terramatrix

Strategic Bushfire Planning Assessment

to inform Structure Planning for Clunes, Daylesford / Hepburn Springs, Glenlyon and Trentham

Prepared for Hepburn Shire Council

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Terramatrix project: HepburnSC-2023-01 Strategic Bushfire Assessment
Cover image: Forest on the southern outskirts of Daylesford.

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1.3	2024-09-05	Correction to typo at dot point 2 of Section 1.7	Jon Boura, Managing Director To client

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1 Summary

1.1 Background

- Hepburn Shire comprises approximately 1,470 sq. km in central Victoria. Its current population of 16,000 is forecast to grow to 17,700 by 2026.
- This strategic bushfire planning assessment has been prepared for Hepburn Shire Council to inform the Hepburn Settlement Strategy, which includes Structure Plans for Clunes, Creswick[1], Daylesford-Hepburn, Glenlyon and Trentham.
- Strategic bushfire planning assessments have been undertaken for Clunes, Daylesford / Hepburn Springs, Glenlyon and Trentham.
- Hepburn Shire Council posed general questions in relation to bushfire risk to settlements, as well as specific questions about whether the bushfire risk is too extreme to allow rezoning to enable intensification of development and expansion of the townships.
- All the townships assessed, other than part of the Clunes town centre, are wholly in a designated Bushfire Prone Area (BPA).
- All the townships and/or associated rural living areas are at least partially covered by the Bushfire Management Overlay (BMO).

1.2 Hazard assessment

- In accordance with the bushfire hazard identification and assessment strategies in Clause 13.02-1S *Bushfire Planning*, the hazard posed by vegetation, topography and weather have been assessed at the following scales:
    - Broader landscape scale, considering conditions between 1 km and at least 20 km around each settlement, to evaluate potential fire behaviour and delineate landscape risk typologies.
    - The local and neighbourhood scale up to 1 km around each settlement to determine likely fire behaviour closer to the site and determine the applicable landscape typology.
    - The site scale, within and up to 150 m around the study areas, including classifying vegetation and topography to determine potential BAL-LOW and BAL-12.5 development areas in accordance with key settlement planning safety thresholds in Clause 13.02-1S, and potential BAL and defendable space requirements under the BMO.
- Vegetation was classified into AS 3959/BMO vegetation groups using DEECA Ecological Vegetation Class (EVC) mapping and aerial imagery, supported by ground truthing around each settlement. All townships, other than Clunes, are exposed to Forest and Grassland. Clunes is exposed only to Grassland and Woodland.

[1] Creswick was subject to a previous bushfire assessment and is outside the scope of this study.

- Analysis of weather data on days of elevated fire danger shows the dominance of northerly and north-westerly winds, with westerly and south-westerly winds also occurring but less frequently, on days of when FFDI is greater than or equal to 50 (i.e. generally when the fire danger rating is Extreme or Catastrophic). The wind data shows that the settlements are least likely to be exposed to direct bushfire attack from the east, south or south-east, which is typical of most locations in Victoria.
- Townships exposed to higher hazard vegetation (Forest or Woodland) on their northern and western (including south-western) interfaces are, therefore, generally at higher risk than settlements with more hazardous vegetation only to their east.
- Topography was analysed using publicly available 10 m and 1 m contour data and a 10 m Digital Elevation Model and Digital Slope Model.
- Assessment of landscape-scale hazard was informed by consideration of terrain ruggedness, convective strength and ember storm potential. The analysis showed that the settlements are unlikely to be subject to fire behaviour beyond the BMO/AS3959 design fire conditions.
- All locations could, however, potentially be exposed to a fully developed bushfire (or grassfire) as envisaged in the BMO/AS 3959 methodology.
- Historically, Hepburn Shire has regularly experienced fires greater than 1,000 ha in size that have resulted in loss of buildings and lives stock. More damaging bushfires have occurred just outside of the municipality, including the East Trentham - Mount Macedon fire of 1983 and the Avoca - Maryborough fire of 1985.
- The four townships were assessed to be Broader Landscape Type 2 or 3, depending on proximity to higher hazard Forest or Woodland.
- Potential expansion areas that are more than 400 m and more than 700 m from substantial areas of Forest or Woodland were identified at Clunes, Daylesford, Glenlyon and Trentham.

1.3 Clunes

- We consider that application of the building controls (i.e. AS 3959) can adequately mitigate the bushfire risk for development within the existing township.
- A focus of the assessment was whether bushfire risk precluded rezoning LDRZ land to NRZ.
- Clunes is exposed to Grassland and scattered Woodland on flat or gently sloping ground.
- Rezoning constitutes 'Settlement planning' pursuant to Clause 13.02-1S and must result in development that will not be exposed to radiant heat flux greater than 12.5 kW/m^2.
- The setbacks from hazardous vegetation required to allow BAL-12.5 construction are likely to be 33 m in areas exposed to Woodland and 19 m in areas exposed only to Grassland. These can be achieved in the LDRZ land.
- Any settlement expansion should build from the edge of the township so that the future development area, with contemporary bushfire protection measures, can provide protection to the existing settlement.
- There are substantial areas outside of the BMO and more than 400 m from classified Woodland, that could be suitable for development.

- Part of the existing town centre is outside the designated BPA and there is an NSP that could provide a place of relative safety during bushfire.
- The bushfire risk to Clunes does not preclude rezoning and settlement expansion and it represents the least bushfire risk of the four towns assessed.

1.4 Daylesford / Hepburn Springs

- We consider that application of the bushfire planning (i.e. BMO) and building (i.e. AS 3959) controls can adequately mitigate the bushfire risk within the BMO1, BMO2 and BPA-only parts of the existing township.
- Infill development on the forest edge at Hepburn Springs and on the northern, western and southern outskirts of Daylesford will require careful planning. Proposals for subdivisions of this LDRZ1 land may be contrary to Clause 13.020-1S, which directs development to low risk areas.
- A focus of the assessment was whether bushfire risk precluded rezoning land from FZ or LDRZ to NRZ.
- The township is exposed to Forest on locally steep slopes, particularly around Hepburn Springs and to the west and south-west of Daylesford. The Grassland to the east of Daylesford is gently sloping.
- Rezoning constitutes 'Settlement planning' pursuant to Clause 13.02-1S and must result in development that will not be exposed to radiant heat flux greater than 12.5 kW/m^2.
- The setbacks from Forest required to allow BAL-12.5 construction will depend on the effective slope present and could be as much as 98 m in the steepest areas. Such large setbacks will be difficult to achieve without significant vegetation removal.
- In contrast, the setbacks required from the gently sloping Grassland to the east of Daylesford are likely to be no more than 22 m and could be achieved without the need to manage native vegetation.
- The eastern edge of Daylesford is outside of the BMO, with substantial areas that are more than 400 m or 700 m from classified Forest and is more suitable for settlement expansion than other parts of the town.
- Any settlement expansion should build from the edge of the township so that the future development area, with contemporary bushfire protection measures, can provide protection to the existing settlement.
- Expansion to the east would enlarge the area that would be rated as BAL-LOW under AS 3959-2018, increasing the depth of the low threat urban area available as a place of shelter.
- The bushfire risk does not preclude rezoning and well planned settlement expansion to the east of Daylesford.

1.5 Glenlyon

- We consider that application of the bushfire planning (i.e. BMO) and building (i.e. AS 3959) controls can adequately mitigate the bushfire risk to infill development within the existing township.
- A focus of the assessment was whether bushfire risk precluded rezoning LDRZ land to TZ.
- Glenlyon is bordered by pasture on gently sloping ground to the north, west and south. The main adjacent treed vegetation is Woodland along the Loddon River to the east.
- Rezoning constitutes 'Settlement planning' pursuant to Clause 13.02-1S and must result in development that will not be exposed to radiant heat flux greater than 12.5 kW/m^2.
- The setback from hazardous vegetation required to allow BAL-12.5 construction in the LDRZ land to the west of the town is likely to be 22 m in response to Grassland, which could be readily achieved through appropriate design of the settlement interface and with little impact on native vegetation.
- Any settlement expansion should build from the edge of the township so that the future development area, with contemporary bushfire protection measures, can provide protection to the existing settlement.
- The LDRZ land south of Back Glenlyon Road is outside of the BMO and more than 400 m (and in places more than 700 m) from substantial areas of Woodland or Forest.
- Whilst there is an existing NSP, Glenlyon is a small settlement that does not provide as large a reliably low threat township area as the other three townships being assessed.
- The bushfire risk does not preclude rezoning and well planned settlement expansion to the west of Glenlyon, but we consider there to be more suitable locations available.

1.6 Trentham

- We consider that application of the bushfire planning (i.e. BMO) and building (i.e. AS 3959) controls can adequately mitigate the bushfire risk within most of the existing township (NRZ land).
- Additional care will be needed in the south-east, between Gleeson Street and Mullens Road, where any future development will be exposed to Forest currently on private land north of Golden Point Road (which is a track through the forest for much of its length) and an enduring bushfire hazard on the public land to the south, and we would not recommend intensification of development in this area.
- A focus of the assessment was whether bushfire risk precluded rezoning LDRZ or RLZ land to NRZ.
- Trentham is situated immediately adjacent to public land, with extensive tracts of Forest to the west and south, and predominantly agricultural Grassland to the north. The terrain is gently sloping in all directions.
- Rezoning constitutes 'Settlement planning' pursuant to Clause 13.02-1S and must result in development that will not be exposed to radiant heat flux greater than 12.5 kW/m^2.

- The setbacks from hazardous vegetation required to allow BAL-12.5 construction are likely to be 57 m in areas exposed to Forest and 22 m in areas exposed only to Grassland, in both cases assuming a Downslope >0°-5°.
- The western and southern outskirts of Trentham interface with Forest on public and private land and in places are serviced by single access roads. These areas would remain exposed to ember attack even if the BAL-12.5 defendable space were to be provided. Whilst dwellings built to a BAL should be resistant to ember attack, there are more suitable locations available for intensification of development.
- The LDRZ and RLZ land to the north-east of the township is exposed predominantly to Grassland, with trees restricted to roadsides and shelter belts. It is outside of the BMO and there are areas more than 400 m from any substantial patches of Forest, that could be suitable for intensification of development.
- Any settlement expansion should build from the edge of the township so that the future development area, with contemporary bushfire protection measures, can provide protection to the existing settlement.
- Trentham provides a reasonably large, reliably low threat area, including an NSP, that could provide a place of relative safety during bushfire.
- The bushfire risk does not preclude rezoning and settlement expansion to the north-east of Trentham, but rezoning is not supported to the west or south.

1.7 Conclusion

- Daylesford / Hepburn Springs, Trentham and Glenlyon are exposed to a very high landscape (up to 20 km).
- The local (up to 1 km) bushfire hazard is extreme at Hepburn Springs and the northern, western and southern outskirts of Daylesford, and the southern and western parts of Trentham.
- Clunes is exposed to the least landscape and local scale hazard.
- The bushfire risk to infill development in much of the existing township areas can be adequately mitigated by application of the bushfire planning (i.e. BMO) and building (i.e. AS 3959) controls.
- Careful planning will be required where existing residentially zoned land abuts Forest. Intensification of development in such areas may be contrary to Clause 13.02-1S, which directs development to low risk areas and areas where biodiversity will not be unacceptably impacted by the required bushfire protection measures.
- All four of the townships assessed have some potential for settlement expansion in areas outside of the BMO and more than 400 m (and in places more than 700 m) from any substantial area of Forest or Woodland.
- Clunes is the most suitable as it is exposed to the least landscape-scale and local hazard, but the eastern edge of Daylesford, the LDRZ and RLZ land on the north-eastern outskirts of Trentham and the southern section of RLZ land at Glenlyon are all well setback from Forest. Bushfire attack on these areas would be from grassfire with limited ember attack.

- In contrast, Hepburn Springs, the northern, western and southern edges of Daylesford, the western and southern edges of Trentham and the eastern side of Glenlyon, are all constrained by the presence of high hazard Forest or Woodland.
- Any settlement expansion should build from the edge of the township so that the future development area, with contemporary bushfire protection measures, can provide protection to the existing settlement.
- The *Design Guidelines, Settlement Planning at the Bushfire Interface* (DELWP, 2020a) provide guidance on settlement design that should be incorporated in any Structure Plan.

Part A
Context and methodology

2 Introduction

Hepburn Shire comprises approximately 1,470 sq. km of land in central Victoria, almost half of which is covered in native vegetation and about a quarter of which is public land. There is currently a population of approximately 16,000, which is projected to grow to 17,700 by 2036 (Hepburn Shire Council, 2022). Hepburn Shire Council are preparing the Hepburn Settlement Strategy, which includes structure plans for Clunes, Creswick[2], Daylesford-Hepburn, Glenlyon and Trentham (Hepburn Shire Council, 2022).

To inform the Structure Plans, Terramatrix have undertaken a strategic bushfire assessment for Clunes, Daylesford / Hepburn Springs, Glenlyon, and Trentham. The existing Strategic Framework Plan for the Shire is shown in Figure 1.

This report does not seek to provide a strategic justification for the expansion of any particular township as there are many factors, other than bushfire, that affect the need for or suitability of an area for settlement expansion. There may also be areas outside of Hepburn Shire that are more suitable locations for population growth at a regional scale, but which are outside the scope of this investigation.

Rather, we investigate the four townships nominated by Hepburn Shire Council and identify lower threat areas that may be suitable for development.

This report has been prepared for the Hepburn Shire Council, to assess the relative bushfire risk to the townships, how this affects their suitability for population growth, and the ability of potential future development in the study areas to respond to the bushfire risk and comply with the applicable planning and building controls that relate to bushfire, especially the objectives and strategies of the Planning Policy Framework (PPF) at Clause 13.02-1S *Bushfire Planning* and, where applicable, Clause 44.06 *Bushfire Management Overlay* (BMO) and associated Clause 53.02 *Bushfire Planning* in the Hepburn Planning Scheme.

Questions for the project are:

- Will large amounts of native vegetation need to be removed to keep our communities safe in the existing settlement areas?
- Where are the safest places to live?
- Where are the areas within and on the edge of settlements that will always be unsafe? (Hepburn Shire Council, 2022).

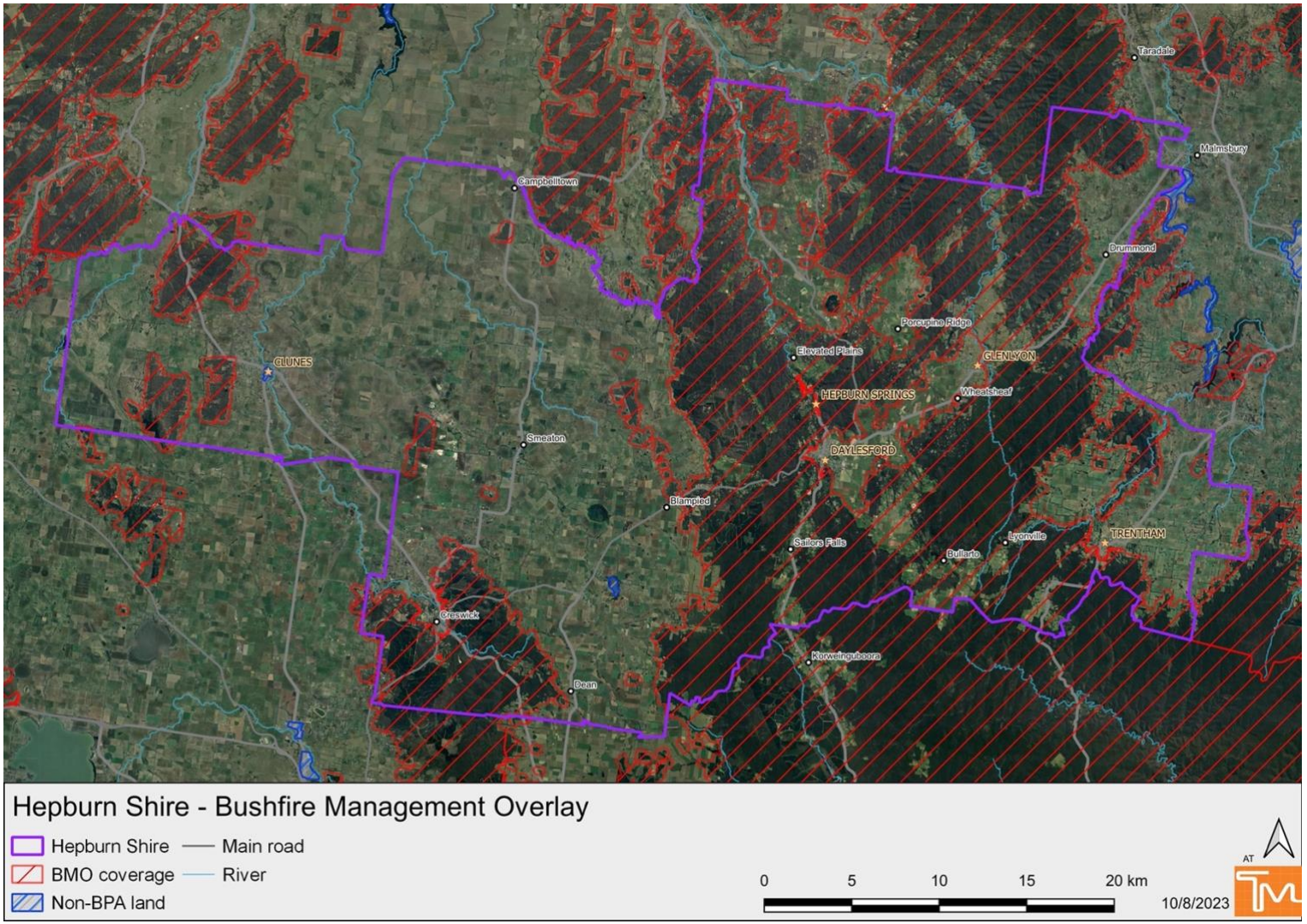
Specific queries in relation to the four township Structure Plans are whether the bushfire risk is too extreme to allow rezoning of specified land to enable intensification of development.

[2] Creswick was subject to a previous bushfire assessment and is outside the scope of this study.

The proposed Structure Plans and potential rezoning represent settlement planning pursuant to Clause 13.02-1S. One of the key strategies for settlement planning at Clause 13.02-1S is to direct development to areas where radiant heat flux is expected not to exceed 12.5 kW/m^2 upon completion of development and where, therefore, future dwellings or other buildings could be constructed to a BAL-12.5 construction standard (Clause 13.02-1S Hepburn Planning Scheme).

The setbacks from hazardous vegetation required to allow BAL-12.5 construction have been identified for each of the Structure Plan areas. The requirement for these setbacks, their location and how they are best created will depend upon the long term vegetated state of adjacent land. Whilst adjacent vegetation outside of the Structure Plan areas is likely to remain in its current state, the study areas for potential rezoning at some townships are large and we anticipate that land would likely be developed over time. As the land to be rezoned has not been finalised, and the timing, sequence, and pattern of any subsequent development has not been determined, it is not possible to map meaningful BAL-12.5 development areas. Therefore this report is limited to describing the extent of potential setbacks that could be applicable to each area to inform more detailed development planning.

Note that the assessment is high level, conducted at a neighbourhood or whole-of-settlement scale for strategic planning. It is not practical or desirable to assess hypothetical development applications for individual properties and therefore the assessments are not considered suitable for statutory planning purposes.



Map 1 – Location of the settlements covered by this Strategic Bushfire Assessment (indicated by star symbol) and BMO and BPA coverage. Whole of map extent is BPA unless otherwise indicated.

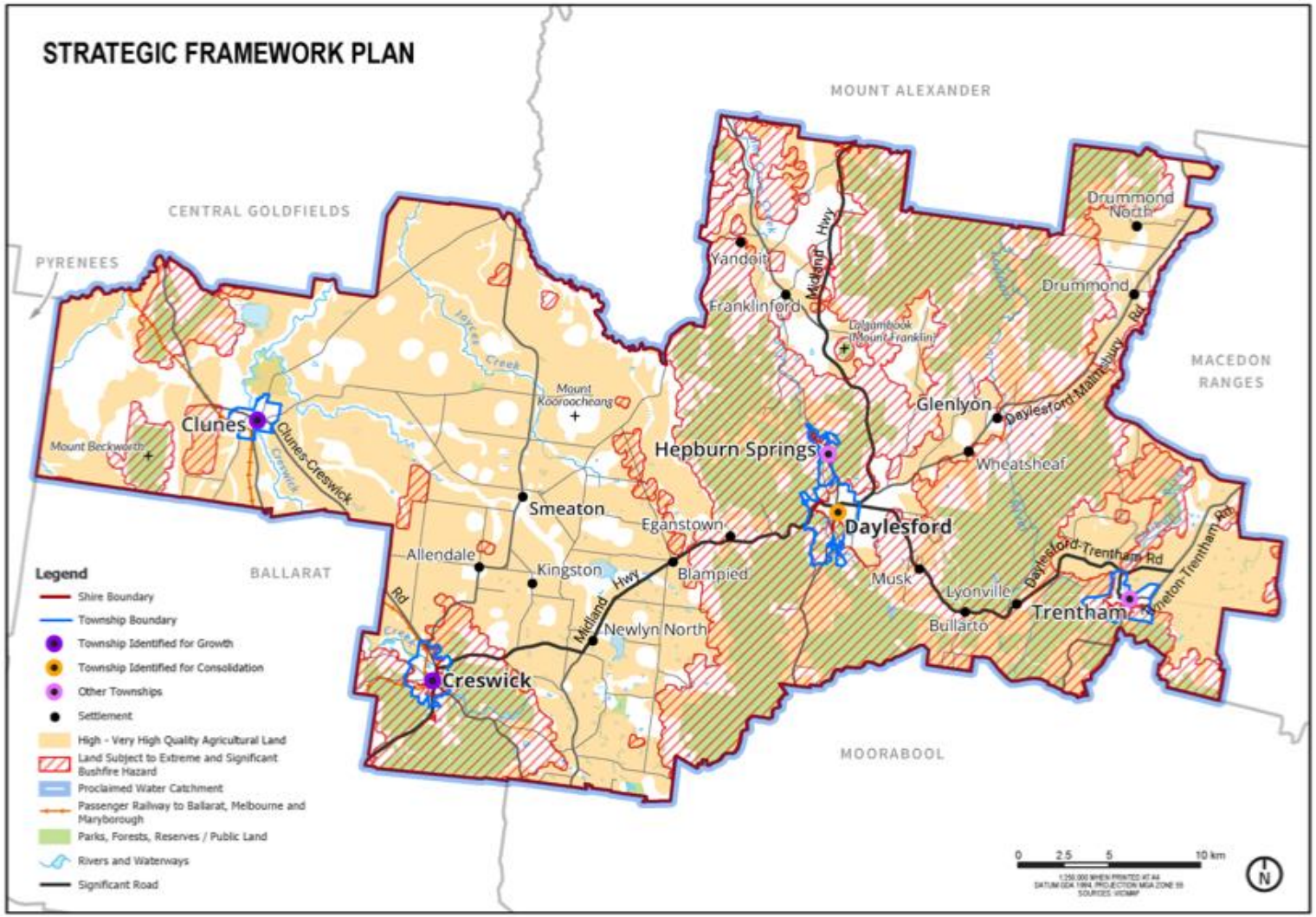


Figure 1 - Strategic Framework Plan (Clause 02.04 Hepburn Planning Scheme).

3 Methodology overview

3.1 Document review

3.1.1 Fire management strategies and plans

The applicable fire management strategies and risk assessments of state and local government were reviewed for content relevant to landscape- and settlement-scale hazard assessment. These were:

- *Grampians Bushfire Management Strategy 2020* (DELWP, 2020b)
- *Joint Fuel Management Program* (FFMVic, 2023b)
- *Grampians Regional Bushfire Planning Assessment* (DPCD, 2012)
- *Hepburn Shire Municipal Emergency Management Plan* (Hepburn Shire Municipal Emergency Management Planning Committee, 2022)
- *Hepburn Shire Council Biodiversity Strategy* (Hepburn Shire Council, 2018).

3.1.2 Agency guidelines

The bushfire assessment has been undertaken, and this report prepared, in accordance with applicable guidance for the assessment of and response to bushfire risk provided in:

- *Design Guidelines Settlement Planning at the Bushfire Interface* (DELWP, 2020a)
- *Bushfire State Planning Policy Amendment VC140*, Planning Advisory Note 68 (DELWP, 2018)
- *Local planning for bushfire protection*, Planning Practice Note 64 (DELWP, 2015)
- *AS 3959-2018 Construction of buildings in bushfire prone areas* (Standards Australia, 2020)
- *Planning Permit Applications Bushfire Management Overlay Technical Guide* (DELWP, 2017)
- *Applying the Bushfire Hazard Landscape Assessment in a Bushfire Management Overlay* (CFA, 2022a).

3.2 Bushfire hazard assessment

3.2.1 Scale of assessment

One of the bushfire hazard identification and assessment strategies in Clause 13.02-1S is to use the best available science to identify the hazard posed by vegetation, topographic and climatic conditions (Clause 13.02-1S Hepburn Planning Scheme). The basis for the hazard assessment should be:

- *'Landscape conditions - meaning the conditions in the landscape within 20 kilometres and potentially up to 75 kilometres from a site;*

- *Local conditions - meaning conditions within approximately 1 kilometre from a site;*
- *Neighbourhood conditions - meaning conditions within 400 metres of a site; and*
- *The site for the development'* (Clause 13.02-1S Hepburn Planning Scheme).

Planning Practice Note 64 *Local Planning for Bushfire Protection* suggests an assessment of the landscape context in 20 km, 10 km and 1 km radii around a study area (DELWP, 2015). The BMO also requires an assessment of landscape risk beyond the 150 m site assessment area around a development site for all subdivisions, and single dwelling applications in non-residential zones.

Section 6 in Part A of this report provides a bushfire hazard assessment for the municipality at a broader landscape scale, considering conditions beyond 1 km and for a minimum 20 km around the settlements, to evaluate potential fire behaviour and delineate landscape risk typologies.

Part B includes an assessment of the hazard posed by vegetation and topography at:

- The neighbourhood and local scale up to 1 km around the townships to determine likely fire behaviour closer to the settlements and determine the applicable landscape typologies
- The site scale, within and up to 150 m around study areas, including classifying vegetation and topography to determine potential BALs and defendable space requirements and to identify potential BAL-LOW and BAL-12.5 development areas in accordance with key settlement planning safety thresholds in Clause 13.02-1S.

3.2.2 Vegetation

Vegetation was classified into AS 3959/BMO vegetation groups using DEECA Ecological Vegetation Class (EVC) mapping, supported by ground truthing around each settlement.

The distribution of Forest and Woodland was mapped using the Vicmap Vegetation – Tree Density Polygon layer, with the layer edited in proximity to study areas to accord with aerial imagery and remove small patches that would not significantly affect fire behaviour.

3.2.3 Topography

The topography was analysed using publicly available 10 m and 1 m contour data, and a 10 m Digital Elevation Model (DEM) and Digital Slope Model (DSM).

The potential range of effective slopes within and around each settlement was identified.

3.2.4 Weather

The frequency and severity of bushfire wind conditions has been analysed, using historical fire weather data from the nearest Bureau of Meteorology (BOM) automatic weather stations with

suitable historical records, located at Bendigo Airport (approximately 80 km north of Daylesford) and Ballarat Aerodrome (approximately 45 km south-west of Daylesford) (see Section 6.3.2).

3.2.5 Potential fire behaviour

A qualitative description of potential fire behaviour and impact is provided at a landscape scale and for each settlement individually.

This is informed by a landscape-scale assessment of terrain ruggedness, convective strength and potential for ember storms using the methodology of Tolhurst (2014).

3.3 Determining acceptable risk locations

The assessment of bushfire hazard, and the resultant risk to new development, at a variety of spatial scales, is a requirement of the Victoria Planning Provisions at Clause 13.02-1S *Bushfire Planning* and Clause 44.06 *Bushfire Management Overlay*.

3.3.1 Mitigating landscape hazard

Bushfire hazard assessment processes are well established at the site scale, using a modified version of the site assessment methodology of AS 3959-2018 *Construction of buildings in bushfire prone areas*. Landscape scale hazard assessment processes, however, are less well developed.

Clause 13.02-1S requires the broader landscape to be considered but provides no metrics for this. DTP and CFA guidance is limited to identifying the broad factors that should be considered, but provides no methodology for analysing the factors, individually or in combination, and the only metric for assessing whether the hazard (and/or resultant risk) might be deemed acceptable in the context of settlement expansion relates to site-based radiant heat flux thresholds.

The Victoria Planning Provisions do not explicitly consider acceptable risk from bushfire in the context of strategic land use planning, rather they focus on 'low risk', for example:

- '*Directing population growth and development to low risk areas*' (Clause 13.02-1S Protection of Human Life strategy)
- *Directing population growth and development to low risk locations, being those locations assessed as having a radiant heat flux of less than 12.5 kilowatts/square metre…'* (Clause 13.02-1S Settlement Planning strategy)
- *'Assessing alternative low risk locations…'* (Clause 13.02-1S Settlement Planning strategy).

The second dot point could be considered to define areas of acceptable risk as being those where radiant heat flux will be less than 12.5 kW/m^2, but there are problems with this. A radiant heat flux of 12.5 kW/m^2 is an important threshold for house loss in bushfire; it is the level at which

unprotected float glass[3] can be expected to fail, opening the building up to ember attack. But it assumes people would be within buildings constructed to a BAL-12.5 standard and has no direct relationship to safety of people out in the open (e.g. 7 kW/m^2 is expected to be fatal to unprotected people after an exposure of just several minutes).

Thus, the radiant heat flux threshold provided in Clause 13.02-1S relates to survivability of buildings based on AS 3959-2018 *Construction of buildings in bushfire prone areas,* the purpose of which, is to assess and mitigate the bushfire risk to buildings. The assumption is that if radiant heat flux is less than[4] 12.5 kW/m^2, then new houses constructed to a BAL-12.5 or higher standard are likely to survive bushfire and provide protection to people.

It should also be noted that radiant heat decreases rapidly with distance from the flame. For example, the difference between 40 kW/m^2 and 12.5 kW/m^2 if exposed to Forest on flat ground, is an additional setback of just 29 m. Achieving a BAL-12.5 setback is not sufficient on its own, for justifying strategic settlement planning decisions.

Consequently, in this bushfire study whilst we assess the ability of potential future development to achieve a BAL-12.5 construction standard, we also consider much larger setback distances of 400 m and 700 m based on studies of the pattern of house loss in major bushfires (see Section 7.2).

The second key policy test for settlement planning is '*Ensuring the availability of, and safe access to, areas assessed as a BAL-LOW rating under AS 3959-2018 Construction of Buildings in Bushfire-prone Areas (Standards Australia, 2018) where human life can be better protected from the effects of bushfire'* (Clause 13.02-1S Hepburn Planning Scheme). The proximity of township areas that are not in a BPA and/or are of sufficient size to provide a substantial low threat area, which could provide a place of relative safety, has been assessed.

The proximity of a Neighbourhood Safer Place (NSP) is also listed for each settlement. These, however, are 'places of last resort' and strategic land use planning decisions about the suitability of a settlement for population growth should not be based on their presence.

3.3.2 Mitigating local hazard

In higher hazard landscapes, an ability for development to comply with the applicable statutory planning (i.e. Clause 53.02) and building controls (i.e. AS 3959) may be inadequate to mitigate the risk to an acceptable level (CFA, 2022a).

CFA guidance states that additional bushfire protection measures are likely to be required in Broader Landscape Types 3 and 4, and that intensification of development may not be supported

[3] Typically, the most vulnerable element of a dwelling not constructed to a BAL.

[4] Note that AS 3959 requires that radiant heat flux *not exceed* 12.5kW/m^2 for BAL-12.5 construction.

(CFA, 2022a), despite the AS 3959/BMO design fire arguably being reflective of Broader Landscape Type 3. This can be explained by the BMO and building systems being focused on the construction of buildings that can survive bushfire, whilst Clause 13.02-1S is much more about the safety of people; and in higher hazard landscapes building survival does not necessarily equate to human survival.

In this bushfire planning assessment, we examine whether it is likely that credible bushfire behaviour in and around the settlements will be beyond the AS 3959/BMO design fire assumptions for fuel, weather and topography, such that that compliance with BMO protection measures for BAL and defendable space may be inadequate for dwelling survival.

4 Bushfire planning and building controls

This section summarises the applicable planning and building controls that relate to bushfire.

4.1 Hepburn Planning Scheme

4.1.1 Clause 02 Municipal Planning Strategy

The Municipal Planning Strategy recognises that '*bushfire is a significant risk for the Shire with Creswick[5], Daylesford, Hepburn Springs and Trentham all identified as high bushfire risk townships. Balancing bushfire management with vegetation and landscape values, and settlement are key challenges*' (Clause 02.01 Hepburn Planning Scheme).

Settlement

Bushfire risk is seen as potentially restricting the ability to develop existing low density zoned land around Creswick and Clunes (Clause 02.03-1 Hepburn Planning Scheme). In addition, it is noted that '*A number of settlements and rural living areas have high risk of bushfires with some requiring restructuring and potentially abandonment to reduce the threats to life and property*' (Clause 02.03 Hepburn Planning Scheme).

Council's strategic planning directions relevant to bushfire include:

- '*Concentrate development into defendable parts of existing township boundaries and settlements to mitigate bushfire risk, protect agricultural land, and limit natural and environment risks.*
- *Facilitate growth in Creswick and Clunes within the designated township boundaries.*
- *Consolidate development in Daylesford within the designated township boundary.*
- *Contain growth of Trentham and Hepburn Springs within the designated township boundaries.*
- *Discourage residential development in settlements within existing residentially zoned boundaries where bushfire risks cannot be mitigated*' (Clause 02.03 Hepburn Planning Scheme).

Environmental and landscape values

Land clearing and bushfire management are listed as threats to biodiversity in the Shire, and minimising wholesale clearing of significant vegetation in areas of high bushfire risk is listed as a biodiversity strategy (Clause 02.03-2 Hepburn Planning Scheme).

[5] Creswick was subject to a previous bushfire assessment and is outside the scope of this study.

Environmental risks and amenity

The Municipal Planning Strategy states '*bushfire poses a significant risk to life and property in Hepburn Shire. Bushfire risk is exacerbated by topography, dispersed townships, ad-hoc development and lack of infrastructure in some locations. There are some locations where residential land uses have been allowed that with current knowledge are unsuitable for settlement and suggest the need for review of boundaries through structure planning. Potential development of existing small lots dispersed across rural landscapes and on the edges of towns are at highest risk from bushfires*' (Clause 02.02-3 Hepburn Planning Scheme).

4.1.2 Clause 13.01-1S Natural Hazards and Climate Change

The objective of this Clause is to minimise the impacts of natural hazards and adapt to the impacts of climate change through risk-based planning.

Specified strategies to achieve the objective are:

- *'Respond to the risks associated with climate change in planning and management decision making processes.*
- *Identify at risk areas using the best available data and climate change science.*
- *Integrate strategic land use planning with emergency management decision making.*
- *Direct population growth and development to low risk locations.*
- *Develop adaptation response strategies for existing settlements in risk areas to accommodate change over time.*
- *Ensure planning controls allow for risk mitigation and climate change adaptation strategies to be implemented.*
- *Site and design development to minimise risk to life, health, property, the natural environment and community infrastructure from natural hazards'* (Clause 13.01-1S Hepburn Planning Scheme).

Especially in southern and eastern Australia, since the 1950s there has been an increase in the length of the fire weather season and an increase in extreme fire weather (CSIRO/BOM, 2022). The trend of a longer fire season and increased number of dangerous fire weather days is projected to continue. Climate change is contributing to these changes in fire weather including by affecting temperature, relative humidity, and associated changes to the fuel moisture content (CSIRO/BOM, 2022).

The Australasian Fire and Emergency Service Authorities Council (AFAC) identify that a failure of building codes and land use planning to adequately adapt to climate change is a significant risk (AFAC, 2018).

Climate change trends associated with the risk of bushfire, support the adoption of a precautionary and conservative approach in identifying and responding to the risk, which has

been adopted in this report as appropriate. Climate change in relation to fire weather is discussed further in the hazard assessment in Section 6.3 of this report.

4.1.3 Clause 13.02-1S Bushfire Planning

Clause 13.02-1S has the objective '*To strengthen the resilience of settlements and communities to bushfire through risk based planning that prioritises the protection of human life*' (Clause 13.02-1S Hepburn Planning Scheme). The policy must be applied to all planning and decision making under the Planning and Environment Act 1987, relating to land which is:

- Within a designated BPA
- Subject to a BMO
- Proposed to be used or developed in a way that may create a bushfire hazard.

Clause 13.02-1S requires priority to be given to the protection of human life by:

- *'Prioritising the protection of human life over all other policy considerations.*
- *Directing population growth and development to low risk locations and ensuring the availability of, and safe access to, areas where human life can be better protected from the effects of bushfire.*
- *Reducing the vulnerability of communities to bushfire through consideration of bushfire risk in decision-making at all stages of the planning process'* (Clause 13.02-1S Hepburn Planning Scheme).

Key strategies are stipulated in Clause 13.02-1S, which require regional growth plans, precinct structure plans and planning scheme amendments to assess the bushfire hazard and respond with appropriate bushfire protection measures. This also applies to planning permit applications for:

- Subdivisions of more than 10 lots
- Accommodation
- Childcare centre
- Education centre
- Emergency services facility
- Hospital
- Indoor recreation facility
- Major sports and recreation facility
- Place of assembly
- Any application for development that will result in people congregating in large numbers.

Clause 13.02-1S sets exposure to radiant heat flux no greater than 12.5 kW/m^2, which is commensurate with a BAL-12.5 construction standard, as a safety threshold in settlement planning. Responsible authorities must '*Not approve any strategic planning document, local planning policy, or planning scheme amendment that will result in the introduction or*

intensification of development in an area that has, or will on completion have, more than a BAL-12.5 rating under AS 3959-2018' (Clause 13.02-1S Hepburn Planning Scheme).

The 'Areas of biodiversity conservation value' strategy is to '*ensure settlement growth and development approvals can implement bushfire protection measures without unacceptable biodiversity impacts by discouraging settlement growth and development in bushfire affected areas that are important areas of biodiversity*' (Clause 13.02-1S Hepburn Planning Scheme). Hepburn Shire Council have commissioned an environmental assessment of the four towns and their surrounds, that is being conducted concurrently with this bushfire study. The findings of the ecological report should be considered along with the bushfire risk assessment in this report (and other strategic planning considerations) to determine the overall suitability of sites for township expansion.

This study assesses the bushfire hazard and advises on the suitability of the townships for intensification of development.

4.1.4 Clause 44.06 Bushfire Management Overlay (BMO)

The purposes of the BMO, which has a variable degree of coverage across the townships subject to this study (see Map 1 and Part B of this report), are:

- *'To implement the Municipal Planning Strategy and the Planning Policy Framework.*
- *To ensure that the development of land prioritises the protection of human life and strengthens community resilience to bushfire.*
- *To identify areas where the bushfire hazard warrants bushfire protection measures to be implemented.*
- *To ensure development is only permitted where the risk to life and property from bushfire can be reduced to an acceptable level'* (Clause 44.06 Hepburn Planning Scheme).

The BMO largely applies to patches of treed vegetation greater than 4 ha in size, where head fire intensity has been modelled to be 30,000 kW/m or more. It also extends over land extending 150 m (and in situations where head fire intensity may be extreme, up to 300 m) from the edge of the vegetation, based on research into house loss from bushfires which found that 92% of house loss occurs within 150 m of the bushfire hazard (DELWP, 2019).

Objectives and compliance measures for Clause 44.06 BMO applications are specified in associated Clause 53.02 *Bushfire Planning,* which contains:

- ***'Objectives:** An objective describes the outcome that must be achieved in a completed development.*
- ***Approved measures (AM):** An approved measure meets the objective.*
- ***Alternative measures (AltM):** 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*' (Clause 53.02 Hepburn Planning Scheme).

4.1.5 Clause 71.02-3 Integrated Decision Making

Clause 71.02-3 states that planning and responsible authorities should integrate policies and balance conflicting objectives in favour of net community benefit. However, in bushfire affected areas, it requires that the protection of human life be prioritised over all other policy considerations (Clause 71.02-3 Hepburn Planning Scheme).

4.2 Bushfire Prone Area (BPA)

All the study area, apart from a section of the Clunes township, is currently designated as a BPA. BPAs are those areas subject to or likely to be subject to bushfire, as determined by the Minister for Planning. Those areas of highest bushfire risk within the BPA are designated as BMO areas (see Map 1).

In a BPA, the Building Act 1993 and associated Building Regulations 2018, through application of the National Construction Code 2022 (NCC), require specific design and construction standards for Class 1, 2 and 3[6] buildings, certain Class 9 and 4 buildings[7], and Class 10A buildings[8] or decks adjacent to, or connected with, these classes of buildings.

For Class 1 buildings (dwellings) and associated Class 10A buildings or decks, the applicable performance requirement in the NCC is:

'A Class 1 building or a Class 10a building or deck associated with a Class 1 building that is constructed in a designated bushfire prone area must be designed and constructed to—

(a) reduce the risk of ignition from a design bushfire with an annual exceedance probability not more than 1:50 years; and

(b) take account of the assessed duration and intensity of the fire actions of the design bushfire; and

(c) be designed to prevent internal ignition of the building and its contents; and

(d) maintain the structural integrity of the building for the duration of the design bushfire (ABCB, 2023).

[6] Class 1, 2 and 3 buildings are defined in the NCC and are generally those used for residential accommodation, including houses and other dwellings, apartments, hotels and other buildings with a similar function or use.

[7] Applicable Class 9 buildings are Class 9a health-care buildings, Class 9b early childhood centres, primary and secondary schools, Class 9c residential care buildings, and any Class 4 parts of a building associated with these Class 9 buildings.

[8] Class 10a buildings are defined in the NCC as non-habitable buildings including sheds, carports, and private garages.

The performance requirement for Class 1, 2 and 3 buildings and associated Class 10a buildings and decks, is deemed to be satisfied by design and construction in accordance with AS 3959-2018 *Construction of buildings in bushfire prone areas*. For Class 1 buildings and associated decks, the NASH Standard – *Steel Framed Construction in Bushfire Areas* (NASH, 2021) is also deemed to satisfy the performance requirement. More onerous performance measures apply to certain Class 9 buildings.

In Victoria, buildings in a BPA must be constructed to a minimum BAL-12.5, or higher as determined by a site assessment, planning scheme requirement or other NCC requirement[9].

A BAL is a means of measuring the severity of a building's potential exposure to ember attack, radiant heat and direct flame contact. There are six BALs defined in AS 3959-2018; which range from BAL-LOW, which has no bushfire construction requirements, to BAL-FZ (Flame Zone) where flame contact with a building is expected (see Section 15 Appendix A).

If future development results in the creation of large, reliably low threat or non-vegetated areas, some parts of the larger townships may become eligible for excision from the BPA.

The DTP reviews and excises eligible areas from the BPA approximately every 6 months, particularly in growth areas where the hazard is removed as urban development occurs.
Land becomes eligible for excision from the BPA if it satisfies statewide hazard mapping criteria, including that the land typically needs to be:

- At least 150 m and up to 300 m from areas of classified vegetation, except Grassland, more than 2 ha in size
- At least 60 m from areas of classified Grassland more than 2 ha in size (DELWP, 2019).

For areas of vegetation less than 2 ha, the shape of the area and connectivity to other hazardous vegetation is a further consideration (DELWP, 2019).

It is possible that if residential development were to occur on the edge of Clunes or the eastern edge of Daylesford, it could result in some additional land being eligible for excision from the BPA. It is considered unlikely that any development credible for Trentham or Glenlyon would result in any area becoming eligible for excision from the BPA.

[9] Class 9 buildings are typically required to meet an enhanced BAL-19 construction standard, as well as comply with other bushfire protection specifications.

5 Regional and municipal bushfire strategies and guidelines

5.1 Bushfire management strategies

5.1.1 Grampians Bushfire Management Strategy 2020

Strategic bushfire management planning in Victoria is jointly delivered by Forest Fire Management Victoria (FFMVic), the Country Fire Authority (CFA), Fire Rescue Victoria (FRV), Emergency Management Victoria (EMV) and local government. A key output is a Bushfire Management Strategy for each of the six planning regions that cover the state. Each strategy informs more detailed operational-level planning, including municipal fire prevention planning, the FFMVic and CFA Joint Fuel Management Program, and readiness and response planning.

Hepburn Shire is covered by the Grampians Bushfire Management Strategy (GBMS), which notes '*Approximately 45% of the shire's population is scattered through numerous small townships, hamlets and rural localities, which are often in forested or semi-forested environments. Many low-density residential developments have resulted in significant areas of privately-owned forest*' (DELWP, 2020b).

The Strategy assesses '*the eastern half of the Grampians region is where the greatest bushfire risk sits, particularly for settlements in and around the Wombat State Forest and Lerderderg State Park, such as Daylesford, Trentham and Gisborne*' (DELWP, 2020b). '*Daylesford is an example of a high-risk town … due to the large amount of forest located to the north, west and south of the town, as well as its population. The township also experiences a large influx of tourists over the fire danger period. The forest around Daylesford could allow fires to become large and intense before impacting the town. Prediction modelling tells us that many fires can reach Daylesford and cause house loss*' (DELWP, 2020b).

The GBMS presents modelled house loss mapping representing comparative bushfire risk within the region (see Figure 2). It shows that all the study area, other than parts of Clunes, are Intermediate (top 40%) to Highest (top 5%) risk locations in the region for potential house loss under a FDI of 130 or above (i.e. well into a Catastrophic fire danger rating). Note these ratings are the result of the combination of potential fire behaviour and the current pattern of development.

The probability of house loss is a relative ranking based on modelled bushfire simulations using assumptions about extreme fire weather and fuel conditions. It should not be seen as definitive, rather a useful comparative risk tool to inform strategic land-use planning at the landscape scale. It should not be applied at a finer scale to assess individual property risk or for statutory planning purposes.

Asset Protection Zones and Bushfire Moderation Zones protect townships in the Wombat sub-landscape (DELWP, 2020b). These are discussed in Section 5.1.2 and, in relation to specific townships, in Part B of this report.

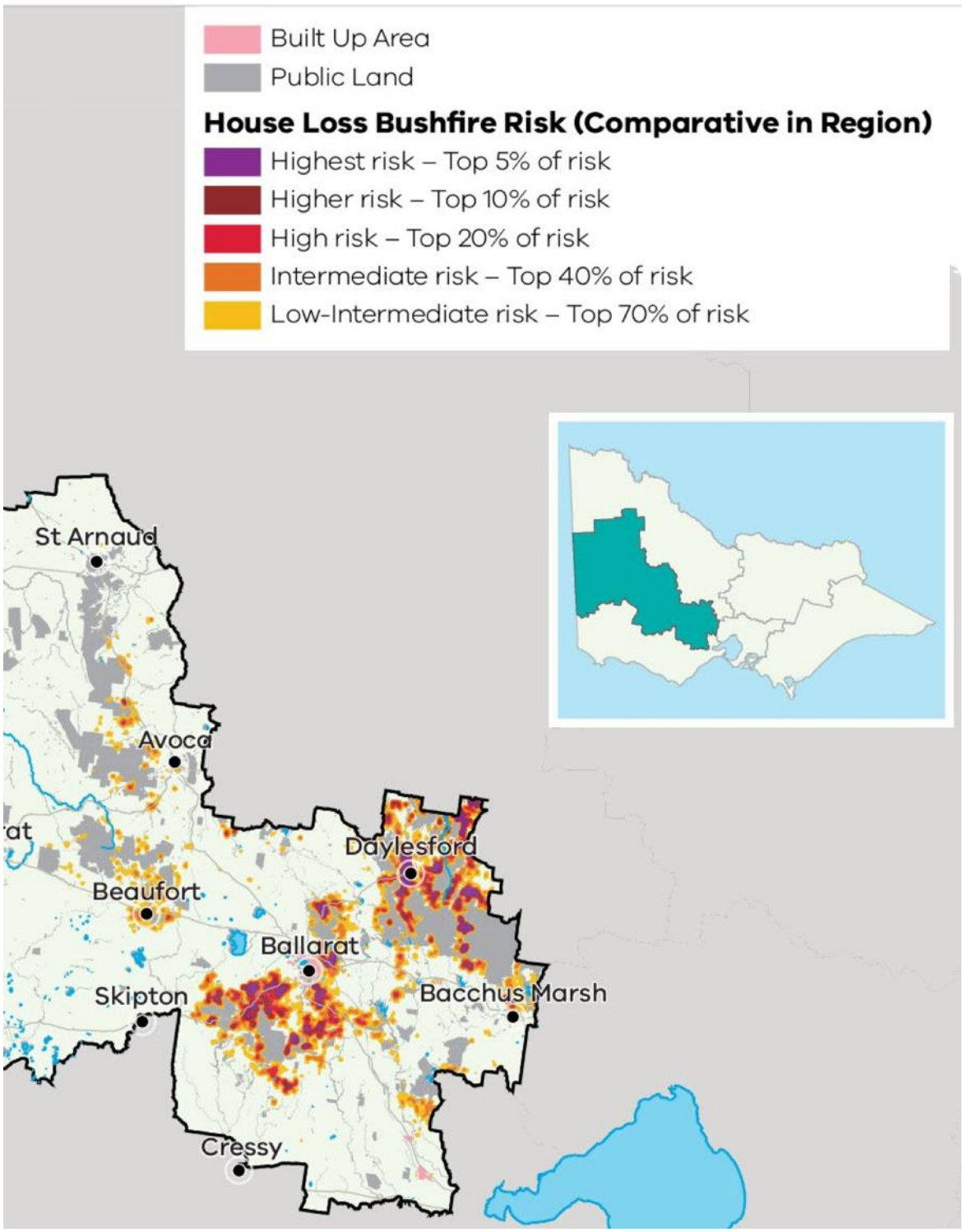


Figure 2 - Comparative house loss risk in Grampians Region (only eastern portion shown) (DELWP, 2020b).

5.1.2 Joint Fuel Management Program

FFMVic have defined Fire Management Zones (FMZs) across areas of largely public land, to protect people and assets by managing fuels to reduce the spread of bushfires and to improve ecosystem resilience (FFMVic, 2023a). Four different FMZs exist:

- ***'Asset Protection Zone** - An area around properties and infrastructure where we intensively manage fuel to provide localised protection to reduce radiant heat and ember attack on life and property in the event of a bushfire. Aim to reduce fuel through planned burning or other methods approximately every 5 to 7 years.*
- ***Bushfire Moderation Zone** - An area around properties and infrastructure where we manage fuel to reduce the speed and intensity of bushfires and to protect nearby assets, particularly from ember attack in the event of a bushfire. Aim to reduce fuel through planned burning or other methods approximately every 8 to 15 years. Length of time between planned burns in some areas can vary due to ecological considerations.*
- ***Landscape Management Zone** - An area where we manage fuel to minimise the impact of major bushfires, to improve ecosystem resilience and for other purposes (such as to regenerate forests and protect water catchments). Planned burning will focus on maintaining and improving ecosystem resilience, and fuel management will also be undertaken for risk reduction.*
- ***Prescribed Burning Exclusion Zone** - An area where we try to avoid planned burning, mainly to protect particular areas that can't tolerate fire'* (FFMVic, 2023a).

Fuel management in an FMZ may include planned burning, slashing/mowing and clearing works, including creating fuel breaks, with the broad aim of reducing the spread and intensity of bushfires to make suppression more achievable and safer (FFMVic, 2023a). FFMVic (2023a) states that '*In areas close to towns, burns are more frequent to protect people and the things they value*'.

It should be noted that FMZs typically assist to manage bushfire risk at a strategic and landscape or local scale. Whilst they can contribute to moderation of fire behaviour at that broader landscape scale, they cannot be relied upon to mitigate risk at a site scale. Planned burning is also subject to resource and weather constraints in any particular year.

Therefore, public land FMZs and proposed planned burning can contribute to risk mitigation but cannot be relied upon to enable development, or on their own as a protection measure, acceptably mitigate risk on adjacent or nearby areas of private or other public land.

The type and location of FMZs in the land around each township are shown in the relevant sections of this report.

5.1.3 Regional Bushfire Planning Assessment

As part of the response to the 2009 Victorian Bushfires Royal Commission, Regional Bushfire Planning Assessments (RBPAs) were undertaken across six regions that covered the whole of Victoria. The RBPAs provide information about 'identified areas' where a range of land use planning matters intersect with a bushfire hazard to influence the level of risk to life and property from bushfire. The RBPAs state that '*This information should be addressed as part of strategic land use and settlement planning at the regional, municipal and local levels'* (DPCD, 2012).

The *Regional Bushfire Planning Assessment – Grampians Region* covers the Hepburn Shire Council LGA. It notes that in the eastern part of the Shire, townships interface with the forest and in some instances their Structure Plans allow for growth in or close to bushfire hazard areas and that growth pressure is being experienced (DPCD, 2012).

Specific bushfire planning matters identified for each settlement are listed in the relevant sections in Part B of this report.

5.1.4 Hepburn Shire Municipal Emergency Management Plan

The Municipal Emergency Management Plan (MEMP) 2022-2025 lists the Bullarto bushfire of 2009 and Hepburn bushfire of 2019 as significant emergencies (Hepburn Shire Municipal Emergency Management Planning Committee, 2022).

5.1.5 Hepburn Shire Council Biodiversity Strategy

The Biodiversity Strategy recognises that fuel reduction works on Council, public and private land have the potential to negatively impact biodiversity values and that fuel reduction burning is a contentious local issue and that lower intensity cultural burning by Djandak may be more acceptable (Hepburn Shire Council, 2018).

The Strategy also identifies land clearing as a threat wherever remnant vegetation occurs on private property (Hepburn Shire Council, 2018). This has implications for the provision of defendable space for subdivisions or other new development in the BMO.

Weed control, including on roadsides, that targets high biomass species such as Gorse, Broom and Canary Grass will also have fire hazard reduction benefits (Hepburn Shire Council, 2018).

It should also be noted that the presence of woody weeds can increase the vegetation classification under AS 3959-2018/BMO (e.g. from Woodland to Forest or Grassland to Scrub based on the presence of shrubs), with a corresponding increase in the amount of defendable space required for any BAL construction standard.

5.2 Agency guidelines

A suite of guidelines have been released by the Department of Transport and Planning (or its predecessors) and CFA to guide assessment and decision-making in regard to bushfire risk.

5.2.1 Local Planning for Bushfire Protection

The Department of Transport and Planning's Planning Practice Note 64 provides guidance about local planning for bushfire protection to assist Councils to tailor local planning policy for bushfire (DELWP, 2015).

It states that bushfire risk should be considered in terms of life, property and community infrastructure, and that '*central to local planning for bushfire is determining the level of risk and whether the risk has been reduced to an acceptable level*' (DELWP, 2015). It also states that '*directing development to the lowest risk locations is the most effective way to prioritise the protection of human life*' (DELWP, 2015).

5.2.2 Design Guidelines – Settlement Planning at the Bushfire Interface

The Department of Transport and Planning's *Design Guidelines – Settlement Planning at the Bushfire Interface* (DELWP, 2020a) advise that identification of areas suitable for development should consider:

- The likely size and intensity of a bushfire and whether it may result in neighbourhood-scale destruction
- The availability of alternative locations for settlement growth and new development
- Access to enable people to move away from a bushfire hazard and options for where people can get to safe areas during a bushfire
- Emergency management response to bushfire and structural fires (DELWP, 2020a).

The application of these guidelines to potential settlement growth at Clunes, Daylesford, Glenlyon and Trentham is discussed in Section 13 of this report.

5.2.3 Technical Guide – Planning Permit Applications Bushfire Management Overlay

The Department of Transport and Planning's BMO Technical Guide identifies the following factors as influencing potential bushfire behaviour at a landscape scale:

- Extent and continuity of vegetation
- Landscape typology
- Potential fire run and area that is likely to be impacted by the fire
- Location and exposure of the urban area, township, isolated rural area to bushfire
- Extent of neighbourhood-scale damage the bushfire may produce (DELWP, 2017).

The Technical Guide states the purpose of the landscape assessment is not to predict the outcome of a bushfire event but to provide information that builds a better understanding of the bushfire risk in a location to help make informed decisions (DELWP, 2017).

The Technical Guide recommends that in complex situations the following be documented:

- A description of likely bushfire scenarios
- Consideration of any state, regional or local bushfire management and prevention actions occurring around the site that is relevant to understanding the bushfire hazard and the level of risk to the site
- An assessment of nearby locations in urban, township or other areas where protection can be provided from the impact of extreme bushfire behaviour to determine:
    - If they are managed in a minimum fuel condition and there is sufficient distance or shielding to protect people from direct flame contact or harmful levels of radiant heat
    - The distance of travel required
    - The risks that may arise on the journey from the subject site to a place of greater protection, for example from roadside vegetation or congestion (DELWP, 2017).

5.2.4 Fire Service Guideline Land Use Planning 008: Strategic Land Use Planning - Bushfire[10]

CFA considers that community resilience to bushfire will be strengthened by:

- Prioritising the protection of human life over other policy considerations when planning to create or expand a settlement at risk from bushfire
- Applying a precautionary approach to planning and decision making when assessing the risk to life, property and community infrastructure from bushfire
- Taking advantage of existing settlement patterns where new development will not expose the community to increased risk from bushfire (CFA, 2015).

Settlement planning decisions should:

- Direct development to locations of lower bushfire risk
- Carefully consider development in locations where there is significant bushfire risk that cannot be avoided
- Avoid development in locations of extreme bushfire risk
- Avoid development in areas where planned bushfire protection measures may be incompatible with other environmental objectives (CFA, 2015).

CFA describe lower risk locations as:

- Not within the BMO

[10] Note this Fire Services Guideline is no longer available on the CFA web site but the principles are still considered valid.

- Have good road access
- Are located more than 700 m from large areas of vegetation like National and State Parks.

Extreme risk areas where development should be avoided are described as:

- Isolated settlements where the size and/or configuration of the settlements will be insufficient to modify fire behaviour and provide protection from a bushfire
- Where bushfire protection measures will not reduce the risk to an acceptable level
- Where evacuation (access) options are severely restricted
- Where the extent and potential impact of required bushfire protection measures may be incompatible with other environmental objectives or issue, e.g. vegetation protection, land subject to erosion or landslip (CFA, 2015).

In extreme risk locations, the following should not be used as justification for consideration of a proposal:

- A lack of alternative sites
- Past strategic planning decisions or policies lacking appropriate consideration of bushfire (CFA, 2015).

5.2.5 Guideline - Applying the Bushfire Hazard Landscape Assessment in a Bushfire Management Overlay

This CFA guideline is primarily focused on development in higher hazard landscapes. It states that the likely size and scale of a bushfire should directly inform how cautiously the bushfire planning provisions should be applied (CFA, 2022).

In Broader Landscape Types 3 and 4, protection of human '*life may not be prioritised*' by the approved measures of the BMO and Clause 53.02 alone, and additional bushfire mitigation measures may be required to achieve these objectives (CFA, 2022). Subdivision creating new lots should be carefully considered and may not be appropriate in such landscapes (CFA, 2022).

6 Landscape bushfire hazard assessment

6.1 Municipal description

Hepburn Shire comprises approximately 1,470 sq. km of land in central Victoria, almost half of which is covered in native vegetation and about a quarter of which is public land.

There is currently a population of approximately 16,000, which is projected to grow to 17,700 by 2036 (Hepburn Shire Council, 2022). Daylesford is the main town within the municipality and is a popular tourist destination with mineral springs, spa retreats and arts scene. Neighbouring Hepburn Springs forms a narrow band of urban development north from Daylesford, bordered on either side by public land, and is also known for its mineral springs. Other significant townships include Clunes, set in pasture and grassy woodland in the west of the Shire and one of Victoria's first gold mining towns, and Trentham on the edge of the forest in the south-east of the municipality.

The Shire comprises a mosaic of forest, farmland and settlements, with many residential areas in or close to bushland. The remnant vegetation is '*unevenly distributed across the Shire and native vegetation on fertile soils of the volcanic plains and river valleys today consist of only small, highly fragmented remnants within a rich agricultural landscape*' (Hepburn Shire Council, 2019). Areas retaining dense and medium tree cover are shown on Map 2.

The Shire spans three bioregions, Central Victorian Uplands, Goldfields, and Victorian Volcanic Plain. The Central Victorian Uplands bioregion comprises higher rainfall areas in the east and south of the Shire, including areas south of Creswick, south of Daylesford, and south and east of Glenlyon (Hepburn Shire Council, 2019). Most of the treed vegetation in this bioregion would likely comprise Forest under the AS 3959-2018 vegetation classification scheme.

The Goldfields bioregion occupies most of the western half of the Shire. This drier environment favours dry forests and woodlands (Hepburn Shire Council, 2019) that under the AS 3959-2018 classification scheme could be classified as Woodland if having a grassy understorey or Forest if a shrubby understorey is present.

The Victorian Volcanic Plain bioregion occupies an area in the centre of the municipality, west of Daylesford, and in the north-east, north of Glenlyon. Remnant native vegetation is predominantly Plains Grassy Woodland (Hepburn Shire Council, 2019) which would be classified as Woodland under AS 3959-2018.

The Shire is at the western extremity of the Great Dividing Range, with topography characterised by undulating hills, valleys, and numerous waterways, including the Loddon and Coliban rivers. The terrain is not extreme or particularly rugged, but there are locally steep slopes, particularly

north and west of Daylesford and Hepburn Springs, and to a lesser extent west of Drummond (see Map 3).

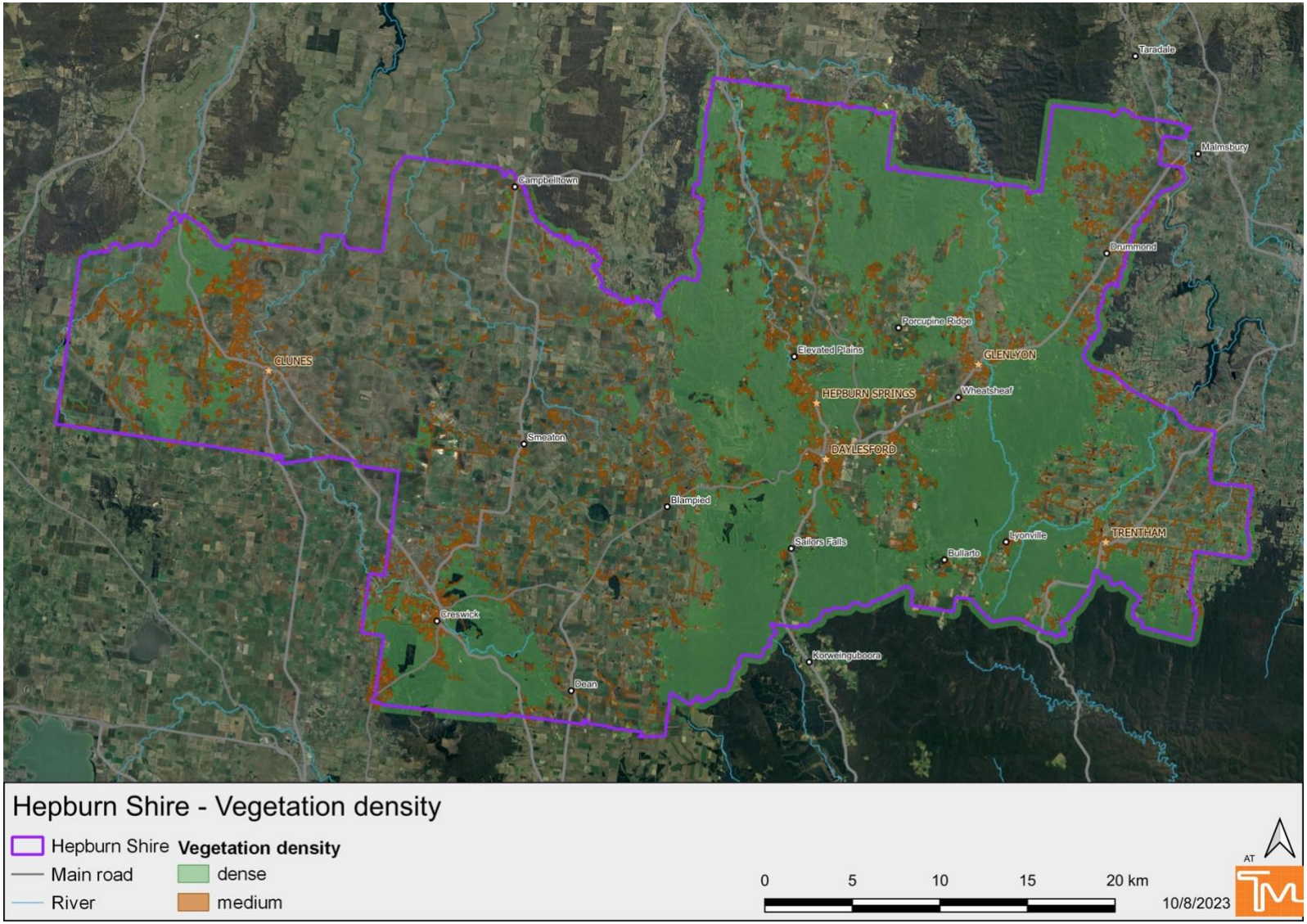
6.2 Bushfire history

The Shire has a significant bushfire history. Map 4 shows unplanned fires since 1960 as recorded in the publicly available dataset, with those over 25 ha labelled with the year of occurrence.

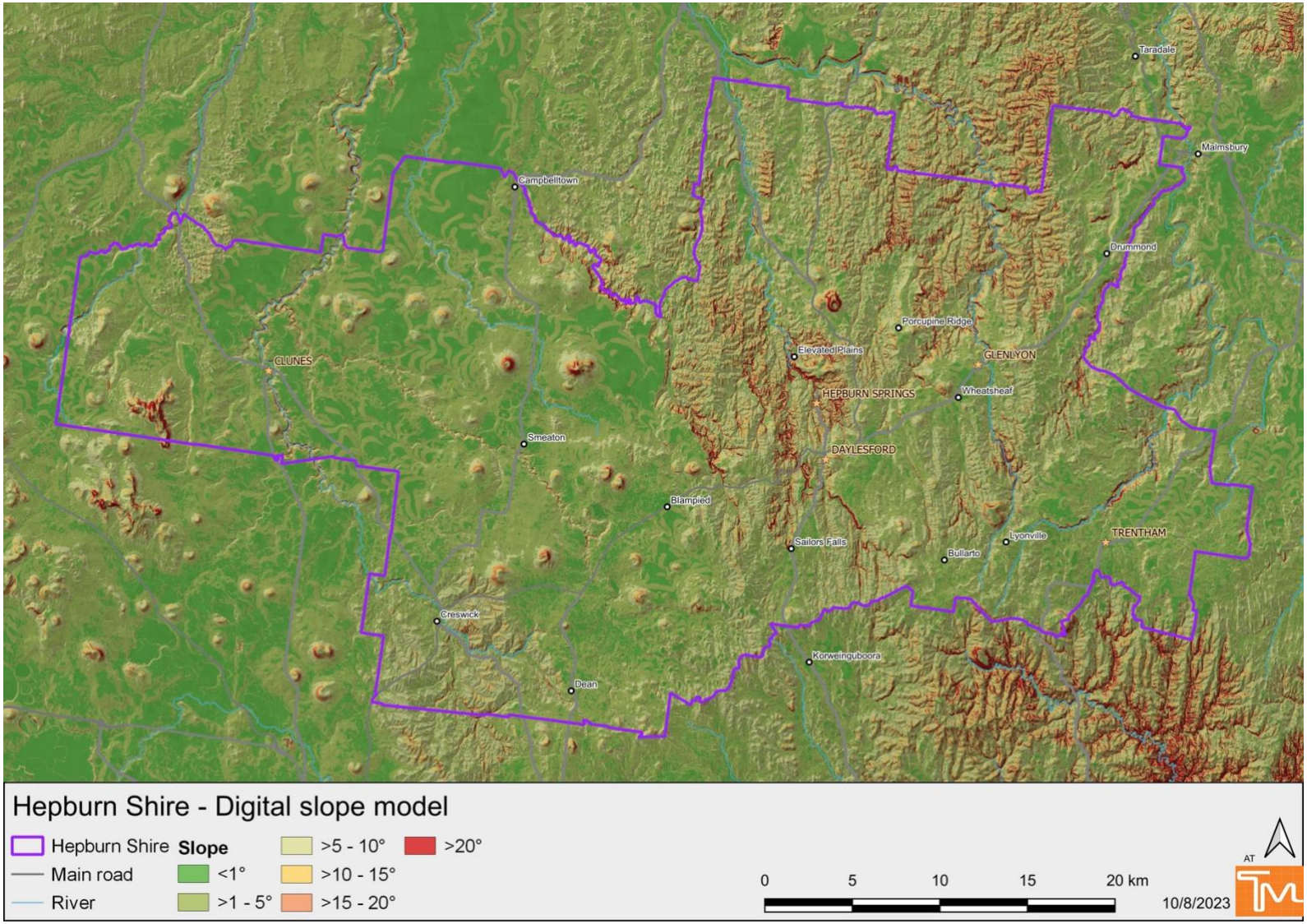
The most significant include:

- The 2,564 ha Musk Vale fire of 2009.
- The Spring Hill fire of 1998 that destroyed 60 buildings.
- A 1,786 ha fire south-east of Creswick in 1997.
- The Avoca-Maryborough fire of 1985, which burnt over 50,000 ha and affected 500 farms, resulting in 3 fatalities, 180 homes destroyed and 46,00 livestock killed. Most of the fire was north of the Shire but it burnt close to Clunes before being controlled.
- The East Trentham-Mount Macedon fire on Ash Wednesday 1983 that began on the eastern edge of the Shire and grew to 29,500 ha and resulted in 7 fatalities and 628 homes being lost in what is now Macedon Ranges Shire.
- The Glengower-Creswick fire of 1977, a fast moving 5,400 ha grassfire that burnt across the length of the Shire east of Creswick, destroying 14 homes and 33 other buildings and killing more than 3,400 livestock.
- Fires that burnt in the north of the Shire in 1969.
- A 5,000 ha fire in the Daylesford and Hepburn Springs area in 1962.

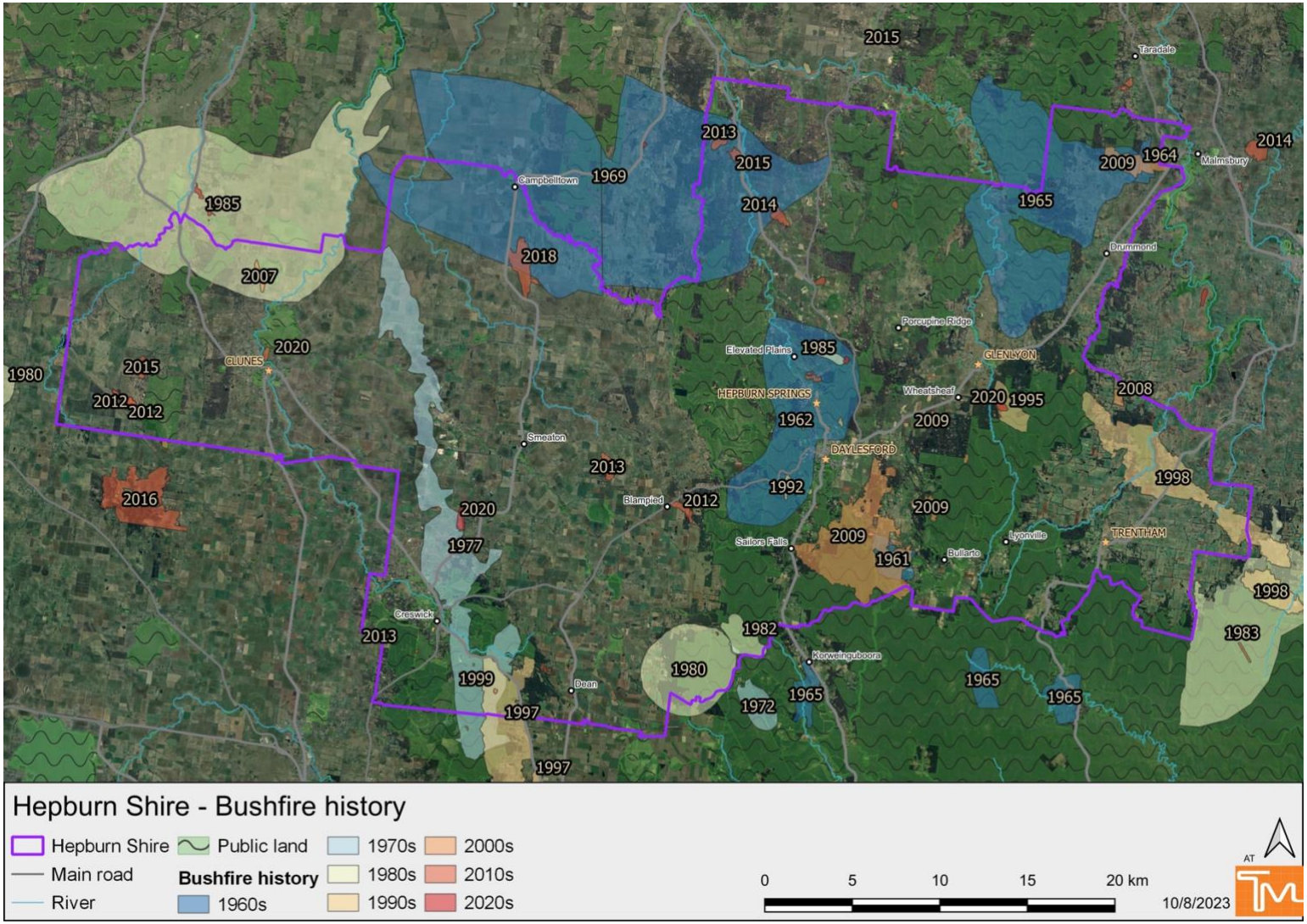
Whilst no ‘disaster fires’ have occurred within the Shire in the last 60 years, the regular occurrence of fires greater than 1,000 ha in size and the significant losses experienced just outside the Shire, show the potential fire danger both in the drier grassland and grassy woodland in the west of the Shire and the damper forests in the east.



Map 2 - Tree density across the Shire.



Map 3 - Digital slope model for the Shire (Note – slopes may be upslope or downslope in respect to any site).



Map 4 - Bushfire history for the Shire since 1960. Fires over 25 ha are labelled with the fire season they occurred in (Note – label shows second year of the fire season, e.g. 2017/2018 fire season is labelled 2018).

6.3 Fire weather and climate

6.3.1 Fire danger indices

The Forest Fire Danger Index (FFDI) and the Grassland Fire Danger Index (GFDI) represent the level of bushfire threat based on weather (and fuel) conditions. An FFDI 100/GFDI 130 is applied in non-alpine areas of Victoria by the building system, to establish a BAL based on building setback distances from classified vegetation in accordance with AS 3959-2018.

The FFDI and GFDI were used for forecasting daily Fire Danger Ratings (FDRs) but were replaced by the Fire Behaviour Index (FBI) when the new Australian Fire Danger Rating System (AFDRS) was adopted by all jurisdictions on 1st September 2022. Table 1 displays the new FDRs, their FBI range, the anticipated fire behaviour and recommended actions for each FDR.

The new AFDRS and FBIs do not correlate directly with the FFDI/GFFDI indices that are still applied in the planning and building system. However, the benchmark FFDI 100 used to represent a 'one size fits all' model of extreme fire weather conditions (and the threshold for the previous ‘Code Red’ FDR), is considered analogous to the new FBI 100 ‘Catastrophic’ FDR.

Note that these extreme conditions have been exceeded during significant fire events, including at some locations in Victoria on ‘Black Saturday’ 2009 and are not necessarily the worst-case conditions for any particular location, including Hepburn Shire.

Additionally, in southern and eastern Australia, since the 1950s there has been an increase in the length of the fire season and an increase in extreme fire weather (CSIRO/BOM, 2022). The trend of a longer fire season and increased number of elevated fire weather days is projected to continue. Climate change is contributing to these changes in fire weather, including increases in temperature, reduced relative humidity and associated reductions to fuel moisture content (CSIRO/BOM, 2022).

The Grampians Bushfire Management Strategy states that in Victoria climate change is expected to extend the length of the Fire Danger Period and increase the frequency of days of elevated fire danger, with potential for larger, more severe and frequent bushfires (DELWP, 2020b).

The latest climate projections for the Murray Basin cluster, that the Shire is in, state that there is a ‘very high confidence’ level that average temperatures in all seasons will continue to increase, with more hot days and warm spells combined with a decline in mean annual rainfall. There is a ‘high confidence’ in a harsher future fire weather climate, although a ‘low confidence’ in the magnitude of the change (CSIRO/BOM, 2023).

Climate change trends associated with the risk of bushfire, support the adoption of a precautionary and conservative approach in identifying and responding to the risk. However, as CFA and DTP have no published policy on FFDI recurrence intervals, there is no compelling reason to apply a different FFDI/GFDI from the FFDI 100/GFDI 130 threshold used throughout non-Alpine areas of Victoria in the planning and building system[11].

Table 1 - Fire Danger Ratings (BOM, 2022)

Forest Behaviour Index	Fire Danger Rating (FDR)	Fire Behaviour	Action
>=100	Catastrophic	If a fire starts and takes hold, lives are likely to be lost.	○ These are the most dangerous conditions for a fire. ○ Your life may depend on the decisions on you make, even before there is a fire. ○ For your survival, do not be in bushfire risk areas. ○ Stay safe by going to a safer location early in the morning or the night before. ○ If a fire starts and takes hold, lives and properties are likely to be lost. ○ Homes cannot withstand fires in these conditions. You may not be able to leave and help may not be available.
50-99	Extreme	Fires will spread quickly and be extremely dangerous.	○ These are dangerous fire conditions. ○ Check your bushfire plan and that your property is fire ready. ○ If a fire starts, take immediate action. If you and your property are not prepared to the highest level, go to a safer location well before the fire impacts. ○ Reconsider travel through bushfire risk areas. ○ Expect hot, dry and windy conditions. ○ Leaving bushfire risk areas early in the day is your safest option.
24-49	High	Fires can be dangerous.	○ There is a heightened risk. Be alert for fires in your area. ○ Decide what you will do if a fire starts. ○ If a fire starts, your life and property may be at risk. The safest option is to avoid bushfire risk areas.
12-23	Moderate	Most fires can be controlled.	○ Stay up to date and be ready to act if there is a fire.

[11] In Alpine areas of Victoria an FFDI 50 applies for determining BALs using Method 1 of AS 3959-2018.

6.3.2 Wind speed and direction

Analysis of weather data was undertaken by Terramatrix to determine wind speed and direction on days of elevated fire danger (and therefore the direction/s of highest threat, i.e. most likely direction/s of approach of a possible bushfire).

The analysis is based on a calculated 'historical' FFDI, using data obtained for the closest Bureau of Meteorology (BOM) stations considered representative of weather conditions for the study area and for which all the required data fields are available. These are the BOM Automatic Weather Stations (AWS) at Bendigo Airport (BOM Station No. 081123), approximately 80 km to the north of Daylesford, and at Ballarat Aerodrome (BOM Station No. 089002) located approximately 45 km south-west of Daylesford.

The analysis is based on synoptic weather data records available for all records that had all the required relative humidity, temperature and wind speed inputs for calculating the FFDI. The drought factor, which is also required to calculate FFDI, was assumed to be 10[12], which is 'worst case', long term drought conditions.

Table 2 summarises the attributes of the stations and data.

The data was cleaned to retain only those records for which all three inputs were available to calculate the FFDI, i.e. relative humidity (%), temperature (˚C) and wind speed (km/h at 10 m above ground level, averaged for the 10 min period before the reading).

Table 2 - Summary of Bendigo Airport and Ballarat Aerodrome BOM stations and data attributes

Attribute	Bendigo Airport	Ballarat Aerodrome
Distance and direction from site	80 km north of Daylesford	45 km south-west of Daylesford
Elevation	210 m	435 m
BOM Station No.	081123	089002
BOM district name	Upper North	South West
Opened	1991	1908
Data available	Synoptic	Synoptic
Date of oldest record with all inputs*	28/10/1991	24/07/2000
Date of most recent record with all inputs*	6/9/2022	17/07/2022
No. of years of data	31	23
No. of records with all inputs when FFDI>or=50*	218	818

*Record with all inputs = record that has all three attributes required to calculate FFDI assuming DF = 10; i.e. relative humidity, temperature and wind speed.

[12] The drought factor (DF) is a numerical scale from 1 to 10, which represents an estimate of the proportion of fine fuels available to be consumed in a fire, based on seasonal weather conditions and time since last rainfall. DF=10 means driest fuel conditions with 100% of fine fuels available to be burnt.

The FFDI analysis was undertaken to assist in analysing the hazard posed by the weather and does not necessarily equate to the actual FFDI or fire weather conditions that may have occurred.

As wind speed and direction is a major influence on fire behaviour, a wind rose was generated to show the frequency of wind speed and direction on days of elevated fire danger (i.e. days when calculated FFDI was greater than or equal to 50).

The results are provided in Figure 3 and Figure 4 and show the dominance of northerly or north-westerly winds on days of elevated fire danger.

The wind roses support the contention that on days of elevated fire danger the settlements are least likely to be exposed to direct bushfire attack from the east, south or south-east.

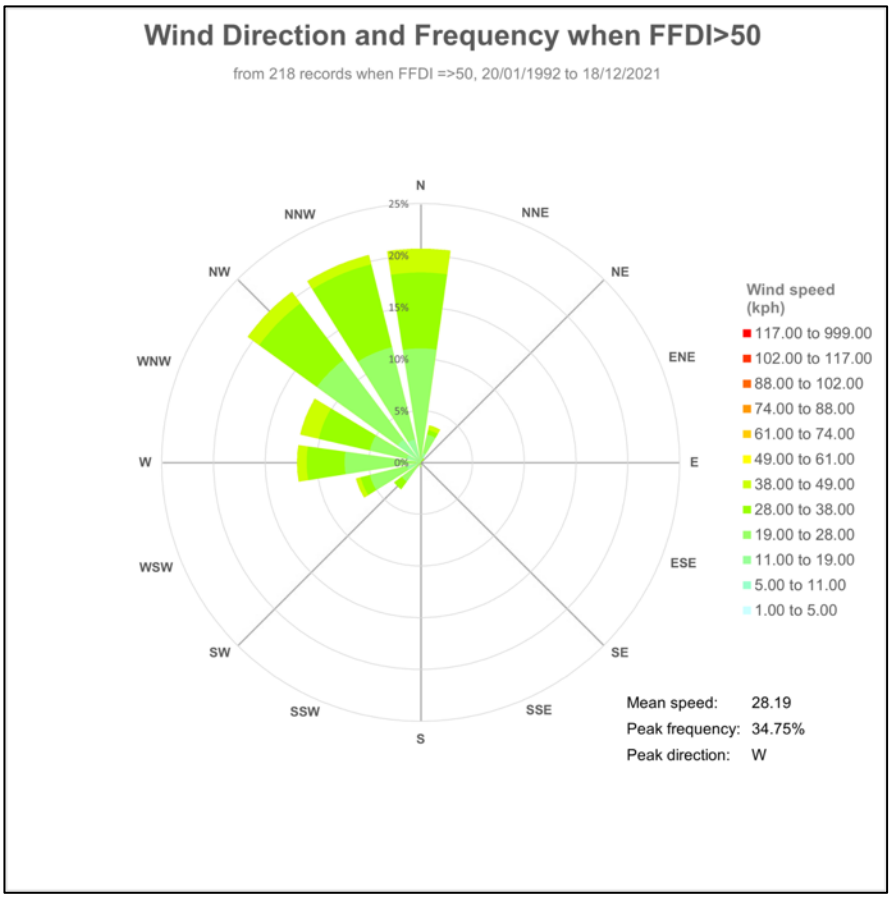


Figure 3 – Bendigo Airport AWS wind rose.

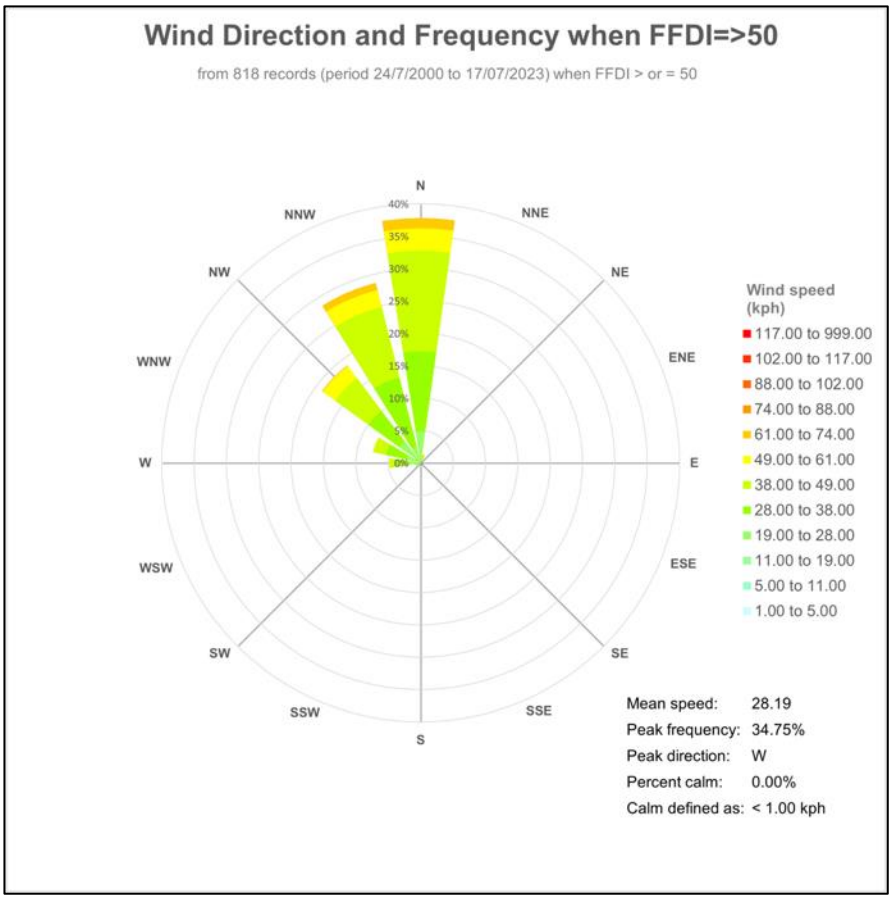


Figure 4 – Ballarat Aerodrome AWS wind rose.

6.4 Landscape-scale fire behaviour

The State Planning Policy for bushfire at Clause 13.02-1S requires, amongst other things, that the protection of human life be prioritised by directing population growth and development to low risk locations with safe access to areas where human life can be protected from the effects of a bushfire (Clause 13.02-1S Hepburn Planning Scheme).

The State policy and the BMO/AS 3959 methodology also require that development is setback from hazardous vegetation ('classified' vegetation) a distance such that radiant heat flux will not exceed defined BAL/radiant heat flux safety thresholds. These radiant heat setback distances are calculated based on a set of assumptions about, and models for, how fuel (vegetation), weather and topography interact to influence likely fire behaviour.

However, these assumptions and models may be less credible in locations where the pattern of topography and vegetation may interact with weather and atmospheric conditions to generate extreme bushfire behaviour that is beyond the design fire conditions underpinning the AS 3959/BMO model.

To help identify locations with the potential for extreme fire behaviour, Tolhurst (2014) described three landscape metrics of potential fire behaviour:

1. Terrain ruggedness
2. Convective strength
3. Ember storm potential

An explanation of these metrics is provided in Appendix B (see Section 16). Consideration of them is in accordance with the Clause 13.02-1S bushfire hazard identification and assessment strategy for '*Applying the best available science to identify vegetation, topographic and climatic conditions that create a bushfire hazard*' (Clause 13.02-1S Hepburn Planning Scheme).

The metrics provide a useful perspective on the potential for fire behaviour beyond the assumptions of the AS 3959/BMO design fire (i.e. where BMO Broader Landscape Type 4 characteristics might apply as identified in the *Technical Guide – Planning Permit Applications Bushfire management Overlay* (DELWP, 2017)). They have not, however, been endorsed by a Victorian government agency and so they have been used in this report to help form an opinion about the potential for the most extreme fire behaviour across the Shire, rather than to quantify potential bushfire behaviour around individual settlements.

Moderately rugged terrain occurs through much of the centre of the Shire, including around Blampied, Daylesford, Hepburn Springs, Elevated Plains, Porcupine Ridge and Wheatsheaf, and also to the north-west and south-west of Clunes, albeit at a greater distance from the settlement. There are no areas of highly or extremely rugged terrain within the municipality.

The modelled convective strength is relatively low (not exceeding 200 MW) around all the settlements, increasing to moderate (up to 400 MW) north of Elevated Plains and south of Trentham. No area of the Shire is rated above moderate for convective strength. The Shire is, therefore, considered a relatively lesser risk location for convective-driven, extreme fire behaviour, although the risk cannot entirely be ruled out, given the expansive areas of public and private forest.

There is a relatively higher risk of ember storm west of Clunes, from a bushfire on Mount Beckworth, and around Blampied, Daylesford / Hepburn Springs, Woodburn and Coomoora. Settlements with large areas of vegetation with a high proportion of stringybark Eucalypts (e.g. Messmate, Red Stringybark) in the canopy within 400 m to the north, north-west or west (directions associated with prevailing winds on days of elevated fire danger, see wind analysis presented in Section 6.3.2) are at higher risk of ember attack, as vegetation with a high cover of fine, fibrous barked Eucalypts can pose an extreme bark hazard that is associated with elevated levels of ember attack. Analysis in Section 7.1 of this report shows stringybarks are a character species in multiple EVCs found in the vicinity of all study areas other than Clunes.

Overall, the Tolhurst modelling suggests that whilst all settlement, other than Clunes, could be exposed to a large forest fire, bushfire behaviour is likely to be within the parameters of the AS 3959/BMO design fire under the FDI 100 conditions presumed by the design fire.

6.5 BMO landscape risk typologies

To assist in assessing landscape risk, four Broader Landscape Types, representing different landscape risk levels, are described in the technical guide *Planning Applications Bushfire Management Overlay*. These are intended to streamline decision-making, and support more consistent decisions based on the landscape risk (DELWP, 2017).

The four types range from lower risk landscapes, where there is little hazardous vegetation beyond 150 m of a site except grasslands and extreme bushfire behaviour is not credible, to extreme risk landscapes with limited or no evacuation options and where fire behaviour could exceed BMO/AS 3959-2018 presumptions (see Table 3).

Whilst the broader Hepburn landscape is not especially conducive to the most extreme fire behaviour (see Section 6.4), the bushfire hazard at a local and neighbourhood scale (i.e. within 1 km of the settlements) for most of the townships is very high or extreme, as all but Clunes are within or adjacent to large areas of forest.

All the townships could potentially be exposed to a fully developed bushfire (or grassfire) as envisaged in the BMO/AS 3959 methodology. This is evidenced by the fact that all have some BMO coverage in and around them, reflecting the proximity of hazardous vegetation and the fact that nearly 50% of the municipality retains native vegetation on public or private land.

The Broader Landscape Type/s that best describe each of the townships are detailed in the relevant sections of this report. Overall, it is considered that the broader landscape around the townships is best characterised as Landscape Type 3, which is typical of BMO landscapes; with some sheltered or central areas of some of the larger townships having some characteristics of Landscape Type 2.

It is important to note that the landscape types are broad and subjective, there are no criteria to objectively define them, they represent a spectrum of risk, and the risk to each township is not necessarily homogenous across all parts of each settlement. Because the descriptions of the four Broader Landscape Types are multi-faceted, many locations will match at least some of the descriptors provided for more than one landscape type, often depending on the geographic scale of assessment. Spatially, it can be difficult to delineate the boundaries between them.

CFA advise that in Broader Landscape Types 3 and 4, additional bushfire mitigation measures may be required to achieve the BMO objectives, above and beyond the approved measures of

and Clause 53.02 (CFA, 2022a). Subdivision creating new lots should be carefully considered and may not be appropriate in such landscapes (CFA, 2022a).

Table 3 - Landscape risk typologies (from DELWP, 2017).

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.* • *Fires have hours or days to grow and develop before impacting.* • *Evacuation options are limited or not available.*
I N C R E A S I N G R I S K →			

7 Local and neighbourhood bushfire hazard assessment

7.1 Vegetation

The hazard posed by vegetation at the local and neighbourhood scales around the townships has been identified by delineating classified vegetation from Ecological Vegetation Classes (EVCs), based on DEECA modelled EVC mapping. The modelled occurrence of EVCs within and up to 1 km around each study area is summarised in Table 4.

Analysis of EVC bioregional benchmarks enables them to be classified into the AS 3959-2018 vegetation groups (see Table 5). The most commonly occurring EVCs are most appropriately classified in the AS 3959 Forest or Woodland groups, in accordance with the principles in Douglas (2011) and Douglas *et al.* (2014).

Table 4 - EVCs within 1 km of each township.

EVC		Township (Bioregion)			
#	Name	Clunes (VVP)	Daylesford (CVU) / Hepburn Springs (Gf)	Glenlyon (CVU)	Trentham (CVU)
18	Riparian Forest				Y
20	Heathy Dry Forest	Y	Y		
22	Grassy Dry Forest		Y		
23	Herb-rich Foothill Forest			Y	Y
47	Valley Grassy Forest		Y		
53	Swamp Scrub	Y			
55	Plains Grassy Woodland	Y		Y	
61	Box Ironbark Forest	Y			
71	Hills Herb-rich Woodland	Y			
175	Grassy Woodland	Y			
198	Sedgy Riparian Woodland			Y	Y
851	Stream Bank Shrubland			Y	

CVU – Central Victorian Uplands; VVP – Victorian Volcanic Plain; Gf - Goldfields.

Table 5 - EVC description and derived AS 3959 classifications from bioregional benchmark information.

EVC	EVC description	% Tree canopy cover & character species	AS 3959-2018 classification
EVC 18 - Riparian Forest	Central Victorian Uplands – '*A tall forest to 30 m tall along river banks and associated alluvial terraces with occasional occurrences in the heads of gullies leading into creeks and rivers. Soils are fertile alluvium, regularly inundated and permanently moist. Dominated by tall eucalypts, but also has an open to sparse secondary tree layer of wattles and scattered dense patches of shrubs, ferns, grasses and herbs*' (DSE, 2004a).	40% • Narrow-leaf Peppermint • Manna Gum • Eurabbie	Forest
EVC 20 - Heathy Dry Forest	Central Victorian Uplands & Goldfields - '*Grows on shallow, rocky skeletal soils on a variety of geologies and on a range of landforms from gently undulating hills to exposed aspects on ridge tops and steep slopes at a range of elevations. The overstorey is a low, open eucalypt forest, poor in form to 20 m tall with an open crown cover. The understorey is dominated by a low, sparse to dense layer of ericoid-leaved shrubs including heaths and peas. Graminoids and grasses are frequently present in the ground layer, but do not provide much cover*' (DSE, 2004a; DSE, 2004b).	30% • Red Stringybark • Red Box • Red Ironbark • Bundy • Broad-leaved Peppermint • Long-leaf Box • Brittle Gum	Forest
EVC 22 - Grassy Dry Forest	Central Victorian Uplands & Goldfields - '*Occurs on a variety of gradients and altitudes and on a range of geologies. The overstorey is dominated by a low to medium height forest of eucalypts to 20 m tall, sometimes resembling an open woodland with a secondary, smaller tree layer including a number of Acacia species. The understorey usually consists of a sparse shrub layer of medium height. Grassy Dry Forest is characterised by a ground layer dominated by a high diversity of drought-tolerant grasses and herb, often including a suite of fern species*' (DSE, 2004a; DSE, 2004b).	30% • Red Stringybark • Bundy • Messmate Stringybark • Red Box • Yellow Box • Bundy	Woodland or Forest depending on density of shrub layer
EVC 23 - Herb-rich Foothill Forest	Central Victorian Uplands - '*Occurs in relatively fertile, moderately well-drained soils on an extremely wide range of geological types and in areas of moderate to high rainfall. Occupies easterly and southerly aspects mainly on lower slopes and in gullies. A medium to tall open forest or woodland to 25 m tall with a small tree layer over a sparse to dense shrub layer. A high cover and diversity of herbs and grasses in the ground layer characterises this EVC'* (DSE, 2004a).	40% • Eurabbie • Messmate Stringybark • Broad-leaved Peppermint	Forest
EVC 47 - Valley Grassy Forest	Central Victorian Uplands & Goldfields - '*Valley Grassy Forest occurs under moderate rainfall regimes of 700-800 mm per annum on fertile well-drained colluvial or alluvial soils on gently undulating lower slopes and valley floors. The tall, open overstorey to 20 m tall may carry a variety of eucalypts, usually species which prefer more moist or more fertile conditions over a*	20% • Yellow Box • Narrow-leaf Peppermint	Woodland

EVC	EVC description	% Tree canopy cover & character species	AS 3959-2018 classification
	sparse shrub cover. In season, a rich array of herbs, lilies, grasses and sedges dominate the ground layer but at the drier end of the spectrum the ground layer may be sparse and slightly less diverse, but with moisture-loving species still remaining' (DSE, 2004a; DSE 2004b).	• Messmate Stringybark • Red Stringybark • Red Box • Candlebark • Bundy	
EVC 53 - Swamp Scrub	Victorian Volcanic Plain – '*Closed scrub to 8 m tall at low elevations on alluvial deposits along streams or on poorly drained sites with high nutrient and water availability. Soils vary from organic loams to fine silts and peats which are inundated during the wetter months of the year and is dominated by Woolly tea-tree* Leptospermum lanigerum *which often forms a dense impenetrable thicket, out-competing other species. Emergent trees (e.g. Swamp Gum* Eucalyptus ovata*) may sometimes be present. Where light penetrates to ground level, a moss/lichen/liverwort herbaceous ground cover is often present*' (DSE, 2004c)	60% • Wooly Tea-tree • Scented paperbark • Blackwood	Scrub
EVC 55 - Plains Grassy Woodland	Victorian Volcanic Plains & Central Victorian Uplands - '*An open, eucalypt woodland to 15 m tall occurring on a number of geologies and soil types. Occupies poorly drained, fertile soils on flat or gently undulating plains at low elevations. The understorey consists of a few sparse shrubs over a species-rich grassy and herbaceous ground layer*' (DSE, 2004c; DSE, 2004b).	15% • River Red Gum • Grey Box • Yellow Box • Buloke	Woodland
EVC 61 - Box Ironbark Forest	Goldfields - '*Occurs in low rainfall areas on gently undulating rises, low hills and peneplains on infertile, often stony soils derived from a range of geologies. The open overstorey to 20 m tall consists of a variety of eucalypts, often including one of the Ironbark species. The mid storey often forms a dense to open small tree or shrub layer over an open ground layer ranging from a sparse to well-developed suite of herbs and grasses'* (DSE, 2004b).	30% • Grey Box • Red Ironbark • Red Box • Yellow Gum	Woodland or Forest depending on density of shrub layer
EVC 71 – Hills Herb-rich Woodland	Central Victorian Uplands - '*A dry, open eucalypt woodland to 15 m tall often with a sparse shrub layer. The understorey is dominated by a carpet of herbs and grasses. Soils are generally shallow but fertile, and outcropping of rock is not uncommon. This seasonally dry environment is favourable for annual herbs, with the fertile nature of the various geologies also supporting perennial herbs. Landform can vary from relatively flat ground to ridge tops on sedimentary sandstones (along seams of mineral-rich sandstone) to undulating, rounded, granite hill landforms*' (DSE, 2004a).	15% • Grey Box • Yellow Box • River Red Gum	Woodland
EVC 175 - Grassy Woodland	Central Victorian Uplands - '*A variable open eucalypt woodland to 15 m tall over a diverse ground layer of grasses and herbs. The shrub component is usually diverse but sparse in cover. In the Goldfields bioregion, Grassy Woodland occurs on sedimentary soils on the lowest slopes*	15% • Red Box • Manna Gum • Yarra Gum	Woodland

EVC	EVC description	% Tree canopy cover & character species	AS 3959-2018 classification
	at the interface between the plains and the infertile woodlands of the sedimentary hills' (DSE, 2004a).	• Snow Gum • Swamp Gum	
EVC 198 – Sedgy Riparian Woodland	Central Victorian Uplands - '*Eucalypt forest or woodland to 15 m tall with sedge-dominated understorey. Occurs on flats along low gradient creeks and drainage lines subject to seasonal inundation and waterlogging in moderately fertile habitats*' (DSE, 2004a).	20% • Swamp Gum • Narrow-leaf Peppermint • Messmate Stringybark	Woodland
EVC 851 – Streambank Shrubland	Central Victorian Uplands - '*Rivers and major streams where the watercourse consists of either rocky banks, a flat rocky stream bed or broad gravel banks which are often dry but are also regularly flooded by fast flowing waters. Annual rainfall is usually below 700 mm. There is a sparse overstorey of trees to 20 m tall, a dominant tall shrub layer and a ground layer of sedges and herbs*' (DSE, 2004a).	10% • Gippsland Blue-gum	Scrub

7.2 Proximity to bushfire hazard

The development setbacks in Clause 13.02-1S and the AS 3959/BMO model are based on proximity to hazardous (classified) vegetation to ensure that a BAL outcome (maximum BAL-12.5 for settlement planning) is met, based on radiant heat flux exposure thresholds for a building (see Appendix A at Section 15 for an explanation of BALs and radiant heat flux exposure thresholds).

However, it is known that embers, much more than radiant heat, account for most houses lost in bushfires in Australia (Blanchi and Leonard, 2005; DELWP, 2017) and that the density of embers decreases exponentially with distance from vegetation, which correlates with decreasing probability of house damage (Tolhurst and Howlett, 2003).

Proximity to hazardous vegetation has been shown to strongly correlate with house loss/survival data from major bushfires throughout Australia. Chen and McAneney (2004, 2010) undertook a spatial analysis of building loss in major forest fires that impacted on peri-urban areas in south-eastern Australia. Based on cumulative data from all the fires, it was found that:

- Approx. 50% of buildings lost were within 20 m of bushland
- Approx. 35% of buildings lost were >20 m to 100 m from bushland
- Approx. 10% of buildings lost were >100 m to 200 m from bushland
- Approx. 5% of buildings lost were located >200 m-700 m from bushland
- No buildings were lost beyond 700 m from bushland.

Other researchers have reported similar findings regarding house loss and the proximity of vegetation (e.g. Crompton *et al.*, 2011; Gibbons *et al.*, 2012; Newnham *et al.* 2012).

George *et al.* (2020) produced more recent cumulative house loss data that included findings from bushfires that occurred in NSW in December 2019-January 2020. Their study reiterated the statistical dependence of house loss data on distance to bushland, but they found the correlation was less significant where ember attack was a major element of the fire behaviour.

Notwithstanding, the results shows that in the nine major Australian bushfires analysed, 95% of all destroyed buildings were within 400 m of bushland in all but one major event, where the 400 m threshold equated to approximately the 93rd percentile.

The findings are shown in Figure 5, with 400 m (the Clause 13.02-1S neighbourhood assessment distance) and 150 m (BMO site assessment distance) indicators added by Terramatrix as dashed lines.

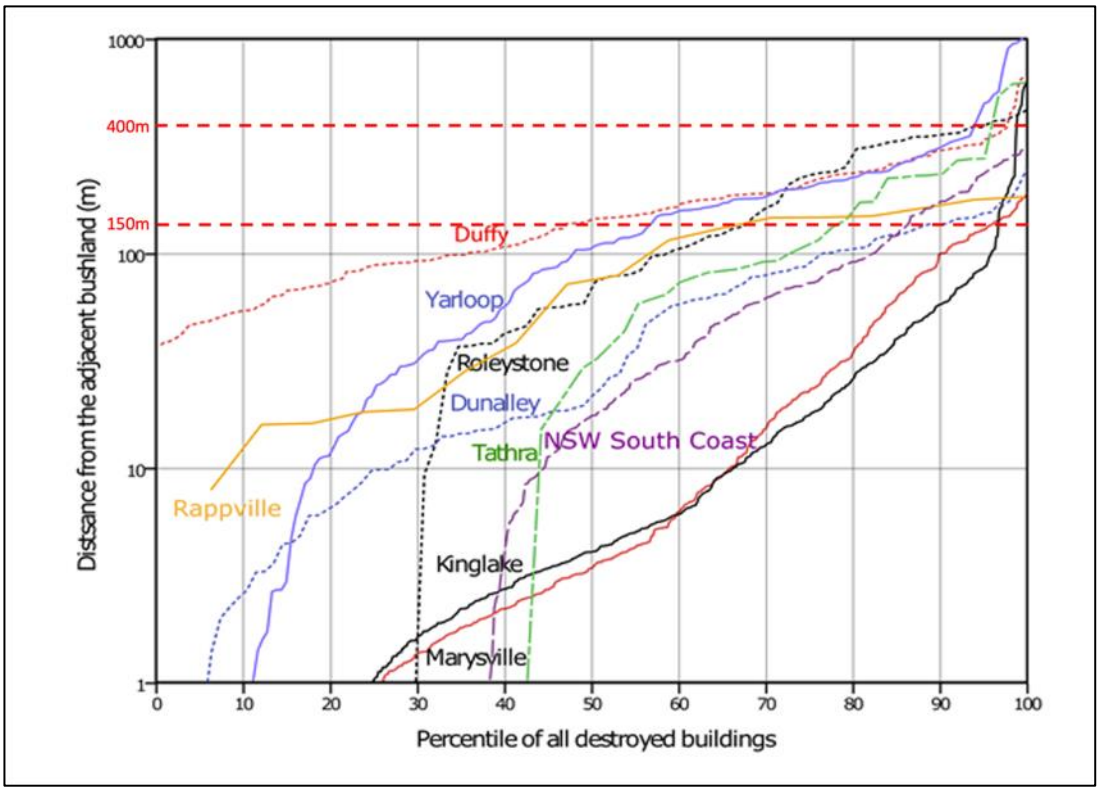


Figure 5 - Percentile of destroyed buildings and proximity to bushland (from George *et al.*, 2020).

Distance to bushland also strongly correlates with statistics for life loss in bushfires. A CSIRO study of 825 bushfire fatalities in the period 1901-2011, found that over 50% of all fatalities occurred within 10 m of forest, 78% occurred within 30 m and 85% occurred within 100 m. Within buildings, the life loss data showed 95% of fatalities were in buildings within 50 m of forest and 88% were in buildings within 30 m (Blanchi *et al.*, 2012).

Note that BMO coverage extends 150 m (and in situations where head fire intensity may be extreme, up to 300 m) from the edge of hazardous vegetation. This indicates that beyond 300 m from the BMO coverage, or a forest/bushland edge, acceptable safety is potentially able to be achieved by compliance with the building regulations, as long as the landscape risk is not extreme, i.e. as long as fire weather, fuel and fire behaviour characteristics at the location will not likely exceed AS 3959/BMO presumptions. Note also, that one of the criteria for an area of land to qualify for exclusion from the BPA designation, is that it must be at least 150 m and up to 300 m from areas of classified vegetation, except Grassland, more than 2 ha in size (DELWP, 2019).

The distance to hazardous vegetation is, therefore, a useful metric for establishing what constitutes an 'acceptable risk' for strategic planning purposes, e.g. if zero house loss is the acceptable risk threshold, then no development should occur within at least 1.3 km of bushland based on South Coast NSW house loss survey data of 426 properties (George *et al.*, 2020). This is considered overly precautionary as the data shows approximately 95% of house losses are within

400 m, and at these distances impact on a dwelling is not by a forest fire but by low density ember attack and/or a grassfire, which is easier to mitigate through the planning and design of settlements and construction of buildings to an appropriate BAL.

It should also be noted that the house loss findings are based on historical data that mostly includes dwellings not built to a BAL or provided with mandated defendable space. Also, the analysis does not take into account other factors such as house-to-house ignitions; house design, maintenance and construction; landscaping around a house; or fire brigade/householder intervention.

The statistics also do not consider the composition, minimum size or shape, that an area of vegetation needs to be to pose a hazard based on its proximity to an asset. Further, the findings are based on large forest fires and do not necessarily reflect Grassland/open Woodland bushfire impacts.

8 Site hazard assessment

AS 3959-2018 *Construction of buildings in bushfire prone areas* requires a site assessment of the vegetation and topography up to 100 m around a building for the purposes of determining the applicable BAL construction standard for that building (Standards Australia, 2020). A site hazard assessment is also required in BMO areas, extending at least 150 m around a building, development site or subdivision boundary (DELWP, 2017).

As no specific development is being proposed for any of the townships, the site assessment process has been utilised to broadly identify potential BALs and commensurate defendable space requirements within the study areas of each township. The assessment has been undertaken broadly, at a strategic level, for settlement planning purposes only. The results should not be used for determining the applicable BAL or BMO measures for statutory planning purposes in relation to a specific site or development application.

This analysis of classified vegetation and topography identifies their potential to meet key settlement planning safety thresholds in Clause 13.02-1S *Bushfire Planning.* Specifically, the location and extent of areas that are likely to be able to support BAL-12.5 development (i.e. where radiant heat flux is anticipated to not exceed 12.5 kW/m^2 upon completion of the development) and any areas that could be defined as BAL-LOW.

These two safety thresholds are key policy tests for settlement planning. Clause 13.02-1S directs population growth and development to 'low risk locations', which are defined as '*…locations assessed as having a radiant heat flux of less than 12.5 kilowatts/square metre under AS 3959-2018 Construction of Buildings in Bushfire-prone Areas…*' (Clause 13.02-1S Hepburn Planning Scheme). The second key policy test for settlement planning is '*Ensuring the availability of, and safe access to, areas assessed as a BAL-LOW rating under AS 3959-2018 Construction of Buildings in Bushfire-prone Areas (Standards Australia, 2018) where human life can be better protected from the effects of bushfire'* (Clause 13.02-1S Hepburn Planning Scheme).

8.1 Classified vegetation

Vegetation within and around the settlements has been classified in accordance with the AS 3959/BMO methodology to identify the hazard at the neighbourhood and site scale. Classified vegetation is vegetation that is deemed hazardous from a bushfire perspective. The vegetation classification system is not directly analogous to Ecological Vegetation Classes (EVCs) but uses a generalised description of vegetation based on the Australian Natural Resources Atlas: No. 7 - Native Vegetation (AUSLIG) classification system. The classification is based largely on the structural characteristics of the vegetation at maturity, but the key determinant should be the likely fire behaviour that it will generate.

EVCs within and around the townships best align with the following BMO vegetation groups.

8.1.1 Forest

Forest vegetation comprises areas with trees to 30 m high or taller at maturity, typically dominated by eucalypts, with 30–70% foliage cover (may include understorey ranging from rainforest species and tree ferns to sclerophyllous low trees or shrubs). Includes pine and eucalypt plantations (Standards Australia, 2020).

8.1.2 Woodland

Woodland vegetation typically comprises areas with trees up to 30 m tall, 10–30% foliage cover dominated by eucalypts (and/or callitris) with a prominent grassy understorey, may contain isolated shrubs (Standards Australia, 2020).

8.1.3 Scrub

Scrub comprises areas with shrubs that have an average height of more than 2 m, with 10% to more than 30% foliage cover. Typical of coastal areas and tall heaths up to 6 m in height. May be dominated by Banksia, Melaleuca or Leptospermum with heights of up to 6 m (Standards Australia, 2020).

8.1.4 Grassland

Grassland is defined as all forms of vegetation (except Tussock Moorlands) including situations with shrubs and trees, if overstorey foliage cover is less than 10%. Includes pasture and cropland (Standards Australia, 2020).

Grassland vegetation is considered hazardous, and therefore classifiable, when it is unmanaged i.e. more than 100 mm tall. Grassland areas are assumed to be unmanaged and classifiable unless there is 'reasonable assurance' that they will be managed in perpetuity, in a low threat state, no more than 100 mm high.

8.1.5 Modified vegetation

Treed vegetation within in and on the periphery of some townships has been partially cleared or otherwise managed. This may be considered Modified vegetation under the BMO.

'Modified vegetation is vegetation that doesn't fit into the vegetation classifications in AS 3959-2018 Construction of buildings in bushfire prone areas (the standard) because it:

- *has been modified, altered or is managed due to urban development, or gardening,*
- *has different fuel loads from those assumed in the standard,*
- *has limited or no understorey vegetation, or*
- *is not low-threat or low-risk vegetation as defined in the standard'* (Clause 53.02-5, Hepburn Planning Scheme).

Modified vegetation may occur where fuel loads are higher than typical residential gardens and therefore the vegetation cannot be excluded as low threat. However, because of the amount of disturbance and modification that has occurred (e.g. reduced or no understorey/surface vegetation) and/or the pattern and configuration of the vegetation (e.g. small, fragmented patches), the fuel load and anticipated fire behaviour is likely to be different from that presumed in the BMO/AS 3959 methodology.

This type of vegetation may not produce a 100 m wide fire front moving at a quasi-steady state rate of forward spread, as presumed in the BMO/AS 3959 methodology, but may generate radiant heat and localised flame contact that needs to be fully considered (DELWP, 2017).

This classification has not, however, been applied in this strategic assessment as CFA guidance in higher risk landscapes is to classify such vegetation according to its undisturbed state (CFA, 2022a).

8.2 Excluded vegetation and non-vegetated areas

Areas of low threat vegetation and non-vegetated areas can be excluded from classification and be deemed non-hazardous in accordance with Section 2.2.3.2 of AS 3959-2018, if they meet one or more of the following criteria:

(a) *'Vegetation of any type that is more than 100 m[13] from the site.*

(b) *Single areas of vegetation less than 1 ha in area and not within 100 m of other areas of vegetation being classified vegetation.*

(c) *Multiple areas of vegetation less than 0.25 ha in area and not within 20 m of the site, or each other or of other areas of vegetation being classified vegetation.*

(d) *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 vegetation.*

(e) *Non-vegetated areas, that is, areas permanently cleared of vegetation, including waterways, exposed beaches, roads, footpaths, buildings and rocky outcrops.*

(f) *Vegetation regarded as low threat due to factors such as flammability, moisture content or fuel load. This includes grassland managed in a minimal fuel condition, mangroves and other saline wetlands, maintained lawns, golf courses (such as playing areas and fairways), maintained public reserves and parklands, sporting fields, vineyards, orchards, banana plantations, market gardens (and other non-curing crops), cultivated gardens, commercial nurseries, nature strips and windbreaks.*

[13] 150 m in BMO areas.

NOTES:

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

2 *A windbreak is considered a single row of trees used as a screen or to reduce the effect of wind on the leeward side of the trees'* (Standards Australia, 2020).

8.3 Defendable space

This report identifies low threat setbacks of townships from the bushfire hazard and the provision of defendable space for buildings covered by the BMO.

Defendable space is defined as '*An area of land around a building where vegetation is modified and managed to reduce the effects of flame contact and radiant heat associated with bushfire*' (Clause 73.01, Hepburn Planning Scheme).

The BMO provides vegetation management standards for defendable space at Table 6 to Clause 53.02-5:
'Defendable space is provided and is managed in accordance with the following requirements:

- *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 10 metres of a building, flammable objects must not be located close to the vulnerable parts of the building.*
- *Plants greater than 10 centimetres in height must not be placed within 3 metres 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 sq. metres in area and must be separated by at least 5 metres.*
- *Trees must not overhang or touch any elements of the building.*
- *The canopy of trees must be separated by at least 5 metres.*
- *There must be a clearance of at least 2 metres between the lowest tree branches and ground level.*

Unless specified in a schedule or otherwise agreed in writing to the satisfaction of the relevant fire authority' (Clause 53.02-5, Hepburn Planning Scheme).

This is the minimum standard envisaged where the terms low threat setback or defendable space are used in this report.

Part B
Townships

9 Clunes

9.1 Study area

9.1.1 Description

Clunes is a small historic gold town in the west of the Shire, approximately 34 km north-east of Ballarat and 139 km north-west of Melbourne. At the 2016 census it had a population of 1,728.

9.1.2 Zoning and overlays

The township area of Clunes is zoned Neighbourhood Residential Zone -Schedule 2 (NRZ2) (see Map 5).

Adjacent land to the west, north-west and north-east is zoned Low Density Residential Zone – Schedule 1 (LDRZ1), which has a minimum lot size of 0.4 ha for areas without reticulated sewerage and 0.2 ha for areas with reticulated sewerage.

Land further to the north-west, either side of the Ballarat-Maryborough Road; immediately north of the township; and to the north-east beyond the LDRZ1 land, is zoned Rural Living Zone – Schedule 1 (RLZ1). RLZ1 has a minimum lot size of 8 ha.

Schedule 1 to Clause 42.01 *Environment Significance Overlay* (ESO1) *Special Water Supply Catchment Protection* applies to the entire study area. It has no apparent implications for bushfire protection.

Schedule 2 to Clause 42.02 *Vegetation Protection Overlay* (VPO2) *Significant Exotic and Native Vegetation* applies to a very small part of the town area and has no apparent implications for bushfire protection.

9.2 Existing hazard and risk assessments

9.2.1 Regional Bushfire Planning Assessment

No bushfire planning issues were identified for Clunes (DPCD, 2012).

9.2.2 Grampians Bushfire Management Strategy

Clunes was rated a Low-Intermediate risk for house loss (DELWP, 2020b).

9.3 Broader landscape hazard assessment

9.3.1 Bushfire scenarios

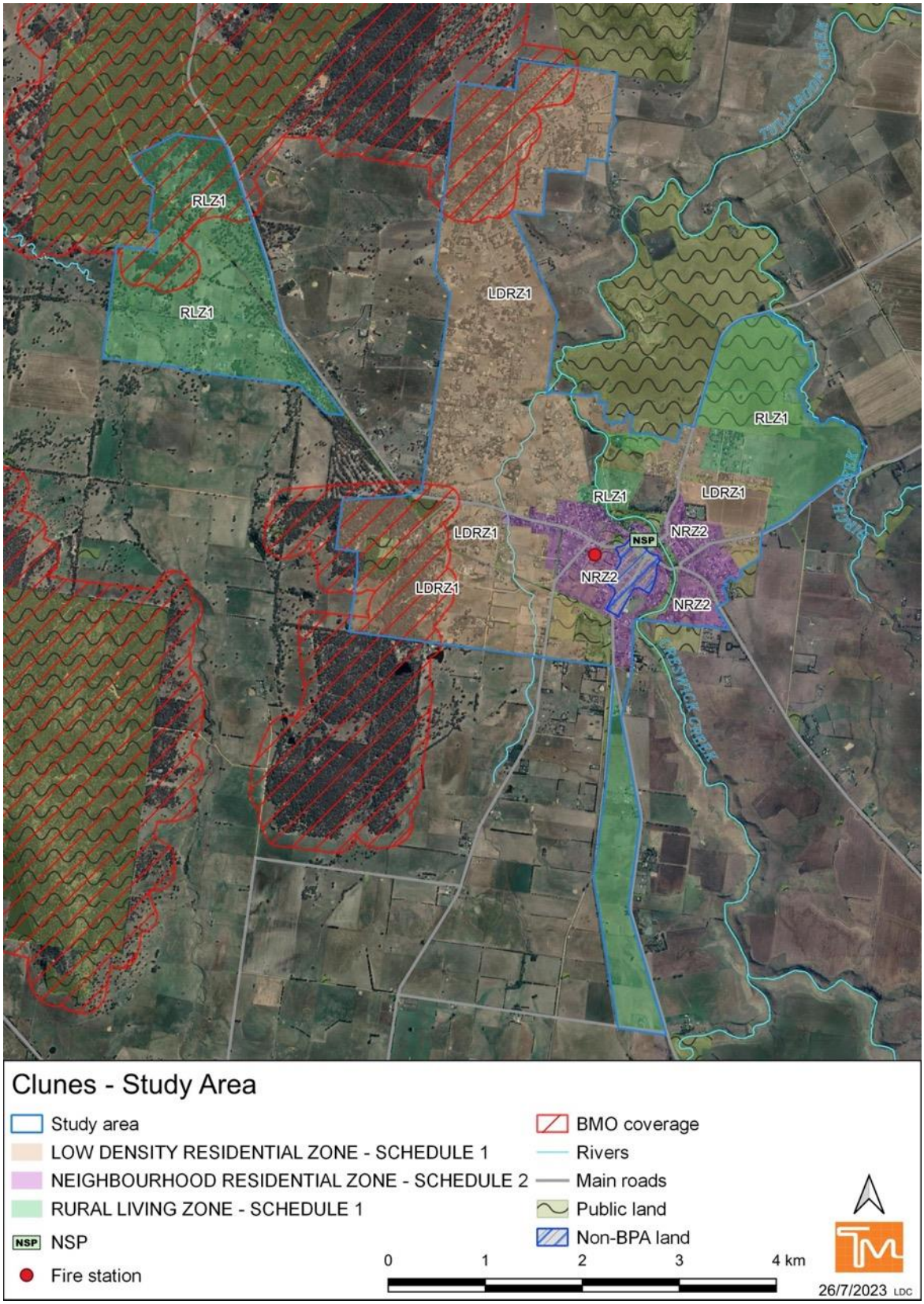
Clunes could be impacted by a large bushfire burning through Woodland from the north or south-west, which are the typical directions of approach under elevated fire weather in Victoria (Long, 2006). Most of the LDRZ1 land is exposed to flat Grassland or remnant grassy Woodland, and whilst fire spread may be rapid, the intensity and level of ember attack will be less than in densely forested areas in other parts of the Shire. Areas close to the Woodland, however, may still experience ember attack, in particular the south-western extremity of the LDRZ1 land, covered by the BMO, due to its proximity to Woodland on steep, elevated terrain to the south-west around Mount Beckworth.

Potential fire behaviour around Clunes should be within the design fire parameters of AS 3959/BMO.

9.3.2 BMO broader landscape type

The Clunes township and immediately adjacent LDRZ1 and RLZ1 land are considered to best accord with Broader Landscape Type 2, in that the existing township area would protect new development on the outskirts from fire approach from some directions and there would be ready egress to the town centre, which is not in a designated BPA and can provide a place of relative safety.

Whilst the risk to most parts of the study area is from grassfire, the western and northern parts of the LDRZ1 (as well as the north-western RLZ1) are much closer to the Woodland hazard and further from the low threat town centre. Consequently, these areas better accord with Broader Landscape Type 3.



Map 5 - Clunes study area showing residential zones and BPA and BMO coverage. Entire map extent is BPA unless otherwise shown.

9.4 Local and neighbourhood hazard assessment

9.4.1 Vegetation

The predominant EVC in and around Clunes is Plains Grassy Woodland (EVC 55). This occurs as small patches scattered through the surrounding rural residential and agricultural land and as larger areas to the west. Swamp Scrub (EVC 53) occurs along Creswick Creek.

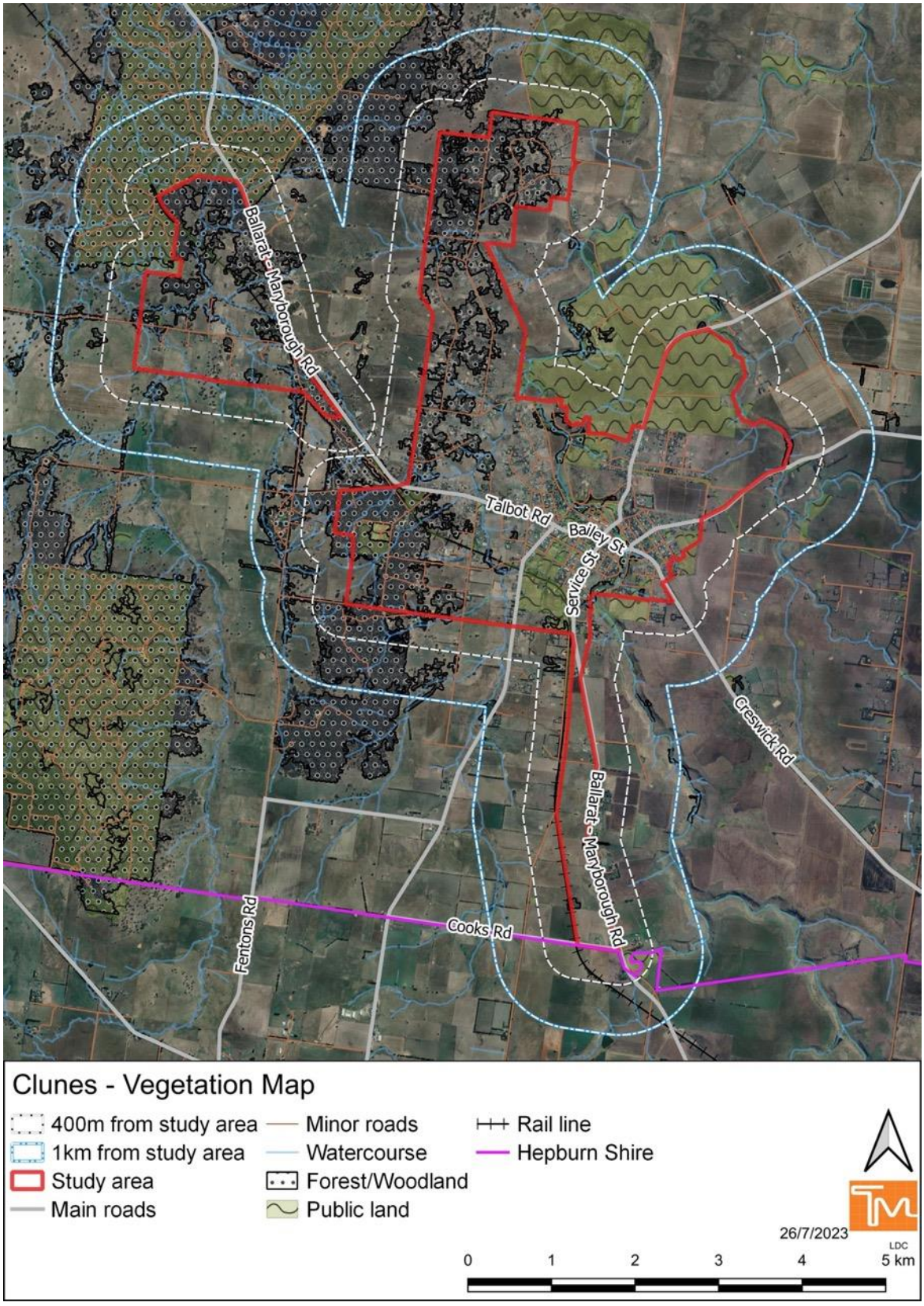
Further to the south-west in the Mount Beckwourth Scenic Reserve is Heathy Dry Forest (EVC 20), Hills Herb-rich Woodland (EVC 71) and Grassy Woodland (EVC 175). To the north-west is Grassy Woodland (EVC 175) and Box Ironbark Forest (EVC 61) in the Clunes State Forest.

The treed EVCs are classifiable in the Woodland group of AS 3959-2018, whilst the Swamp Scrub is classified as Scrub and the pasture as Grassland. Areas of tree cover equating to a probable Woodland classification are shown on Map 6.

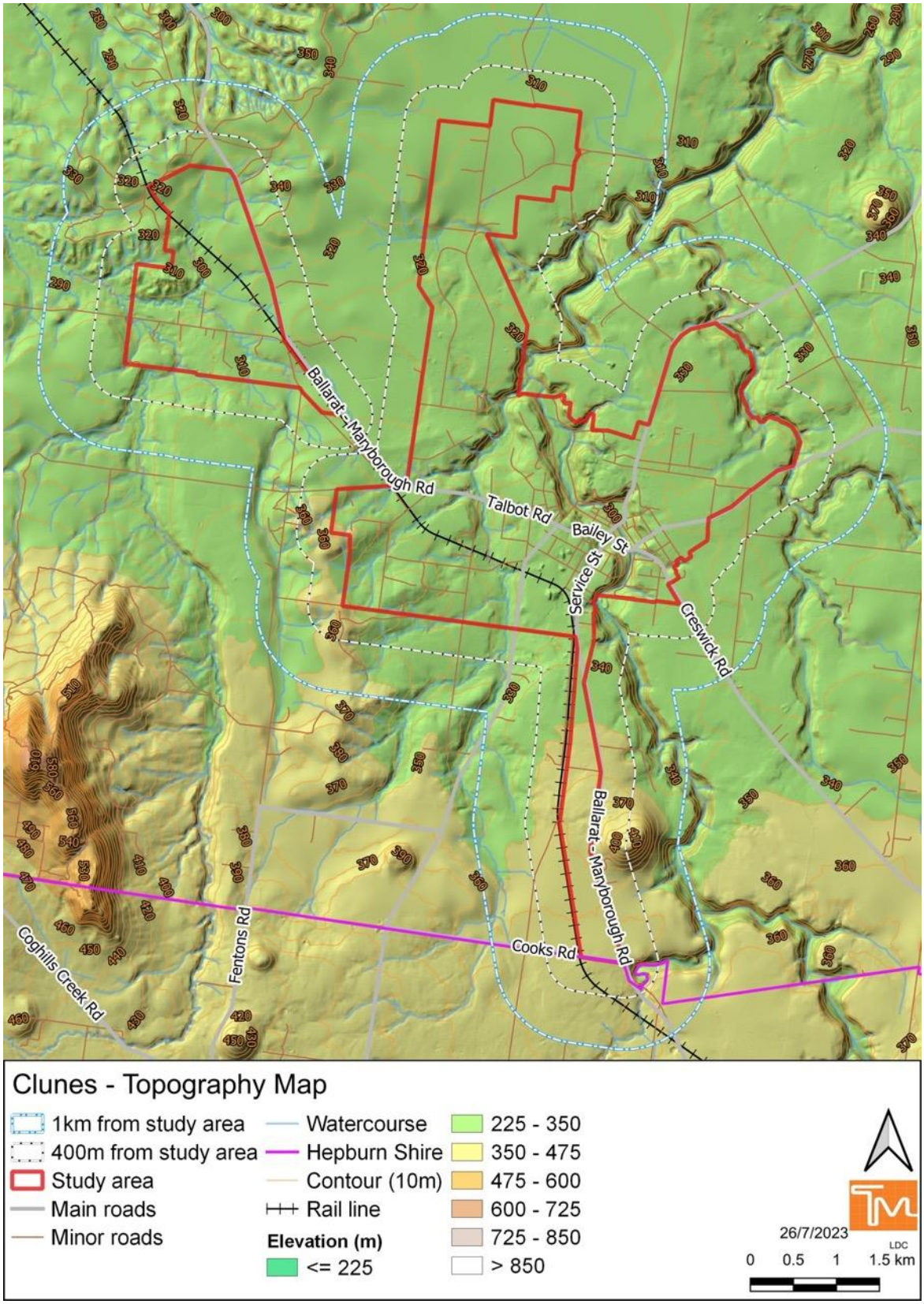
9.4.2 Topography

The main topographical features are the Mount Beckworth range to the south-west and the steep gully of the Creswick Creek, which runs through the town centre (see Map 7 and Map 8).

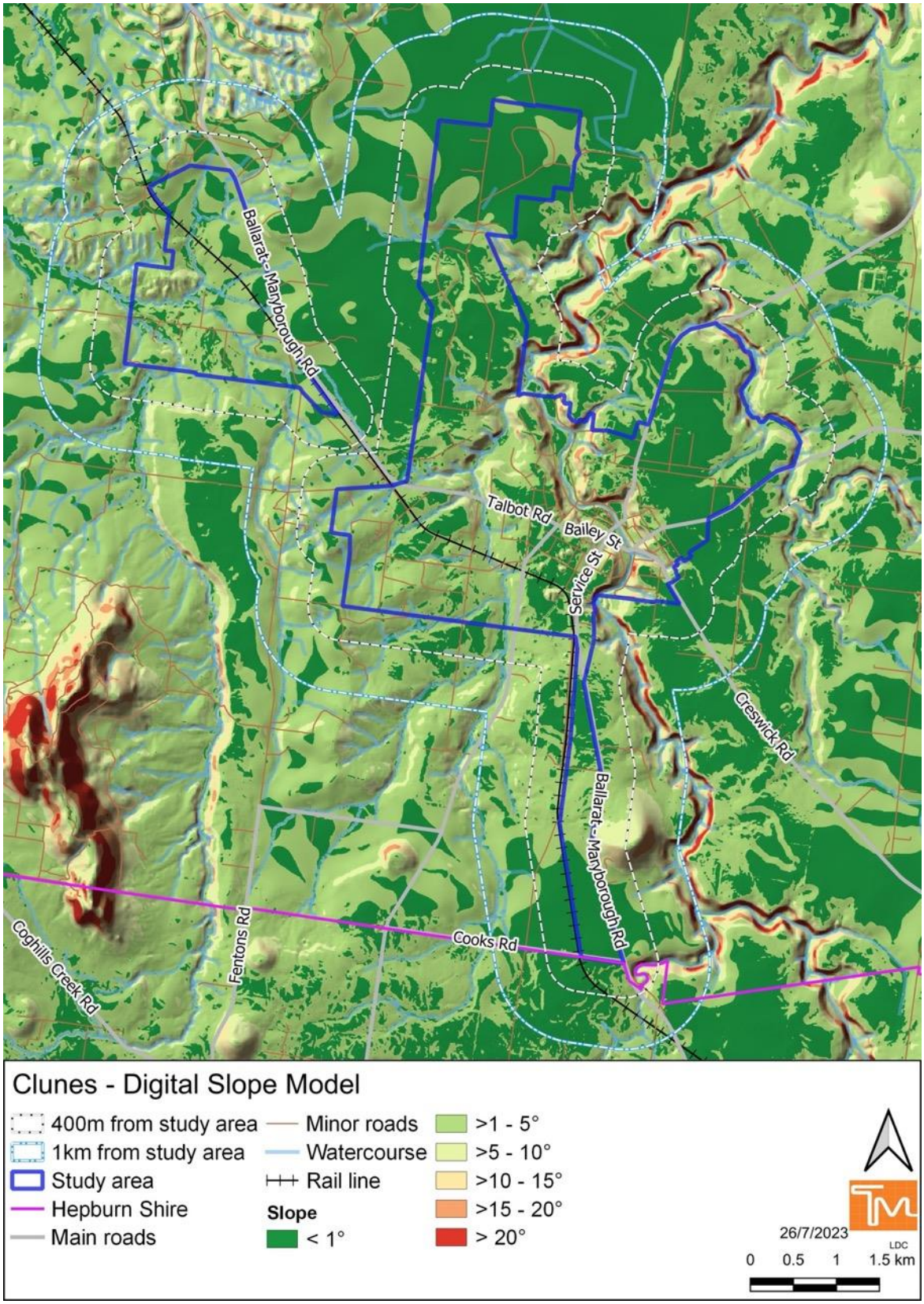
The terrain within the LDRZ1 and RLZ1 land is flat or gently sloping, generally less than 5^{o}. The land becomes more dissected in the Dunach Nature Conservation Reserve to the north-west of the study area.



Map 6 - Distribution of Woodland.



Map 7 - Topography (elevation).



Map 8 - Digital slope model (Note – slopes may be upslope or downslope in respect to any site).

9.4.3 Mitigation

Joint Fuel Management Program

Land in the Clunes Conservation Nature Reserve, and further afield in the Merin Merin and Middle Swamp Wildlife Reserve, Dunach Nature Conservation Reserve and Mount Beckworth Scenic Reserve, is zoned Landscape Management Zone (see Figure 6).

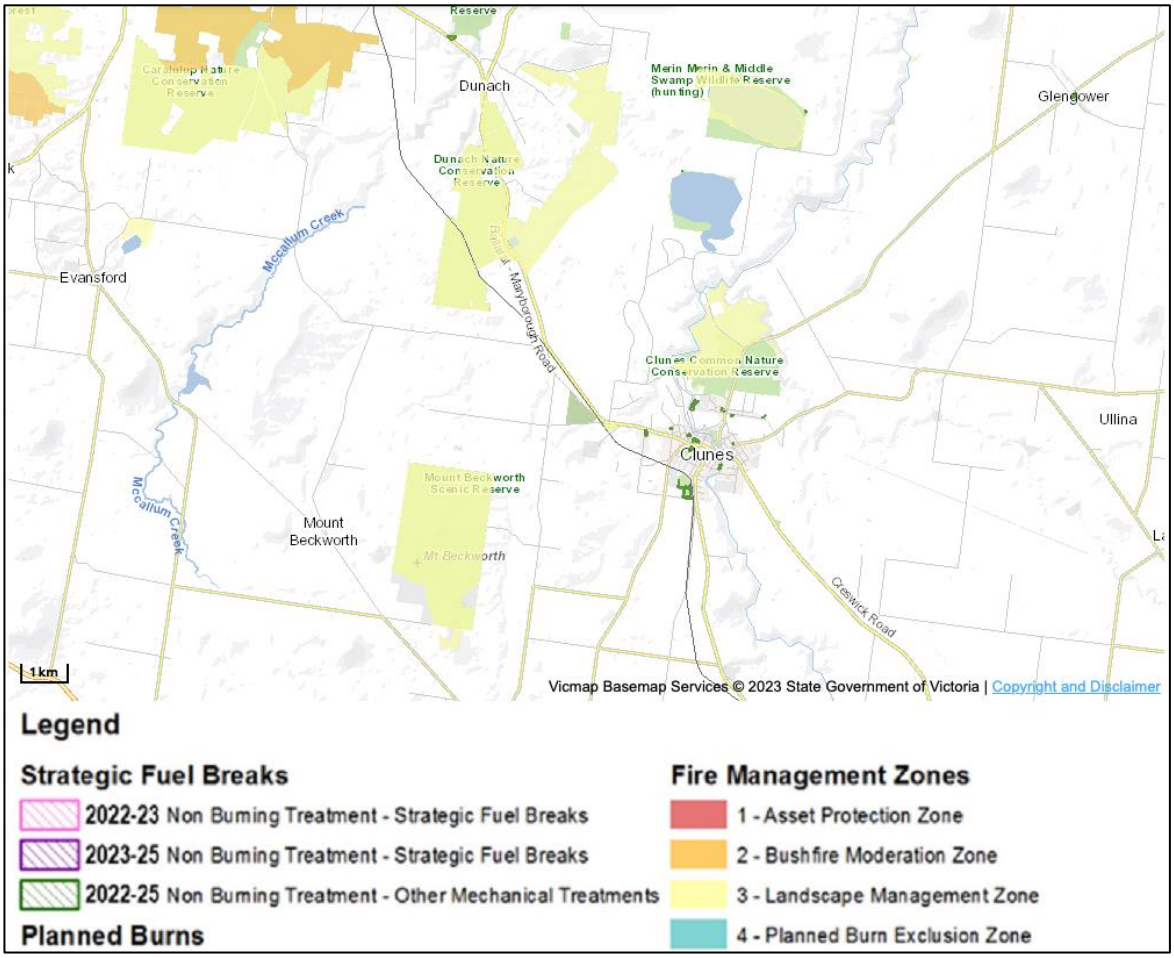


Figure 6 - Fuel management zones in the vicinity of Clunes (FFMVic, 2023b).

FMZs typically assist to manage bushfire risk at a strategic and landscape or local scale. Whilst they can contribute to moderation of fire behaviour at that broader landscape scale, they cannot be relied upon to mitigate risk at a site scale. The BMO requires reasonable assurance that defendable space beyond the property boundary will remain in a state consistent with the objective of defendable space. Prescribed burning does not assuredly create defendable space, as the vegetation management standards in Table 6 to Clause 53.02-5 are typically not achieved and fuel loads reaccumulate over time. Planned burning is also subject to resource and weather constraints in any particular year.

BMO and BPA

Most of the Clunes township (other than a small central section) and all land around it is a designated BPA and applicable building classes, including dwellings, will need to be constructed to a BAL.

The BMO applies to the western and northern extremities of the LDRZ1 land. Subdivision and/or buildings and works in the areas covered by the BMO will trigger the requirement for a planning permit and development will need to satisfy the objectives at Clause 53.02 in the Hepburn Planning Scheme.

Neighbourhood Safer Place

Clunes - Central Business District, Fraser Street between Templeton and Service Streets (approx. 6 km and 7 min by car from the north of the study area).

Note – This is a 'place of last resort' and strategic land use planning decisions about the suitability of a settlement for population growth should not be based on its presence.

9.5 Discussion

9.5.1 Development in the existing NRZ2

The Municipal Planning Strategy provides strategic planning directions for Clunes in relation to bushfire, including to:

- '*Concentrate development into defendable parts of existing township boundaries and settlements to mitigate bushfire risk, protect agricultural land, and limit natural and environmental risks.*
- *Facilitate growth in … Clunes within the designated township boundaries.*
- *Discourage residential development in settlements within existing residentially zoned boundaries where bushfire risks cannot be mitigated*' (Clause 02.03 Hepburn Planning Scheme).

None of the NRZ2 zoned land at Clunes is covered by the BMO and an area in the centre of town is not in a designated BPA (see Map 5). Almost all the NRZ2 land is more than 400 m from any substantial area of Woodland and much of it more than 700 m.

Residential development throughout the NRZ2 is considered likely to be safe and appropriate from a bushfire risk perspective if future buildings are constructed to a BAL commensurate to their setback from any classified Grassland. We recommend that the principles of the *Design Guidelines: Settlement Planning at the Bushfire Interface* (DELWP, 2020a) (see Section 13) be applied to any proposed subdivision and, to the extent practicable, infill development.

9.5.2 Potential rezoning

The Request for Quote made the following comment in relation to Clunes:
'*We may consider upzoning land in Clunes from LDRZ to NRZ but we are unsure if the bushfire risk is too extreme to allow for further development*' (Hepburn Shire Council, 2022).

In this section we assess the bushfire risk to the LDRZ1 land and the potential settlement design requirements if it were to be rezoned.

BAL safety thresholds

The Clunes Structure Plan, and any rezoning arising from it, represent settlement planning pursuant to Clause 13.02-1S. One of the key strategies for settlement planning is to direct development to areas where radiant heat flux is expected not to exceed 12.5 kW/m^2 upon completion of development and where, therefore, future dwellings or other buildings could be constructed to a BAL-12.5 construction standard (Clause 13.02-1S Hepburn Planning Scheme).

The setbacks from hazardous vegetation required to allow BAL-12.5 construction are likely to be 33 m in areas exposed to classified Woodland and 19 m in areas exposed only to classified Grassland.

The requirement for these setbacks, their location and how they are best created will depend upon which land is proposed to be rezoned and the long term state of vegetation on the adjacent land. There are potential growth area/s to the west, south and north-east of the existing township that could provide the requisite setbacks.

Proximity to hazard

Proximity to hazardous vegetation has been shown to strongly correlate with house loss/survival and loss of human life in major bushfires throughout Australia (see Section 7.2). In all but one of the nine major Australian bushfires analysed, 95% of all destroyed buildings were within 400 m of bushland, and in the outlier the 400 m threshold equated to approximately the 93rd percentile. Further, in all but one of the bushfires, no house was lost more than 700 m from bushland.

Consequently, 400 m and 700 m are suggested as thresholds beyond which there is a low and very low direct risk to future dwellings from a bushfire. At these distances impact on a building is not by flames or radiant heat from a fire in the Woodland, but by low density ember attack and/or a grassfire, which are easier to mitigate through the planning and design of settlements and construction of buildings to an appropriate BAL.

Land more than 400 m from substantial areas of Woodland (contiguous areas 10 ha or greater) is shown on Map 9 as pale yellow shading between the orange and yellow lines. Land beyond the yellow line, shaded blue, is more than 700 m from the Woodland. It should be noted that these distances are very conservative in the context of fragmented, grassy Woodland, and at Clunes absence of BMO coverage may be a better indicator of relatively low risk areas.

The analysis shows there are large, currently undeveloped, areas to the east and west of the existing township that are more than 400 m from any substantial area of Woodland. We understand that the land to the east is high quality native grassland and hence less suitable for development than the land to the west of the town.

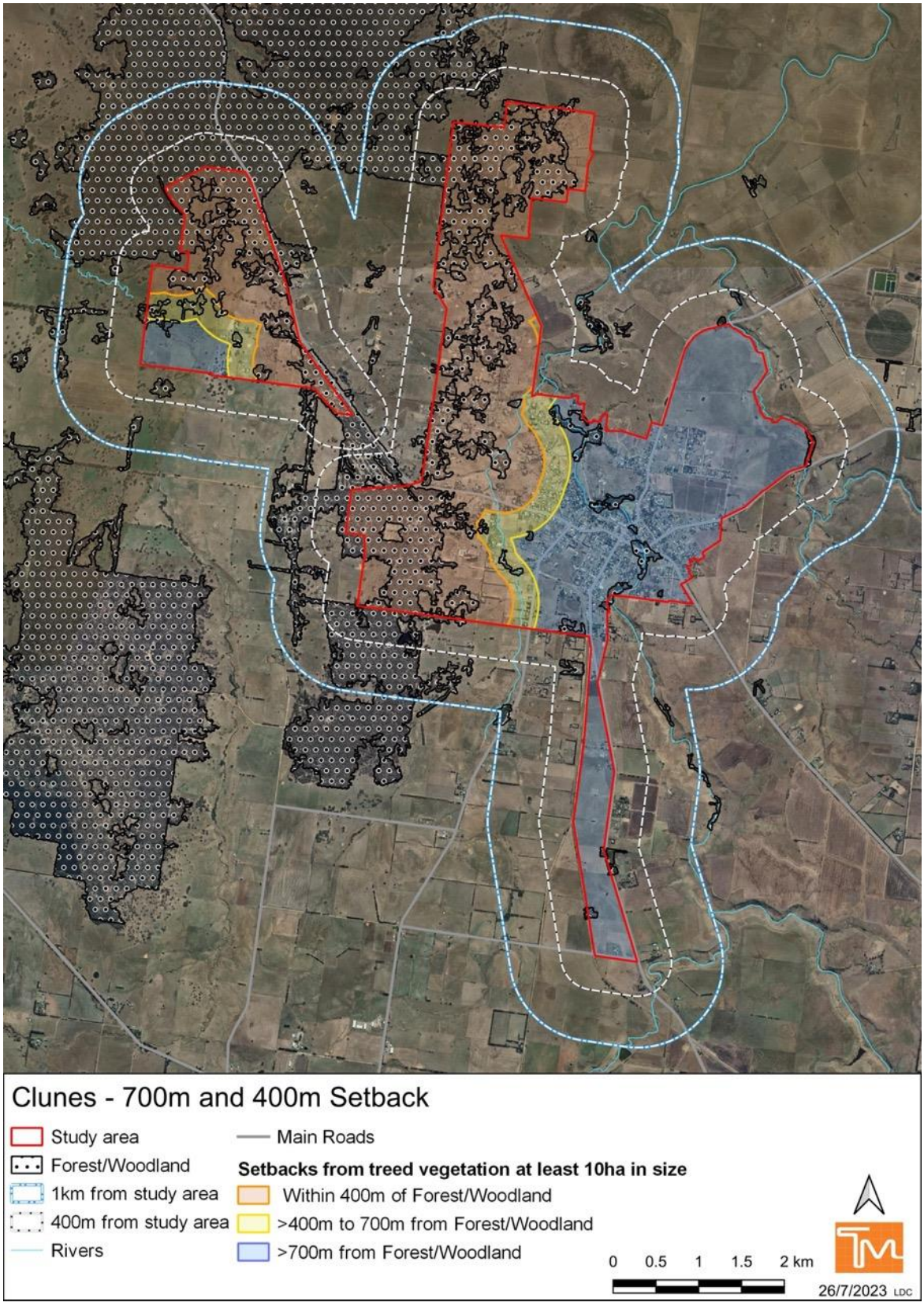
Proximity to safer area

The second key policy test for settlement planning is '*Ensuring the availability of, and safe access to, areas assessed as a BAL-LOW rating under AS 3959-2018 Construction of Buildings in Bushfire-prone Areas (Standards Australia, 2018) where human life can be better protected from the effects of bushfire'* (Clause 13.02-1S Hepburn Planning Scheme).

Under AS 3959-2018, a BAL-LOW area requires a setback of 50 m from classified Grassland and 100 m from classified Woodland on any slope. Parts of the existing Clunes township, including the area that is not a designated BPA, meet the BAL-LOW criteria. This area could expand if additional, reliably low threat residential area were to be established on the outskirts of the township.

Settlement design

We recommend that the principles of the *Design Guidelines: Settlement Planning at the Bushfire Interface* (DELWP, 2020a) (see Section 13) be applied to any proposed subdivision and, to the extent practicable, infill development. This includes the use of roads (whether existing or to be created through subdivision) as hard edges to the settlement, and the siting of vulnerable uses (such as schools, child care, health care, residential aged care etc.) away from the bushfire interface.



Map 9 - Proximity to Woodland bushfire hazard.

9.6 Conclusion

From a bushfire risk perspective, the existing NRZ2 area is considered safe and appropriate for infill development and/or subdivision, if future buildings are constructed to a BAL commensurate to their setback from any classified Grassland.

The bushfire risk does not preclude rezoning of some land to allow for intensification of development. Rezoning of LDRZ1 land immediately adjacent to the western edge of the existing NRZ2 would allow any future residential area, with contemporary bushfire protection measures, to provide protection to the existing settlement. There are substantial areas more than 400 m from classified Woodland that could be suitable for development, where a BAL-12.5 or BAL-LOW rating would apply, and which could provide ready egress to a place of relative safety.

As the township and potential growth area is exposed to predominantly flat Grassland and grassy Woodland, the amount of vegetation required to be managed in a low threat state to enable BAL-12.5 construction of new dwellings would be relatively small and would be largely confined to grass.

Clause 13.02-1S requires that settlement growth and development approvals can implement bushfire protection measures without unacceptable biodiversity impacts (Clause 13.02-1S Hepburn Planning Scheme). The findings of the ecological assessment being undertaken by Hepburn Shire Council, concurrently with this bushfire assessment, should be considered in determining the suitability of areas for development.

10 Daylesford / Hepburn Springs

10.1 Study area

10.1.1 Description

Daylesford is a tourist spa town in the western foothills of the Great Dividing Range, approximately 108 km north-west of Melbourne and 46 km north-east of Ballarat. At the 2016 census it had a population of 2,548.

Hepburn and Hepburn Springs, to the immediate north of Daylesford, have the largest concentration of mineral springs in Australia. At the 2016 census their combined population was 928.

10.1.2 Zoning and overlays

The township area of Daylesford and the 'spine' of Hepburn Springs along Main Road comprises a variety of residential, commercial and industrial zones. Beyond this, adjacent to the bushland, is predominantly Low Density Residential – Schedule 1 (LDRZ1) to the north, west and south and Farming Zone – Schedule 2 (FZ2) to the east. LDRZ1 has a minimum lot size of 0.4 ha for areas without reticulated sewerage and 0.2 ha for areas with reticulated sewerage.

Schedule 1 to Clause 42.01 *Environment Significance Overlay* (ESO1) *Special Water Supply Catchment Protection* applies to the entire study area. It has no apparent implications for bushfire protection.

Schedule 2 to Clause 42.01 *Environment Significance Overlay* (ESO2) *Mineral Springs and Ground Water Protection* applies to the entire study area. It has no apparent implications for bushfire protection.

Schedule 2 to Clause 42.02 *Vegetation Protection Overlay* (VPO2) *Significant Exotic and Native Vegetation* applies to small parts of the Daylesford township area and has no apparent implications for bushfire protection.

10.2 Existing hazard and risk assessments

10.2.1 Regional Bushfire Planning Assessment

- *Residential lots in Hepburn and Hepburn Springs are in the bushfire hazard area associated with forested areas generally in Hepburn Regional Park to the east and west and vegetation in the townships* (Identified Area Code 29-011).
- *Rural-residential lots from Sailors Falls to Hepburn, including around Daylesford are in bushfire hazard area associated with the Hepburn Regional Park and surrounding vegetation. Existing vegetation includes areas of high and very high conservation significance* (Identified Area Code 29-012).
- *Residential lots in Daylesford are in the bushfire hazard area associated with surrounding Hepburn Regional Park* (Identified Area Code 29-017).
- *Daylesford Structure Plan provides for rural-residential lots in close proximity to bushfire hazard. Existing vegetation of high and very high conservation significance* (Identified Area Code 29-032).
- *Townships rely primarily on Main Road for access and egress from bushfire hazard area* (Identified Area Code 29-038) (DPCD, 2012).

10.2.2 Grampians Bushfire Management Strategy

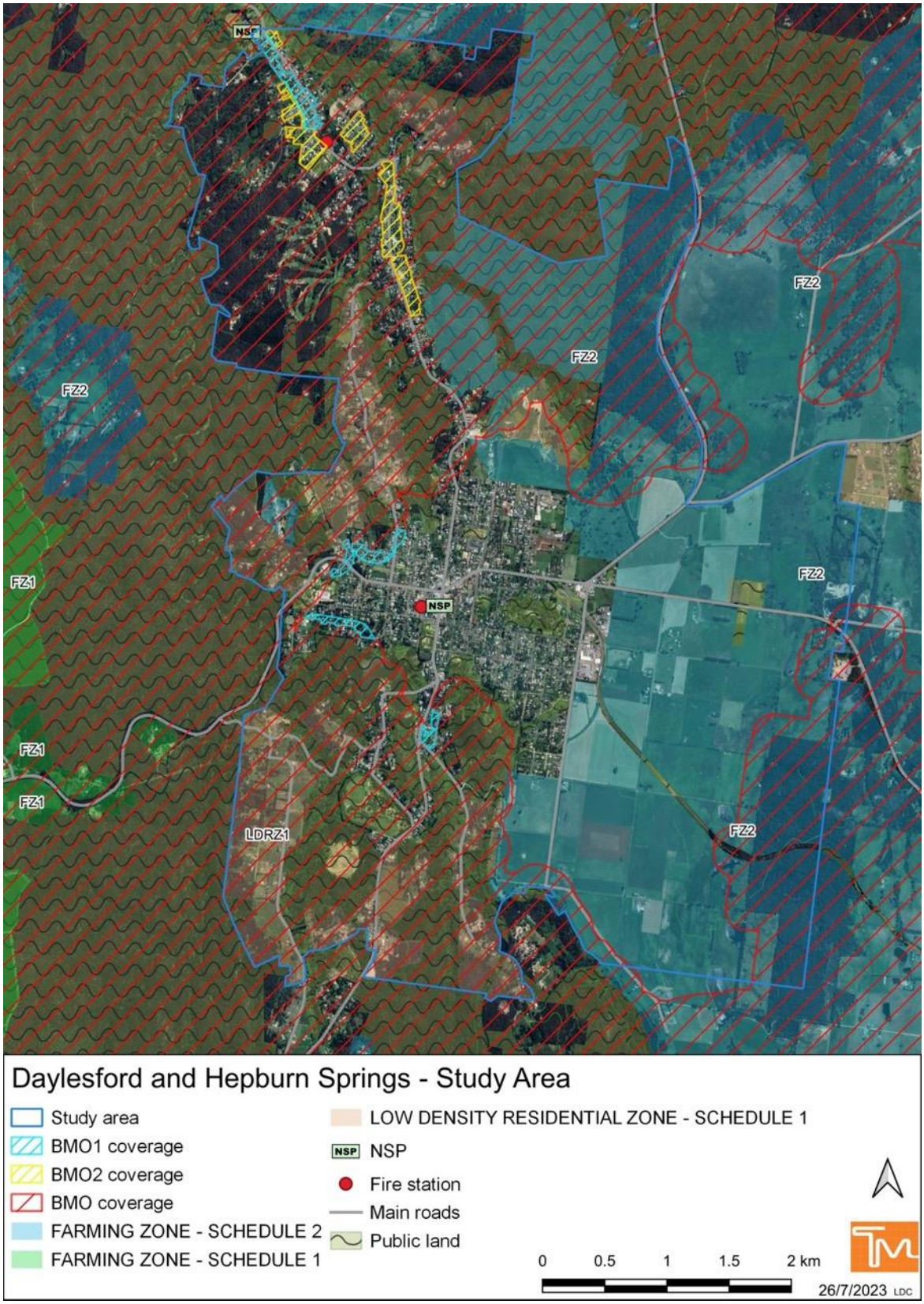
The Daylesford / Hepburn Springs area was rated a Higher or Highest risk for house loss (DELWP, 2020b), reflecting the large number of dwellings located close to Forest.

10.3 Broader landscape hazard assessment

10.3.1 Bushfire scenarios

Daylesford / Hepburn Springs could be impacted by a large bushfire burning through Forest from the north, west or south-west, which are the typical directions of approach under elevated fire weather in Victoria (Long, 2006). A fire approaching from the north could run through more than 10 km of contiguous Forest. Most of the LDRZ1 land is immediately adjacent to Forest, much of which is on public land. Particularly in the north, local slopes can be steep. Ember attack may be severe, particularly in long unburnt areas where stringybarks are present.

Potential fire behaviour around Daylesford / Hepburn Springs should be within the design fire parameters of AS 3959/BMO, but the extensive exposure and proximity of many buildings to the bushfire hazard means that losses may be substantial under elevated fire danger conditions.



Map 10 - Daylesford / Hepburn Springs study area showing residential zones and BMO coverage. Entire map extent is BPA.

10.3.2 BMO broader landscape type

Overall, Daylesford and Hepburn Springs are considered to best accord with Broader Landscape Type 3, in that the settlements could be approached by bushfire from multiple directions with the potential for ember attack and spot fires into the township area. Whilst there are NSPs in Daylesford and Hepburn Springs, travel to them from the outer lying areas often relies on single main roads.

The eastern side of Daylesford is sheltered from much of the Forest by the township area and is exposed only to Grassland on gently sloping ground. This area has characteristics of Broader Landscape Type 2.

10.4 Local and neighbourhood hazard assessment

10.4.1 Vegetation

Daylesford interfaces with native forest to the north, west and south. The predominant EVCs are Heathy Dry Forest (EVC 20) and Valley Grassy Forest (EVC 47) to the north and west and Herb-rich Foothill Forest (EVC 23) to the south.

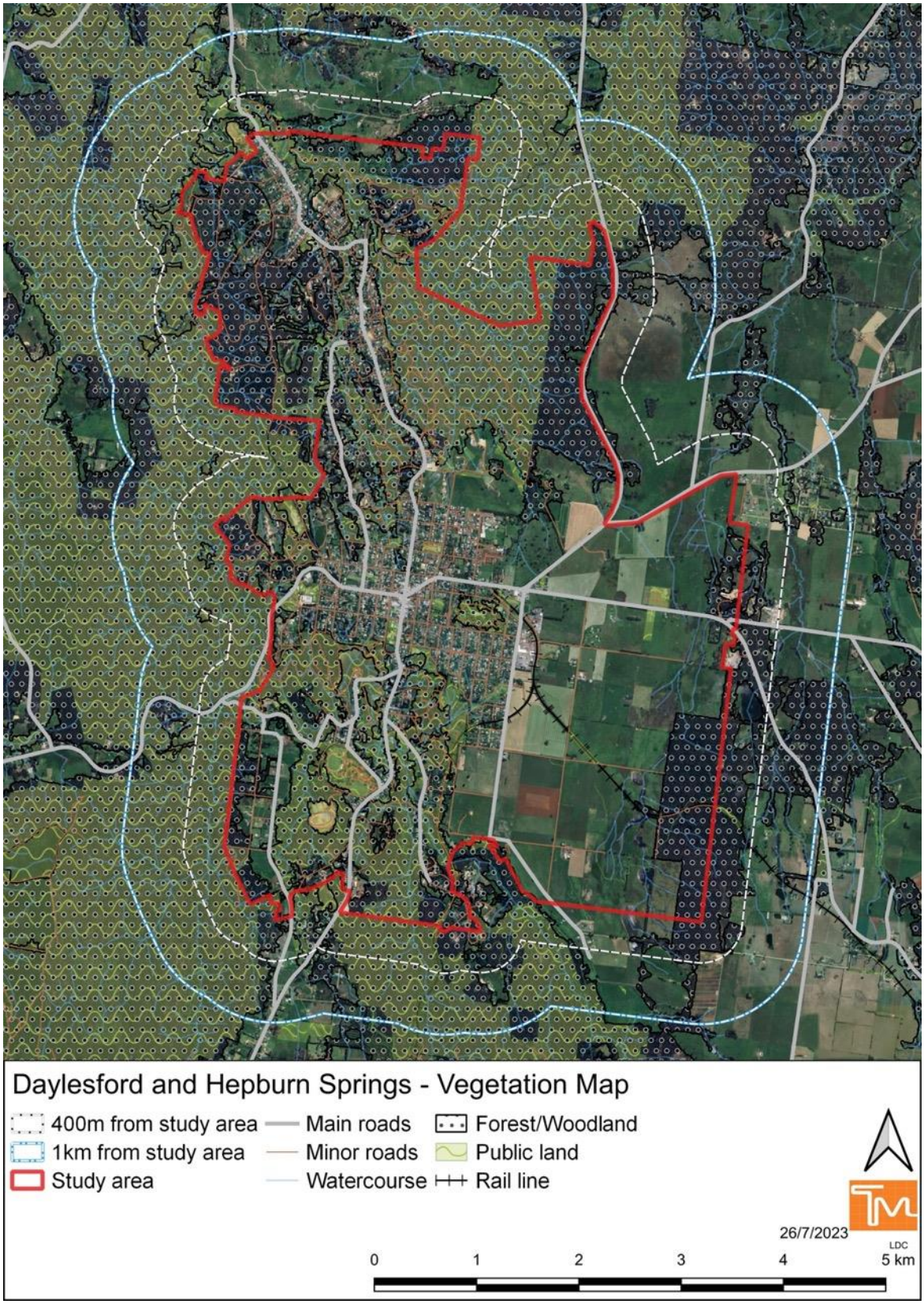
Hepburn Springs is bordered predominantly by Valley Grassy Forest (EVC 47) to the east and Grassy Dry Forest (EVC 22) to the west.

Heathy Dry Forest and Herb-rich Foothill Forest are classifiable in the Forest group of AS 3959-2018, whilst Valley Grassy Forest and Grassy Dry Forest are potentially classifiable as Woodland unless a (possibly weedy) shrubby understorey means they are better classified as Forest. Areas of tree cover equating to a Woodland or Forest classification are shown on Map 11. As a precaution all treed vegetation is assumed to be Forest for the purposes of this assessment.

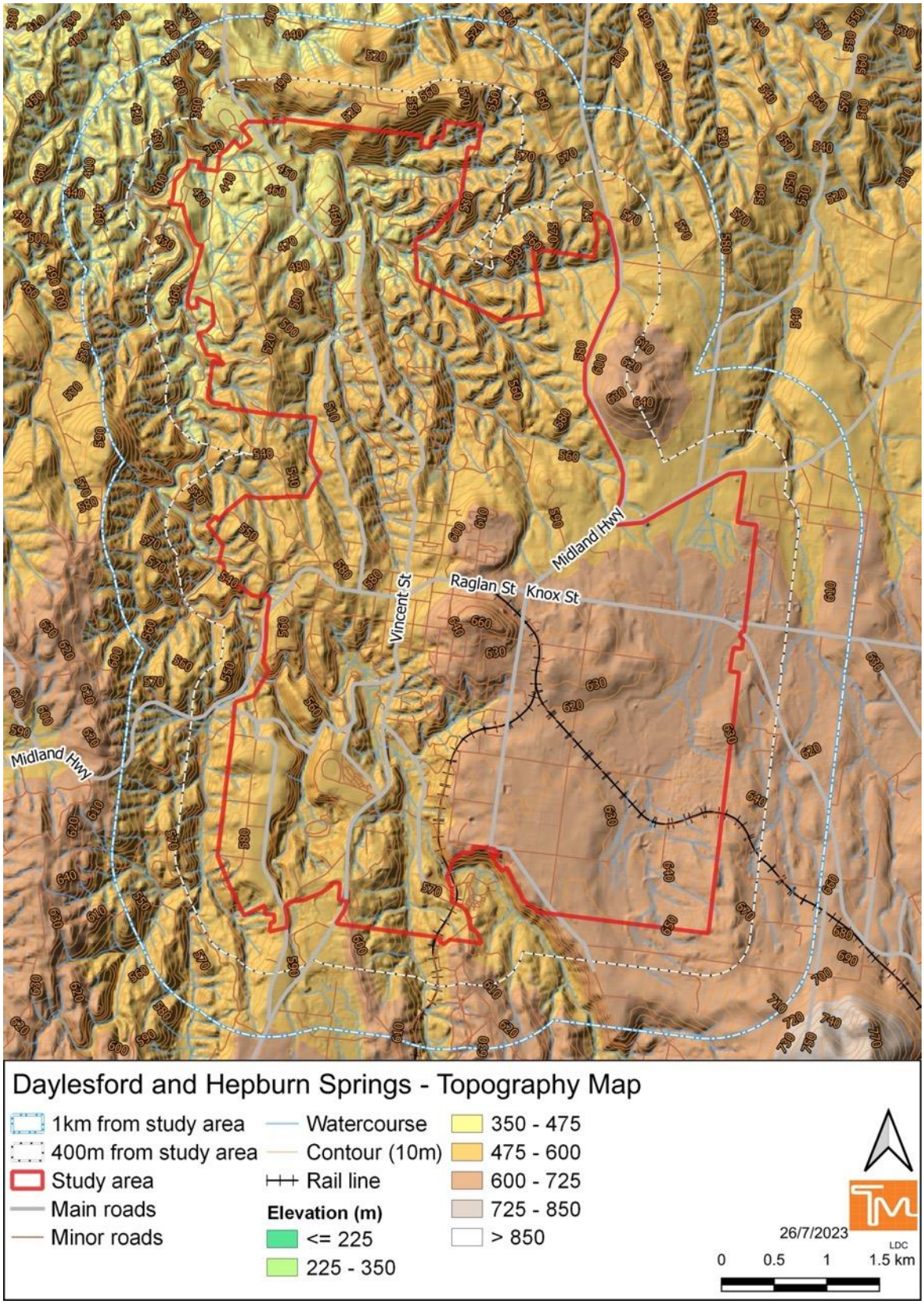
10.4.2 Topography

The topography either side of Hepburn Springs and to the west and south-west of Daylesford is complex, with locally very steep slopes associated Sailors Creek, Spring Creek and secondary drainage lines (see Map 12 and Map 13). This results in much of the private land on the edges of the settlement being exposed to steep downslopes, some more than 20^{o} and outside the scope of the BMO defendable space tables at Clause 53.02-5.

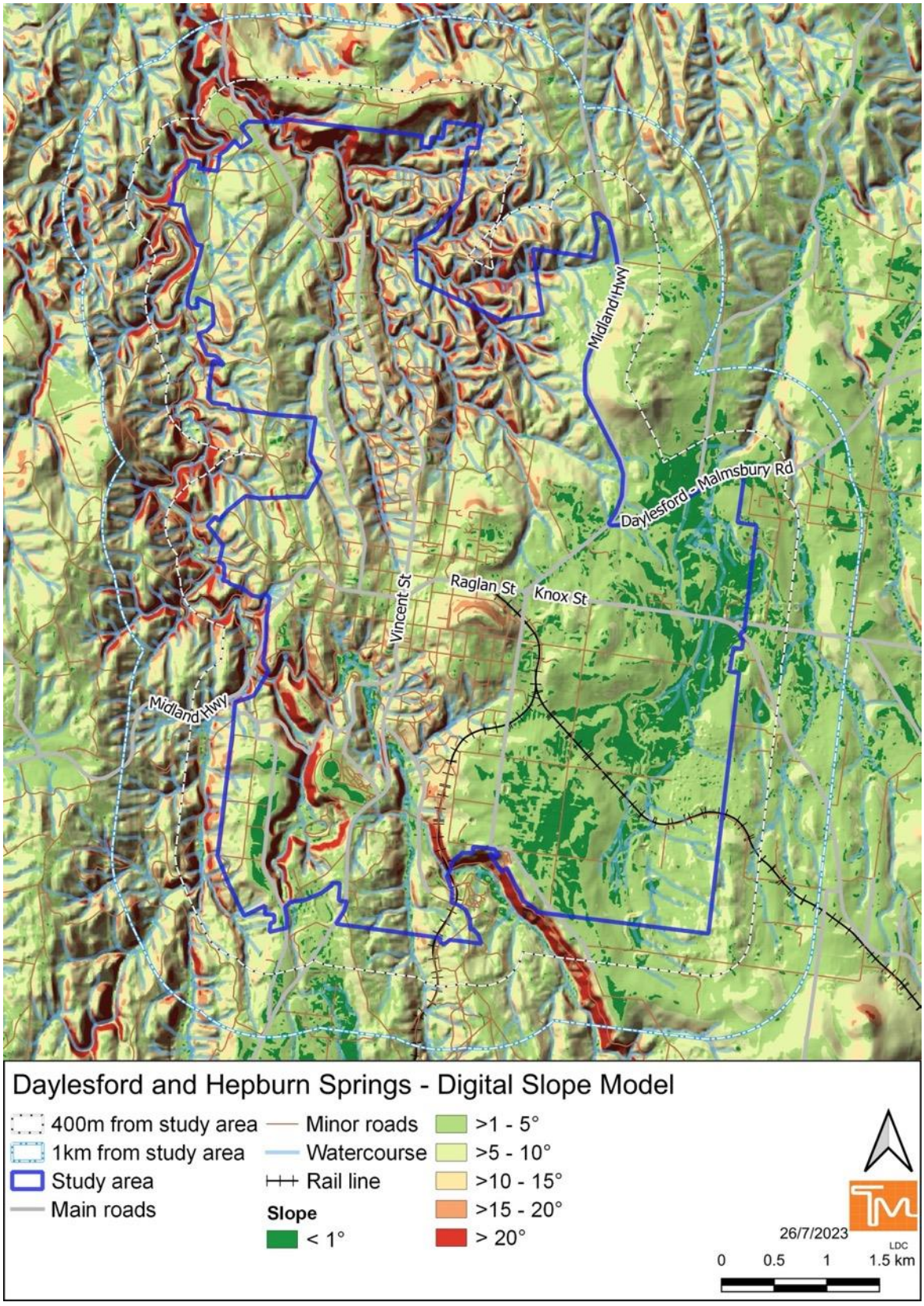
The terrain is much gentler to the east of Daylesford, with most of the farm land adjacent to the township being flat or less than 5^{o} (see Map 12 and Map 13).



Map 11 - Distribution of Forest/Woodland.



Map 12 - Topography (elevation).



Map 13 - Digital slope model (Note – slopes may be upslope or downslope in respect to any site).

10.4.3 Mitigation

Joint Fuel Management Program

Public land adjacent to the residential areas is Asset Protection Zone or Bushfire Moderation Zone, with extensive areas of Landscape Management Zone beyond (see Figure 7).

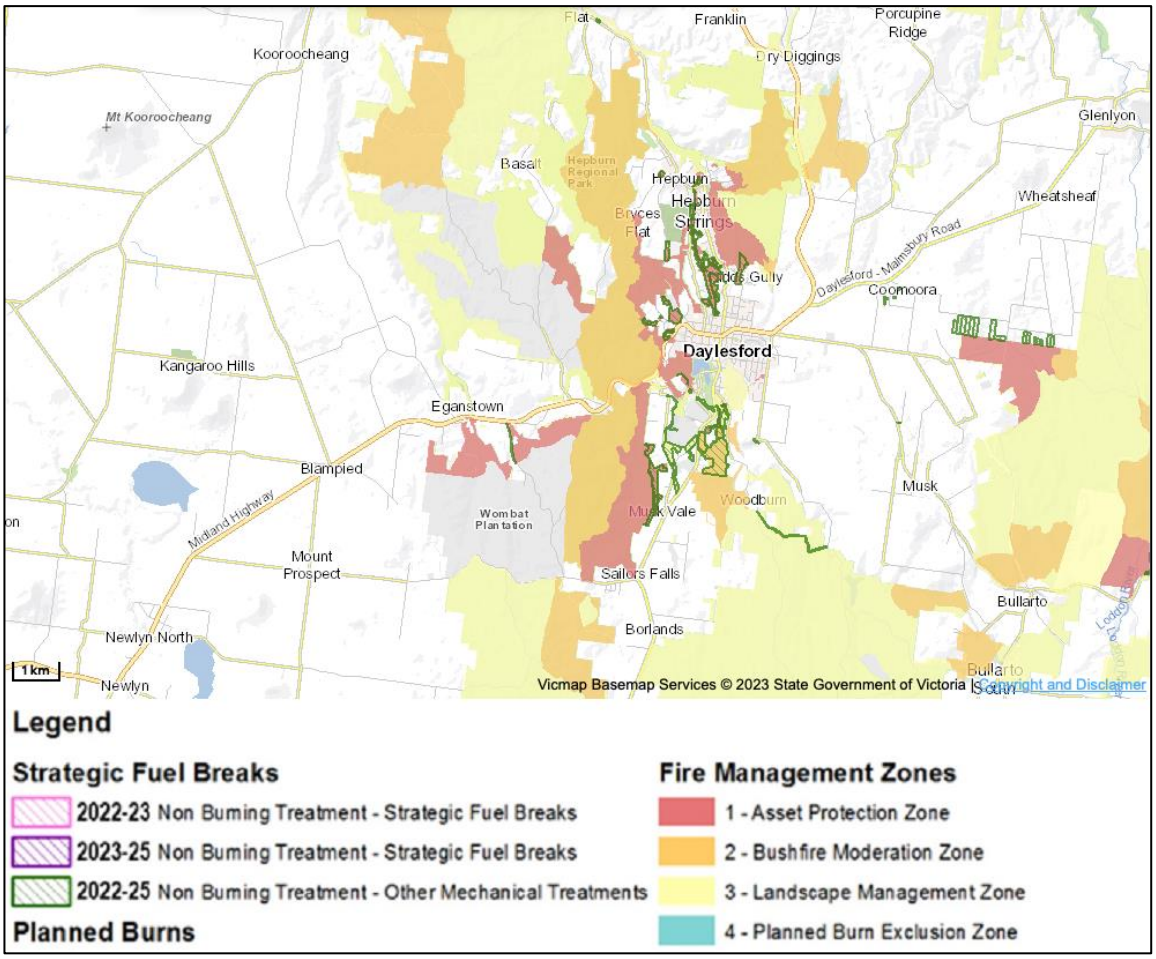


Figure 7 - Fuel management zones in the vicinity of Daylesford / Hepburn Springs (FFMVic, 2023b).

FMZs typically assist to manage bushfire risk at a strategic and landscape or local scale. Whilst they can contribute to moderation of fire behaviour at that broader landscape scale, they cannot be relied upon to mitigate risk at a site scale. The BMO requires reasonable assurance that defendable space beyond the property boundary will remain in a state consistent with the objective of defendable space. Prescribed burning does not assuredly create defendable space, as the vegetation management standards in Table 6 to Clause 53.02-5 are typically not achieved and fuel loads reaccumulate over time. Planned burning is also subject to resource and weather constraints in any particular year.

BMO and BPA

All of Hepburn Springs, and the northern, western and southern outskirts of Daylesford, are covered by the BMO. Small areas are covered by Schedule 1 or 2 to the BMO. Subdivision and/or buildings and works in the areas covered by the BMO will trigger the requirement for a planning permit and development will need to satisfy the objectives at Clause 53.02 in the Hepburn Planning Scheme.

The urban centre of Daylesford and the farm land to the east are not covered by the BMO but are a designated BPA and applicable building classes, including dwellings, will need to be constructed to a BAL.

Neighbourhood Safer Place

Hepburn – Hepburn Recreation Reserve, corner Main Road and Twentieth Street.

Daylesford – Central Business District, Albert Street, Camp Street and Central Springs Road.

Note - These are 'places of last resort' and strategic land use planning decisions about the suitability of a settlement for population growth should not be based on their presence.

10.5 Discussion

10.5.1 Development in the existing township area

The Municipal Planning Strategy provides strategic planning directions for Daylesford and Hepburn Springs in relation to bushfire, including to:

- '*Concentrate development into defendable parts of existing township boundaries and settlements to mitigate bushfire risk, protect agricultural land, and limit natural and environmental risks.*
- *Consolidate development in Daylesford within the designated township boundary.*
- *Contain growth in … Hepburn Springs within the designated township boundaries.*
- *Discourage residential development in settlements within existing residentially zoned boundaries where bushfire risks cannot be mitigated*' (Clause 02.03 Hepburn Planning Scheme).

Hepburn Springs

All of Hepburn Springs is covered by the BMO. Areas along Hepburn Road and Main Road are covered by Schedule 2 to the BMO, which specifies BAL-29 construction and defendable space for 30 m or to the property boundary, whichever is the lesser distance. The presence of the BMO2 indicates that the lots are sufficiently setback from the Forest to enable BAL-29 construction, and/or surrounding land is considered to contain Modified vegetation (i.e. not reliably low threat). Existence of the Schedule also indicates that, at the time of its introduction, the lots were considered appropriate for development with a single dwelling.

Existing township areas of Hepburn Springs covered by BMO2 are considered suitable for infill residential development but are not recommended for subdivision or new vulnerable use development (such as schools, child care, health care, residential aged care etc.). Bushfire planning considerations for areas under the BMO, but not scheduled, are discussed in Section 10.5.2.

Daylesford

The northern, western and southern outskirts of Daylesford are covered by the BMO (see Map 10). Small areas are covered by Schedule 1 to the BMO, which specifies BAL-12.5 construction and defendable space for 30 m or to the property boundary, whichever is the lesser distance. The presence of the BMO1 indicates that the lots are sufficiently setback from the Forest to enable BAL-12.5 construction and the intervening land is considered reliably low threat.

Existing township areas of Daylesford that are either covered by BMO1 or not covered by the BMO are considered suitable for infill development. The BPA-only area is more suitable for subdivision and intensification of development than are the BMO1 areas. Bushfire planning considerations for areas under the BMO, but not scheduled, are discussed in Section 10.5.2.

10.5.2 BALs for future development in interface areas of Hepburn Springs and Daylesford

The interface areas of Hepburn Springs and Daylesford are covered by the BMO. The request for quote asked whether the existing parts of Hepburn Springs and Daylesford can be developed if they are above BAL-29, stating a preference to not approve the removal of large amounts of native vegetation on lots to achieve a BAL-29 (Hepburn Shire Council, 2022).

Many of the residential lots are exposed to classified Forest, on locally steep downslopes in places, that creates a requirement for large areas of defendable space. Some lots, particularly in the NRZ4 zone, are too small to provide the defendable space required for BAL-29 (or lower) within their property boundaries, and nearby private and public land may not be in a low threat condition and/or does not provide the required assurance that it would remain at BMO defendable space standard.

It should be noted that in all settings, CFA generally consider a lower BAL with more defendable space provides a better safety outcome than a higher BAL with less defendable space. In higher hazard landscapes, Column D defendable space and BAL-40 construction is not usually supported.

Clause 53.02 provides two application pathways depending on the zoning of the land in question. Applications in non-residential zones have additional application requirements (such as assessment of the landscape scale bushfire hazard) and more onerous protection measures than

an application for comparable development in a residential zone. Zoning is, however, a poor proxy for the level of bushfire risk and the residentially zoned land at the interface with the Forest at Daylesford and Hepburn Springs is more hazardous than much of the FZ land to the east of the town.

It should also be noted that CFA state that in Broader Landscape Type 3, such as at Hepburn Springs and in Daylesford's interface with the Forest, an ability for development to comply with the applicable statutory planning (i.e. Clause 53.02) and building controls (i.e. AS 3959) may be inadequate to mitigate the risk to an acceptable level. Additional bushfire protection measures are likely to be required and intensification of development may not be supported (CFA, 2022a).

Dwellings in existing settlements

Under the BMO, Clause 53.02-3 'Pathway 1' applies to applications to develop a single dwelling on a lot in a Neighbourhood Residential Zone, General Residential Zone, Residential Growth Zone, Urban Growth Zone, Low Density Residential Zone, Township Zone, or Rural Living Zone (Clause 53.02-3 Hepburn Planning Scheme). Most of the residential area of Hepburn Springs and Daylesford falls into one of these zones – predominantly NRZ4, LDRZ1 or RLZ1.

The bushfire protection objective at Clause 53.02-3 includes reducing the risk to life and property to an acceptable level, but neither it nor the associated approved measures explicitly require a consideration of bushfire risk in the broader landscape beyond the 150 m site assessment zone (in contrast to Approved Measure 2.1 at Clause 53.02-4 which applies to development in non-residential zones).

Approved Measure 1.2, which meets the bushfire protection objective for dwellings in existing settlements, requires a building to provide defendable space in accordance with Table 1 Columns A, B, C, D or E to Clause 53.02-5, with the dwelling constructed to the corresponding BAL. Thus, the approved measure envisages construction up to and including BAL-FZ (flame zone).

Clause 53.02, however, pre-dates the State bushfire planning policy at Clause 13.02-1S, which is generally accepted to now require greater caution in approving development in very high bushfire risk areas. Thus, regardless of Approved Measure 1.2 envisaging that construction up to and including BAL-FZ can meet the bushfire protection objective, we consider development that relies on Column E defendable space is very unlikely to be supported.

Column D defendable space and BAL-40 construction may be acceptable for infill development that cannot achieve Column C defendable space, but which can comply with the other applicable BMO approved measures. Situations where the hazardous vegetation is at least partially modified, where defendable space for a new dwelling would remove a bushfire hazard to existing neighbouring dwellings, and/or where the proposal does not extend the length of the interface with the bushfire hazard, are more likely to be considered acceptable.

Dwellings in other zones

Clause 53.02-4 'Pathway 2' applies to development in non-residential zones. A substantial area of RCZ2 occurs between Hepburn Road and Western Avenue, with smaller patches further to the west beyond Cobblers Gully, in the north adjacent to the Hepburn Recreation Reserve and in the north-east on Back Hepburn Road.

Approved Measure 3.1, which meets the defendable space and construction objective at Clause 53.02-4.2, allows Column D defendable space to Table 2 at Clause 53.02-5 if there are '*significant siting constraints*' (Clause 53.02-4.2 Hepburn Planning Scheme), otherwise defendable space from Columns A, B or C must be applied, corresponding to BAL-12.5, BAL-19 and BAL-29 construction respectively. CFA's usual position is that they do not support Column D defendable space and BAL-40 construction in higher hazard landscapes, such as Daylesford / Hepburn Springs. So BAL-40 construction should not be seen as a substitute for providing Column C defendable space if it is possible to do so.

BAL-40 may be acceptable for infill development that cannot achieve Column C defendable space for BAL-29 construction, but which can comply with the other applicable BMO approved measures, including Approved Measure 2.1 which requires that '*the bushfire risk to the development from the landscape beyond the site can be mitigated to an acceptable level*' (Clause 53.02-4.1 Hepburn Planning Scheme). As in residential zones, situations where the hazardous vegetation is at least partially modified, where defendable space for a new dwelling would remove a bushfire hazard to existing neighbouring dwellings, and/or where the proposal does not extend the length of the interface with the bushfire hazard, may be more acceptable.

BAL-40 construction (with Colum D defendable space) is unlikely to be supported on lots immediately adjacent to Forest or exposed to steep downslopes.

Subdivision

The setting of the lots within or adjacent to a wider area of Forest, will likely make it difficult to meet the applicable subdivision objectives and some approved measures of the BMO. Additional small-scale subdivision is unlikely to significantly reduce the bushfire risk to existing properties or create a large, reliably low threat area that could provide a place of acceptable safety. It is more likely to be a continuation of, and extension to, the current 'bush block' and 'forest edge' development, which is undesirable from a bushfire safety perspective. It is noted that creation of defendable space to allow BAL-29 or lower construction would likely have biodiversity impacts.

Overall, further subdivision in the interface areas is considered contrary to Clause 13.02-1S, which directs development to low risk locations.

10.5.3 Potential rezoning

The Request for Quote made the following comment in relation to Daylesford / Hepburn Springs: '*We may consider upzoning land on the edges of Daylesford from FZ, LDRZ to NRZ but we are unsure if the bushfire risk is too extreme to allow for further development'* (Hepburn Shire Council, 2022).

In this section we assess the bushfire risk to the LDRZ and the FZ land adjacent to the existing township and the potential settlement design requirements if it were to be rezoned.

BAL safety thresholds

The Daylesford / Hepburn Springs Structure Plan, and any rezoning arising from it, represent settlement planning pursuant to Clause 13.02-1S. One of the key strategies for settlement planning is to direct development to areas where radiant heat flux is expected not to exceed 12.5 kW/m^2 upon completion of development and where, therefore, future dwellings or other buildings could be constructed to a BAL-12.5 construction standard (Clause 13.02-1S Hepburn Planning Scheme).

In response to Forest in the 'Downslope >15^o-20^o' slope class, defendable space of 98 m is required to reduce radiant heat flux to below 12.5 kW/m^2. It is highly unlikely that any of the LDRZ1 land at Hepburn Springs, or the western and south-western edges of Daylesford, can achieve this without substantial removal of vegetation, and nearby public land would prevent this in some areas. Areas exposed to lesser slopes, such as to the south-east of Daylesford along Lake Road, would require less defendable space.

It is noted that some areas in and around the study area may be classifiable as Modified vegetation where the pattern of development or history of mining and other disturbance has resulted in narrow strips/small patches of vegetation, often with a frequent occurrence of less flammable exotic (often deciduous) species. The BMO allows for less defendable space but a higher BAL-29 construction standard in response to Modified vegetation.

BAL-12.5 defendable space distances for Grassland on flat or gently sloping land to the east of Daylesford will likely be no more than 22 m. The requirement for these setbacks, their location and how they are best created will depend upon which land is proposed to be rezoned and the and the long term state of vegetation on the adjacent land. There appear to be potential growth area/s to the east of the existing township that could provide the requisite setbacks.

A well designed residential area adjacent to the eastern edge of the town should be resistant to grassfire and ember attack.

Proximity to hazard

Proximity to hazardous vegetation has been shown to strongly correlate with house loss/survival and loss of human life in major bushfires throughout Australia (see Section 7.2). In all but one of

the nine major Australian bushfires analysed, 95% of all destroyed buildings were within 400 m of bushland, in the outlier the 400 m threshold equated to approximately the 93rd percentile. Further, in all but one of the bushfires, no house was lost more than 700 m from bushland.

Consequently, 400 m and 700 m are suggested as thresholds beyond which there is a low and very low direct risk to future dwellings from a forest fire. At these distances impact on a building is not by flames or radiant heat from a fire in the Forest, but by low density ember attack and/or a grassfire, which are easier to mitigate through the planning and design of settlements and construction of buildings to an appropriate BAL.

Land between 400 m and 700 m from substantial areas of Forest (contiguous areas 10 ha or greater but excluding Wombat Hill botanical gardens) is shown on Map 14 as pale yellow shading between the orange and yellow lines. Land shaded blue is more than 700 m from the Forest.

The analysis identifies that agricultural land at the eastern edge of the township is more than 400 m from any substantial area of hazardous forest, and further to the east the setback increases to more than 700 m.

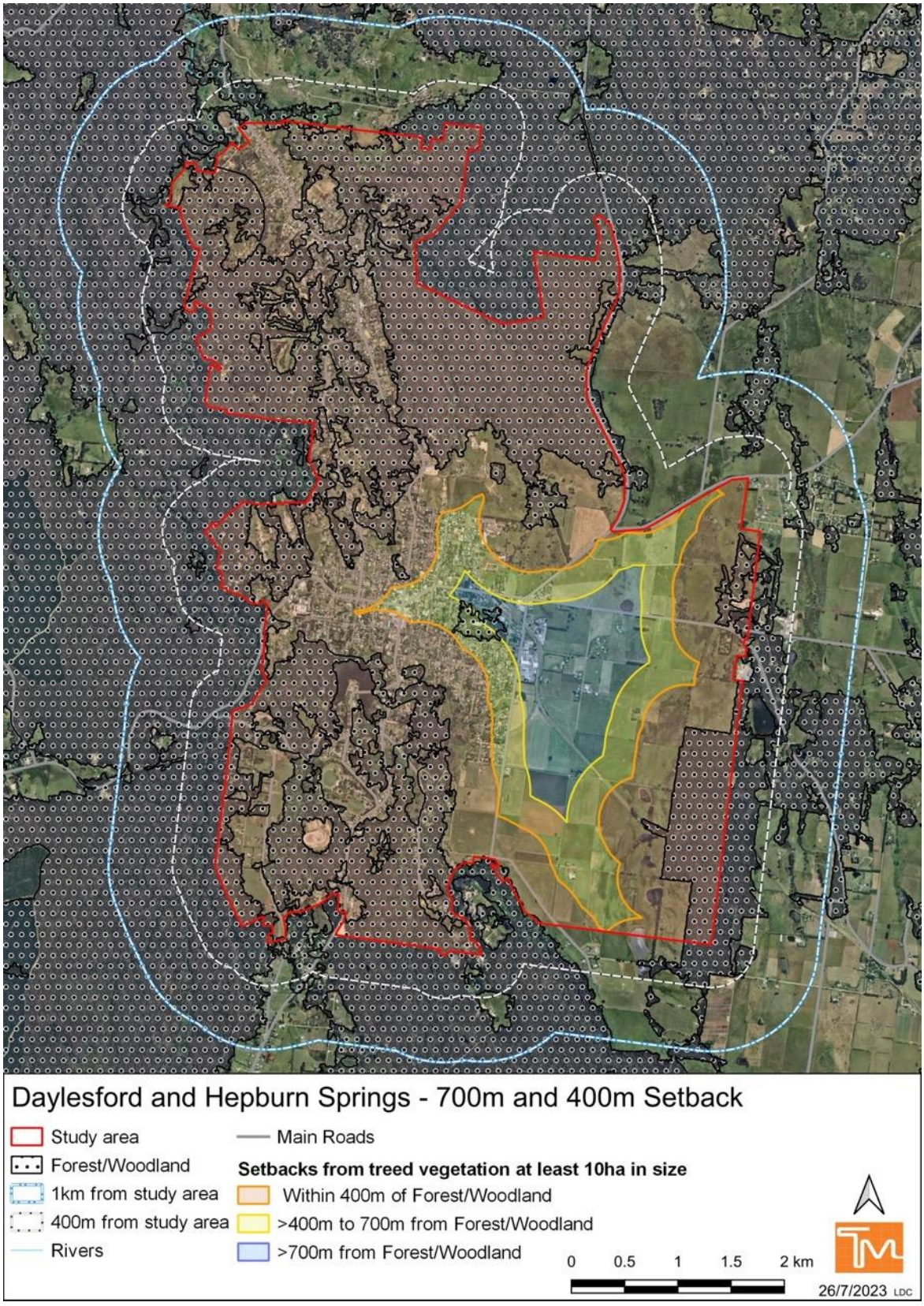
Proximity to safer area

The second key policy test for settlement planning is '*Ensuring the availability of, and safe access to, areas assessed as a BAL-LOW rating under AS 3959-2018 Construction of Buildings in Bushfire-prone Areas (Standards Australia, 2018) where human life can be better protected from the effects of bushfire'* (Clause 13.02-1S Hepburn Planning Scheme).

Under AS 3959-2018, a BAL-LOW area requires a setback of 50 m from classified Grassland and 100 m from classified Forest on any slope. A large part of the existing Daylesford township meets this criterion, though it is designated as a BPA. Growth of the township to the east would increase the amount of the existing urban area that could achieve a BAL-LOW rating and residents of the growth area would have ready access to it in the event of a bushfire.

Settlement design

We recommend that the principles of the *Design Guidelines: Settlement Planning at the Bushfire Interface* (DELWP, 2020a) (see Section 13) be applied to any proposed subdivision and, to the extent practicable, infill development. This includes the use of roads (whether existing or to be created through subdivision) as hard edges to the settlement, and the siting of vulnerable uses (such as schools, child care, health care, residential aged care etc.) away from the bushfire interface.



Map 14 - Proximity to Forest/Woodland bushfire hazard.

10.6 Conclusion

Daylesford / Hepburn Springs is exposed to a very high bushfire risk in the broader landscape. The neighbourhood-scale hazard within 400 m of Hepburn Springs and the northern, western, and southern outskirts of Daylesford is even greater, with many lots on the edge of the township exposed to Forest on short, but in places extremely steep, slopes.

The BMO1, BMO2 and BPA-only areas of the existing settlement are considered suitable for appropriately planned infill development.

Infill development on the forest edge at Hepburn Springs and on the northern, western and southern outskirts of Daylesford will require careful planning. Proposals for subdivision of this LDRZ1 land may be contrary to Clause 13.02-1S, which directs development to low risk areas.

BAL-40 construction of infill development may be acceptable where a lot cannot achieve Column C defendable space for BAL-29 construction but can comply with the other applicable approved measures, including mitigating landscape risk. BAL-40 construction should not be seen as a substitute for providing Column C defendable space if it is possible to do so.

The broader landscape and neighbourhood hazard make the rezoning of LDRZ1 land at Daylesford and Hepburn Springs highly inadvisable. Providing the mandated BAL-12.5 defendable space would require large areas of remnant vegetation on private and public land to be managed, which would likely be deemed unacceptable, and may not adequately mitigate the landscape risk.

The flatter farmland adjacent to the eastern edge of the township is more suitable for rezoning from a bushfire risk perspective. There is a large area more than 400 m from Forest and urban growth in this direction would increase the BAL-LOW area of the township.

11 Glenlyon

11.1 Study area

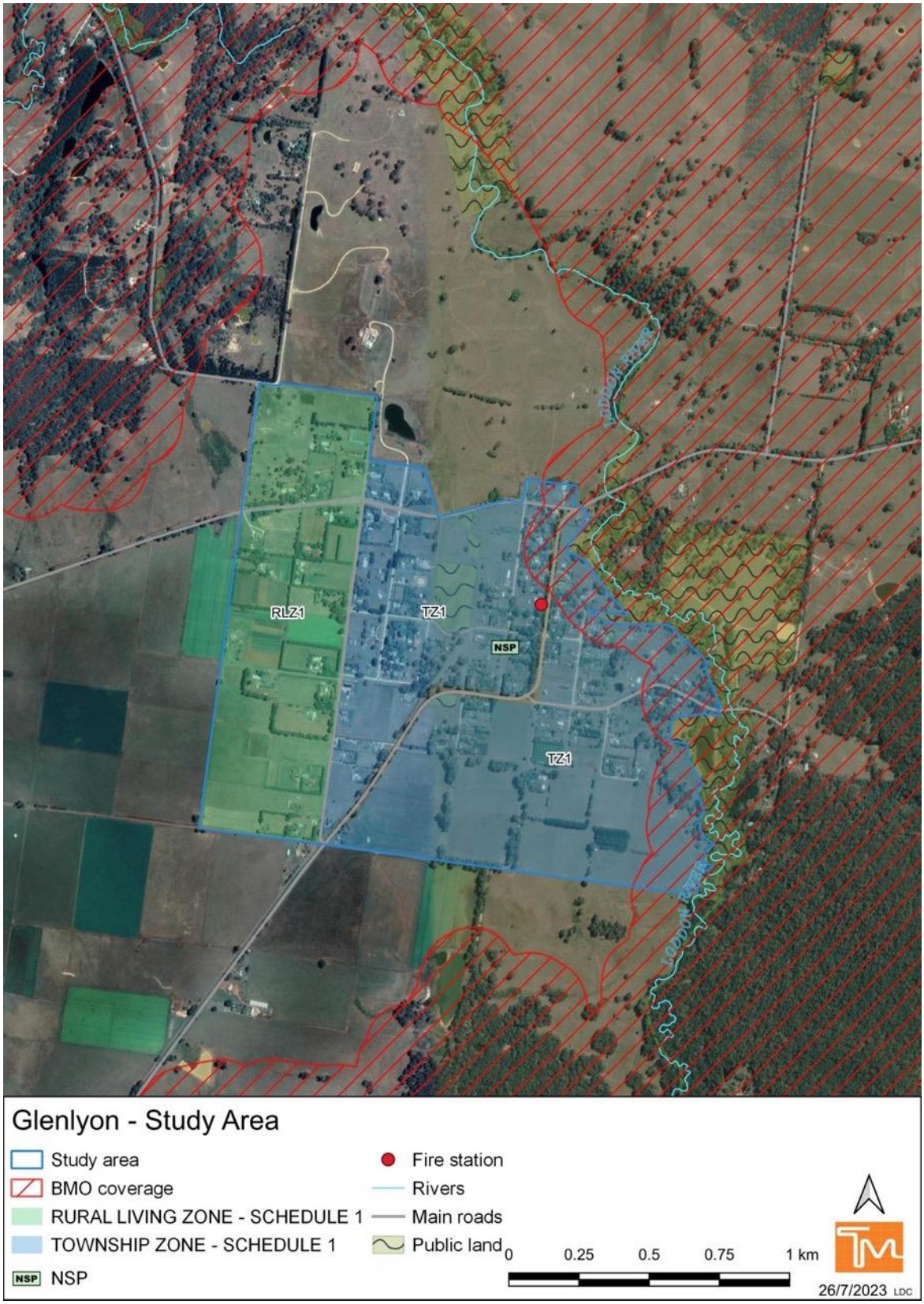
11.1.1 Description

Glenlyon is a small village on the Loddon River, approximately 10 km north-east of Daylesford and 100 km north-west of Melbourne. At the 2016 census Glenlyon and immediate hinterland had a population of 389. Glenlyon is part of a productive agricultural area and serves as a dormitory for workers commuting to Daylesford, Ballarat or Melbourne.

11.1.2 Zoning and overlays

The township area of Glenlyon is zoned Township Zone -Schedule 1 (TZ1) and does not have reticulated sewerage. Adjacent land to the west is zoned Rural Living Zone – Schedule 1 (RLZ1) (see Map 15), which has a minimum lot size of 8 ha.

Schedule 1 to Clause 42.01 *Environment Significance Overlay* (ESO1) *Special Water Supply Catchment Protection* applies to the entire study area. It has no apparent implications for bushfire protection.



Map 15 - Glenlyon study area showing residential zones and BMO coverage. Entire map extent is BPA.

11.2 Existing hazard and risk assessments

11.2.1 Regional Bushfire Planning Assessment

- *Glenlyon is experiencing development pressure. It is located in close proximity to a bushfire hazard area. Existing vegetation includes areas of high and very high significance* (Identified Area Code 29-005).
- *Small lots in Glenlyon, experiencing development pressure. It is located in close proximity to a bushfire hazard area. Existing vegetation includes areas of high and very high significance* (Identified Area Code 29-026) (DPCD, 2012).

11.2.2 Grampians Bushfire Management Strategy

The Glenlyon area was rated a Higher or Highest risk for house loss (DELWP, 2020b), reflecting the concentration of dwellings that could be exposed to a large bushfire burning out of the nearby Forest.

11.3 Broader landscape hazard assessment

11.3.1 Bushfire scenarios

Glenlyon could be impacted by a large bushfire burning through Forest from the north or, less likely, south-west, which are the typical directions of approach under elevated fire weather in Victoria (Long, 2006). A fire approaching from the north or north-west could spread through more than 10 km of contiguous Forest before reaching the Grassland around Glenlyon.

Most of the RLZ1 land to the west of the town is directly exposed to flat Grassland or remnant grassy Woodland, and whilst fire spread may be rapid, the intensity and level of ember generation will be less than in forested areas to the north, south and east. The northern section of the RLZ1, however, may experience elevated ember attack, due to its proximity to the Forest to the north-west.

Potential fire behaviour around Glenlyon should be within the design fire parameters of AS 3959/BMO.

11.3.2 BMO broader landscape type

The Glenlyon township and immediately adjacent RLZ1 land are considered to best accord with Broader Landscape Type 3, in that bushfire could approach from multiple directions. Direct impact, however, would be from a grassfire. There is an open-air NSP in Eldon Street that has been assessed by CFA as providing a place of last resort shelter.

11.4 Local and neighbourhood hazard assessment

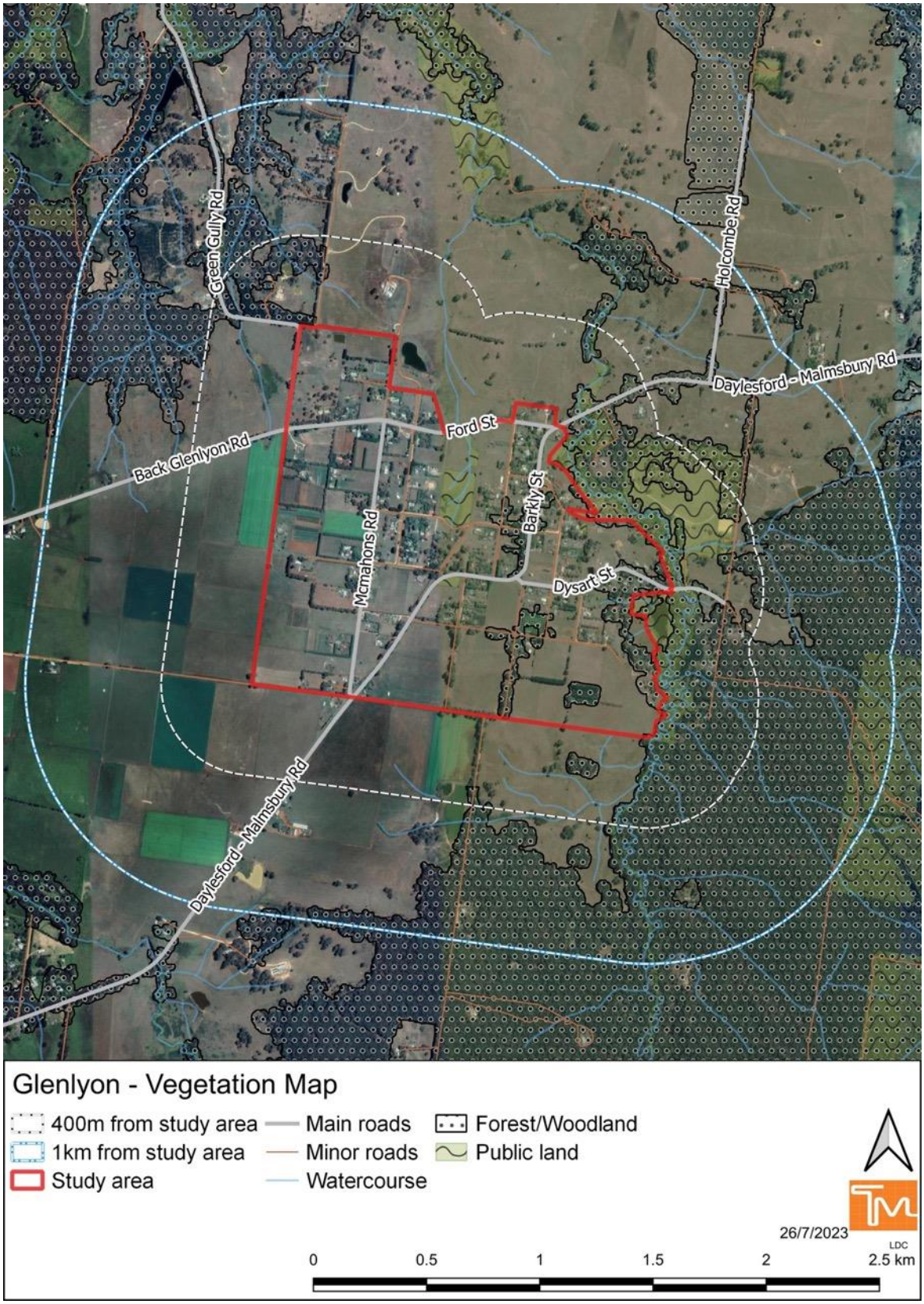
11.4.1 Vegetation

Glenlyon is set in pasture, with DEECA mapping showing small patches of remnant Plains Grassy Woodland (EVC 55) within and to the east of the township. Stream Bank Shrubland (EVC 851) and Sedgy Riparian Woodland (EVC 198) occur along the Loddon River. Further afield to the north-west, east and south is Herb-rich Foothill Forest (EVC 23).

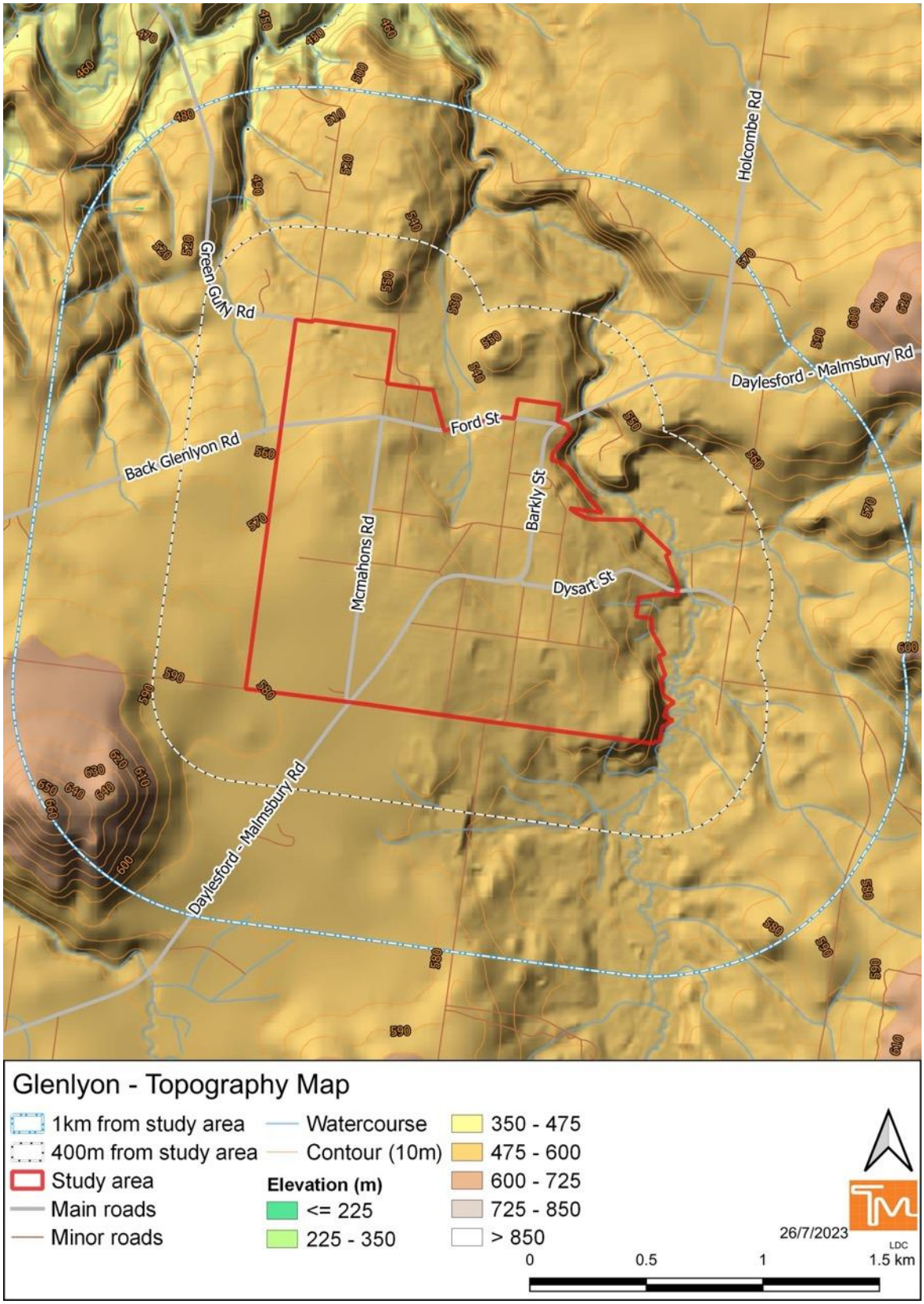
Plains Grassy Woodland and Sedgy Riparian Woodland are classifiable in the Woodland group and Herb-rich Foothill Forest in the Forest group of AS 3959-2018. Stream Bank Shrubland might be classifiable as Scrub or Shrubland depending on its height. Pasture is classifiable as Grassland. Areas of tree cover equating to a probable Woodland or Forest classification are shown on Map 16.

11.4.2 Topography

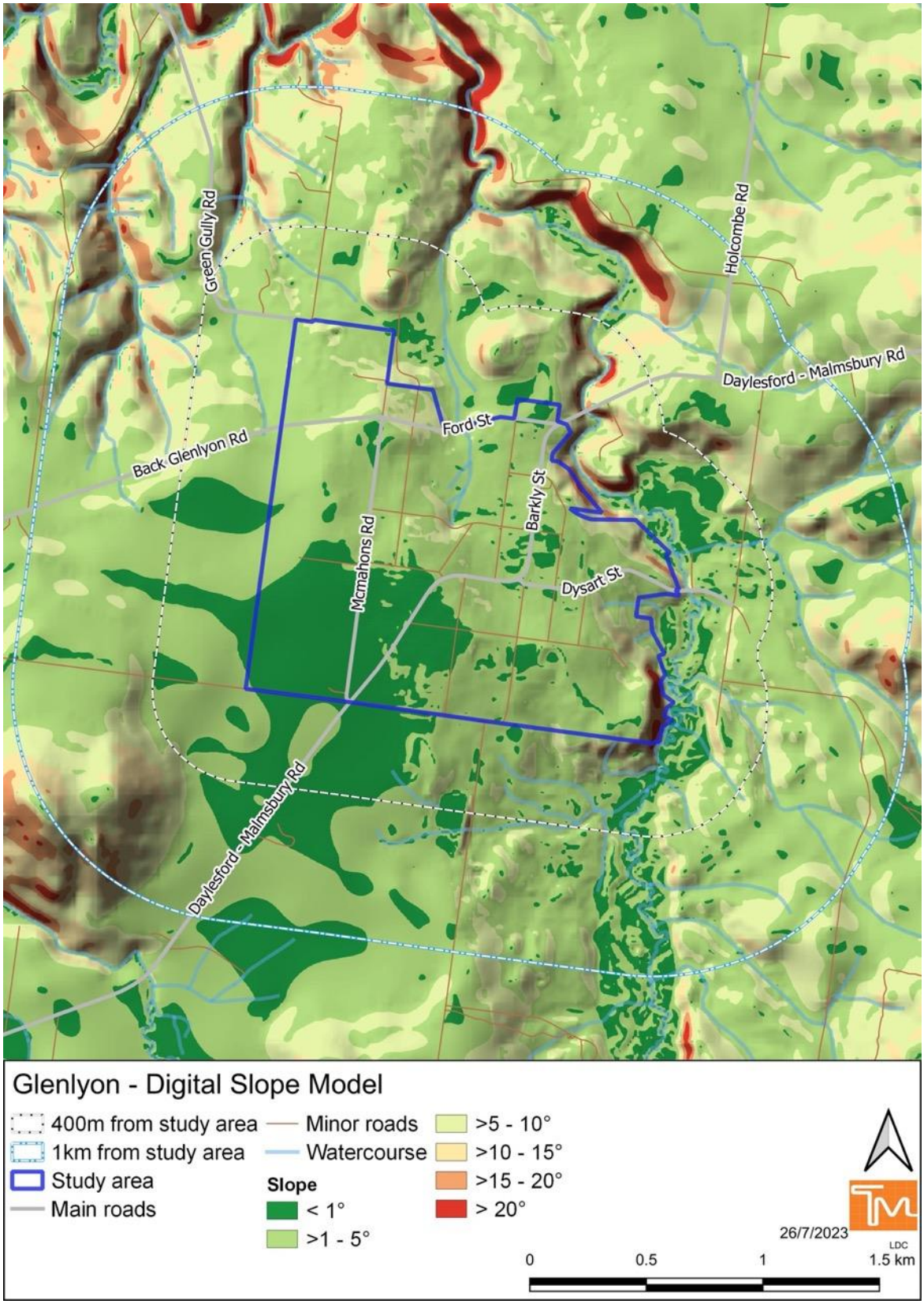
The main topographical feature is the Loddon River, which runs along the eastern boundary of the township. The land within and abutting the RLZ1 area west of the township is flat or gently sloping, less than 5^{o} (see Map 17 and Map 18). The land becomes steeper to the north and south-west, and in the south-east where it drops down to the river, but these steeper slopes will not affect the setbacks for future development in the RLZ1 area to the west.



Map 16 - Distribution of Forest/Woodland.



Map 17 - Topography (elevation).



Map 18 - Digital slope model (Note – slopes may be upslope or downslope in respect to any site).

11.4.3 Mitigation

Public land to the north-west and south-east of the township is zoned Landscape Management Zone (see Figure 8). There is no public and zoned as an FMZ close to the township.

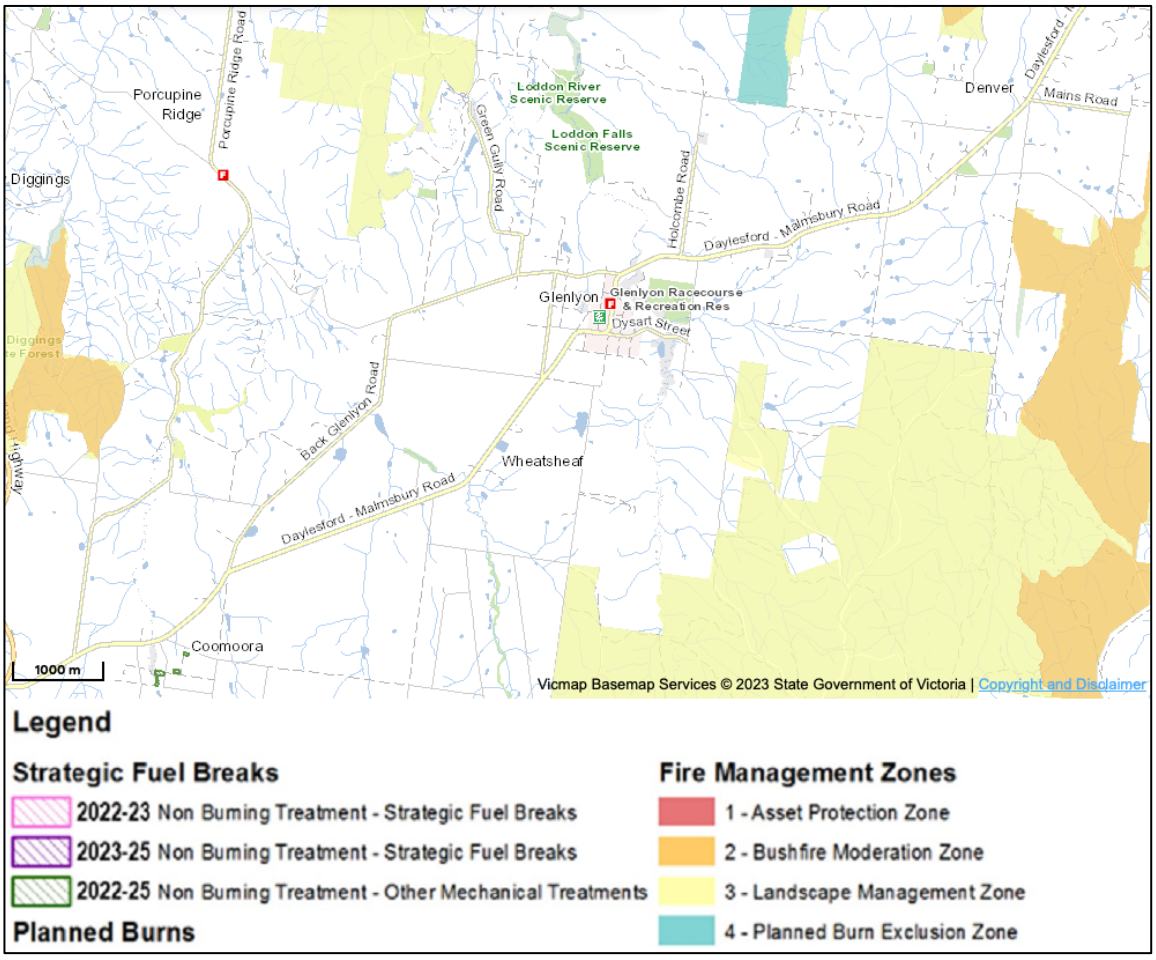


Figure 8 - Fuel management zones in the vicinity of Glenlyon (FFMVic, 2023b).

BMO and BPA

All of Glenlyon and surrounding land is a designated BPA and applicable building classes, including dwellings, will need to be constructed to a BAL.

Areas of Forest to the north-west, east and south are covered by the BMO. The BMO also covers the eastern edge of the existing TZ1 land where it abuts Woodland along the Loddon River. Subdivision and/or buildings and works in this area will trigger the requirement for a planning permit and development will need to satisfy the BMO objectives at Clause 53.02 in the Hepburn Planning Scheme.

Neighbourhood Safer Place

Glenlyon – Eldon Street, between Molesworth Street and house #19 (approx. 2 km and 3 min travel by car).

This is a 'place of last resort' and strategic land use planning decisions about the suitability of a settlement for population growth should not be based on its presence.

11.5 Discussion

11.5.1 Development in the existing TZ1

The Municipal Planning Strategy provides strategic planning directions in relation to bushfire, including to:

- '*Concentrate development into defendable parts of existing township boundaries and settlements to mitigate bushfire risk, protect agricultural land, and limit natural and environmental risks.*
- *Discourage residential development in settlements within existing residentially zoned boundaries where bushfire risks cannot be mitigated*' (Clause 02.03 Hepburn Planning Scheme).

The BMO covers a relatively narrow strip of the existing TZ1 land adjacent to the Loddon River. The remainder of the existing township is in the BPA only.

We consider that application of the bushfire planning (i.e. BMO) and building (i.e. AS 3959) controls can adequately mitigate the bushfire risk within the existing township. The BPA-only land is, however, less exposed to the Woodland to the east and hence comparatively more suitable than further development in the BMO area.

11.5.2 Potential rezoning

The Request for Quote made the following comment in relation to Glenlyon:
'*We may consider upzoning land in Glenlyon from LDRZ to TZ but we are unsure if the bushfire risk is too extreme to allow for further development. Land in Glenlyon is not sewered*' (Hepburn Shire Council, 2022).

In this section we assess the bushfire potential to rezone the LDRZ1 land to the west of Glenlyon and the potential design requirements if it were to be rezoned.

BAL safety thresholds

The Glenlyon Structure Plan, and any rezoning arising from it, represent settlement planning pursuant to Clause 13.02-1S. One of the key strategies for settlement planning is to direct development to areas where radiant heat flux is expected not to exceed 12.5 kW/m^2 upon

completion of development and where, therefore, future dwellings or other buildings could be constructed to a BAL-12.5 construction standard (Clause 13.02-1S Hepburn Planning Scheme).

The setback from hazardous vegetation required to allow BAL-12.5 construction is likely to be no more than 22 m in response to classified Grassland on downslopes up to 5°.

The requirement for these setbacks, their location and how they are best created will depend upon which land is proposed to be rezoned and the long term state of vegetation on the adjacent land. There appears to be a potential growth area in the RLZ1 land, to the west of the existing township, that is outside of the BMO coverage and could provide the requisite setbacks.

Proximity to hazard

Proximity to hazardous vegetation has been shown to strongly correlate with house loss/survival and loss of human life in major bushfires throughout Australia (see Section 7.2). In all but one of the nine major Australian bushfires analysed, 95% of all destroyed buildings were within 400 m of bushland, in the outlier the 400 m threshold equated to approximately the 93rd percentile. Further, in all but one of the bushfires, no house was lost more than 700 m from bushland.

Consequently, 400 m and 700 m are suggested as thresholds beyond which there is a low and very low direct risk to future dwellings from a fire in the bushland. At these distances impact on a building is not by flames or radiant heat from a bushfire in the Forest, but by low density ember attack and/or a grassfire, which are easier to mitigate through the planning and design of settlements and construction of buildings to an appropriate BAL.

Land between 400 m and 700 m from substantial areas of Forest to the north and Woodland to the east (contiguous areas greater than 10 ha) is shown on Map 19 as pale yellow shading between the orange and yellow lines. Blue shaded land beyond the orange line is more than 700 m from the Forest and Woodland. There is a substantial area to the west of the existing township, in the RLZ1 land south of Back Glenlyon Road, that can provide at least a 400 m setback.

Proximity to safer area

The second key policy test for settlement planning is '*Ensuring the availability of, and safe access to, areas assessed as a BAL-LOW rating under AS 3959-2018 Construction of Buildings in Bushfire-prone Areas (Standards Australia, 2018) where human life can be better protected from the effects of bushfire'* (Clause 13.02-1S Hepburn Planning Scheme).

Under AS 3959-2018, a BAL-LOW area requires a setback of 50 m from classified Grassland and 100 m from classified Forest or Woodland on any slope. Whilst there is an NSP in the Glenlyon TZ1 area, the current mosaic of residential properties and pasture means there is not a large area that would receive a BAL-LOW rating under AS 3959-2018. If a significant portion of the RLZ1 were to be rezoned to TZ1 and fully developed, it is possible that a larger, reliably BAL-LOW area

could be created in this area. Less or scattered development may not achieve a reliable BAL-LOW area.

Settlement design

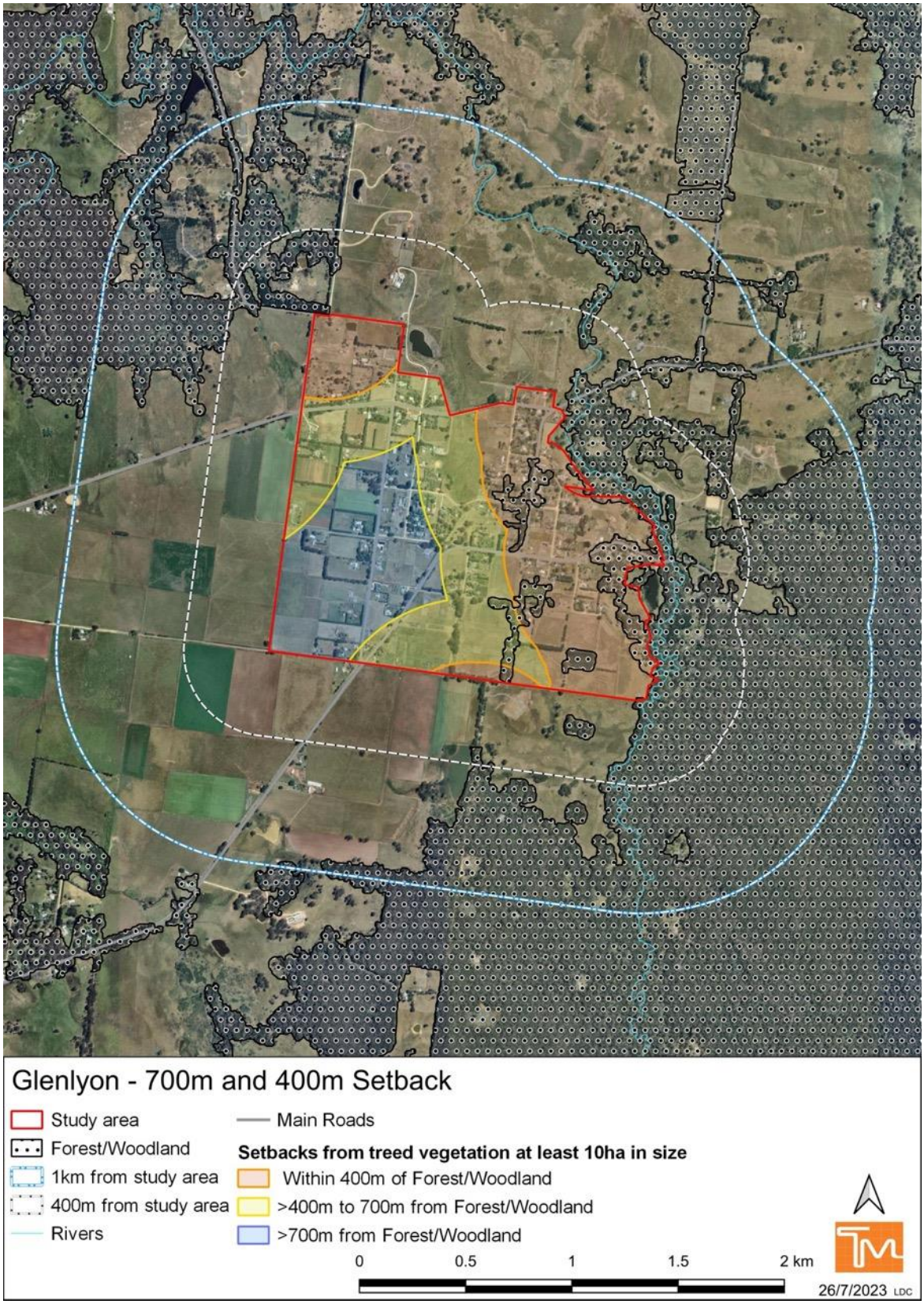
We recommend that the principles of the *Design Guidelines: Settlement Planning at the Bushfire Interface* (DELWP, 2020a) (see Section 13) be applied to any proposed subdivision and, to the extent practicable, infill development. This includes the use of roads (whether existing or to be created through subdivision) as hard edges to the settlement, and the siting of vulnerable uses (such as schools, child care, health care, residential aged care etc.) away from the bushfire interface.

11.6 Conclusion

Further development in the existing TZ1 area is considered acceptable from a bushfire risk perspective.

Rezoning of RLZ1 land south of Back Glenlyon Road to TZ1 could result in a new residential area that could achieve a BAL-12.5 or BAL-LOW rating under AS 3959-2018, in accordance with key 'Settlement planning' strategies at Clause 13.02-1S. It would be more than 400 m, and in places more than 700 m, from any substantial area of Woodland or Forest and the direct hazard to new development would be from grassfire and limited ember attack. Any settlement expansion should build from the edge of the township so that the future residential area, with contemporary bushfire protection measures, can provide protection to the existing settlement.

As the township and potential growth area is exposed to predominantly flat Grassland, with Woodland restricted to the river to the east, the amount of vegetation required to be managed in a low threat state to enable BAL-12.5 construction of new dwellings would be relatively small and would be largely confined to grass.



Map 19 - Proximity to Forest/Woodland bushfire hazard.

12 Trentham

12.1 Study area

12.1.1 Description

Trentham is an agricultural town on the northern edge of the Wombat State Forest, approximately 24 km east of Daylesford and 87 km north-west of Melbourne. At the 2016 census it had a population of 1,180.

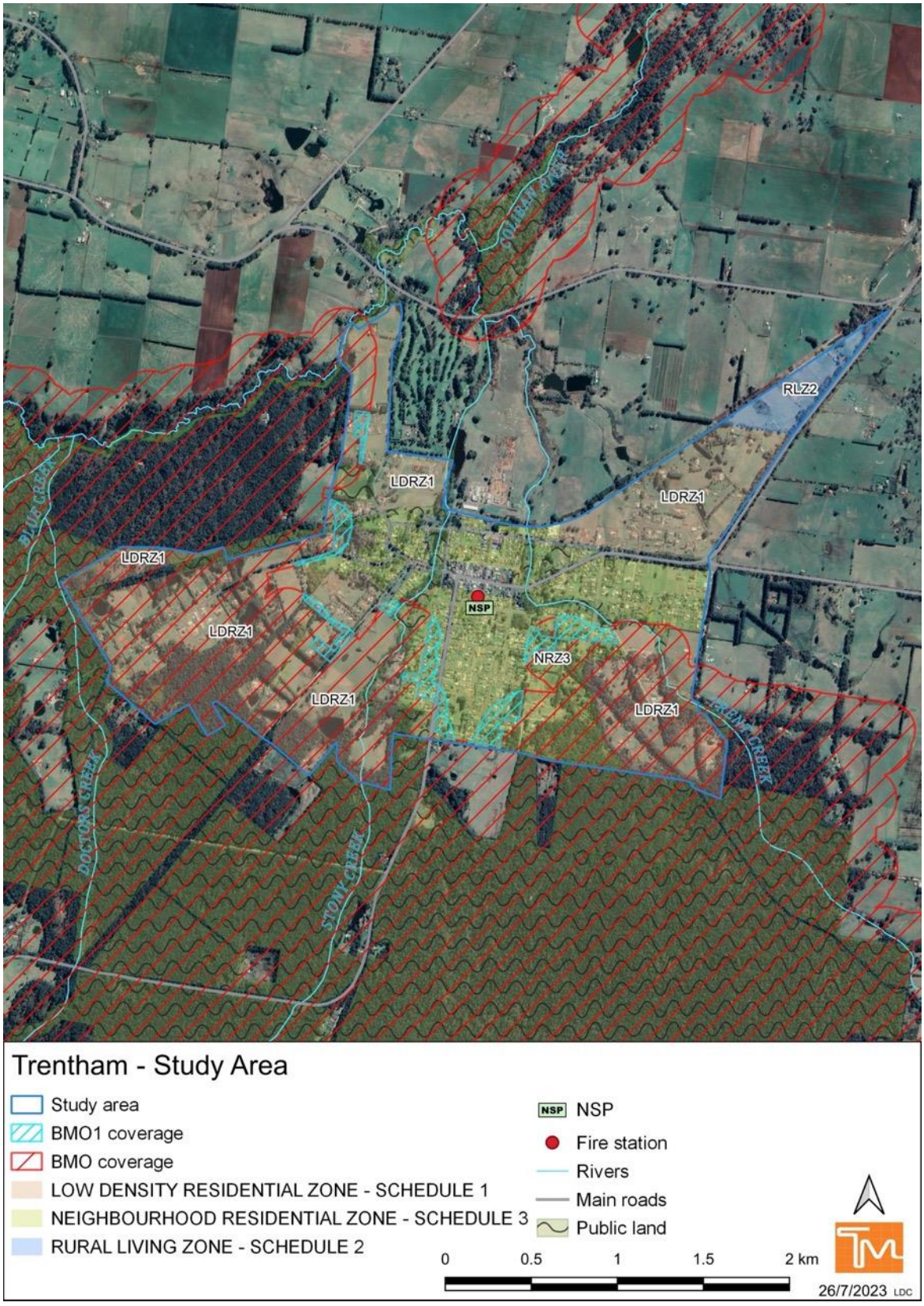
12.1.2 Zoning and overlays

The township area of Trentham is predominantly zoned Neighbourhood Residential Zone – Schedule 3 (NRZ3). Low Density Residential Zone - Schedule 1 (LDRZ1) land adjoins the town to the north-west beside the golf course, to the south-west along Mulcahys Road and Blue Mount Road, to the south-east around Racecourse Road and Cranneys Lane, and to the north-east along Kyneton-Trentham Road. LDRZ1 has a minimum lot size of 0.4 ha for areas without reticulated sewerage and 0.2 ha for areas with reticulated sewerage.

A small area of Rural Living Zone – Schedule 2 (RLZ2) occurs further to the north-west. RLZ2 has a minimum lot size of 4 ha.

Schedule 1 to Clause 42.01 *Environment Significance Overlay* (ESO1) *Special Water Supply Catchment Protection* applies to the entire study area. It has no apparent implications for bushfire protection.

Clause 42.02 *Vegetation Protection Overlay* (VPO) applies to parts of the Trentham township area and nearby road reserves but has no apparent implications for bushfire protection.



Map 20 - Trentham study area showing residential zones and BMO coverage. Entire map extent is BPA.

12.2 Existing hazard and risk assessments

12.2.1 Regional Bushfire Planning Assessment

- *Residential lots in Trentham and surrounding rural-residential lots are in and in proximity to the bushfire hazard area associated with state forest to the south and west. The area includes vegetation of high and very high conservation significance* (Identified Area Code 29-001).
- *Single constructed road servicing cluster of dwellings (Horvaths Road)* (Identified Area Code 29-004) (DPCD, 2012).

12.2.2 Grampians Bushfire Management Strategy

Trentham was rated a Higher or Highest risk for house loss (DELWP, 2020b), reflecting the large number of dwellings that could be exposed to a large bushfire burning out of the adjacent Forest.

12.3 Broader landscape hazard assessment

12.3.1 Bushfire scenarios

Trentham could be impacted by a large bushfire burning through Forest from the west or south-west, which are the typical directions of approach under elevated fire weather in Victoria (Long, 2006). Contiguous Forest extends more than 20 km to the south-west and 10 km to Wheatsheaf in the north-west.

The LDRZ1 land on the western and southern outskirts of the town is immediately adjacent to Forest, much of which is on public land. Ember attack may be severe, particularly in long unburnt areas where stringybarks are present.

The LDRZ1 and RLZ2 land to the north-east of the town is much less exposed to Forest but could be impacted by grassfire from multiple directions. Fire spread may be rapid, but the intensity and level of ember attack will be less than in forested areas.

Potential fire behaviour around Trentham should be within the design fire parameters of AS 3959/BMO, but the extensive exposure and proximity of many buildings to the bushfire hazard means that losses may be substantial under elevated fire danger.

12.3.2 BMO broader landscape type

Overall, Trentham best accords with Broader Landscape Type 3, in that the township could be approached by bushfire from multiple directions with the potential for ember attack and spot

fires into the township area. Whilst there is an NSP, travel to it from the outer lying areas often relies on single roads.

The north-eastern side of Trentham is sheltered from the Forest by the township area and is exposed only to Grassland on gently sloping ground. This area has characteristics of Broader Landscape Type 2.

12.4 Local and neighbourhood hazard assessment

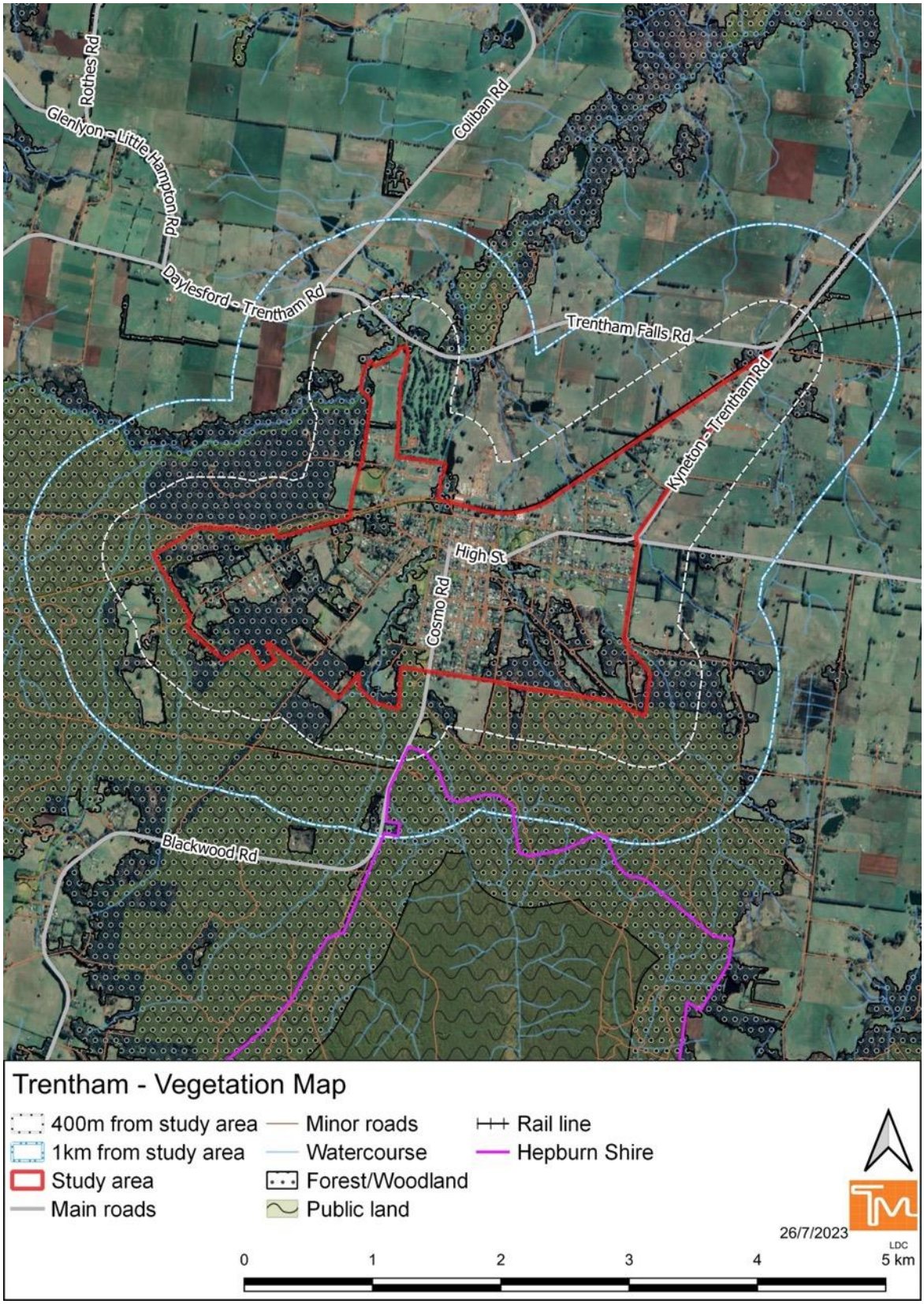
12.4.1 Vegetation

Trentham is situated immediately adjacent to public land, with extensive tracts of Forest to the west and south, and pasture with a strip of Forest along the Coliban River to the north. To the west and south, the predominant EVCs are Herb-rich Foothill Forest (EVC 23), with Sedgy Riparian Woodland (EVC 198) along the Coliban River and secondary drainage lines. In a strip along the river to the north of the township, there is also Riparian Forest (EVC 18), bordered by Herb-rich Foothill Forest (EVC 23).

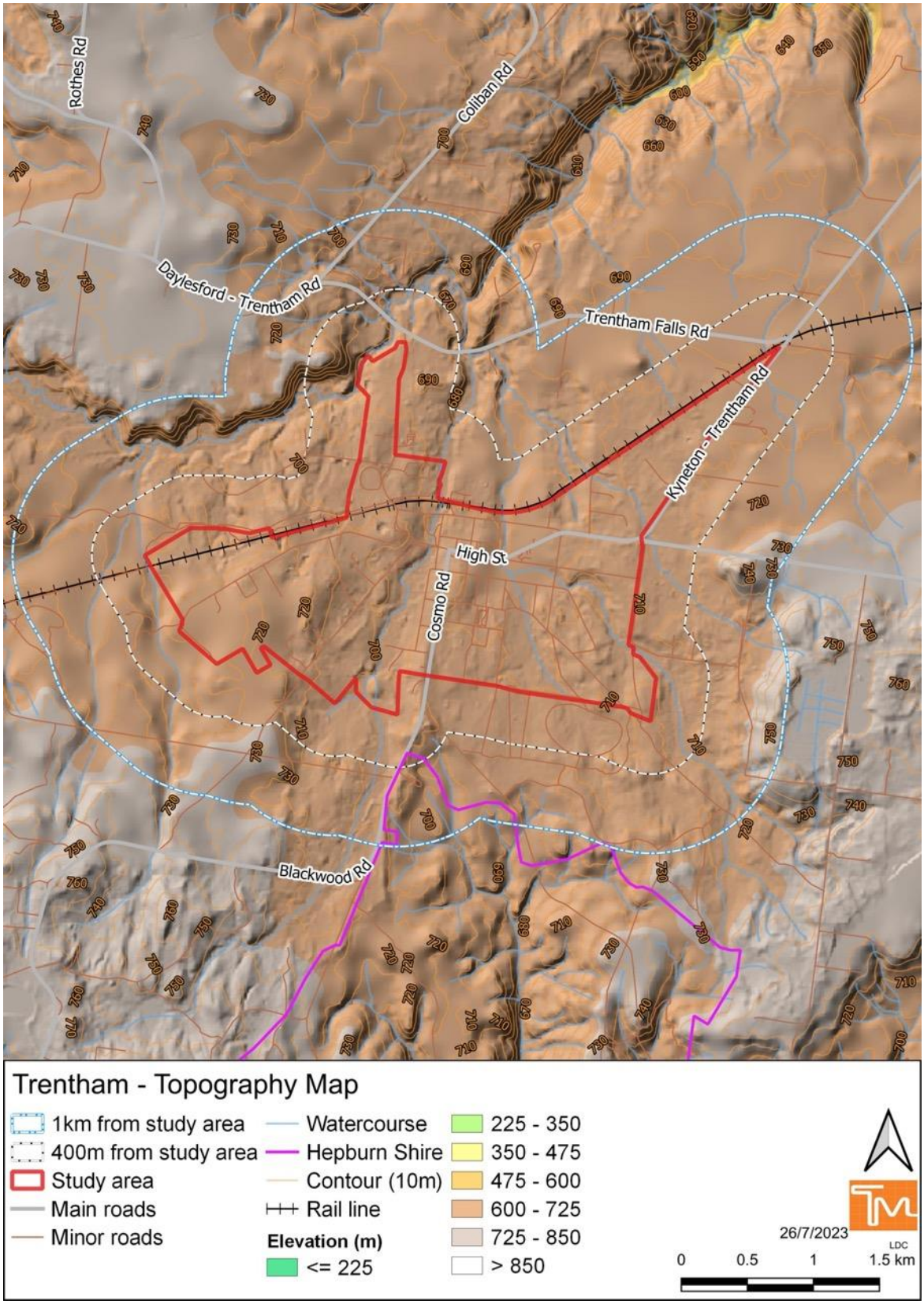
Riparian Forest and Herb-rich Foothill Forest are classifiable in the Forest group of AS 3959-2018, whilst Sedgy Riparian Woodland is potentially classifiable as Woodland. Pasture is classifiable as Grassland. Areas of tree cover equating to a probable Woodland or Forest classification are shown on Map 21.

12.4.2 Topography

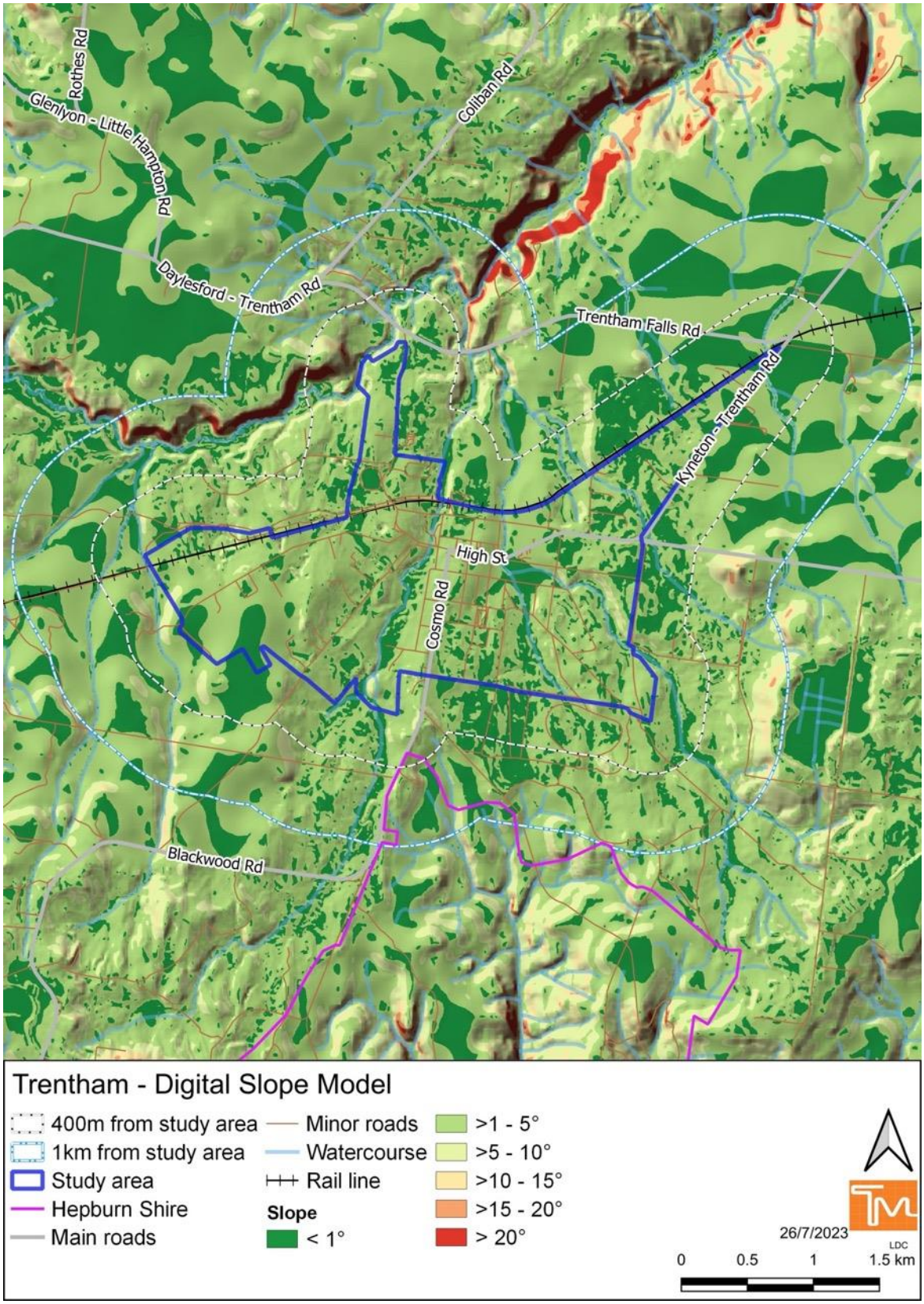
Most of the study area and immediate surrounds is flat or gently sloping, up to 5°. There are short but very steep slopes to the north of the town associated with the Coliban River, but these do not affect the bushfire protection requirements of any of the potential rezoning areas.



Map 21 - Distribution of Forest/Woodland.



Map 22 - Topography (elevation).



Map 23 - Digital slope model (Note – slopes may be upslope or downslope in respect to any site).

12.4.3 Mitigation

Public land immediately south of Trentham is Asset Protection Zone, this is complemented by large areas of Bushfire Moderation Zone further to the west and south, with Landscape Management Zone beyond (see Figure 9).

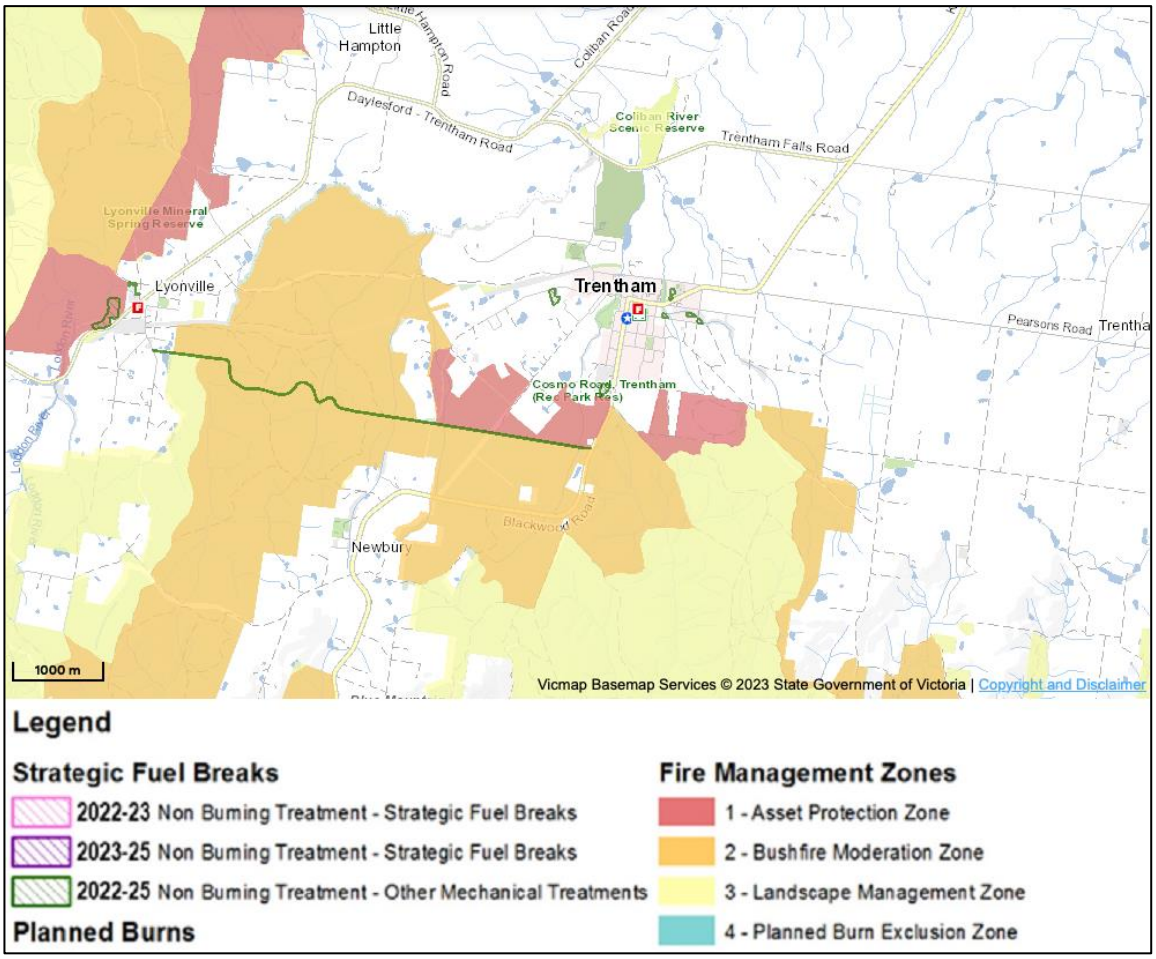


Figure 9 - Fuel management zones in the vicinity of Trentham (FFMVic, 2023b).

FMZs typically assist to manage bushfire risk at a strategic and landscape or local scale. Whilst they can contribute to moderation of fire behaviour at that broader landscape scale, they cannot be relied upon to mitigate risk at a site scale. The BMO requires reasonable assurance that defendable space beyond the property boundary will remain in a state consistent with the objective of defendable space. Prescribed burning does not assuredly create defendable space, as the vegetation management standards in Table 6 to Clause 53.02-5 are typically not achieved and fuel loads reaccumulate over time. Planned burning is also subject to resource and weather constraints in any particular year.

BMO and BPA

All of Trentham and surrounding area is designated BPA and applicable building classes, including dwellings, will need to be constructed to a BAL.

The BMO covers the western and southern edge of the township, including most of the LDRZ1 land and some of the existing NRZ3 land. There are small areas of BMO – Schedule 1 (which species BAL-12.5 construction). Subdivision and/or buildings and works in the areas covered by the BMO will trigger the requirement for a planning permit and development will need to satisfy the BMO objectives at Clause 53.02 in the Hepburn Planning Scheme.

Neighbourhood Safer Place

Trentham – 25 Market Street (approx. 2.5 km and 5 mins travel by car from the south-western extremity of study area).

Note - This is a 'place of last resort' and strategic land use planning decisions about the suitability of a settlement for population growth should not be based on its presence.

12.5 Discussion

12.5.1 Development in the existing NRZ3

The Municipal Planning Strategy provides strategic planning directions for Trentham in relation to bushfire, including to:

- '*Concentrate development into defendable parts of existing township boundaries and settlements to mitigate bushfire risk, protect agricultural land, and limit natural and environmental risks.*
- *Contain growth of Trentham … within the designated township boundaries.*
- *Discourage residential development in settlements within existing residentially zoned boundaries where bushfire risks cannot be mitigated*' (Clause 02.03 Hepburn Planning Scheme).

Large areas of the NRZ3 land at Trentham are not covered by the BMO, but all are in a designated BPA.

The BMO or Schedule 1 to the BMO apply to the outer edges of the NRZ3 land, to the west, south and east where it interfaces with treed vegetation. The BMO1 applies to development applications for single dwellings on a lot and stipulates BAL-12.5 construction and defendable space for 30 m or to the property boundary, whichever is the lesser distance. The presence of the BMO1 indicates that the lots were considered sufficiently setback from classified Forest and/or Grassland to enable BAL-12.5 construction and the lots are either large enough to provide the requisite defendable space within their boundaries or the surrounding land was considered reliably low threat.

We consider that application of the bushfire planning (i.e. BMO) and building (i.e. AS 3959) controls can adequately mitigate the bushfire risk within most of the existing township. Additional care will be needed in the south-east, between Gleeson Street and Mullens Road, where any future development will be exposed to Forest currently on private land north of Golden Point Road (which is a track through the forest for much of its length) and an enduring bushfire hazard on the public land to the south, and we would not recommend intensification of development in this area.

We recommend that the principles of the *Design Guidelines: Settlement Planning at the Bushfire Interface* (DELWP, 2020a) (see Section 13) be applied to any proposed subdivision and, to the extent practicable, infill development in the NRZ3. This includes the use of roads (whether existing or to be created through subdivision) as hard edges to the settlement, and the siting of vulnerable uses (such as schools, child care, health care, residential aged care etc.) away from the bushfire interface.

12.5.2 Potential rezoning

The Request for Quote made the following comment in relation to Trentham:
'*We are looking to rezone land in Trentham from LDRZ or RLZ to NRZ but we are unsure if the bushfire risk is too extreme to allow for further development*' (Hepburn Shire Council, 2022).

In this section we assess the bushfire risk to the LDRZ1 and RLZ2 land on the outskirts of Trentham and the potential settlement design requirements if it were to be rezoned.

BAL safety thresholds

The Trentham Structure Plan, and any rezoning arising from it, represent settlement planning pursuant to Clause 13.02-1S. One of the key strategies for settlement planning is to direct development to areas where radiant heat flux is expected not to exceed 12.5 kW/m^2 upon completion of development and where, therefore, future dwellings or other buildings could be constructed to a BAL-12.5 construction standard (Clause 13.02-1S Hepburn Planning Scheme).

The setbacks from hazardous vegetation required to allow BAL-12.5 construction are likely to be 57 m in areas exposed to classified Forest (on a Downslope >0^o-5^o) or 22 m in areas exposed only to classified Grassland on the same slope.

The requirement for these setbacks, their location and how they are best created will depend upon which land is proposed to be rezoned and the and the long term state of vegetation on the adjacent land.

Provision of 57 m of defendable space in the southern LDRZ1 areas appears feasible but would likely require management of native vegetation in some places. Intensification of development in

much of this area, however, is considered contrary to the strategies at Clause 13.02-1S, which direct development to low risk areas. An exception may be immediately adjacent to the NRZ3 land (e.g. north-east from Manna Lane and/or east of Falls Road to the south of the golf course). This land is outside of the BMO coverage and intensification of development could harden the edge of the existing township.

Provision of 22 m of defendable space in the LDRZ1 north-east of the town, in response to Grassland, is more feasible and intensification of development in this direction would accord better with the strategies at Clause 13.02-1S.

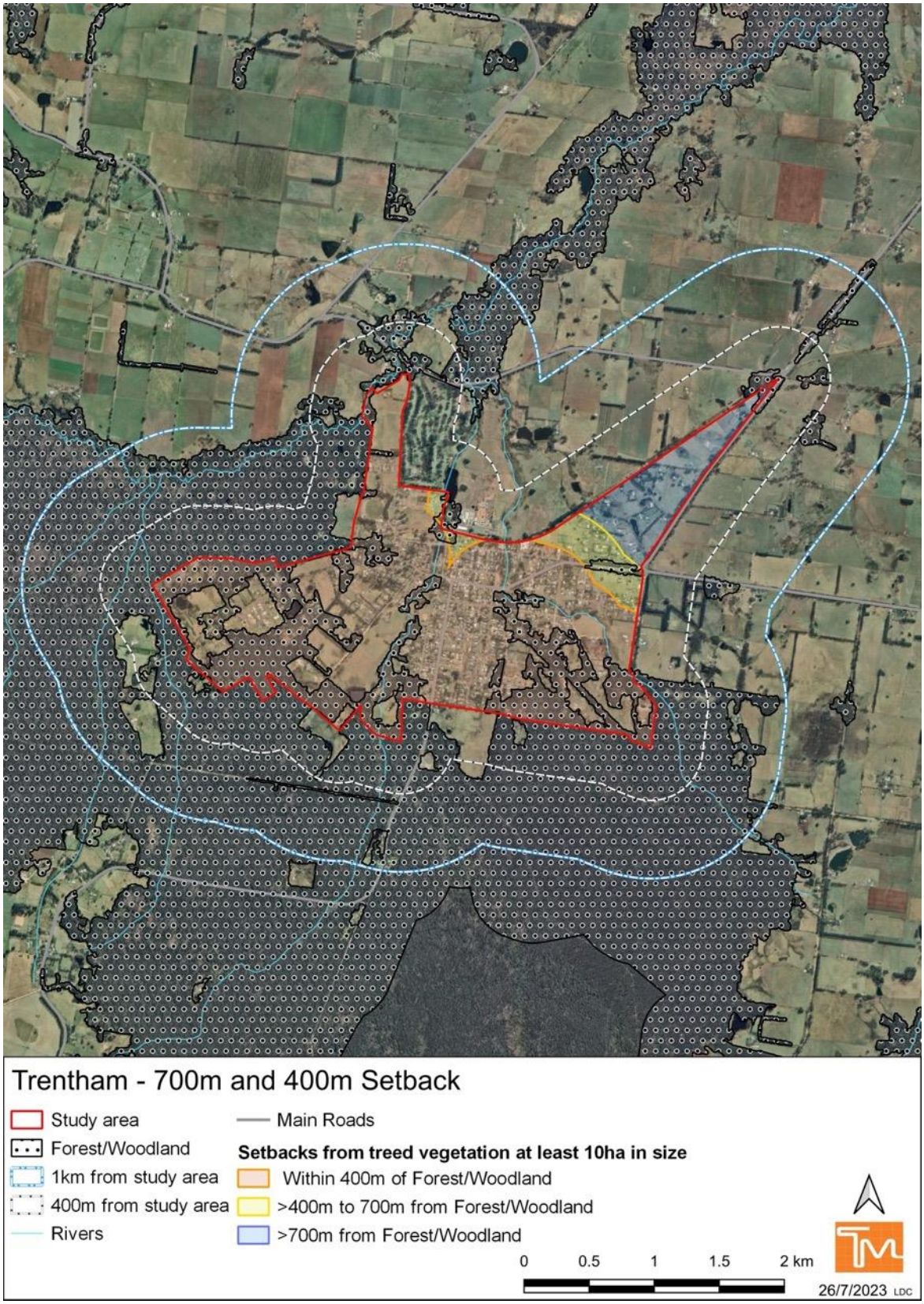
Proximity to hazard

Proximity to hazardous vegetation has been shown to strongly correlate with house loss/survival and loss of human life in major bushfires throughout Australia (see Section 7.2). In all but one of the nine major Australian bushfires analysed, 95% of all destroyed buildings were within 400 m of bushland, in the outlier the 400 m threshold equated to approximately the 93rd percentile. Further, in all but one of the bushfires, no house was lost more than 700 m from bushland.

Consequently, 400 m and 700 m are suggested as thresholds beyond which there is a low and very low direct risk to future dwellings from a fire in the bushland. At these distances impact on a building is not by flames or radiant heat from a fire in the Forest, but by low density ember attack and/or a grassfire, which are easier to mitigate through the planning and design of settlements and construction of buildings to an appropriate BAL.

Land more than 400 m from substantial areas of Forest (contiguous areas greater than 10 ha) is shown on Map 24 as pale yellow shading between the orange and yellow lines. Land beyond the yellow line, shaded blue, is more than 700 m from the Forest. This analysis identifies an area of LDRZ1 and RLZ2 land to the north-east of the town that is sufficiently setback from the Forest such that the direct fire attack would be from grassfire.

Note that more detailed assessment of treed vegetation along Kyneton-Trentham Road, Pearsons Road and small patches within the township (such as in the area west of Falls Road between Blighs Road and Mulcahys Road) may result in some being excluded from classification, which would increase the amount of land more than 400 m from Forest.



Map 24 - Proximity to Forest/Woodland bushfire hazard.

Proximity to safer area

The second key policy test for settlement planning is '*Ensuring the availability of, and safe access to, areas assessed as a BAL-LOW rating under AS 3959-2018 Construction of Buildings in Bushfire-prone Areas (Standards Australia, 2018) where human life can be better protected from the effects of bushfire'* (Clause 13.02-1S Hepburn Planning Scheme).

Under AS 3959-2018, a BAL-LOW area requires a setback of 50 m from classified Grassland and 100 m from classified Forest or Woodland on any slope. Parts of the existing Trentham township meet the BAL-LOW criteria and there is an NSP in Market Street. The area rated as BAL-LOW would expand if an additional, reliably low threat residential area were to be established on the north-eastern outskirts of the township, but the increase is unlikely to be significant give the size and shape of the potential rezoning area.

Settlement design

We recommend that the principles of the *Design Guidelines: Settlement Planning at the Bushfire Interface* (DELWP, 2020a) (see Section 13) be applied to any proposed subdivision and, to the extent practicable, infill development. This includes the use of roads (whether existing or to be created through subdivision) as hard edges to the settlement, and the siting of vulnerable uses (such as schools, child care, health care, residential aged care etc.) away from the bushfire interface.

12.6 Conclusion

Trentham is exposed to a very high bushfire risk in the broader landscape. The more immediate hazard within 400 m of the southern and western outskirts is also very high, with many LDRZ1 lots serviced by single roads extending southward from the town proper.

Residential development in most of the NRZ3 is considered appropriate from a bushfire risk perspective, but we do not recommend intensification in the south-east, between Gleeson Street and Mullens Road, which would expand the settlement towards the enduring bushfire hazard to the south.

Rezoning of much of the LDRZ1 land to enable intensification of development on the western and southern outskirts of Trentham is considered contrary to Clause 13.02-1S strategies that direct settlement growth to low risk locations. Whilst BAL-12.5 subdivision of current LDRZ1 land immediately adjacent to the western and south-western edge of the NRZ3 is possible, we consider the north-eastern LDRZ1 land, north of Kyneton-Trentham Road, to be a more suitable location for rezoning. This area is exposed only to Grassland, making it easier to create the defendable space required for BAL-12.5 development, and is buffered from the predominant bushfire hazard to the south by the existing township.

Trentham contains areas that would be rated as BAL-LOW under AS 3959 that could be readily accessed from any additional residential area to the north-east.

13 Design Guidelines – Settlement Planning at the Bushfire Interface

No decision has been made by Council to rezone any of the study areas being examined in this study. Any new development on the outskirts of these townships will be exposed to an enduring bushfire hazard on the adjacent rural land, and in this section we provide a general discussion about the implications of the *Design Guidelines: Settlement Planning at the Bushfire Interface* (DELWP, 2020a) (hereafter referred to as the 'Guidelines') for any potential rezoning and subsequent residential development that expands the townships.

13.1 Form and structure of settlements

The Guidelines identify four key considerations for the form and structure of settlements at the bushfire interface:

1. The bushfire hazard in directing settlement growth
2. The distribution of land uses in the settlement
3. Lot sizes in settlement layout
4. Vegetated areas within a settlement (DELWP, 2020a).

13.1.1 The bushfire hazard in directing settlement growth

The Guidelines advocate:

- Directing growth to the east of existing settlements so that the existing township provides protection to the new development; and/or
- Directing growth away from areas of greater bushfire hazard; and/or
- In lower risk landscapes, directing settlement growth to the higher risk areas so that the new development, with contemporary bushfire protection measures, provides protection to the older, less well protected existing settlement (DELWP, 2020a).

Daylesford / Hepburn Springs, Trentham and, to a lesser extent, Glenlyon are in very high risk locations, directly abutting Forest or Woodland. Any rezoning that allows for intensification of development should be away from the predominant hazard. At Daylesford, this favours any expansion being directed to the east of the township and at Trentham to the north-east. Glenlyon, however, is located to the immediate west of Woodland along the Loddon River and arguably the least exposed area for settlement expansion is the RLZ1 land south of Back Glenlyon Road.

Clunes is in a lower risk landscape and there is potential to expand to the immediate west of the existing township in an area exposed only to Grassland. Well planned development, with contemporary bushfire protection measures, could provide protection to the existing township area.

13.1.2 The distribution of land uses in the settlement

The Guidelines advocate:

- Locating vulnerable uses (such as education, child care, residential aged care, hospital, leisure and recreation facility or place of assembly) away from the settlement interface; and
- Locating hazardous uses (such as a petrol station) away from the settlement interface and to the east of residential areas if possible so that prevailing winds will blow any toxic smoke away from the settlement (DELWP, 2020a).

This level of detailed planning is not available for any of the townships at this stage, but these principles should be considered in any development planning that occurs.

13.1.3 Lot sizes in settlement layout

The Guidelines advocate a residential lot size of 800-1,200 sq. m to be optimal at the edge of townships.

Small lot sizes can offer bushfire safety advantages, if the lot size is small enough that it creates a 'dense' urban area that contains only low threat vegetation and non-vegetated areas with a resultant limited potential for bushfire to spread through it (March *et al.*, 2011).

Conversely, studies have found a correlation between house loss in a bushfire and proximity to other houses, due to the potential for heavy 'urban' fuels (such as houses, sheds, other structures, fences, garden vegetation, landscaping elements and woodpiles) to increase flame, radiant heat and ember attack on nearby dwellings (Price and Bradstock, 2013; Blanchi and Leonard, 2005).

The Guidelines consider lot sizes between 800 sq. m and 1,200 sq. m provide a balance between the risk of larger lots retaining more vegetation within a residential area, and smaller lots providing an increased risk of house-to-house ignitions or increased house losses from ember attack due to the higher housing density (DELWP, 2020a).

To 'harden' an existing township boundary, such as at Clunes, rezoning would ideally enable lot sizes in this range, at least immediately adjacent to the existing residential area which lacks contemporary bushfire protection measures.

13.1.4 Vegetated areas within a settlement

The Guidelines identify that vegetated areas within a settlement, such as parks and nature reserves, can create a bushfire hazard (DELWP, 2020a). Areas of potentially hazardous vegetation within a settlement can be responded to through:

- The provision of low threat setbacks of buildings from them; and/or

- Management of the vegetation they contain in a low threat state (DELWP, 2020a).

This could be a consideration for any settlement expansion at Clunes, where it may be desirable to retain existing small areas of grassy Woodland within an expanded residential area. The likely maximum setbacks required from retained classified vegetation are detailed in Table 6.

Table 6 - Low threat setbacks to achieve a BAL-12.5 rating at potential growth area Clunes.

Vegetation type	Effective slope	Low threat setback distance (m)
Woodland	All upslopes and flat land	33
	Downslope >0˚-5˚	41
Grassland	All upslopes and flat land	19
	Downslope >0˚-5˚	22

Note that no or lesser setbacks may be appropriate from areas of unmanaged vegetation that meet one or more of the exclusion criteria for low threat vegetation under AS 3959-2018, including:

- Single areas of vegetation less than 1 ha in area and at least 100 m from other areas of classified vegetation
- Multiple areas less than 0.25 ha (2,500 sq. m) in area that are at least 20 m from a building or each other
- Strips of vegetation less than 20 m wide that are at least 20 m from a building, other strips or any other area of classified vegetation.

Managing retained vegetation would appear to be less relevant to Daylesford / Hepburn Springs, Trentham or Glenlyon, where we would advocate that any expansion that is to occur be into areas that currently appear to be largely devoid of native vegetation.

13.2 The settlement interface

The Guidelines identify three key considerations for the settlement interface:

1. Apply the required setback
2. Design the settlement interface
3. Design access and egress (DELWP, 2020a).

13.2.1 Apply the required development setback

As a planning scheme amendment is required to rezone land, the 'Settlement planning' strategy at Clause 13.02-1S applies. The 'Settlement planning' strategy aims to strengthen the resilience of settlements and communities and prioritise protection of human life, including by:

- *'Directing population growth and development to low risk locations, being those locations assessed as having a radiant heat flux of less than 12.5 kilowatts/square metre[14] under AS 3959-2018 Construction of Buildings in Bushfire-prone Areas (Standards Australia, 2018).*
- *Not approving any strategic planning document, local planning policy, or planning scheme amendment that will result in the introduction or intensification of development in an area that has, or will on completion have, more than a BAL-12.5 rating under AS 3959-2009 Construction of Buildings in Bushfire-prone Areas (Standards Australia, 2018)'* (Clause 13.02-1S Hepburn Planning).

To satisfy this strategy, development defined as settlement planning must be sufficiently setback from classified vegetation to enable a BAL-12.5 construction standard. The range of setback distances that apply to the townships are discussed in Sections 9, 10, 11 and 12 of this report.

Setbacks will be required from:

- Classified vegetation beyond the boundaries of the township
- Any classified vegetation retained or created within the township.

If settlement expansion is to occur, we recommend thought be given to a planning mechanism that requires development to respond to the enduring bushfire hazard by precluding construction within the setback area. There are examples of such instruments in various Schedules to the Urban Growth Zone.

13.2.2 Design the settlement interface

The requisite setbacks can be provided through a combination of:

- The provision of perimeter roads
- The provision of low threat public open space on the interface
- Excluding development from the setback area, i.e. the setback of building envelopes within lots adjacent to the precinct boundary
- The creation of a low threat buffer on adjoining land through a formal agreement with the landowner.

Perimeter roads are a useful design feature to separate future development from hazardous vegetation and to facilitate property protection and fire fighting (see Figure 10) and should meet

[14] Note that the first strategy is to ensure radiant heat flux is less than 12.5 kW/m^2 (author's emphasis). The second strategy stipulates a maximum BAL-12.5 construction standard (which requires that radiant heat flux not exceed 12.5 kW/m^2). It is assumed the intent of both strategies to ensure that BAL-12.5 is a maximum construction standard for settlement planning, which is consistent with the wording of the latter strategy and the criteria and setback distances for BAL-12.5 in AS 3959-2018.

fire authority guidelines as detailed in *Vehicle Access and Water Supply Requirements in Residential Developments* (CFA, 2022b).

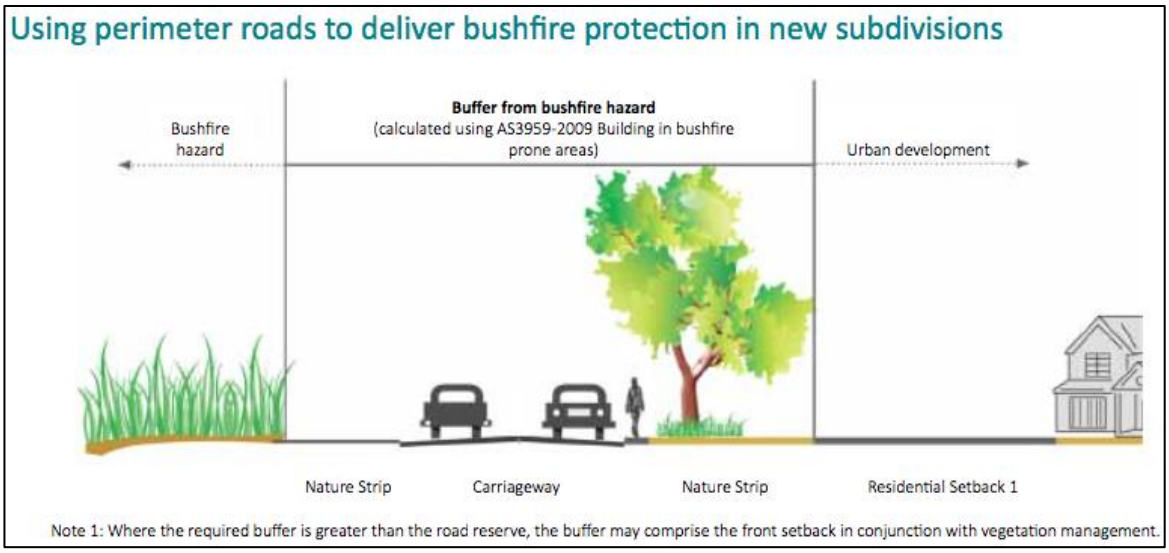


Figure 10 - Illustration of a perimeter road to provide required development setbacks (DELWP, 2015).

13.2.3 Design access and egress

The Guidelines list the elements of an effective road network as:

- Ensuring the spacing of roads leading away from the hazard are no more than 120 m apart on average
- Designing road widths to meet planning scheme requirements and those of the relevant fire authority
- Providing multiple roads leading away from the hazard edge
- Ensuring travel to and from a location is not alongside a bushfire hazard and providing multiple access and egress routes within developed areas to minimise the use of perimeter roads during bushfire
- Effectively connecting roads to the broader road network within the settlement (DELWP, 2020a).

This level of detailed planning is not available for any of the townships at this stage, but these principles should be considered in any development planning that occurs, and roads should also meet applicable fire service requirements (see CFA, 2022b).

13.3 Vegetation management within the settlement

Vegetation on private property throughout the potential settlement expansion areas will need to be maintained in a low threat state. This may require a planning control, such as a Design and Development Overlay or similar, to regulate vegetation management, particularly on any larger or low density residential lots with the potential for fuel accumulation.

It is noted that within defendable space areas for lots covered by the BMO, permit conditions requiring vegetation management should ensure vegetation on private land within expansion areas is low threat where a BMO development application is approved.

14 Conclusion

The four townships have varied exposure to bushfire hazard and, consequently, different bushfire planning considerations.

Clunes is, from a bushfire planning perspective, a comparatively lesser risk location and therefore, more suitable for expansion than other study areas. It is rated as Broader Landscape Type 2 and has the least exposure to higher hazard vegetation, being restricted to pasture and small areas of grassy Woodland on predominantly flat ground. This level of hazard can be effectively mitigated by good settlement planning and design of the interface with adjoining rural land. There are areas more than 400 m from any substantial patches of Woodland and outside of the BMO that could easily achieve a BAL-12.5 rating under AS 3959.

The non-BPA town centre provides a reliably low threat area that could be a safe place to shelter during bushfire and its size would increase if the town expanded. Any expansion should build from the existing edge of the township and, if this were to be from the western edge, the new residential area with contemporary bushfire protection measures could enhance the safety of the existing township. This includes the use of roads (whether existing or to be created through subdivision) as hard edges to the settlement, provision of multiple routes into the town centre, creation of lots in the 800 – 1,200 sq m range, and the siting of vulnerable uses (such as schools, child care, health care, residential aged care etc.) away from the bushfire interface.

Glenlyon has the next lower immediate exposure to bushfire hazard, as it is bordered by pasture to the north, west and south, with the main adjacent treed vegetation being to the east. If some of the southern part of the RLZ1 land were to be rezoned it would be more than 400 m (and in places 700 m) from substantial areas of Forest or Woodland and good settlement planning and design of the interface with adjoining rural land could provide an effective response to the Grassland hazard.

Glenlyon is, however, a small township and does not offer a large, reliably low threat area. For this reason it is considered less suitable for settlement expansion than Clunes.

Daylesford / Hepburn Springs and Trentham have greater exposure to landscape-scale (Broader Landscape Type 3) and local bushfire hazards, being directly abutted by Forest. In places, the outer lying residential areas are interspersed with bushland creating long and complex interfaces, which present challenges for the protection of the existing settlements. Public land fuel management may contribute to risk mitigation, but provision of BMO style defendable space to existing dwellings would require ongoing management of large areas of native vegetation on public and private land, with an associated cost to biodiversity, and ember attack would remain a significant threat.

Additional development in areas close to Forest is unlikely to replace the existing interface with a more reliably low threat area and, rather, would increase the exposure of life and property to the bushfire hazard. Thus, rezoning of land close to Forest to enable intensification of development is considered contrary to Clause 13.02-1S strategies that direct settlement growth to low risk locations.

Both Daylesford and Trentham are large enough to provide a reliably low threat town centre and have eastern or north-eastern edges of the settlement that are sheltered from the predominant bushfire hazard by the existing township area. There is FZ, LDRZ1 or RLZ2 land that is at least 400 m, and in places more than 700 m, from Forest, meaning the immediate bushfire hazard is restricted to Grassland and limited ember attack. Good settlement planning and design of the interface with adjoining rural land could provide an effective response to this level of hazard and settlement expansion in these directions could be considered.

Clause 13.02-1S requires settlement growth and development to be able to implement bushfire protection measures without unacceptable biodiversity impacts by discouraging development in areas with high biodiversity value. Hepburn Shire Council have commissioned an environmental assessment of the four towns and their surrounds, that is being conducted concurrently with this bushfire study. The findings of the ecological report should be considered along with the bushfire risk assessment in this report (and other strategic planning considerations) to determine the overall suitability of sites for township expansion.

Consolidating residential development within existing or expanded township boundaries would help create reliably low threat areas that can be better protected from bushfire. This is line with Council's strategic planning directions at Clause 02.03 and is considered preferable to low density lots that expand the residential area closer to the bushfire hazard without creating a substantial reliably low threat area.

15 Appendix A – BALs explained

Bushfire Attack Level (BAL)	Risk Level	Construction elements are expected to be exposed to…	Comment
BAL-LOW	VERY LOW: There is insufficient risk to warrant any specific construction requirements but there is still some risk.	No specification.	At 4 kW/m^2 pain to humans after 10 to 20 seconds exposure. Critical conditions at 10 kW/m^2 and pain to humans after 3 seconds. Considered to be life threatening within 1 minute exposure in protective equipment.
BAL-12.5	LOW: There is risk of ember attack.	A radiant heat flux not greater than 12.5 kW/m^2	At 12.5 kW/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 19 kW/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 29 kW/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 42 kW/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 45 kW/m^2 ignition of timber in 20 seconds (without piloted ignition).

Adapted from Standards Australia (2020).

16 Appendix B – Landscape-scale fire behaviour

To help identify locations with the potential for extreme fire behaviour, Tolhurst (2014) described three landscape metrics of potential fire behaviour:

1. Terrain ruggedness
2. Convective strength
3. Ember storm potential

The following section analyses these metrics across the municipality, to determine the potential for extreme fire behaviour, i.e. where BMO Broad Landscape Type 4 characteristics might apply as identified in the *Technical Guide – Planning Permit Applications Bushfire management Overlay* (DELWP, 2017).

The analysis is in accordance with the Clause 13.02-1S bushfire hazard identification and assessment strategy for '*Applying the best available science to identify vegetation, topographic and climatic conditions that create a bushfire hazard*' (Clause 13.02-1S Hepburn Planning Scheme).

Data for the mapping and analysis is reproduced with permission (*pers. comm*. from Dr Kevin Tolhurst, April 2023).

16.1.1 Terrain ruggedness

Terrain 'ruggedness' has been associated with very large fires exhibiting extreme fire behaviour including lightning ignition 'swarms', development of pyrocumulus/pyrocumulonimbus convective plume driven fires, and atypical fire spread resulting from wind phenomena in mountainous terrain including channelling and lee-side effects (Weber *et al.*, 2008; Sharples *et al.*, 2012; McRae and Sharples, 2013).

Tolhurst (2014) analysed the location of houses involved in the 2009 Black Saturday fires and found a strong association between areas of house loss and terrain 'ruggedness', indicating that terrain complexity may be an important contributing factor to house loss in severe bushfires.

McRae *et al.* (2007), when analysing a large number of fires that occurred in 2003, which were associated with dry thunderstorms in high country areas across south-east Australia, found that those ignited by lightning occurred preferentially in the most rugged terrain locations, providing further evidence that rugged terrain was a landscape risk factor for bushfire development and behaviour.

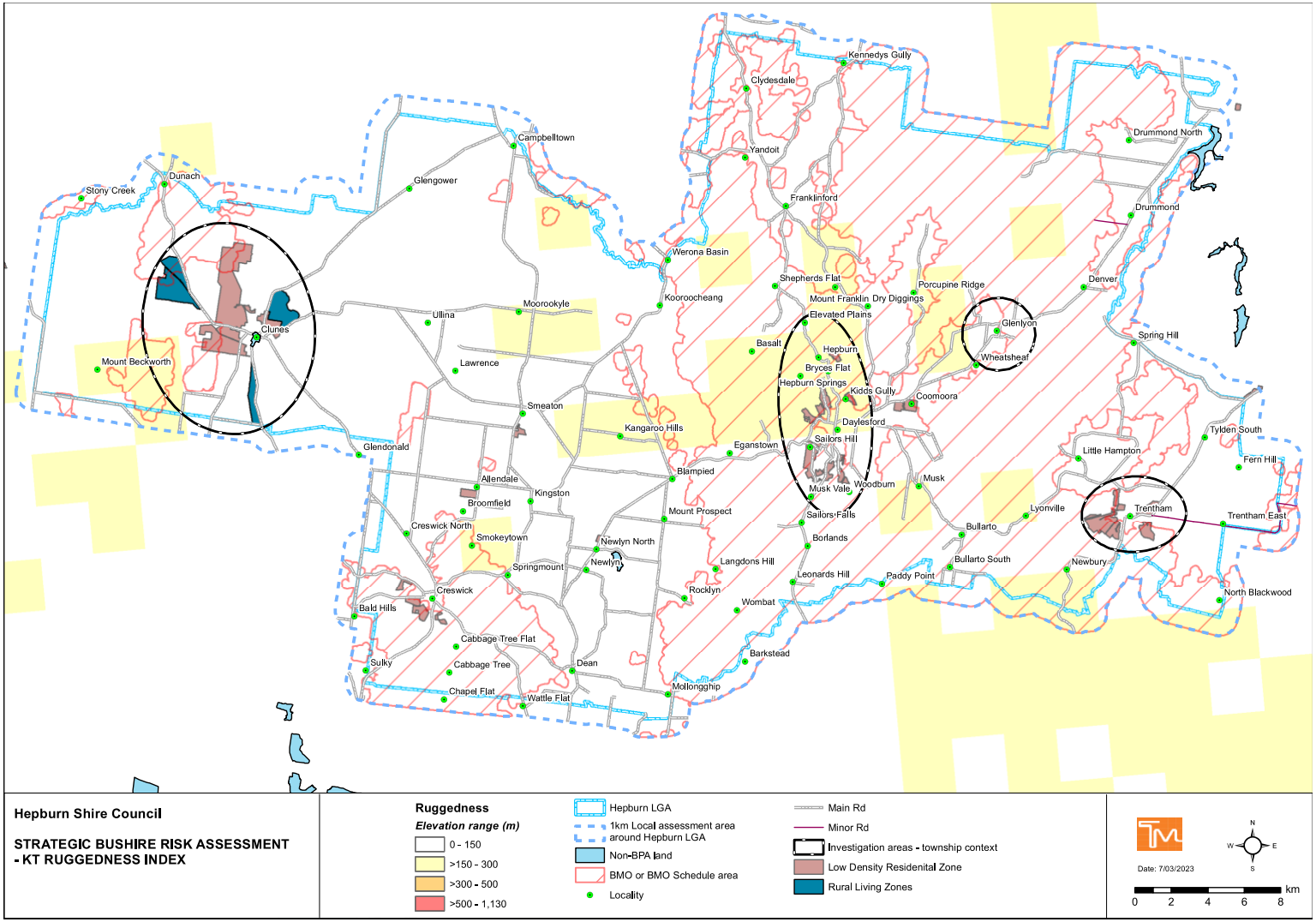
Terrain ruggedness can be calculated for more than 20 km around the Hepburn Shire, following the method of Weber *et al.* (2008), McRae and Sharples (2013) or Tolhurst (2014) using GIS

analysis to determine the range in elevation (m) within a 1.5 km radius of 30 m x 30 m cells. The following terrain complexity classes were then assigned:

Rating	Elevation range within 1.5 km
Low:	0 – 150 m
Moderate:	>150 – 300 m
High:	>300 – 500 m
Extreme:	> 500 m

The analysis shown in Map 25 identifies that Moderate rugged terrain occurs through much of the centre of the Shire, including around Blampied, Daylesford, Hepburn Springs, Elevated Plains, Porcupine Ridge and Wheatsheaf; and also to the north-west and south-west of Clunes, albeit at a greater distance from the settlement.

There are no areas of High or Extreme ruggedness within the municipality.



Map 25 - Landscape hazard assessment - Terrain ruggedness (after Tolhurst, 2014).

16.1.2 Convective strength

The AS 3959/BMO approach (and Clause 13.02-1S in the Planning Policy Framework) is based on applying development setbacks to achieve radiant heat flux thresholds that are considered to provide acceptable safety. However, up to around 80% of heat energy from a bushfire can be in the form of convection, with only around 20-40% being radiation (Tolhurst and Cheney, 1999).

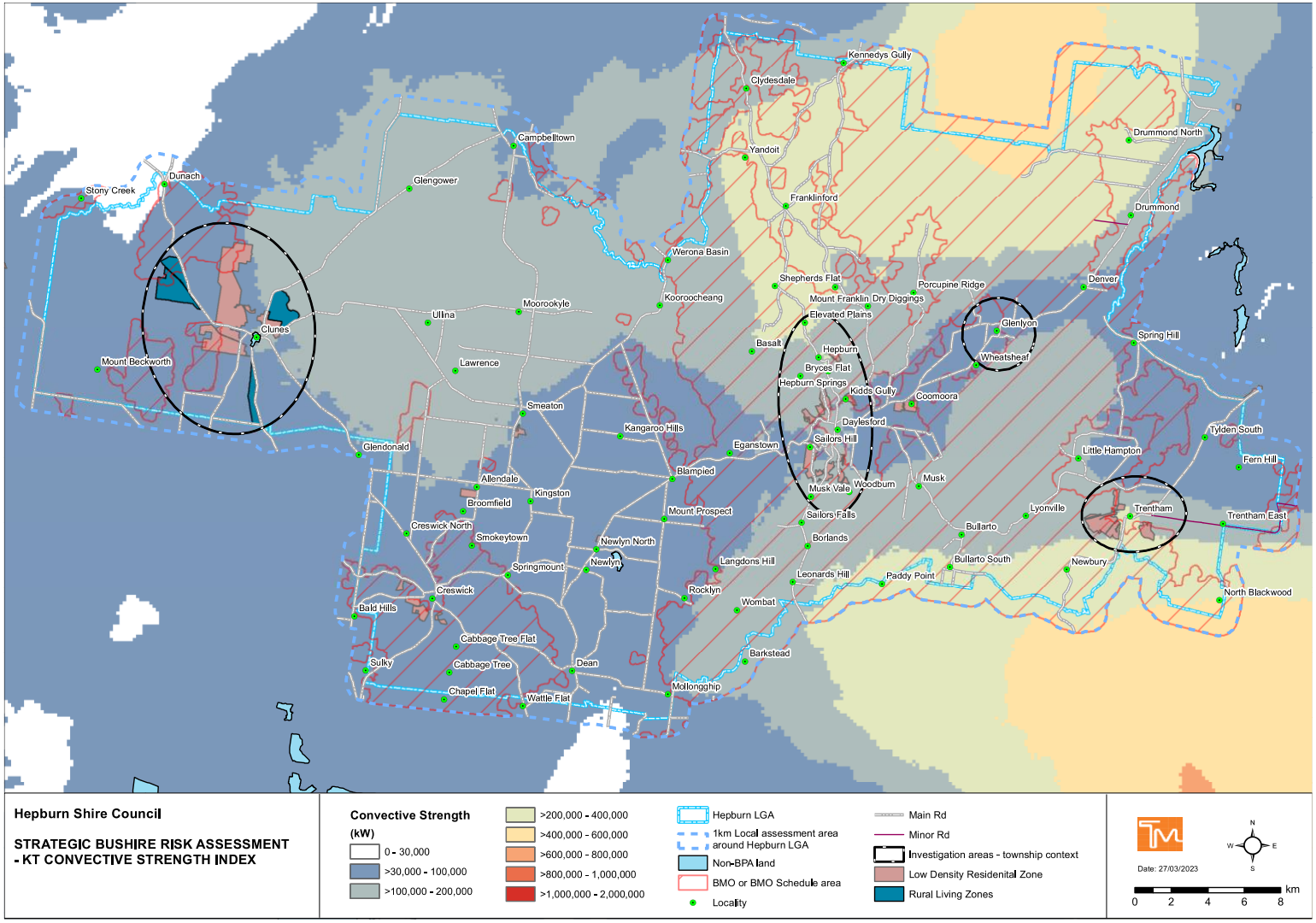
Tolhurst and Chong (2011) found there was a strong correlation between convective strength and houses lost during the 2009 'Black Saturday' bushfires. There is also a strong correlation between convective strength and severe winds that can cause tree fall, create openings in the building fabric such that embers can penetrate and land on combustible surfaces, or, in more extreme situations, cause catastrophic damage such as roofs being blown off or significantly compromised and/or windows blown in (Tolhurst *et al.*, 2017).

Therefore, the development setback distances (defendable space) for buildings from vegetation in the BMO and AS 3959, which are based only on radiant heat flux, do not take into account other forces that may impact on a building and cause it to lose tenability during a bushfire, such as the severe winds and convective energy associated with large convection driven bushfires. The fire behaviour associated with such plumes can be extreme when it is coupled with atmospheric conditions. They are formed by fire-heated air that ascends and condenses due to cooling as it rises, which adds further heat into the system. They are associated with high rates of spread, erratic and unpredictable winds, a deep convective core and intense spotting (Badlan *et al.*, 2021).

Map 26 shows the average computed convective strength (MW) calculated by Tolhurst (2014) using the PHOENIX RapidFire bushfire simulation model, with fire weather inputs based on conditions for 'Ash Wednesday', 16th February 1983[15]. Fire characteristics within 180 m x 180 m cells across the state, were calculated from ignitions across a 2 km statewide grid, which resulted in approximately 50,000 simulated fires. The fire characteristics for each cell were averaged from every occasion it was impacted by a simulated fire.

Convective Strength is based on the total fire intensity within a cell as a function of the amount of fuel available to burn, the topography of the land, severity of the weather conditions and hence, the size and rate of spread of the fire.

[15] Including a Forest Fire Danger Index (FFDI) of 140 (c.f. the FFDI 100 applied in the planning and building system), long term drought conditions (i.e. Drought Factor 10), and no recent fire history (i.e. vegetation in long unburnt state analogous to maximum fuel loads). As the weather data was based on Melbourne Airport records, relative humidity and air temperature were adjusted for elevation (Tolhurst K., *pers. comm.*).



Map 26 - Landscape hazard assessment - Convective strength (after Tolhurst, 2014).

The resultant relative 'Convective risk rating' is shown to be 'Low' (not exceeding 200 MW) for all of the study areas, increasing to Moderate (up to 400 MW) north of Elevated Plains and south of Trentham. No area of the Shire is rated as High or Extreme for convective strength.

The Shire is, therefore, considered a relatively lesser risk location for convective-driven, extreme fire behaviour, although the risk cannot entirely be ruled out given the expansive areas of public and private forest.

16.1.3 Ember storm (drop zone) potential

Tolhurst defines a 'Drop Zone' as an area downwind of the main fire area that is exposed to mass ignition from spotting, leading to firestorm conditions. In the 2009 'Black Saturday' fires, Strathewen, Narbethong, and Marysville were examples of drop zone locations (Tolhurst, 2014).

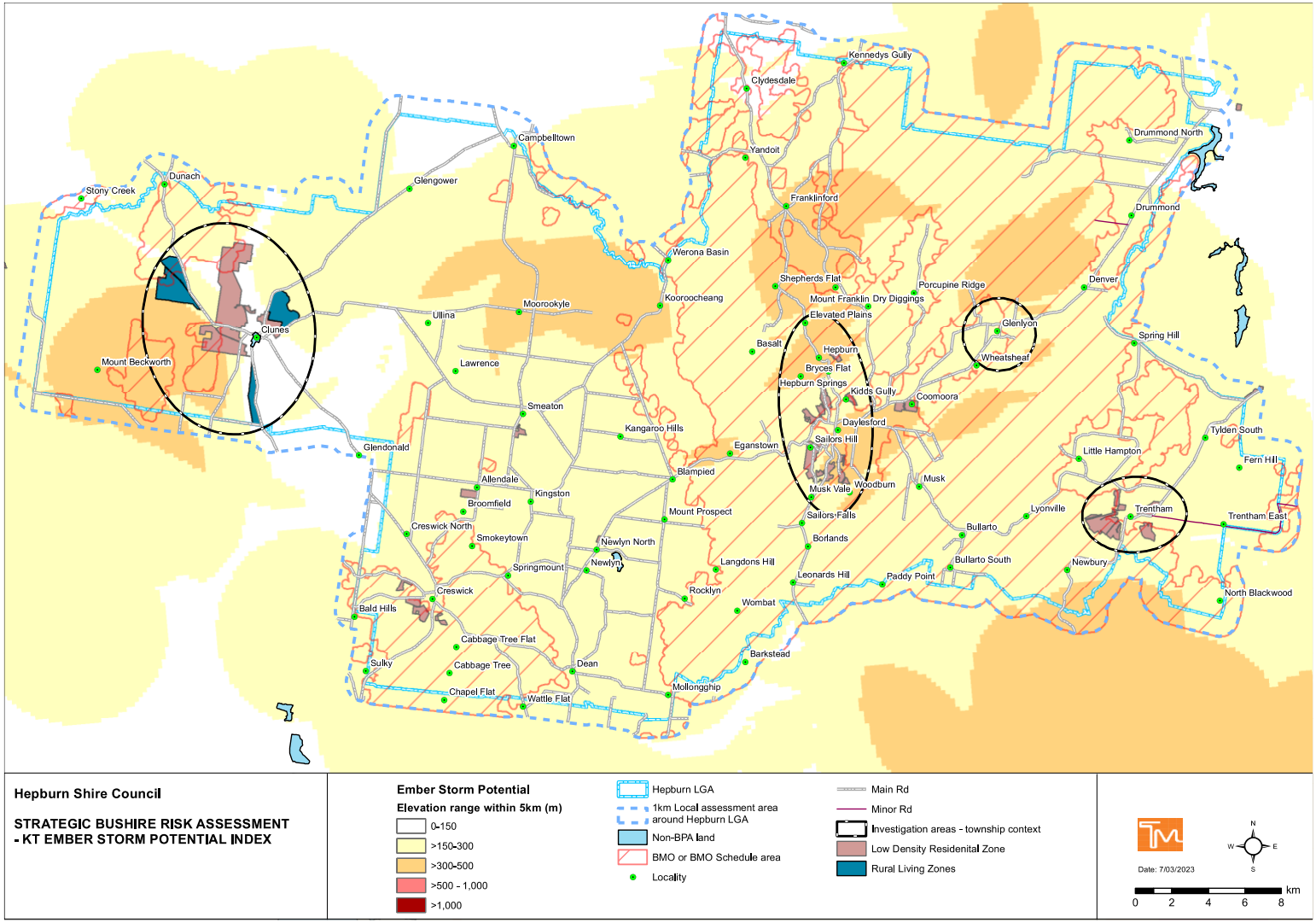
The landscape characteristics associated with a drop zone, and hence potentially extreme fire behaviour, are a plateau or ridge 300 m above and within about 5 km of a site, such that significant quantities of embers and firebrands can 'rain down' into the drop zone, causing mass ignition of spot fires that can coalesce into a firestorm (Tolhurst, 2014). This type of fire behaviour is described by Badlan *et al.* (2021) as 'deep flaming', whereby spot fires from lightning strikes and/or embers coalesce into a sustained, large and intense area of flaming over hundreds of hectares, which can develop into a violent pyroconvective event.

A drop zone is more likely if the higher ground above the site is a forested ridge, since the fire will have accelerated to the top of the ridge, increasing the amount of energy for the ember launch (Tolhurst, 2014). If the ridge or plateau is dominated by shrub, heath or grassland vegetation, it is unlikely that the area downwind will experience a firestorm as these vegetation types do not typically generate significant levels of embers.

Map 27 shows that there is a High risk of an ember storm west of Clunes from a bushfire on Mount Beckworth; and around Blampied, Daylesford / Hepburn Springs, Woodburn and Coomoora.

Study areas with large areas of vegetation with a high proportion of stringybark Eucalypts (e.g. Messmate, Red Stringybark) in the canopy within 400 m to the north, north-west, west or south-west (directions associated with prevailing winds on days of elevated fire danger - see wind analysis presented in Section 6.3.2), are at higher risk of ember attack, as vegetation with a high cover of fine, fibrous barked Eucalypts can pose an extreme bark hazard that is associated with elevated levels of ember attack.

Analysis in Section 7.1 of this report shows stringybarks are a character species in multiple EVCs in the vicinity of all study areas other than Clunes.



Map 27 – Landscape hazard assessment - Ember storm (drop zone) potential (after Tolhurst, 2014).

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