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WYE RIVER & SEPARATION CREEK

BAL Assessment Study

Report

April 2016

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DELWP-2016-1 Wye River & Separation Creek BAL Mapping
Report prepared by Terramatrix for DELWP, 2016.

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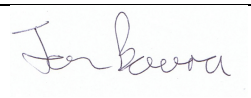
Approval for release	Jon Boura	

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31st March 2016	Report	DELWP
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Executive Summary

Terramatrix were commissioned by DELWP to provide advice about ongoing fuel management and associated Bushfire Attack Levels (BALs) for dwellings in those parts of Wye River and Separation Creek burnt by the 25 December 2015 bushfire. The outcomes of the project will contribute to the development of an integrated planning control (incorporated under Clause 52.03 Specific Sites and Exclusions) for the fire-affected area that will streamline the planning permit process for people wishing to rebuild houses lost in the bushfire.

There are five key tasks:

1. Review previous bushfire studies, with a particular focus on the areas burnt or destroyed by the 25 December bushfire;
2. Undertake a whole of settlement BMO assessment and provide advice on appropriate bushfire mitigation measures including BALS, vegetation management and defendable space;
3. Map vegetation in the Wye River and Separation Creek study area, and classify in accordance with the AS 3959-2009 schema;
4. Provide allotment level BAL mapping for two vegetation management scenarios – "managed" and "status quo"; and
5. Provide advice on additional requirements that could achieve a greater built resilience to bushfire.

The report is structured around the five key tasks, with Key Tasks 2 and 4 presented together in Section .

The entire study area is covered by the Bushfire Management Overlay, the purposes of which include to prioritise protection of life, strengthen community resilience and only permit development if the risk to life and property can be reduced to an acceptable level (Colac Otway Planning Scheme, 2014a). The BMO requires use of a modified site assessment methodology from AS 3959-2009 to determine BAL and defendable space requirements.

Task 1 – Review of Previous Bushfire Studies

The 2013 Colac Otway Bushfire Planning Policy Project was undertaken by Terramatrix and Tract Consultants to assess the bushfire risk at eight nominated settlements to inform the suitability of inland settlements for residential growth and to provide increased clarity in regards to development and bushfire risk mitigation in all the settlements.

The *Colac Otway Bushfire Planning Policy Project Final Report* (Tract Consulting and Terramatrix, 2014) was provided to the Colac Otway Shire in May 2014, and underpinned by a strategic bushfire risk assessment documented in the *Colac Otway Shire Council Bushfire Planning Policy – Bushfire Technical Report* (Terramatrix, 2013).

The assessment of landscape risk, potential bushfire scenarios and impact, and potential mitigation treatments provided in the *Bushfire Technical Report* is considered to still be valid.

The assessment of indicative BALs, to identify areas that may have been suitable for coverage by a Schedule to the BMO is, however, now obsolete. Subsequent to that analysis, Planning Scheme Amendment VC109 altered the design fire for the BMO by lowering the FFDI and flame temperature used in the calculation of flame length and radiant heat flux. Thus the setback distances required for each BAL have been reduced.

In addition, the *Bushfire Technical Report* was intentionally conservative in its treatment of slope and vegetation to ensure that any areas covered by the Schedule would qualify for BAL-29 construction standard or lower as required by a Schedule at that time. An additional classification of Modified vegetation was also introduced by Amendment VC109. Whilst the *Bushfire Technical Report* identified 'partially modified' vegetation within the settlements there was, at that time, no established method of determining BALs in response to it.

Task 3 – Mapping of Vegetation

Four vegetation scenarios were considered in the current study; one of which was the vegetation classification used in the 2013 *Colac Otway Bushfire Planning Policy* project to identify areas potentially suitable for coverage by a BMO Schedule, and the other three were variations of potential vegetation management in the future that would result in lower BAL ratings across the settlements.

The vegetation scenarios mapped were:

- Status quo – the distribution of vegetation as mapped for the 2013 Colac Otway Bushfire Planning Policy project (Terramatrix, 2013), which included a significant number of parcels within the Wye River settlement classified as Forest.
- Managed Vegetation Scenario 1 – all private lots within the settlements will be managed as Modified vegetation, the remaining vegetation (i.e. including drainage lines, reserves, foreshore etc.) will remain classified Forest or Scrub or Low Threat as applicable.
- Managed Vegetation Scenario 2 – all vegetation within the settlements (i.e. including drainage lines, reserves, foreshore etc.) will be managed as Modified vegetation unless already classified as Low Threat.
- Managed Vegetation Scenario 3 - A perimeter Asset Protection Zone is provided in the adjoining private Forest that if managed to BMO defendable space standard would enable the outermost row of houses to be constructed to BAL-40 anywhere on their lots. This scenario complements either of the other managed vegetation scenarios.

The difficulty of maintaining reliably Low Threat vegetation across the settlements was discussed by the Project Reference Group, with the consensus of professional opinion being that given the wet forest canopy, steep slopes and, in part, absentee property owners it would be difficult to maintain vegetation on private lots as Low Threat in perpetuity. Rather, it was considered more realistic to anticipate that residential lots would, in the future, contain a mosaic of managed and unmanaged vegetation that was best classified as Modified under the BMO. It was also considered not to be feasible to manage most of the steep Council reserves.

Clause 52.47 refers to modified vegetation as 'vegetation that is sufficiently varied from the vegetation classification in AS 3959-2009 Construction of buildings in bushfire prone areas' (Colac Otway Planning Scheme, 2014b), however, the extent to which the vegetation must be varied or modified from the form of the classified vegetation is not clearly defined. *Planning Practice Note 65* notes that Modified vegetation can occur where fuel loads are high but the vegetation is modified because of urban development, gardens, the way the vegetation is configured (for example limited or no understorey), or because the fuel loads are different from those assumed by AS 3959-2009, but the vegetation cannot be excluded as it is not low-threat or low-risk (DTPLI, 2014a). A large proportion of the residential lots within the study area (including both developed and undeveloped lots) comprised Modified vegetation prior to the fire, and are likely to again given the difficulty of effective and on-going vegetation management on steep, erodible slopes.

Managed Vegetation Scenario 1 was selected by the Project Reference Group as the basis for assessing BAL and defendable space requirements across the study area.

Tasks 2 & 4 – BMO Assessment and BAL Mapping

The landscape scale bushfire risk of the Otways is extreme with potential for very intense fire behaviour given the inputs of occasional elevated FFDIs, steep slopes and extensive eucalypt forests. The settlements of Wye River and Separation Creek occur within this landscape risk with little separation or differentiation between the Forest and the residential area. The broader landscape is classified as Type 4 according to *Planning Practice Note 65* (DTPLI, 2014a).

The 25 December 2015 bushfire occurred under significantly milder fire weather conditions than those assumed by the BMO (less than 50% of assumed FFDI). The pattern of fire spread, severity and loss is likely to be different if the settlements were to be impacted under the BMO assumed FFDI of 100, or higher.

An assessment of the study area was conducted using the site assessment methodology of the BMO. The vegetation inputs to this assessment were those described in Status Quo and Managed Vegetation Scenario 1. We recommend the Managed Vegetation Scenario 1 analysis as the most appropriate to inform determination of BALs across the settlement. It should be noted, however, that the actual BAL applied to any building will vary with its

location on the lot, and the standard of vegetation management achieved within the lot and on neighbouring land.

To determine BALs in response to the classified vegetation external to the residential area, radiant heat flux was measured from the classified vegetation abutting the settlements using Method 2 of AS 3959-2009. The BAL-FZ band is shown on Map 8 and Map 9 as the red band around the perimeter of the residential area. In the modelling FFDI, flame temperature and fuel loads were retained as the BMO defaults; whilst the rate of spread, and hence flame length, on effective downslopes greater than 20^{o} was capped at 14km/h (equivalent to an effective downslope between 22^{o} and 23^{o}), and the effective upslope was capped at -10^{o}. Although less precautionary than the BMO Table 1 distances, Method 2 of AS 3959-2009 allows alternative approaches to modelling fire behaviour and this approach was adopted at the suggestion of the Project Reference Group.

Where a dwelling is exposed only to Modified hazardous vegetation a range of BALs (BAL-29, BAL-40 or BAL-FZ) if the defendable space in Table 1 of Clause 52.47-3 can be provided, i.e. 50m or to the property boundary whichever is the lesser. Planning Practice Note 65 states the extent to which the vegetation is managed will determine the final outcome (DTPLI, 2014a). For lots at Wye River and Separation Creek exposed only to Modified hazardous vegetation and where defendable space for 50m or the property boundary, whichever is lesser, cannot be reasonably assured, we consider the more appropriate construction standard for most lots to be BAL-40 due to:

- The distribution of significantly sized patches of vegetation on slopes greater than 20^{o} that are unlikely to be managed as defendable space or sufficiently modified vegetation on a reliable ongoing basis;
- The probability that on some other slopes, less than 20^{o} but still steep, ongoing management of grass and shrubs and clearing of leaf litter will be difficult for some residents;
- The prevalence of holiday homes with periodic and short-term occupancy and where the owner responsible for vegetation management may be absent for extended periods;
- The need to protect soil stability on steep slopes precludes the removal of canopy trees to achieve the canopy cover and separation distances required for defendable space under the BMO;
- The steep slopes promoting elongated flames in close proximity to dwellings; and
- The tendency for dwellings built on the slopes (and to good hillside design principles as recommended by the geo-technical consultant's report) to be elevated above the fall of the land, potentially with flames and radiant and convective heat impacting the underside of the elevated building elements.

The BAL-40 area is shown as orange shading on Maps 4 and 5. This combines the BAL-40 area in response to classified vegetation outside the settlements and in the reserves, and the Modified vegetation within the settlements. The BAL-40 standard is in accord with the

opinion of the Project Reference Group, and assumes some intermittent flame contact compared to BAL-29.

A smaller number of lots have been identified where BAL-29 may be appropriate in response to the Modified vegetation. These are shown as yellow shading on Map 8 and Map 9, and generally the lots:

- Are not exposed to radiant heat flux greater than 29kW/m^2 from classified vegetation outside the settlements or in the reserves;
- Do not have, or are unlikely to have, Modified or Classified vegetation below them (i.e. on downslopes);
- Are more than 25m from other substantial areas of Modified vegetation on slopes greater than 20^o (where vegetation management may be problematic);
- Have a site slope (within the lot) mostly less than 20^o and thus should be able to provide defendable space within the property boundary;
- Are contiguous to other lots with similar or lower risk characteristics (e.g. Low Threat cultivated gardens etc.); and
- Are on the ocean side of the settlement.

Under the BMO, the BAL for a dwelling requires that the requisite distance of defendable space be provided between the building and the hazardous vegetation. Dwellings should seek to provide the applicable defendable space distance from Table 1 of Clause 52.47-3. In the case of Modified vegetation this distance is stipulated as to the property boundary, which may vary widely between lots (i.e. from a few metres up to a maximum of 50 metres). The constraints of providing full defendable space on some lots was recognised by the Project Reference Group (refer Section 7.5.6) and a potential alternative standard for vegetation management has been suggested for consideration (refer Section 7.5.7).

Terramatrix were instructed by DELWP that approach to be taken for re-development in the study area was to achieve the a net improvement in bushfire safety compared to pre-December 2015 conditions given the severe constraints of the existing settlements. A net improvement is considered achievable by building to BAL-FZ, BAL-40 or BAL-29 as appropriate, even if compliance with the provisions of the BMO cannot be achieved on individual lots.

Task 5 – Additional Requirements

There are a number of emergency management arrangements that would enhance life safety from bushfire at Wye River and Separation Creek.

The settlements of Wye River and Separation Creek were successfully evacuated in response to the threat of the 25 December 2015 bushfire. The FFDI at the time of the fire was less than half that presumed by the BMO and there were several days notice that evacuation may be necessary. The scenario of a large fully developed high intensity forest fire

impacting upon the settlement with little advance notice and under FFDI of 100 or more, should also be considered.

Neither of the settlements contains a Community Fire Refuge or a Neighbourhood Safer Place (NSP). There are, however, informal places within each settlement where people may congregate to seek shelter, information, assistance and moral support during a bushfire. These are likely to be community buildings near the Great Ocean Road (such as the Surf Life Saving Club) or the beach itself. As there are no NSPs and evacuation routes will be unsafe in some scenarios, these informal places may play a vital role, and consideration should be given to how they can be incorporated into agency planning and community/tourist education to improve public safety.

Alternatively, consideration could be given to a formal community place of shelter.

In established settlements, provision of a private bushfire shelter can reduce the assessed BAL by one level (Colac Otway Planning Scheme, 2014b). A private bushfire shelter would therefore result in a BAL-40 construction standard for those lots currently assessed as BAL-FZ, which meet all the Approved Measures of Clause 52.47-1. A private bushfire shelter would also provide additional surety for those lots unable to provide BMO standard defendable space. However, installation shelters might be problematic on the steep slopes.

Vegetation management within the residential area of Wye River and Separation Creek can increase the survivability of individual buildings and moderate, but not prevent, fire spread and behaviour within the settlement. It cannot, however, fundamentally alter the likelihood or severity of a bushfire reaching the settlements. Moderation of fire behaviour of an approaching bushfire requires large strategic areas of fuel management in the run up to the settlements. The potential to institute a strategic fuel management program in the forest adjoining the settlements should be investigated.

An intensively managed APZ or fuel break around the perimeter as illustrated in Managed Vegetation Scenario 3 could reduce flame and radiant heat impact on houses abutting the forest. The constraints of steep slopes may prevent the APZ being created in entirety, but even partial implementation would offer enhanced protection to some dwellings.

1 Introduction

1.1 Scope of Study

Terramatrix were commissioned by DELWP to determine ongoing fuel management and associated Bushfire Attack Levels (BALs) for dwellings in those parts of Wye River and Separation Creek burnt by the 25 December 2015 bushfire. The outcomes of the project will contribute to the development of an integrated planning control (incorporated under Clause 52.03 Specific Sites and Exclusions) for the fire-affected area that will streamline the planning permit process for people wishing to rebuild houses lost in the bushfire.

There are five key tasks:

- Review previous bushfire studies, with a particular focus on the areas burnt or destroyed by the 25 December bushfire;
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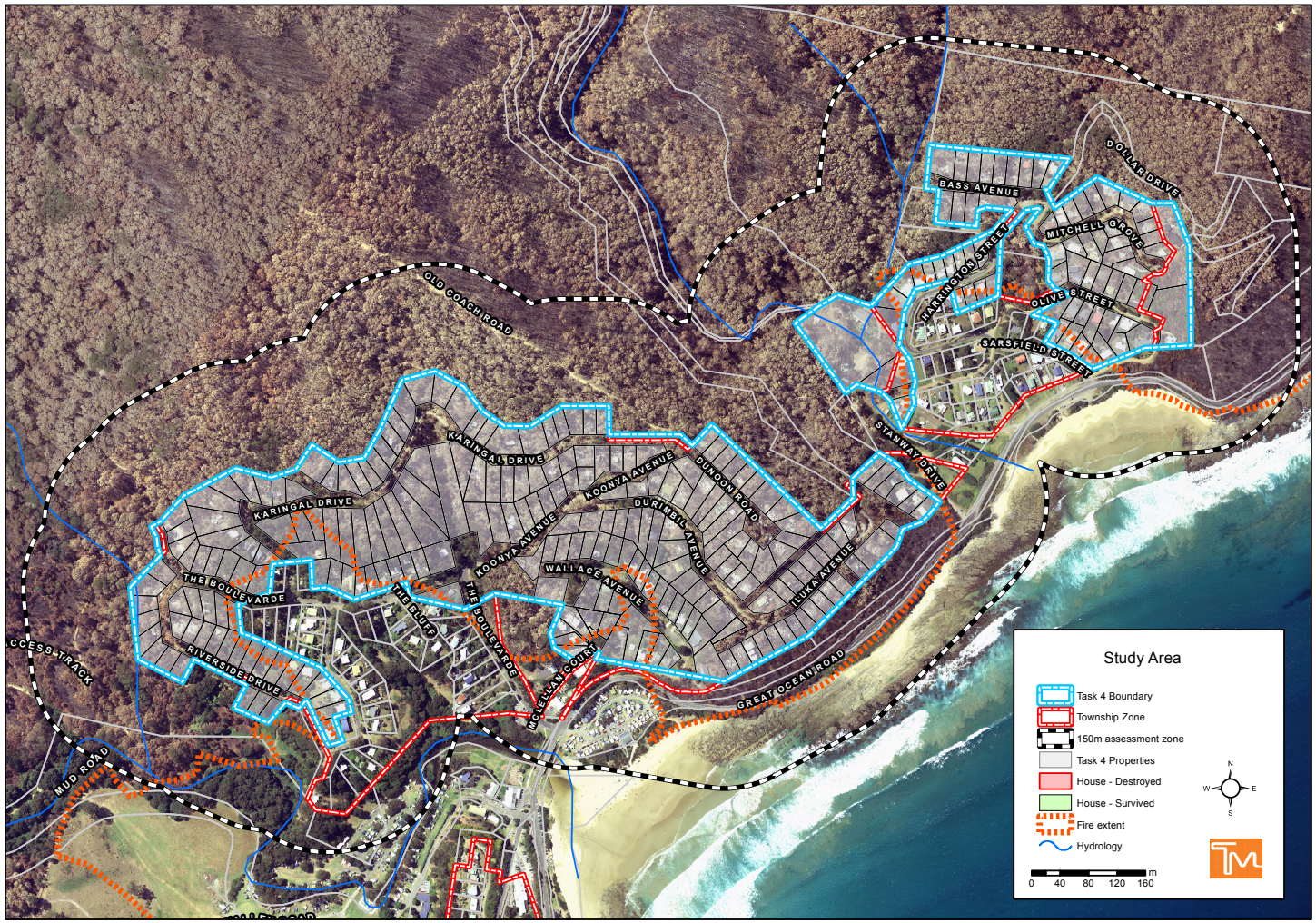
This report is structured around the five key tasks, with Key Tasks 2 and 4 presented together in Section 7.

A Project Reference Group, led by the Department of Environment, Land, Water and Planning (DELWP), and consisting of key emergency service agencies and other stakeholder organisations, was formed to advise on the project. This group met three times to provide technical support, input and evaluation. A number of key methodological steps were determined with the input of this group, and their professional opinion on the draft BAL results was also heeded.

1.2 Study Area

The study area was determined by DELWP, and accords largely with the area burnt by the 25 December 2015 bushfire (refer. To this a 150m wide BMO site assessment zone was added.



Map 1 - Wye River and Separation Creek study area.

2 Buildings and Bushfires

Most research into building loss and human safety has been conducted in relation to high intensity forest fires, and thus is directly relevant to the Wye River and Separation Creek study area.

The 'prepare, stay and defend or leave early' policy as set out by the Australasian Fire Authorities Council in the *Position Paper on Bushfires and Community Safety* (AFAC, 2005) was well supported by historical evidence (Tibbits *et al.*, 2008) and research into building survivability (Blanchi and Leonard, 2008; Leonard and Bowditch, 2003). It was reviewed following the *2009 Victorian Bushfires Royal Commission Final Report* (VBRC, 2010) and a number of significant changes were made. Whilst the underlying principles remain (AFAC, 2010), much greater emphasis is put on people leaving on Extreme or Code Red days before a bushfire impacts upon an area, either as a personal choice or as an organised evacuation.

Research, however, indicates that many people will not routinely re-locate on days of extreme fire danger and the AFAC position explicitly recognises that many people will leave later than is considered ideal. Thus in bushfire prone localities, residential areas should be designed and constructed to minimise the spread of bushfire into the residential area and limit its impact on the housing stock; and to facilitate evacuation and provide a variety of shelter options (AFAC, 2010). Significant portions of fire-affected populations in many fires have been found to rely upon their houses as part of their bushfire survival strategy.

The mechanisms of bushfire attack on a dwelling are well understood (Wilson and Ferguson, 1986; Ramsay and Dawkins, 1993; Ramsay and Rudolph, 2003; Blanchi and Leonard, 2005, 2008) and comprise a combination of sparks and embers, direct flame contact and radiant heat (see Figure 1). Extremely strong winds may cause structural damage to the building making ignition by embers easier and compromising its ability to effectively shelter occupants (Leonard, 2009). After a bushfire has entered a peri-urban area secondary ignition sources such as burning houses, outbuildings and fences become significant (Gill *et al.,* 2003).

Ember attack is statistically the most common mechanism of house ignition during bushfire. The impact of embers extends much further from the unmanaged fuel than flame contact and radiant heat, and can continue to pose a risk many hours after the fire front has passed. Embers start small fires on or near the structure that get larger and, in the absence of effective suppression, will spread to destroy the building.

Arguably, however, it is flame contact and radiant heat ignition that pose the greatest threat to human survival. These mechanisms can result in rapid involvement of the entire dwelling, and by definition cause the house to ignite during the passage of the fire front when, in most cases, there is no option for people present other than to shelter within the dwelling.

Ignition by direct flame contact can occur in two quite different circumstances:

- Flames and radiant heat from nearby bushland as the high intensity fire front passes; or
- Localised flame contact from fuel close to the building such as garden vegetation, outdoor furniture etc. which may be ignited by embers or lower intensity fire spreading through a garden setting.

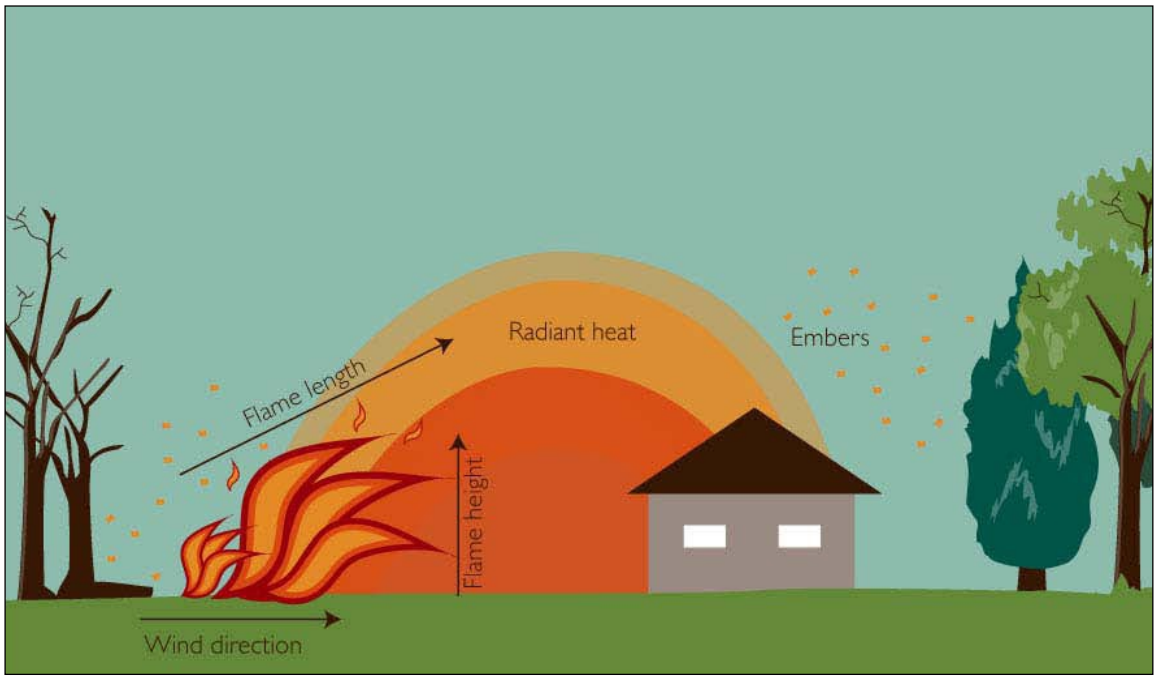


Figure 1 - Mechanisms of bushfire attack on a house.

Ramsay and Dawkins (1993) state that it is desirable to have a fuel reduced area to reduce the potential for attack by radiant heat or flame contact. Gibbons *et al.* (2012) stress that vegetation type and quantity within 40m of a dwelling has a significant impact in determining house survival.

Siting a building or managing vegetation to reduce fire intensity such that the building is unlikely to be ignited by direct flame contact or radiant heat has long been a corner stone of CFA's community safety policy, as articulated through land use planning controls (e.g. CFA, 2010; Maughan and Krusel, 1999) and public education programs.

The rationale for this position is that the dwelling is often the primary protection from radiant heat for people within a fire area, and thus needs to survive the passage of the fire front during which period conditions in the open may be lethal. After the fire front has passed it may be relatively safe for people to come out of the house and extinguish ember ignitions or even take refuge on burnt ground if the building fire is unable to be extinguished.

This strategy will fail if the house ignites and becomes untenable at the same time as conditions outside the house are lethal, or if people fail to leave the house before it becomes untenable. This could happen because:

- The house is ignited by direct flame contact or radiant heat during the passage of the fire front; and/or
- The house is ignited by embers in advance of the fire front and is unable to be extinguished and becomes untenable during the passage of the fire front; and/or
- The house is significantly damaged by wind allowing mass entry of embers that overwhelm active defence and results in rapid fire spread through the building; and/or
- People shelter-in-place but do not actively defend and fail to leave the burning building.

If dwellings are to have a role in bushfire safety, then the purpose of development controls must be to promote the dwelling surviving the passage of the fire front. This can be done by:

- Reducing the severity of the hazard by siting and/or managing vegetation; and/or
- Reducing the vulnerability of the dwelling by design and construction; and/or
- Facilitating active defence of the dwelling through provision of water, access, firefighting equipment and training etc.

The Victorian land use planning and building controls actively address these three components in an integrated manner through the Victoria Planning Provisions and Building Regulations.

3 Planning Context

3.1 State Planning Policy Framework

Clause 13.05-1 provides Bushfire Hazard Identification and Risk Assessment strategies. These are to:

- 'Apply the best available science to identify vegetation, topographic and climatic conditions that create a bushfire hazard.
- Assess the risk to life, property and community infrastructure from bushfire at a regional, municipal and local scale.
- Identify in planning schemes areas where the bushfire hazard requires that:
  - Consideration needs to be given to the location, design and construction of new development and the implementation of bushfire protection measures.
  - Development should not proceed unless the risk to life and property from bushfire can be reduced to an acceptable level' (Colac Otway Planning Scheme, 2011).

The Strategic and Settlement Planning strategies are to:

- 'Ensure that strategic and settlement planning assists with strengthening community resilience to bushfire.
- Consult with the relevant fire authority early in the strategic and settlement plan making process and implement appropriate bushfire protection measures.
- Ensure that planning to create or expand a settlement in an area at risk from bushfire:
    - Addresses the risk at the both the local and broader context.
    - Reduces the risk to future residents, property and community infrastructure from bushfire to an acceptable level.
    - Ensures any biodiversity and environmental objectives specified in the planning scheme are compatible with planned bushfire protection measures.
    - Ensures the risk to existing residents, property and community infrastructure from bushfire will not increase as a result of future land use and development.
    - Ensures future residents can readily implement and manage bushfire protection measures within their own properties' (Colac Otway Planning Scheme, 2011).

Clause 13.05-1 also stipulates Planning Scheme Implementation strategies to:

- 'Specify in planning schemes the requirements and standards for assessing whether the risk to a proposed development from bushfire is acceptable and the conditions under which new development may be permitted.
- Ensure the planning schemes, in particular the Municipal Strategic Statement, Local Planning Polices and zones applying to land, provide for use and development of land in a manner compatible with the risk from bushfire.
- Ensure that planning schemes support bushfire management and prevention and emergency service actions and activities.
- Ensure that planning schemes do not prevent the creation of required defendable space around existing development through the removal and management of vegetation' (Colac Otway Planning Scheme, 2011).

Development Control strategies are also provided:

- 'In areas identified in the planning scheme as being affected by bushfire hazard, require a site-based assessment to be undertaken to identify appropriate bushfire protection measures for development that has the potential to put people, property or community infrastructure at risk from bushfire.
- Only permit new development where:
    - The risk to human life, property and community infrastructure from bushfire can be reduced to an acceptable level;
    - Bushfire protection measures, including the siting, design and construction of buildings, vegetation management, water supply and access and egress can be readily implemented and managed within the property; and

- The risk to existing residents, property and community infrastructure from bushfire is not increased' (Colac Otway Planning Scheme, 2011).

Particular advice is provided on assessing single dwellings in established townships, where a localised response may be required, and planned or existing fire management actions may affect the bushfire protection measures required on the site.

The policy guidelines require that any relevant approved State, regional and municipal fire prevention plan should be considered in land use planning.

Clause 13-05-1 refers to "acceptable" risk in multiple places. This is a key concept for any study of bushfire risk.

Most of rural Victoria is at risk from bushfire to a greater or lesser extent. It is not feasible to avoid all bushfire risk; doing this would preclude any development in rural areas. Rather the key criterion is whether the bushfire risk arising from the development is acceptable. Acceptable risk is not defined in the VPPs or the Colac Otway Planning Scheme. For statutory planning purposes (i.e. assessment of BMO applications), if the landscape (topography, vegetation and proximity to existing settlements) is in accordance with the BMO presumptions, and the proposed development can meet the appropriate objectives by complying with Approved and/or Alternative Measures, then the risk is considered to be reduced to an acceptable level (DTPLI, 2014a).

Re-development of entire settlements destroyed by bushfire is unlikely to have been envisaged by the BMO. In this situation, where BMO compliance cannot be readily achieved and the settlement is to be re-established, it may be expedient to redefine the concept of "acceptable risk". An alternative test may be whether the best level of safety achievable, given the constraints of the setting, will result in a net improvement in bushfire safety compared to the situation prior to the fire.

The concept of net improvements in bushfire safety compared to pre-December 2015 conditions was discussed at Project Reference Group Meeting 3, and has been used as an underlying premise guiding this project. Overall a net improvement should be achievable by building to BAL-FZ, BAL-40 or BAL-29 as appropriate, even if compliance with the provisions of the BMO cannot be achieved on individual lots. The appropriateness of this approach in the context of the re-building of Wye River and Separation Creek is a planning policy decision for DELWP. The BAL mapping presented is based on this premise.

3.2 Bushfire Management Overlay

The purposes of the BMO include to prioritise protection of life, strengthen community resilience and only permit development if the risk to life and property can be reduced to an acceptable level (Colac Otway Planning Scheme, 2014a).

The BMO largely applies to patches of treed vegetation greater than 4ha in size, where head fire intensity has been modelled to be 30,000 kW/m or more. Typically, it extends over land 150m around those areas, based on research into house loss from bushfires which has found that 92% of house loss occurs within 150m of the bushfire hazard (DPCD, 2013).

Clause 52.47 Planning for Bushfire applies to BMO applications and contains:

- **Objectives:** An objective describes the outcome that must be achieved in a completed development.
- Approved measures: An approved measure meets the objective.
- Alternative measures: An alternative measure may be considered where the responsible authority is satisfied that the objective can be met. The responsible authority may consider other unspecified alternative measures.
- Decision guidelines: The decision guidelines set out the matters that the responsible authority must consider before deciding on an application, including whether any proposed alternative measure is appropriate (Colac Otway Planning Scheme, 2014b).

3.3 Bushfire Prone Area

BPAs are those areas subject to, or likely to be subject to, bushfires, as determined by the Minister for Planning. Those areas of highest bushfire risk within the BPA are designated as BMO areas.

The Building Act 1993 and associated Building Regulations 2006, through application of the National Construction Code (NCC), require bushfire protection standards for certain classes of buildings in designated BPAs. In Victoria in BPAs the NCC requires that a Class 1, 2 or 3 building, and a Class 10a building or deck associated with a Class 1, 2 or 3 building must:

> *'…to the degree necessary, be designed and constructed to reduce the risk of ignition from a bushfire, appropriate to the —*
>
> *(a) potential for ignition caused by burning embers, radiant heat or flame generated by a bushfire; and*
>
> *(b) intensity of the bushfire attack on the building'* (ABCB, 2015).

Compliance with AS 3959-2009 *Construction of Buildings in Bushfire Prone Areas* (Standards Australia, 2009) is deemed-to-satisfy the performance requirement. In Victoria, applicable buildings must be constructed to a minimum Bushfire Attack Level (BAL)-12.5, or higher as determined by a site assessment or planning scheme requirement (refer Appendix 1 for an explanation of BALs).

3.4 Ministerial Direction No. 11 Strategic Assessment Guidelines

The purpose of Ministerial Direction No. 11 is to designate bushfire risk as a fundamental strategic consideration. An amendment must be assessed to determine whether the changes proposed will result in any increase to the risk to life as a priority, property, community infrastructure and the natural environment from bushfire.

Planners are prompted to consider whether:

- The amendment meets the objective and gives effect to the strategies of Clause 13.05 of the State Planning Policy Framework;
- The view of the relevant fire authority has been sought in formulating the amendment, and summarised in the explanatory report; and
- The amendment is consistent with the Local Planning Policy Framework relating to bushfire risk.

3.5 Erosion Management Overlay

The entire study area is covered by an Erosion Management Overlay (EMO) and Schedule 1, to protect areas prone to erosion, landslip or other land degradation processes, by minimising land disturbance and inappropriate development (Colac Otway Planning Scheme, 2015). A permit is required to construct a building or carry out works, or to remove, destroy or lop any vegetation (Colac Otway Planning Scheme, 2015).

A number of exemptions are provided to the permit requirement for clearing of native vegetation. Of relevance to this project are the following exemptions for fire protection:

- The vegetation is ground fuel within 30m of a building;
- The vegetation is to be removed, destroyed or lopped in accordance with a fire prevention notice under Section 41 of the Country Fire Authority Act 1958 or Section 8 of the Local Government Act 1989; and
- The vegetation is to be removed, destroyed or lopped to reduce fuel loads on roadsides to minimise the risk to life and property from bushfire of an existing public road managed by the relevant responsible road authority (as defined by the Road Management Act 2004) in accordance with the written agreement of the Secretary to the Department of Environment, Land, Water and Planning (as constituted under Part 2 of the *Conservation, Forest and Lands Act 1987*) (Colac Otway Planning Scheme, 2015).

In addition Schedule 1 provides a further permit exemption for:

- The removal, destruction or lopping of any vegetation providing the roots below ground level are retained (Colac Otway Planning Scheme, 2013).

A decision guideline in Schedule 1 is the impact of future vegetation removal for bushfire protection and whether any such vegetation removal would result in an increase to the risk to property and/or the risk to life as measured against the tolerable risk criteria defined in the AGS Guidelines 2007 (Colac Otway Planning Scheme, 2013).

4 Bushfire Attack Levels

Bushfire Attack Levels (BALs) are a measure of the anticipated level of bushfire attack (described in terms of radiant heat, flame contact and ember attack) on a building. Each BAL equates to a level of construction in AS 3959-2009 that sets minimum standards for construction and materials.

Under the BMO, BALs are determined by a site assessment that utilises the AS 3959-2009 (Standards Australia, 2009) methodology, but with the site assessment zone extended to 150m from the proposed building (DTPLI, 2014a).

The BAL is determined by the level of radiant heat calculated to impact the building from a bushfire burning in hazardous vegetation within the 150m assessment zone. Radiant heat flux is determined from inputs including the calculated flame length, which in turn is calculated from the rate of spread of a bushfire under pre-determined weather conditions (set at an FFDI of 100 in non-alpine parts of Victoria) and the fuel load and slope of the land (as determined through the site assessment process) (Standards Australia, 2009).

Radiant heat diminishes rapidly with distance from the source (i.e. the flames), and hence the distance from the hazardous vegetation is the key determinant of the BAL of a building.

In addition, solid objects block radiant heat and hence shielding of a building by other buildings, or the lay of the land, may also reduce the amount of radiant heat reaching the building and hence lower its BAL.

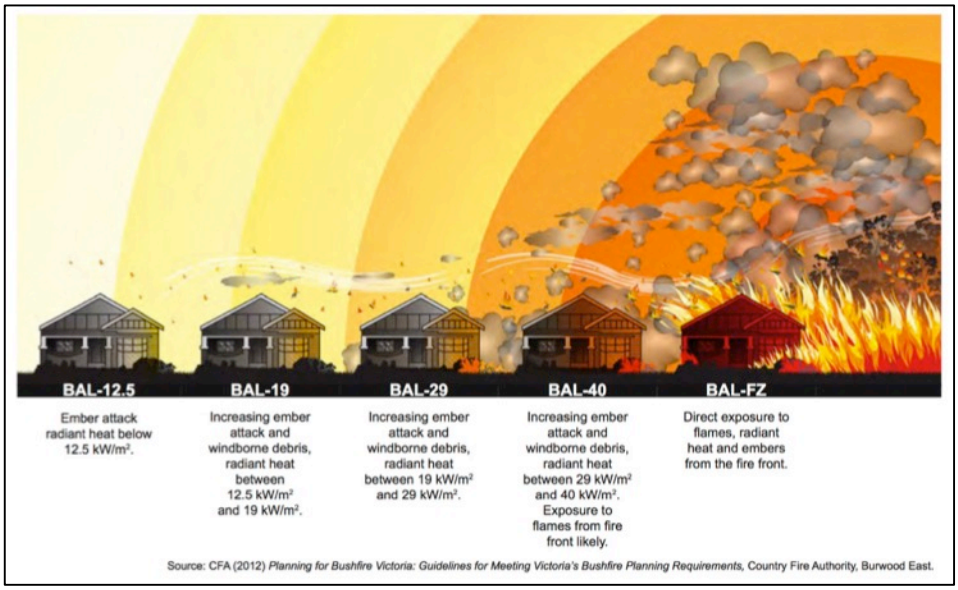


Figure 2 - Explanation of BALs (CFA, 2012).

Table 1 - BALs risk level and construction requirements applicable to Bushfire Prone Areas in Victoria (from Standards Australia, 2009).

Bushfire Attack Level (BAL)	Risk Level	Construction elements are expected to be exposed to…	Comment
BAL-12.5	LOW: There is risk of ember attack.	A radiant heat flux not greater than 12.5 kW/m^2	At 12.5kW/m^2 standard float glass could fail and some timbers can ignite with prolonged exposure and piloted ignition.
BAL-19	MODERATE: There is a risk of ember attack and burning debris ignited by windborne embers and a likelihood of exposure to radiant heat.	A radiant heat flux not greater than 19 kW/m^2	At 19kW/m^2 screened float glass could fail.
BAL-29	HIGH: There is an increased risk of ember attack and burning debris ignited by windborne embers and a likelihood of exposure to an increased level of radiant heat.	A radiant heat flux not greater than 29 kW/m^2	At 29kW/m^2 ignition of most timbers without piloted ignition after 3 minutes exposure. Toughened glass could fail.
BAL-40	VERY HIGH: There is a much increased risk of ember attack and burning debris ignited by windborne embers, a likelihood of exposure to a high level of radiant heat and some likelihood of direct exposure to flames from the fire front.	A radiant heat flux not greater than 40 kW/m^2	At 42kW/m^2 ignition of cotton fabric after 5 seconds exposure (without piloted ignition).
BAL- FZ (Flame Zone)	EXTREME: There is an extremely high risk of ember attack and a likelihood of exposure to an extreme level of radiant heat and direct exposure to flames from the fire front.	A radiant heat flux greater than 40 kW/m^2	At 45kW/m^2 ignition of timber in 20 seconds (without piloted ignition).

5 Key Task 1 - Review of Previous Bushfire Studies

The Colac Otway Bushfire Planning Policy Project was undertaken by Terramatrix and Tract Consultants to assess the bushfire risk at eight nominated settlements to inform the suitability of inland settlements for residential growth and to provide increased clarity in regards to development and bushfire risk mitigation in all the settlements.

The *Colac Otway Bushfire Planning Policy Project Final Report* (Tract Consulting and Terramatrix, 2014) was provided to the Colac Otway Shire in May 2014, and underpinned by a strategic bushfire risk assessment documented in the *Colac Otway Shire Council Bushfire Planning Policy – Bushfire Technical Report* (Terramatrix, 2013). The *Bushfire Technical Report* included:

- Bushfire context, including bushfire behaviour and descriptions of the Otways environment;
- The methodology used for assessing bushfire impact for each project part;
- Generic recommendations relating to bushfire; and
- Technical bushfire reports for each settlement.

A summary of those parts of the *Bushfire Technical Report* relevant to Wye River and Separation Creek is provided in Appendix 1.

Our review of the *Bushfire Technical Report* suggests that the assessment of landscape risk, potential bushfire scenarios and impact is still valid. The discussion of potential mitigation treatments also remains relevant, and we continue to recommend them (refer Section 8).

The assessment of indicative BALs, to identify areas that may have been suitable for coverage by a Schedule to the BMO is, however, now obsolete. Subsequent to that analysis, Amendment VC109 altered the design fire for the BMO by lowering the FFDI and flame temperature used in the calculation of flame length and radiant heat flux. Thus the setback distances required for each BAL have been reduced.

In addition, the *Bushfire Technical Report* was intentionally conservative in its treatment of slope and vegetation to ensure that any areas covered by the Schedule would qualify for BAL-29 construction standard or lower as required by a Schedule at that time. An additional classification of Modified vegetation was also introduced by VC109. Whilst the *Bushfire Technical Report* identified 'partially modified' vegetation within the settlements there was, at that time, no established method of determining BALs in response to it.

6 Key Task 3 – Mapping of Vegetation

Four vegetation scenarios were considered. These were:

- Status quo – the distribution of vegetation as mapped for the 2013 Colac Otway Bushfire Planning Policy project (Terramatrix, 2013) (refer Map 2).
- Managed Vegetation Scenario 1 – all private lots within the settlement are managed as Modified vegetation, remaining vegetation remains as per 2013 classification (refer Map 3).
- Managed Vegetation Scenario 2 – all vegetation within the settlement (i.e. including drainage lines, reserves, foreshore etc.) is managed as Modified vegetation (refer Map 4).
- Managed Vegetation Scenario 3 - A perimeter Asset Protection Zone is provided to BMO defendable space standard for the distance necessary to enable the outermost row of houses to be constructed to BAL-40 anywhere on their lots (refer Map 5).

AS 3959-2009 and the BMO define Forest as trees greater than or equal to 10m in height with foliage cover of 30-70% (may include understorey). This group includes native forests with an established understorey (ranging from rainforest and tree ferns, to tall shrubs, low trees or grasses) and plantations (Standards Australia, 2009).

Scrub is defined as shrubs greater than 2m in height with foliage cover of 10-30% (Open Scrub) or greater than 30% (Closed Scrub) (Standards Australia, 2009). The species composition can be variable.

Clause 52.47 refers to modified vegetation as 'vegetation that is sufficiently varied from the vegetation classification in AS 3959-2009 Construction of buildings in bushfire prone areas' (Colac Otway Planning Scheme, 2014b), however, the extent to which the vegetation must be varied or modified from the form of the classified vegetation is not clearly defined. *Planning Practice Note 65* notes that Modified vegetation can occur where fuel loads are high but the vegetation is modified because of urban development, gardens, the way the vegetation is configured (for example limited or no understorey), or because the fuel loads are different from those assumed by AS 3959-2009, but the vegetation cannot be excluded as it is not low-threat or low-risk (DTPLI, 2014a).

Areas that can be xcluded from classification, in accordance with Section 2.2.3.2 of AS 3959-2009, are:

i. Single areas of vegetation less than 1 ha in area and not within 100m of other areas of vegetation being classified.

ii. Multiple areas of vegetation less than 0.25 ha in area and not within 20 m of the site, or each other.

iii. Strips of vegetation less than 20 m in width (measured perpendicular to the elevation exposed to the strip of vegetation) regardless of length and not within 20 m of the site or each other, or other areas of vegetation being classified.

iv. Non-vegetated areas, including waterways, roads, footpaths, buildings and rocky outcrops.

v. Low threat vegetation, including grassland managed in a minimal fuel condition[1], maintained lawns, golf courses, maintained public reserves and parklands, vineyards, orchards, cultivated gardens, commercial nurseries, nature strips and windbreaks' (Standards Australia, 2009).

Vegetation and its implication for fire behaviour and the BMO is further discussed in Section 7.2.2.

The difficulty of maintaining reliably Low Threat vegetation across the settlements was discussed at Project Reference Group Meetings 2 and 3. The consensus of professional opinion was that given the wet forest canopy, steep slopes and, in part, absentee property owners it would be difficult to maintain vegetation on private lots as Low Threat in perpetuity. Rather, it was considered more realistic to anticipate that residential lots would, in the future, contain a mosaic of managed and unmanaged vegetation best classified as Modified under the BMO.

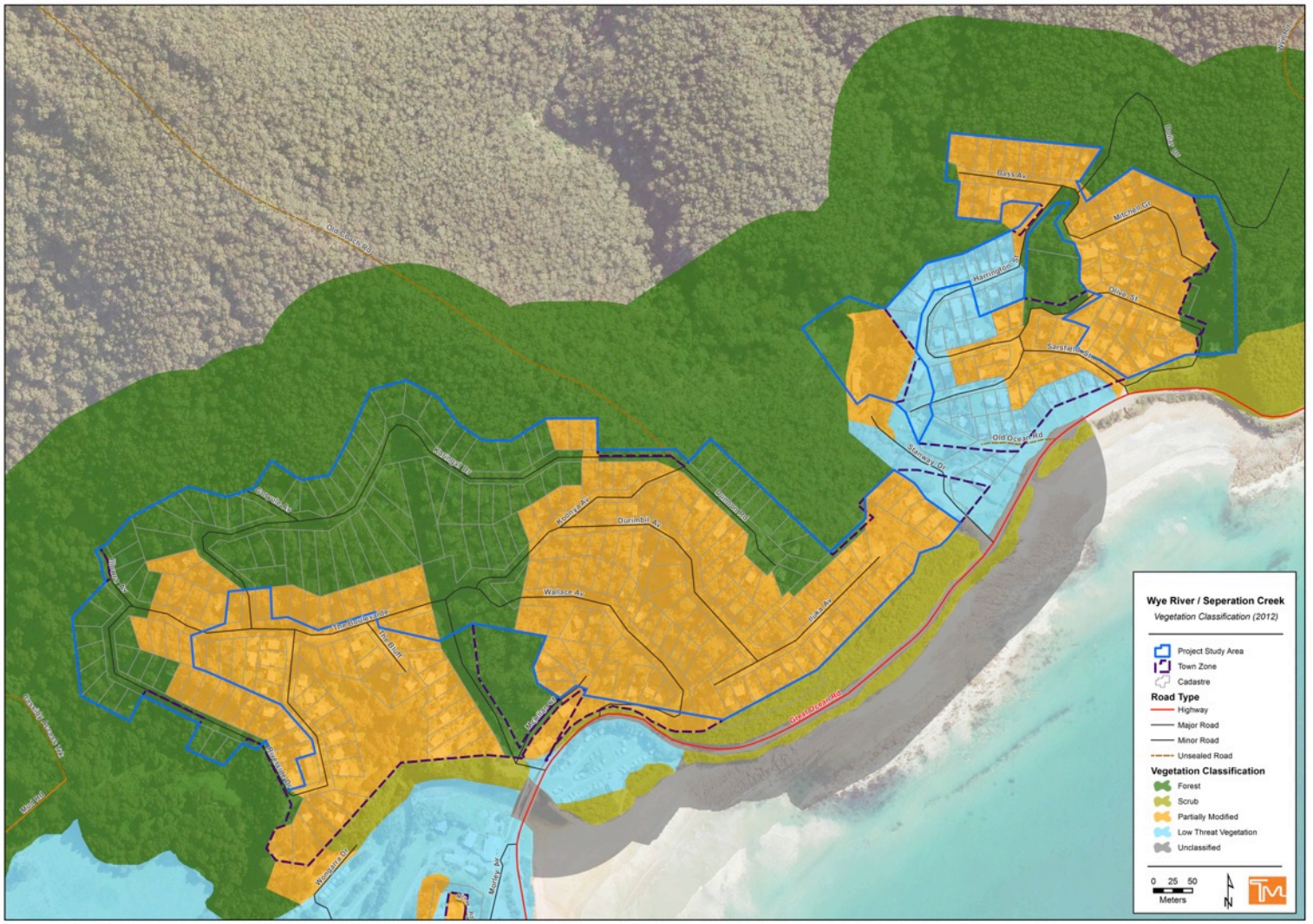
The BMO (but not AS 3959-2009) considers Modified vegetation. *Planning Practice Note 65* notes that Modified vegetation can occur where fuel loads are high but the vegetation is modified because of urban development, gardens, the way the vegetation is configured (for example, limited or no understorey), or because the fuel loads are different from those assumed by AS 3959-2009 but the vegetation cannot be excluded as it is not Low Threat or low-risk (DTPLI, 2014a). *Planning Practice Note 65* cautions that if there is any doubt as to whether the vegetation is modified, the vegetation should not be considered as modified but rather be assigned the vegetation type that otherwise best fits (DTPLI, 2014a).

A proportion of the residential lots within the study area (including both developed and undeveloped lots) comprised Modified vegetation prior to the fire and are likely to again in the absence of effective and on-going vegetation management.

The BAL mapping presented in Section 7.4 uses the Status Quo Scenario and Managed Vegetation Scenario 1, with the latter being the scenario recommended for use in the Incorporated Document. Managed Vegetation Scenario 2 was not pursued due to the difficulty of managing vegetation in the steep reserves and associated soil stability concerns.

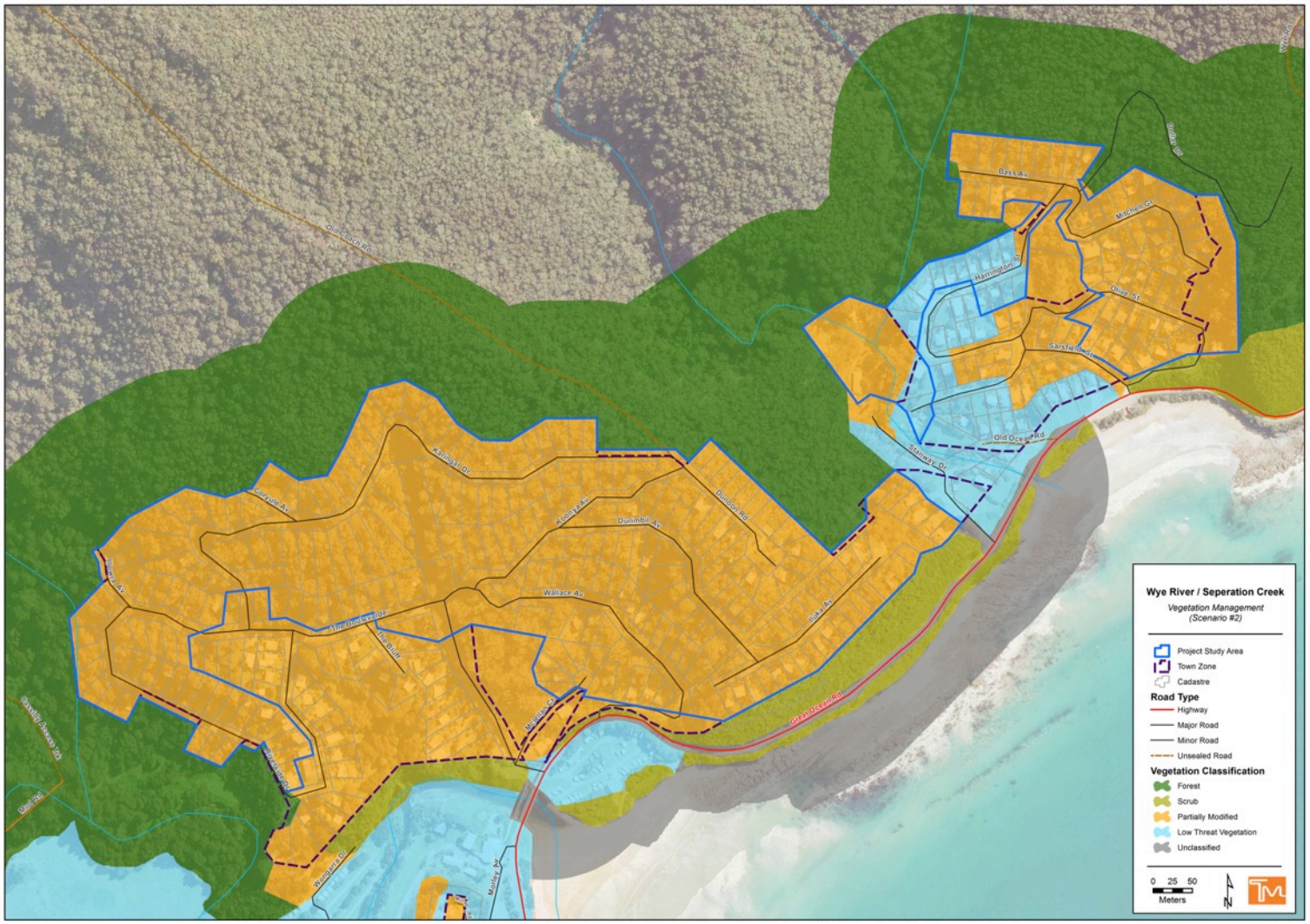
The vegetation scenarios are by necessity simplifications of complex vegetation patterns, and it is recognised that in reality the nature of vegetation will vary across the study area leading to local variations in bushfire hazard. These local variations cannot be accurately predicted into the future.

[1] Minimal fuel condition means there is insufficient fuel available to significantly increase the severity of the bushfire attack (recognisable as short-cropped grass for example, to a nominal height of 100mm (Standards Australia, 2009).



Map 2 - 'Status Quo' scenario vegetation classification (from Terramatrix, 2013).

Map 3 - Managed Vegetation Scenario 1.



Map 4 - Managed Vegetation Scenario 2.

Map 5 - Managed Vegetation Scenario 3.

7 Key Tasks 2 & 4 – BMO Assessment and BAL Mapping

7.1 Approach

The study area exhibits three vegetation arrangements that influence the BAL rating of lots. These are:

- Large area of classified Forest outside of, but abutting, the perimeter of the settlements;
- Modified or potentially modifiable vegetation (including some areas presently classified as Forest) on private lots within the settlements; and
- Small inliers of Classified vegetation (Forest or Scrub) that penetrate the settlement (e.g. drainage reserves and foreshore).

Each of the three arrangements of vegetation requires a different approach for determining the BAL response on the residential lots. In many cases an individual lot will be exposed to vegetation in more than one of these settings, and the BAL assigned needs to reflect the greatest hazard. The extent to which the BAL is affected by each setting will also vary with the managed vegetation scenarios (refer Section 6).

Forest on the perimeter of the settlements

The defendable space/BAL required in response to the classified Forest outside of the settlements can be determined using the simplified procedure known as Method 1 of AS 3959-2009 (i.e. Table 1 of Clause 52.47) wherever the effective downslope does not exceed 20°.

Downslopes >20° (up to 30°) are outside the scope of Method 1 and require the detailed procedure known as Method 2. Downslopes exceeding 30° are problematic as convective heat from bushfire flames is no longer negligible and the relationship used to adjust the forward rate of spread becomes inapplicable when the effective slope is over 30° (Standards Australia, 2009).

Modified vegetation

Modified vegetation is not considered in AS 3959-2009, but is defined in the BMO (DTPLI, 2014a). Under the BMO, buildings exposed to only Modified vegetation may be built to BAL-29 or BAL-40 with defendable space provided for 50m or to the property boundary whichever is the lesser distance, or to BAL-FZ with defendable space to the satisfaction of the responsible authority (see Table 1 Clause 52.47). Clause 52.47 provides no clear direction on under what circumstances BAL-29 or BAL-40 should be selected, however *Planning Practice Note 65* states "the extent of modification will determine the final outcome" (DTPLI, 2014a).

AS 3959-2009 provides a description of the level of fire attack each of the construction standards is designed for (Standards Australia, 2009) (see Table 2). This description, the probable nature of the fuel hazard in the Modified vegetation, the guidance provided about Modified vegetation in *Planning Practice Note 65* (a, 2014), and the design and construction

features of the BALs was used to guide our recommendation for BALs on lots exposed only to Modified vegetation.

Table 2 - Description of predicted bushfire attack and levels of exposure for BAL-29, BAL-40 and BAL-FZ (Standards Australia, 2009).

BAL	Heat flux exposure threshold	Description of predicted bushfire attack and levels of exposure
BAL-29	>19kW/m^2 ≤ 29kW/m^2	Increasing levels of ember attack and burning debris ignited by windborne embers together with increasing heat flux
BAL-40	>29kW/m^2 ≤ 40kW/m^2	Increasing levels of ember attack and burning debris ignited by windborne embers together with increasing heat flux with the increased likelihood of exposure to flames (my underlining)
BAL-FZ	>40kW/m^2	Direct exposure to flames from fire front in addition to heat flux and ember attack

Inliers of classified vegetation

The AS 3959-2009 Method 1 design fire assumes a bushfire will be at the steady-state forward rate of spread for the nominated fuel load (determined by the vegetation class) and effective slope (i.e. the slope under the classified vegetation) under the pre-determined weather conditions (in the study area this is an FFDI of 100) (Standards Australia, 2009). It further assumes, for the purpose of calculating radiant heat flux, a flaming fire front 100m wide (Standards Australia, 2009). In situations where either of these assumptions is invalid, or a more site-specific BAL determination is required, Method 2 of AS 3959-2009 can be used to determine BALs.

There are a number of locations within the study area where the only Classified (as opposed to Modified) vegetation occurs as relatively small areas or narrow strips. In these locations consideration was given to using Method 2 to determine more site-specific BALs. An important consideration was whether the inlier was isolated from other hazardous vegetation (i.e. Classified or Modified) and this will depend, in part, on what vegetation management is going to occur within the settlements.

7.1.1 Caution in Interpreting and Applying Results

There are inherent methodological limitations in the study that are explained below. Calculating and mapping radiant heat flux and flame length from the Classified vegetation, under the vegetation management scenarios is best seen as an important input to DELWP and the Project Reference Group making an informed decision about the appropriate planning response.

BALs and defendable space

Under the BMO, the BAL for a dwelling requires that the requisite distance of defendable space be provided between the building and the hazardous vegetation. Dwellings should seek to provide the applicable defendable space distance from Table 1 of Clause 52.47-3. In the case of Modified vegetation this distance is stipulated as to the property boundary,

which may vary widely between lots (i.e. from a few metres up to a maximum of 50 metres). The constraints of providing full defendable space on some lots was recognised by the Project Reference Group (refer Section 7.5.6) and a potential alternative standard for vegetation management has been suggested for consideration (refer Section 7.5.7).

Fire modelling

It should be noted that all bushfire modelling outcomes have a high degree of uncertainty due to the need to simplify or make assumptions about inherently complex systems including vegetation, topography and weather. This applies to both the Method 1 modelling embedded in the setback tables of AS 3959-2009/BMO and to more detailed Method 2 analysis.

It is important that all fire behaviour modelling be seen only as an indicative, rather than authoritative, description of potential fire behaviour for any site. Cruz and Alexander (2013) found that only 3% of modelled outcomes represented observed outcomes for rates of spread in surface and crown fires, and suggested an error interval of +/- 35% is a reasonable standard for assessing model performance.

State of the vegetation

The vegetation scenarios are by necessity simplifications of complex vegetation patterns, and it is recognised that in reality the nature of vegetation will vary across the study area leading to local variations in bushfire hazard. There was a need to make assumptions about vegetation within the study area, both in terms of what was there before the bushfire and what may re-grow into the future.

The category of Modified vegetation used under the BMO, but not by AS 3959-2009, is poorly defined and the boundaries between Forest and Modified, and Modified and Low Threat vegetation are therefore quite subjective.

Absence of definite development proposal including building plans

There are limitations in determining BALs without knowing the siting, footprint and elevation of the proposed building. As radiant heat reduces rapidly with distance, the appropriate BAL to be applied to a building depends, in part, upon where it is sited on the lot. A detailed site assessment of an individual property and development proposal may provide a number of alternate tailored safety solutions, particularly if Method 2 of AS 3959-2009 were to be employed. Individual advice could be sought where multiple BAL options are possible.

Siting of the dwelling on the lot will also affect the width required if a perimeter APZ (Managed Vegetation Scenario 3) were to be provided. The mapping of the perimeter APZ from the rear of the property boundary over states the amount of defendable space required to be provided in the adjacent private forest, as the dwellings would be set back some distance from their rear boundaries.

7.1.2 Data

Spatial data were obtained from Colac Otway Shire, DELWP and the State of Victoria (i.e. data.vic). Terramatrix created derived spatial data utilised during the analysis. Details of spatial data used in the analysis can be seen below in Table 3.

Table 3 - Spatial data to be used in the analysis.

Spatial dataset	Supplier/Owner	License current
Pre-fire aerial imagery (2011, 35cm resolution)	Colac Otway Shire Council (COSC)	In progress
Pre-fire aerial imagery (2014, 15cm resolution)	DELWP	Yes
Post-fire aerial imagery (2016, 18cm resolution)	DELWP	Yes
Defined study area	DELWP/COSC	Yes
House footprints	DELWP	Yes
Topographic data (2.5m contour interval)	Data.vic.gov.au	Yes
Hydrology (water course)	Data.vic.gov.au	Yes
Transport network (roads)	DELWP	Yes
Cadastre	DELWP	Yes
Phoenix fuel data	DELWP	Yes
EVC_2005	DELWP	Yes
Planning zones	Data.vic.gov.au	Yes
Planning overlays	Data.vic.gov.au	Yes
Public land management	Data.vic.gov.au	Yes
Vegetation Classification (AS 3959-2009)	Terramatrix	n/a
Digital Elevation Model (DEM)	Terramatrix	n/a
Slope model	Terramatrix	n/a

7.2 Hazard Assessment

7.2.1 Landscape Risk

The findings of the *Colac Otway Bushfire Planning Policy* report (Terramatrix, 2013) in regards to the bushfire risk in the Otways and at Wye River and Separation Creek remain valid.

The landscape scale bushfire risk of the Otways is extreme with potential for very intense fire behaviour given the inputs of occasional elevated FFDIs, steep slopes and extensive eucalypt forests. The settlements of Wye River and Separation Creek occur within this landscape risk with little separation or differentiation between the Forest and the residential area. The broader landscape is classified as Type 4 according to *Planning Practice Note 65* (DTPLI, 2014a). The characteristics of each Broader Landscape Type are provided in Table 4.

A large, well-developed forest fire could approach the settlements from several directions between north and south-west from Great Otway National Park and private forest. Long tracts of Forest and/or Modified vegetation extending into both settlements may facilitate extreme bushfire behaviour in very close proximity to houses. Several areas of both

settlements interface with Forest. Prolonged ember attack, radiant heat impact and direct flame impact are possible under the FFDI 100 presumed by the BMO. Areas of Forest and Modified vegetation within the settlements could allow intense fire behaviour to reach beyond the houses on the periphery. Ignitions in the coastal Scrub may impact the seaward side of the settlement and could compromise accessibility on the Great Ocean Road. A south-westerly wind change may mean that a fire in the Apollo Bay direction could impact the settlements. Under this scenario, the built up area of Wye River may ease conditions for Separation Creek, but a severe bushfire could be expected to burn through both settlements.

Unpredictable fire behaviour may occur close to or within the settlement due to the interaction of hot inland wind, coastal breeze, strong wind change and/or dramatic topography. Significant impact to the houses and people of the community is likely.

It should be noted that the 25 December 2015 bushfire that did such damage to the settlements occurred under significantly milder fire weather conditions than those assumed in the *Colac Otway Bushfire Planning Policy* project (approximately 30% of assumed FFDI) and the current BMO (less than 50% of assumed FFDI).

Table 4 - Landscape risk (from DTPLI, 2014a).

Broader Landscape Type 1	Broader Landscape Type 2	Broader Landscape Type 3	Broader Landscape Type 4
There is little vegetation beyond 150 metres of the site (except grasslands and low-threat vegetation). Extreme bushfire behaviour is not possible. The type and extent of vegetation is unlikely to result in neighbourhood- scale destruction of property. Immediate access is available to a place that provides shelter from bushfire.	The type and extent of vegetation located more than 150 metres from the site may result in neighbourhood-scale destruction as it interacts with the bushfire hazard on and close to a site. Bushfire can only approach from one aspect and the site is located in a suburban, township or urban area managed in a minimum fuel condition. Access is readily available to a place that provides shelter from bushfire. This will often be the surrounding developed area.	The type and extent of vegetation located more than 150 metres from the site may result in neighbourhood-scale destruction as it interacts with the bushfire hazard on and close to a site. Bushfire can approach from more than one aspect. The site is located in an area that is not managed in a minimum fuel condition. Access to an appropriate place that provides shelter from bushfire is not certain.	The broader landscape presents an extreme risk. Evacuation options are limited or not available.
I N C R E A S I N G R I S K →			

7.2.2 Vegetation

Managed vegetation scenarios

Four vegetation scenarios were initially considered, with three being deemed worthy of further analysis. These were:

- Status quo – the distribution of vegetation as mapped for the 2013 Colac Otway Bushfire Planning Policy project (Terramatrix, 2013).
- Managed Vegetation Scenario 1 – all private residential lots within the study area are managed as Modified vegetation, remaining vegetation remains as per 2013 classification.
- Managed Vegetation Scenario 3 - all vegetation within the study area (i.e. including drainage lines, reserves, foreshore etc.) is managed as Modified vegetation and a perimeter Asset Protection Zone is provided to BMO defendable space standard for the distance necessary to enable the outermost row of houses to be constructed to BAL-40 anywhere on their lots.

Vegetation classification

AS 3959-2009 and the BMO use a vegetation classification system to determine the fire behaviour models and fuel loads to be applied in determining defendable space/BAL requirements. The seven broad vegetation groups used within the BMO and AS 3959-2009 (Standards Australia, 2009) to determine the requisite BAL and defendable space distances are shown in Table 5.

The classification system does not directly align to Ecological Vegetation Classes (EVCs) but uses a generalised description of vegetation based on the AUSLIG (Australian Natural Resources Atlas: No. 7 - Native Vegetation) classification system. Based on the mature height and projective foliage cover of overstorey and understorey vegetation (as described in the relevant EVC/Bioregion Benchmark for Vegetation Quality Assessment) and the amount of elevated fuel, each EVC can be been assigned to the most appropriate BMO vegetation group. The CFA have produced a key to differentiate EVCs into AS 3959-2009/BMO vegetation groups (Douglas *et al.*, 2014).

Table 5 -The vegetation groups used in AS 3959-2009 and the BMO for determining fire behaviour.

Vegetation groups in AS 3959-2009 and the BMO
A. Forest
B. Woodland
C. Shrubland
D. Scrub
E. Mallee/Mulga
F. Rainforest
G. Grassland

Under the BMO if more than one vegetation type is present within 150 m of an application site the 'worst case scenario' is typically applied - the predominant vegetation type present is not necessarily the worst-case scenario (Standards Australia, 2009).

Each vegetation group is assigned a fuel load by AS 3959-2009. The amount of fuel is important in the fire behaviour models used by AS 3959-2009. In Forest, the more fuel the more intense the fire (if fuel load is doubled then fire intensity increases fourfold (Noble *et al.*, 1980)). Fine fuels such as leaves, twigs and bark, make a much greater contribution to bushfire behaviour than coarse fuels (Hines *et al.*, 2010). Fine fuels dry faster and combust more rapidly. Coarse fuels influence the duration of the fire activity as tree trunk and logs can continue burning long after the fire front has passed.

Different vegetation communities grow and accumulate biomass differently. In general, a plant community will accumulate biomass rapidly after a disturbance, such as bushfire. After a period, generally a number of years, the amount of biomass reaches equilibrium where growth and deposition of litter roughly equal the rate of decomposition. This is known as the quasi-steady state fuel load. The steady state surface fuel load represents the maximum likely to accumulate if the vegetation is long undisturbed. The quasi-steady state fuel loads differ between vegetation communities. In more productive sites, where there is an abundance of nutrients, the maximum fuel load may exceed 35 t/ha (Tolhurst, 2009). In more limited sites the maximum quasi-steady state fuel loads are lower.

AS 3959-2009 and BMO consider the differences in fuel load between different vegetation communities by assigning a quasi-steady state fuel load to each of the seven broad vegetation classes. Thus the fuel load assigned is meant to be broadly representative of all forms of that vegetation type across Australia rather than of a particular EVC.

AS 3959-2009 and the BMO define Forest as trees greater than or equal to 10m in height with foliage cover of 30-70% (may include understorey). This group includes native forests with an established understorey (ranging from rainforest and tree ferns, to tall shrubs, low trees or grasses) and plantations (Standards Australia, 2009). The requisite defendable space for forest is calculated for a surface fine fuel load of 25 t/ha and an overall fine fuel load of 35 t/ha (Standards Australia, 2009).

Scrub is defined as shrubs greater than 2m in height with foliage cover of 10-30% (Open Scrub) or greater than 30% (Closed Scrub) (Standards Australia, 2009). The species composition can be variable. The requisite defendable space for scrub is based on a presumed 3m average vegetation height and a fine fuel load of 25 t/ha (Standards Australia, 2009).

The fuel loads used by DELWP for fire behaviour predictions using the Phoenix RapidFire fire simulator were also considered for use. Phoenix groups EVCs into fuel types with similar fuel load and arrangement (Tolhurst, 2005). The fuel types present within the study area and the applicable fuel loads are detailed in Table 6. It should be noted that the Phoenix fuel loads do not include the additional canopy fuel load that AS 3959-2009 requires to be considered when using Method 2 (Standards Australia, 2009).

Table 6 - Phoenix fuel loads.

Fuel type	Description	Fuel load (t/ha)	Equivalent BMO classification
1	Moist shrubland	10.7	'Scrub'
7	Forest, herb-rich	19.5	'Forest'
9	Woodland, grass/herb-rich	9.8	'Modified' when applied to the residential area
11	Wet forest, shrub & wiregrass	35.6	'Forest'
13	Riparian forest, shrub	21.9	'Forest'

If the additional canopy fuel load is applied to fuel types 7 and 13 they become roughly equivalent to the BMO default overall fuel load for Forest (approx. 30 and 32t/ha vs 35t/ha), and if applied to fuel type 11 it becomes significantly greater than the BMO default (approx. 46t/ha vs 35t/ha).

The Project Reference Group agreed to use the BMO default fuel loads in Method 2 modelling.

Size of patches of classified vegetation

Where only a short run of fire is possible, i.e. in an isolated patch of Classified vegetation, fire spread can be modelled as accelerating from a point ignition. The accelerating rate of spread applied is derived from a theoretical acceleration curve for a single point ignition. This curve describes a growth relationship when fuel moisture and weather conditions are stable, represented by the equation:

$$R(t) = R_{ss}\, e^{-a/t}$$

Where: $R(t)$ = Rate of spread at time t

R_{ss} = Steady-state rate of spread when time t approaches infinity

a = Constant determining growth rate

Cheney and Bary (1969), Cheney (1981)

Sullivan *et al.* (2014) found that the acceleration curve correlated well with laboratory data for fire growth in eucalypt fuels under mild weather conditions, but expressed caution about extrapolating it to field use.

The applicability of using this approach for the narrow strip of coastal Scrub and/or the narrow drainage reserves was examined during the analysis process, but disregarded after consultation with As the Project Reference Group.

Where the distribution of the Classified and Modified vegetation permits only narrow head fire development (due to being restricted by Low Threat areas on either side), a building will receive less radiant heat than assumed by Method 1 of AS 3959-2009, which assumes a flame width of 100m, i.e. the dwelling is being impacted by radiant heat emitted from a 100m wide head fire (Standards Australia, 2009). The View Factor radiant heat modelling was corrected for the maximum width of flame front possible for that site.

Radiant heat from flames more than 100m distant is negligible and not considered by AS 3959-2009.

7.2.3 Topography

Effective slopes are those under Classified vegetation (Standards Australia, 2009). Effective slopes were determined for lots by analysis of 2.5m interval contours (refer Map 6).

Slopes were classified as upslopes or downslopes in relation to the lots based on the elevation of the slope in relation to lots/dwelling locations and credible direction of fire spread through the Classified or Modified vegetation. The site slope defaulted to the effective slope as applies in Tables 1 and 2 to Clause 52.47-3 (DTPLI, 2014b).

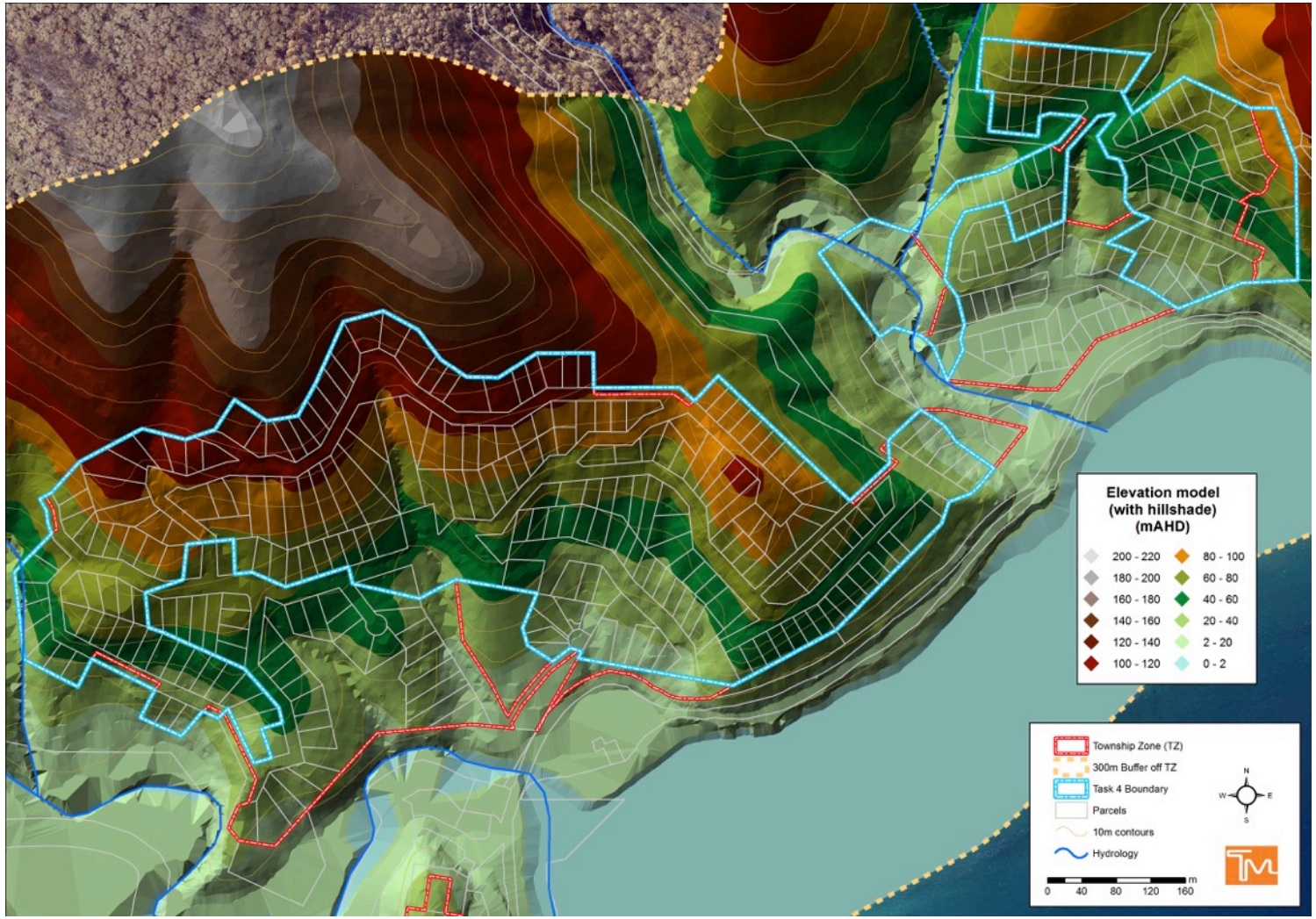
Steep downslopes

In recognition of the steep terrain, which goes beyond the parameters of AS 3959-2009 and Table 1 of Clause 52.47, the additional slope classes of >20-25^{o} and >25-30^{o}, and >30^{o} were mapped.

Modelling of fire behaviour on such steep slopes is problematic, and produces unrealistically large flame lengths (Tolhurst and Howlett, 2003). On effective down slopes greater than 30^{o} convective heating of the building becomes a significant factor (Tolhurst and Howlett, 2003), and the standard slope vs rate of spread relationship may not hold due to fuel discontinuity on such steep slopes (Cheney, 1981). Convective heating is not considered by AS 3959-2009/BMO and slopes greater than 30^{o} are outside the scope of the Standard (Standards Australia, 2009).

As discussed at Project Reference Group Meetings 2 and 3, an upper threshold for forward rate of spread was utilised to cap the resulting flame lengths based on the peak rates of spread reported for major bushfires under Code Red FFDIs.

Corrected forward rates of spread and flame length were calculated for all slopes >20^{o} using the equations used in AS 3959-2009 (Standards Australia, 2009), but with the rate of spread capped at 14km/h. This is in line with Tolhurst and Howlett (2003) who capped forward rate of spread at 14km/h and fire intensity at 120,000kW/m in their House Ignition Likelihood Index (HILI) on the grounds that these were the maximum ever recorded under extreme weather conditions, and the Wildfire Management Overlay that likewise capped intensity at 120,000kW/m for the purpose of determining defendable space requirements under an FFDI of 120 (Maughan and Krusel, 1999).



Map 6 - Topography of Wye River and Separation Creek.

It should be noted that spotting heavily influences the rate of spread of large fires in eucalypt forest. The average or peak rates of spread reported in the literature include the effect of the fire spotting hundreds of metres to a few kilometres ahead of itself, and thus over report the actual speed of the flame front burning through the fuel. Conversely, it should also be recognised that the reported rates of spread are typically long term (several hours) averages with the short-lived effect of short steep downslopes averaged out.

In accordance with AS 3959-2009 forward rate of spread in Forest was calculated as:

$$R = 0.0012*FDI*w$$

Where: R = Rate of spread (km/h)
FDI = Forest Fire Danger Index
w = Surface fuel load (t/ha)

Noble *et al.* (1980)

In accordance with AS 3959-2009 forward rate of spread in Scrub was calculated as:

$$R = 0.023*V^{1.21}*VH^{0.54}$$

Where: R = Rate of spread (km/h)
V = Average wind speed at 10m above ground level (km/h)
VH = Average height of Classified vegetation (m)
w = Surface fuel load (t/ha)

The equation used by AS 3959-2009 to correct for the effect of downslope on forward rate of spread is:

$$R_{slope} = R \exp (0.069 \text{ slope})$$

Where: R_{slope} = forward rate of spread adjusted for effective slope (km/h)
R = forward rate of spread (km/h)
Slope = effective slope (^{o})

Noble *et al.* (1980)

Upslopes

As a precautionary approach AS 3959-2009 and the BMO treat all upslopes as flat land for the purpose of modelling fire behaviour and hence defendable space requirement (Standards Australia, 2009; DTPLI, 2014b). In reality, fires burn relatively more slowly coming down a hill (Cheney, 1981), although the effect of an upslope in decreasing the rate of spread is less than that of a downslope of the same steepness in increasing the rate of spread (McArthur, 1967). Other researchers have reported that the rate of spread on upslopes decreases until a gradient of about 20^{o} and then increases again, until on an upslope of 45^{o} it is similar to flat ground (Van Wagner, 1988; Rossa *et al.*, 2015).

A number of homes on the perimeter of the settlements are exposed to a Forest fire burning down hill towards them (i.e. upslopes). It should be noted, however, that many of these homes are also exposed to Modified vegetation on steep downslopes below them, and their BAL will also need to respond to this Modified vegetation.

Method 2 of AS 3959-2009 assumes that the rate of spread will be less on an upslope and that the defendable space and/or BAL requirements can be lowered. Where Method 2 modelling of upslopes was considered appropriate, the effect of an upslope was capped at 10^{o}. This is more conservative than the advice provided in Appendix B of AS 3959-2009 'that there is limited evidence supporting the relationship for adjusting the forward rate of spread on steeper slopes. Therefore, where the effective upslope is greater than 15 degrees, then 15 degrees is used' (Standards Australia, 2009).

The equation used by AS 3959-2009 to correct for the effect of upslope on forward rate of spread is the inverse of that used for downslopes (and thus appears to misrepresent McArthur (1967)). The equation is:

$$R_{slope} = R \exp(-0.069 \text{ slope})$$

Where: R_{slope} = forward rate of spread adjusted for effective slope (km/h)
R = forward rate of spread (km/h)
Slope = effective slope (^{o})
Noble *et al.* (1980)

7.2.4 Fire Weather

The weather factors that result in severe bushfires include high temperatures, dry air, lack of rain and strong winds. These factors are represented by the Forest Fire Danger Index (FFDI). The FFDI indicates the level of bushfire threat (i.e. the likelihood of a fire igniting and spreading and the difficulty of suppression) on a given day based on a set of fuel moisture and weather conditions. The FFDI is most commonly used by fire services to forecast bushfire threat and predict potential fire behaviour, which is then used to undertake operational planning and preparedness. The CFA also use the FFDI to issue fire warnings to communities, scaling the FFDI into a set of Fire Danger Ratings that correspond with the level of threat (see Table 7).

The FFDI is also a critical input for calculating the anticipated rate of spread of a bushfire in Forest, the resultant flame length and hence extent of defendable space or BAL setback distance required to reduce radiant heat to acceptable levels.

Table 7 - Forest Fire Danger Ratings (CFA, 2009).

Fire Danger Rating	Forest Fire Danger Index
Low-Moderate	0-11
High	12-24
Very high	25-49
Severe	50-74
Extreme	75-99
Code Red	100+

The FFDI is based on four weather inputs; the Drought Factor (DF) (0-10), relative humidity (RH) (%), temperature (T) (°C) and wind speed (V) (km/h). The drought factor represents the dryness of the fine fuel on a scale of 0 to 10, with 10 being the driest and is used to represent fine fuel availability. The FFDI equation is shown below:

$$FFDI = 2.e^{(-0.45 + 0.987.\ln(DF) - 0.0345.RH + 0.0338.T + 0.0234.V)}$$

Where: FFDI = Forest Fire Danger Index
DF = Drought factor
RH = Relative humidity (%)
T = Air temperature (^{o}C)
V = Wind speed (km/h)

Noble *et al.* (1980)

The BMO adopts the AS 3959-2009 methodology, which applies an FFDI of 100 to all of Victoria, other than alpine areas, to calculate rate of spread for Forest vegetation (Standards Australia, 2009).

In Scrub, an average wind speed of 45km/h and average vegetation height of 3m is used to calculate rate of spread instead of FFDI (Standards Australia, 2009).

A preliminary analysis of extreme fire weather in the Otways found that FFDIs greater than 100 had been recorded at Aireys Inlet and locations immediately north of the ranges, although not at Cape Otway or Weeaproinah (Terramatrix, 2013).

Adoption of FFDI 100 across all of non-Alpine Victoria is a State policy decision. It is important to note that the FFDI 100 benchmark is intended to represent a 'one size fits all' model of extreme fire weather conditions. It is not intended to be necessarily the worst case conditions for any particular location. There is no compelling reason to vary the FFDI for the Wye River/Separation Creek study area.

It should also be noted that climate change may increase the likelihood of weather conditions that lead to bushfires (Hennessy *et al.*, 2006; Lucas, 2007). Climate modelling predicts an increased number of extreme (or worse) fire weather days and lengthened fire season (Clarke *et al.*, 2013).

7.3 BAL Assessment Methodology

7.3.1 Method 1

Method 1 of AS 3959-2009 was used where it is considered all of the following criteria are likely to be met:

- Steady-state rate of spread will be reached;
- Building will be exposed to a 100m wide flame;
- Classified vegetation poses a bushfire hazard within 150m of the building, and
- The effective downslope does not exceed 20°.

In effect, this was the application of Table 1 defendable space/BAL combinations from Clause 52.47.1 that apply to single dwelling applications (or works associated with single dwellings) in residential and rural-residential zones.

The inputs and assumptions of Method 1 are detailed in Table 2.4.1 and Table B2 of AS 3959-2009 (Standards Australia, 2009).

7.3.2 Method 2

Application

Method 2 of AS 3959-2009 was used where the effective downslope exceeded 20o or was an upslope.

Inputs

Inputs to Method 2 calculations:

- FFDI = 100 (BMO default)
- Flame temperature = 1090K (BMO default)
- Height of receiver – Calculated on worst case flame angle and height as per AS 3959-2009.
- Emissivity – 0.95 as per AS 3959-2009 default.
- Fuel loads = BMO defaults for Forest (25t/ha surface and 35t/ha overall) and Scrub (25t/ha) as applicable
- Scrub height = 4m (as measured on site)
- Down slopes >20° = Modelled for a maximum forward rate of spread of 14km/h (equivalent to a 22°-23° downslope).
- Up slopes = Modelled as -10° upslopes (the range of upslopes was -12° to -20°) (n.b. this is more conservative than advice in Appendix B of AS 3959-2009 which stipulates maximum of -15° (Standards Australia, 2009))
- Run length for inliers of Classified vegetation = Considered on a site-specific basis dependent on distribution of Classified and Modified vegetation and effective slope under that vegetation.
- Head fire width for inliers of Classified vegetation = Considered on a site-specific basis dependent on distribution (and separation) of Classified and Modified vegetation.

The validity of altering BMO default inputs or assumptions needs to be considered in respect to individual sites, and taking the broader landscape context into consideration.

Note on shielding

Attenuation of radiant heat by vegetation, topography or buildings between the flames and the receiver (i.e. house being assessed) can significantly reduce the radiant heat the house receives over time as the fire approaches (Siggins *et al.* 2013, Newnham *et al.*, 2013, 2014).

AS 3959-2009 allows for the shielding effect of the building itself to be considered in determining a lower BAL for elevations not exposed to the source of bushfire attack. That is, if all of the straight lines between that elevation and the source of the bushfire attack are obstructed by another part of the building, then the construction requirements for the shielded elevation can be reduced to the next lower BAL than that determined for the exposed elevation (Standards Australia, 2009).

AS 3959-2009 is silent, however, on quantifying the effect of other objects in blocking the radiant heat reaching a building. CSIRO have described approaches to do this (Siggins *et al.* 2013, Newnham *et al.*, 2013, 2014), but this work is developmental and has not, to our knowledge, been used in BMO applications and requires data and analysis beyond the scope of this project.

Consideration of shielding requires the direction of fire approach to be known, and then the orientation of the receiver (house) and potential shielding object(s) in relation to the hazardous vegetation, and the proximity and relative elevation of the building and the potential shielding object(s) in relation to the predicted flame height, will determine to what extent the receiver is shielded (RFS, 2007). It is not possible to assess the impact of shielding without having the dimensions (height and area) and exact location of all buildings in the vicinity (including those that survived the fire and those to be re-built). Shielding has therefore not been applied.

The presence of Modified vegetation throughout the settlement would also limit the effectiveness of shielding in reducing BALs, as the bushfire hazard may not be limited to one direction.

Note on flame immersion

The decrease in radiant heat with distance from the flame is measured from the mid-point of the flame. Radiant heat diminishes rapidly with distance from the heat source (in accordance with the inverse square law). This means that in some situations radiant heat (measured from the mid-point of the flame) will have dropped significantly, e.g. to less than 29kW/m^2, but the receiver (in our case a building) will actually be within the theoretical flame length. This phenomenon may occur with Method 2 modelling and also occurs with the some of the Table 1 distances in Clause 52.47 without resulting in an increase in the BAL or construction level.

The theoretical flame length was mapped for the purpose of providing information to the Project Reference Group.

In accordance with AS 3959-2009 flame length in Forest was calculated as:

$$Lf = [13R_{slope} + 0.24W]/2$$

Where: Lf = Flame length (m)
R_{slope} = Forward rate of spread adjusted for effective slope (km/h)
W = Overall fuel load

RFS (2001)

In accordance with AS 3959-2009 flame length in Scrub was calculated as:

$$Lf = 0.0775I^{0.46}$$

Where: Lf = Flame length (m)
I = Fireline intensity (kW/m)

Byram (1959)

7.4 BAL Results

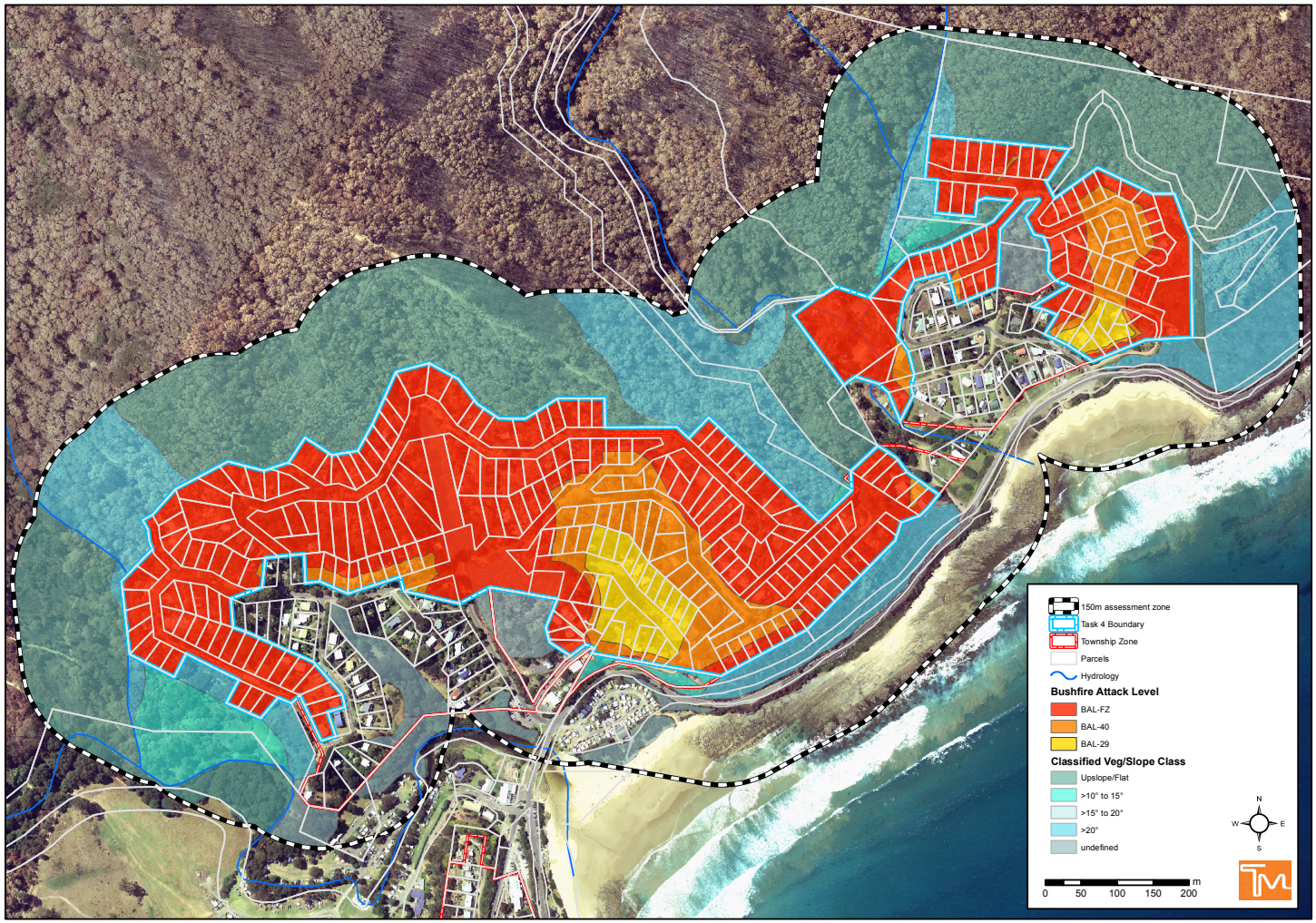
7.4.1 BALs Assuming Status Quo Vegetation

The BAL results assuming that the vegetation across the settlements is the same as when it was classified for the 2013 Bushfire Technical Report (refer Map 2) are provided in Map 7. The presence of large areas of classified Forest within the residential areas provides an extensive BAL-FZ area, showing the importance of managing vegetation across the study area to a Modified standard at least.

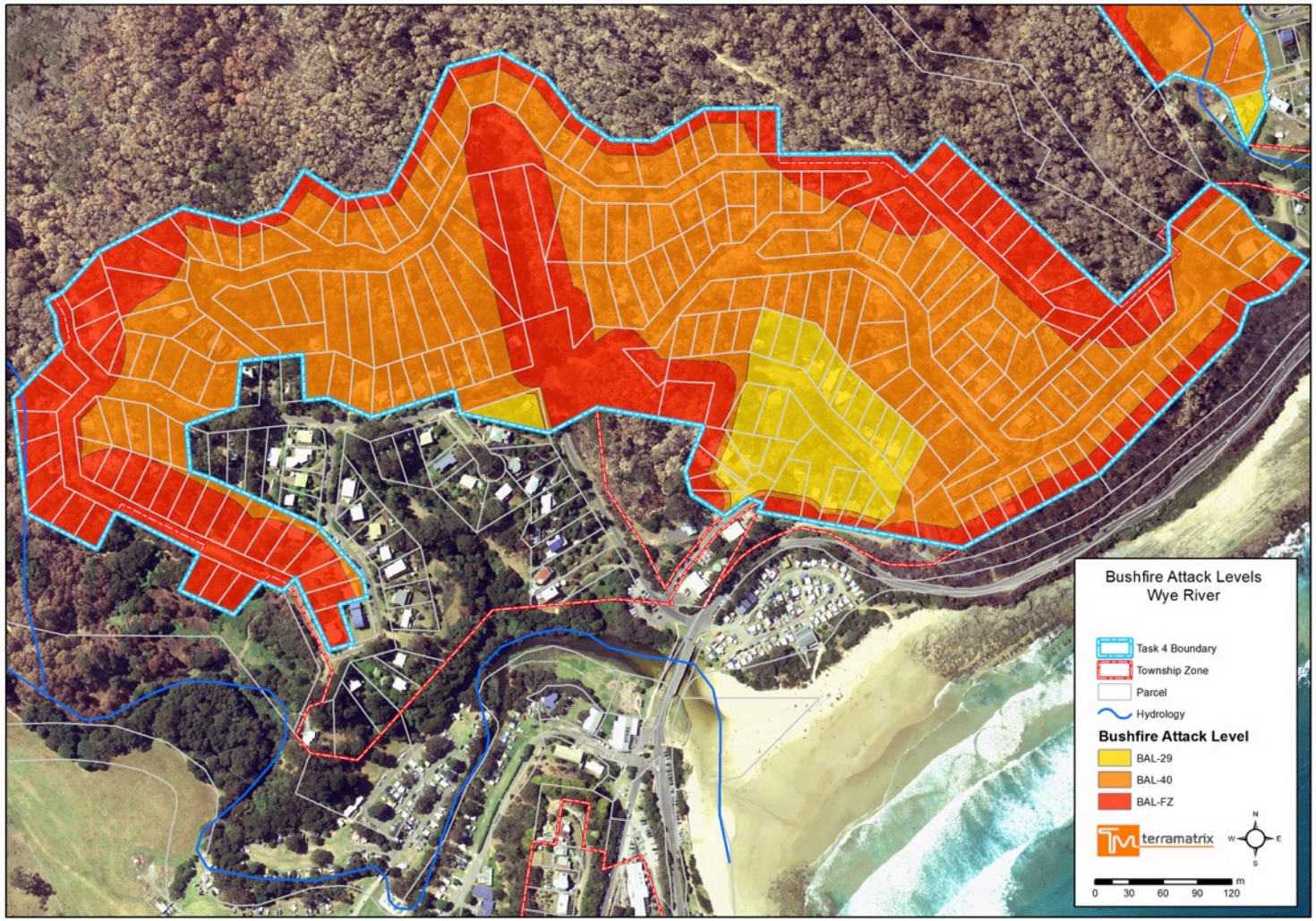
7.4.2 BALs Assuming Managed Vegetation Scenario 1

The BAL results assuming that vegetation across the settlements will be managed as per Managed Vegetation Scenario 1 (refer Map 3) and that dwellings will provide requisite defendable space are presented in Map 8 for Wye River and Map 9 for Separation Creek. There is a band of BAL-FZ immediately adjacent to classified vegetation adjoining or within the settlements. In general this band only constrains those lots immediately adjacent to classified vegetation on a steep downslope. In most other situations only a portion of the lot is within the BAL-FZ band and, depending upon siting of a future dwelling, a lower BAL may be achieved.

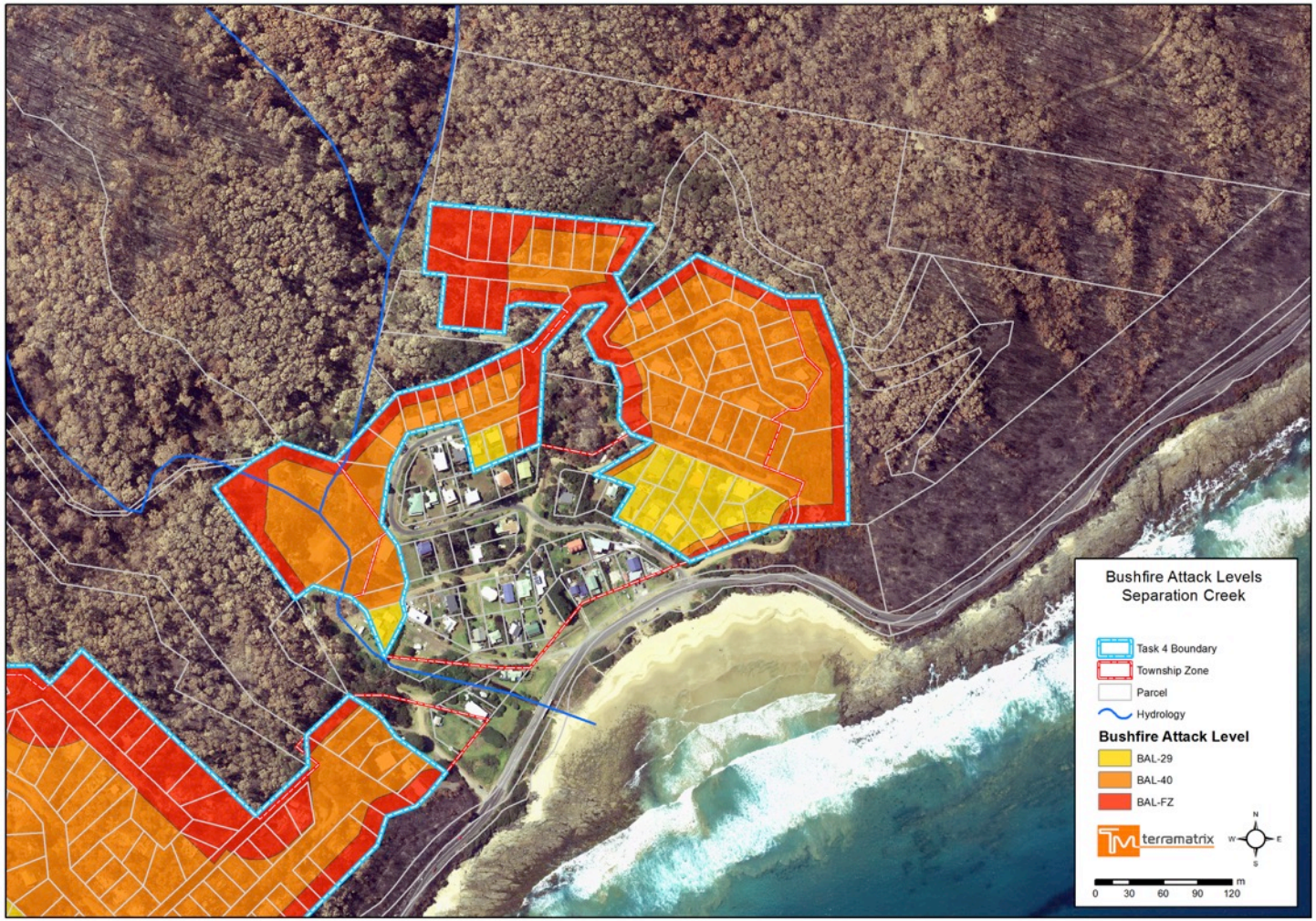
Dwellings exposed only to Modified vegetation are assigned either a BAL-40 or BAL-29. BAL-40 lots are generally where there is Modified vegetation down hill from them through which a fire could burn up the hill towards them. A scenario in which this could occur are spot fires into the Modified vegetation being drawn back by the convective updraft of a large fire approaching the settlements. The criteria for determining BAL-40 or BAL-29 are discussed further in Section 7.5.2.



Map 7 - BAL results for Wye River and Separation Creek assuming Status Quo Vegetation Scenario.



Map 8 - Wye River BAL results for Managed Vegetation Scenario 1.



Map 9 - Separation Creek BAL results for Managed Vegetation Scenario 1.

7.5 Discussion

7.5.1 Vegetation Management

Vegetation management in the Wye River and Separation Creek study area is required for two purposes:

1. At settlement scale to ensure that a sufficient area of vegetation is managed to qualify the interior of the residential area as Modified vegetation pursuant to the requirements of the BMO; and
2. At an individual dwelling scale to provide the requisite defendable space to enable the nominated BAL construction standard in response to classified and/or Modified vegetation.

A significant amount of vegetation management is required to enable any of the BAL responses described in Section 7.4.

This vegetation management needs to be reasonably assured and ongoing for the life of the dwelling (unless altered by change in situation or regulation at a later date). There are, however, significant constraints to meeting both the amount and standard of defendable space stipulated by the BMO (refer Section 7.5.6).

7.5.2 Appropriate Response to Modified Vegetation

For lots exposed only to Modified vegetation and where defendable space for 50m or the property boundary, whichever is lesser, can be reasonably assured, we consider the most appropriate construction standard to be BAL-40. This is in recognition of:

- The distribution of significantly sized patches of vegetation on slopes greater than 20^{o} that are unlikely to be managed as defendable space on a reliable ongoing basis (see Map 10);
- The probability that on some other slopes, less than 20^{o} but still steep, ongoing management of grass and shrubs and clearing of leaf litter will be difficult for some residents;
- The prevalence of holiday homes with periodic and short-term occupancy and where the owner responsible for vegetation management may be absent for extended periods;
- The need to protect soil stability on steep slopes precludes the removal of canopy trees to achieve the canopy cover and separation distances required for defendable space;
- The steep slopes promoting elongated flames in close proximity to dwellings; and
- The tendency for dwellings built on the slopes (and to good hillside design principles - refer Smith, 2016) to be elevated above the fall of the land, potentially with flames and radiant and convective heat impacting the underside of the elevated building elements.

Increasing BALs are designed to withstand increasing levels of bushfire attack (see Figure 2 and Table 2) and as such, there are significant differences between BAL-29, BAL-40 and BAL-FZ construction requirements.

For lots exposed only to Modified vegetation and where defendable space for 50m or the property boundary, whichever is lesser, cannot be reasonably assured, Approved Measure 1.2 of Clause 52.47-1 would require BAL-FZ. This is discussed further in Section 7.5.3 and 7.5.7.

7.5.3 BAL-FZ

A number of lots on the perimeter of the settlements were assessed as potentially BAL-FZ. Approved Measure 1 at Clause 52.47-1 of the Colac Otway Planning Scheme allows for BAL-FZ construction on lots in the Township Zone. Our understanding is that the zoning is being used as a proxy for the level of bushfire risk, with the reasoning being that lots in existing settlements are likely to be in a less hazardous landscape setting than those in rural zones.

Given the extreme landscape bushfire risk facing Wye River and Separation Creek, we believe it pertinent to also consider Alternative Measure 3.5 at Clause 52.472-2 that applies to lots not in a Neighbourhood Residential Zone, General Residential Zone, Residential Growth Zone, Urban Growth Zone, Low Density Residential Zone, Township Zone or Rural Living Zone. Alternative Measure 3.5 states:

'A building used for a dwelling (including an extension or alteration to a dwelling) may provide defendable space to the property boundary where it can be demonstrated that:

- The lot has access to urban, township or other areas where:
  - Protection can be provided from the impact of extreme bushfire behaviour.
  - Fuel is managed in a minimal condition.
  - There is sufficient distance or shielding to protect people from direct flame contact or harmful levels of radiant heat.
- Less defendable space and a higher construction standard is appropriate having regard to the bushfire hazard landscape assessment.
- The dwelling is constructed to a bushfire attack level of BAL-FZ.

This alternative measure only applies where the requirements of AM 3.1 cannot be met.'

(Colac Otway Planning Scheme, 2014b)

Planning Practice Note 65 advises that Landscape Types 3 and 4 are more complex and additional information will be required to support an application for BAL-FZ.

Provision of a private bushfire shelter (a Class 10c building within the meaning of the Building Regulations 2006) can reduce the assessed BAL by one level (Colac Otway Planning Scheme, 2014b), i.e. in the case of those lots assessed as BAL-FZ allow BAL-40 construction.

Provision of private bushfire shelters in combination with the BAL-40 construction being proposed for many lots in response to the Modified vegetation on steep slopes within the settlements, would allow these lots to meet the Approved Measures of Clause 52.47 even if

it is not practicable to provide BMO defendable space for 50m or to the property boundary. Installation of private bushfire shelters might, however, be problematic on the steep slopes.

7.5.4 Perimeter APZ

An APZ is proposed outside of the settlement boundary as shown on Map 5. The APZ contains a range of slopes, some greater than 20°. The APZ should be maintained to the following standard through the Fire Danger Period.

APZ area	Vegetation management standard
Steep (>20°)	Stringybark tree species removed. Tall shrubs (>3m in height) removed.
Moderate slope (<20°)	Stringybark tree species removed Understorey species are cut to 10cm from ground level during the Fire Danger Period.

7.5.5 Defendable Space

Defendable space is defined as 'an area around a building where vegetation is modified and managed to reduce the effects of flame contact and radiant heat associated with a bushfire' (DTPLI, 2014a). Under the BMO, the BAL for a dwelling requires that the requisite distance of defendable space be provided between the building and the hazardous vegetation. The requisite defendable space distances for the study area are shown in Table 8.

Table 8 - Defendable space requirements for a range of BALs for the vegetation and slope combinations found in the Wye River and Separation Creek study area.

Vegetation Type	Effective Slope Class	Defendable Space Distance (m)		
		BAL-29	BAL-40	BAL-FZ
Forest	Upslope ≥10°[2]	17	13	<13
	Flat or Upslope <10°	25	19	<19
	Downslopes >0-5°	32	24	<24
	Downslopes >5-10°	39	31	<31
	Downslopes >10-15°	49	39	<39
	Downslopes >15-20°	61	50	<50
	Downslope >20°[3]	67	56	<56
Scrub	Downslopes >15-20°	21	15	<15
Modified	All	50 or property boundary	50 or property boundary	To satisfaction of responsible authority

Where a dwelling is exposed only to Modified hazardous vegetation a range of BALs (BAL-29, BAL-40 or BAL-FZ) are possible depending upon the extent to which the vegetation is managed (DTPLI, 2014a) and whether the defendable space in Table 8 can be provided.

[2] Method 2 calculation with upslope capped at 10°.

[3] Method 2 calculation with forward rate of spread capped at 14km/h.

The standard of vegetation allowed within the defendable space is described by *Planning Practice Note 65* (DTPLI, 2014a) and CFA (2014) (see Table 9).

Table 9 - Vegetation management standard for defendable space.

Planning Practice Note 65	CFA Standard Permit Conditions
• Within 10m of a building flammable objects such as plants, mulches and fences must not be located close to the vulnerable parts of the building such as windows, decks and eaves. • Trees must not overhang the roofline of the building; touch walls or other elements of a building. • Grass around properties should be kept short. 5cm or less is considered short. All leaves and vegetation debris must be removed at regular intervals. • Shrubs should not be planted under trees. • Plants greater than 10cm in height at maturity must not be placed directly in front of a window or other glass feature. • Tree canopy separation of two metres and overall canopy cover of no more than 15% at maturity.	• Grass must be short cropped and maintained during the declared fire danger period. • All leaves and vegetation debris must be removed at regular intervals during the declared fire danger period. • Within 10m of a building, flammable objects must not be located close to vulnerable parts of the building. • Plants greater than 10cm in height must not be placed within 3m of a window or glass feature of the building. • Shrubs must not be located under the canopy of trees. • Individual and clumps of shrubs must not exceed 5 square metres in area and must be separated by at least 5m. • Trees must not overhang or touch any elements of the building. • The canopy of the trees must be separated by at least 5m. • There must be a clearance of at least 2m between the lowest tree branches and ground level.

7.5.6 Constraints on Providing Defendable Space

The steep slopes within the residential area of both settlements make vegetation management to create and maintain defendable space difficult (refer Table 10). Map 10 and Map 11 show contiguous areas of potentially unmanageable vegetation greater than 100m^2 in size and on slopes greater than 20^o. The threshold of 20^o was selected, as beyond this gradient ongoing vegetation management would be difficult. Roads, house sites or domestic zones within 10m of house sites have been excluded on the basis that they are likely to be actively managed in a non-vegetated or Low Threat state.

Where slopes greater than 20° occur within the property boundary and within 50m of the proposed dwelling then the lot is unlikely to be able to provide assurance of ongoing defendable space for 50m or the property boundary, whichever is closer, as required by Table 1 of Clause 52.47. In these instances, a BAL-FZ construction may be required to comply with the BMO.

Landscapes on steep slopes can be difficult to maintain. Machinery such as tractors and mowers are limited to working on slopes within the design limits of the machine, the site constraints and the operators' experience that above 15° there are limitations viable options, and that maintenance would most commonly be by people working on foot.

The results of the geo-technical survey currently in progress may also inform the feasibility of various types and extents of vegetation management.

Table 10 - Site slopes and maintenance limitations.

Slope (degrees)	Management options
5°	Almost no limitations
10°	Few limitations
15°	Maximum slope for a "standard" ride on mower to be used in either direction (Cox Lawn Care Products, 2015)
20°	Above 21° a 15m horizontal buffer required around drainage lines on erosive soils. On steep slopes (greater than 20°), engineering advice will assist in minimising the risk of road failure (DEPI, 2014a)
25°	Maximum slope for an "all-terrain" mower (e.g. Razorback CMX227)
30°	Ground based machinery must not be used for logging coupes above 30°, cable logging can be used above 30 degrees where the risk of soil movement is not too high (DEPI, 2014b)
34°	Maximum slope for self-levelling cabin mower (e.g. Harper industries ATM 162)

7.5.7 Potential for Altered Vegetation Management Requirements in Response to Modified Vegetation

The standard for vegetation within the defendable space is the same for all BALs, with only the width of the zone altering between BALs. This is despite the vegetation and other combustible objects within the defendable space contributing embers, radiant heat and potential flame attack on the building in addition to the attack from the Classified or Modified vegetation beyond the defendable space. Increasing BALs are designed to withstand increasing levels of radiant heat, and for BAL-40 and BAL-FZ, increasing levels of flame contact. Thus it is reasonable that buildings constructed to a higher BAL may be able to withstand more fuel/vegetation within the defendable space than buildings of lower BAL.

Table 11 details potential alternative standards for defendable space in the Wye River and Separation Creek study area. The alternative standard is for discussion purposes only, and DELWP and the Project Reference Group need to determine that it:

- Provides an adequate level of protection for BAL-40 buildings set in Modified vegetation; and

- Can be implemented given the difficulty of managing vegetation on steep slopes and the risk of landslip.

An intensively managed inner zone of 10m would be provided for all buildings regardless of the slope. This area is critical to house survival, and should be accessible for maintenance of vegetation. Beyond the inner zone would be an outer zone of an additional 40m or to the property boundary whichever is the lesser distance. Within the outer zone there would be ongoing vegetation management requirements on slopes of less than 20°, but these would be largely exempted on steep slopes greater than 20°. The inability to achieve the canopy foliage cover and separation distances would be compensated for by removing all tall shrubs (>3m) to provide vertical separation between fuel strata.

7.5.8 Mechanisms for Requiring Vegetation Management

There are a number of statutory mechanisms available for regulating the vegetation management necessary for the BALs presented in Section 7.4.

New/replacement dwellings in the area covered by the Incorporated Document

The requisite defendable space, whether to BMO standard or the proposed alternative standard described in Section 7.5.7, can be a requirement of the Incorporated Document for development of a dwelling or other works.

Existing dwellings in the area covered by the Incorporated Document and other parts of the settlements

There are several mechanisms available to facilitate vegetation management on lots with existing houses. These include:

- Promoting vegetation management to the agreed defendable space standard through community education and extension programs, e.g. providing an annual pre-summer green waste program;
- Highlighting residents' 10/50 right to clear vegetation under Clause 52.48 Bushfire Protection Exemptions (Colac Otway Planning Scheme, 2014c);
- Issuing Fire Prevention Notices pursuant to Section 41 of the *Country Fire Authority Act 1958* requiring the establishment and maintenance of the applicable defendable space.

Vacant lots

Given the narrowness of many lots within the settlements, many dwellings would benefit from the provision of defendable space beyond their property boundaries. Where this defendable space falls upon a vacant lot, a Fire Prevention Notice could be issued pursuant to Section 41 of the *Country Fire Authority Act 1958* requiring the establishment and maintenance of the applicable defendable space.

Abutting private forest

Flame and radiant heat impact from the forest immediately adjacent to the settlements can be mitigated by creation of an intensively managed APZ or fuel break around the perimeter

as illustrated in Managed Vegetation Scenario 3 (refer Section 6). The constraints of steep slopes may prevent the APZ being created in entirety, but even partial implementation would offer enhanced protection to some dwellings. The perimeter APZ or firebreak could be required by a Fire Prevention Notice issued pursuant to Section 41 of the *Country Fire Authority Act 1958*.

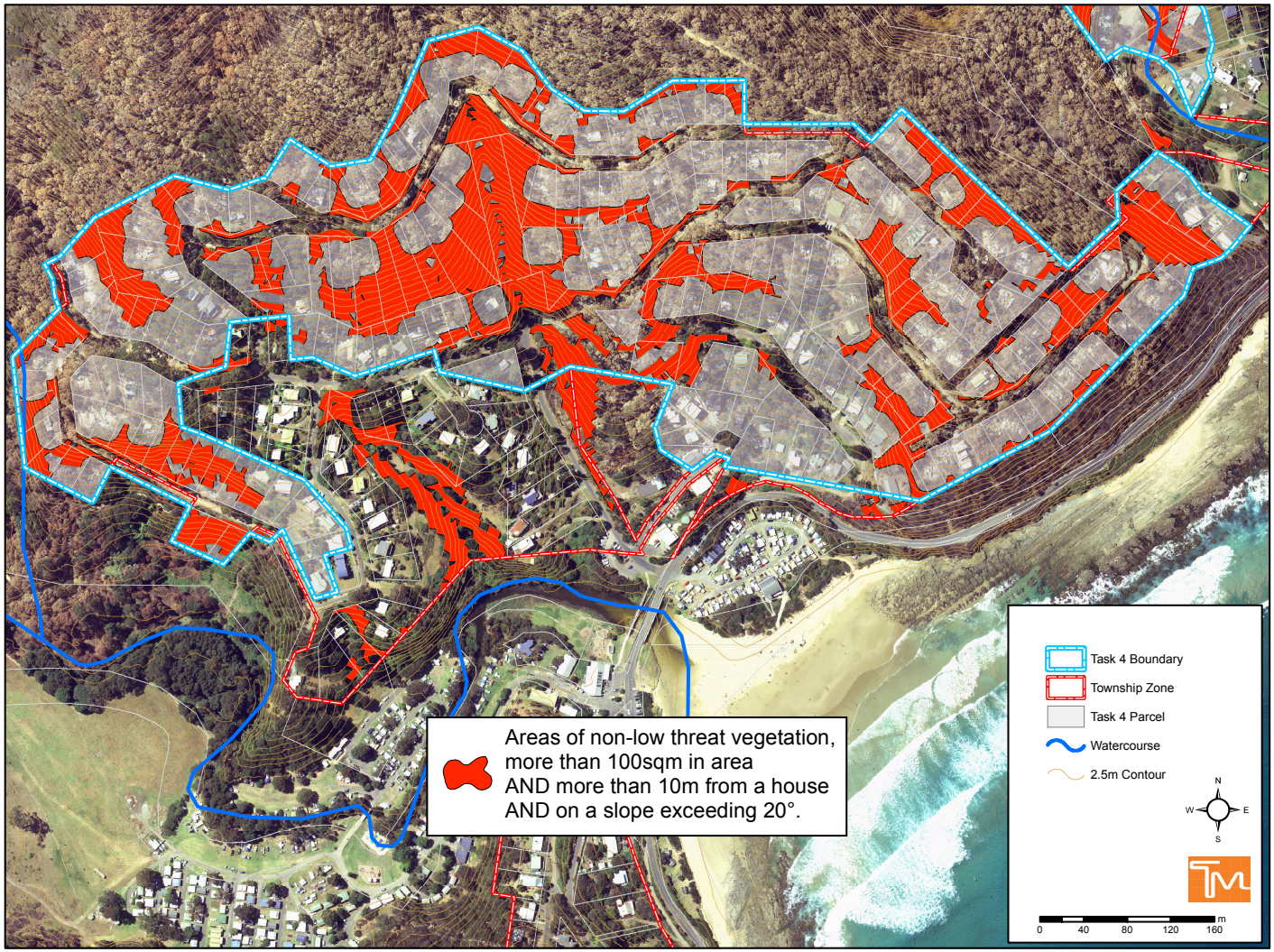
An alternative approach could be to negotiate an agreement with the owner for relevant parts of the land to be managed as part of the public land planned burning program. Whilst this may transfer cost and responsibility to government, the strategic importance of fuel management to the safety of Wye River and Separation Creek in the future means it may be a viable option.

Council managed road reserves

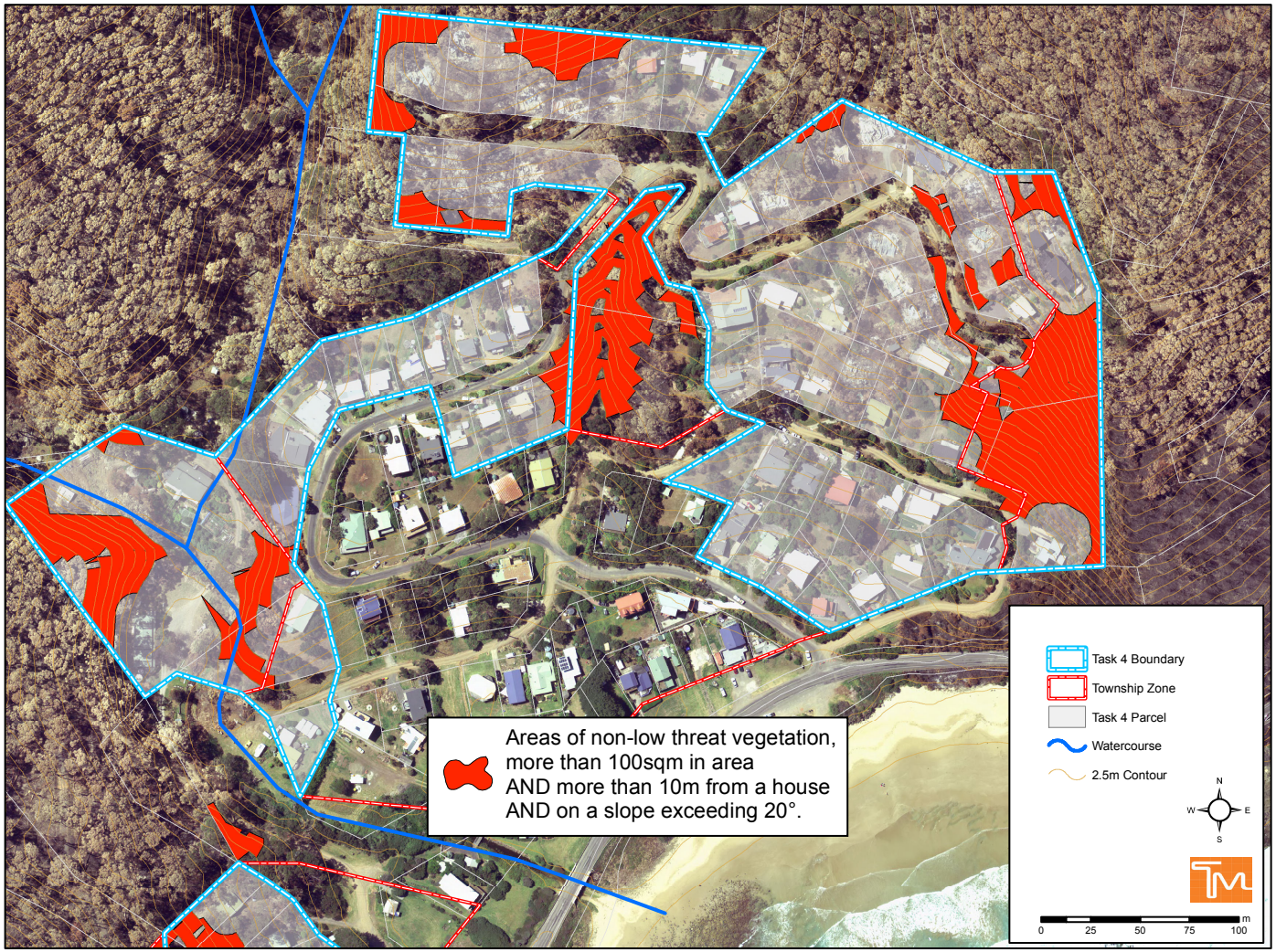
Council can seek an agreement with DELWP to exempt fuel management of the existing public road network from permit requirements for native vegetation removal. Road reserves that are, by definition, accessible from the road network may be easier to manage than some less accessible areas of private land.

Table 11 - Potential amended defendable space standards that respond to the site constraints and anticipated BAL of replacement buildings in Wye River and Separation Creek.

Vegetation/ Fuel Element	Inner Zone (10m depth from building)		Outer Zone (40m depth from inner zone)	
	Within 3m	Within 10m	Slope <20°	Slope > 20°
Leaf litter	All leaf litter and vegetation debris must be removed at regular intervals during FDP	All leaf litter and vegetation debris must be removed at regular intervals during FDP	All leaf litter and vegetation debris must be removed at regular intervals during FDP	As far as practicable
Grass	Grass close to homes must be short cropped (<5cm) during FDP	Grass close to homes must be short cropped (<5cm) during FDP	Grass must be slashed (<45cm) during FDP where accessible	As far as practicable
Mulch	Only non-combustible mulch is allowed	Only non-combustible mulch is allowed	No requirement	As far as practicable
Ground cover	Plants must be less than 10cm in height at maturity and from FireWise list	Plants must be less than 1m in height at maturity and from FireWise list	No requirement	As far as practicable
Shrubs	No shrubs permitted	Shrubs must be no more than 1m high at maturity and from the FireWise list	Shrubs must be no more than 3m at maturity and from the FireWise list	As far as practicable
		Shrubs must not be located under the canopy of trees	Shrubs must not be located under the canopy of trees	As far as practicable
		Shrubs must be separated from each other by 5m	Individual and clumps of shrubs must not exceed 5 square metres in area and must be separated by at least 5m.	As far as practicable
Trees	Trees must not overhang or touch the building	Trees must not overhang or touch the building	No requirement	No requirement
	No tree stems within 3m of buildings	Clearance of at least 2m between lowest branches and ground level	Clearance of at least 2m between lowest branches and ground level	No requirement
Combustible objects	No combustible objects within 3m of buildings	No combustible objects within line of sight of windows or within 6m of building	No requirement	No requirement



Map 10 - Contiguous areas of potentially difficult to manage vegetation more than 100 square metres in size and on slopes greater than 20° in Wye River.



Map 11 - Contiguous areas of potentially difficult to manage vegetation more than 100 square metres in size and on slopes greater than 20° in Separation Creek.

8 Key Task 5 - Additional Requirements

8.1 Evacuation Planning

The settlements of Wye River and Separation Creek were successfully evacuated in response to the threat of the 25 December 2015 bushfire. This action is credited with saving lives.

It should be noted, however, that the FFDI at the time was less than half that presumed by the BMO and there were several days notice that evacuation may be necessary. The scenario of a large fully developed high intensity forest fire impacting upon the settlement within 4-8 hours of ignition and under FFDI of 100 or more, should also be considered. Evacuation from the settlements is potentially dangerous unless conducted early. Egress from Wye River and Separation Creek is limited to the Great Ocean Road and runs through forest and/or coastal scrub that could be impacted by fire.

8.2 Community Bushfire Shelter

Neither of the settlements contains a Community Fire Refuge or a Neighbourhood Safer Place (NSP). There are, however, informal places within each settlement where people may congregate to seek information, assistance and moral support during a bushfire. This is likely to be community buildings near the Great Ocean Road (such as the Surf Life Saving Club) or the beach itself. As there are no NSPs and evacuation routes will be unsafe in some scenarios, these informal places may play a vital role, and consideration should be given to how they can be incorporated into agency planning and community/tourist education to improve public safety.

Alternatively, consideration should be given to a formal community place of shelter.

8.3 Private Bushfire Shelters

Provision of a private bushfire shelter (a Class 10c building within the meaning of the Building Regulations 2006) can reduce the assessed BAL by one level (Colac Otway Planning Scheme, 2014b).

Provision of a private bushfire shelter would result in the BAL-40 construction being proposed for manyt lots (either in response to the forest beyond the perimeter of the settlement or the modified vegetation on steep slopes within the settlements) meeting the relevant Approved Measure of Clause 52.47 even if it was not practicable to provide defendable space for 50m or to the property boundary.

Installation of private bushfire shelters might, however, be problematic on the steep slopes.

8.4 Vegetation Management Beyond the Residential Area

The amount of vegetation management credible within the residential area of Wye River and Separation Creek can increase the survivability of individual buildings and moderate, but not prevent, fire spread and behaviour within the settlement. It cannot, however, fundamentally alter the likelihood or intensity of a bushfire reaching the settlements.

Moderation of fire behaviour of an approaching bushfire requires large strategic areas of fuel management in the run up to the settlements. DELWP landscape fire risk modelling using the Phoenix fire spread simulator should identify priority areas of forest for fuel management to reduce the likelihood and severity of a fire reaching Wye River and Separation Creek. The fact that much of this forest is in private, rather than public, ownership may complicate fuel management planning, but given its importance to the safety of the settlements it should be addressed.

Flame and radiant heat impact from the forest immediately adjacent to the settlements can be mitigated by creation of an intensively managed APZ or fuel break around the perimeter as illustrated in Managed Vegetation Scenario 3 (refer Section 6). The constraints of steep slopes may prevent the APZ being created in entirety, but even partial implementation would offer enhanced protection to some dwellings.

9 Conclusion

The landscape scale bushfire risk of the Otways is extreme with potential for very intense fire behaviour given the inputs of occasional elevated FFDIs, steep slopes and extensive eucalypt forests. The settlements of Wye River and Separation Creek occur within this landscape with little separation or differentiation between the Forest and the residential area.

The re-development of the fire affected areas of Wye River and Separation Creek in compliance with the BMO is severely constrained by the extremely steep slopes, adjacent Forest and small lot sizes that limit siting options and ability to provide reliably managed defendable space within the property boundary. Compliance with BMO requirement for defendable space is problematic for many lots.

BALs were assessed for lots across the study area for an agreed scenario of future vegetation management, that comprised all the private lots being managed as Modified vegetation as described by the BMO, and the reserves and adjacent forest being largely unmanaged. Detailed analysis using Method 2 of AS 3959-2009 was used to model radiant heat flux from the vegetation adjoining the perimeter of the settlements, whilst those lots exposed only to Modified vegetation were assigned BAL-40 or BAL-29 depending upon criteria outlined in this report.

It should be noted that under the BMO, the BAL for a dwelling requires that the requisite distance of defendable space be provided between the building and the hazardous vegetation. Thus the applicability of the BAL mapping in providing an acceptable risk, according to the BMO, is dependent on the geographic extent and fuel reduction standard of the vegetation management around and within the settlements. The BAL mapping assumes that the requisite defendable space will be provided. As discussed by the Project Reference Group, an alternative approach would be to achieve a net improvement in bushfire safety compared to pre-December 2015 conditions. A net improvement should be achievable by building to BAL-FZ, BAL-40 or BAL-29 as appropriate, even if compliance with the provisions of the BMO cannot be achieved on individual lots. This would be a pragmatic approach that recognises the significant constraints of the existing settlements, but is a policy decision for DELWP or government.

Building of dwelling to BALs and providing defendable space is, however, only one strategy for improving resilience to bushfire. Other approaches including evacuation planning, formal and informal places of shelter, and strategic fuel management beyond the boundaries of the settlement are also recommended.

10 References

ABCB (2015) *The Building Code of Australia: Volumes One and Two of the National Construction Code*. Australian Building Codes Board, Canberra.

AFAC (2005) *Position Paper on Bushfires and Community Safety*. Australasian Fire Authorities Council Limited, East Melbourne.

AFAC (2010) *Bushfires and Community Safety Position version 4.1*. Australasian Fire Authorities and Emergency Services Council, East Melbourne.

Blanchi R and Leonard J (2005) *Investigation of Bushfire Attack mechanisms Resulting in House Loss in the ACT Bushfire 2003*. Bushfire Co-operative Research Centre, Melbourne.

Blanchi R and Leonard J (2008) 'Property safety: judging structural safety'. In Handmer J and Haynes K (eds). *Community Bushfire Safety*. CSIRO Publishing, Collingwood.

Building Act, 1993. Parliament of Victoria, Melbourne.

Building Regulations, 2006. Parliament of Victoria, Melbourne.

Byram GM (1959) Combustion of forest fuels. In Davis KP (ed) *Forest Fire Control and Use*. McGraw-Hill, New York

CFA (1983) *The Major Fires Originating 16th February 1983*. Country Fire Authority, Melbourne.

CFA (2009) *Understanding Fire Danger Ratings*. Country Fire Authority, Burwood East.

CFA (2010) *Building in a Wildfire Management Overlay Applicant's Workbook 2010*. Country Fire Authority, Burwood East.

CFA (2011) *Landscaping for Bushfire: Garden Design and Plant Selection*. Country Fire Authority, Burwood East.

CFA (2012) *Planning for Bushfire Victoria: Guidelines for Meeting Victoria's Bushfire Planning Requirements*. Country Fire Authority, Burwood East.

CFA (2014) *Standard Permit Conditions (Bushfire Management Overlay)*. Viewed at www.cfa.vic.gov.au

Cheney NP (1981) Fire behaviour. In Gill AM, Groves RH and Noble IR (eds) *Fire and the Australian Biota*. Australian Academy of Science, Canberra.

Cheney NP and Bary GAV (1969) The propagation of mass conflagrations in a standing eucalypt forest by the spotting process. *Collected Papers Mass Fire Symposium, Canberra, 10-12 February 1969*. Defence Standards Labs, Maribyrnong.

Clarke H, Lucas C and Smith P (2013) Changes in Australian fire weather between 1973 and 2010. *International Journal Of Climatology*, **33(4)** 931–944.

Colac Otway Planning Scheme (2011) *Clause 13.05 Bushfire*. Department of Environment, Land, Water and Planning. Viewed March 2016 at http://planningschemes.dpcd.vic.gov.au

Colac Otway Planning Scheme (2013) Schedule 1 to the Erosion Management Overlay. Department of Environment, Land, Water and Planning. Viewed March 2016 at http://planningschemes.dpcd.vic.gov.au,

Colac Otway Planning Scheme (2014a) *Clause 44.06 Bushfire Management Overlay*. Department of Environment, Land, Water and Planning. Viewed March 2016 at http://planningschemes.dpcd.vic.gov.au

Colac Otway Planning Scheme (2014b) *Clause 52.47 Planning for Bushfire*. Department of Environment, Land, Water and Planning. Viewed March 2016 at http://planningschemes.dpcd.vic.gov.au

Colac Otway Planning Scheme (2014c) *Clause 52.48 Bushfire Protection: Exemptions*. Department of Environment, Land, Water and Planning. Viewed March 2016 at http://planningschemes.dpcd.vic.gov.au

Colac Otway Planning Scheme (2015) *Clause 44.01 Erosion Management Overlay*. Department of Environment, Land, Water and Planning. Viewed March 2016 at http://planningschemes.dpcd.vic.gov.au

Country Fire Authority Act, 1958. Parliament of Victoria, Melbourne.

Cruz MG and Alexander ME (2013) Uncertainty associated with model predictions of surface and crown fire rates of spread. *Environmental Modelling and Software*, **47**, 16-28.

Cruz MG, Sullivan AL, Gould JS, Sims NC, Bannister AJ, Hollis JJ and Hurley RJ (2012) Anatomy of a catastrophic wildlife: The Black Saturday Kilmore East fire in Victoria, Australia. *Forest Ecology and Management*, **284**, 269-285.

DELWP (2016) *Request for Quotation and Project Specification for Wye River & Separation Creek – BAL Assessment Study*. Department of Environment, Land, Water and Planning, Melbourne.

Douglas G, Gooding O and Leahy, J (2014) *Vegetation Classes – Victorian Bushfire Management Overlay*. Country Fire Authority, East Burwood.

DPCD (2013) *Advisory Note 46, Bushfire Management Overlay Mapping Methodology and Criteria*. Department of Planning and Community Development, Melbourne.

DTPLI (2014a) *Preparing and Assessing a Planning Application Under the Bushfire Provisions in Planning Schemes*. Planning Practice Note 65, Department of Transport, Planning and Local Infrastructure, Melbourne.

DTPLI (2014b) *Clause 52.47 Planning for Bushfire*. Department of Transport, Planning and Local Infrastructure (DTPLI) <http://planningschemes.dpcd.vic.gov.au/schemes>.

Gibbons P, van Bommel L, Gill AM, Cary G, Driscoll DA, Bradstock RA, Knight E, Moritz MA, Stephens SL and Lindenmayer DB (2012) Land management practices associated with house loss in wildfires. *PLoS ONE* **7(1)**:e29212.doi10.1371/journal.pone.009212.

Gill AM, Bradstock R and Cohn J (2003) Fire management tradeoffs at the bushland-urban interface? *3rd International Wildland Fire Conference and 10th Annual AFAC Conference*, 2-6 October 2003, Sydney.

Hennessy K, Lucas C, Nicholls N, Bathols J, Suppiah R and Ricketts J (2006) *Climate Change Impacts on Fire-weather in South-east Australia*. CSIRO, Melbourne.

Hines F, Tolhurst K, Wilson A and McCarthy G (2010) *Overall Fuel Hazard Assessment Guide 4th Edition*. Department of Sustainability and Environment, Melbourne.

Leonard J (2009) *Report to the 2009 Victorian Bushfires Royal Commission – Building Performance in Bushfires*. http://www.royalcommission.vic.gov.au/Documents/Document-fiels/Exhibits/TEN-066-001-0001.pdf

Leonard JE and Bowditch PA (2003) Findings of studies of houses damaged by bushfire in Australia. *3rd International Wildland Fire Conference and 10th Annual AFAC Conference*, 2-6 October 2003, Sydney.

Long M (2006) A climatology of extreme fire weather days in Victoria. *Australia Meteorological Magazine*, **55**, 3-18.

Lucas C (2007) *Fire Climates Of Australia: Past, Present And Future.* Bureau of Meteorology Research Centre/Bushfire CRC, Melbourne.

Maughan D and Krusel N (1999) *WMO Site Assessment Methodology – A Technical Overview.* Country Fire Authority, Burwood East.

McArthur AG (1967) *Fire Behaviour in Eucalypt Forests*. Paper submitted to Ninth Commonwealth Forestry Conference, India. Leaflet No 107, Department of National Development Forestry and Timber Bureau, Canberra.

Newnham G, Blanchi R, Siggins A, Opie K and Leonard J (2014) *Bushfire Decision Support Toolbox Radiant Heat Flux Modelling - Case Study Two: Wangary, South Australia*. CSIRO, Melbourne.

Newnham G, Blanchi R, Leonard J, Opie K and Siggins A (2014) *Bushfire Decision Support Toolbox Radiant Heat Flux Modelling - Case Study Three: Springwood Fire New South Wales*. CSIRO, Melbourne.

Noble IR, Bary GAV and Gill AM (1980) McArthur's fire-danger meters expressed as equations. *Australian Journal of Ecology*, **5**, 201-203.

Ramsay C and Dawkins D (1993) *Building in Bushfire Prone Areas: Information and Advice*. CSIRO and Standards Australia, Melbourne.

Ramsay C and Rudolph L (2003) *Landscape and Building Design for Bushfire Areas*. CSIRO Publishing, Collingwood.

Rossa CG, Davim DA and Viegas DX (2015) Behaviour of slope and wind backing fires. *International Journal of Wildland Fire*, **24**, 1085-1097.

RFS (2001) *Planning for Bushfire Protection – A Guide for Councils, Planners, Fire Authorities and Home Owners*. NSW Rural Fire Service, Sydney.

RFS (2007) *View Factor*. Community Resilience Fast Facts 9/07. NSW Rural Fire Service, Sydney.

Siggins A, Leonard J, Newnham G, Blanchi R, Lipkin F. Opie K and Culvenor D (2013) *Modelling Radiant Heat Exposure at the Urban Fringe: Pine Ridge Road, Kinglake West, Case Study*. CSIRO, Bushfire CRC, Melbourne.

Smith T (2016) *Wye River and Separation Creek – Geotechnical, Land Capability and Wastewater Solutions*. Coffey Geotechnics Pty Ltd, Abbotsford.

Standards Australia (2009) *AS 3959-2009 Construction of Buildings in Bushfire Prone Areas*. SAI Global, Sydney.

Sullivan AL, Cruz MG, Ellis PFM, Gould JS, Plucinski MP, Hurley R, and Koul V (2014) *Fire Development, Transitions and Suppression Final Report*. Bushfire CRC, Melbourne.

Terramatrix (2013) *Colac Otway Shire Council Bushfire Planning Policy – Bushfire Technical Report*. Terramatrix, Collingwood.

Tibbits A, Handmer J, Haynes K, Lowe T and Whittaker J (2008) 'Prepare, stay and defend or leave early: Evidence for the Australian approach'. In Handmer J and Haynes K (eds) *Community Bushfire Safety*. CSIRO Publishing, Collingwood.

Tolhurst K (2005) *Conversion of Ecological Vegetation Classes (EVCs) to Fuel Types and Calculation of Equivalent Fine Fuel Loads with Time Since Fire, in Victoria*. Unpublished report. The University of Melbourne, Creswick.

Tolhurst K (2009) *Report on the Physical Nature of the Victorian Fires Occurring on 7th February 2009*. The University of Melbourne, Creswick.

Tolhurst K and Cheney NP (1999) *Synopsis of the Knowledge Used in Prescribed Burning in Victoria*. Department of Natural Resources and Environment, Melbourne.

Tolhurst K and Howlett K (2003) House Ignition Likelihood Index – An Hazard Assessment Method for Land Managers in the Wildland-Urban Interface. *Proceedings of 10th AFAC Conferences and 4th International Wildland Fire Conference*. Sydney.

Tract Consultants and Terramatrix (2014) *Colac Otway Planning Policy Project Final Report*. Tract Consulting, Richmond.

Van Wagner CE (1988) Effect of slope on fires spreading downhill. *Canadian Journal of Forest Research*, **18**, 818-820.

VBRC (2010) *2009 Victorian Bushfires Royal Commission Final Report*. 2009 Victorian Bushfires Royal Commission, Melbourne.

Wilson A and Ferguson I (1986) Predicting the probability of house survival during bushfires. *Journal of Environmental Management*, **23**, 259-270.

Appendix 1 Review of Colac Otway Bushfire Planning Policy Study

Purpose of the 2012/2013 Colac Otway Bushfire Planning Policy Study

The Colac Otway Bushfire Planning Policy Project was undertaken by Terramatrix and Tract Consultants to assess the bushfire risk at eight nominated settlements to inform the suitability of inland settlements for residential growth and to provide increased clarity in regards to development and bushfire risk mitigation in all the settlements. The *Colac Otway Bushfire Planning Policy Project Final Report* (Tract Consulting and Terramatrix, 2014) was provided to the Colac Otway Shire in May 2014. The report was underpinned by a strategic bushfire risk assessment documented in the *Colac Otway Shire Council Bushfire Planning Policy – Bushfire Technical Report* (Terramatrix, 2013). The report included:

- Bushfire context, including bushfire behaviour and descriptions of the Otways environment;
- The methodology used for assessing bushfire impact for each project part;
- Generic recommendations relating to bushfire; and
- Technical bushfire reports for each settlement.

Part One of the project was to assess the potential to develop Schedules to the Bushfire Management Overlay (BMO) that would streamline and improve planning decisions in regard to development of existing allotments in the Township zones of the coastal settlements of Skenes Creek, Kennett River, Separation Creek and Wye River; and the inland settlements of Beech Forest, Gellibrand, Lavers Hill and Forrest.

Two broad levels of assessment were conducted; a description of the landscape scale risk and then more detailed modelling of radiant heat flux and requisite BALs for dwellings within the settlements.

Summary of Bushfire Planning Issues

The following bushfire planning issues were identified for Wye River and Separation Creek:

- Large areas of the settlements interfaces the forest;
- Poor telecommunications coverage hindering effective warning of bushfire;
- The settlements are located within an inherently flammable landscape;
- Significant number of township zone lots that interface bushland;
- Few mechanisms for strategic fuel management of adjacent privately owned forest;
- Surety of public land fuel management;
- Increased population over summer due to tourism;
- The complex topography and high fuel load vegetation may facilitate intense fire behaviour impacting the settlements;
- Steep forested gullies running through the settlements, increasing the risk of fire penetration;
- Potential spotting into settlements and fire spread back up steep hills;

- Absentee landlords (may affect their ability/interest to maintain vegetation around properties);
- Limited egress via the Great Ocean Road and public road network that may limit firefighter access and public egress;
- No Community Fire Refuge or Neighbourhood Safer Place;
- Public road network that may limit firefighter access;
- Bush gardens that do not qualify as Low Threat under the BMO;
- Vegetation retention requirements under the VPP and preference by residents to retain a 'bush feel' within the settlement make it difficult to maintain shared defendable space;
- Small block sizes and steep slopes may limit ability to meet water requirements of the BMO; and
- Limited opportunity to replace dwellings that cannot meet standard BMO requirements.

Hazard Analysis

Fire History

Fire history records indicated that the landscape around Wye River and Separation Creek is capable of carrying large forest fires. The mapping of the 1939 bushfire indicated that the southwest flank of the fire came within 100 m of the current settlement boundary, possibly closer given the coarseness of the data. One wildfire of 6.5 ha, 8.5 km to the west of the settlements, had been recorded by DEPI within the previous 5 years. Other fires impacting the wider Victorian landscape indicated that the vegetation types of coastal scrub, heathland and forest will carry severe fire under the right conditions. The Ash Wednesday fire (1983) and the escaped fuel reduction burn at Moggs Creek (1994), among others, confirmed the the coastal environment is fire prone.

Fire Weather

An analysis of data collected at automatic weather stations (AWS) relevant to the Otways revealed that elevated FFDIs were infrequent but possible. Wye River and Separation Creek lie between the Aireys Inlet and Cape Otway AWS. The Aireys Inlet AWS is probably the most indicative of the weather patterns experienced at Wye River and Separation Creek, and is of high value to fire weather analysis due to the high frequency of recording (an observation every 30mins), however recordings are only from 1990. In that time there had been two days where the FFDI has peaked over 100. The 7th February 2009, gave the most extreme results with FFDI peaking at 150. The Cape Otway AWS has weather records since 1861. In this time there were only two days where the FFDI surpassed 75. These were both in the 1990s, the highest being 88 on 12th December 1994. It is likely that the frequency and severity of elevated FFDIs at Wye River and Separation Creek is between that experienced at Aireys Inlet and Cape Otway.

Other AWS within and surrounding the Otway ranges contributed to the bigger picture dataset, indicating that elevated FFDI's do occur in the Otways landscape. Although the

coastal location of the settlements may moderate temperature and relative humidity under all but the most extreme fire weather conditions, strong inland weather systems may dominate and, particularly after prolonged drought, catastrophic bushfire conditions cannot be discounted. All fire behaviour was therefore modelled using an FFDI of 120, consistent with the BMO at the time of the study.

Bushfire Scenarios

The Bushfire Technical Report identified potential for intense fire behaviour in the Otways given the inputs of occasional elevated FFDIs, steep slopes and extensive eucalypt forests.

A number of plausible scenarios for bushfire that could impact Wye River and Separation Creek were described. A large, well-developed forest fire could approach the settlements from several directions between north and south-west from Great Otway National Park and private forest. Long tracts of forest extending into both settlements may facilitate extreme bushfire behaviour in very close proximity to houses. Several areas of both settlements interfaced with forest meaning that the potential impact was assessed as high. Prolonged ember attack, radiant heat impact and direct flame impact were considered possible. Areas of forest and partially modified forest in the settlement could allow intense fire behaviour to reach beyond the houses on the settlement periphery. Smaller secondary ignitions in the coastal scrub may impact the seaward side of the settlement and could compromise accessibility on the Great Ocean Road.

A south-westerly wind change may mean that a fire in the Apollo Bay direction could impact the settlements. Under this scenario, the built up area of Wye River may ease conditions for Separation Creek, but a severe bushfire is expected to burn through both settlements. Unpredictable fire behaviour may occur close to or within the settlement due to the interaction of hot inland wind, coastal breeze, strong wind change and/or rolling topography. Significant impact to the houses and people of the community is possible.

Impact Analysis

Potential Bushfire Impact

The landscape scale bushfire risk of the Otways is extreme. The settlements of Wye River and Separation Creek were found to occur within this landscape risk with little separation or differentiation between the forest and the residential area. It was concluded that considerable investment in other risk reduction strategies would be required to fundamentally change this situation.

The study concluded that a fire that reached Wye River and Separation Creek would have the potential to expose the dwellings within the settlement to significant levels of flame and radiant heat. The modelling indicated that many allotments, many of which are already built on, have the potential to be exposed to levels of radiant heat that are likely to be in excess of what houses built prior to the introduction of AS 3959 have been built to withstand.

There was also a likelihood of extreme impact from embers, as stringy and ribbon barked tree species dominate the canopy in close proximity to the settlement boundaries, both of which are major contributors to spot fires.

Once fire entered the settlements, secondary ignition sources such as garden vegetation, dwellings, outbuildings etc. could become significant. These level of impact could not be modelled, but is likely to significantly add to the radiant heat load on buildings. The problem of house-to-house spread of fire is not dealt with well by the BMO or AS3959-2009, but may be a significant feature in areas with small allotments and steep slopes, such that that the flames from a burning house impinge on an adjacent neighbour or one further up the hill.

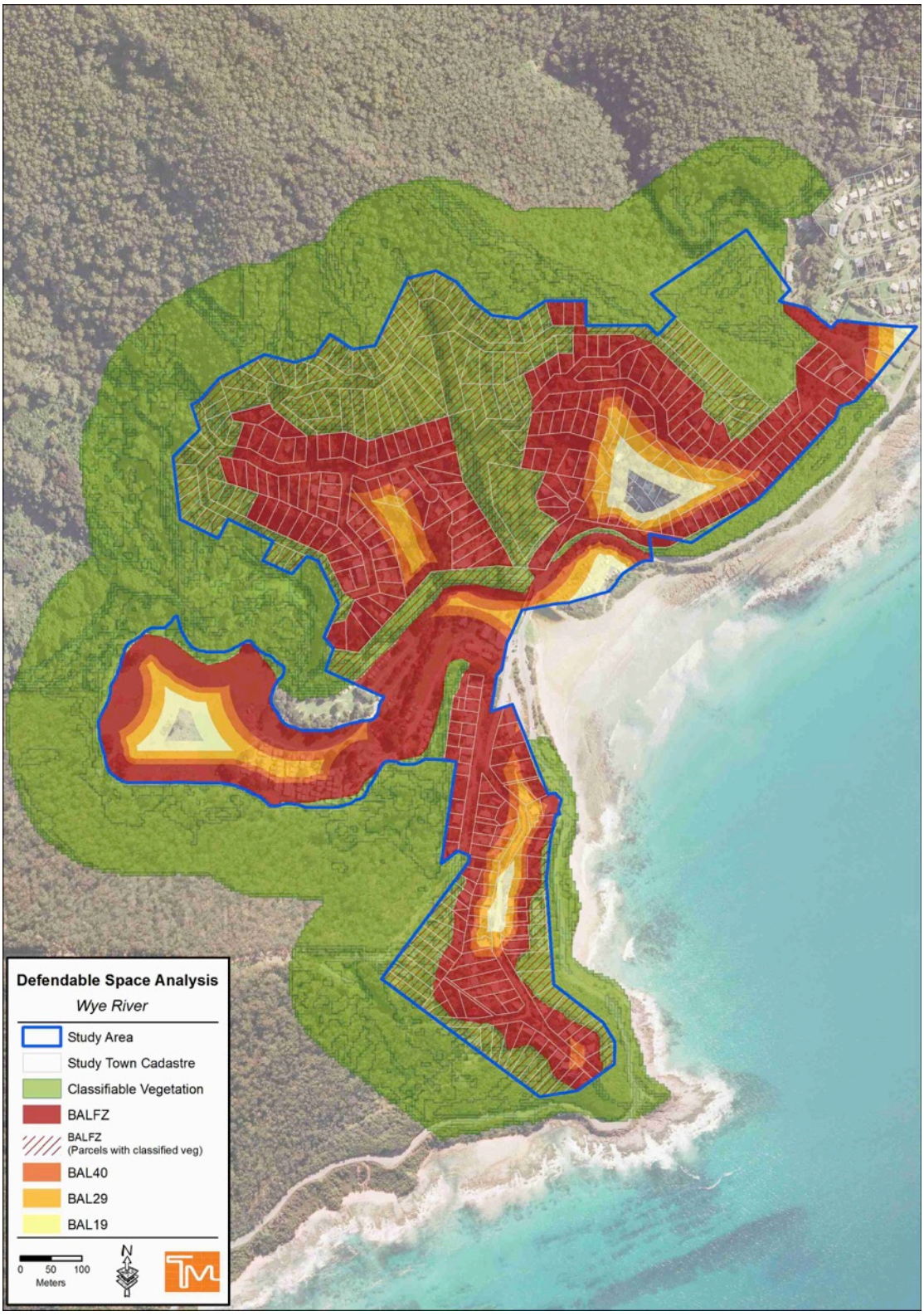
BAL Mapping

Existing allotments within Wye River and Separation Creek were assessed in relation to the level of radiant heat they would be subjected to during a major bushfire under Code Red weather conditions using a methodology aligned to the BMO (VC 83) site assessment process. This allowed indicative BALs to be assigned. As the purpose of the assessment was to identify lots where it was clearly appropriate to provide streamlined BMO provisions in the form of a Schedule, a conservative approach was taken to determining the BALs so that there was confidence that any lot nominated for coverage by a Schedule would qualify for the BAL specified. Any lot that was not included in the Schedule would remain covered by the standard BMO process and provisions.

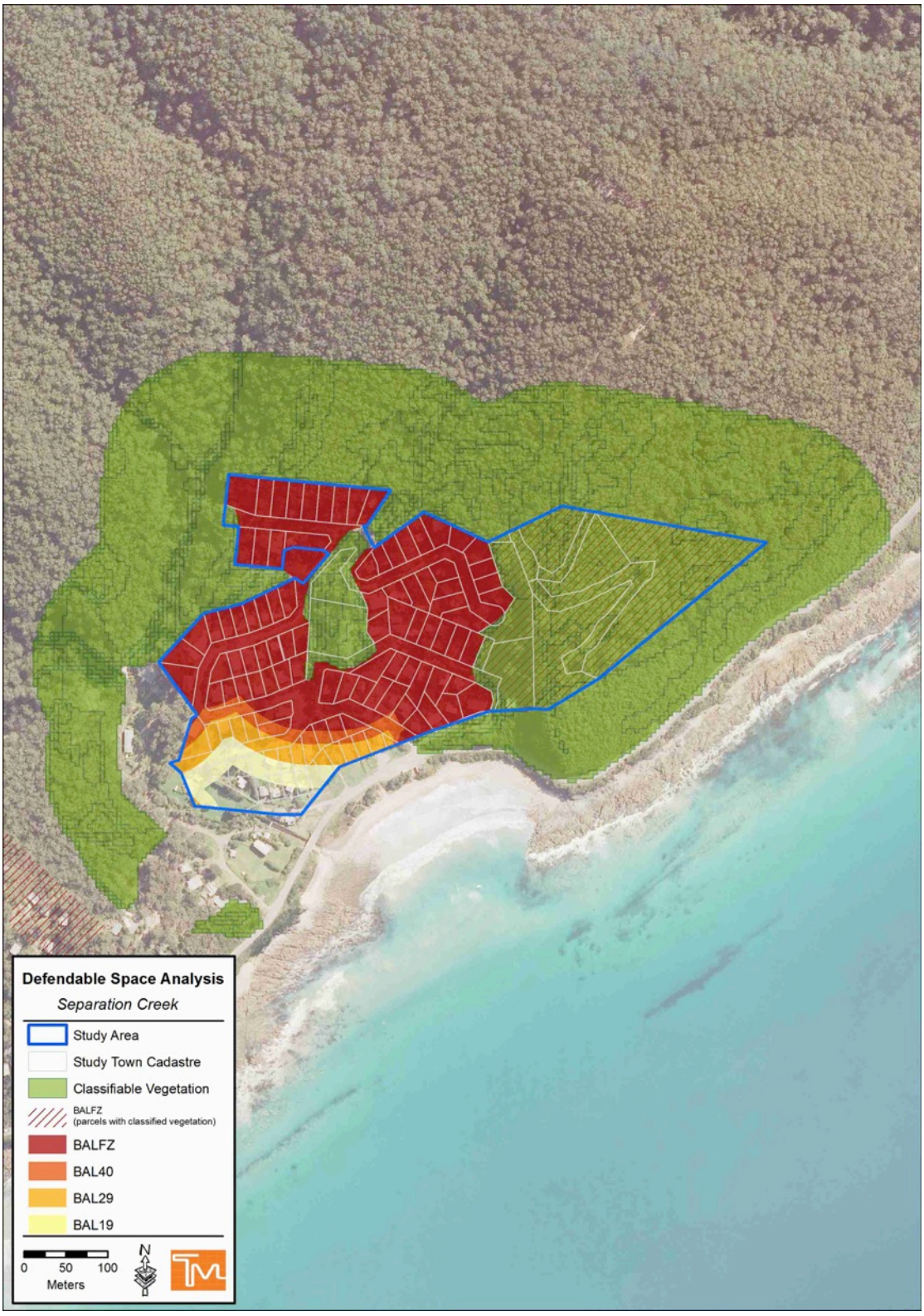
Wye River and Separation Creek were analysed together due to their proximity and similar bushfire characteristics. They are bordered by forest, which extends into the residential area towards the coast at several places. Many of the existing allotments contain 'partially modified' bush gardens. Slopes are locally steep and with a variety of aspects. A severe bushfire is likely to burn through the settlements, and the level of flame, radiant heat and ember attack would be extreme. As classified Forest extends into the Township Zone of the settlements radiant heat flux was modelled from the boundary of the classifiable vegetation. The results of this assessment are shown on Map 12 and Map 13.

Partially modified vegetation was excluded from the final modelling exercise, and thus the modelled radiant heat flux illustrated in the report may have underestimated the radiant heat impact on allotments located well within the settlements. It was considered probable that fire would spread throughout the settlement area with ignition of houses likely from radiant heat and flame ignitions from nearby partially modified vegetation. A conservative approach was adopted in which it was assumed that all allotments within the settlement could be affected by high radiant heat flux and flame contact from local sources.

On the advice of CFA and DPCD (now DELWP) areas where BAL-40 or BAL-FZ construction would be required under the BMO were considered unsuitable for coverage by a Schedule to the BMO that would facilitate development. The 'partially modified' forest vegetation throughout much of the residential area would exacerbate fire conditions, and very few allotments were likely to be rated as BAL-29 or less. For these reasons a BMO Schedule was not recommended.



Map 12 - BAL mapping for Wye River from the Colac Otway Bushfire Planning Policy report (Terramatrix, 2013).



Map 13 - BAL mapping for Separation Creek from the Colac Otway Bushfire Planning Report (Terramatrix, 2013).

In some locations, the standard bushfire protection measures of the BMO may have been inadequate mitigation for the risk.

The analysis of radiant heat flux from the classified vegetation also indicated that many existing dwellings, built prior to the introduction of AS 3959, could be subjected to radiant heat well above the levels they could withstand.

Bushfire Mitigation

Vegetation Management

Given the significance of the surrounding forest and bush gardens within the settlement, it was recommended that consideration be given to developing a township vegetation management plan that had improving bushfire safety as a primary objective.

The survivability of buildings, and those that occupy and shelter within them, can be significantly enhanced or endangered by the type of plants around the building (CFA, 2011). The condition of vegetation within close proximity of the house may determine its survivability, with a recent study (Gibbons *et al.*, 2012) showing that the condition of vegetation within 40 m of the house was a major factor in determining its survivability on Black Saturday.

The CFA publication *Landscaping for Bushfire* (CFA, 2011b) was recommended as a good resource for residents. The guide sets out clear principles for landscaping that will reduce the likelihood of bushfire impact. It also provides examples and lists appropriate plant species for a range of settings including coastal and hills forest. To enhance the relevance of this guide, it was recommended that Council consider developing a product (e.g. pamphlet or webpage) that lists plants residents should plant (such as native species of low flammability) and should not plant (such as invasive weeds).

Terramatrix recommended the development of detailed hazard management plans for each settlement. Hazard management planning should include:

- Mapping of necessary defendable space for existing housing stock. Some reconciliation would need to be made between vegetation management and housing BAL. In some areas broad vegetation management may be most appropriate, whilst in other areas where only limited vegetation management is achievable retrofitting of buildings to a higher BAL may also be required.
- Development of a series of landscape plans and sections that communicate the levels of hazard and asset management to achieve a safer settlement, including consideration of other planning overlays and integration with DEPI (now DELWP) fuel management zones.
- Long-term implementation of plans using community education, Fire Prevention Notices and ongoing works on Crown Land, Council land and private land.

It was recognised that some reduction in exposure to bushfire impact may be possible through collective management of vegetation within and around the settlements. Any such

management would need to occur in a spatially planned manner and to agreed standards. Using a township vegetation management plan was considered to be a way of achieving this. Getting greater setback from the hazard would have allowed applicants more chance of meeting the defendable space requirements in Clause 52.47, however other standards may still have been difficult to satisfy. Implementing a township vegetation management plan would also require consideration of other, potentially conflicting, planning objectives.

The analysis of the bushfire characteristics of the settlements highlighted the high bushfire risk to the existing population and visitors, and the difficulty of effectively mitigating risk within the immediate surrounds of the settlements, reinforcing the need for strategic fire management at a landscape scale through the Otways. The forest adjacent to the settlements at Wye River and Separation Creek is private property, and it was considered that there were insufficient mechanisms for strategically managing fuel on a large scale on private land.

Improving Resilience of Existing Building Stock

The *Bushfire Technical Report* identified that in several settlements, including Wye River and Separation Creek, there was a need to improve the bushfire resistance of the existing building stock. Under the VC 83 BMO in force at the time of the study, it would have been extremely difficult to replace an existing building built to no bushfire standard with a modern building constructed to a high BAL rating, as the new build could not satisfy the BMO requirements for defendable space etc. It was recommended that the concept of 'net safety improvement' be considered in situations where the development proposal would not increase the number of people exposed to the hazard, e.g. it should be possible to replace a 40 year old three bedroom fibrous cement sheet dwelling with a three bedroom dwelling constructed to BAL-FZ.

Evacuation

Evacuation from the settlements was assessed as potentially dangerous unless conducted early. Egress from Wye River and Separation Creek is limited to the Great Ocean Road and runs through forest and/or coastal scrub.

Places of Shelter

Neither of the settlements had a Community Fire Refuge or a Neighbourhood Safer Place (NSP). There were, however, considered to be informal places within each settlement where people would congregate to seek information, assistance and moral support during a bushfire. In the coastal settlements this was likely to be the beach or Great Ocean Road. As there are no NSPs and evacuation routes will be unsafe in some scenarios, these informal places may play a vital role, and consideration should be given to how these informal places can be incorporated into agency planning and community/tourist education to improve public safety.