-badged Handbook.

At the time of publishing this Handbook, the Victorian Fire Service Commissioner was preparing documentation specific to the design, operation and management of the three refuges in the pilot program. Upon completion of the program in May 2014 it is intended that a revision of this Handbook will be produced to include relevant information derived from the documentation.

Regardless of the content of this Handbook, it must be acknowledged that it is not possible to guarantee that occupation of a *refuge* built in accordance with the information presented in this Handbook, will eliminate the risk of serious injury or fatality. This general concept is also reflected within the International Fire Engineering

Guidelines[2], in that it acknowledges that fire and its consequential effects on people and property are complex and variable; that a goal of absolute safety is not attainable and there will always be a finite risk of injury, death or property damage.

Therefore; the fundamental priority of community members must be to leave an area well before there is a risk of *bushfire*, either in the area, or along a route to an area not prone to *bushfire attack.*

Care must be taken by responsible authorities to avoid creating a perception within the community that a *refuge* will provide a degree of protection that aligns with it being considered a first resort option. Sheltering in a *refuge* must be accepted by the public as being a last resort option when it is no longer safe to move to an area not prone to *bushfire* risk, but sufficiently safe to reach a *refuge*.

The Handbook has been developed as a performance-based document. Information presented in the Handbook is intended to assist building designers and approval authorities to make informed professional judgments on the most appropriate means of mitigating the risk to life safety during a *bushfire event* by occupation of a *refuge.*

It must be emphasised however, that a *refuge* is not a stand-alone solution to mitigating a risk to life safety. Technical building Handbooks are only one consideration in developing a comprehensive set of measures to counteract the effects of a *bushfire event* that include effective land-use planning, fuel management, community strategic bushfire planning and emergency services strategies.

Based on evidence presented to the VBRC, it is considered that seeking shelter in a *Community Bushfire Refuge*, or *Private Bushfire Shelter*, may be a useful 'Plan B' when efforts to defend a property have failed, or when for some reason it has not been possible to evacuate a property, or find alternative shelter.

Nevertheless, fire can be unpredictable and assistance from fire defence resources may not be available to individual properties. As the VBRC heard, even well prepared community members lost their lives in some instances.

[2] *International Fire Engineering Guidelines, Edition 2005, published by the Australian Building Codes Board, 2005, endorsed by the Australasian Fire Authorities Council, Australian Institute of Building Surveyors and Society of Fire Safety of Engineers Australia.*

Acknowledgements

The ABCB and the Victorian Fire Service Commissioner acknowledge the valuable contributions of members of their respective advisory groups.

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Additionally, the ABCB acknowledges the expert contribution of Stephen Kip in undertaking a peer review of this first edition of the Handbook.

Table of Contents

1 Design Standards

1.1 General

The Building Code of Australia (BCA) comprises Volume One and Two of the National Construction Code Series. The BCA is adopted by all State and Territory governments as a mandatory performance-based code for the design and construction of Class 1 to Class 10 buildings. However, the BCA does not contain specific provisions relating to the design and construction of a *Community Bushfire Refuge (refuge)*.

Class 1 to Class 10 buildings are classified under the BCA in consideration of the use of the building and the potential risk to occupants in the event of fire within the building. The primary strategy for facilitating life safety in the event of a building fire is to evacuate occupants to a safe place, with the loss of the building being a societally acceptable outcome.

Conversely, the primary objective of a *refuge* is to provide temporary shelter to members of the community who have not been able to defend their property or evacuate the local area prior to the passage of a *bushfire* and consequently find themselves displaced. While a *refuge* may provide temporary shelter for a limited number of community members, temporary shelter may also be provided by a *Private Bushfire Shelter* constructed for private use by individuals.

It is possible that a *refuge* is developed as a secondary use of a building. In such circumstances, it will be necessary to supplement the existing life safety measures so that a building can be occupied as a *refuge* during exposure to a *bushfire event*.

Accordingly, this Handbook has been developed to enable informed decision making by professional practitioners undertaking the design of a *refuge*, as well as assisting third party authorities responsible for assessing and approving proposed designs.

Section 2 of the Handbook contains *performance criteria* describing the level of performance required from a *refuge*; i.e. to maintain a *tenable environment* for occupants of the building during the passage of external *untenable conditions* arising from a *bushfire event*.

The Handbook does not include a comprehensive 'Deemed-to-Satisfy' building solution for the design of a *refuge*. Instead; Section 2 provides a Table of

acceptance criteria related to compliance with specific components of the *performance criteria*.

Therefore, in all instances, designers will need to use professional judgment in order to develop designs proposed to comply with the *performance criteria*.

Appendices to this Handbook provide additional information on a range of considerations related to the design, construction and operation of a *refuge*.

1.2 Scope

The Handbook presents a *performance criteria*, relevant a*cceptance criteria* and ancillary information related to the design and construction of a *refuge*.

The *performance criteria* has been developed to apply to two alternative forms of building, being –

(i) adaptation of an existing building to develop a *refuge*, and
(ii) the design and construction of a new *refuge*.

The content of the Handbook may not meet the specific needs of people with a disability, respiratory or cardiovascular illnesses, children or the aged. It is strongly recommended that people within these categories evacuate areas at risk from a *bushfire event* in sufficient time to avoid potential exposure to *bushfire attack.*

The specific needs of individuals, as well as the specific characteristics of individual sites, reinforce the benefits of developing a performance-based Handbook capable of producing a site specific outcome, rather than developing a prescriptive Handbook that would produce a generic outcome.

1.3 The objective and role of the Handbook

The objective of the Handbook is to provide guidance in the design and construction of community bushfire refuges.

The role of the Handbook is to promote informed decision making by professional practitioners undertaking the design of a *refuge*.

The content of the Handbook is based on acknowledged data and input from a broad representation of practitioners and stakeholders. It has been developed to ensure that a *refuge* built in accordance with the Handbook provides a reasonable degree of protection to occupants.

It is critical that a *refuge* is not considered to be a 'stand-alone solution' to potential risks to life safety in a *bushfire event*. Rather, it should be considered to be a life safety measure that is a last resort component of a 'Bushfire Risk Management Strategy'. If the option of sheltering in a refuge is included in a strategy, it is strongly recommended that people familiarise themselves with the potential risks of planning to occupy a *refuge* during a *bushfire event*, as well as the risks and the time involved in travelling from their property to a *refuge*.

To provide a perspective on the role of *refuges*, as well as an understanding of where these structures may fit within a broader 'Bushfire Risk Management Strategy', use has been made of the National Fire Protection Association (NFPA) Fire Safety Concepts Tree[3].The concepts tree can also be used to analyse the potential impact of *refuges* and to identify parameters that are critical in order for a *refuge* to fulfil its function in the provision of community life safety.

Further information on the NFPA Fire Safety Concepts Tree is provided in Appendix E.

1.4 Risk Mitigation

The 2009 Victorian Bushfires Royal Commission (VBRC) Interim Report 2 identified a critical need for property owners and occupiers to be made aware of the risks involved in deciding to stay and defend their property and potentially their lives, when exposed to *bushfire attack.*

It was strongly recommended that occupants of properties located in *designated bushfire prone areas* have bushfire safety plans developed and make themselves aware of the significant risks involved in planning to occupy a *refuge*.

Risk associated with *bushfire events* can be measured in terms of multiplication of the 'likelihood' of an event and the 'consequences' of an event.

No event can have a zero level of risk. Expenditure on life safety systems can reduce the risk, however, the community and individuals can only afford to reduce risk to an acceptable level. This concept is referred to as ALARP, or "as low as reasonably practicable", where risks are reduced to a level where they are generally acceptable.

[3] *NFPA 550 Guide to the Fire Safety Concepts Tree 2007 edition National Fire Protection Association. USA 2007*

1.4.1 Individual risk

As mentioned previously, it is not possible to guarantee that the availability of a *refuge* built according to this document will result in zero risk to occupants. This is because of the uncertainty, variability and indeterminacy of exposure to *bushfire.* In the context of life safety strategies, seeking protection in a *refuge* is a form of risk mitigation.

However, residual risks may still be high, particularly in regard to risks related to safe travel from a fire affected property to a *refuge*, risks related to occupation of a *refuge* and the risk of 'bushfire safe' accommodation being available after the passage of a *bushfire*.

This Handbook presents a design methodology broadly based on a risk management approach to fire safety engineering. The complexity and depth of design methodologies vary and an appropriate method should be selected for the task. Many methods have been developed in the nuclear industry and have been successfully applied to the industrial process, petrochemical, rail industries as well as for fire safety.

The risk management methodology presented in AS/NZS ISO 31000 (2009) is generally regarded as a leading edge approach.

Further detail on industry acceptable risk assessment methods should be obtained and the following additional guidance specific to *refuges* may also be considered.

1.4.2 Societal risk

Societal risk refers to the probability of an event with multiple fatalities. In general, it is graphically represented by an FN-curve that shows exceedance probabilities of the potential number of fatalities on double log scale (Jonkman et al, 2011).

It relates to the estimation of the chances of more than one individual being harmed simultaneously by an incident. In relation to *refuges*, the concept may be applied to estimating the risk of failure of an occupied *refuge*.

An individual risk criterion alone cannot prevent the too frequent occurrence of multi-fatality events. When individual exposures are low, there could still be a chance that a single event causes a large number of fatalities. It is therefore considered that both the individual and societal risks need to be evaluated.

1.5 Application of the Handbook

The Handbook is a non-mandatory document presented, in essence, in a performance-based format. The *performance criteria* presented in clause 2.3 enables the design of a *refuge* to be developed from first principles to maximise its potential to meet community needs on a specific site, providing better outcomes.

1.6 Design pathways

The Handbook provides two pathways for the development of designs complying with the *performance criteria*. One pathway involves the application of fire engineering practice from first principles and requires designers to apply professional judgment on all design matters.

An alternative pathway involves the application of fire engineering practice in combination with appropriate operational and exposure design procedures that demonstrate compliance with *acceptance criteria* described in clause 2.4.

1.7 Acceptance Criteria

Acceptance criteria are presented in Section 2.4 Table 1 for specific components of the *performance criteria.*

Acceptance criteria in the Table are not purported to address all of the 'heads of consideration' listed in the *performance criteria*. Therefore; any design consideration not addressed in the Table must be addressed from first principles.

1.8 Definition of terms

Defined terms used within the text of the Handbook are printed in italics.

Definitions of terms used in the Handbook may be different to similar terms used in AS3959 (2009) or in the BCA.

For the purposes of the Handbook the following definitions apply –

1.8.1 Acceptance Criteria:

Criteria that are considered acceptable to meet respective components of the performance criteria.

1.8.2 Appropriate authority

Has the same meaning as that in the BCA.

1.8.3 Bushfire:

An unplanned fire burning in vegetation.

1.8.4 Bushfire attack:

Includes burning embers, radiant heat, convective heat, flame, wind and smoke generated by a *bushfire,* which might result in ignition and subsequent damage or destruction of a building.

1.8.5 Bushfire attack level (BAL):

Has the same meaning as that within AS3959 (2009).

1.8.6 Bushfire intensity:

The rate of release of calorific energy in watts from a *bushfire* determined either theoretically or empirically, as applicable.

1.8.7 Bushfire event:

The period of *bushfire attack*, plus the period of *consequential fire events*, during which a *refuge* is required to provide shelter to the public.

1.8.8 Community Bushfire Refuge:

A building designed and constructed in accordance with this Handbook that may, as a last resort, provide shelter from immediate life threatening effects of a *bushfire event*.

1.8.9 Combustible:

Has the same meaning as that in the BCA.

1.8.10 Consequential fire event:

A fire in an adjacent building or structure, or fire from any significant fuel load, consequential to *bushfire attack*.

1.8.11 Designated bushfire prone area:

Has the same meaning as that in the BCA.

1.8.12 Fire-resistance level (FRL):

Has the same meaning as that in the BCA.

1.8.13 Non-combustible:

Has the same meaning as that in the BCA.

1.8.14 Performance Criteria:

The *performance criteria* presented in Section 2.3, which states the level of performance that a proposed *refuge* must achieve.

1.8.15 Private Bushfire Shelter:

Has the same meaning as that within the BCA.

1.8.16 Tenable environment:

The environment within a *refuge* required to sustain human life during the passage of *untenable conditions* arising from a *bushfire event.*

1.8.17 Untenable conditions:

Ambient external environmental conditions associated with a *bushfire event* in which human life is not sustainable.

1.9 Limitations

(I) At the time of publication of this Handbook it was not practicable to provide acceptable design solutions that have been tested and found to achieve compliance with the *performance criteria.*

(II) As described previously, the Victorian Fire Service Commissioner intends to prepare technical documentation specific to the design, operation and management of refuges developed under a Victorian Government pilot program. Upon completion of the Fire Service Commissioner's documentation, it is intended that a revision of this Handbook will be produced to include additional information, as appropriate, resulting from the pilot program.

(III)The Handbook is not intended to –

- override or replace any legal rights, responsibilities or requirements; or
- address administrative requirements for a *refuge*.

1.10 Appendices

Appendices A – E provide explanatory information relating to the design, construction, operation and maintenance of *refuges*.

2 Design Requirements

2.1 Objective

The objective of the Handbook is to facilitate temporary shelter for people who could not safely defend their property or evacuate the local area prior to the passage of a *bushfire event* and have no safer place to shelter.

2.2 Functional Statement

A structure designed for emergency occupation during a *bushfire event* must provide shelter to occupants from the direct and indirect actions of a *bushfire*.

2.3 Performance Criteria

A *community bushfire refuge* must be designed and constructed to provide a *tenable environment* for occupants during the passage of *untenable conditions* arising from a *bushfire event*, appropriate to the –

(a) location of the *refuge* relative to fire hazards including-
  (I) predominant vegetation; and
  (II) adjacent buildings, structures and movable objects; and
  (III) car parking area/s and allotment boundaries; and
  (IV) other *combustible* materials;

(b) number of occupants to be accommodated within the *refuge*, and

(c) duration of occupancy, and

(d) *bushfire intensity* having regard to the *bushfire attack level;* and

(e) intensity of potential consequential fires, and

(f) safe access within the site to the *refuge,* (including carpark areas), as well as occupant egress after the *bushfire event*; and

(g) occupant tenability within the *refuge* for the duration of occupancy before, during and after the *bushfire event*; and

(h) generation of smoke, heat and toxic gases from materials used to construct the *refuge*; and

(i) combined effects of structural and fire loads and actions to which the *refuge* may reasonably be subjected; and

(j) necessary degree of occupant awareness of external conditions; and

(k) provision of fire-fighting equipment and water supply to facilitate protection of the *refuge*; and

(l) necessary degree of communications and signage; and

(m) necessary degree of sanitary and other facilities required for all occupants; and

(n) necessary degree of essential maintenance.

2.4 Acceptance Criteria

Acceptance criteria for nominated components of *refuges* designed to comply with *performance criteria* in 2.3 are presented in Table 1.

Acceptance criteria in the Table may not address all of the 'heads of consideration' listed in the *performance criteria*.

Therefore; any design consideration not addressed in the Table must be addressed from first principles.

Table 1 - Acceptance Criteria

DESIGN CONSIDERATION	ACCEPTANCE CRITERIA	COMMENT
LOCATION OF THE REFUGE		
Separation distance between a *refuge* and primary vegetation	Sufficient distance to avoid exposure to a radiant heat flux exceeding 10kW/m^2 from a combination of sources; OR Exposed construction of a *refuge* to have a minimum FRL of 60/60/60 and any openings suitably protected.	Separation reduces potential fire spread between primary vegetation and a *refuge*. 10 kW/m^2 will enable fire-fighters wearing protective clothing to approach a *refuge* for a short period of time.
Separation distance between a *refuge* and adjacent buildings and structures	10m minimum to an adjacent building or substantial structure; OR Exposed construction of a *refuge* to have an FRL of 60/60/60 and any openings suitably protected; OR Sufficient distance to avoid exposure to a radiant heat flux exceeding 10kW/m^2 from a combination of sources.	Adjacent structures include sheds, carports etc. Separation or provision of fire-resisting construction reduces potential fire spread between adjacent buildings and a *refuge.*

Separation distance between a *refuge* and car parking areas and allotment boundaries	10 m minimum; OR Exposed construction of a *refuge* to have an FRL of 60/60/60 and with any openings suitably protected; OR Sufficient distance to avoid exposure to a radiant heat flux exceeding 10kW/m^2 from a combination of sources.	Separation or provision of fire-resisting construction reduces potential fire spread between adjacent buildings and a *refuge.*
Separation distance to other significant *combustible* materials	Sufficient distance to avoid exposure to a radiant heat flux exceeding 10kW/m^2 from a combination of sources.	Potential fuel sources include vehicles, fences, gas storage bottles, liquid fuel or similar.
Separation from adjacent minor hazards	1.5m wide on-ground *non-combustible* pathway around the perimeter of the *refuge.*	A *non-combustible* barrier/apron will reduce the potential for fire spread from external ground level sources.
BUSHFIRE INTENSITY		
Radiant heat flux on exposed building elements. (Also see criteria for access pathways below)	Maximum 10kW/m^2 from a combination of sources.	Sufficient radiant heat flux will cause ignition of *combustible* materials and break materials such as glass.
ACCESS TO THE COMMUNITY BUSHFIRE REFUGE		
Main access doorways to be automatic opening when the building is operating as a *refuge*	See clause B.3	Community members should be able to access a *refuge* without delay when the building is operating as a *refuge.*
MAIN ACCESS PATHWAYS		
Surface of pathways leading from carpark areas and adjacent buildings	Surfaces must be *non-combustible*.	Access pathways should be readily identifiable and have a relatively even surface.
Unobstructed width of pathways leading from carpark areas and adjacent buildings	Minimum clear width of 1 m.	Vegetation adjacent to a pathway should not become a hazard to travel. Vegetation management procedures should be applied.
Pathways used to hold people unable to be safely accommodated	Exposure to a maximum radiant heat flux of 1 kW/m^2.	Pathways should only be used to accommodate excess people.

within a *refuge*		Human exposure to excessive radiant heat flux can result in severe burning of skin. People may require face-masks to reduce inhalation of excessive quantities of smoke.
PROVISION OF TENABLE CONDITIONS		
Duration of occupancy	Minimum 60 minutes.	The minimum period of occupation for which a *tenable environment* should be maintained. It is assumed that occupants will not close main access doors until exposure to *untenable conditions* is imminent. A *refuge* may be occupied for longer periods, either pre-*bushfire attack* or post-*bushfire attack*, in an open state i.e. with doors or windows open.
Floor area	Minimum 0.75 m^2 per person.	Minimum 'floor area' criterion addresses the relationship between the occupancy period and the number of occupants in the *refuge.*
Volume	Minimum 1.2 m^3 per person.	Minimum 'volume' criterion is intended to provide sufficient air for a maximum duration of 60 minutes. Design durations greater than 60 minutes will require a specific assessment of air supply.
Interior air temperature OR Interior mean Modified discomfort index (MDI) for 60 minutes	Maximum 45°C (Patterson et al. 2010). Maximum mean 39°C (Patterson et al. 2010).	A *tenable environment* within a *refuge* can be detrimentally affected by increased air temperature and relative humidity (refer to A.7.4). Internal temperatures ≤ 35^0C are preferable.

Interior surfaces temperature	Maximum 60°C for readily accessible surfaces.	Interior surface temperatures can be estimated by exposure to design fire conditions. Typical surfaces are those which an occupant of a *refuge* would be able to touch. Guarding or insulating of materials may be required. Interior surface temperatures will influence interior air temperatures.
Interior air toxicity	Construction materials forming part of a *refuge* that are likely to give off gas when exposed to temperatures exceeding 100°C must be tested to BS 6853 (1999) Appendix B2. Gases must be limited to - (a) carbon monoxide 30 ppm; (b) hydrogen chloride 1.0 ppm; (c) hydrogen bromide 0.5 ppm; (d) hydrogen fluoride 0.5 ppm; (e) hydrogen cyanide 1.0 ppm; (f) nitrogen dioxide 0.5 ppm; and (g) sulphur dioxide 2.5 ppm.	Materials used for construction of a *refuge* should not unduly influence the *tenable environment* within a *refuge* during occupation.
Ventilation	Natural ventilation must be provided by openings such as doors or other devices that, when open, have an aggregate open area of not less than 5% of the floor area of the *refuge*; OR A mechanical air-handling system must be provided to maintain adequate air quality.	*Refuge*s may require ventilation to ensure a *tenable environment* is provided. Ventilation may be used to supplement air supply and quality when external conditions are suitable. If a system serving the primary use of a *refuge* requires external air intake, it will be necessary to shut this system down when the *refuge* is sealed so that the potential for embers to enter the internal space is minimised.

EXTERNAL ENVELOPE		
Structural design	The structural design of a *refuge* must be in accordance with Volume One of the BCA. All loads and actions to which a *refuge* may reasonably be subjected must be considered, as necessary, for a building having an Importance Level not less than 3 as per BCA Volume One Table B1.2a.	The building is to be designed with regard to - (a) topography of the site; (b) dead loads; (c) live loads; (d) impact loads (e.g. collapsing trees); and (e) wind loads.
SIGNAGE		
External signage	(a) A permanent sign made from durable materials must be fixed adjacent to the main access roadway on the allotment on which a *refuge* is located. (b) The sign shall be headed "COMMUNITY BUSHFIRE REFUGE" in red letters on a white background in letters at least 100 mm high. (c) The sign must include the following information in red letters at least 25 mm high; i. the distance to the *refuge* on the allotment; and ii. the general direction in which the *refuge* is located (using words or a directional arrow).	Some examples may be found in the Victorian Fire Service Commissioner's 'Community Fire Refuges' manual. A copy may be downloaded at the Fire Services Commissioner Victoria website (www.firecommissioner.vic.gov.au)

Internal signage	(a) A permanent sign made from durable materials must be fixed inside a *refuge* adjacent to the main access door. (b) The sign shall be headed "COMMUNITY BUSHFIRE REFUGE" in red letters at least 25 mm high on a white background. (c) The sign must include the following information in letters at least 20mm high - (d) the designed number of occupants; (e) the designed duration of occupation; (f) advice that increasing the designed number of occupants will decrease the maximum duration of occupation.	Some examples may be found in the Victorian Fire Service Commissioner's 'Community Fire Refuges' manual. A copy may be downloaded at the Fire Services Commissioner Victoria website (www.firecommissioner.vic.gov.au)
CAPACITY TO ASSESS EXTERNAL CONDITIONS		
Viewing opening or window	See clause A.10	Prior to leaving a *refuge* occupants will need to visually assess external conditions and a viewing opening, or window would be an appropriate mechanism.
FIRE FIGHTING EQUIPMENT		
Hose reels	Coverage of the perimeter of the *refuge* for a distance of 10m perpendicular to the perimeter.	The provision of hose reels will allow occupants to extinguish embers, pre-event and consequential fires presenting a hazard to the *refuge.*
Water supply for hose reels	A *non-combustible* water tank connected to a pump with sufficient back-up power to supply water to hose reels. Water tank capacity to be determined by the *appropriate authority*.	

SANITARY FACILITIES		
Sanitary facilities to be provided for occupants	Compliance with National Construction Code; OR Supplementation of existing facilities with portable facilities for a *refuge* developed from an existing building.	The scope of sanitary facilities to be provided will relate to the designed number of occupants. Portable facilities may include sealable buckets.
EMERGENCY POWER SUPPLY		
Diesel powered generator Diesel fuel storage	Generator capacity to be determined by the *appropriate authority*. Diesel fuel storage capacity and location to be determined by the *appropriate authority*.	An emergency power supply is essential to provide power for lighting, mechanical ventilation, air-conditioning (if provided) and certain fire-fighting equipment. Diesel generator performance must be sufficient to enable the concurrent operation of emergency equipment for the designed duration of occupation of a *refuge*.
MAINTENANCE		
Maintenance of fire safety and other essential design components	A *refuge* must be maintained in accordance with the regulations applicable in the State or territory in which it is located.	*Refuge*s should be capable of performing as required at all times. See clause A.14

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Appendix A Design considerations

A.1 Location of a community bushfire refuge relative to fire hazards

The location of a *refuge* will influence the outcome of a number of design and construction requirements.

The proximity of a *refuge* relative to potential hazards such as predominant vegetation, adjacent buildings and structures, allotment boundaries; moveable objects such as vehicles, rubbish bins and other *combustible* materials, should be assessed in order to determine the imposed fire exposure of the *refuge*, or elements of construction that comprise the *refuge.* As an example, pine treated with copper, chromium and arsenic (CCA) is commonly used for landscaping and retaining walls can be easily ignited and emits toxic gases during the combustion process. Therefore, any treated pine material within 2 metres of a *refuge* should be replaced with a hardwood, or encased with a *non-combustible* material.

Notwithstanding the above, it is prudent for *refuges* to be located to provide an appropriate measure of separation from potential fuel sources, including vegetation. In general, a *refuge* should not be located within 10m of a significant fire source such as another building on the same allotment or an allotment boundary, unless exposed building elements are appropriately protected. The minimum separation distance between the *refuge* and a fire hazard to which it is exposed is the distance at which the radiant heat received at the *refuge* exceeds 10kW/m^2 using an appropriate Forest Fire Danger Index (FFDI) for the site and a temperature of 1200K, unless advised otherwise by the *appropriate authority*.

In certain cases it is likely that exposure to a heat source such as a burning building on an adjoining allotment may be more of a risk than exposure to vegetation on the same allotment or a passing fire front.

In the event of *bushfire attack*, adjacent buildings or structures, vehicles, rubbish bins and other *combustible* materials, should be considered as potential radiant heat and flame sources, regardless of whether they may be concurrent or isolated exposure hazards.

A.2 Number of occupants

A.2.1 General considerations

The potential occupancy of a *refuge* is a vital consideration in the design process. As the building may be several years old before it is required to be occupied in an emergency event, the designed occupancy and the required occupancy on the day of an emergency event may differ, e.g. due to population growth in the local community.

Therefore, it is essential that during the building design process the likely consequences of excessive occupancy on the performance of a *refuge* are identified and understood. In doing so, the operators of the *refuge* will become aware of specific design criteria that can adversely impact the performance of the *refuge.*

When determining the required capacity of a *refuge* , it should be noted that people who may generally feel vulnerable during a life-threatening situation may become significantly stressed while occupying a potentially confining enclosure, e.g. the very young or the elderly, people with disabilities, or people with cardiovascular or respiratory illnesses*. To avoid complications, potentially vulnerable people should be encouraged to evacuate the local area or make alternative arrangements for protection before the onset of a *bushfire event*.

Factors to be considered when determining the design occupancy of a *refuge* include –

(a) the maximum number of occupants that a specific *refuge* can safely accommodate;

(b) the potential number of occupants that may seek shelter;

(c) the potential for excess numbers to be protected if they remained outside the *refuge*;

(d) the characteristics of likely occupants (if community advice has been taken, children and elderly people, people with a disability, people with cardiovascular or respiratory illnesses* should not be occupants);

(e) the likely composition of occupants, e.g. local community members, tourists or people not familiar with the English language;

(f) whether the safety of human occupants could be compromised by accommodating family pets or farm animals; and

(g) whether the *refuge* is to be used for other than emergency occupation, e.g. used for post-event recovery activities, which would further limit occupant numbers.

*Note: When exposed to a Modified Discomfort Index of 39°, particularly if entering a *refuge* when hot or tired, potential occupants should consider not just the thermal consequences, but also the possible impact upon cardiovascular health. These conditions will significantly increase cardiovascular strain, possibly leading to heat exhaustion in some individuals and perhaps even precipitating serious and life-threatening cardiovascular complications.

A.3 Duration of occupancy

A prediction of the expected duration of occupation of a *refuge* may be derived from analysis of the likely bushfire front and *bushfire attack* periods, derived from the FFDI and local topography for the site.

The design duration of occupancy should at least cover the predicted period of *untenable conditions* and can be influenced by –

(a) the numbers of occupants;
(b) the predicted duration of exposure to *bushfire attack* mechanisms and products of combustion;
(c) adjacent consequential fires; and
(d) the capacity of available resources and equipment to maintain tenable conditions.

The design duration of occupancy should be considered in relation to at least the following exposures –

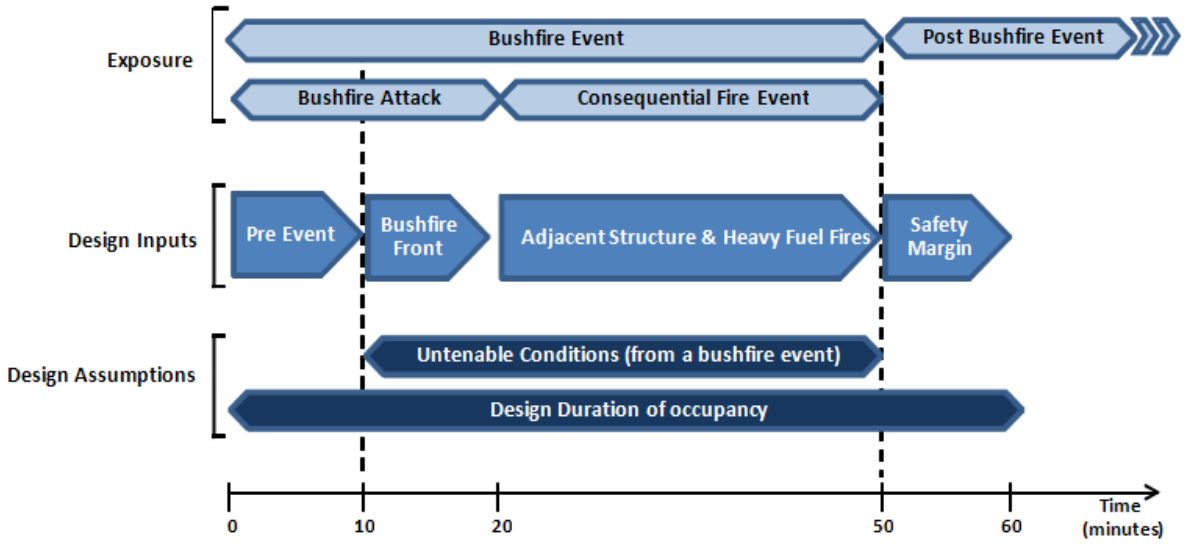
(a) **Bushfire Attack** – the period during direct *bushfire attack*; and
(b) **Consequential Fires** – a period including exposure to other fire hazards such as adjacent structures and other heavy fuel fires.

Design durations of occupancy for a typical *bushfire event* are –

(a) **Pre-event** – 10 minutes.
(b) **Fire Front** – 10 minutes.
(c) **Consequential Fires** - 30 minutes.
(d) **Safety margin** - 10 minutes.
(e) **Total** - 60 minutes.

The phases and design durations are represented in Figure 1.

Figure 1 - Design durations of occupancy for a typical bushfire event



A *refuge* should provide a *tenable environment* for occupants during the period in which openings in the building envelope (windows, vents and doors) are required to be in their closed positions. It is anticipated that in practice, the actual occupancy period may be longer than the duration of the 'closed' state; i.e. if the building is air-conditioned and maintains appropriate internal temperatures in the pre-event phase or during either the pre-*bushfire event* or post-*bushfire event* periods when *untenable conditions* may not be present in the vicinity of the *refuge*. Occupants should be made aware that a *refuge* designed to be most effective in a 'closed' state, may be occupied in an 'open' state with doors or vents in the open position when external conditions are suitable. Signage and procedures manuals advising of these varying modes of operation should be provided within a *refuge*.

The design duration of the 'closed' state occupation for the designed number of occupants, should be clearly identified on signage provided within a *refuge*. This sign should clearly convey a message to occupants that the building has a limited capacity and that overcrowding may place other occupants in danger.

In *refuges* where a designed occupancy is for a limited time, a means for occupants to measure the designed duration should be provided e.g. a reliable clock.

A.4 Bushfire intensity

A.4.1 General

There are several products of a *bushfire* that may become catalysts for serious injury or death to humans and/or damage or destruction of property, including flames, radiant heat, embers, smoke and air pressure/wind.

Each of these products is capable of spreading fire, either in isolation or in combination, given a suitable environment and a source of fuel.

The period of a *bushfire* will generally involve a number of stages commencing with the ignition of fuel. If there is no form of intervention, a fire will generally develop and spread until the supply of fuel is depleted.

A *bushfire* will 'travel' and the speed and distance it will travel can depend on factors such as the availability of fuel, the topography of bushland, the direction of wind etc. As the 'front' of the *bushfire* moves forward, heat from the flaming fuel preheats un-burnt fuel ahead of the fire front, which facilitates the rapid ignition of the fuel and the rapid spread of fire. Additionally, during a *bushfire* windblown sparks and embers can create spot fires well in advance of the main fire front.

Some sites can be exposed to multiple fire fronts and increased impact from secondary fires. The likelihood of such outcomes occurring should be considered when designing a *refuge* to resist the overall *bushfire attack* and associated *bushfire intensity*.

It is important to consider the expected intensity of a *bushfire* and to predict the impact of radiant heat flux on exposed materials in order to provide an appropriate level of protection to occupants of a *refuge.*

A.5 Bushfire-resistance level

A.5.1 General

A *refuge* should be designed to protect occupants from the following exposures that may occur during a *bushfire event*, depending upon the proximity to the bushfire front, other potential fire sources and the prevailing conditions.

(a) direct flame contact;

(b) radiant heat;

(c) burning debris;

(d) embers;

(e) smoke;

(f) wind; and

(g) windborne debris.

The level of protection should be such that a *tenable environment* is maintained in the *refuge* for the required period of occupation.

In order to verify the performance of a *refuge* design, it is necessary to nominate design actions and *acceptance criteria.* These are discussed in more detail below.

A.5.2 Design Exposure Conditions

The structure is expected to provide internal tenable conditions before, during and after the passage of a *bushfire* by withstanding wind, flying debris, ember attack, radiation exposure and flame contact from localised sources (direct flame contact from a flame front is omitted via site selection). This is achieved by specifying the upper bounds of each of these criteria -

(a) flame contact: caused by localised sources and accumulation of combustible debris, not flame front interaction that is negated by site selection. This can be simulated by using ISO or ASTM cribs, or alternative flame sources, in an evidence based testing approach;

(b) radiation: thermal heat field of an estimated level using *bushfire attack level* (BAL) assessment process with appropriate inputs plus the potentially concurrent contribution from surrounding combustible elements and buildings;

(c) burning debris: elements capable of being lofted or projected from surrounding locations given the above wind conditions including aerodynamic debris from surrounding structures;

(d) ember attack: combustible or combusting material both fine and course entering gaps and or accumulating and causing localised ignitions; and

(e) wind: averaging ‘x’ and gusting to ‘x’, or as a % over and above the local 200 year exceedance level, plus an acceptable safety margin to account for fire induced winds if the 2000 year exceedance level, whichever is greater.

A.6 Safe access and egress

Unobstructed and safe access to a *refuge* should be provided and maintained over the life of the building.

Reference to the NFPA fire safety concepts tree (Appendix E) shows that in addition to providing a safe destination it is necessary to "provide movement means" and "cause movement of exposed".

Primary access roads to a *refuge* should provide a safe route of travel during a *bushfire event.* In particular, primary roads should be subjected to assessment of potentially dangerous trees and structures and a vegetation management program undertaken prior to each *bushfire* danger period, so that the risk of exposure to excessive radiant heat flux from fallen trees or fire from other structures is minimised.

Hazardous amounts of *combustible* material should not be located within 18m of an entry to the *refuge* when the *refuge* is open for emergency occupation.

A.6.1 Access to a community fire refuge

A safe means of access to a *refuge* should be provided for occupants. Pathways should have dimensions and characteristics, such as surfaces and slope, suitable for a person with an ambulant disability to safely use a *refuge*. Ensuring vegetation and other *combustible* materials are kept clear of the access path to the *refuge* is critical.

As local electricity supply systems are highly likely to be disabled at the time of emergency occupation, consideration should be given to the need to access the *refuge* when visibility could be poor, such as at night or if the *refuge* is engulfed by thick smoke. Potential occupants should be encouraged to bring a torch to facilitate safe movement.

The timing of entry to a *refuge* is critical to the safety of occupants. The doors of the *refuge* need not be closed if the external environment is not threatening. Closing the door too early may compromise the *refuge*'s ability to provide sufficient air quality for the duration of external *untenable conditions*. However; a *refuge* should be occupied in sufficient time to ensure entry doors can be closed as soon as *untenable conditions* become evident in the proximity of the building.

It is possible that some occupants arriving at a *refuge* when a fire front is imminent may be exposed to spot fires and other hazards such as burning

vehicles in the carpark of the *refuge*. Exposure to even low levels of radiant heat (>2.5kW/m^2) can cause significant burning on humans, which could become problematic as it is likely that a significantly injured person could not be adequately treated for a substantial period of time.

Thick smoke causing poor visibility will limit a person's ability to leave a vehicle and may also prevent emergency services personnel from assisting.

Potential access to the *refuge* site for emergency service vehicles during a *bushfire event* should also be assessed. Evidence given to the VBRC advised that fire-fighters were unable to gain vehicular access to a particular property because trees had fallen across the entrance road. Therefore, if a vegetation management plan cannot be suitably implemented, an alternative means of vehicular access/egress should be identified for the site.

A.6.2 Egress from a refuge

During and after a *bushfire event* the influence of various forces and actions may result in effective egress from an occupied *refuge* being compromised.

Before deciding whether it is safe to leave a *refuge,* the condition of the surrounding environment needs to be assessed and potential hazards identified. Large trees may continue to burn for a substantial time after a *bushfire event*, particularly if they have hollow trunks. Consequently, the *refuge* site may be susceptible to falling branches or trees for some time.

When occupants leave a *refuge* they should remain aware of changes to environmental conditions. As an example, a change in wind direction could change the direction of the movement of a *fire front*. Evidence to the VBRC identified that a change in wind direction after the fire front had passed placed a family that had chosen to defend their home in repeated danger and subsequently resulted in the destruction of their property.

After the fire front has passed, departing occupants may be exposed to hazardous conditions and should be protected by suitable clothing. Clothing including gloves should be able to withstand likely temperatures of exposed surfaces, especially metal surfaces.

Calculations based on the Society of Fire Protection Engineers (SFPE) Engineering Guide, ‘Predicting 1st and 2nd Degree Skin Burns from Thermal Radiation’, indicate that occupants without any significant protection from clothing would experience pain after approximately 18 seconds of exposure to a

radiant heat flux of 4 kW/m^2, e.g. a level of radiant heat similar to that generated by a large domestic space heater.

Burning buildings and vehicles may contain potentially explosive items such as gas cylinders. Fuel tanks, either bulk storage or in vehicles and burning rubbish bins can also be a significant unpredictable explosion risk. Seemingly insignificant items including children's play equipment and outdoor furniture can present sources of potentially toxic smoke following *bushfire* exposure.

Vegetation should be cleared to the extent that if a *spot fire* occurs there should be sufficient separation to allow exiting occupants to either re-enter or safely access or egress the *refuge*.

A.7 Tenable environment within a refuge

A.7.1 General considerations

In order to provide a *tenable environment* for a specific number of occupants within a *refuge*, there is a need to consider a number of contributing factors, including –

(a) location factors such as adjacent hazards and topography (refer to A.1);
(b) predicted duration of occupation (refer to A.3);
(c) floor area/volume of the *refuge* based on occupant numbers (refer to A.2)
(d) sealing a building's external envelope (refer to A.7.2);
(e) air supply (refer to A.7.3);
(f) air temperature and humidity (refer to A.7.4); and
(g) the psychological temperament of occupants (refer to A.7.5).

A.7.2 Sealing of refuges

The provision of a *tenable environment* within a *refuge* exposed to *bushfire* will be influenced by the degree to which the external envelope of the building is sealed. Ambient air pressure will rise during a *bushfire* as ambient air temperature rises. External air pressure would be expected to be greater than the pressure inside a *refuge*.

Therefore, it is likely that external smoke and other products of *bushfire,* such as embers, will enter a *refuge* unless there is an adequate degree of sealing around typical openings such as doorways, glazed panels and possible service penetrations.

Alternatively, the establishment of higher internal air pressure than external air pressure will force air out through openings in the building and minimise smoke entry.

Generally, all openings and penetrations through the envelope of a *refuge* should be sealed in an appropriate manner. However; consideration should be given to methods of providing airflow through a *refuge* during occupation in non-critical periods. In such cases, openable vents fitted with wire mesh screens or similar devices that restrict the ingress of embers and windblown debris may be appropriate. Special consideration should be given to the sealing of doors (refer to A.8.5.4).

Sealing the envelope of a *refuge* will mitigate the effects of potential smoke infiltration; however sealing may also introduce a range of issues including –

(a) limited air supply while seals remain in place;

(b) oxygen depletion;

(c) carbon dioxide build-up (potentially more significant than oxygen depletion);

(d) elevation of internal temperatures from external heat sources;

(e) elevation of internal temperatures from human occupation, and

(f) elevation of internal humidity reducing the effectiveness of personal cooling through perspiration.

Literature dismisses the possibility of suffocation inside an unsealed *refuge* due to oxygen deficiency, on the basis that humans can survive at atmospheric oxygen concentrations below the flammability limit. This is supported by research that demonstrates flaming combustion ceases at atmospheric oxygen concentrations less than 11% (Butler & Putnam 2001).

The proposed method of sealing the envelope should be carefully considered. Door and vent seals will need to withstand anticipated exposure temperatures during a *bushfire event.* Common sealants used in passive fire protection (e.g. intumescent materials) can give off toxic or noxious gases when exposed to high temperatures and some may change their composition, adhere to material surfaces and prevent doors from being readily opened.

A.7.3 Air supply

The pressure differential across an element of construction would be expected to be dominated by wind effects and there is potential for a positive pressure

between the outside and inside of the *refuge,* potentially permitting toxic gases to flow through any small openings.

Therefore, there is potential for external smoke to enter the *refuge* unless there is an adequate seal around typical openings such as doorways. Designs of entrances comprising a short corridor with doors at either end (i.e. an air lock) may be particularly effective where the first door can be opened readily and the second door can be fitted with smoke seals. A system that exhausts air in the small corridor may minimise smoke entry via the second door.

The potential toxicity of smoke from burning materials in the vicinity of the *refuge* should also be considered. (See also A.6.1) Typical *combustible* materials near a *refuge* could include –

(a) other buildings;
(b) vehicles and farm equipment;
(c) associated sheds and outbuildings and their contents (paints and fuels);
(d) garden mulch;
(e) water tanks (plastics);
(f) vegetation;
(g) treated timber and fences;
(h) plastics;
(i) playground equipment; and
(j) rubbish bins.

A sealed *refuge* should have sufficient air supply to provide a *tenable environment* for the required period of occupation. In the design process it is critical to specify the scope of potential inclusions in a *refuge* because additional inclusions to those addressed at the design stage can reduce the volume of air available to occupants during occupation.

High carbon dioxide levels (hypercapnia) can be potentially fatal and are generally caused by exposure to environments containing abnormally high concentrations of carbon dioxide, which can occur by re-breathing exhaled carbon dioxide in an enclosed space. Carbon dioxide scrubbing systems, which include filters to remove harmful gases and toxins from within a *refuge* (e.g. pre-filled absorber chemical cartridges) may be useful.

A.7.4 Tenable thermal conditions

Thermal tenability (comfort) of the occupants of the *refuge* is essential to avoid a life risk situation within the *refuge.* To avoid this, the occupants should be provided with the means of thermally cooling themselves at all times during the *bushfire event*. This can be achieved by maintaining the ambient conditions below certain combinations of temperature and relative humidity (by maintaining an ambient wet bulb temperature well below the normal core body temperature of the occupants).

This can be estimated by using thermal models or algorithms that take into account -

(a) all heat sources within and exterior to the refuge;

(b) the insulating and thermal mass characteristics of the refuge;

(c) the capability of any active and passive climate control systems to manage the thermal loads experienced before, during and after the fire event;

(d) for the active and or passive climate control system to operate in the absence of an external power source; and

(e) the reliability of the climate control system.

A.7.5 Psychological considerations

An occupant's ability to act and make optimal choices during a *bushfire event* will be influenced by their mental preparation, the availability of information for decision making, their perception of a real threat and their considered response.

In this context, an occupant may experience heightened anxiety due to their involvement in a *bushfire event* and their potential confinement within a *refuge*, which may influence body temperature and oxygen consumption. Therefore, it is essential that occupants become familiar with the operation of a *refuge* and the likely duration of confinement, particularly occupants with claustrophobic or associated tendencies.

A.8 Materials and construction

A.8.1 General

In many areas of *refuge* design, the potential impact of specific hazards can be reduced by the use of appropriate construction systems. As an example, a flooring system comprising a concrete slab on ground, as opposed to a

suspended floor system, is a common means of reducing risks of ignition from ember build-up in concealed, or difficult to access, spaces.

The considered use of risk reduction construction methods can significantly enhance the overall performance of a *refuge.*

A.8.2 Durability

While *bushfires* in the natural environment are common occurrences in Australia, recurrent exposure of individual sites is not as common. It may potentially be many years before a *community fire refuge* is required in a *bushfire event*. Accordingly, the durability of the structure, materials and active systems should be considered as part of the initial design and as on-going and long term maintenance.

A.8.3 Selection of materials

Walls, roof and floor systems (if raised) need to be constructed using appropriate *non-combustible* and fire rated elements for the expected radiant heat flux against the building. The systems need to be insulating and/or have sufficient high thermal mass to prevent excessive internal surface temperatures.

For structures where local flame sources are possible, the exposed section of the external wall also needs to attain a full *bushfire* rating consistent with the duration of exposure to the source. (Note: this is not sufficient for considering main fire front interactions).

A.8.4 Construction gaps

During the construction of a *refuge* it is critical that no significant gaps occur, or develop, between elements of construction, so that:

(a) the building does not exceed the maximum allowable air exchange rate allowing excessive smoke entry;

(b) embers are not able to pass through gaps and reach combustible elements within the refuge; and

(c) localised flame sources, including accumulated combustible debris, are not able to impinge on gaps of any size.

Any gaps that do occur should be filled with a fire-resistant material. Floor systems that are raised, walls, and roofs, should be constructed from *non-combustible* material.

A.8.5 Doors

A.8.5.1 Location of door/hatch openings

To reduce the potential for egress to be compromised, alternative means of exiting a *refuge* is preferable in *refuges* on sites with substantial vegetation. Where multiple means of access and egress and are provided, these should not be located within close proximity of each other.

A door opening in the external envelope of a *refuge* will present a 'weak spot' in the capacity of the building to resist the impact of external sources of heat and smoke. In a sealed *refuge,* the door is also a likely failure point for smoke seals. Therefore, wherever practicable, doors should be located so that they are not exposed to major sources of radiant heat, such as vegetation, adjoining buildings on the same allotment or an allotment boundary in close proximity to the *refuge.*

Consideration should be given to the provision of two doorways separated by an air- lock or similar. In such a layout, the exposed door would be used as a means of protecting the inner non-exposed ‘smoke sealed’ door. The design of the door/hatch should also consider the internal face temperature of the door during exposure.

A.8.5.2 Type of doors

External doors for air-lock application should be *non-combustible* and be flat face closing so that thermal exposure cannot cause the door to jam in place. The door and closed face needs to maintain function following exposure to radiation from a *bushfire event.*

Internal doors for air-lock application can be of conventional design; although these should have a tight fitting smoke seal that assists the building in meeting air tightness requirements.

A.8.5.3 Direction of swing and latching

The direction of door swing should be the most appropriate to facilitate safe access and egress for occupants in consideration of factors that may restrict occupants ability/capacity to readily open the door when required. Such factors include –

(a) an outward swinging door may be blocked by debris;

(b) an inward swinging door may be blocked by occupants or contents;

(c) an inward opening door may be more difficult to seal against strong wind effects; and

(d) a pressure differential or strong wind may restrict closing or opening of a door.

Doors should be able to be unlocked from both inside and outside the *refuge* after exposure to the *bushfire* front or other critical exposure[4.] This will reduce the potential for occupants to become trapped inside and also facilitate external intervention by emergency services personnel. In some instances, it may be necessary to install barriers over a door opening in order to reduce the potential for a doorway to become blocked by falling debris during occupation. However, the preference should be to eliminate the sources of debris from the area.

A.8.5.4 Sealing of door openings

Gaps between the base of an unsealed door and the floor of a *community fire refuge* are likely to perform to a higher standard if fitted with a draught excluder made of *non-combustible* materials.

A.9 Loads and actions

A.9.1 General

The structural design of a *refuge* should be in accordance with Section B of Volume One of the BCA. All loads and actions to which a *refuge* may reasonably be subjected should be considered, as necessary, for a building having an Importance Level of 3 or more as per Table B1.2a of Volume One of the BCA.

The location of the *refuge* and its immediate surrounds will determine the loads that it will be subjected to. Wind loads in particular will be influenced by the surrounding topography and any shielding. Existing site conditions may indicate whether *bushfire attack* from a particular direction is likely to be more severe than from other directions.

Likely future site conditions have the potential to significantly alter the direction and severity of *bushfire attack* and the potential impact of the conditions on the design of the *refuge* also require consideration. The predicted *bushfire intensity*

[4] *Building in Bushfire Prone Areas – Interim Recommendations – Submissions of Counsel Assisting; 2009 Victorian Bushfires Royal Commission, 28 September 2009 - paragraphs 4, 13 and 31.*

and predicted duration of the *bushfire event* can impact on the structural integrity of the *refuge*.

A.9.2 Dead loads

Refer to Section B of Volume One of the BCA.

A.9.3 Live loads

A *refuge* should be designed and constructed to maintain its function as a sealable structure if subjected to the impact of windblown objects. Trees located within 1.5 times the height of the tree (i.e. approximate striking distance with a tail wind) of the *refuge* should be removed, or subject to regular inspection and maintenance by a qualified arborist.

The building should be designed and constructed to maintain its function as a sealable structure when subjected to the high winds that are a feature of extreme *bushfire* weather (both ambient and induced).

A.9.4 Effects of bushfire attack on structural elements

High levels of radiant heat expected during *bushfire attack*, as well as fire in adjacent structures and other properties (in the post bushfire attack period), may reduce the load carrying capability of structural elements. Similarly, damage to a *refuge* caused by other consequences of a *bushfire*, such as collapsing trees or other structures, may compromise the function of the *refuge*, or its adequacy to mitigate other attack mechanisms. This potential reduction in structural capacity needs to be considered in the design of a *refuge*.

A.10 Occupant awareness of the external environment

Glazed windows or similar devices should be provided in the external envelope of a *refuge* to allow occupants to periodically observe the passing of the *bushfire* front and also to visually evaluate the likely tenability of external conditions. This is also important for occupants to be alerted when other people, such as rescuers, are approaching a *refuge.*

A window or similar device used for external awareness will need to simultaneously withstand the heat, wind forces and debris impact during a *bushfire event*. Windows may also be required to withstand the effects of localised flame sources if located near horizontal projections or should be designed so that they do not have large rebates that can trap wind borne debris.

In order to achieve this, either wired glass construction or ‘grade A’ safety glass windows with *non-combustible* external ember protection screens should be provided.

A.11 Fire-fighting equipment

A.11.1 External fire hose reels

An external fire hose reel (FHR) provides the ability for community members to suppress any fires caused by burning embers or small consequential fires. All FHR should be installed in accordance with the BCA and AS2441-2005.

Installed FHR should be able to reach all parts of the *refuge* including the edges of the roof, not be more than 36m in length to prevent a person going too far from the *refuge* and be located within 4 metres of an access door to ensure users can quickly find access into the *refuge*.

A.11.2 Water supply

Independent water supply to a FHR should be supplied from a *non-combustible* tank and fittings and be sufficient to enable the FHR to deliver the minimum demand required from AS2441. Use of a water tank for both fire and domestic purposes is appropriate on the condition the domestic supply outlet is located at a level higher than the amount of water required for fire-fighting purposes.

Currently, the minimum supply to a FHR is 0.33L/s and should be achieved by the two most hydraulically disadvantaged FHR operating simultaneously for a period of time not less than the designed duration of occupation of the *refuge* in its closed state.

A.11.3 Fire pump

A fire pump should comply with relevant Australian Standards, and be protected from direct sun light, wind, embers and potential consequential fires. Fire pumps are typically protected by an ember resistant enclosure.

A diesel or electric pump is suitable provided there is sufficient back-up power in the form of a back-up diesel generator.

A.12 Communications and signage

A.12.1 Verbal communication systems

A suitable form of verbal emergency communication may provide assistance to occupants of a *refuge*. The application and performance of available systems may vary depending on site specific conditions or the accessibility of local communication networks.

A.12.2 Radio, telephone communication systems

A suitable means of communication with the local Incident Control Centre (ICC) allows for information between the agencies and the occupants of the *refuge* is considered essential. Other suitable methods of communication that should be considered include battery operated AM/FM radio, ADSL to allow persons taking *refuge* to use their own devices, i.e. android, dedicated land line to ICC, 000.

Examples of communications systems used during the Victorian pilot program are contained within the 'Community Fire Refuge' operational procedures manual, which can be downloaded from the Fire Services Commissioner's website.

A.12.3 Signage to identify the location of a refuge

Signs should be strategically located on roads and site specific vehicle entry points to enable community members and emergency services personnel or other rescuers to readily identify a *refuge* site*.* The sign at the entry of the *refuge* should contain basic information about the *refuge* and be clearly visible. See Table 1 in clause 2.4 for details.

A.12.4 Signage within a community bushfire refuge

A sign should be located within a *refuge* to advise occupants of the designed capacity of the *refuge* with regard to the number of occupants and the maximum period of occupation in its closed state, i.e. with the entrance door and other openings closed and sealed.

Signs should also be provided that convey information relating to the safe use of the *refuge* and the operation of any critical equipment, including fire-fighting equipment, and air conditioning equipment, standby generator, etc. See Table 1 for details.

Examples of signing used in the Victorian pilot program are contained within the 'Community Fire Refuge' operational procedures manual, which can be downloaded from the Fire Services Commissioner's website.

A.13 Sanitary facilities

The scope and number of sanitary facilities provided for the primary use of the building serving as a *refuge* should comply with the BCA. Additional sanitary facilities may be required to accommodate the potential number of occupants of the building during its use as a *community bushfire refuge*. See Table 1 for details.

A.14 Essential maintenance

A.14.1 General

Like all other buildings a *refuge* will require regular maintenance if it is to act as an effective form of public shelter when required, which may be several years after its construction or upgrade.

A property specific *bushfire* safety management and maintenance plan should address the maintenance of all *bushfire* protection measures prior to the start of the bushfire season, including maintenance of a *refuge*.

The general objective of maintenance provisions is to ensure that safety measures in buildings, which perform satisfactorily at the time of initial construction and occupation of a building, continue to perform to at least the same standard throughout the life of the building.

In essence, there are a number of fundamental issues that should be included within a comprehensive maintenance regime for *refuges*, including those contained in A.7.2 to A.7.4.

A.14.2 Maintenance Audits

Every *refuge* should be audited prior to each fire season to ensure it remains fit for purpose. This process may require that a new *refuge* be constructed in a way that readily allows access to certain parts of the building, including essential fire safety measures to determine its fitness for service, e.g. the use of solid wall load bearing construction compared to cavity construction.

For existing buildings, access holes may need to be provided to allow for inspections to determine suitability of key elements of building construction,

essential safety measures and/or allow for building works or maintenance to be undertaken to achieve required building standards.

A.14.3 Management of the physical environment

It is critical that the condition of the physical environmental on which the design of a *refuge* has been based is not changed in a manner that could compromise the capacity of a *refuge* to perform as required for the life of the structure.

Factors such as vegetation and topography in the immediate area of the building, or subsequent construction adjacent to a *refuge*, or access pathways should all be managed to ensure this outcome. Where possible, implementation of a hazard reduction strategy that includes removal of existing hazards may enhance the performance of a *refuge* in a *bushfire event.*

A.14.4 Periodic trial occupations

Likely occupants of a *refuge* should be encouraged to participate in periodic trial occupations to ensure –

(a) they become familiar with any pre-occupation activities they may be required to undertake; and

(b) the *refuge* is capable of performing its intended function in the event of a *bushfire* related emergency.

A.14.5 Maintenance of active systems

Active fire safety systems, such as mechanical ventilation systems, hose reels or external façade water spray systems, would be expected to require significant ongoing maintenance in order to ensure that they perform effectively in the event of an emergency.

A.14.6 State and Territory legislative requirements

Specific information relating to the maintenance of *refuges* should be sought from the relevant State or Territory agency. Information on individual jurisdictions requirements is provided in Appendix E.

Appendix B Operation of a community bushfire refuge

B.1 General

In Victoria, a pilot program for development of 'Community Fire Refuges' has been implemented by the Victorian Government. A component of the program was the production of a suite of operational procedures to facilitate a consistent state-wide approach to the operation of a *refuge* during a *bushfire* related emergency.

A key principle incorporated within the operating procedures is that a *refuge* should be able to operate effectively without intervention by, or assistance from, emergency services personnel.

B.2 Operation Procedures Manual

To achieve maximum benefits from a *refuge* and minimise the risk of compromising the integrity of the building, an operational procedures manual should be developed. The manual should provide information on the location and operation of all fire-fighting equipment and installed safety systems and other key operational requirements.

The Victorian Fire Service Commissioner has developed a template for an operation procedures manual that can be used by the community to develop a manual that is specific to individual *refuges*. A copy can be downloaded from the Fire Service Commissioner's website.

B.3 Systems approach to opening a refuge

It is important to ensure a *refuge* can be easily and quickly opened by persons seeking to shelter during a *bushfire event* without the owner being present. A systems approach developed by the Victorian Fire Service Commissioner, which is connected into the fire services community warning and advice system, allows for a *refuge* to be automatically opened when there is a fire in the landscape and a 'Watch and Act' or 'Emergency Warning' is issued by the Incident Controller. This system also allows for remote opening by pushing a button at the front door of the *refuge* and asking the emergency services operator to open the door. This approach will enable occupation of a *refuge* without compromising the security of the building when it is operating as its primary use. Details of this entry system are contained within the Fire Service Commissioner's operational procedures manual.

B.4 Key safe

Other suitable opening systems could include having a key safe located at the front door of the *refuge* or other similar devices; this however has limitations as it will rely on a person who knows the location of the key or combination attending the *refuge* or being contactable.

B.5 Safety equipment including first aid

Consideration should be given to meeting the essential needs of occupants during and immediately after a *bushfire event*. The following items may be of considerable value -

(a) an AM/FM radio may provide a means of receiving news of the bushfire situation;

(b) a mobile phone may provide a means of contacting emergency services;

(c) a First Aid Kit may enable treatment of minor cuts and burns as well as possible heat stress;

(d) a torch can provide short periods of light both inside the shelter and also externally at night and during poor visibility;

(e) stored potable water may be critical if a reticulated water supply fails. Water can also be used to wet towels and blankets to provide protection from heat; and

(f) P2 face masks that filter particulate material from intake air will be valuable if smoke enters the *refuge*.

For safety equipment to be of benefit during a *bushfire event* it is essential that it be appropriately maintained so it can be effectively used at any time.

Appendix C Ancillary information

C.1 Additional State or Territory requirements

State or Territory agencies may have a range of requirements for the approval, construction, use and maintenance of a *refuge*.

C.1.1 Australian Capital Territory

In the ACT, construction of bushfire refuges is regulated primarily under the Building Act 2004, and the Planning and Development Act 2007. Those Acts are ACT laws, but they also apply in Jervis Bay Territory as well as in the ACT. Other ACT laws and Commonwealth laws might also apply in addition to, or instead of, ACT laws in certain circumstances.

Under the Building Act 2004, certain building work, including bushfire refuge construction, alteration or demolition, should only be done in accordance with the statutory approval process set out in that Act, which includes requirements for compliance with the Building Code of Australia. Under that Act it is unlawful to occupy or use certain buildings, including certain bushfire refuges, unless a relevant certificate permitting that occupancy or use has been issued under that Act, for the bushfire refuge.

Under the Planning and Development Act 2007, certain development of land, including bushfire refuge construction, alteration or demolition, should only be done in accordance with the development approval process set out in that Act. The process covers design, siting, land use, lease, heritage, free protection, urban planning, environmental impact, neighbourhood impact and other matters.

Note, however, that both the Building Act and the Planning and Development Act also have provisions that exempt certain prescribed buildings or developments from the application of the above, and if such exemptions apply to a particular bushfire refuge the relevant requirements mentioned above might not apply in that case.

ACT laws are available at: www.legislation.act.gov.au. Further advice on building in the ACT is available from www.actpla.act.gov.au. The above information is subject to change.

C.1.2 New South Wales

C.1.2.1 An overview

The Environmental Planning and Assessment (EP&A) Act 1979 and the EP&A Regulation 2000 reference the Building Code of Australia (BCA) as the technical standard for the design and construction of new buildings and new building work. The application of the BCA is to work that requires a development application (DA), or a complying development certificate (CDC). Under the State Environmental Planning Policy (Exempt and Complying Development Codes) 2008 (the 'Codes SEPP'), work that is categorised as exempt development must also comply with the BCA.

The version of the BCA that is applicable to any building work is the one in force at the time the construction certificate (CC) or CDC is applied for. (See EP&A Regulation 2000 clauses 136A and 145).

C.1.2.2 Development on bushfire prone land

Before granting consent for development on bushfire prone land (other than certain subdivisions), under section 79BA of the EP&A Act a consent authority must –

- be satisfied that the development conforms with relevant specifications and requirements of Planning For Bushfire Protection, produced by the NSW Rural Fire Service (RFS); or
- be provided with a certificate issued by a person who is recognised by the RFS as a qualified consultant in bushfire risk assessment stating that the development conforms to the relevant specifications and requirements; or
- if the development does not conform to the relevant specifications and requirements, consult with the Commissioner of the RFS, concerning measures to be taken with respect to the development to protect from the dangers of bushfire.

In addition, a bushfire safety authority issued under Section 100B of the Rural Fires Act 1997 must be obtained for subdivision of bushfire prone land that could lawfully be used for residential or rural residential purposes, or development of bushfire prone land for a special fire protection purpose.

The construction or installation of a community bushfire refuge on bushfire prone land must comply with the relevant processes described above and any other requirements under the applicable environmental planning instrument.

As Planning for Bushfire Protection does not specially address community bushfire refuges, the assessment of such developments requires consultation with the Commissioner of the RFS.

Approval for the construction of a community bushfire refuge requires a DA and CC.

C.1.2.3 Community Bushfire Refuges not on bushfire prone land

Where a community bushfire refuge is proposed on land that is not bushfire prone land, councils should before granting consent for the development, consult with the Commissioner of the RFS.

The text of NSW legislation is available at the NSW Legislation website (www.legislation.nsw.gov.au).

C.1.3 Northern Territory

Please contact the appropriate Territory government agency.

C.1.4 Queensland

There are no state-specific building requirements for community bushfire refuges in Queensland. Building work associated with a community bushfire refuge will need to meet the building assessment provisions under the Building Act 1975, including the National Construction Code.

C.1.5 South Australia

South Australia has no legislation that specifically regulates the use of a community bushfire refuge.

A community bushfire refuge is building work, and hence development under the Development Act 1993 requiring a development approval.

All development work is assessable for both planning and building consents unless it is excluded by either Schedule 3 or 4 of the Development Regulations 2008. There are no exclusions for a community bushfire refuge.

Applications for Building Rules Consent are assessed against the relevant requirements of the Building Rules including any referenced codes, standards or Minister's Specifications. Where a building is outside the scope of a building

surveyor's expertise they will seek certification by an independent person who is recognised as a technical expert in the particular area.

C.1.6 Tasmania

The design and construction of Community Bushfire Refuges will require planning and building permits under the Land Use and Planning Approval Act 1993 and the Building Act 2000 respectively.

C.1.7 Victoria

The Victorian Government introduced the Building Amendment (Community fire refuge Construction) Interim Regulations 2011 which, amongst other things, set out a performance requirement for construction of a refuge. These regulations expired on 28 July 2012 and were not re-made; based on the view that these structures should be controlled within Government until appropriate prescriptive technical standards and an approval methodology were established.

There are currently no specific standards or design guidelines for community fire refuges and they are not classifiable structures under the Building Code of Australia (BCA), adopted under the Building Act 1993.

On 1 August 2012, the Minister for Planning issued Ministerial Direction No. 4 (MD4) and the Guide to MD4, for application to construction of refuges by Government and to ensure the relevant performance requirement was used to progress future technical standards.

C.1.8 Western Australia

The building approval process for Western Australia is set out in the Building Act 2011 and its associated Building Regulations 2012. The granting of a building permit is required from the relevant permit authority before undertaking building work, unless an exemption applies. A building permit is generally required for the construction of a community bushfire refuge.

As part of the building approval process a building surveyor registered under the Building Services (Registration) Act 2011 is required to sign a certificate of design compliance confirming that the building complies with the applicable building standards.

Plans and specifications provided to the registered building surveyor should accurately reflect, in sufficient detail for the registered building surveyor assessing the application, how the building intends to comply with the

regulations and standards once constructed. As the particulars for each building or its site may differ, the information required for establishing compliance with the applicable building standards will need to be determined by the building surveyor on a case by case basis.

Appendix D Model design process

An optional model design process is presented below. The model process is offered as a simple checklist of components of a possible design process and may not be sufficiently comprehensive for complex designs.

Step One – Selection of bushfire attack level (BAL)

An assessment of the *bushfire attack level* (BAL) is undertaken generally in accordance with Section 2 of AS 3959 (2009); however a flame temperature of 1200^0K is to be used in lieu of the standard 1090^0K (See Appendix A.1) This assessment will determine the critical factor relating to the design of a *refuge,* i.e. the bushfire intensity.

Step Two – Determine duration of occupation

The duration of occupation is made up of a number of factors –

(a) the pre-*bushfire attack* time when people access the *refuge*; prepare themselves and wait for the *bushfire*;

(b) the duration of the *bushfire attack*; and

(c) the period of *consequential fire event*s from other sources (structures and the like) and when people assess conditions outside and determine an appropriate time to safely leave the *refuge*.

Step Three - Determine requirements for tenability

Having determined the duration of occupation and knowing the design number of occupants, the requirements to maintain tenable conditions can be determined depending on the following –

(a) temperature rise, this will be a combination of –

  I. heat from the fire entering the *refuge* (largely determined by the level of insulation provided by the construction materials);

  II. heat build-up from the occupants themselves; and

(b) air supply – the volume of air required in the *refuge* for the design number of occupants;

(c) smoke – the *refuge* should be sufficiently sealed against the entry of smoke in order to minimise air contamination and maintain reasonable visibility; and

thermal mass of the *refuge*.

Step Four – Determine other design requirements

Depending on the location of the *refuge* it may be necessary to design the *refuge* to resist the following structural actions –

(a) earth pressure;

(b) wind loads for an Annual Probability of Exceedance of 1:2000;

(c) vehicular loads where appropriate, particularly where the building is partly or wholly underground;

(d) impact resistance to falling debris (branches, building elements); and

(e) aerial water bombing.

Step Five – Determine construction materials

Construction materials can now be selected on the basis of performance criteria including –

(a) *fire-resistance level* (FRL);

(b) *non-combustibility*;

(c) resistance to structural loads;

(d) testing to AS 1530.8.1;

(e) testing to AS 1530.8.2; and

(f) low toxicity emission materials.

Step Six – Determine appropriate design details

Once the basic construction has been determined, a number of design details need to be considered –

(a) visibility – e.g. a small view window to allow assessment of external condition;

(b) smoke seals on doors, service penetrations and other such openings;

(c) lighting and communication; and

(d) drainage, particularly where the building is partly or wholly underground.

Appendix E NFPA Fire Safety Concepts Tree

To provide a perspective of the role of *refuges* and to provide an understanding of where they may fit within a broader 'Bushfire Risk Management Strategy', use has been made of the National Fire Protection Association (NFPA) Fire Safety Concepts Tree[5]. The concepts tree can also be used to analyse the potential impact of *refuges* and to identify parameters that are critical in order for a *refuge* to realise its life safety objectives.

The Fire Safety Concepts Tree includes a series of logic gates i.e. "or" and "and" gates.

An "or" gate indicates that any one of the concepts below will cause, or have as an outcome, the concept above it. Therefore, only one concept below the gate would need to be implemented to achieve the desired outcome if the system was 100% reliable. However in practice no systems are 100% reliable and in a robust design a number of concepts below an "or" gate will be implemented to improve the holistic reliability of the strategy.

An "and" gate indicates that all the concepts below are needed to achieve the concept above it. This means that if one of the concepts below the gate is not achieved the concept above would not be met. Therefore, it is critical to maximise the reliability in achieving all the concepts below an "and" gate.

Figure 2 shows the upper part of the Fire Safety Concepts Tree. The dark blue boxes indicate concepts that relate to *refuges*. The objective of *refuges* considered in the Handbook is the life safety of occupants.

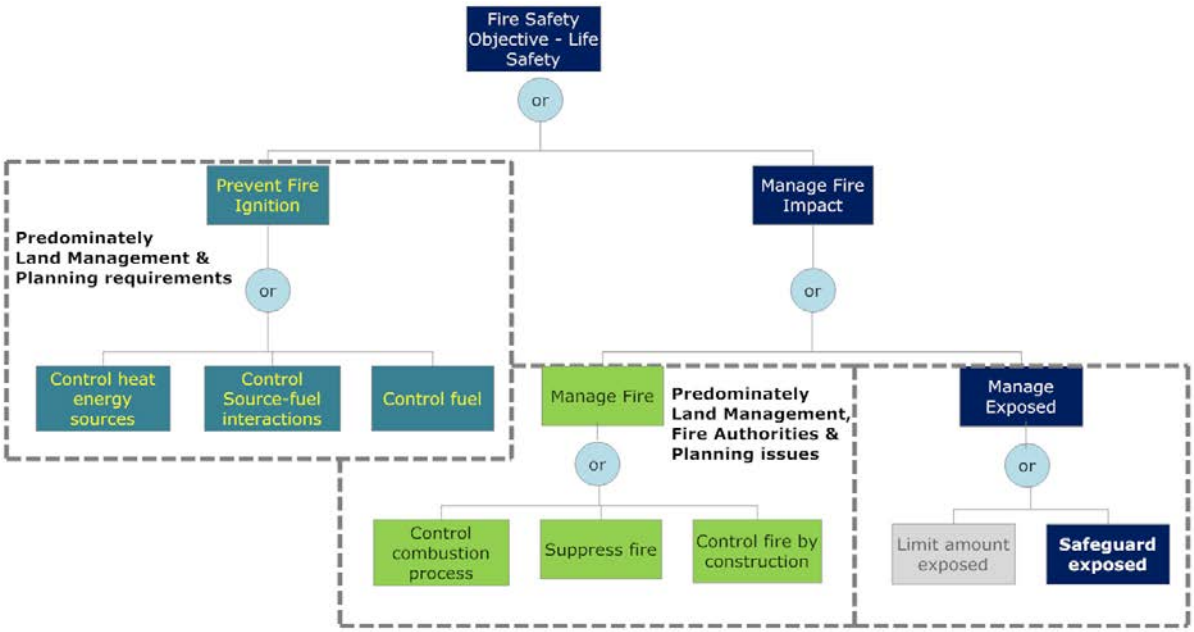
As Figure 2 shows the objective of life safety (primary concept) can be achieved by either preventing ignition or managing the impact of the fire. The concept of preventing ignition relates predominately to land management/planning, education and policing since a significant number of ignitions are caused by some form of human action or involvement. This branch of the fire safety concepts tree has not been expanded further since it does not relate to the design and construction of *refuges*.

[5] NFPA 550 Guide to the Fire Safety Concepts Tree 2007 edition National Fire Protection Association. USA 2007

The impact of a fire can be managed by either 'managing the fire' or 'managing the exposed'. The 'manage fire' branch again relates to land management/planning issues and fire-fighting operations.

The control of fire by construction concept in the context of this branch generally refers to barrier systems within buildings to limit fire spread within a building and therefore has little direct relevance to *bushfires*. The 'manage fire' branch of the Fire Safety Concepts Tree has therefore not been expanded but it should be noted that local management of fire by for example vegetation management on an allotment could and should be a consideration with respect to the potential exposure of a *refuge* and paths of travel to a *refuge.*

Figure 2 Upper Branches of the Fire Safety Concepts Tree



There are two options to satisfy the concept of 'managing the exposed', i.e. 'safeguard the exposed' or 'limit the amount exposed'. Limiting the amount of people exposed relates to planning restrictions (limiting development in high risk areas) and preventing access to high risk areas during a *bushfire* emergency and is not relevant to the construction of *refuges.*

The 'Safeguard Exposed' branch relates directly to *refuges* and has been expanded in Figure 3. Since *refuges* may not be part of a building the 'Move Exposed' branch is the most relevant with the *refuge* intended to satisfy the concept of the provision of a safe destination.

The safe destination requires the same concepts to be considered as a 'defend in place strategy' but in addition it is necessary to satisfy both the “Cause movement of exposed” and “Provide movement means" concepts.

The 'move exposed' branch can also be applied to the concept of a ‘safe place’ and an 'evacuate early' strategy, which are outside the scope of this Handbook.

Figure 3 - Expansion of the Manage Exposed branch of the Fire Safety Concepts