EDEN PARK BUSHFIRE

Erosion Mitigation Plan

A Pre and Post-Bushfire Land Management Guide

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CONTENTS

EXECUTIVE SUMMARY

Eden Park, located within the City of Whittlesea, has been identified as an area at high risk of bushfire. The area is subject to a Wildfire Management Overlay and is rated as being Very High to Extreme Risk on the Victoria Fire Risk Register. The area avoided the Kilmore East – Murrindindi bushfire of 2009 and the last recorded fire in Eden Park was a small grass fire in 1970. However, Eden Park is considered to be vulnerable to the impacts of bushfire due to the area containing a verity of land managers and a fragile landscape.

Eden Park is over 3,300 hectares in size and the lower slopes and plains of the area have previously been cleared for agriculture. The area now consists of a mixture of large scale agricultural properties and rural-residential allotments meaning that there are a large number of different land managers responsible for managing bushfire risk in the area on properties ranging from 0.75 to 200 hectares in size. In addition, there are several biophysical constraints within Eden Park that makes the area vulnerable to erosion including the presence of shallow skeletal soils, areas of steep topography and fine, easily mobilised soils. These factors increase the risk of damage to infrastructure, assets and environmental values in the event of a bushfire when the protective layers on the soil may be removed and the soil structure may be altered, increasing the likelihood and consequence of erosion. This is particularly true if a bushfire is followed by a storm or rain event before the landscape has had an opportunity to recover.

In order to reduce the likelihood and consequence of post-bushfire erosion in Eden Park, the City of Whittlesea has commissioned this report to identify:

1. The areas of Eden Park at highest risk of erosion,
2. Appropriate pre-fire erosion mitigation techniques for the area including a list of drainage and road maintenance considerations,
3. Post-fire erosion mitigation techniques suited to the area,
4. Ways to implement bushfire hazard reduction techniques to minimise erosion risks, and
5. Legislation, roles and responsibilities in relation to erosion and bushfire management.

The City of Whittlesea's aim for this plan is to build the capacity of community and agency stakeholders to understand potential erosion impacts that may occur following bushfire and to respond to this risk by implementing pre and post-bushfire mitigation techniques.

01 PROGRAM RATIONAL

Eden Park has been identified as an area at high risk of bushfire within the City of Whittlesea (CoW) by the Municipal Fire Management Planning Committee. A large portion of Eden Park is subject to a Wildfire Management Overlay and the Victorian Fire Risk Register rates the area as Extreme Risk to Very High Risk. Eden Park contains several biophysical constraints such as areas of steep topography and soils containing erodible properties. Experiences from the 2009 Kilmore East – Murrindindi bushfires (herein referred to as the 2009 Victorian bushfires) demonstrated the impact of soil erosion under similar biophysical and post-fire conditions.

A combination of factors including a variety of land managers, a fragile landscape and infrastructure has created an area that is vulnerable to the impacts of bushfire. The effective land management of Eden Park both pre and post-bushfire will influence how well the land and other ecological values recover following a fire.

Experiences from the 2009 Victorian bushfires have demonstrated that identifying key locations likely to be impacted by erosion following a bushfire will enable a community to be better positioned to respond to the impacts of erosion following a bushfire. It is also considered that a better response would be achieved by creating a list of pre and post-fire erosion treatment methods suitable to local conditions. This also includes evaluating the relative advantages and disadvantages of pre-fire bushfire hazard reduction methods.

This plan aims to build the capacity of community and agency stakeholders to understand potential erosion impacts that may occur following bushfire and how best to be prepared for such impacts should a bushfire occur.

02 PROGRAM BRIEF

The Eden Park Bushfire Erosion Mitigation Plan has been undertaken with the aim of creating an action plan that defines priorities and treatments to be shared with stakeholders to mitigate the impacts of erosion following a bushfire event in Eden Park. The plan will be used to guide planning and recovery efforts to insure a viable and sustainable landscape and to assist municipal staff and other stakeholders prior to a potential bushfire event.

The Eden Park Bushfire Erosion Mitigation Plan forms part of a larger program that consisted of four main components including:

1. Erosion likelihood mapping and modelling;
2. Identification of pre-fire and post-fire erosion mitigation measures including an erosion treatment catalogue;
3. A factsheets series; and
4. Community stakeholder sessions.

2.1 MAPPING AND MODELLING

A series of maps and models have been prepared that identify:

1. Areas that have a likelihood of being subject to erosion following a bushfire event;
2. Infrastructure and natural assets at risk of erosion following bushfire; and
3. Biodiversity values within Eden Park.

The erosion likelihood model considers factors such as the influence that fire has on soil, hillslope morphology and areas in the landscape that have an increased likelihood on high severity fire. The model is categorised into areas that have a high, medium and low likelihood of erosion following a bushfire event.

An asset risk map has been produced to identify infrastructure and natural assets most at risk of erosion following a bushfire event. Asset risk has been assigned by undertaking a risk assessment using the erosion likelihood model.

A biodiversity map has been produced that categorises core habitat values for significant flora and fauna. Core habitat values and significant roadside trees were identified and assessed in the field.

A Technical Note supporting the mapping and modelling program can be viewed in Appendix B.

2.2 BUSHFIRE EROSION MITIGATION PLAN

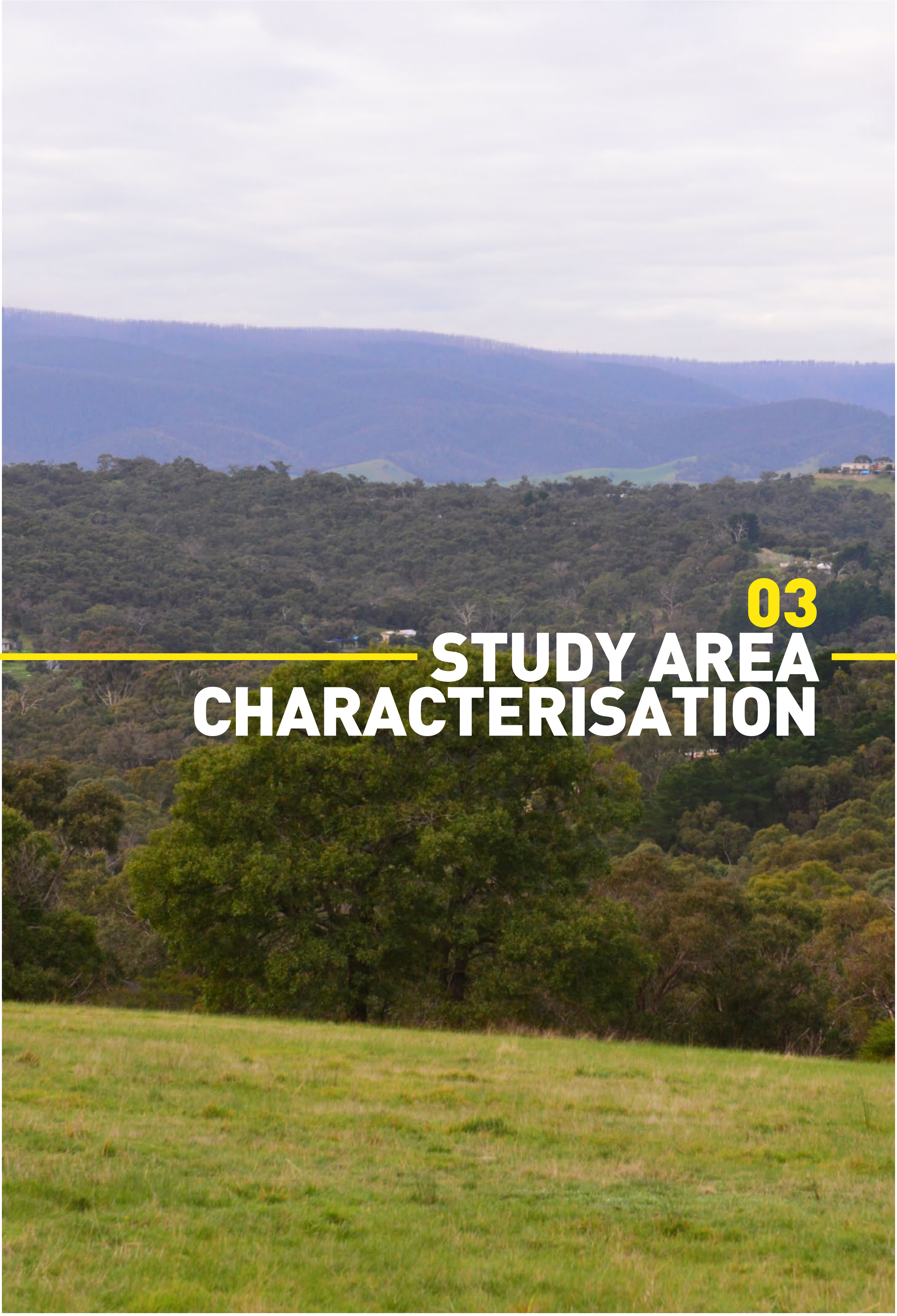
The bushfire erosion mitigation plan characterises the environmental condition of Eden Park and provides a description of the impact that bushfire may have on environmental features. The plan also details treatments for pre-bushfire hazard reduction methods in terms of the effects on erosion, and post-bushfire erosion mitigation measures including a catalogue of treatment techniques. The plan is intended to be shared with community and agency stakeholders to prepare for the risk of erosion as a result of bushfire in Eden Park.

2.3 FACTSHEETS

Three factsheets have been prepared to accompany the Bushfire Erosion Mitigation Plan. The factsheets provide detailed information on key erosion mitigation treatments in an accessible format to be used by community stakeholders.

2.4 COMMUNITY STAKEHOLDER SESSIONS

Two community stakeholder sessions were undertaken to engage the community in the planning process and to create greater awareness amongst the community of erosion processes in a post-



03 STUDY AREA CHARACTERISATION

3.1 EDEN PARK PROFILE

Eden Park is located within the CoW in Melbourne's north, approximately 45 kilometres from the central business district (refer to Figure 1). With the exception of three council owned properties, Eden Park is made up of privately owned land ranging in size from 0.75 hectares to over 200 hectares. Eden Park is made up of a mixture of land uses predominately made up of livestock grazing in the northern and south-eastern parts of the study area. This includes the Melbourne Polytechnic training centre 'Northern Lodge' which operates as an equine and agricultural training centre in the south-eastern part of the study area. Eden Park also contains a large portion of rural – residential allotments some of which do not contain residential dwellings.

Eden Park is characterised by a north – south trending mountain range that reaches elevations of 410 metres and is surrounded by undulating hills to the north and slopes and plains in other directions. The central range is vegetated with remnant eucalypt sclerophyll forest which provides significant habitat to several Commonwealth and Victorian threatened flora and fauna species. Eden Park forms the headwaters of Barbers Creek which flows into the Plenty River south of Eden Park at Yan Yean. Plate 1 provides an overview of the study area.

Plate 1 Eden Park facing north from Plenty Valley Rise

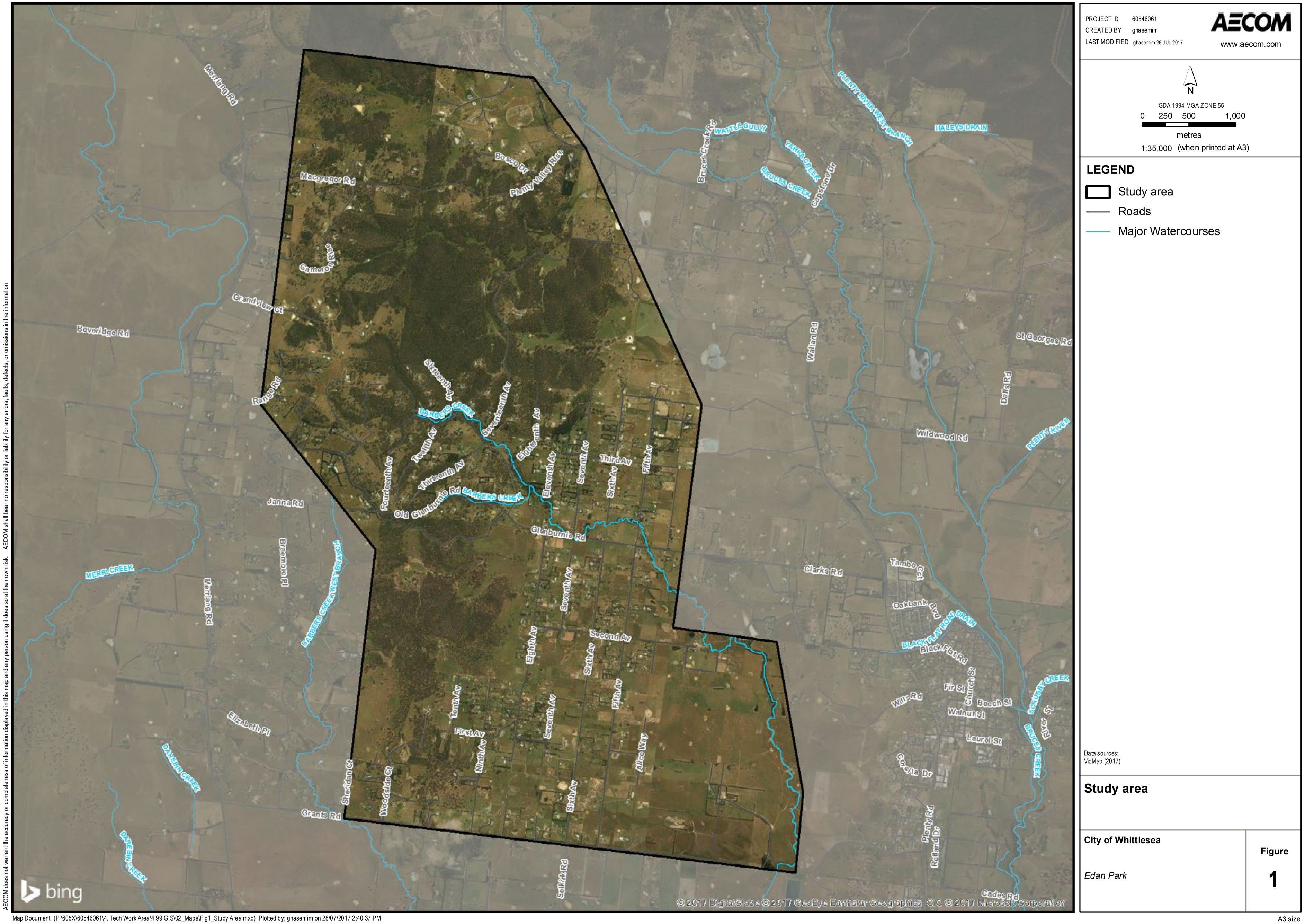


Figure 1 Eden Park study area

3.2 FIRE HISTORY

The CoW Municipal Fire Management Plan provides a list of recorded significant bushfires that have affected the municipality. A summary of recorded fires that have affected Eden Park is provided in Table 1. In recent history Eden Park has been subject to grass fires leaving the elevated bushland areas of Eden Park un-burnt for a significant period of time. Although the Municipal Fire Management Plan indicates that fires within the CoW travel from the northwest to southeast under strong northerly winds, local consultation has indicated that fires originating south of the municipality and travelling north under a southerly change should not be discounted as occurring. This has been the direction of travel for several recent local bushfires including the 2009 Black Saturday fires.

3.3 BIODIVERSITY

3.3.1 VEGETATION

Eden Park is located within the Highland Southern Fall bioregion which covers the southern slopes of the Victorian uplands east of Melbourne and is characterised by a variable rainfall and vegetation types across its range. Geology within the bioregion generally consists of Ordovician inter-bedded siltstones and sandstones similar to that of Eden Park. Eden Park is located adjacently east of the Victorian Volcanic Plain which is characterised by open plains vegetated with woodlands and treeless grasslands dominated by grassy and herb-rich understories.

Areas of remnant vegetation within Eden Park are generally restricted to elevated areas and adjoining slopes and plains. Vegetation within these elevated areas is generally consistent with the Grassy Dry Forest Ecological Vegetation Class (EVC). This vegetation type is characterised by a low to medium height open forest to 20 metres. The understory usually consists of a sparse shrub layer of medium height and the understory is species rich consisting of drought tolerant grasses and herbs. Canopy species generally consists of Red Stringybark Eucalyptus macrorhyncha, Long-leaved box Eucalyptus goniocalyx and Red Box Eucalyptus polyanthemos.

The quality of remnant vegetation across Eden Park varies subject to the type and intensity of past landuses. A map provided in Figure 2 categorises areas of remnant vegetation within Eden Park into broad habitat qualities.

Other less common vegetation communities that occur within Eden Park include:

- Valley Grassy Forest (EVC 47);
- Grassy Dry Forest (EVC 22);
- Swampy Riparian Complex (EVC 126);
- Creekline Herb-rich Woodland (EVC 164); and
- Grassy Woodland (EVC 175).

Table 1 Bushfire in Eden Park (CoW 2012)

YEAR	LOCATION AND DESCRIPTION
Feb 1851	**Mt Disappointment to Bundoora** Mt Disappointment fire jumped into Whittlesea and all the way to Bundoora. Miles of fencing lost, 20,000 bushels of wheat lost, cattle lost and 100 persons made homeless and penniless. The McLelland family of Arthurs Creek suffered greatly, with mother and five children perishing.
Feb 1926	**Mt Disappointment to Kinglake** Fire originating in Wandong burnt out most of Mt Disappointment and then jumped into Bruce's Creek, Humevale, Strathewen and Kinglake. No lives lost but many houses burnt.
Jan/Feb 1968	**Donnybrook/Woodstock** Multiple fires in three consecutive weeks at Donnybrook Road, Grants Road and Merriang Road. Merriang Road fire damaged Woodstock hall and church.
March 1970	**Eden Park** Grassfire at Eden Park, 100 acres burn out, two houses damaged, stopped at Grants Road.

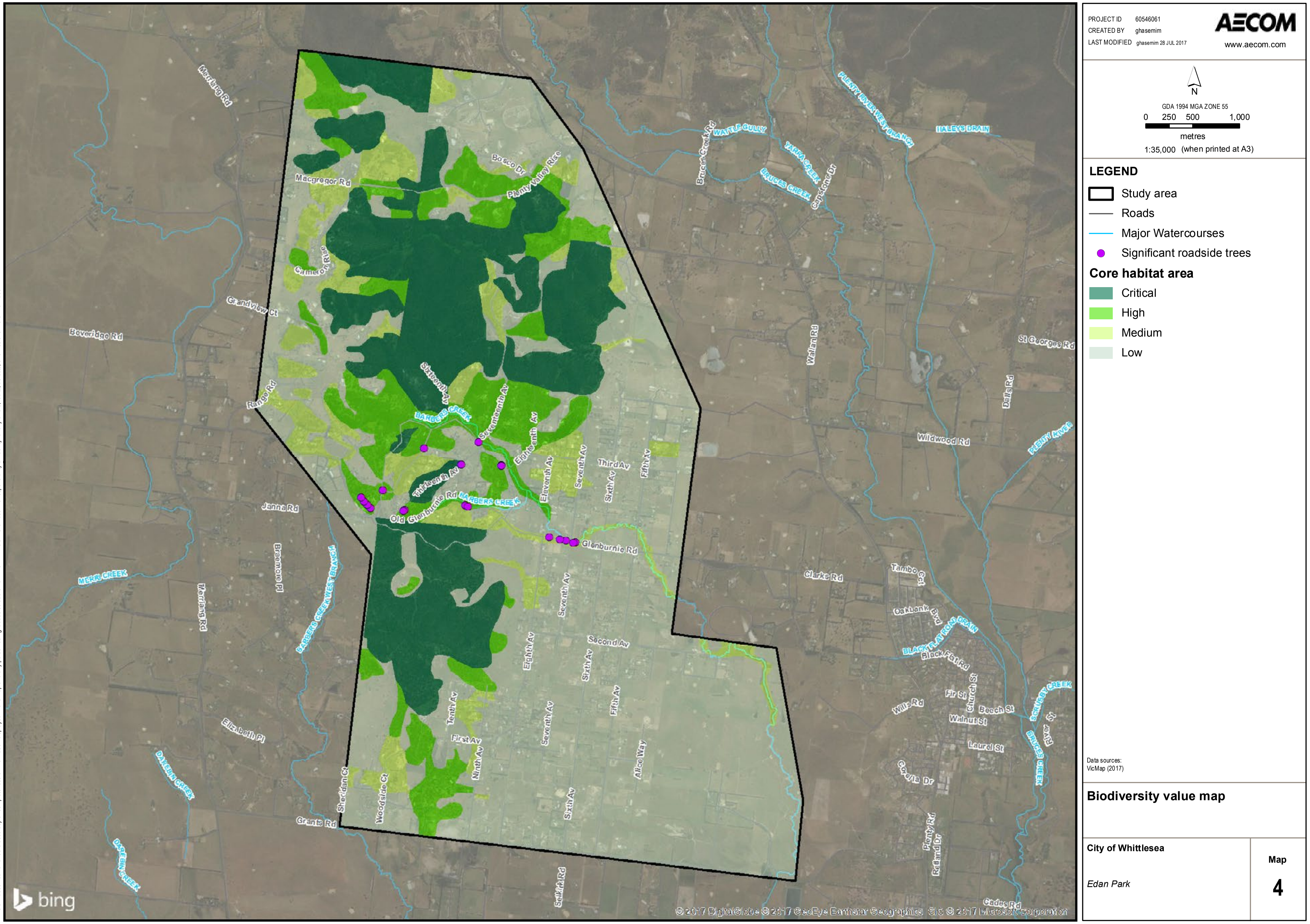


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Figure 2 Vegetation and habitat quality map

3.3.2 FLORA AND FAUNA

Forested areas within Eden Park provide an important fauna habitat refuge for mammals and birds. These forested areas are important in the context of the Highland Southern Fall bioregion as it is one of the last remaining privately owned intact woodland areas of a large size within the bioregion. Many species are fire adapted and rely on fire as part of their life cycle (for regeneration) or to modify habitat that supports different animals. This includes creating hollow and providing a mosaic of burnt and unburnt areas. Bushland within Eden Park provides habitat for the Victorian Flora and Fauna Guarantee Act 1988 (FFG Act) listed Bush-tailed Phascogale Phascogale tapoatafa of which there are recent and historical records in the central part of the study area.

Bush-tailed Phascogale is a small carnivorous marsupial that is distinguished by its black bushy tail, grey body and relatively large ears. The Brush-tailed Phascogale lives in low density populations within larger bushland areas. They prefer dry forests which have a relatively open understorey that contains rough-barked tree species such as Long-leaved Box and Red Stringybark which are found throughout Eden Park. They are dependent on tree hollows for breeding and shelter, particularly from predators. Fallen logs and timber also provide an important habitat refuge for mammals and reptiles. A map provided in Figure 2 categorises areas of remnant vegetation within Eden Park into broad habitat qualities for fauna including the Brush-tailed Phascogale.

Eden Park also contains suitable habitat for a range of significant flora species. This includes several herb and graminoid species which have been recently recorded in the south-eastern part of the study area in former grassy woodland vegetation types. This includes the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) and FFG Act listed Matted Flax-lily Dianella amoena and Austral Crane's-bill Geranium solanderi var. solanderi s.s. Matted Flax-lily is a perennial, tufted, mat-forming lily which has small blue-violet flowers from October to April. Flowers are replaced by purple-blue berries. Austral Crane's-bill is a small herb which contains a small pink flower in spring.

3.3.3 ROADSIDE HABITAT

Roadside vegetation provides an important habitat source for native fauna within Eden Park in particular the Brush-tailed Phascogale. A roadside may link two or more areas of bushland on private land and preform the function of a wildlife corridor. A wildlife corridor network acts as a route for animals and birds to move between vegetated areas (e.g. possums and other arboreal mammals move between trees via overlapping canopies or by gliding between trees). Threes, shrubs and ground covers and other habitat components contribute to corridors. Roadsides also contain hollow baring trees and often large hollow logs used as habitat refuge (see Plate 2 and Plate 3). The City of Whittlesea has undertaken a roadside conservation value mapping program that identifies roadsides of high conservation value within Eden Park (see Figure 3). Figure 3 also identifies the location of significant roadside habitat trees.

Plate 2 Significant roadside habitat tree (White 2017)

Plate 3 Mammal habitat in a roadside tree (White 2017)

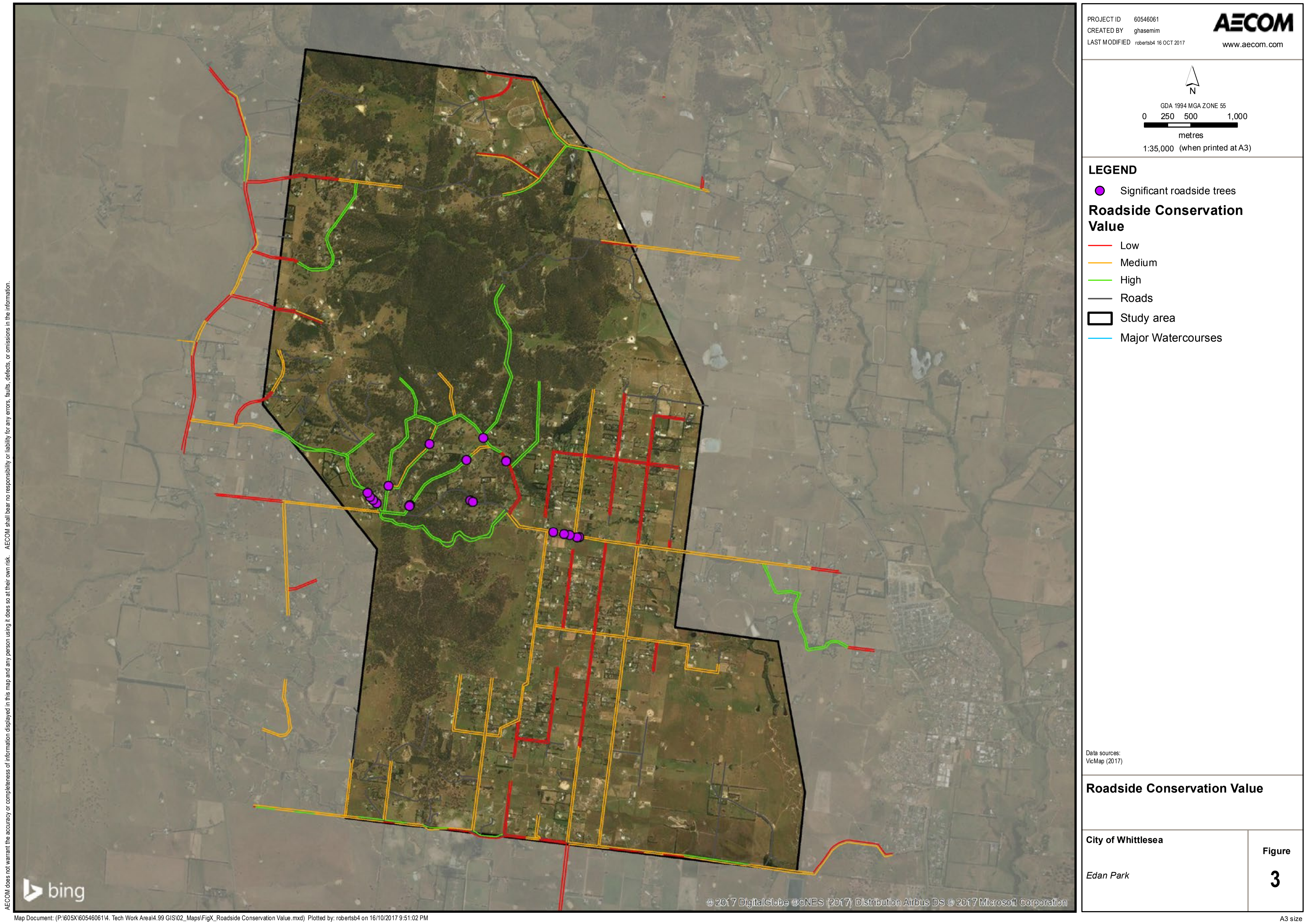


Figure 3 Roadside conservation value map

3.4 WATERWAYS

The elevated regions of Eden Park, north of Glenburnie Road form the headwaters of Barbers Creek. Barbers Creek is an ephemeral waterway that flows through the central and eastern parts of Eden Park in a south-eastern direction before joining Plenty River at Yan Yean. The upper reaches of Barbers Creek contain remnant mature riparian vegetation before it reaches Glenburnie Road. South of this location Barbers Creek has been subject to significant gully erosion and has recently been the focus of riparian revegetation and cattle exclusion activities. No significant flora and fauna species have been recorded within or immediately adjacent to Barbers Creek in the past 20 years.

Merri Creek is located to the west of Eden Park and forms the western catchment of the study area north of Jenna Road. The northern reaches of Merri Creek are significant in the context of several threatened flora and fauna species as it provides vestiges of remaining habitat. This includes habitat for the EPBC Act listed and FFG Act listed Growling Grass Frog Litoria raniformis immediately west of the study area.

Bruces Creek and Plenty River occur to the east of Eden Park and form the eastern catchment of the study area. These waterways also contain significant aquatic and riparian vegetation which provides important fauna habitat.

3.5 GEOLOGY

Eden Park is characterised by a north - south trending mountain range (elev. 410m asl.) forming part of the southern foothills of the Great Dividing Range. Eden Park falls within the Melbourne Zone structural formation which is characterised by sedimentary bedrock of deep marine origin deposited in the Silurian and Devonian periods (354-441 million years ago (mya)). These Palaeozoic rocks are steeply dipping sandstones and siltstones which have been subject to intensive folding and faulting during a structural deformation event known as the Tabberabberan orogeny (about 380 mya). Several road cuttings on the Wallan Road provide examples of the steeply dipping bedrock. It was this orogenic event which resulted in the development of the north – south trending mountain range in Eden Park. Hundreds of millions of years of erosional processes have denuded the Eden Park landscape to leave hillslopes with steep angles and deeply dissected gully's. Many of the elevated slopes have been left with shallow skeletal soils whilst the surrounding plains, terraces and fans on the perimeter of Eden Park contain a relatively deep deposit of Quaternary colluvium and alluvium.

Eden Park is located on the eastern edge of the Newer Volcanics from the Pliocene (2-5 mya) which consist of extensive basalt plains and valleys interspersed with volcano formations.

3.6 SOIL

Soils that occur within Eden Park are largely a product of the inherent properties from the underlying Silurian and Devonian sandstones and siltstones that are common throughout north-east Melbourne. These soils generally have three obvious horizons: a pale-coloured A horizon, overlying a yellow, brown or even red B horizon, which grades into a C horizon or zone of weathering parent material. The A horizon generally has a higher percentage of sand sized particles and the B horizon contains a higher percentage of clay. Soils with such a textural contrast between the A and B horizon are referred to as duplex soils.

The Victorian soil type mapping program has identified three broad soil types within Eden Park and have assigned a moderate reliability rating for the quality and relevance of originating source of the soil data. The soil types have been classified using the Australian Soil Classification system. The three soil types mapped as occurring within Eden Park and their percentage of total area include:

- Sodosol (55.9%);
- Dermosol (30.7%); and
- Chromosol (13.3%).

Sodosol: Soils with a clear or abrupt textural B horizon and in which the major part of the upper 0.2 m of the B2 horizon (or the major part of the entire B2 horizon if it is less than 0.2m thick) is sodic and not strongly acid (CSIRO 2016).

Dermosol: Soils with structured B2 horizons and lacking strong texture contrast between A and B horizons (CSIRO 2016).

Chromosol: Soils with a clear or abrupt textural B horizon and in which the major part of the upper 0.2 m of the B2 horizon (or the major part of the entire B2 horizon if it is less than 0.2 m thick) is not sodic and not strongly acid (CSIRO 2016).

Soils within Eden Park are susceptible to various types of erosion under existing condition such as tunnel erosion and gully erosion. Sodosol's are part of a group of soils termed 'dispersive soils or dispersive clays' due to the presence of a sodic B horizon within the soil profile. This process occurs where clays with increased levels of sodium ions spontaneously disperse upon wetting. The presence of a sodic B horizon can lead to gully widening and deepening and tunnel erosion when surface runoff is provided a pathway to the soil B horizon. Dispersive soils are found throughout south-eastern Australia. Examples of existing gully and tunnel erosion observed within Eden Park are shown in Plate 4 and Plate 5.

Approximately 82% of tunnelling in Victoria is reported to occur on duplex soils including Sodosols and Chromosols which are described above as occurring within Eden Park (DJTER 2017). Duplex soils are a group of soils which can include dispersive soils which have a district textural contrast between the A and B horizon which often includes a clay B horizon (see Figure 4).

Tunnel erosion has been recorded in all Australian states and is often associated with sheet erosion due to over grazing by stock and vermin (Boucher 1990). This is an important cause in the context of post-bushfire management as similar groundcover conditions occur following a severe burn. Bare patches of ground are subjected to the mechanical action of rain splash, which gives a crusted appearance to the often poorly-structured, hard-setting A horizon, reducing its permeability and producing increased surface runoff (Boucher 1990). These factors are likely to be exasperated by bushfire influences on soil such as soil glazing which creates water repellancy and increased energy of surface water run-off.

Plate 4 Dispersive clay leading to gully erosion

Plate 5 Gully head erosion after fire

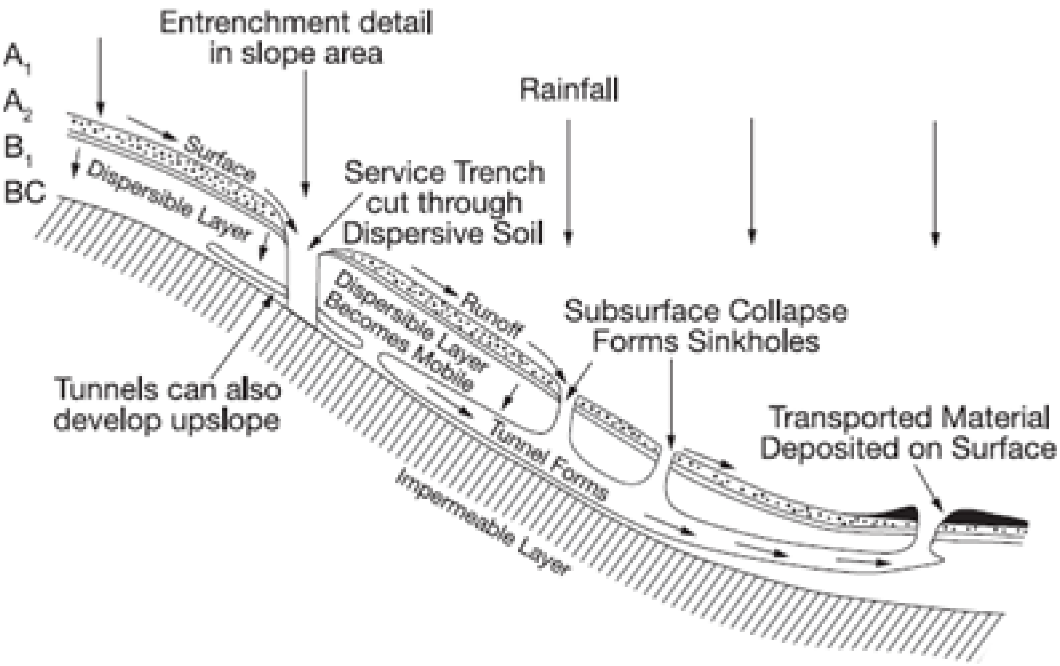


Figure 4 Formation of tunnel erosion (Boucher 1990)

04
IMPACTS OF FIRE

4.1 FIRE IMPACTS ON SOIL AND EROSION

The occurrence of a bushfire does not change the erosive forces on soil; however, it has the ability to make a site more vulnerable to the same forces by reducing the soil protective layers, altering the soil structure and increasing overland flow and volume (Scott et al. 2009). Subject to burn severity, bushfire has the ability to reduce soil cohesion and expose bare soil to erosive forces such as rain splash and overland flow. A process whereby post-fire soils develop water repellency within the upper soil profile can increase the energy of overland water flow. This effect is accelerated by a lack of ground cover to intercept overland flow. Other factors including slope morphology (slope grade, length, divergent and convergent slopes) and the presence of erodible soil types as discussed in Section 3.6 also have an effect.

Organic matter plays an important role in soil stabilisation by aiding soil aggregates to form via particle cohesion. Surface organic matter on the forest floor or in an agricultural setting provides protection to the soil surface from erosive forces including rain splash impact (see Plate 6). Organic litter has the added benefit of adding roughness to the soil surface, thus intercepting overland flow (increasing roughness co-efficient). Vegetative root systems in a forest environment also play an important role in aiding soil stability. It has been identified that soils that have been exposed to high temperature fire can result in organic material both on the soil surface and within the upper soil profile being combusted and turning to ash. This process removes an important protective and cohesive component, making soils vulnerable to erosive forces.

Plate 6 Soil erosion resulting from rain splash impact (Arenamontanus)

High intensity fires have the ability to produce water repellency in soils (soil glazing) effecting between 20 – 50mm of the upper soil profile (Scott et al. 2009). This process has the ability to reduce the infiltration capacity of soil, thus increasing the quantity and energy of overland water flow. Additionally, detachment of soil and ash particles can block soil pores and seal the soil surface which increases the impact of sheet flow on bare soils.

Increases in overland flow leads to water moving across slopes without concentrating, a process known as inter-rill erosion (See Plate 7 where inter-rill erosion is leading to rill erosion). Inter-rill erosion generally involves detachment of soil particles by raindrop impact and transported via sheetwash, which is a more spatially uniform flow (Smith et al. 2011). Convex slopes that become steeper down slope will accelerate flowing water and therefore increase erosion.

When a hill slope forms into a concave shape at the base of the slope, flow concentrates and small rills will form. Rill erosion involves the formation of small channels across the soil surface where water flows preferentially (Smith et al. 2011). Water's erosive power increases as depth increases, therefore, where concave slopes occur and converge, rill erosion rates are greater and channel erosion can form (Scott et al. 2009) (see Plate 8). Recent studies indicate that rill and channel erosion can account for up to 80 percent of measured post-fire sediment yields (Moody and Martin 2001).

Plate 7 Sheet erosion post-fire

Plate 8 **Channel formation at slope convergence (rill formed soon after a fire with slopes beginning to revegetate)**

Plate 9 **Landscape susceptible to erosion post fire**

4.2 FIRE IMPACTS ON ENVIRONMENTAL FEATURES

4.2.1 ECOLOGY

Fire is a natural part of the Australian landscape and has largely shaped the richness, composition, distribution and adaptations of the organisms and ecosystems that are present today (Cheal 2010). Australian flora and fauna species have evolved to use the environmental conditions that fire creates to trigger key biological stages. The interaction of biotic and abiotic factors may be altered by the presence or absence of fire (Eldridge and Green 1994). Many species lack the ability to regenerate without the presence of fire and others are affected by infrequent, repeated or too short an interval between fires (Cheal 2010).

A program undertaken by DELWP identified that the maximum Tolerable Fire Interval (TFI) for native vegetation within Eden Park is generally 45 years. This refers to the maximum period of time in which fire would most suitably be absent from Eden Park for native vegetation communities and their constituent flora and fauna to succeed and function sustainably. In general it is also identified that the minimum tolerable fire interval is 15 years for high severity fires and 10 years for low severity fires. This includes the minimum period of time in which fire would most suitably occur within native vegetation types present in Eden Park to not change vegetation composition. The EVCs that are present in the Eden Park area and their respective fire classification and thresholds are provided in Table 2.

Table 2 Eden Park ecological vegetation communities and land uses

ECOLOGICAL VEGETATION CLASS (EVC)	VEGETATION ASSOCIATION / CLASSIFICATION[1]	VEGETATION TYPE1	TOLERABLE FIRE INTERVAL (TFI)		
			MAX TFI	MIN TFI FOR HIGH SEVERITY FIRES	MIN TFI FOR LOW SEVERITY, MOSAIC FIRES
Grassy Dry Forest (EVC 22)	Woodland	Open Woodland	45 yrs	15 yrs	10 yrs
Valley Grassy Forest (EVC 47)	Woodland	Open Woodland	45 yrs	15 yrs	10 yrs
Swampy Riparian Complex (EVC 126)	Woodland	Low Woodland	150 yrs	30 yrs	30 yrs
Creekline Herb-rich Woodland (EVC 164)	Woodland	Low Woodland	-	30 yrs	10 yrs
Grassy Woodland (EVC 175)	Woodland	Open Woodland	45 yrs	15 yrs	10 yrs
Pastoral land	Grassland	Dense sown pasture	n/a		
Exclusion - Low Threat vegetation	Maintained lawns, golf courses, public reserves, parklands, orchards, commercial nurseries, etc.		n/a		

1 Vegetation association / classification and type determined in accordance with Australian Standard 3959: Construction of buildings in bushfire-prone areas (incorporating Amendment Nos 1, 2 and 3), 2009. The Fire Danger Index is 100 (Victoria – general, excluding alpine areas).

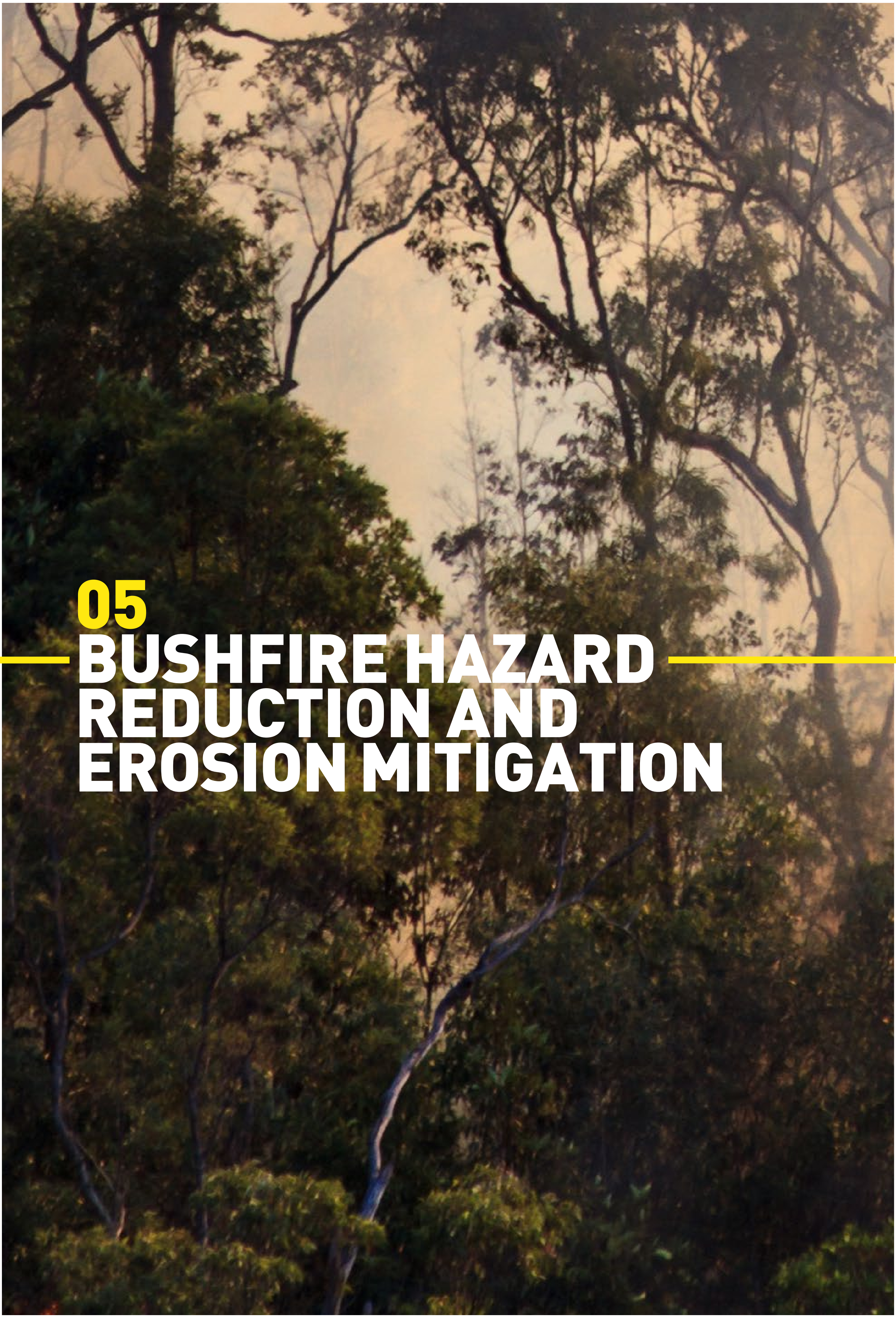
4.2.2 WATERWAYS

Intense bushfires can have significant impacts on waterways and associated infrastructure in a number of ways. The effects that fire has on soil described in Section 4.1 leads to increased yields of sediment loss from slopes in the upper catchments and fire effected farmland on lower slopes and plains. The most frequently reported impacts from sediment loss relate to suspended sediment and nutrients in waterways (Smith et al. 2011) (see Plate 10). Sediment yields are reported to be greatest in the first post-fire year after which point vegetation cover has re-established throughout the catchment. It is reported that suspended sediment yields vary from 0.017 to 3.3 t ha-1 which is 1.3 to 1,459 times the annual average yield of unburnt areas (Smith et al. 2011). Sediment loads vary based on burn extent, severity and post-fire weather patterns. The impact of increased sediment loads in waterways can impact waterway composition including increased nutrient loads and critically low dissolved oxygen. This in turn has a direct and in-direct impact on aquatic fauna by limiting food sources, physical habitat resulting in reduced population densities, changed species compositions, mortalities and altered migration patterns (Smith et al. 2011).

Burning patterns of riparian vegetation can often be variable given the increased moisture in these parts of the landscape. However, when riparian vegetation does burn, it can have implications on water quality and the structural integrity of stream banks. Streamside vegetation acts as a sediment trap or buffer by slowing the flow of water and limiting the delivery of sediment to waterways. Riparian vegetation also plays an important role in stabilising stream banks against scour erosion. This is particularly the case in areas such as Eden Park which are subject to significant gully and channel erosion.

Plate 10 Turbid water downstream of a fire effected area

Plate 11 Downstream impacts from increased flows, debris and sediment post-fire



05 BUSHFIRE HAZARD REDUCTION AND EROSION MITIGATION

The impacts of unplanned bushfire on people, infrastructure, assets and the environment can be significant and have a lasting effect. For this reason it is important to undertake preventative actions to reduce the likelihood of large-scale bushfire occurring as well as attempt to reduce the consequences if an unplanned bushfire were to occur. Mitigation measures to reduce bushfire hazards may include a variety of methods involving planned burning, mechanical hazard reduction or a combination of these methods. Whilst these activities may be effective at reducing bushfire hazard, they also have the potential to result in an increased risk of erosion. Thus the need to reduce the bushfire risk of an area to reduce erosion risk, along with the risk to people and property, needs to also consider the potential for these methods to increase erosion through their implementation.

5.1 BUSHFIRE HAZARD REDUCTION

Mitigation measures to reduce the likelihood and / or severity of a large-scale bushfire can be multiple and may include various methods associated with planned burning, mechanical hazard reduction or a combination of these methods. Ideally, the method selected for a site will be influenced by the site locality and will consider the recommended fire interval for the ecological community present as well as the ecology of threatened species that may be present and the location of assets, waterways and heritage places across the site.

The purpose of this plan is not to provide a Bushfire Management Plan which uses a risk-based approach to inform planning to reduce bushfire hazards at Eden Park and to identify the most appropriate bushfire hazard reduction methods for areas within the site. The City of Whittlesea has developed a risk-based Municipal Fire Management Plan (MFMP) using the principles outlined in the Integrated Fire Management Plan Framework and Guide, and the Guidelines for Municipal Fire Management Planning in Part 6A of the Emergency Management Manual Victoria. The MFMP fulfils Section 55A of the Victoria Country Fire Authority Act 1958 (CFA Act). This is the primary document for identification of prevention, preparedness, response and recovery actions in relation to bushfire in the City of Whittlesea area. The MFMP refers to the following plans and programs for obtaining additional direction relating to bushfire planning which are relevant to erosion mitigation:

- Northern and Western Metropolitan Regional Strategic Fire Management Plan 2011;
- Country Fire Authority (CFA) Bushfire Response Plans;
- CFA Bushfire Preparedness Program 2;
- DELWP Fire Operations Plan;
- SP Ausnet Bushfire Mitigation Transmission Network Management Plan 2011 – 12 (Draft);
- City of Whittlesea Overhead Electrical Line Clearance Plan;
- Vic Roads – Roadside Management Strategy; and
- Vic Track's Annual Fire Management Program.

These documents typically identify the location and the preferred intervals of particular bushfire hazard reduction activities are intended to occur within the Eden Park area. This report has not been prepared for this purpose.

5.2 REDUCING THE IMPACT OF BUSHFIRE HAZARD REDUCTION

In order to determine what the most appropriate bushfire hazard reduction method is for an area, the characteristics of the area need to be mapped, and the sensitivity of the built assets, ecological communities, flora, fauna, heritage sites, wetlands and waterways to fire need to be determined.

In this way, planning for bushfire hazard reduction can consider:

- The most appropriate TFI for the ecological community which will be the subject of any recommended planned burns;
- The requirement to implement a planned burn for ecological purposes (i.e.: to maintain the structure and diversity of an ecosystem and to encourage regeneration and reproduction of particular flora species);
- The most effective way to introduce heterogeneity to a landscape or create a mosaic of vegetation stages and age classes to reduce the potential rate of spread of a bushfire and to encourage flora growth at various stages to improve recovery potential post-fire;
- The location of threatened flora and fauna species so as to protect these locations during planned burns or mechanical hazard reduction and to ensure the ecology of the species in question is understood to reduce impacts to these species;
- The location of places that are of historic, indigenous and natural heritage value which are potentially sensitive to fire need to be identified to protect these areas during bushfire hazard reduction works; and
- The location of waterways, wetlands or other waterbodies which will require protection during bushfire hazard reduction works and which may require protection from erosion which may result from these works.

Considering these aspects will reduce potential negative impacts on the environment from the implementation of bushfire hazard reduction methods. Importantly, the considerations of these aspects can actually improve environmental conditions if the hazard reduction method is selected based on the local conditions and values.

5.3 EROSION AND BUSHFIRE HAZARD REDUCTION METHODS

Bushfire hazard reduction methods can be broadly separated into two categories:

a. **Planned burning -** the planned application of fire, either on the ground or from the air, under prescribed weather conditions and within defined boundaries, to modify fuel characteristics including overall fuel hazard, continuity and arrangement.

b. **Mechanical hazard reduction -** the planned management of fuel by mechanical practices to reduce the availability of fuel through modifying the amount of material available or through complete removal without requiring burning.

A description of these methods in relation to the impact they may have on the environment in general, and on erosion in particular, are provided in the following sections.

5.3.1 PLANNED BURNING

Planned burning is the deliberate introduction of fire into the landscape to modify fuel hazard, bushfire hazard and damage potential. It is considered to be the most effective method for managing fuel hazard over large areas. A key consideration in planning and conducting planned burns, is the fire regime most appropriate for the vegetation / ecological community and species present on the site. Planned burns can have positive impacts on ecosystems and native species through the creation of structural diversity and a mosaic of fuel ages.

The advantages of this method are that:

- Controlled fires are low intensity;
- Fuel loads are reduced;
- Connectivity between areas of older fuels (i.e. areas that have not been burnt for a long time) is reduced;
- A mosaic of vegetation with different fuel age classes is created (i.e.: landscape heterogeneity);
- Structural diversity of vegetation is encouraged;
- Regeneration of some native plant species is encouraged; and
- Vegetation cover is retained.

The disadvantages of this method are that:

- Fires can escape and become bushfires;
- Smoke and air pollution can be produced;
- May cause some areas of erosion as organic matter is removed through burning and soil surface may be exposed; and
- Soil repellency is unlikely to result from low intensity planned burns but this is still possible.

5.3.1.1 Ecological planned burning

Ecological planned burning is a form of planned burning that is used for stimulating regeneration, influencing vegetation community structure and composition, reducing weed populations and creating landscape heterogeneity. Although it is not primarily used for hazard reduction, fuel loads may be reduced through this method. The type of EVC should be determined along with the appropriate fire regime for the EVC, the time since the last fire, and the location of areas containing threatened flora species, fauna species and heritage values so that these areas can be protected. The same advantages and disadvantages apply for ecological planned burning.

5.3.1.2 Perimeter burning

Perimeter burning, or edge burning, is when a strip is burnt surrounding an area as a means to protect the area (i.e. a property) or to strengthen buffer areas and reduce the chance of fire escaping in a planned burn. The advantages and disadvantages of perimeter burning are less than those associated with planned burning in general as only a small area is burnt using this method.

5.3.1.3 Elevated fuel burns

Burning to remove elevated fuels is another form of planned burning whereby fire is applied to the base of trees with stringy / ribbon bark in order to remove the bark fuels. This assists with preventing fires from travelling up from the ground to the crown of trees using the bark (known as laddering). This method may be used before a planned burn to reduce the risk of a planned burn escaping. It may also be used when it is not appropriate to use planned burns across a whole area. The limited extent of this type of planned burning means that the disadvantages of the method are similarly limited. In terms of advantages, whilst reducing fuels, vegetation cover is retained and organic matter is retained thus reducing erosion risks.

5.3.2 MECHANICAL HAZARD REDUCTION

Mechanical hazard reduction refers to the methods used to reduce fuel loads or the risk of bushfire without using planned burning. There are a range of options available some of which are described in the following sections. Some of these methods result in an exposed soil surface which makes the area vulnerable to erosion. To minimise soil erosion, at least 75% of ground cover should be retained and this method should be avoided in isolated areas of vegetation less than 1 hectare in size and for strips of vegetation less than 20m wide associated with linear features such as roads, rail, river or stream corridors.

5.3.2.1 Cutting, slashing and mowing

This refers to the use of equipment such as brush cutters, slashes and mowers to reduce the height of surface fuels so that a fire in this area would be easier to control. It is used predominantly in strategic zones and around built assets. If slashing is conducted early in the growth season (i.e. early spring) and is continued regularly through the growth season, then this will prevent the accumulation of biomass over the time that slashing is conducted.

The advantages of this method are that:

- Areas of conservation value can be avoided;
- Retains a vegetation cover to protect against soil erosion; and
- No smoke / air pollution produced.

The disadvantages of this method are that:

- It cannot be used on steep or rocky areas;
- Only reduces the height of fuel, it does not remove the biomass resulting from slashing (unless area is raked after);
- It can result in a change to the vegetation structure by encouraging grasses instead of shrubs; and
- It may increase weed distribution.

5.3.2.2 Hand removal and skirting

Skirting is the trimming of lower branches to prevent laddering (spread of fire from the ground layer to canopy by moving from branch to branch). Hand removal refers to the manual cutting and removal of branches, trees and shrubs which is generally used where larger equipment cannot access the area (i.e. around buildings) or where careful and selective removal is required (i.e. where threatened flora may be present). Rake-hoes, secateurs, loppers and poles are used for this method.

The advantages of this method are that:

- Species of conservation or ornamental value can be retained;
- Sufficient vegetation and litter cover can be retained to control erosion;
- Suitable for difficult sites (steep, rocky, or boggy) where others methods cannot be used; and
- No specialist equipment is required and no smoke or air pollution is reduced.

The disadvantages of this method are that it is slow, labour intensive and expensive for large areas.

5.3.2.3 Ploughing, scraping, grading or herbicide application

This refers to the removal of surface fuels through ploughing, grading or bulldozing to create a bare earth fuel break. Herbicide could also be applied to create a bare earth break noting that this would take longer to become bare earth then the other methods listed and would therefore be most appropriate for use prior to planned burns.

The advantages of this method are that:

- A mineral earth fire control line is produced;
- The method is relatively cheap and large areas can be covered by one operator; and
- No smoke or air pollution is produced.

The disadvantages of this method are that:

- It is not suitable for steep or rocky sites;
- Increases erosion risk as the soil surface is exposed and left unprotected;
- The soil structure may be damaged in the process;
- It may contribute to the spread of plant diseases and weeds;
- Specialist equipment is required; and
- There may be a requirement for approval for removal of native vegetation.

5.3.2.4 Mulching / trittering (turbo mowing)

This refers to the use of large mechanical slashers or turbo mowers that mulch the understorey and shrub layer and leave the mulch in-situ. This is used in place of slashing in areas where the overstorey vegetation is to be maintained while removing the understorey.

The advantages of this method are that:

- It can be used to control erosion as organic matter is spread on soil surface and this reduces the erosion potential of surface flows; and
- No smoke or air pollution is produced.

The disadvantages of this method are that:

- It is not suitable for areas of conservation value;
- Specialist equipment is required; and
- The method is not suitable for steep slopes or areas of conservation value.

5.3.2.5 Grazing

This refers to the introduction of grazing animals such as goats, cattle and sheep to reduce total surface fuel loads, total biomass and fuel heights. Stock can be introduced at high numbers for short periods to rapidly reduce fuel loads (referred to as 'crash grazing'). This method is most suitable to grazing and weed infested areas. This method is not recommended for areas of native vegetation or of conservation value such as in riparian zones.

The advantages of this method are that:

- Grazing animals may alter the fuel structure. Most effective in grassy regions.
- No smoke or air pollution produced;
- It is cost effective;
- It is effective at reducing surface fuels;

The disadvantages of this method are that:

- It is not suitable for native bushland with shrubby or healthy understorey;
- It may damage plant species of conservation value;
- It may increase weed distribution;
- Stock needs to be managed, including fencing;
- Cloven hoofed animals may damage soil structure and increase the risk of soil erosion; and
- Stock may be unavailable when needed.

5.3.2.6 Replacement Planting

This refers to the replacement of existing vegetation with lower-flammability vegetation that can be used to prevent the spread of fires through the absorption of radiant heat. Generally, large leaved succulent plants without stringy or woody bark, are most effective, and ideally plants would be selected from those native to the region.

The advantages of this method are that:

- No smoke or air pollution produced; and
- It can be used in the vicinity of assets as an alternative to a slashed grass or bare-earth break;
- Aesthetic values can be selected.

The disadvantages are that:

- All plants are flammable to a degree so this method is best for fuel alteration rather than reduction;
- There are a limited number plant local species that are considered low flammability vegetation so this method may rely on the introduction of exotic species;
- It is not suitable for areas of conservation value;
- It may encourage weed invasion during the plant establishment and maturation period; and
- Watering and maintenance is required, particularly during the establishment period.

5.4 ENVIRONMENT PROTECTION GUIDELINES FOR BUSHFIRE HAZARD REDUCTION

All methods for reducing bushfire hazards have the potential to cause negative environmental impacts if implemented incorrectly or without regard for the environment in which they are applied. For this reason, guidelines have been developed to reduce the likelihood and consequence of these impacts. These guidelines draw on information provided in the Ecological Guidelines for Fuel and Fire Management Operations (Kitchin and Matthews 2012) and the Bushfire Environmental Assessment Code for NSW (NSW Rural Fire Service 2006).

5.4.1 GUIDELINES FOR PLANNED BURNS

To reduce the potential negative environmental impacts from planned burns, the following guidelines and standards should be applied:

- Burns should generally be low intensity and patchy across the burn area with an aim to achieve 30% unburnt (in patches), 70% burnt and less than 10% crown scorch;
- Vehicles should remain on existing tracks and formed crossings wherever possible;
- Vehicles should be washed down to remove weeds before and after attending burns to prevent the spread of weeds;
- Minimise burning and felling of habitat and hollow bearing trees along containment lines or roads;
- Avoid burning moist gullies and drainage lines wherever possible;
- Moderate or high intensity planned burns should not be conducted in areas mapped as high likelihood of erosion following fire (Figure 6). The burn plan must include measures to ensure that moderate or high intensity fire is not used on soil surface slopes greater than 18 degrees;
- Use of fire-fighting foam should be minimised wherever possible;
- Fire-fighting foam should not be:
  - Used in high conservation areas;
  - Allowed to enter any aquatic ecosystem;
  - Used, handled or mixed within 200m of any wetland;
  - Used, handled or mixed within 100m of any standing water body, major river or water way containing threatened fish; or
  - Used, handled or mixed within 50m of any aquatic ecosystem;
- Fire-fighting retardant should not be used in prescribed burn operations;
- Aquatic ecosystems should be excluded from planned burns wherever possible;
- No lighting of a planned burn is permitted within the riparian buffer zone distances specified in Table 3.
- No lighting of a windrow burn is permitted within 20 metres of any water body. The distance (metres) is measured from the highest bank or shore (or mean high water for tidal waters) on either side of the water body.
- For planned burns being conducted near water bodies, all reasonable steps (excluding clearing vegetation and the use of foams or retardants) should be taken to ensure that the fire does not burn within the riparian buffer zone. Fires should be lit under conditions so that if they do burn within the riparian buffer zones they are patchy and low intensity.
- Sediment and erosion control requirements should be assessed following burning and remedial measures should be implemented where necessary;
- Planned burning should not be conducted in fire-sensitive ecological communities where the time since the previous fire is within the minimum TFI for the community;
- Areas with significant patches/thickets of shrubby vegetation which may be used by threatened bird species should not be burnt in spring to avoid the primary nesting season;
- Where a spring burn is undertaken in bird habitat, patches or thickets of shrubby vegetation should be left unburnt to provide habitat and nesting areas;
- Lighting crews should avoid igniting individual shrubs or thickets where nests are observed; and
- Planned burning should not be conducted in areas containing threatened flora species during the flowering period for the species.

Table 3 Riparian buffer zones for planned burns

WATER BODY	RIPARIAN BUFFER ZONE WIDTH (METRES)
Unmapped, ephemeral streams	5
Wetlands, lakes and lagoons greater than or equal to 0.1 ha but less than 0.5 ha	5
Wetlands, lakes and lagoons greater than or equal to 0.5 ha but less than 2 ha.	10
Waterways, rivers, estuaries, wetlands, lakes and lagoons greater than or equal to 2.0 ha.	20

Source: Bushfire Environmental Assessment Code (NSW Rural Fire Service 2006)

5.4.2 GUIDELINES FOR SLASHING

- Slashing should not be undertaken in areas containing threatened ecological communities, threatened flora species or Indigenous heritage sites;
- Slashing should not be undertaken below 10cm slash height in conservation areas and in areas where the soil erosion is a risk;
- Slashing should not be undertaken below 5cm slash height in areas where soil erosion is a risk;
- Slashing machinery is not permitted on slopes greater than 18 degrees;
- Slashing machinery, implements and vehicles must be washed down between slashing areas;
- Slashing should be avoided if noxious weed species or Weeds of National Significance are present and seeding;
- Slashing debris must not be permitted to enter aquatic ecosystems or be left where water could wash them into these habitats; and
- Slashing must not be undertaken in the riparian zones identified in Table 4.

5.4.3 GUIDELINES FOR GRADING AND PLOUGHING

- Grading or ploughing should not be undertaken in areas containing threatened ecological communities, threatened species or Indigenous heritage sites;
- Grading or ploughing is not permitted on slopes greater than 10 degrees;
- Machinery work must not reshape the soil surface or result in re-direction of surface water runoff;
- All topsoil must remain on the soil surface;
- Machinery work should be conducted parallel to contours; and
- Slashing must not be undertaken in the riparian zones identified in Table 5.

Table 4 Riparian buffer zones for slashing

WATER BODY	RIPARIAN BUFFER ZONE WIDTH (METRES)
Unmapped, ephemeral streams	5
Wetlands, lakes and lagoons greater than or equal to 0.1 ha but less than 0.5 ha	10
Wetlands, lakes and lagoons greater than or equal to 0.5 ha but less than 2 ha.	15
Waterways, rivers, estuaries, wetlands, lakes and lagoons greater than or equal to 2.0 ha.	20

Table 5 Riparian buffer zones for grading and ploughing

WATER BODY	RIPARIAN BUFFER ZONE WIDTH (METRES)
Unmapped, ephemeral streams	5
Wetlands, lakes and lagoons greater than or equal to 0.1 ha but less than 0.5 ha	15
Wetlands, lakes and lagoons greater than or equal to 0.5 ha but less than 2 ha.	20
Waterways, rivers, estuaries, wetlands, lakes and lagoons greater than or equal to 2.0 ha.	20

5.4.4 GUIDELINES FOR GRAZING

- Stock grazing should not be undertaken in areas containing threatened ecological communities, threatened flora species or Indigenous heritage sites;
- Before grazing with introduced stock, grass fuel hazard measures should be assessed to determine if required standards are already being met by native herbivore grazing and/or drought. If standards are being met, further grazing should not be undertaken;
- Continuous grazing should be avoided. Crash or mob grazing over short periods interspersed by lengthy rest periods is the preferred strategy;
- Native ground layer vegetation should not be grazed below 20 cm;
- Fertilizers should not be applied and exotic pasture species should not be sown where this method is used in natural areas;
- Supplementary feeding should be minimised. While the necessity to use 'licks' to maintain animal health is recognised, they must not be used to maintain stock in an area longer than is necessary to achieve fuel standards; and
- Weed populations should be controlled and the area monitored for new weed emergence.

5.4.5 GUIDELINES FOR CHEMICAL APPLICATION

- Chemical application should be restricted to the target species only;
- No herbicide other than those with Glyphosate as the active constituent should be used within 50m of an aquatic habitat;
- Chemical application should be undertaken in accordance with label instructions and the Victorian Government publication 'A guide to using agricultural chemicals in Victoria'. Chemical label instructions can be found on the Australian Pesticides and Veterinary Medicines Authority website www.apvma.gov.au.
- Mixing of chemical solutions should not be undertaken within 50m of any aquatic habitat
- Boom spraying should not be undertaken within 50m of:
  - Any aquatic habitat;
  - An area containing an endangered species; or
  - An area containing a threatened ecological community or Indigenous heritage sites.
- No chemical spray-application should be used within 10m of:
  - Any mapped threatened flora species (cut and dab application may be used where essential); or
  - An area containing a threatened ecological community.
- As far as possible, chemical use for native vegetation control must only be applied to shrubby and regrowth vegetation and should not be applied to ground cover vegetation;
- Boom spraying must cease if wind conditions cause spray to drift onto non-target native vegetation; and
- Chemical application should be minimised where possible within threatened ecological communities.

5.4.6 GUIDELINES FOR PHYSICAL REMOVAL OF VEGETATION

- The physical removal of native vegetation should not be undertaken in areas containing threatened ecological communities or Indigenous heritage sites;
- Native trees with a Diameter at Breast Height (DBH) >20cm should not be removed;
- Habitat trees, hollow bearing trees or standing dead trees should not be removed;
- Native vegetation removal should be minimised during spring to avoid disturbance to threatened and declining bird breeding;
- Removed vegetation or disturbed soil should not be dumped, scattered or windrowed in adjacent native vegetation or grassland areas for extended periods of time;
- Full excavation of tree stumps is not recommended in native vegetation areas due to the high level of soil disturbance;
- Where trees are removed on slopes greater than 10 degrees the root structure must be left undisturbed;
- Tree removal is not permitted on slopes greater than 18 degrees;
- Plant and other vehicles should not be driven or parked in undisturbed native vegetation. Equipment should be kept on tracks and slash zones only; and
- Vegetation removal should not be undertaken in the riparian zones identified in Table 6 (noting that trimming of limbs is acceptable).

5.4.7 GUIDELINES FOR ACTIVITIES FOR LAND MANAGEMENT, MAINTENANCE AND EROSION CONTROL

- Plant and vehicles undertaking access management should not impact on adjacent vegetation and habitat for the purpose of parking, refuelling, passing or turn-around requirements;
- Earth and rock requiring dumping must be taken off site – no rock or earth is to be dumped on adjacent native vegetation;
- Hay bales used for sediment control in high conservation areas must contain only sterile and weed free straw.
- Spoil from culvert cleaning operations should be removed from the site and disposed in appropriate spoil dumps. In weed free areas, spoil may be distributed over the existing road pavement. Spoil should not be allowed to run-off into any aquatic ecosystem

Table 6 Riparian buffer zones for physical vegetation removal

WATER BODY	RIPARIAN BUFFER ZONE WIDTH (METRES)
Unmapped, ephemeral streams	5
Wetlands, lakes and lagoons greater than or equal to 0.1 ha but less than 0.5 ha	15
Wetlands, lakes and lagoons greater than or equal to 0.5 ha but less than 2 ha.	15
Waterways, rivers, estuaries, wetlands, lakes and lagoons greater than or equal to 2.0 ha.	20

Source: Bushfire Environmental Assessment Code (NSW Rural Fire Service 2006)

5.5 FIRE CONTROL LINES FOR MANAGING FUEL IN THE EVENT OF A BUSHFIRE

Fire control lines are put in place prior to or in the event of a fire for the purposes of containing fire spread. They can be used for planned burns or to aid in the control of an unplanned bushfire. The purpose of a control line is to create a mineral earth break to contain and limit the spread of a fire and provides an advantage zone for fire fighters to put in place backburns (i.e. areas in front of a fire that are burnt to reduce the available fuels). The size of a control line can vary from man-made rakehoe trails to wider breaks created using a grader or bulldozer. Fire control lines are placed either at the fire edge or in strategic locations in front of the fire for the purposes of containing the fire or to undertake back burning operations. Fire control lines are sometimes created specifically to protect houses, farm buildings and other assets.

Importantly, a control line is not intended to stop a fires spread as it will most likely spot over the control line and continue burning. It is intended to provide a strategically located fuel free area that assists fire fighters with management or that may assist with managing the fire edge.

5.5.1 GUIDELINES FOR CONSTRUCTING FIRE CONTROL LINES

When constructing fire control lines the following guidelines should be applied. These guidelines reference the Bushfire Environmental Assessment Code for NSW under the Rural Fires Act 1997 (RFS 2006):

- The closest natural / existing containment lines to the intended perimeter of the burn should be used where available;
- Construction of additional control lines must be limited to the minimum extent necessary to carry out the burn safely;
- The width of a control line must not exceed 4 metres;
- Control lines must be constructed in a manner that minimises the potential for soil erosion;
- Control lines should be constructed where native vegetation has already been disturbed, in preference to undisturbed vegetation;
- Conditions must be imposed that control lines constructed through native vegetation must be allowed to regenerate following the burn;
- Control lines that run parallel to a water body must not be constructed within the riparian buffer distances specified in Table 6;
- Control lines may be constructed within riparian buffers where they are constructed perpendicular to a stream;
- Drainage structures must be constructed between 5 and 20 metres of the highest bank of the stream;
- Drainage structures (such as crossbanks and culverts) must be constructed at 50 metre intervals under the following circumstances:
  - where hill slope greater than 18 degrees;
  - where soil erosion risk maps are not available), and
  - the control line will be perpendicular to the contour, and
  - the control line will be greater than 1 metre wide.
- Where land is mapped as susceptible to mass movement, works must be consistent with the relevant conditions specified in Section 5.4.7.

5.5.2 EDEN PARK FIRE PRIORITY ROADS

The Whittlesea Municipal Fire Management Plan identifies the primary Fire Priority Roads as all major roads running east to west in the municipality. Fire Priority Roads will be the roads that are the basis of fire control lines in the event of an unplanned bushfire to gain control of a fire. They also form a main part of the primary fire breaks in the municipality. These breaks are slashed to a height of 100mm, fence to fence (where practicable), including the road reserves.

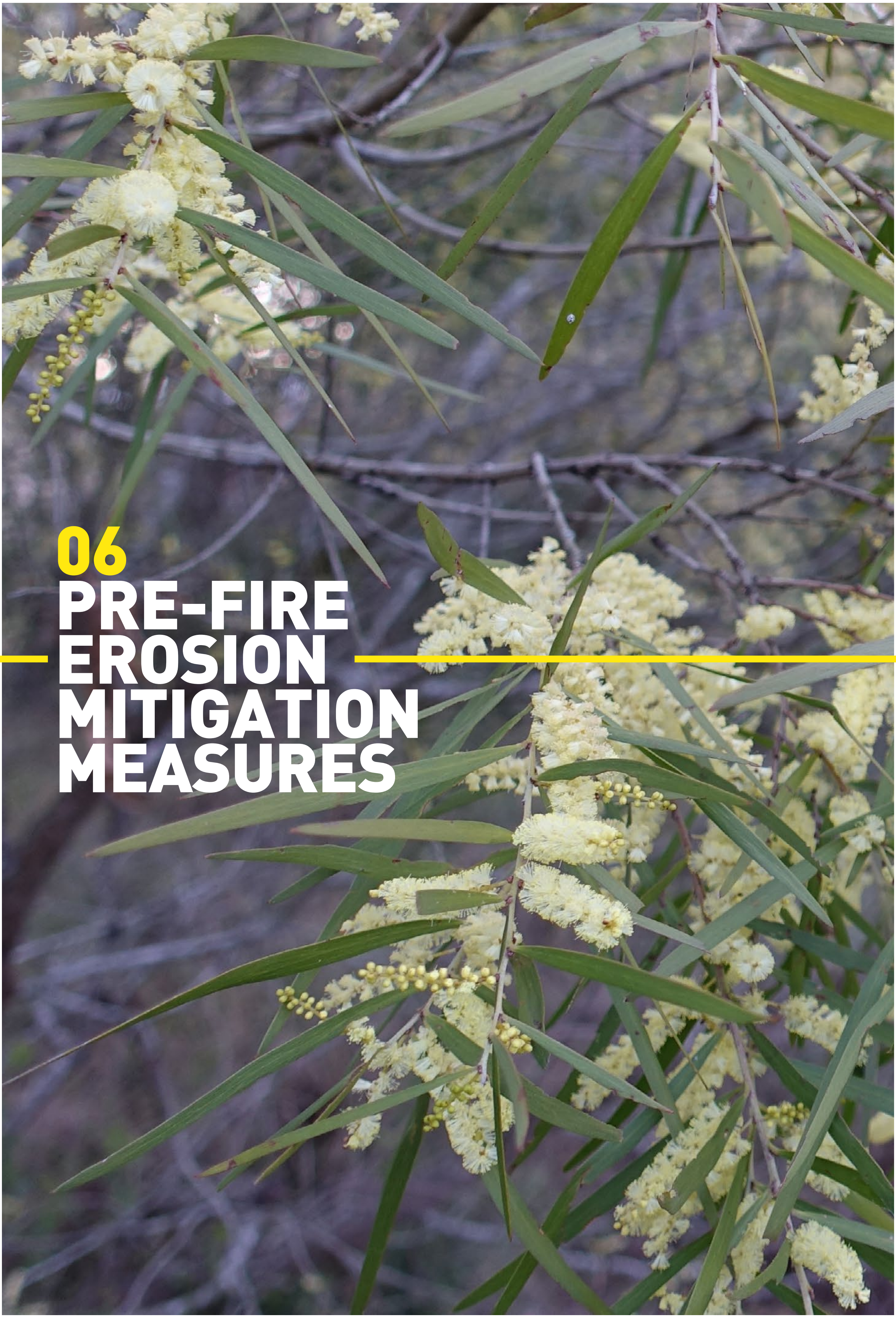
The following roads have been identified as the Priority Fire Roads by CoW within Eden Park:

- Janna Road, Eden Park;
- Glenburnie Road, Eden Park;
- Clarks Road, Whittlesea;
- Grants Road from Merriang Road Woodstock in the west to Plenty Road, Whittlesea;
- Plenty Valley Rise, Whittlesea;
- Towts Road, Whittlesea; and
- Bruces Creek Road, Whittlesea.

It is unlikely that a fire control line would be placed in the central range passing through Eden Park from First Avenue to north of Macgregor Road due to the steep and inaccessible nature of the area, the presence of environmental sensitivities in these locations and the possibility that post-fire biodiversity and soil erosion impacts could result from a fire control line in such an area.

It has been identified through community consultation that more suitable locations for fire control lines would be flatter areas of Eden Park surrounding the central range. A limitation that has been identified with placing a control line in such locations is the large number of small land parcels in these areas particularly in the eastern and southern parts of Eden Park. This increases the number of landowners and associated infrastructure that is affected. Thus, the strategic use of existing cleared thoroughfares such as public roads would be preferential.

If private land is to be targeted by fire control lines, experiences from Black Saturday highlight the importance of emergency services consulting with affected landowners as early as possible. Early planning and consultation will assist in easing stress associated with an emergency event. This will allow the farming community of Eden Park to appropriately contain stock and limit the risk of wandering stock interacting with moving traffic.



06 PRE-FIRE EROSION MITIGATION MEASURES

A bushfire is likely to remove the protective layers on the soil and may alter the soil structure increasing the likelihood and consequence of erosion. This is particularly true if a bushfire is followed by a storm or rain event before the landscape has had an opportunity to recover. The resulting erosion can be costly to remediate and may lead to other impacts or risks such as:

- Reduction in the usable area for agriculture,
- Injury of people to on the site,
- Injury of domesticated animals,
- Impact to areas of biodiversity or environmental value,
- Decrease in water quality,
- Damage to vehicles, equipment and machinery,
- Damage to infrastructure, and
- Decreased accessibility to areas of the site.

Infrastructure planning and pre-fire erosion mitigation and planning is required to reduce the likelihood of dealing with expensive and strenuous post-fire erosion related rehabilitation activities. By planning and improving the ability of critical infrastructure to function under post-fire conditions, impacts from post-bushfire erosion can be decreased. Primarily this would include a review of drainage infrastructure to cope with increased flow requirements and implement appropriate infrastructure design where appropriate. It would also require an evaluation of road design, the current extent of areas experiencing erosion and hazardous trees that may require management.

6.1 DRAINAGE DESIGN

The following drainage activities are suggested to be undertaken by the CoW to reduce the potential for erosion impacts following a bushfire. These recommendations may also be applicable to private landowners who may wish to review their drainage infrastructure to mitigate unnecessary erosion impacts. A useful reference for understanding hydrologic requirements of drainage infrastructure can be found in the Australian Rainfall and Runoff Guidelines at arr.ga.gov.au (ARR 2016).

6.1.1 NEW DEVELOPMENT REQUIREMENTS

Peak stormwater flows may increase after a fire and proper sizing, alignment and slope of the culvert is recommended to prevent road loss and erosion. For all new developments, the activities identified in Table 7 are recommended for fire risk areas.

Table 7 New development drainage recommendations

ACTIVITY	DESCRIPTION
Culvert sizing	An assessment of culvert size and appropriateness for the nature and size of the catchment is recommended. Stormwater runoff modelling would be required to determine whether culverts are appropriately sized. Australian Rainfall and Runoff should be used when assessing hydrologic design requirements.
Culvert placement alignment/slope	An assessment of culvert location is recommended to determine whether culverts are placed in a suitable location, are of a suitable grade and are aligned appropriately.
Erosion register	It is recommended that a register of erosion activity (hot spots) is developed and maintained. This register would record specific occurrences of erosion and details of the immediate risk and severity of the problem.
Erosion toolkit	An erosion toolkit is recommended to enable the prompt addressing of registered erosion hotspots. The toolkit should categorise remedial actions against soil type and link treatment to the cause of erosion. The toolkit should also consider the management of vegetation in and around drainage infrastructure. The toolkit may include treatment methods suggested in the Erosion and Sediment Treatment Catalogue in Appendix A

6.1.2 ANNUAL REQUIREMENTS

The activities identified in Table 8 should be implemented annually to ensure that drainage infrastructure continues to operate in accordance with design requirements. Figure 5 identified drainage and road infrastructure that has been mapped to occur in areas containing a high likelihood of erosion following a bushfire. These areas may become a priority for drainage upgrade and monitoring programs.

Table 8 Annual drainage recommendations

ACTIVITY	DESCRIPTION
Condition assessment	An annual condition inspection of all drainage infrastructure is recommended. This assessment should be undertaken in parallel with the road condition assessment and should record and rate the severity of any issues identified within an erosion register. This erosion register should be updated following the condition assessment.
Address erosion	Where required, changes to erosion condition identified through the annual condition inspection should be addressed promptly.
Maintenance	It is recommended that maintenance of drainage infrastructure and erosion protection works be undertaken on a regular basis. Maintenance activities should include clearing culvert blockages, cleaning drainage grates and maintaining vegetation in open channels.
Culvert modification	An assessment of culvert functional design is recommended to determine if enhancements or modifications are required to reduce the risk of erosion related impacts. This may include undertaking culvert modification treatments suggested in the Erosion and Sediment Treatment Catalogue in Appendix A
Communication	Liaison with Commonwealth and Victorian Government Authorities and private landowners is recommended to ensure access to high erosion risk areas is maintained, drainage is adequate and sites are free from erosion.

6.2 ROAD DESIGN

The road activities in Table 9 are recommended to be undertaken by public road managers within Eden Park to reduce the potential for erosion impacts following a bushfire. These recommendations may also be applicable to private landowners who may wish to review their road and track infrastructure to mitigate unnecessary erosion impacts. The AustRoads guidelines contain multiple parts that relate to road drainage which should be considered when undertaking road upgrade design or maintenance (AustRoads 2013). VicRoads have a supplement to the Austroads guidelines which should also be considered when working on a VicRoads managed road (VicRoads 2013).

Table 9 Road design activity recommendations

ACTIVITY	DESCRIPTION
Sealed roads	
Condition assessment	An annual condition inspection of all sealed roads is recommended. This assessment should be undertaken in parallel with the drainage condition assessment (Table 8) and should record and rate the severity of any issues identified.
Road maintenance	All road condition issues identified through the condition assessment should be addressed as necessary. Prioritisation of road issues should consider key fire access routes and the condition assessment rating.
Unsealed roads	
Condition assessment	Unsealed roads can cause significant sediment production and erosion is more likely on these roads than on sealed surfaces. An annual condition inspection of all unsealed roads is recommended. This assessment should be undertaken in parallel with the drainage condition assessment (Table 8) and should record and rate the severity of any issues identified.
Grading	Grading of unsealed roads is required to remove depressions, corrugations and potholes. This may include profiling the road to ensure effective drainage of the road surface (Appendix A). Maintenance should be avoided in higher rainfall months which may lead to erosion and poor compaction. The integrity of all drainage structures should be checked prior to completion of road works to ensure drainage structures remain free from defect and blockage.
Road modification	An assessment of unsealed road design is recommended to determine if upgrades are required to reduce the risk of erosion related impacts. This may include undertaking road upgrade treatments suggested in the Erosion and Sediment Treatment Catalogue in Appendix A.
Communication	Liaison with State and Federal Government Authorities and private land owners is recommended to ensure access to high risk fire areas is maintained and sites are free from erosion.

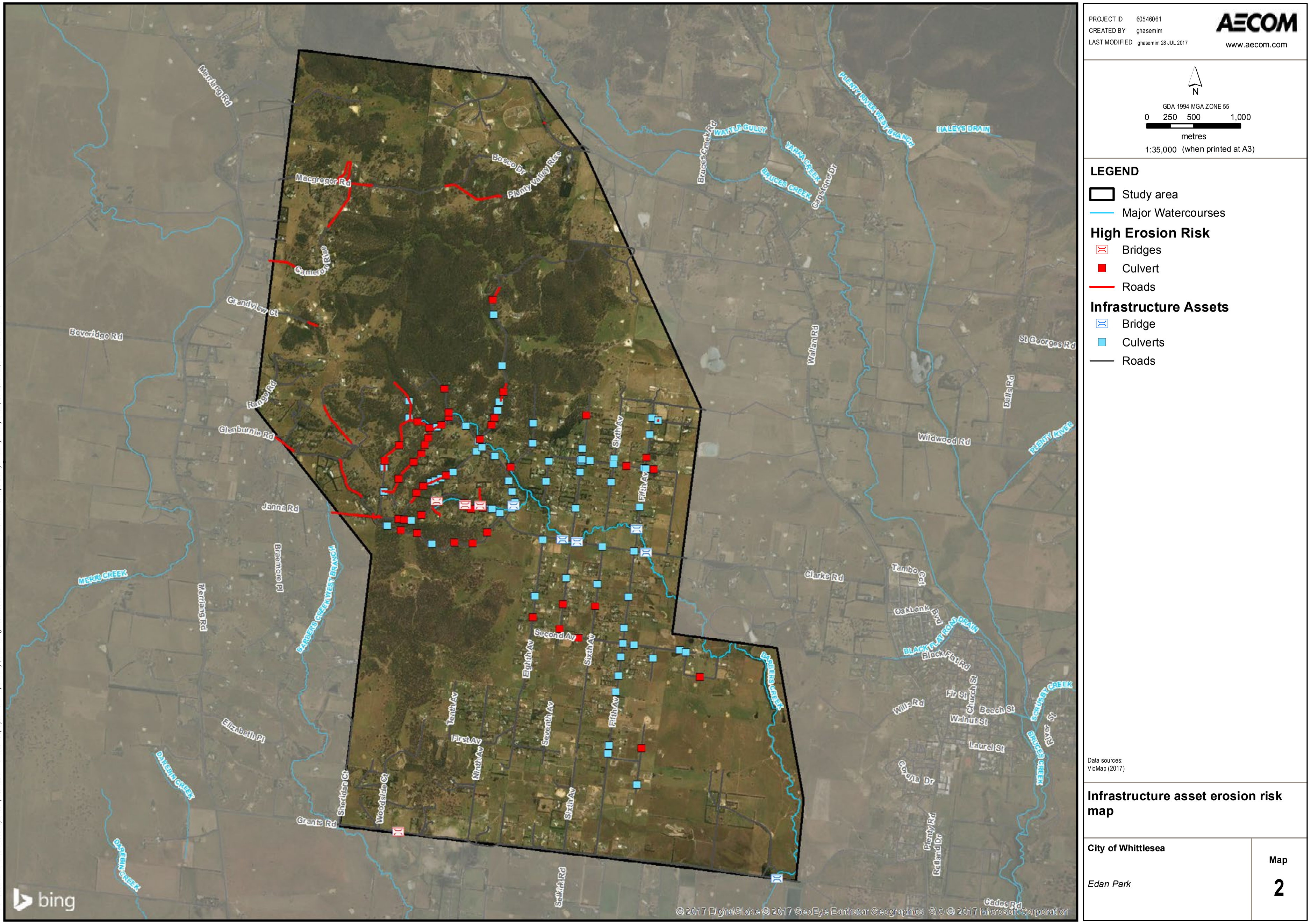


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Figure 5 Drainage and road infrastructure erosion risk map

6.3 EROSION REMEDIATION

Studies around the world have demonstrated that post-fire storm events, particularly during the first post-fire year influence the level of erosion experienced within burnt areas. In particular, the first storms following bushfire are typically the most erosive because this is when the sites are most vulnerable to post-fire effects on soil. Therefore, it is important to understand which areas have a likelihood of erosion following a bushfire. Information provided in the erosion likelihood map provided in Figure 6 combined with post-fire information including burn extent and severity mapping, will allow authorities to target particular areas to establish post-fire erosion mitigation controls.

Although hill slope erosion is considered a significant cause of sediment loss following high severity bushfires, pre-fire erosion planning should also focus on existing types and areas of erosion within Eden Park. The presence of dispersive clays within Eden Park combined with past land uses, has led to significant areas of gully erosion. Although eroded gullies may be at various stages of development, it is likely that increased run-off following a bushfire event will re-activate or increase the severity of existing areas of gully and tunnel erosion. Understanding the location and severity of existing gully/channel erosion will allow for preventative treatments such as those discussed in Appendix A to be undertaken to avoid significant post-fire sediment loss.

6.4 HAZARDOUS TREES

Pre-fire hazardous tree management generally relates to trees which are likely to fall onto or come into contact with an electrical line. The Electricity Safety Act 1998 (ES Act) states that a municipal council must specify, within its Municipal Fire Management Plan:

a. procedures and criteria for the identification of trees that are likely to fall onto, or come into contact with, an electric line (hazard trees); and

b. procedures for the notification of responsible persons of trees that are hazard trees in relation to electric lines for which they are responsible.

The Electricity Safety (Electric Line Clearance) Regulations 2010 further states that a responsible person may cut or remove a tree provided that the tree has been assessed by a suitably qualified arborist; and that assessment confirms the likelihood of contact with an electric line having regard to foreseeable local conditions.

There are a number of organisations that have responsibility for line clearance within the CoW which include:

- Jemena;
- AusNet Services; and
- In the Declared Areas – Whittlesea.

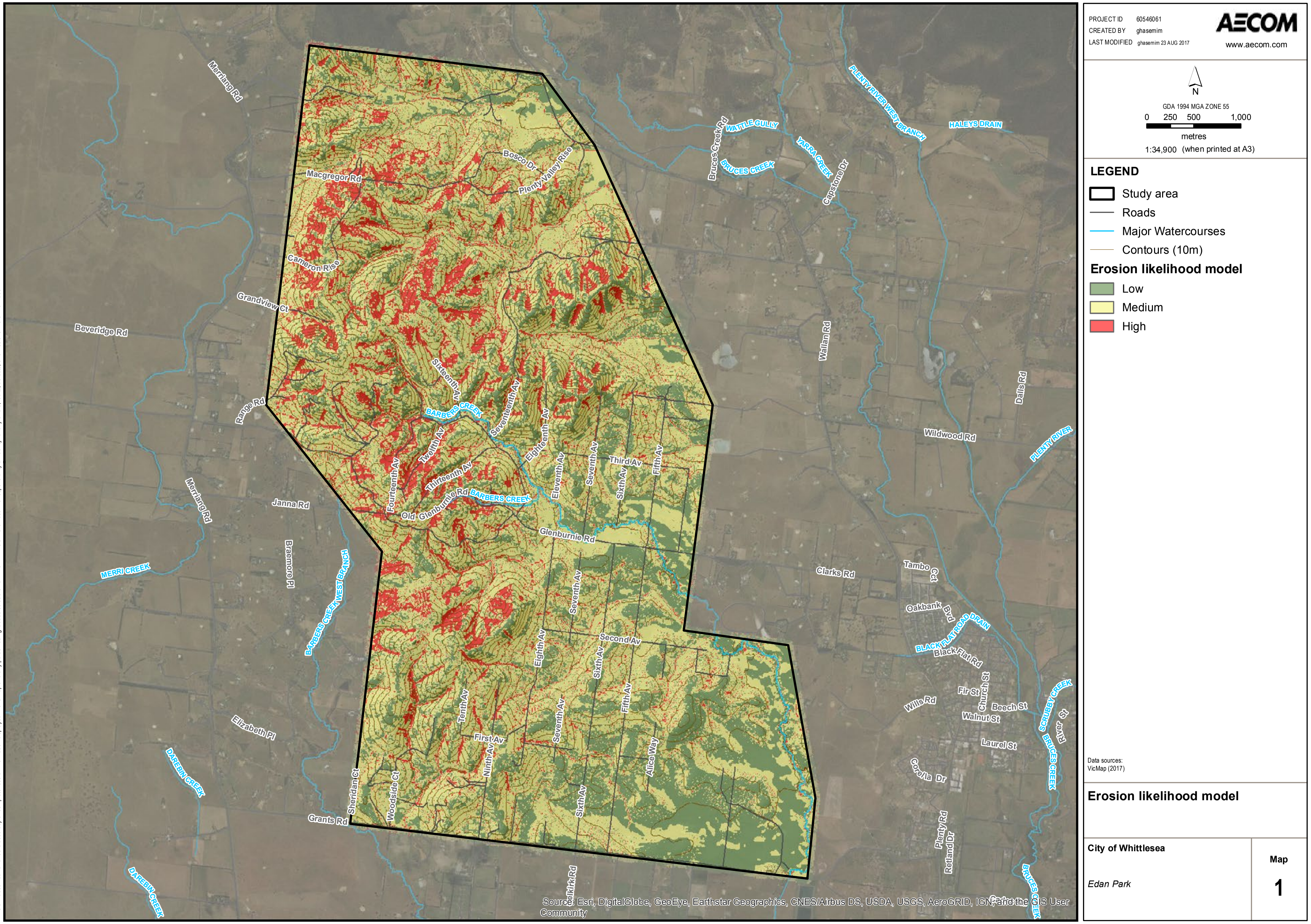

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Figure 6 Erosion Likelihood Map

07 POST-FIRE EROSION MITIGATION MEASURES

Post-fire mitigation measures have been developed by incorporating techniques recommended for a range of post-fire and regular erosion mitigation and management situations. Following the 2009 Kilmore East – Murrindindi bushfires a Burned Area Emergency Response (BAER) team from the United States Department of Agriculture (USDA) were engaged to assess the extent and severity of the fire and fire suppression impacts. The BAER team identified emergency stabilisation and rehabilitation techniques and priorities. The USDA has undertaken extensive research in the effects of fire on the environment, in particular soil responses to fire and associated treatment techniques. This information has been coupled with Australian information on erosion mitigation and management along with local experiential learnings following the Kilmore East – Murrindindi bushfires. The Murrindindi fire complex north of Eden Park shares similar environmental conditions to those of Eden Park, therefore post-fire experiences from this area are seen as a valuable resource.

Treatments for land, channel, roads, tracks and biodiversity have been covered in this section. A description of treatment objectives along with suitable circumstances for treatments is provided in a treatment catalogue in Appendix A.

Potential limitations in implementing treatment methods listed in Appendix A include:

- Limited vehicular access to steep areas (no road access);
- Limited, if any, availability of certified weed free straw;
- Establishment of noxious weeds;
- Difficulty in coordinating treatment responses amongst adjoining landowners and landowners implementing treatments in isolation; and
- Disturbing problematic soils.

It is important that a detailed site assessment is undertaken by experienced and qualified technicians to determine the type and extent of treatment required to mitigate or address post-fire erosion. A detailed and thorough site assessment allows works to be prioritised and the most appropriate techniques selected, avoiding potential unnecessary expense.

7.1 LAND TREATMENTS

Land treatments are generally focussed on avoiding sediment loss from hillslope erosion. Possible treatments could include various types of mulching and sediment traps including logs, fibre rolls and silt fences. A full list of land treatments is provided in Appendix A.

There are several considerations to be reviewed when identifying appropriate treatment areas and methods. Burn extent and severity as well as the sites likelihood of erosion should be considered. Practical considerations should also be reviewed including site accessibility and coordination of works with surrounding landowners. A more effective result will be achieved by landowners on the same slope or within the same sub-catchment coordinating works rather than working in isolation or not at all. Targeted slopes with good access maybe suitable for hydro-mulching or hand application of straw. Upper catchment slopes are generally more important and more effective to treat than lower slopes. Treating upper catchment slopes has the ability to reduce flow distances and interrupt overland flow before it hits lower slopes and washes away mulch cover.

7.2 STREAM TREATMENTS

Stream treatments are used to reduce or mitigate the impact on water quality, water velocity, sediment distribution, and geomorphology. Through the control of stormwater runoff and the management of stream power, stream treatments may reduce adverse impacts to downstream values including property and critical natural or cultural assets. A full list of stream treatments is provided in Appendix A.

Long term erosion mitigation and river rehabilitation activities such as revegetation should commence as soon as practicable. These activities should be considered with re-fencing activities to consider potential riparian fencing offsets.

Experienced and qualified waterway rehabilitation specialists with experience in hydrology, hydraulics and ecology should be engaged to plan stream treatments prior to implementation of treatment techniques.

7.3 ROADS AND TRACKS

Following a bushfire, opportunities may arise for road managers or private landowners to undertake road and track treatment measures discussed in Appendix A. There are many types of treatments that are used for road and track protection as well as protection of downstream values. Within Eden Park, this is likely to include un-made roads, private access tracks and farm tracks. Due to the resources required to implement road and track treatments discussed in Appendix A, where practicable these treatments should be considered as preventative measures. Treatments discussed in Appendix A will also reduce the risk of erosion in high rainfall events under normal conditions and post-fire.

Appropriately experienced and qualified road engineers should be engaged to plan and design road upgrades prior to the implementation of treatment techniques.

7.4 ROADSIDE VEGETATION MANAGEMENT

Roadside vegetation provides an important habitat source for native fauna within Eden Park in particular the Brush-tailed Phascogale. Roadsides have the potential to provide habitat corridors between link two or more areas of bushland on private land. Roadsides contain significant habitat values such as habitat trees and understory shrubs and grasses and logs. It is important that these values are maintained so far as practicable to when undertaking bushfire fuel management and suppression activities.

When considering the removal of hazardous trees it is important to review the Standard Operating Procedure discussed in Section 7.5.

7.5 HAZARD TREES

On the fire ground, hazardous trees pose a legitimate risk to firefighter and public safety particularly from trees that have been fire killed, drought affected, have large amounts of decay or have been damaged. Emergency services are often tasked with the decision of whether to remove trees which potentially pose a safety risk.

A Standard Operating Procedure has been developed for emergency services to identify tree hazards on the fire ground and mitigate the risk of injury (see Appendix A) (EMV SOPJ8.03). Additionally, a pictorial guide for identifying hazardous trees on the fire ground has been prepared by DELWP and is also provided in Appendix A (DSE 2011). Due to the potential for large trees on the fire ground containing environmental and cultural values, it is recommended that both of these documents are consulted when deciding on trees to be removed.

It is important to note that under Section 52.17-7 and 52.48-1 of the Whittlesea Planning Scheme that the some exemptions apply to clearance of native vegetation in association with Emergency works and Bushfire protection. When undertaking vegetation clearance associated with bushfire protection it is recommended that a council planning or biodiversity representative is consulted to ensure vegetation removal is exempt from requiring a permit under the Whittlesea Planning Scheme.

7.6 FARM DAMS

Dam leakage and tunnelling is an issue experienced across Victoria and is exasperated following a bushfire. Dam failure can be attributed to poor planning, design and construction techniques. In Eden Park, this may involve the use of problem soils such as Sodosols and Chromosols discussed in Section 3.6 during dam construction. Clay dam embankments in Eden Park often contain minimal vegetation limiting the structural integrity of the dam wall (see Plate 12 showing dam embankment failure following fire).

Erosion of dam spillways was a commonly experienced problem following the Kilmore East – Murrindindi bushfire (see Plate 12). The spillway of a dam provides a critical role in returning high energy water to the floor of a drainage line and avoiding damage to the dam wall (Strumfels 2010). A well designed spillway will reduce the energy of water leaving a dam to avoid scouring of the downstream channel and potential dam failure. A wide, flat, well vegetated channel is the preferred style of channel overflow. To treat spill-ways with existing erosion damage may require the extension of the spillway, installation of a trickle flow pipe or relocating the spill-way location (Strumfels 2010). A trickle flow pipe is a low cost, easy to build structure, designed to intercept the small overflows at the top of the spillway and deliver it safely back into the base of the natural drainage line (DEDJTR 2017).

Plate 12 Dam embankment failure following the Kilmore East - Murrindindi bushfire

Plate 13 Dam failure around overflow pipe

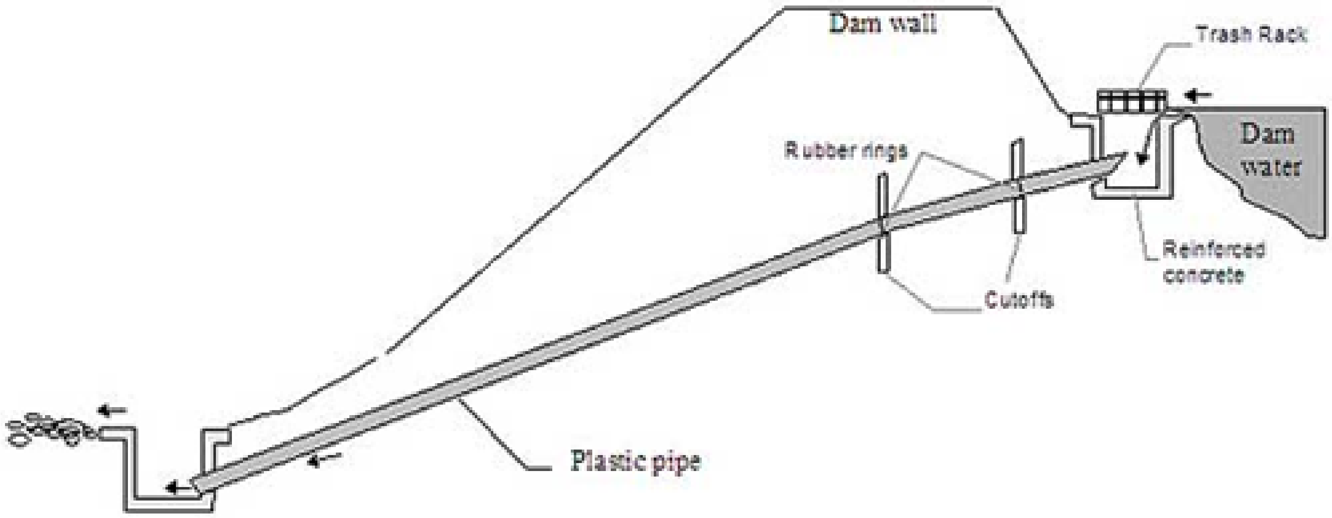


Figure 7 Example trickle flow pipe design (DEDJTR 2017)

7.7 FIRE CONTROL LINE REHABILITATION

Rehabilitation of fire control lines should be a priority, particularly when they occur in areas with a high likelihood of erosion such as those identified in Appendix A. All landowners that have fire control lines should be contacted prior to recovery work to determine if there are any site specific requirements. With this information, land managers will be able to identify threats to these sites, prioritize sites for rehabilitation, and prescribe the appropriate techniques to prevent further damage to these areas.

Where fire control lines traverse dispersive soils such as those described in Section 3.6, exposed soils should be recovered and rehabilitated as soon as practical. Before windrowed soils is spread across fire control lines, a soil ameliorant such as gypsum (if soil pH >6.5) or lime (if soil pH <5) or a mixture of both (if soil pH is within the range of 5 to 6.5) may be applied to exposed soil to reduce the risk of activating dispersive soils (DPIW 2008). Alternatively, a soil ameliorant may be top dressed following spreading of soil windrows across exposed soil. Dispersive soils should be covered with a minimum of 100mm of non-dispersive soil and firmly compacted prior to revegetation (DPIW 2008).

7.8 WEED HYGIENE PROCEDURES

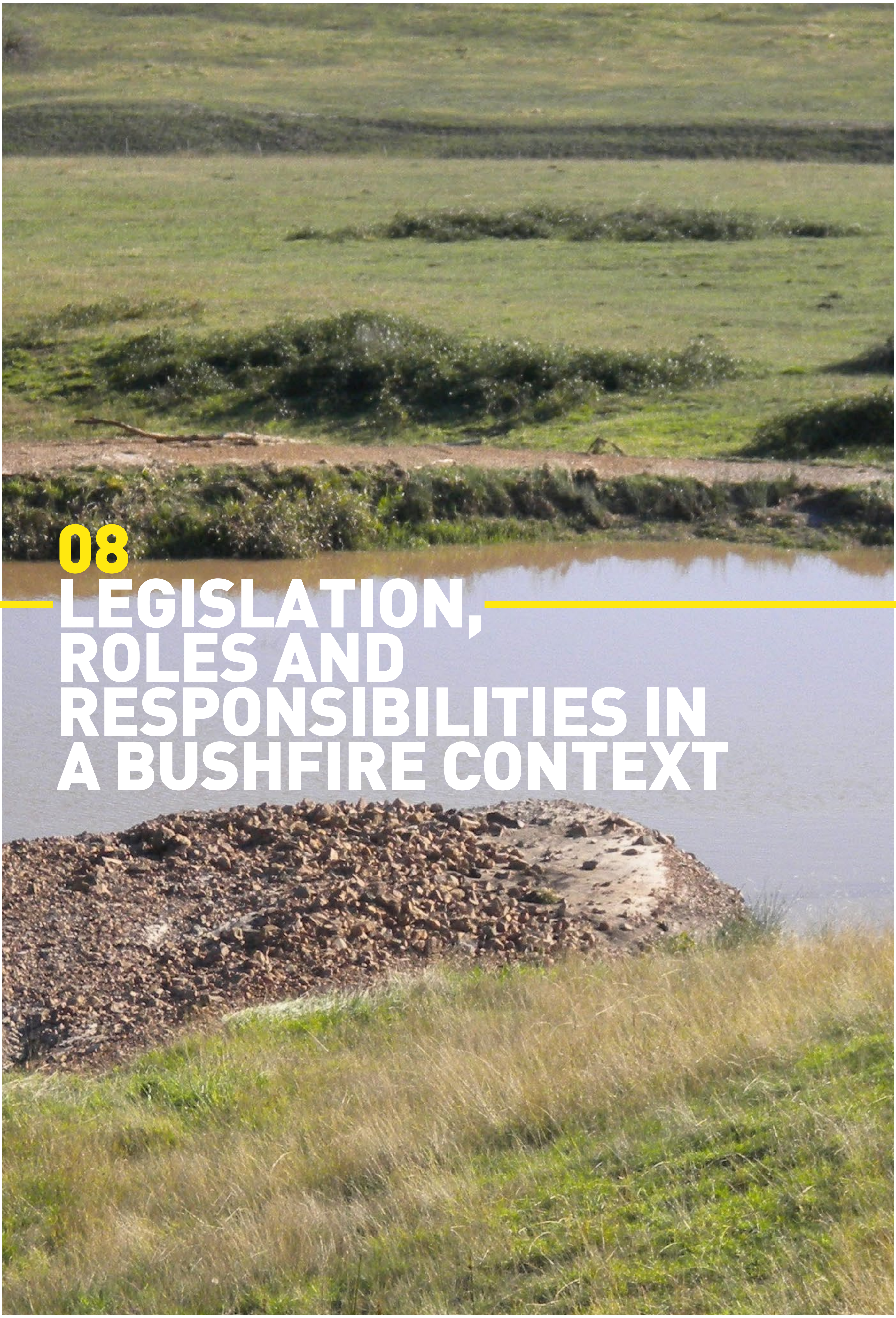
Vehicles and personnel have the potential to transfer or spread weeds, since they can carry seeds or organic matter caught on clothing, in tyres or under the vehicle body. Similarly, weeds can be introduced to an area via equipment that is contaminated with plant matter or soil from previous work/fire locations. The potential impact of weeds into areas that were previously weed free can be substantial, from both environmental and economic perspectives.

Under the CaLP Act, landholders have a duty to prevent the growth and spread of regionally controlled weeds on their property and on adjoining roadsides and to eradicate regionally prohibited weeds. Declaration and management of weed issues within the catchment including Eden Park is undertaken by Port Phillip and Westernport Catchment Management Authority.

The importation and spread of weeds in a post-fire environment is a significant risk to the environmental and agricultural values of Eden Park. In the event of a fire on private land, contactor plant and equipment are mobilised within various parts of the region for fire retention, suppression and rehabilitation activities. Additionally, resources and materials are applied to the fire ground for post-fire rehabilitation activities which provide an opportunity for weed spread. This is at a time when the environment is vulnerable to opportunistic weed spread prior to native colonisers or desired pasture grass species having had the opportunity to establish.

Hygiene procedures are recommended during all phases of fire control and rehabilitation to minimise the risk of spreading weeds. These management measures should include:

- Where practicable, consultation should be undertaken between emergency services and individual landowners prior to emergency services entering private land. This will allow hygiene issues to be identified and managed. This may include certified organic properties, specialised animal husbandry facilities or known weed infested properties.
- Plant hygiene will be thorough so as to remove all soil or organic matter from the surface of vehicles, equipment and portable infrastructure, including the undercarriage and running gear.
- Designated wash-down areas and facilities should be identified and available for contractors prior to commencing work on the fire ground. This may include areas such as CoW depots or fire staging areas.
- All vehicle and machinery movement should be confined to designated work areas (i.e. fire control lines) and access of vehicles and personnel to areas of known noxious weed infestation will be restricted. Vehicles entering and leaving such areas may need to be re-washed. Air cleaning may be appropriate in dry conditions but where topsoil conditions are moist, appropriate wash down will be required.
- Signage will be installed at approved wash-down areas and advice communicated at briefing sessions to advise contractors and volunteers of this requirement.
- Transfer of soil between properties should be minimised when constructing fire control lines or other earth moving activities.
- Where practicable, certified weed free material should be used during rehabilitation activities. Gaining weed free certified material may prove challenging, therefore, CoW should investigate the feasibility of establishing a register of suppliers that meet Councils hygiene requirements for the provision of rehabilitation products.
- In the months and years following a fire event, community vigilance should be dedicated to identifying, monitoring and controlling noxious weeds.



08 LEGISLATION, ROLES AND RESPONSIBILITIES IN A BUSHFIRE CONTEXT

Bushfire management is a shared responsibility between the community, Government and industry. An integrated approach is the most effective way to minimise the risk of bushfire and reduce impacts to lives, property and environmental assets. Understanding the roles and responsibilities of each of these groups is important for prevention, being prepared, responding and recovering from bushfires.

8.1 LEGISLATIVE FRAMEWORK

The following Commonwealth and Victorian Acts are relevant to bushfire management and environmental protection in Eden Park:

- Environmental Protection (Commonwealth)
  - Environment Protection Biodiversity Conservation Act 1999.
- Bushfire Management (Victoria)
  - Emergency Management Act 2013,
  - Emergency Management Act 1986,
  - Country Fire Authority Act 1958,
  - Forests Act 1958, and
  - Electricity Safety Act 1998.
- Environmental Protection (Victoria)
  - Planning and Environment Act 1987,
  - Flora and Fauna Guarantee Act 1988, and
  - Catchment and Land Protection Act 1994.

8.2 COMMONWEALTH LEGISLATION

8.2.1 ENVIRONMENT PROTECTION BIODIVERSITY CONSERVATION ACT 1999 (EPBC ACT)

The aim of the EPBC Act is to provide for the conservation of biodiversity and the protection of the environment, particularly those aspects that are considered to be Matters of National Environmental Significance (MNES). The EPBC Act defines nine MNES, these are:

- World heritage properties;
- National Heritage places;
- Wetlands of International Importance (listed under the RAMSAR Convention);
- Listed threatened species and ecological communities;
- Migratory species protected under international agreements;
- Commonwealth marine areas;
- Great Barrier Reef Marine Park;
- Nuclear actions; and
- A water resource in relation to coal seam gas development and large coal mining development.

Under the EPBC Act, actions that are likely to have a significant impact upon MNES require referral and potentially approval from the Federal Environment and Energy Minister to undertake those actions.

One EPBC Act flora species has been observed within the Eden Park study area and recorded in the Victorian Biodiversity Atlas (VBA) in the past 20 years. This includes Matted Flax-lily Dianella ameona which is listed as Endangered under the EPBC Act. Matted Flax-lily has previously been recorded in the south-eastern corner of the study area. All pre and post-fire activities should consider the presence of suitable habitat for this species. One migratory species has previously been recorded within Eden Park including the White-throated Needletail Hirundapus caudacutus. White-throated Needletail is a marine migratory species listed under the CAMBA, JAMBA and ROKAMBA agreements. This species does not breed in Australia and is unlikely to be impacted by pre and post-fire activities. No other matters protected under the EPBC Act are considered to occur within Eden Park.

8.3 VICTORIAN LEGISLATION

8.3.1 BUSHFIRE MANAGEMENT

8.3.1.1 *The Emergency Management Act 2013* (EM Act 2013) and *Emergency Management Act 1986* (EM Act 1986)

The EM Act 2013 Act establishes Emergency Management Victoria (EMV) which consists of the Emergency Management Commissioner (EMC) who is responsible for coordinating the response to major emergencies, and the Chief Executive of Emergency Management Victoria who is responsible for the day-to-day management of EMV being the overarching body for emergency management, coordination of emergency management policy and implementation of emergency management reform.

The EM Act 2013 establishes the State Crisis and Resilience Council and the Inspector-General for Emergency Management. The council is responsible for providing emergency management policy and strategy advice to the Victorian Government. The Inspector-General is responsible for developing and maintaining a monitoring and assurance framework, and evaluating the performance of the sector. Additionally, the EM 2013 Act provides for the development of the State Emergency Response Plan and the State Emergency Recovery Plan.

It operates concurrently with the EM Act 1986 with the intention that the latter will ultimately be repealed.

8.3.1.2 *Country Fire Authority Act 1958* (CFA Act)

The CFA Act establishes the Country Fire Authority that is responsible for the prevention and suppression of fires and for the protection of life in the country area of Victoria. The country area of Victoria is defined as 'that part of Victoria which lies outside the Metropolitan Fire District, but does not include any forest national park or protected public land'.

The CFA Act requires every municipal council and public authority to take all practical steps (including burning) to prevent the occurrence of fires on, and minimise the danger of the spread of fires on and from any land vested in it or under its control or management. It enables the Municipal Fire Prevention Committee (MFPC) that is responsible for issuing permits to burn during the fire danger period and issuing fire prevention notices for hazard removal to private landowners in their municipality

As the primary fire authority responsible for Eden Park, several exemptions are afforded to the CFA with respects to native vegetation clearance in emergency situations such as fire response. This includes exemptions for emergency works and fire protection as stated in Section 52.18-7 of the Whittlesea Planning Scheme.

- Emergency works:
  - The native vegetation presents an immediate risk of personal injury or damage to property and only that part of vegetation which presents the immediate risk is removed, destroyed or lopped.
  - By or on behalf of a public authority or municipal council to create an emergency access or to enable emergency works
- Fire protection:
  - For fire-fighting measures, periodic fuel reduction burning, or the making of a fuel break or fire-fighting access track up to 6 metres wide.

When undertaking vegetation clearance associated with bushfire protection it is recommended that a council planning or biodiversity representative is consulted to ensure vegetation removal is exempt from requiring a permit under the Whittlesea Planning Scheme.

8.3.1.3 *Forests Act 1958* (Forests Act)

Provisions are made under the Forests Act in relation to fire management in State forests. It enables the Forests (Fire Protection) Regulations "the Regulations" which restrict activities that could lead to fire on public land, in particular the lighting of campfires, use of engines, and activities of sawmills and other operators. The Regulations generally apply to land within national parks, State forests and on protected public land. They can also apply to certain parts of private land that border these areas.

With the exception of three municipal managed properties within Eden Park, all land within Eden Park is privately owned and does not come under the jurisdiction of the Forests Act 1958. Despite this, large parcels of public land surround Eden Park which may contribute to future bushfires passing through Eden Park. Therefore, this legislation is relevant to bushfire management in Eden Park.

8.3.1.4 *Electricity Safety Act 1998* (ES Act)

Under the ES Act, companies responsible for energy distribution are required to prepare Bushfire Mitigation Plans. The ES Act additionally requires an annual Vegetation Management Plan pursuant to the Electricity Safety (Electric Line Clearance) Regulations 1999.

Provisions are made under Section 52.18-7 of the Whittlesea Planning Scheme for native vegetation clearance to occur for fire protection under a code of practise prepared under the ES Act. These include:

- To keep the whole or any part of any native vegetation clear of an electric line in accordance with a code of practice prepared under Part 8 of the ES Act.
- In accordance with any code of practice prepared in accordance with Part 8 of the ES Act in order to minimise the risk of bushfire ignition in the proximity of electricity lines.

8.3.2 ENVIRONMENTAL PROTECTION

8.3.2.1 *Planning and Environment Act 1987* (P&E Act)

The P&E Act is the primary State legislation governing the use, development and environmental protection of land in Victoria. The planning legislation provides a framework for integrating planning policies and environmental considerations (e.g. clearing of native vegetation) on local, regional and State levels through instruments such as planning permits and Precinct Plans. These policies and considerations are enacted through the Victorian Planning Provisions (VPP) incorporated under the municipal planning scheme.

Victoria's Permitted clearing of native vegetation – biodiversity assessment guidelines (the Guidelines) (DEPI 2013) provide instructions on how an application for a permit to remove native vegetation is to be assessed under the P&E Act. In accordance with Section 52.18-7 of the Whittlesea Planning Scheme, exemptions apply to native vegetation clearance for emergency works and fire protection. When undertaking vegetation clearance associated with bushfire protection it is recommended that a council planning or biodiversity representative is consulted to ensure vegetation removal is exempt from requiring a permit under the Whittlesea Planning Scheme.

8.3.2.2 *Flora and Fauna Guarantee Act 1988* (FFG Act)

The FFG Act was established to provide a legal framework for enabling and promoting the conservation of all Victoria's native flora and fauna, and to enable management of potentially threatening processes. One of the main features of the FFG Act is the listing process, whereby native species and communities of flora and fauna, and the processes that threaten native flora and fauna, are listed in the schedules of the Act. This assists in identifying those species and communities that require management to survive and identifies the processes that require management to minimise the threat to native flora and fauna species and communities within Victoria.

Under the FFG Act a permit is required to take, kill or destroy flora and fauna species that are listed under the Act.

Four species listed under the FFG Act have been observed within the Eden Park study area and recorded on the Victorian Biodiversity Atlas (VBA) in the past 20 years. This includes two flora species and two fauna species. Both Matted Flax-lily and Austral Crane's-bill have been recorded in the south-eastern corner of the study area. Brush-tailed Phascogale has recently been recorded in the central-west part of the study area. Additionally, it is likely that Brush-tailed Phascogale occur in other parts of the study area containing bushland (J Booth, pers. comm. 8 June 2017). White-throated Needletail has also been previously recorded within the study area. All pre and post-fire activities should consider the presence of suitable habitat for this species.

8.3.2.3 *Catchment and Land Protection Act 1994* (CaLP Act)

The CaLP Act establishes a framework for management and protection of catchments through the management of land and water resources. The CaLP Act is the principle legislation relating to the management of pest plants and animals in Victoria. Under the Act, landowners have a responsibility to avoid causing or contributing to land degradation, including taking all reasonable steps to conserve soil, protect water resources, eradicate regionally prohibited weeds, prevent the growth and spread of regionally controlled weeds and where possible, eradicate established pest animals as declared under the CaLP Act.

Invasive species can cause environmental and/or economic harm or are considered to have the potential to cause such harm. They can also present risks to human health.

The importation and spread of weeds in a post-fire environment is a significant risk to the environmental and agricultural values of Eden Park. This includes resources and materials that are applied to the fire ground for post-fire rehabilitation activities. Measures discussed in Section 7.8 should be undertaken to minimise the potential of weed spread and growth.

8.4 EMERGENCY MANAGEMENT PLANS AND ARRANGEMENTS

The Emergency Management Manual Victoria (EMMV) is the principle document in guiding the responsibilities and arrangements for all agencies with a role in emergency management in Victoria. It is issued by the EMC and complies with requirements of the EM Act 2013 and EM Act 1986. More specifically, the State Bushfire Plan provides an overview of the current plans and arrangements for managing bushfires which are presented below Table 10.

Table 10 Emergency management plans and arrangements in Victoria

JURISDICTION	EMERGENCY MANAGEMENT PLANS	FIRE MANAGEMENT PLANS	AGENCY INTERNAL OPERATING ARRANGEMENT
STATE	Emergency Management Manual Victoria	State Bushfire Plan 2014	Joint agency SOPs Individual agency SOPs
REGIONAL	Regional Emergency Response Plans Regional Emergency Relief and Recovery Plans	Regional Strategic Fire Management Plans	CFA/ DELWP Local Mutual Aid Plans CFA Regional Operational Management Plans DELWP Regional Readiness and Response Plans DELWP Fire Management Plans
MUNICIPAL	CoW Municipal Emergency Management Plan	CoW Municipal Fire Management Plan	DELWP Fire Operations Plans (for DELWP Fire Districts)

8.5 ROLES AND RESPONSIBILITIES

8.5.1 THE EMERGENCY MANAGEMENT COMMISSIONER

Under the EM 2013 Act, the EMC is responsible for coordinating response and recovery activities as well as managing consequences to major emergencies (including ensuring appropriate control arrangements are in place) and operating effectively during major emergencies. Major emergencies are defined as either:

- Class 1, includes major fires and other major emergencies where the control agency is CFA, MFB or VIC SES. The EMC will appoint a State Response Controller to manage the response.
- Class 2, includes any other major emergency that is not a Class 1 emergency or a warlike act, act of terrorism, hijack, siege or riot. The EMC will direct the appointment of a State Controller if one has not been appointed by the control agency for the Class 2 emergency. The EMC is also responsible for managing the State Control Centre, providing government (and appropriate ministers) timely and accurate advice about major emergencies, setting operational standards and procedures, planning, risk mitigation and culture change to ensure the sector works effectively and together with the community.

8.5.2 COMMUNITY, GOVERNMENT AND INDUSTRY

The community, Government and industry roles and responsibilities for prevention, being prepared, responding and recovering from bushfires in Eden Park are presented in Table 11. Each group may take on the following roles:

- Prevention - the elimination or reduction of the incidence or severity of emergencies and the mitigation of their effects;
- Preparedness - the establishment of structures, development of systems and testing and evaluation by organisations and communities of their capacity to perform their allotted roles in an emergency;
- Response - the combating of emergencies and the provision of rescue and immediate relief services; and
- Recovery - the assisting of people and communities affected by emergencies to achieve a proper and effective level of functioning.

Table 11 Community, Government and industry roles and responsibilities for bushfire management in Eden Park

GROUP	ROLE	RESPONSIBILITIES
Electrical distributor (AusNet & Jemena)	Prevention Recovery	AusNet and Jemena are Australian energy companies that operate within Victoria. It is their responsibility to maintain the energy supply across regions in which they operate and restore any lost supply within their jurisdiction.
Country Fire Authority (CFA) - Eden Park	Prevention Preparedness Response Recovery	CFA is a volunteer based agency that responds to bushfires, house fires, industrial fires, road accidents, rescues and other emergencies. They are the lead agency for fire on private land within Country Area Victoria. The CFA broadens community awareness and preparedness to minimise the impact of a bushfire on the community.
Department of Economic Development, Jobs Transport & Resources (DEDJTR)	Response Recovery	DEDJTR is a Government department that supports DELWP and CFA in assisting farmers repair and restore fences damaged by fire or suppression activities by collecting information from affected primary producers and refer private fencing damage to municipal councils, and fences on public land to DELWP.
Department of Environment, Land Water & PlannIng (DELWP)	Prevention Response Recovery	DELWP is a Government department responsible for the formulation of policy and regulation for bushfire management in state forest, national parks and protected public lands and planning and delivery of programs to reduce the risk of bushfire in state forest, national parks and protected public lands. DELWP is a support agency to CFA for fires on private land.
Eden Park landowners	Prevention Preparedness Response Recovery	It is a landowner's responsibility to maintain awareness and manage bush fire hazards and risks on their property.
Melbourne Water (MW)	Prevention Preparedness Response Recovery	MW is a Government owned statutory authority managing Melbourne's water including supply catchments, sewage, rivers, creeks and other major drainage systems. MW protects and manages water supply catchments, to prevent contamination, and provides support services including providing personal (trained fire fighters) and equipment such as bulldozers, water carts, generators and water-bombing helicopters during bushfire events.
Municipal Fire Management Planning Committee (MFMPC)	Prevention Preparedness Response Recovery	The Whittlesea MFMPC is responsible for providing a strategic and integrated approach to fire management for the Whittlesea municipality. The committee plans for fire management in a manner that coordinates cooperative fire management activities across agencies and provides information to and engages with the community on matters related to fire management planning.
Port Phillip and Westernport Catchment Management Authority (PPWCMA)	Prevention Preparedness Recovery	The PPWCMA provides leadership to a range of stakeholder groups and works to deliver integrated catchment management and sustainability of the region's catchment assets by building cooperation, coordination and partnerships amongst these groups. The PPWCMA works with community groups, councils and Government agencies to develop and implement projects for protecting, preparing and restoring from bushfires in the region.
Council of Whittlesea (CoW)	Prevention Preparedness Response Recovery	The CoW has responsibilities under the Emergency Management Act to undertake municipal risk assessment and develop programs such as the MFMP to treat those risks, to carry out risk-deduction activities such as roadside slashing and community awareness programs, to develop a Municipal Emergency Management Plan to support agencies such as the CFA, DELWP and Victoria Police to respond to the emergency, and to manage the local recovery process, working with DEDJTR and DELWP to support the community and rehabilitate both public and productive land.
Victoria State Emergency Service (VICSES)	Preparedness Response	The VIC SES is a volunteer-based organisation providing emergency assistance in floods, storms, earthquakes and road rescue. They provide assistance in search and rescue operations and a support role during major bushfires.

8.6 RESPONDING TO A BUSHFIRE IN EDEN PARK

The State Emergency Response Plan (Part 3 of the EMMV) outlines the arrangements for management of all emergencies in Victoria. It uses a three-tiered approach to managing bushfires from an incident to major bushfires at a regional and state level.

A bushfire may be classed as an incident if it has a definite duration yet still requires human intervention while a major bushfire has the potential to cause loss of life, extensive damage to infrastructure, the environment and the community. Major fires are deemed as Class 1 emergencies.

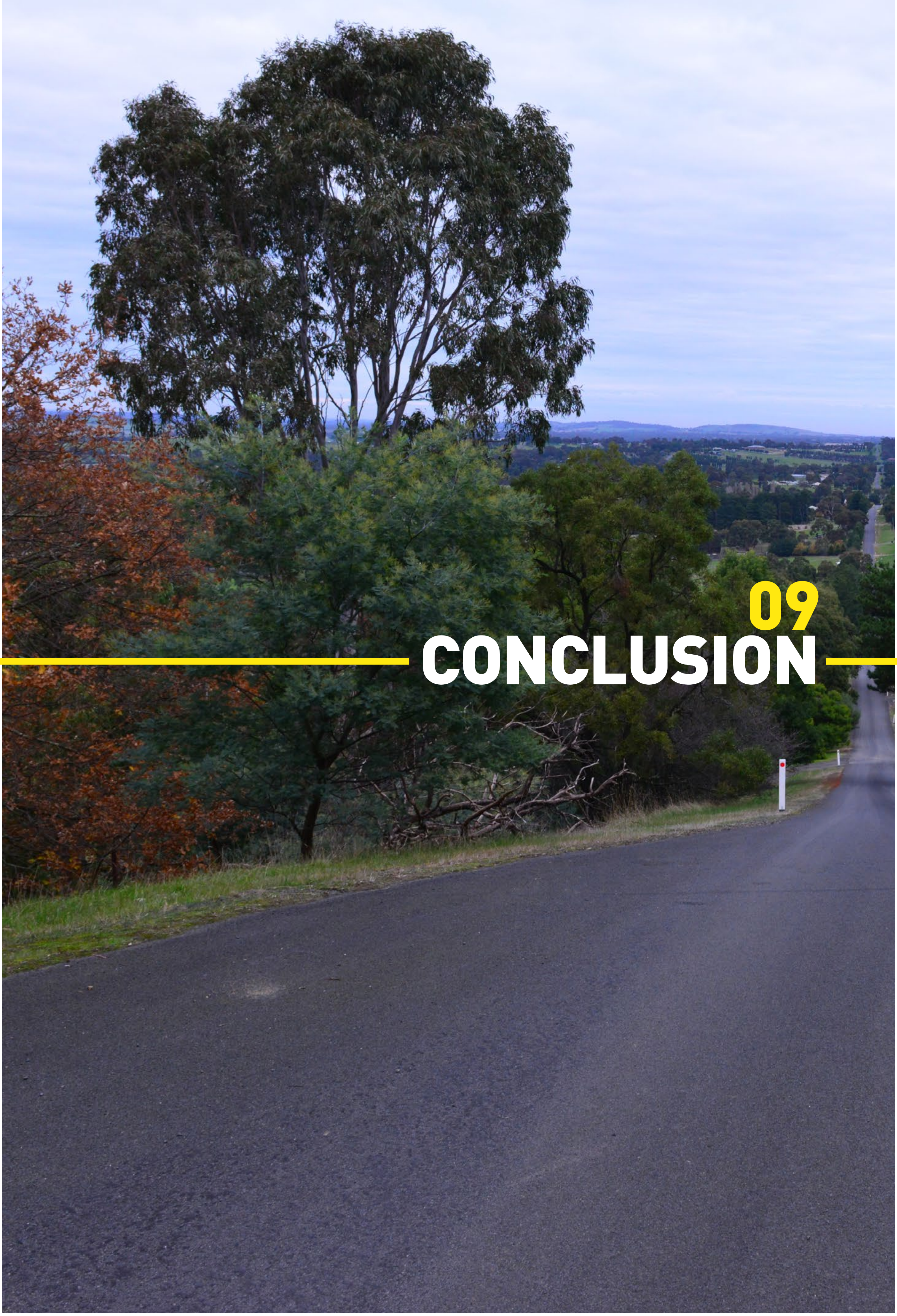
The State Emergency Response Plan is intended to identify agencies and their role according to the State Emergency Management Priorities and to identify a single line of control for an emergency.

For Eden Park the CFA is the fire service agency responsible for the first response to a bushfire incident due to the area being predominately private land. In the case of a major bushfire, the CFA would be the response agency to a bushfire with DELWP providing support. However, all agencies, that are capable, may provide support during the event of a major bushfire. The EMC leads the State response to, and those that have potential to become, a major bushfire.

LEVEL	CONTROL	RESPONSE
	Emergency Management Commissioner	
State Major Bushfire	State Response Controller	CFA DELWP as key support with other agencies support
Region Major Bushfire	Regional Controller	CFA DELWP as key support
Local Bushfire Incident	Incident Controller	CFA

Figure 8 Line of control for a bushfire in Eden Park

Note: The State Emergency Response Plan may be used to identify roles and line of control, however specific roles and responsibilities are confirmed for each fire scenario



09 CONCLUSION

Since European settlement Eden Park has avoided the impacts of large scale bushfire leaving the elevated bushland areas of Eden Park un-burnt for a significant period of time. Subsequently, Eden Park is considered an area at high risk of bushfire within the City of Whittlesea. Native vegetation has generally been retained in elevated area of Eden Park which provides an important fauna habitat refuge for species including the FFG Act listed Bush-tailed Phascogale. These areas are also significant in that they provide some of the last remaining privately owned intact woodland areas of a large size within the Highland Southern Fall bioregion.

A combination of diverse landowners and parcel sizes, a fragile landscape and non-conventional infrastructure planning creates a landscape that is vulnerable to bushfire impacts. Eden Park contains areas with steep topography and soils that are inherently susceptible to soil erosion. When combined with post-fire soil conditions such as soil water repellency, loss of soil protective layer and poor soil structure, Eden Park is considered to be particularly vulnerable to post bushfire erosive forces. Therefore, this report not only incorporates post-fire erosion mitigation treatments, it considers ways to reduce the likelihood of bushfire occurring and reducing fire intensity by undertaking pre-fire mitigation treatments. This includes implementing bushfire hazard reduction methods in accordance with appropriate guidelines along considering drainage management techniques.

Areas with a likelihood of erosion following a fire have been modelled and are included in this report. A post-fire erosion mitigation treatment catalogue has also been prepared specifically to Eden Park conditions and provides advantages and limitations of each method. This report also provides context around the roles and responsibilities of stakeholders and agencies following a bushfire. This includes the legislative framework of emergency events relevant to Eden Park.

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11
USEFUL LINKS

AUSTROADS GUIDE TO ROAD DESIGN:

This guide is intended to provide designers with a framework that promotes the concept of context-sensitive design for roads. It covers topics including drainage, culverts, floodways and the roadside environment.

http://www.austroads.com.au/road-construction/road-design/guide-to-road-design?_sm_au_=iVVbLFHqZnbrVPMk

BLAZE AID:

Volunteer based organisation that works with families and individuals in rural Australia after natural disasters such as fires and floods.

http://blazeaid.com.au/

CITY OF WHITTLESEA WEBSITE

This website provides guidance on local council matters including building, planning, development, community support, waste and environment. It also provides information on grants, awards and competitions which may be of assistance for erosion and bushfire planning.

https://www.whittlesea.vic.gov.au/community-support/grants-awards-and-competitions/

COUNTRY FIRE AUTHORITY – HOW TO PREPARE YOUR PROPERTY

Provides guidance and advice on vegetation management, tree management, landscaping, home improvements, farms and burning off as preparation for a bushfire event. The website includes information on planned burns in your area, notifications of incidents and contact details for registering burns, contacting the CFA and local area advice.

http://www.cfa.vic.gov.au/plan-prepare/how-to-prepare-your-property/

EMERGENCY MANAGEMENT VICTORIA

This website provides advice on how emergency management is handled in Victoria, recovering from emergencies, grants and current emergencies.

https://www.emv.vic.gov.au/

APPENDICIES

APPENDIX A EROSION TREATMENT CATALOGUE
APPENDIX B MAPPING TECHNICAL NOTE
APPENDIX C HAZARDOUS TREE MANAGEMENT

APPENDIX A
EROSION TREATMENT CATALOGUE

Treatments for land, channel, roads, tracks and biodiversity have been covered in this catalogue which includes a description of treatment objectives and treatment scenarios. This treatment catalogue compiles information from the a Burned Area Emergency Response (BAER) Report prepared for the Kilmore East – Murrindindi bushfire along with information from the Erosion Control Association (IECA) Australasian Chapter's Best Practice Erosion and Sediment Control book. Other resources have been utilised including local experiences of implementing post-fire erosion control following Black Saturday.

PART A: LAND TREATMENTS

HYDRO-MULCHING

Purpose of Treatment

Hydro-mulch is used in high-burn severity areas with increased erosion potential and slopes greater than 15 degrees. The primary purpose of hydro-mulching is to stabilise soils however native understory seed can also be applied to enhance vegetation regeneration. This has the added benefit of stabilising hillslope soils long-term after hydro-mulching material has broken down.

Description

Hydro-mulching involves the spraying of a slurry mix consisting of seed +/- fertiliser, paper pulp or wood pulp and acrylic polymer or other tackifier (see Plate 14). Hydro-mulch can be sprayed directly from a truck up to 30 metres away, or via hose extensions up to 100 metres away. Seed within the hydro-mulch mix generally sticks to the pulp which improves conditions for seed germination so long as moisture is maintained. The rate of application should be between 2.2 to 3.4t/ha with a desirable minimum of 80 to 100% cover (IECA 2010). Different organic based soil binders and tackifiers can be used to achieve short term or long term stabilisation results. Similarly, various application rates can be used for different slope grades. Experienced local contractors should be used to undertaken hydro-mulching.

Suitable sites

- Soils with high-burn severity and high-erosion likelihood;
- Slopes greater than 15 degrees without effective soil cover; and

Limitations

- Dry hydro-mulch is easily damaged by vehicular or pedestrian traffic (which allows water to enter under and detach the matrix);
- Runoff causing rilling above or within hydro-mulched areas may break up the hydro-mulch blanket;
- Long and steep slopes may lead to riling as run-off concentrates;
- Vehicular access may limit where hydro-mulching can be applied;
- Cost and time of application; and
- Availability of indigenous seed to add to hydro-mulching mix.

Other Considerations

- Coir-logs may be required in areas of potential riling to slow and disperse water flow to prevent the hydro-mulching blanket breaking up.
- The use of fibrous mediums for erosion control (including mediums such as straw, paper and organic matter) is a growing area of research and new products are becoming available regularly. It is recommended that the most suitable fibre application method is used.

Plate 14 Hydro-mulching forming a protective soil layer (USDA 2006)

BONDED FIBRE MATRIX

Purpose of Treatment

Bonded Fibre Matrix (BFM) treatment is the application of organic matter, water and non re-wettable glues to soil at risk of erosion. The BFM is applied by hydraulic equipment (i.e. truck mounted blowers) and performs a function similar to erosion control blankets once dry. BFM and other forms of light mulch can be used in a post-fire setting to provide suitable seed germination conditions and reduce soil loss. The surface cover and application rate of BFM are critical to erosion control. BFMs reduce raindrop impact and wind erosion, assist in reducing moisture loss from the soil and reduce surface sealing.

Description

BFM has a viscous bonding agent that dries to form a protective skin over the soil surface. They contain long wood-fibre strands as the basis for the mulch. Mulch, glue, seed and fertiliser are all contained within the slurry. The process differs from hydro-mulching due to the incorporation of non-wetting glues, thus allowing better performance in wet environments. A minimum required application rate of 0.5kg/m2 is typically specified with a minimum 400kg/0.01km2 of non re-wettable tackifier. Soil preparation, treatment and testing are critical for successful vegetation establishment.

Suitable sites

- Steep slopes;
- Areas where heavy rainfall could dislodge loose mulch;
- Clayey soils that could potentially release high levels of turbidity; and
- Areas that have been identified for seeding.

Limitations

- Runoff causing riling above or within BFM areas may break up the BFM blanket;
- Long and steep slopes may lead to riling as run-off concentrates;
- Vehicular access may limit where BFM can be applied;
- Cost and time of application;
- Availability of indigenous seed to add to hydro-mulching mix;
- Dry BFM is easily damaged by vehicular or pedestrian traffic;
- BFMs normally require 12 – 24 hours to dry before becoming fully effective;
- A short-term erosion control technique (approximately 2 to 6 months);
- Should not be placed directly onto dispersive soil; and
- Wind may blow BFM offsite.

Other Considerations

- Most useful during heavy rainfall.
- Can be used without seed content as a non-vegetated, short-term erosion control technique but not recommended.

STRAW MULCHING

Purpose of Treatment

Straw mulch provides immediate ground cover and protects the soil from erosion and loss of nutrients. Straw has typically been the most commonly used mulch, particularly in association with seeding. Mulch can reduce downstream peak flows by absorbing rainfall and allows pre-wetting of water repellent soil. Straw helps to secure the soil seedbank or manually broadcast seed. Straw mulch on burned areas helps maintain favourable moisture for seed germination and growth. Straw can be applied manually by hand crews, via truck mounted straw blowers or aerially by helicopter in broad scale agricultural settings. When straw is applied with truck mounted straw blowers, indigenous seed may be applied initially followed by straw and then a tackifier to hold straw in place (three stage process). Approximately 1 ha can be applied per truck each day. Straw mulching may be a suitable treatment in areas of Eden Park with smaller allotments as straw can be hand spread by individual landowners.

Description

Straw mulch with weed-free straw helps provide temporary cover to erosion-vulnerable areas as a result of the fire. Straw can be applied by hand or straw blowers from a light truck. Past studies have shown that straw mulch is an effective treatment when applied to suitable sites and appropriate groundcover is achieved. Various sources suggest that at least 2.5 t/ha with at least 70% cover should be applied for best results (USDA 2006). Straw has been suggested as providing greater reductions in erosion than hydro-mulching due to straw having longer fibres that require greater shear force to displace. Although straw can be moved by runoff, straw can interlock along the contour allowing it to store sediment and slow velocities.

Suitable sites

- Soils with high and moderate burn severity and high erosion likelihood;
- Slopes up to 30 degrees without effective soil cover;
- Upper slopes of catchment with high and moderate burn severity;
- Areas that have been identified for seeding; and
- Areas that do not receive high winds.

Limitations

- Availability of certified weed free straw;
- Potential germination of high risk weeds;
- Water runoff moving straw offsite;
- Wind blowing straw offsite;
- Logistics of moving straw around fire effected area;
- Inadequate application resulting in limited erosion control or suppressing vegetation growth;
- Vehicular access may limit where hydro-mulching can be applied; and
- Availability of indigenous seed.

Other Considerations

- Coir-logs may be required in areas of potential rilling to slow and disperse water flow and prevent straw from washing away.

FIBRE BLANKET

Purpose of Treatment

Fibre blankets are used on sites small sites around critical assets such as waterways that require immediate soil cover. When properly implemented fibre blankets are effective in reducing soil loss and sedimentation. They tend to be a temporary erosion control technique for exposed soils that are not subject to concentrated flow. Critical to the performance of the fibre blanket is the ability to control raindrop impact and sheet erosion within the underlying soil. Intimate contact between the blanket and soil is fundamental to successful revegetation.

Description

Fibre blankets come in a variety of materials including wood fibre, wool, recycled fibre, coir (coconut fibre), straw and jute (plant product) and are generally used in conjunction with seeding or revegetation. Fibre blankets are used on sites that require immediate soil cover and can be used on moderate sloping batters, embankments and other sheet-flow environments (see Plate 15). The thinner blanket type allows vegetation growth up through the blanket (ideal for placing over seeded soil). Thicker varieties of blankets are more desirable for weed control purposes. Wind damage resistance is related to the spacing of anchor pins and the strength of the root reinforcing and/or mulch.

Suitable sites

- High-burn severity areas;
- Presence of water-repellent soils;
- Bedrock areas with low infiltration and high runoff;
- Ground surface areas free of grass and objects; and
- Low to medium velocity sheet flow with suitable anchoring.

Limitations

- Temporary erosion control technique;
- Synthetic blanket reinforcing can entrap wildlife such as snakes, birds and lizards;
- Unless plant establishment is quickly achieved, most 100% organic-based blankets can experience slips (distortion) when placed on steep slopes.

Other Considerations

- Synthetic reinforced fibre blankets should ideally be avoided within bushland and other areas where they could endanger wildlife such as ground-dwelling animals.
- 'Jute' blankets have a service life of around three months, whereas 'Coir' blankets (made from coconut fibres) last around the same time as a domestic door mat when placed in direct contact with soil.
- Ideally not placed over dispersive soils as this can lead to displacement of the blanket or severe rilling under the blanket.

Plate 15 Fibre blanket near waterway where sheet erosion may occur

FIBRE ROLLS

Purpose of Treatment

Fibre rolls form part of an erosion control and stabilisation treatment strategy by trapping sediment and displaced soil. They are suited to high burn severity areas where there is a risk of soil loss and/or water quality deterioration. Fibre rolls are used where log erosion barriers are not practical.

Description

Fibre rolls are designed to slow overland runoff, reduce the length of a slope (to slow overland flow velocity) and improve infiltration. They are prefabricated rolls manufactured from rice straw and wrapped in jute netting or ultraviolet degradable plastic (see Plate 16). Approximately 23cm in diameter and up to 7.5m long, fibre rolls are designed for low-surface flows (i.e. not stream channels or gullies). Fibre rolls trap sediment, provide a seedbed for vegetative recovery and if water repellent soils are present can improve infiltration. Fibre rolls can function for up to two years but remain for several years after placement.

Suitable sites

- Heritage sites or other high value areas at risk;
- High and moderate burn severity areas;
- Slopes with less than 20% of the original ground cover remaining;
- Slopes between 10 and 20 degrees;
- Soils not less than approximately 20cm deep;
- Work best when recessed into a slope with complete ground contact and firm anchoring; and
- Coarse-grain soils.

Limitations

- Can attract small rodents, which in turn attract snakes that may be trapped in the netting;
- Availability of certified weed free fibre rolls;
- Difficult to install and awkward to transport; and
- Do not reduce erosion but trap sediment on a slope.

Other Considerations

- Fibre rolls may be used around existing tunnel erosion areas to divert sheet-flow runoff around tunnels;
- Inspect after each storm event; and
- Fibre rolls should be installed in a U-shape to trap sediment and disperse runoff velocities.

Plate 16 Fibre roll on slope where erosion control is required

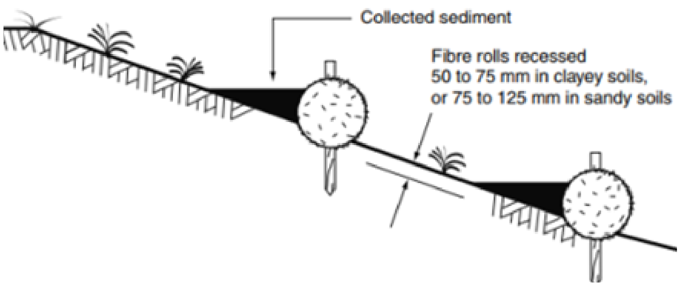


Figure 9 Fibre role application drawing (IECA 2010)

SILT FENCE

Purpose of Treatment

Silt fences form part of an erosion control and stabilisation treatment strategy by trapping sediment and displaced soil. They are placed in areas of high value including water quality, aquatic and heritage assets. Silt fences can be used as part of a monitoring programme to monitor sediment movement. Erosion reduction from the use of silt fences can be highly effective when installed properly and maintained appropriately, however they have a poor capture rate for the finer silt particles (<0.02mm).

Description

Silt fences are a geotextile fabric installed with wooden posts or metal star pickets. The typical height of a silt fence is 600 to 700mm and at least 300mm of fabric must be buried either in a 200mm trench or under a continuous 100mm high layer of aggregate or sand (not earth).

Suitable sites

- Areas accessible for inspection and maintenance;
- In areas with high value where other forms of sediment traps may not be ineffective; and
- Ideally installed along the contour (i.e.: on a level surface across a slope).

Limitations

- Require significant installation effort;
- Require on-going maintenance and monitoring;
- Proximity to vehicle access;
- Most fabrics have an effective service life of around six months;
- Time consuming to install; and
- Can cause concentration of runoff if poorly located (or installed).

Other Considerations

- Once the site is stabilised remove the fences;
- If the fence is located across contour ensure regular ‘returns’ to avoid water concentrating along the fence; and
- Inspect the fence at least weekly and after any significant rain.

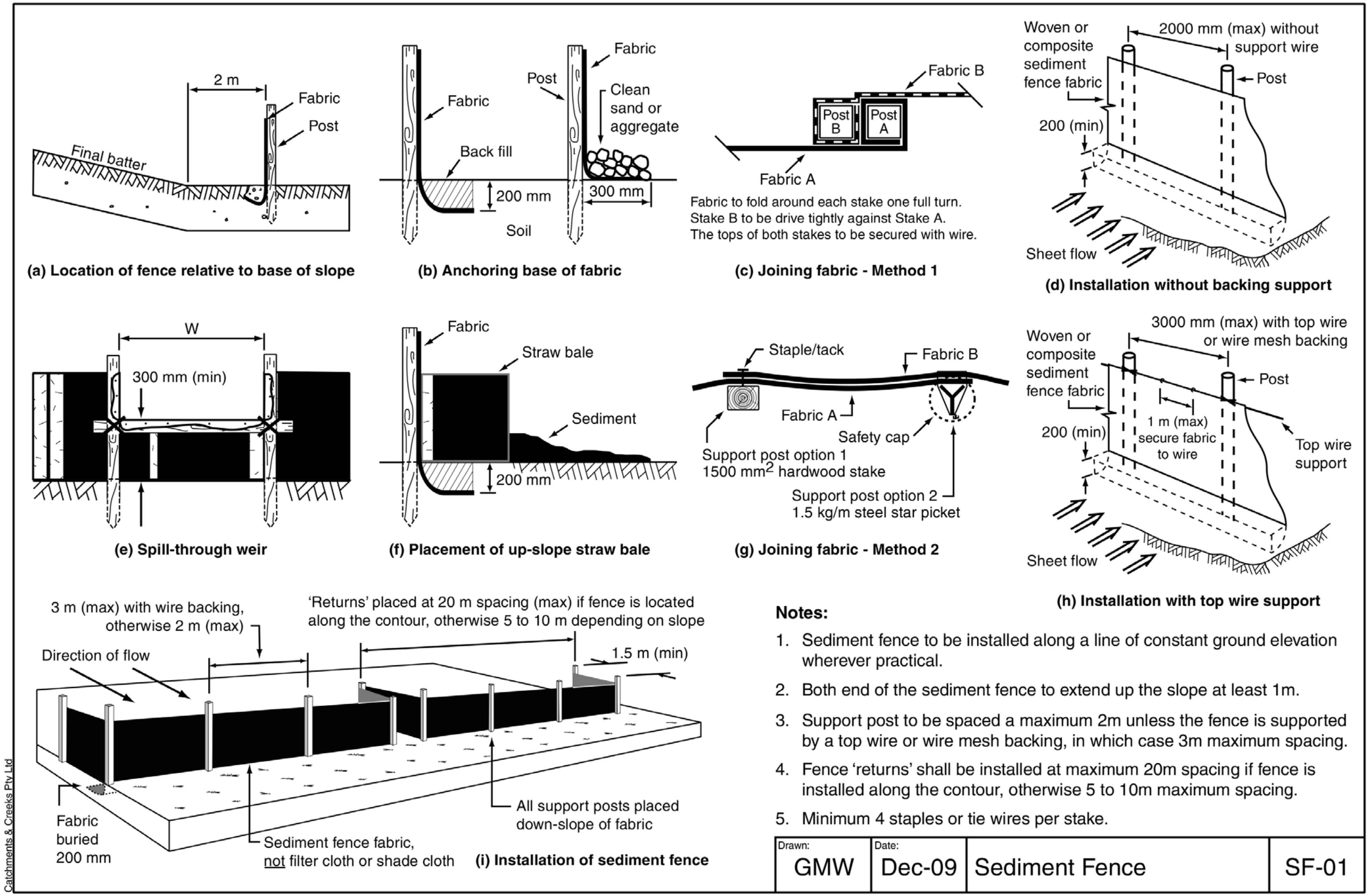


Figure 10 Silt fence assembly diagram (IECA 2010)

LOG EROSION BARRIER

Purpose of Treatment

Log erosion barriers (LEBs) are used in moderate and high burn severity forested areas where hillslope erosion rates are increased significantly from fire. They reduce erosion by shortening slope length, improving infiltration, trapping sediment and increasing surface roughness. LEBs can be installed using fallen timber and can provide important ground dwelling habitat after a fire event.

Description

LEBs are logs that are placed in a shallow trench or on the contour of a slope (see Plate 17) and trap sediment if laid in a bricklayer pattern. The volume of retained sediment is dependent upon the slope, the size and length of the trees and upon correct implementation. Those LEBs with soil end berms trap more sediment. End berms can be earthen or made out of coir logs and are placed at the end of logs and run up-slope to trap sediment and prevent terminal scouring.

Suitable sites

- Slopes between 15 and 30 degrees;
- Slopes with moderate and high burn severity;
- Catchments with high values at risk; and
- Water repellent soils are present.

Limitations

- Soil depths, rainfall intensity and soil water holding capacity can dictate LEB effectiveness; and
- Areas with rocks can hinder correct installation of LEB and result in erosion.

Other Considerations

- Ensure correct implementation as trees improperly bedded can cause runoff and erosion under or (for those not placed on the contour) at the ends of the log.
- Untrimmed limbs can prevent ground contact and result in erosion.

Plate 17 Log erosion barriers on severely burnt slope

CATCH DRAINS

Purpose of Treatment

Catch drains can be used to direct stormwater runoff around disturbed soil or an unstable slope. They are designed to collect sheet flow runoff from an unstable slope before it causes rill erosion. Catch drains can collect sediment laden runoff downslope of a disturbance and direct it to a sediment trap.

Description

Catch drains are small open channels formed at regular intervals down a slope, or immediately down-slope or upslope of sensitive areas. These channels are usually excavated with U-shaped excavation tools or a grader blade. They typically have standardised cross-sectional dimensions. 'Push-down' (channel-bank) catch drains are formed by pushing the excavated material down-slope of the drain. Catch drains are relatively quick and inexpensive to establish (or re-establish if disturbed).

Suitable sites

- Low gradient;
- Upslope of batters;
- Intermittently down long, exposed slopes; and
- Upslope of sensitive areas located within overland flow paths.

Limitations

- Only suitable for relatively small flow rates;
- Can cause flow concentration and significant erosion problems if overtopped during heavy storms;
- Short to medium term solution;
- Heavy earth moving equipment required; and
- Not suitable for dispersive soils.

Other Considerations

- Catch drains must be designed for local hydrological and soil conditions.
- If earth-lined catch drains discharge to an unstable outlet then erosion can occur downstream of the outlet (commonly experienced when cut into dispersive soils).
- Subsoil erosion-resistance should be investigated before planning or designing.
- A suitable sediment trap should be included in plans if the diverted water is expected to contain sediment.
- Maintenance schedules should include regularly inspection of all catch drains and in particular, after storm events.

PART B: WATERWAY TREATMENTS

FIBRE BLANKET

Refer to 'Land Treatment' – 'Fibre Blanket' for application of fibre blankets as the same principles apply around riparian zones. Fibre blankets are used to stabilise the riparian zone and stream bank only- not within a stream.

CHECK DAMS

Purpose of Treatment

Check dams trap sediment and slow water movement reducing the sediment load entering waterways. The sediment deposits of soil, ash and organic material can serve as fertile sites that encourage vegetation recovery.

Description

Check dams can be constructed from straw, log, sand bags, fibre rolls, stiff grass or rock depending on the location and availability of materials. Strawbale check dams are a temporary erosion control measure built with three to five strawbales depending on the size of the channel. Strawbale check dams are placed in ephemeral channels with a moderate gradient to trap and reduce sediment delivered to channels (see Plate 18). Log check-dams are built from logs within the fire area (see Plate 19). The size, slope, and space between logs influences the amount of material trapped. Rock check-dams are used where there are high values at risk and a rock source is close by.

Suitable sites

- Swales with gentle gradient that allow for sediment storage;
- High burn severity areas with highly erodible soils;
- Areas with less than 20% groundcover;
- Catchments with high values at risk; and
- Catchments with small drainage areas, generally less than 2 hectares.

Limitations

- Treatment success varies if not properly installed;
- Not suitable for larger catchments greater than 2 hectares;
- Short to medium term (two to five year) rehabilitation period;
- Can fill to capacity from storms and require maintenance;
- Approximately 20% of the check-dams fail, resulting in further damage;
- Failure mechanisms include undercutting of water around the structure; and
- Not suitable for steep gradients.

Other Considerations

- Hydraulic, hydrologic and sediment yield analysis is recommended.
- The crest of the check should be curved or a 'v notch' should be designed in the centre to allow flow over the centre of the dam, to reduce scouring down the banks of the drain.
- Inspection after storm events is recommended.
- All types of check dams appear to work better when implemented in gentle gradients high in the catchment, and placed in a series.

Plate 18 Strawbale check dam with energy dissipater (USDA 2006)

Plate 19 Log check dam from trees in burnt area

STREAM BANK ARMOURING

Purpose of Treatment

Streambank armouring reduces impacts such as bed and bank scouring from increased peak flows. In some catchments, waterway banks are a major source of sediment after a bushfire.

Description

Armouring is the placement of rock along the waterway bank to reduce erosion (see. Armouring may include the permanent placement of inter-locking rock to protect stream banks with existing or at risk of erosion.

The critical design parameter is rock size which is primarily dependent on flow velocity, rock shape and density, and the longitudinal slope of the waterway or channel. The placement of interlocking rock is critical to the prevention of further blowouts surrounding the armouring.

Suitable sites

- Locations exhibiting existing erosion problems;
- Highly erodible streambanks; and
- Areas with high values at risk.

Limitations

- Proximity to suitable rock source;
- Haul distance; and
- Size of material required.

Other Considerations

Ensuring the rocks are appropriately recessed into the terrain to allow the unrestricted entry of water runoff into the channels.

Plate 20 Armouring of roadside drainage channel

GEO LOGS (COIR LOGS)

Purpose of Treatment

Geo logs are 'isolation barriers' primarily used to separate recently established lower-bank vegetation from minor wave action or persistent stream flows.

Description

Geo logs are large diameter densely packed tubes bound together with netting. Geo logs are typically 200, 300 and 500mm in diameter and in lengths of 1.2 to 3m. They are typically manufactured from 100% bio-degradable materials such as jute, coir (coconut fibre) or a combination of both.

The logs are used to as flow control to channel water in a chosen direction and typically used in a single row (see Plate 21) or staked to create terraces (see Plate 22). Critical design consideration include the log placement relative to the water's edge and the method of securing, such as with stakes or tie cords (see Figure 11).

Suitable sites

- Ephemeral streams subject to flood; and
- Tracks and trails.

Limitations

- Should only be used as a temporary measure where revegetation will provide all necessary long-term bank stability;
- The geo logs degrade over time and the typical operating life is around 2 - 4 years depending on moisture conditions; and
- Maximum allowable stream velocity is around 1.5m/s. If stream flows overtop the logs then bank scour may occur.

Other Considerations

- The logs must be secured properly, by staking around either side not through the log.
- The use of geo logs that contain non-biodegradable synthetic netting is not recommended in bushland and riparian areas.
- Placement of rock or logs laterally up the bank can reduce erosion if the stream flows overtop the logs.
- Post installation monitoring should be undertaken after high flow events for the first year.

Plate 21 Geo log placement in a single line (IECA 2010)

Plate 22 Terraced geo logs (IECA 2010)

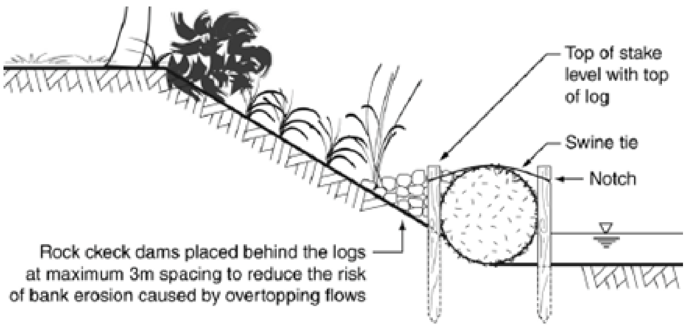


Figure 11 Cross section showing typical placement of geo log with additional bank erosion protection (IECA 2010)

PART C: ROADS AND TRACKS

CULVERT MODIFICATION

Purpose of Treatment

Culvert modification or upgrades may be required to avoid loss of critical road infrastructure, erosion and sedimentation of drainage lines. These modifications are equally applicable to both municipal and private drainage assets as drainage technologies or catchment conditions may have changed since the initial installation of culverts. Therefore, a review of culvert drainage capacity and condition assessment may be required. Culvert modification treatments include debris racks, riser pipes and overflow structures.

Description

a. Debris rack
Debris racks are structural measures that protect culverts from plugging with debris and causing potential stream diversion. Debris varies in size and includes sediment, rock, small and large limbs, and logs.

b. Riser pipe
Riser pipes are vertical pipe extensions that help prevent culverts from plugging with sediment and floating debris. The pipes capture sediment and reduce downstream impacts to water quality. Riser pipes also reduce peak flows by storing water and sediment. Risers are used to protect road infrastructure from failure.

c. Overflow structure
Overflow structures are used on roads to control runoff across the road prism and to protect the road fill. Structures are placed in defined channels, or more commonly, in areas between defined channels where increased stormwater runoff is predicted due to reduced infiltration.

Post-fire stormwater runoff comes from various sources including hillslopes, waterways and defined road drainage structures. Controlling the runoff to avoid culvert failure, maintain access, and prevent road and hillslope erosion is important.

Overflow structures can consist of armoured rolling dips (see Plate 23), overside drains (see Plate 24) and overlapping rock-level spreaders.

Suitable sites

a. Debris racks
- High flow drainage lines downstream of a high burn severity area.

b. Riser pipe
- Drainage lines (confined) that have high bedload transport;
- Drainage lines (waterways) that have high bedload transport capabilities; and
- Ephemeral drainage lines.

c. Overflow structure
- Roads located below high and moderate burn severity areas;
- Road segments that have a long continuous grade and infrequent drainage; and
- Roads that have infill drainage.

Limitations

- Cost of installation.

Plate 23 Armoured Rolling dip (USDA 2006)

Plate 24 Rock lined overside drain (Roberts 2017)

MITRE DRAINS

Purpose of Treatment

Mitre drains relieve the flow of water in table drains before it reaches an erosive volume or velocity by directing it from the shoulders of a road to a stable discharge area. They are simple, low-cost structures that allow the passage of vehicles without affecting their speed.

Description

Mitre drains involve forming a cut into the road edge to direct flows from table drains or crowned road surfaces into adjoining land (see Plate 25 and Figure 12).

Suitable sites

Mitre drains are most commonly used in elevated regions where velocities in table drains is greatest however they provide effective drainage in a range of situations and grades are particularly effective when used in association with crowned surfaces. This treatment may be suitable for private driveways or farm tracks on steep or undulating terrain.

Limitations

- Mitre drains spaced too far apart leading to high velocity flows and mitre drain failure;
- Potential loss of roadside vegetation; and
- Heavy earth moving equipment required.

Other Considerations

- Suitable to be used in association with crowned road surfaces.
- Excavate to a depth of no more than 300 mm and a grade between 1:50 (1degree) and 1:20 (3 degrees) – a low grade will encourage sediment to settle and deposit (see Figure 12 for CoW design drawing).
- Consideration should be given to including a rock lining of the mitre drain to reduce flow velocity and the associated risk of scouring.
- Remove sediment build-up in the mitre drain and any windrowed soil blocking the inlet.

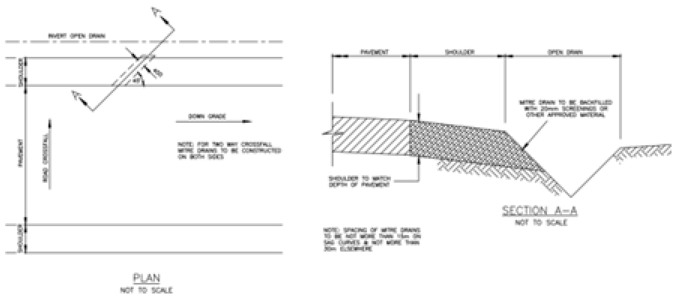


Figure 12 CoW mitre drain drawing (CoW 2014)

Plate 25 Mitre drain example (Roberts 2017)

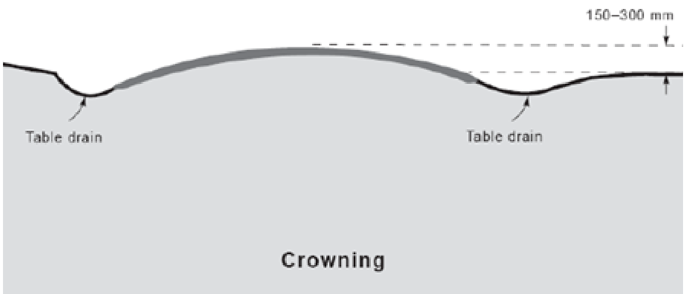


Figure 13 Figure showing crowning drainage (OEH 2012)

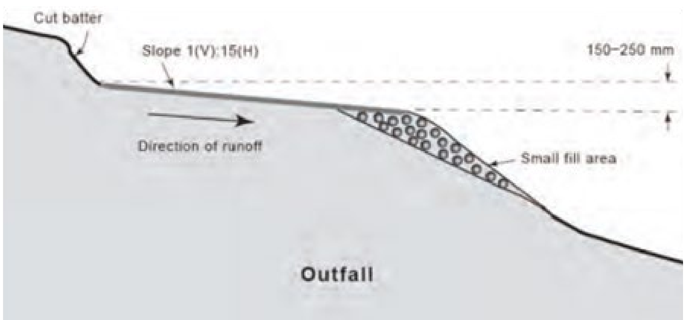


Figure 14 Figure showing outfall drainage (OEH 2012)

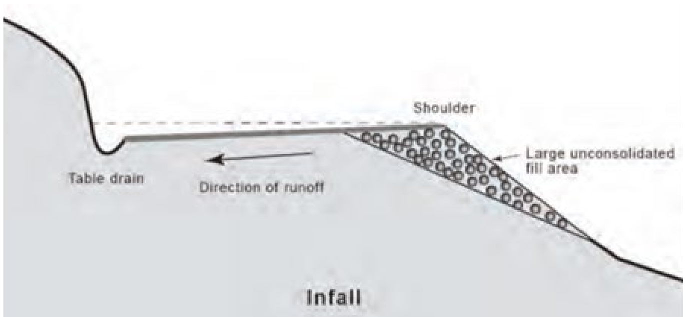


Figure 15 Figure showing in-fall drainage (OEH 2012)

ROAD MODIFICATION

Purpose of Treatment

Road or track upgrades may be required to avoid loss of road surface material and to prevent erosion caused by road surface runoff. Due to unsealed municipal roads generally being installed and maintained to a minimum standard, these road modification suggestions maybe most applicable to private driveways and farm tracks, particularly those located on steep and undulating terrain. Road drainage treatments include crowning drainage, out-fall drainage and in-fall drainage.

Description

a. Crowning drainage

Crowning, also known as camber, involves raising the centre of the road profile 150 - 300 mm above the table drain or natural surface so that water drains from a high point in the centre to both sides of the road (Figure 13). By creating a camber in the centre of the road allows surface runoff to drain into side table drains and in to mitre drains or drainage lines in a controlled fashion.

Cross slope drainage

Cross slope occurs where the road surface slopes in one continuous direction with one side of the road being the highest point. This is the preferred road profile slope where water is to be directed toward one side of the road. Types of cross slope drainage include;

Outfall drainage: The road surface slopes away from a cut batter or hillside with water flowing evenly to the shoulder of the fill or lower side of the road (Figure 14). This is generally used on moderate slopes for low traffic volume roads and stable soils.

In-fall drainage: The surface water is directed towards a cut batter or hillside to be captured by a table drain (Figure 15). This is commonly used with a table drain on steep terrain and/or where fill batters are not stable and/or exceed 1.5 m in height.

Rollover

A rollover (also known as a grade dip) is an earth bank with an upstream channel used to direct water flow across the road to discharge onto a stable surface (Figure 16).

Suitable sites

- Moderate slopes (outfall drain); and
- Steep slopes (in-fall drain).

Limitations

- Heavy earth moving equipment required; and
- Cost of installation.

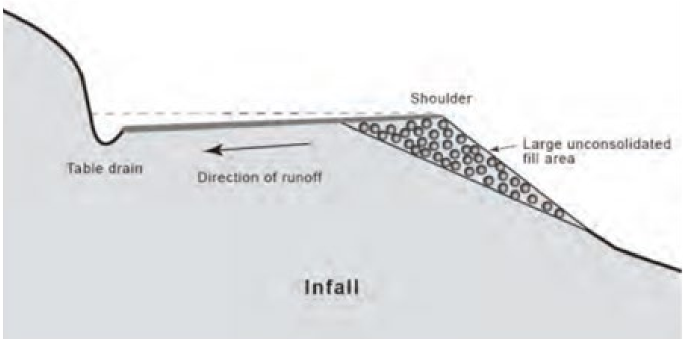


Figure 16 Design drawing for a rollover (OEH 2012)

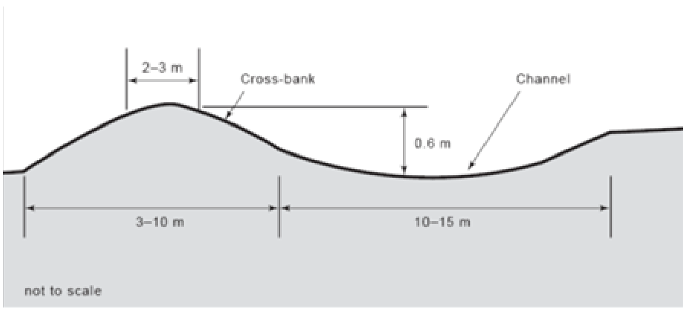
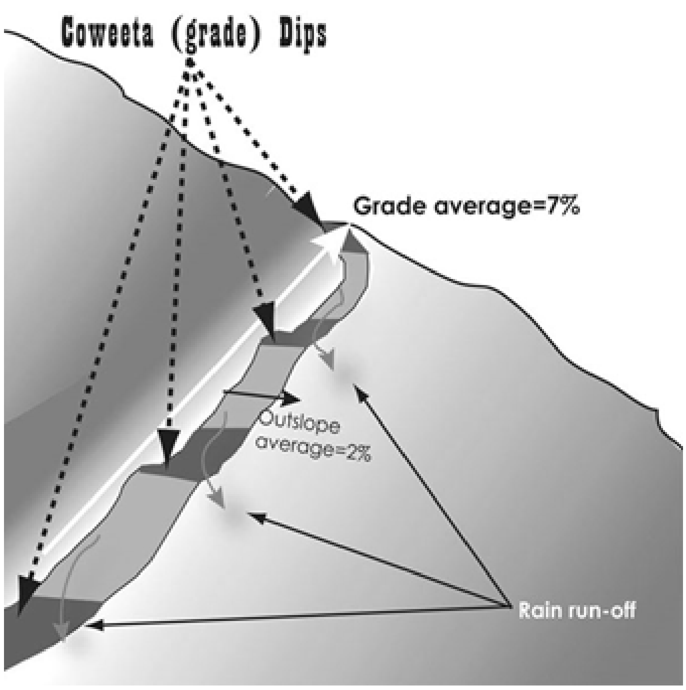
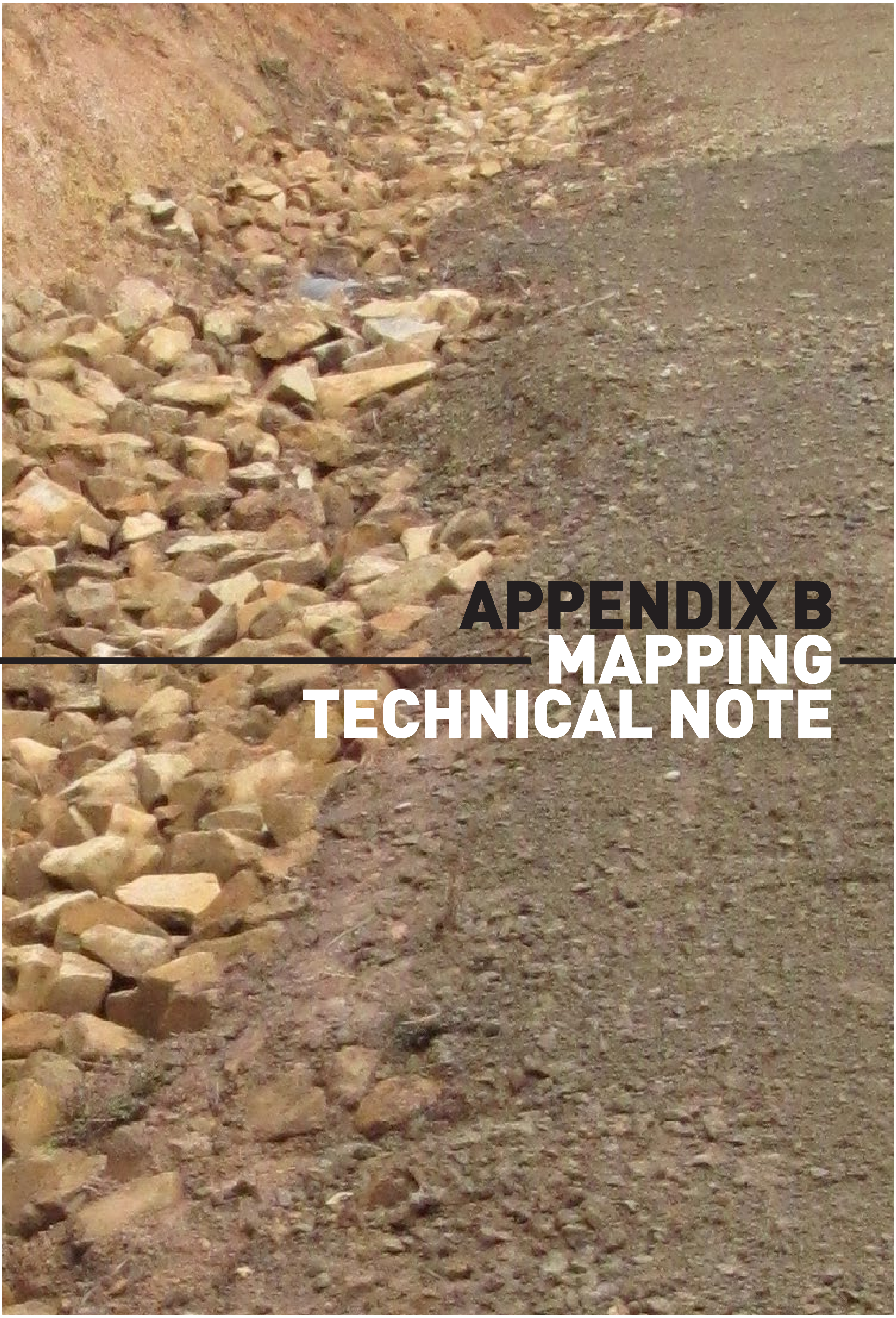


Figure 17 Design drawing for a rollover showing outfalls, slope and drainage





APPENDIX B
MAPPING TECHNICAL NOTE

AECOM

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Eden Park Bushfire Mitigation Plan - GIS Technical Note

To	James Booth	Page	1
CC			
Subject	GIS Technical Note- Bushfire erosion model and asset risk		
From	Ben Roberts		
File/Ref No.		Date	31-Jul-2017

This technical note is designed to inform the interpretation of the GIS shapefiles listed Section 2.0. These files have been produced as part of the Bushfire Mitigation Plan project for the Eden Park study area by AECOM Australia Pty Ltd (AECOM) on behalf of the City of Whittlesea (CoW). The intent of these mapping files is to assist the CoW understand the areas of Eden Park that are likely to be most vulnerable to erosion following a bushfire event. Additionally, infrastructure and natural assets that are likely to be at risk of erosion related impacts have also been identified.

1.0 Mapping deliverables

1. model and categorise areas vulnerable to erosion following bushfire
2. identify assets at risk of erosion-related impacts following a bushfire event and provide the modelling undertaken to determine these assets and risk
3. map biodiversity values such as core habitat areas for threatened species and significant roadside trees.

2.0 Mapping outputs nomenclature

1. Eden Park_Erosion_Likelihood
2. Asset erosion risk
   i. Infrastructure_asset_erosion_risk_point
   ii. Infrastructure_asset_erosion_risk_polyline
   iii. Natural_asset_erosion_risk_point
   iv. Natural_asset_erosion_risk_polyline
3. Biodiversity mapping
   i. Core_habitat_area
   ii. Significant_roadside_trees

3.0 Erosion vulnerability model

3.1 Objective

The objective of the erosion model was to classify areas within Eden Park that are likely have have increased vulnerability to erosion following a bushfire event. The intention of erosion vulnerability modelling is to assist CoW to guide resources and actions for effective pre and post-fire erosion mitigation. It is important to note that the degree of erosion following fire varies greatly and is influenced by the environmental setting and fire characteristics, particularly burn size and severity and post-fire rainfall/storm events. This model does not seek to identify areas of existing erosion or model areas vulnerable to erosion from every-day conditions. The model has weighed biophysical parameters that influence post-fire erosion. The occurrence of fire does not affect the erosive forces as such, however it may make the site less resilient to those same erosive forces by changing the soil and landscape characteristics (Scott *et al.*).

3.2 Literature review

A literature review was undertaken of post-fire erosion behaviour and the parameters influencing erosion. It is noted that rainfall and overland flow are the more common agents of erosion following bushfires, and these two factors have been subject to the most research. The occurrence of intense bushfire promotes the vulnerability of the soil surface to erosive forces via the following factors:

- exposing the soil by removing the understorey vegetation layer and organic material,
- reducing the ability of the soil to aggregate by combusting or transforming soil organic matter (Ubeda & Outeiro 2009),
- forming a water repellent layer on the soil surface (soil glazing) up to 20 – 50mm into soil profile (Doerr *et al.* 2006).

Increases in overland flow result in inter-rill (sheetwash) erosion when water flows downslope without concentrating. Hillslope geomorphic factors are also considered when identifying areas vulnerable to erosion. Sheet wash flow will increase on convex and planar slopes and where a hillslope has a concave landform (sediment reservoir), flow concentrates and rill erosion will occur more quickly (Moody and Martin 2009). The erosive power of water increases with water depth; therefore rill erosion rates are generally greater than sheetwash erosion (Scott *et al*. 2009). Given sufficient overland flow volume, gullies will form and quickly incise (Scott *et al*. 2009).

Where possible these post-fire soil attributes have been considered when selecting biophysical factors and their weighting in the erosion model. A full methodology of producing the model is described in Section 3.3.

3.3 Methodology

This model seeks to identify areas vulnerable to erosion following bushfire. Generally there is a positive correlation between areas that are subjected to high fire intensity and the impact this has on soil characteristics that result in erosion. Biophysical factors that contribute to high fire intensity along with those that contribute to increased erosion have been considered in this model. Table 1 provide a list of biophysical parameters that have been included in the model along with a justification for the inclusion. Table 2 provides the weighting prescribed to each model parameter.

Table 1 Erosion model parameters

Biophysical parameter	Weighting and ranking
Soil	**Data source:** Victorian Soil Type Mapping (VicMap). Three soil types occur within Eden Park: Chromosols (CH), Sodosols (SO) and Dermosols (DE). Sodosols and Chromosols (CH) are considered vulnerable to tunnel and gully erosion due to dispersive sub-soil horizons.
Forested vegetation extent	**Data source:** 2005 Native Vegetation Extent (VicMap). Whilst forested vegetation plays an important role in limiting soil erosion under normal conditions, forested areas encourage a higher fire temperature which in turn increases the vulnerability of soil to erosion (see Section 3.2). Accordingly, forested areas within Eden Park have been ranked high and non-forested areas are given a low ranking in the model. Because vegetation included in the 2005 Native Vegetation Extent includes non-discriminant vegetation areas such as shelter/screening and amenity plantings in semi-residential areas, only larger forested areas within Eden Park have been considered.

Biophysical parameter	Weighting and ranking
Curvature Combined	**Data source:** 10m Digital Elevation Model (VicMap). The ArcGIS combined curvature tool was utilised as it maps the profile curvature which affects the acceleration and deceleration of flow and therefore influences erosion and deposition. Considering both plan and profile curvature co-incidentally allows a more accurate understanding of the flow across a surface. Positive values (representing convergent slopes) are ranked 3, planar slopes 2 and divergent slopes 1.
Curvature Plan	**Data source:** 10m Digital Elevation Model (VicMap). The ArcGIS planform curvature tool was utilised to map the convergent flow paths across a hillslope surface. The plan curvature influences convergence and divergence of flow. Positive values (representing convergent slopes) are ranked 3, planar slopes 2 and divergent slopes 1.
Slope	**Data source:** 10m Digital Elevation Model (VicMap). Slope influences the rate at which sheet flow travels across the soil surface and the rate of water flow within channels. Therefore, steeper slopes have been ranked higher than flatter slopes. A 10m Digital Elevation Model has been used to undertake a slope analysis. The ArcGIS slope spatial analyst tool was used to perform this function.
Elevation	**Data source:** 10m Digital Elevation Model (VicMap). In steep terrain, bushfire has the ability to dry fuels as the fire travels upslope, effectively increasing fire severity as elevation increases. As such, elevated areas have been ranked higher than non-elevated areas.
Aspect	**Data source:** 10m Digital Elevation Model (VicMap). Within CoW, bushfire is most likely to travel from northwest to southeast, usually under a strong north-westerly wind (CoW 2012). Under normal fire behaviour, fire travels faster and hotter up-slope and slows once reaching a ridge apex. Therefore, north and western aspects have been ranked higher than south and eastern aspects. The ArcGIS aspect spatial analyst tool was used to perform this function.

To produce this model, a Weighted Overlay Analysis has been used. Weighted overlay is a type of suitability or constraint analysis used to analyse site conditions based on multiple criteria. Weighted overlay analysis allows us to combine the weight and rank of different parameters and visualise it to evaluate the impact of multiple factors at once.

Table 2 Weighted overlay analysis weighting and classification

Erosion Model							
Re-classification	Soil	Vegetation	Curvature Combined	Curvature Plan	Slope	Elevation	Aspect
Weighting	10%	5%	30%	30%	15%	5%	5%
1	Dermosol (DE)	Non-forested	Positive values	Positive values	5 - 15 degrees		
2			Neutral values	Neutral values	>15 - <25 degrees	Ridge lines (280-330m AHD)	East
3	Sodosol (SO) / Chromosol (CH)	Forested	Negative values	Negative values	>25 degrees	Peaks (>330m AHD)	North & West

4.0 Asset risk identification

4.1 Objective

The objective of the asset risk layers is to identify assets most vulnerable to impacts of erosion following a bushfire event. This includes infrastructure (built) and natural (biodiversity) assets.

4.2 Methodology

Natural and man-made assets are considered a priority for asset risk analysis. As such, asset shapefiles were compiled from a range of sources including CoW, VicMap and AECOM's data catalogue. Data for several natural assets including core habitat areas and significant roadside habitat trees were collected in the field. The following process was undertaken to produce the asset risk assessment.

1. Identify assets to be included within the asset risk assessment and classify assets into the infrastructure and natural asset types.
2. Apply high, medium and low risk proximity buffers to each asset as shown in Table 3 and Table 4. Proximity buffers were determined by considering the threshold of erosional impacts that could occur within particular distances from each asset type before the asset is lost or is rendered unable to function to its pre-fire capacity.

Table 3 Infrastructure asset proximity risk table

Infrastructure Assets					
	Bridges	Roads	Unnamed roads	Pipe assets	Culverts
1 (Low) Safe distance from asset	50m	30m	15m	20m	20m
2 (Medium) Close to asset	40m	20m	10m	15m	15m
3 (High) Asset	30m	10m	5m	10m	10m

Table 4 Natural asset proximity risk table

Natural Assets			
	High flow Waterways	**Low flow Waterways**	**Scattered roadside trees**
1 (Low) Safe distance from asset	40m	30m	17m
2 (Medium) Close to asset	30m	20m	15m
3 (High) Asset	20m	10m	12m

1. The asset proximity layers were merged and overlaid onto the erosion likelihood model. An intersect layer was developed where asset high proximity risk intersected with areas of high likelihood of erosion.
2. In order to determine assets at high risk of impact from erosion following bushfire, assets that contain >40% of the intersect layer within the high risk proximity buffer are classified as high risk as shown in Table 5 Asset erosion risk table.

Table 5 Asset erosion risk table

		Likelihood (of erosion occurring post-fire)		
		Low Erosion Risk	Medium Erosion Risk	High Erosion Risk
Consequence (of asset being damaged or lost to erosion)	> 40% of Asset occurs in erosion risk area	Low	Medium	High
	>25 - < 40% of Asset occurs in erosion risk area	Low	Low	Medium
	<25% of Asset occurs in erosion risk area	Low	Low	Low

5.0 Biodiversity values

5.1 Objective

The objective of the biodiversity mapping was to identify area within the study area that provide important habitat value for threatened species including areas of core habitat for Brush-tailed Phascogale *Phascogale tapoatafa*. This includes habitat links/corridors as well as large, isolated trees that occur within roadside reserves. It is intended that this information will be used in planning activities associated with the development of the Bushfire Mitigation Plan including the design of preferred locations for fire control lines. Information from the biodiversity mapping is also intended to be used internally by CoW when planning infrastructure maintenance and upgrade projects.

5.2 Methodology

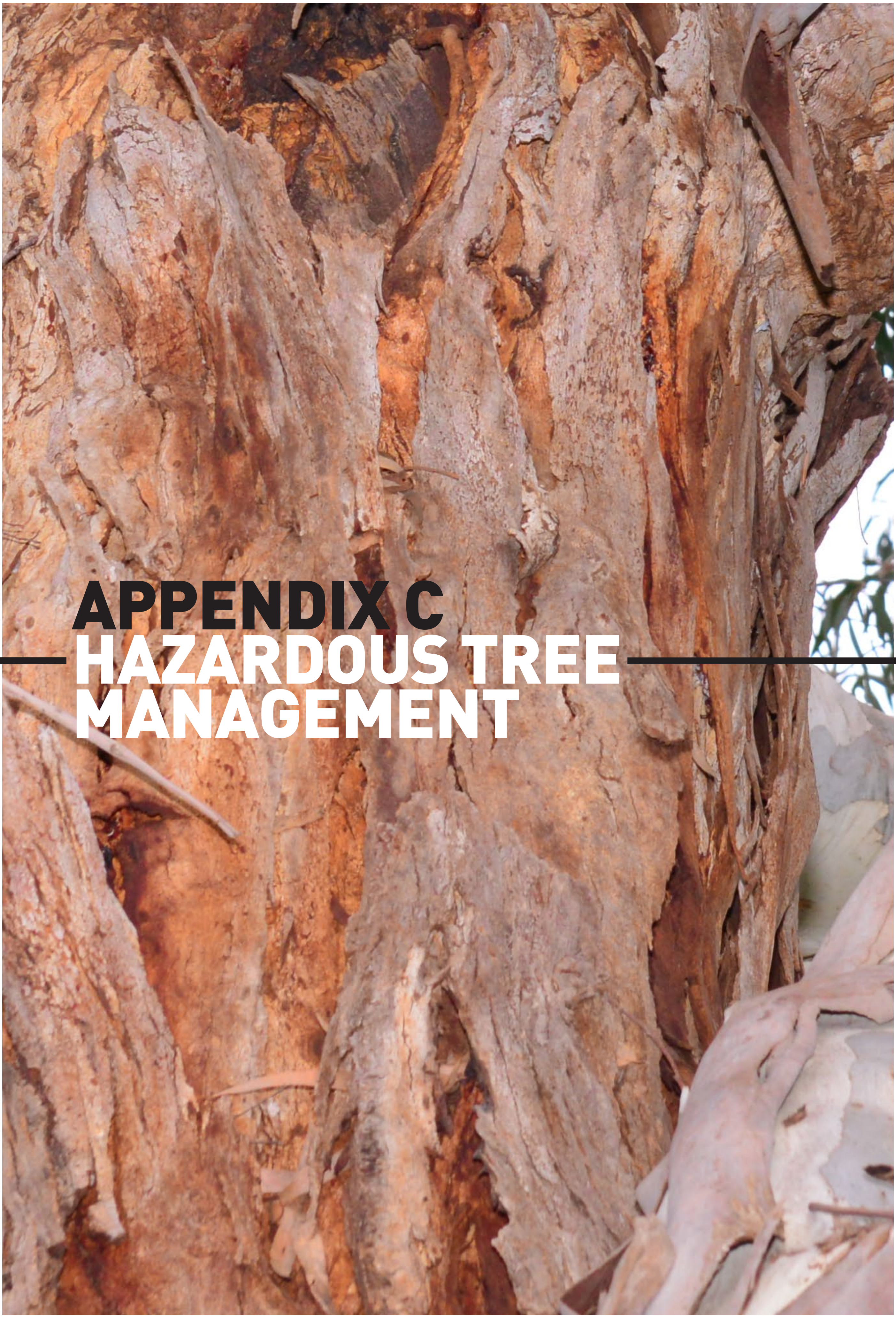
A field assessment was undertaken over two days by an experienced ecologist to assess the quality of habitat for significant species within Eden Park. Remnant trees within road reserves that were considered to provide potential fauna habitat or significant amenity value were also recorded. Although detailed assessments where not undertaken on privately owned parcels, assessments were undertaken from publicly accessible areas including road reserves and CoW-owned properties. The method provided in Table 6 was used to assess the quality of core habitat areas.

Table 6 Core habitat area assessment methodology

Attribute	Value	Description	Collection Method
Type	Remnant Patch	An area with three or more indigenous canopy trees where the tree canopy cover is >20% An area of native vegetation, with or without trees, where >25% of the total perennial understory plant cover is native plants.	Field and desktop
	Group of scattered trees or non-remnant patch	An area with a group of indigenous canopy trees where the tree canopy cover is <20% An area of native vegetation, with or without trees, where <25% of the total perennial understory plant cover is native plants.	
Canopy Layer	Intact	A remnant patch of trees that contains >15–20 trees per/Ha that are >60-70cm DBH and / or >20% canopy cover (refer to EVC benchmark).	Field
	Modified	A remnant patch that contains <15-20 trees per/Ha that are >60-70cm DBH and / or >20% canopy cover (refer to EVC benchmark).	
	Absent	A remnant patch (of treed vegetation) that lacks canopy trees.	
Understory	Intact	>50% of understory species and high species diversity (refer to EVC benchmark).	Field
	Modified	<50% of understory species and / or low species diversity (refer to EVC benchmark).	
	Absent	Understory species absent	
Weeds	> 30% cover	> 30% cover of weeds	Field
	<30% cover	< 30% cover of weeds	
Logs	Intact	>50% of EVC benchmark log length	Field
	Modified	Between 10 and 50% of EVC benchmark log length	
	Absent	Logs effectively absent	

Table 7 Core habitat quality ranking method

Canopy	Understory	Weeds	Landscape Condition Score	Score
Intact = 3	Intact = 3	≤30% = 3	≥15 = 3	≥10 = Critical
Modified = 2	Modified = 2	>30% = 2	≥10 - <15 = 2	≥6 - <10 = High
Absent = 1	Absent = 1	>30% = 2	<10 = 1	≤5 = Medium
Group of scattered trees or non-remnant patch				= Low



APPENDIX C
HAZARDOUS TREE MANAGEMENT

Department of
Sustainability and
Environment

Pictorial Guide

Hazardous Tree Management

State Government Victoria

Contents

Hazardous tree management - pictorial guide

Aim

This guide aims to assist firefighters conducting hazardous tree risk assessments with visual indicators and descriptors of trees that:

- should be avoided when marking a fire control line
- need protecting from being further weakened by fire
- are to be marked as displaying 'Clear and Present Danger;' and
- wherever possible protected or extinguished due to their cultural or environmental significance

The guide also recommends treatment options and the marking system for managing the risk of hazardous trees before and during fire operations.

Background

The increased fire activity, particularly since the 2002–03 fire season, has resulted in many trees posing a potential threat to the public and firefighter safety and/or burn or bushfire security within fire control lines. During fire operations, firefighters need to make decisions on locating fire control lines and treating these trees. Priority trees for treatment will depend on the risk exposure to firefighters and others that need to enter the fire area and individual tree characteristics.

Scope

When firefighters are either planning a burning operation or responding to a bushfire they should use the 'Hazardous Trees Treatment Options Flowcart' as a guide for dealing with hazardous and potentially hazardous trees. The flowchart aims to provide a consistent approach in managing the risk of hazardous trees.

The guide identifies:

- stands of trees that pose a greater risk of falling branches and trees
- defects of potentially hazardous trees
- 'Clear and Present Danger' trees and hung up branches
- cultural heritage trees and trees that have high conservation value

The guide provides information on some of the pre and post fire treatment options in eliminating or reducing the risk of the hazard. It also provides information on Aboriginal scarred trees and what to do if you find one.

Hazardous trees treatment options flowchart

Pre Fire – Fire Suppression (time permitting) or Planned Burning

A. Multiple potential hazardous trees or high percentage of dead spars

NO → **B.** Several potential hazardous trees and dead spars present

NO → **C.** Few potential hazardous trees – treat during burn or suppression

A. **YES** → Possible to re-locate the fire control line?

- **NO** → see 1–4 below
- **YES** → Relocate fire control line then consider **B.** above

B. **YES** →

1. For Planned Burning consider pre-burn 'candling' and edge burning in the mop-up area.
2. Clear around potential hazardous trees near the fire control line (**trees needing protection mark with a yellow dot** (•).
3. If too dangerous to extinguish or fall if the tree catches on fire remove tree – **mark trees for removal with a yellow** (**X**). Apply non-removal options only for trees with cultural or significant environmental values.
4. If adjoining a Class A or B road provide an additional set-back fire control line 1 tree length from the road. Alternatively mark potential hazardous trees for removal – **mark trees for removal with a yellow** (**X**).

Post Fire – Fire Suppression or Planned Burning

A. High percentage of dead spars or trees too dangerous to extinguish or fall?

NO → **B.** Several trees and dead spars that present a 'Clear and Present Danger'?

NO → **C.** Few hazardous trees – where possible extinguish potential hazardous trees

A. – YES → Cordon off the area 2 x tree lengths around the trees and re-locate the fire control line

INITIAL ATTACK → Preferably use plant supported by fire bombing aircraft. Hand crews top and flanks only (wind < 20kph), supported by aircraft

B. – YES and **C.** →

1. Undertake the hazardous tree marking system – **mark 'Clear and Present Danger' trees with a** (**K**) and simultaneous fall any dead spars burning at the base. Apply non-removal options only for trees with cultural or significant conservation values.
2. Prior to mop-up remove trees marked (**K**).
3. If adjoining a Class A or B road provide traffic management while tree removal is implemented.
4. Ensure safe work areas (usually 2 tree lengths) are maintained between different fire operational activities.

Options to manage the risk

High risk stands

Firefighters need to be aware of stands of trees that have a high risk of falling branches and trees. These stands include fire killed (eg young fire killed ash species and snow gum), stands that are drought affected with a high percentage of dead spars and old growth stands that have many hollows, dead tops and hung-up branches. There are also forests with areas of significantly increased fuel hazard due to wind throw, snow damage, insect or pathogen attack and ring-barked trees (these are not individually covered in this guide). Wherever possible high risk stands and areas of increased fuel hazard need to be avoided or diverted around when establishing fire control lines.

Fire Killed Ash

Red Gum Dead Spars

Fire killed species

These stands are particularly hazardous as dead spars (poles) often burn off at the base and fall soon after a fire has passed and before a hazard assessment can be completed. On steep slopes dead spars are prone to spearing down hill without notice.

For initial fire attack it may only be safe to construct control lines above and down the sides of a fire in these areas. This is particularly the case on high wind days (>20kph) due to increased limb fall. Aerial applied retardant should be used to control the downhill side of these fires and ground crews should not go into or below the fire area until at least 2 days after the fire is no longer spreading. Areas where burning trees may fall or slide into need to be included in the area treated by fire retardant.

Drought affected species

As with fire killed species, drought affected stands have dead spars that burn off at the base soon after a fire has passed.

For initial attack in these stands, construct fire control lines with machines that have Falling Object Protection (FOP) and push over dead spars that have been impacted by the fire during that operation. Follow-up with an assessment and treatment of additional affected spars prior to mop-up.

Over Mature Forest

Group of ring-barked dead trees

Old growth forests

These forests are hazardous to work in following a fire due to the higher likelihood of whole or part of trees and large branches falling.

Fires in these forests are often difficult to secure as large burning embers can be dropped across fire control lines for several days following the initial fire. Wherever possible divert the fire control line around or away from these stands.

Trees killed by insect or pathogen attack or by ring-barking

These trees are usually in relatively smaller areas to stands that have been killed by fire. Wherever possible relocate fire control lines around these stands.

Tree defects of potential hazardous trees

These are trees that can have significant decay or rot but if not further weakened by fire they don't pose a high risk. Their location to areas frequently accessed by firefighters and the public and to key assets largely determines the treatment options employed. **Wherever possible prior to ignition (backburn or planned burn) these trees should be hand raked or cleared around with a machine and/or foam suppressant applied to protect them**. Following a fire early mop-up will help prevent further weakening of these trees and them becoming hazardous.

Pipe

Dry Side

Pipe

A pipe or chimney is formed up inside the trunk of a tree where fire is able to burn the decayed heart of a tree. The entry of fire can occur via burnt out roots, dry sides or hollowbutts. There may be a complete pipe in which flames and sparks will be visible out the top of the pipe, or may be incomplete with only smoke coming out of the crown.

Dry Side

This is a strip of dead wood on the trunk of a tree usually caused by a previous fire or other damage (eg another tree falling against it). In combination with decay or rot, dry side can result in hollowbutt.

Hollowbutt

Hollow

Hollowbutt

A tree that has a hollow at the base due to disease or damage. It may have also been burnt away by bushfires or planned burns. There are often other faults such as significant rot or heart decay which can spread a surface fire higher up a tree.

Hollows

These may be hollows in the stem (picture opposite) or hollow limbs and will vary in their shape, depth and difficulty to extinguish. They are formed by either rot or fire usually following structural damage of the tree (eg a limb breaking off).

Dead Crown

'Widow-maker'

Dead Crowns

Trees which contain a significant amount of dead wood in their crowns (top of the tree) may cause safety issues or problems in containing a burn or bushfire. Dead crowns are often the result of a tree becoming over mature or from fire damage, insect attack or disease. Trees with dead or damaged crowns are a key concern on the fire line as they are likely to burn longer, shower burning embers and part or all of the crown fall.

'Widow-makers'

These are limbs which are hooked up or tangled in other limbs and can be dislodged during falling or burning. Trees with 'widow makers' don't necessarily need to be felled but the hazard needs to be identified and marked off with hazard tape to reduce the likelihood of an accident during mop-up. 'Widow makers' in high use areas such as fill-up points, briefing areas and access routes need to be removed prior to ignition if possible or as a priority following the fire.

Dead Stag

'Hung-up' Dead Spar

Dead Stags and Spars

Large dead trees are known as stags while smaller dead regrowth are known as spars. Recent dead trees, including fire and drought killed species have hazards including burning off at the base. Other hazards include large sections of bark falling 1–2 years after a fire and larger branches (0.5–3cm) begin falling about 4 years after a fire. Where stags are large they pose a significant threat, both in duration of burning and the amount of burning material in the crown and are often difficult to extinguish.

'Hang-ups'

Occasionally a tree may fall and 'hang-up' on another tree. These are particularly dangerous if leaning across a road or track but can be just as dangerous to firefighters during mop-up. These are often very difficult to get down by falling or pushing and if not leaning across a key work area are best taped off with hazard tape as an area to avoid.

The dead 'hung-up' spar in the photo has burnt off at ground level but other 'hang-up' trees can be a result of burnt out roots, wind throw or ground heave.

‘Clear and Present Danger’ trees

In practical terms a ‘Clear and Present Danger’ tree is when a trained firefighter looks at a tree or limb and recognises ‘that will fall soon.’ As a minimum DSE will ensure ‘Clear and Present Danger’ trees are assessed and treated within mop-up areas and along main roads prior to systematic mop-up. Systematic mop-up follows the initial patrol of the fire that ensures the fireline isn’t breached. It is the fire agency’s responsibility to treat ‘Clear and Present Danger’ trees prior to handing back control to the land manager or road authority.

The four images on page 15 (hollowbutt, pipe, stag and dead crown) are examples of ‘Clear and Present Danger’ trees where the tree is being impacted by fire and all or part of the tree could fall soon. An on-sight risk assessment is required to determine if these trees can be felled or whether an exclusion zone around the tree needs to be put in place until the tree falls. It is important to first restrict access into the area around a hazardous tree and only approach the tree **away** from the direction of fall.

There are other trees that are not as obvious but also fall soon after a fire. Having someone with knowledge of local trees and experience in the area of the fire to assist in assessing trees is a key requirement in identifying hazardous trees.

All firefighters however need to observe fallen trees on the fireline and identify the indicators as to why trees have fallen. The photos on page 16 show trees that have fallen due to hollowbutt (15–25% holding wood remaining) and hollows where a tree has fallen about half way up. Also dead spars (photo 4 on page 16) that burn off at the base are relatively easy to identify (small dead trees with smoke coming from the base) and preferably knocked over while assessing trees along the fireline.

Hollowbut

Pipe

Stag

Dead Crown


Hollowbutt trees that have failed with 25% and 15% of holding wood respectively

Hollow tree failed about ½ way up

Dead spar burnt off at the base

Aboriginal scarred trees and trees with high conservation value

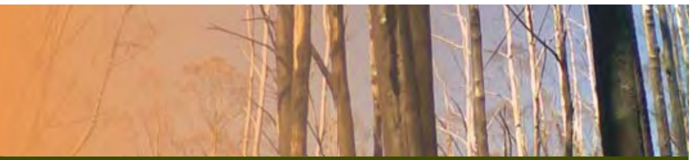
It is recognised that trees provide essential habitat for native fauna, and it is the preferred option to protect and retain trees wherever possible. High conservation value trees include roosting trees of threatened species and those with nesting hollows. Scarred trees provide valuable clues about Aboriginal people and all Aboriginal cultural places and artefacts are protected.

What to do if you find a Scarred Tree

- Check the scar for key characteristics (scar is more-or-less regular, often with parallel sides and slightly pointed or rounded ends).
- Record the tree's location and its condition.
- Wherever possible prevent further disturbance; particularly from fire control line construction or fire suppression operations.
- Help to preserve Aboriginal cultural places by reporting their presence to Aboriginal Affairs Victoria through the local Cultural Heritage Officer.

High Conservation Tree (nesting hollow)

Aboriginal Scarred Tree



The hazardous tree marking system

The hazardous tree marking system is mostly concerned with trees that present 'Clear and Present Danger' to firefighters, the public and/or assets. It is recognised however that prior to and during fire control line construction that potential hazardous trees either need to be felled or protected from being further weakened by fire.

System currently being used to protect or remove potential hazardous trees is:

- A yellow cross (**X**) on trees to be **pushed over or felled** as part of fire control line construction or planned burn preparation.
- A yellow dot (•) on trees to be **protected** (hand raked or machine cleared around and/or fire suppressant applied) prior to the fire.

(Note: hazard tape is not used to identify the location of potential hazardous trees as hazard tape purpose is to warn others of a hazard and restrict access to those treating the hazard).

Tree marked with an X (felled during Fire Control Line construction)

Tree marked with a • (protected from being further weakened by fire)

System for **assessing and marking 'Clear and Present Danger' trees:**

- Ensure firefighters don't commence systematic mop-up until hazardous trees are assessed and treated.
- Where safe, mark the tree in yellow with (**K**) for killer tree and mark the nearest point on the fire control line with yellow and black hazard tape – 1 length of tape for one tree length from the control line and 2 lengths of tape for two tree lengths from the control line. If unsafe to mark the tree put length/s of tape beside the fire control line only.
- If it is unsafe to fall or push the tree, relocate the fire control line, at least 2 tree lengths from the hazardous tree, and block off access and/or establish traffic control to prevent firefighters entering the area.

Tree marked with K identifying 'Clear & Present Danger'

Flagging Tape beside Fire Control Line

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JOINT SOP	
Title	Tree hazard - bushfire response
Purpose	To mitigate the risk to emergency service personnel of injury or death from falling trees and branches during bushfire response.
Scope	This Joint SOP applies to all emergency services personnel (including emergency service agencies and contractors) involved with bushfire response operations. Specifically in relation to the identification of tree hazard in the forested/treed environment and mitigating the risk of consequent injury, or damage to equipment while accessing or being on the fire ground. This Joint SOP does not apply to planned burning or operations arising from flood, storms or other events.
Applicable Agencies	This procedure applies to the following agency personnel; • CFA • DELWP • MFB • VICSES
Content	The procedural contents of this SOP are: • Step 1: Identify the potential existence of tree hazard during bushfire response. • Step 2: Mitigate the risk arising from tree hazard during access to bushfire incidents • Step 3: Mitigate the risk arising from tree hazard on the fire ground. • Step 4: Mitigate the risk of unidentified hazard trees on the fire ground. • Step 5: Complete operations. • Schedule 1: Qualifications and Experience for Hazard Tree Assessment • Schedule 2: Hazard Tree Marking System • Schedule 3: Hazard Tree Treatment • Schedule 4: Tree Hazard Mitigation Matrix: Identification, Assessment, Marking and Treatment
Responsibilities	All emergency service personnel involved in bushfire response, including Incident Controllers, Operations Officers, Sector Commanders, Crew Leaders, crew members, and all others entering a fire ground are responsible for following this procedure.

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	Specifically: 1. Incident Controllers are to ensure tree hazard is considered along the route(s) used to enter/leave the fire ground. 2. Incident Controllers are to ensure that known areas of high tree hazard are identified during the development of the Incident Action Plan, particularly in relation to deployment orders and safety messaging. 3. Incident Controllers are to ensure that crews are briefed at shift commencement on known areas of high tree hazard. 4. Incident Controllers are to ensure that mop-up/blacking out or patrol does not commence until a hazard tree assessment has been completed for that portion of the fire control line or mitigation controls are in place. 5. Incident Controllers are to ensure Clear and Present Danger trees that remain standing on the fire ground after the passage of the fire are treated.
Definitions	The following definitions apply to this procedure: **Advanced or Intermediate Faller** A tree faller meeting the requirements of the relevant Public Safety Training Package Unit of Competency *Fall trees manually (advanced)* or *Fall trees manually (intermediate)* or successor(s). **Assess (tree hazard)** To locate and evaluate the extent of tree hazard by appropriately qualified and/or experienced personnel. **Bushfire** Unplanned vegetation fire. A generic term which includes grass fires, forest fires and scrub fires both with and without a suppression objective. **Clear and Present Danger tree (CPD)** A tree or branch that is likely to fall within the expected timeframe of the current operation and impact personnel in its potential impact zone. **Dispatching Officer** The agency or other authorised person initiating the act of ordering attack crews and/or support units to respond to a fire, or from one place to another. **Going Fire** Any bushfire which is expanding and suppression actions have not yet contained the fire. **Hazard Tree** The collective term for Hazardous trees and Clear and Present Danger trees.

Hazardous Tree
A tree or branch which in its current state may in its current state may in part or wholly fall and impact personnel in its potential impact zone (but not considered likely to do so during the expected timeframe of the current operation).

Identify (tree hazard)
The ability to recognise stands of, or individual trees that present an increased risk to personnel safety (as included in basic bushfire hazard recognition training).

Initial Attack
The first suppression work on a fire.

Mop up/Blacking Out
The process of extinguishing or removing burning material along or near the fire control line, felling stags, trenching logs to prevent rolling and the like, in order to make the fire safe.

Potential Clear and Present Danger tree
A tree which in its current state does not appear hazardous, but may become a Clear and Present Danger tree if it catches alight or is impacted by wind or other disturbance.

Tree Hazard
The overall combined safety risk to personnel from hazard trees within an area. *For example, an area of fire killed trees.* Refer to Schedule 4 for supporting detail.

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PROCEDURE

1. Step 1: Identify the potential existence of tree hazard during fire response.

   1.1 Local Mutual Aid Plans (LMAPS) are to contain, where relevant, map(s) indicating geographic areas with known and/or predicted high concentrations of tree hazard (eg. tree species, fire history including fire intensity overlays, stand history and health including disease, wind/snow damage and/or silvicultural treatments) overlaid with the fire access roads and tracks.

   1.2 LMAPS are also to contain details and/or maps of those fire access routes on which tree hazard has been assessed and treated.

2. Step 2: Mitigate the risk arising from tree hazard during access to bushfire incidents.

   2.1 Where the preferred access route to a fire ground is through known and/or predicted areas of high tree hazard which have not had tree hazard assessment and treatment, resources may only be deployed via this route if the risk factors are considered acceptable under the current conditions; e.g. relevant weather factors such as wind speed (refer Schedule 3).

   2.2 Once deployed, personnel need to maintain awareness of hazard trees while commuting through or working in these areas and any identified unacceptable risks mitigated.

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2.3 Where personnel consider the risk of injury from tree hazard significant, the Incident Controller needs to be advised and acceptable lower risk alternative implemented.

2.4 LMAPS are to include arrangements for the accessing the appropriately resources for the assessment and treatment of hazard trees (including appropriately equipped chainsaw and plant operators).

2.5 Incident Action Plans are to clearly identify areas where access is restricted in response to the risk arising from tree hazard

3. Step 3: Mitigate the risk arising from tree hazard on the fire ground.

3.1 General Principles:

3.1.1 Awareness and identification of trees which present a hazard must form part of the ongoing dynamic risk assessment performed by all personnel on the fire ground at all times.

Refer to the Hazardous Tree Management Pictorial Guide, DEPI 2013 for more information on tree hazard identification.

3.1.2 Safety from hazard trees during fire emergencies will take priority over other considerations (such as the conservation of biological values) consistent with the State Strategic Control Priorities. When in doubt or dispute over either the risk associated with a tree or its values, the decision will favour safety.

3.1.3 Where alternative effective fire control options are available, relocate control lines and temporary access roads and tracks away from known tree hazard areas and/or establish exclusion zones.

3.1.4 Where a fire has impacted or otherwise damaged trees, access/control lines and other work areas in or near the impacted area, hazard trees will be assessed, marked and treated. Refer to Schedule 3 for details on the assessment area.

3.1.5 Crew Leaders/Sector/Division Commanders are to ensure appropriately qualified or experienced personnel assess, mark and treat hazard trees on the fire ground (including staging/briefing/assembly points), where practicable. Refer to Schedule 1 for a description of qualified and experienced personnel

3.2 Pre-fire

3.2.1 Any planned retention of CPD, Hazardous, or Potential CPD trees where protection is not reliably assured, should be avoided where possible.

3.3 Initial attack/going fire

3.3.1 Awareness and identification of trees which present a hazard must form part of the ongoing dynamic risk assessment performed by all personnel on the fire ground at all times.

3.3.2 During attack on a going fire (ie. prior to mop-up/blacking out), personnel need to be particularly vigilant regarding identification of hazard trees and treat any identified unacceptable risks.

3.3.3 Any hazardous or potential CPD trees assessed are to be marked and CPD trees isolated in accordance with this procedure.

3.3.4 Where personnel consider the risk of injury from tree hazard significant, the Incident Controller needs to be advised and alternative lower risk alternatives considered. This consideration will balance the priorities placed on responder safety and any community members known to require assistance.

3.4 Following the passage of fire

3.4.1 As soon as practicable after the passage of fire, hazard trees within striking distance of access/control lines will be assessed, marked and treated (including possible isolation). Refer to Schedule 3 for details on the assessment area. In exceptional circumstances where this requirement is impracticable, the Incident Controller must approve and record alternative actions.

3.4.2 Before the commencement of any mop-up/blacking out/patrol of areas where fire has affected trees, hazard trees within striking distance of access/control lines will be assessed, marked and treated (including possible isolation). Refer to Schedule 3 for details on the assessment area. In exceptional circumstances where this requirement is impracticable, the Incident Controller must approve and record alternative actions.

3.5 Mark hazard trees on incident ground.

3.5.1 The agreed marking system for hazard trees will be used at all times, to ensure consistency and protect responder safety. Refer to Schedule 2 for details of the hazard tree marking system.

3.6 Treat hazard trees on the fire ground.

3.6.1 Treat hazard trees before and after the passage of fire on access routes, assembly areas, and control lines in accordance with the hierarchy of risk controls. Refer to Schedule 3 for details of hazard tree treatment.

3.6.2 Consider evacuation of treed areas when conditions such as wind speed, tree-fall, or other factors become unfavourable.

Refer to Schedule 4 for an overview of hazard tree identification, assessment, marking and treatment.

4. Step 4: Mitigate the risk of unidentified hazard trees on the fire ground.

4.1 Where Crew Leaders/Sector/Division Commanders believe that the residual risk from unmarked hazard trees on the fire ground requires vigilance, awareness is to be maintained by reference in fire ground briefings and close supervision.

5. Step 5: Complete operations.

5.1 Incident Controllers are to ensure removal of all marked CPD trees prior to transition to recovery, so far as is reasonably practicable.

5.2 Where marked CPD trees remain at the conclusion of the response phase, the Incident Controller will ensure the location of these trees forms part of the handover to recovery agencies and/or land manager.

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SAFETY

Emergency Personnel need to ensure that the protection and preservation of life is maintained at all times.

In the application of this JSOP there the following safety considerations apply:

- CFA Safety Alert No 31 *Hazardous Trees* (8 January 2014)
- DSE Safety Alert Number 08/11 *Use of Plant and Equipment in the vicinity of Hazardous Trees* (13 December 2011)
- MFB Advisory Notice 7/2012 *Hazardous Tree Identification*.

REFERENCE

Related Documents	Booklet: Guideline for fire control lines and management of hazardous trees (DSE/CFA 2011) Booklet: Hazardous Tree Management – Pictorial Guide (DEPI 2013) SOPJ 8.02: Dynamic Risk Assessment VICSES SOP019 Operations Involving Trees (SES 2015) Training manual: Bushfire Firefighter Reference Manual (CFA/DSE 2011) EMV Safety Fact Sheet SOP J 02.01 – Local Mutual Aid Plans
Environment	Nil

REVIEW	
Date Issue	5 June 2017
Date Effective	1 August 2017
Date to be Reviewed	August 2020
Date to Cease	

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AUTHORITY
The Emergency Management Commissioner has issued this SOP under section 50 of the Emergency Management Act 2013.

Approved	**Signature**	**Date**
Craig Lapsley Emergency Management Commissioner		
Endorsed	**Signature**	**Date**
Steve Warrington Chief Officer, CFA		
Stephanie Rotarangi Chief Fire Officer, FFM Vic - DELWP		
Paul Stacchino Acting Chief Officer, MFB		
Trevor White Chief Officer, VICSES		

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Schedule 1

Qualifications and Experience for Hazard Tree Assessment

1. Only appropriately, qualified or experienced personnel can carry out a hazard tree assessment. This does not preclude any other personnel from identifying a hazard tree and treating it appropriately (e.g. exclusion).

2. Appropriate qualification to carry out hazard tree assessment is:

   2.1 Formal timber industry endorsement as a tree faller in native forest with (or accompanied by a person with) (22023VIC) *Basic Wildfire Awareness* training OR (PUAOHS002B) *Maintain Safety at an Incident Scene* Unit of Competency; or

   2.2 Arborist with (or accompanied by a person with) (22023VIC) *Basic Wildfire Awareness* training OR (PUAOHS002B) *Maintain Safety at an Incident Scene* Unit of Competency.

3. Appropriate experience to carry out hazard tree assessment is:

   3.1 Operations Officer or Crew Leader with extensive experience in forest firefighting and/or forest harvesting; or

   3.2 Responder with extensive experience in suppression/ forest firefighting activities involving similar assessment of tree soundness.

Schedule 2

Hazard Tree Marking System

The system for marking hazard trees is described below and must be read in conjunction with SOP J8.03 Tree hazard - bushfire response.

1. Pre-fire and Pre-ignition for Backburning and Burning Out

    1.1 **Yellow cross "X"** on hazardous trees (not yet CPD), or potential CPD trees which cannot be reliably protected, are accordingly marked for removal. These will normally be pushed over or felled as part of access/line construction.

    1.2 **Yellow dot "•"** on (as yet) non-hazard trees to be protected (ie hand raked or machine cleared around and/or fire suppressant applied) prior to the fire.

    1.3 Although uncommon pre-fire or pre-ignition, **Yellow "K"** trees (see below) if identified, should be managed as outlined below.

NB: Potential CPD trees marked for retention (and thus protection from fire), must have a high probability of surviving the fire intact based on the proposed protection measures and likely response resources available. If this is not reasonably assured, these trees are otherwise likely to become CPD trees post-fire and add unnecessary complexity to the fire response and should be pre-emptively removed.

2. Initial Attack/ First Response and Post-fire

    2.1 **Yellow "K":** Where it is considered by those qualified or experienced (SOP J8.03 Schedule 1) that in the circumstances it is safe to mark the tree, a yellow "K" identifies a tree which presents a "Clear and Present Danger". This is painted on two sides with non-flammable spray yellow paint in >30cm capital, and an exclusion zone is established (SOP J8.03 Schedule 3).

    2.2 <u>Where it is not safe to approach</u> a CPD tree, it is left unmarked and an exclusion zone is established (SOP J8.03 Schedule 3).

    2.3 If at all practicable, the mapped location of "K" (i.e CPD) trees is to be made available to fire ground personnel as soon as possible after marking.

    2.4 Although **Yellow "X"** trees are primarily identified and removed pre-fire it is not uncommon for new ones to be identified during and post fire. These should be removed as soon as practical after marking.

    2.5 **Yellow dot "•"** trees should be adequately resourced and patrolled to ensure they do not catch alight.

    2.6 If protection of a **Yellow dot "•"** tree has failed and the tree catches alight, extinguishment should be attempted as soon as possible provided it is safe to do so. If the tree cannot be reliably and effectively extinguished and threatens the work space/control line, it then becomes a CPD ("K") tree and treated as per paras 2.1and 2.2 above.

Refer to the Hazardous Tree Management Pictorial Guide, DEPI 2013 for more information on the Identification and Marking System.

Schedule 3

Hazard Tree Treatment

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ASSESSMENT AREA

The work area

Hazard trees or branches situated inside or immediately adjacent to the area where ground crew may be working. This area could the road itself if no mop up/blacking out is planned, or may include the blacking out depth where planned.

Outside the work area

The area beyond the work area where Clear and Present Danger trees present a risk by falling into or sliding downhill into the work area.

TREATMENT OPTIONS

1. ELIMINATE

   1.1 **Removal** of the hazard by downing trees is the preferred method of treating the hazard. Hazard trees should be machine felled where ever possible. Hand falling of hazard trees should be avoided unless it is both essential and safe and in accordance with dynamic risk assessment. Both intermediate and advanced fallers may hand fall hazard trees within the range limits of their competency..

   1.2 **Extinguishment** in-situ by water, fire suppressant and/or retardant, if safe to do so. If a tree is assessed to be a hazard tree it should be removed after extinguishment.

2. SUBSTITUTE

   2.1 **Move** or **abandon** the control line if CPD trees cannot be eliminated. Construct or select an alternative location for a control line.

3. ISOLATE

   3.1 **Isolate** CPD trees by locally re-aligning the control line (to provide at least a 2 tree length separation) or by establishing an exclusion zone.

   3.2 Generally, an **exclusion zone** shall be a distance of at least 2 tree lengths around a tree hazard. The actual distance in each instance is determined by site factors such as slope and may be larger (or in some rare instances smaller) than 2 tree lengths.

   3.3 The perimeter of an exclusion zone is marked using yellow and black hazard tape on sufficient individual trees to indicate its extent.

   3.4 Exclusion zones should only entered by plant or vehicles with falling object protection canopies or appropriately skilled crew tasked to remove the CPD tree.

   3.5 When an exclusion zone is established over a control line relevant incident personnel should be advised of its location.

   3.6 Where an exclusion zone extends across a track that exclusion needs to be effective and actively managed to ensure crew do not drive through the zone.

3.6.1 Traffic control needs to be established to warn others and prevent personnel entering the area while the hazard remains until it is removed or burns down.

3.6.2 If for some exceptional reason traffic control is not implementable, the existence of the exclusion zone must be marked with hazard tape on a piece of wood (or similar) across the middle of the track/control line.

3.7 Consider **evacuation** of treed areas on the fire ground when tree-top wind-speed triggers are exceeded. This will vary depending on circumstances but will generally be triggered by an observation or forecast of Gale force winds/wind gusts (ie Beaufort Wind Scale = 8, 63-75km/hr), or greater.

3.7.1 The Incident Controller will determine the level and type of response based on the risk and operational environment. In general, deployment of personnel into areas where the level of tree hazard is unacceptably high, will only be considered if there is an imminent threat to life.

3.7.2 Operations staff need to be prepared for rapid crew withdrawal if trees are falling, forecast become unfavourable, or weather actually deteriorates.

3.7.3 Where an area is dominated by hazard trees and the opportunity for safe work is severely restricted, crew levels should be reduced to essential tasks only and where possible only purpose-built (for falling object protection) vehicles should be used.

Note: To maintain its effectiveness as an alert, yellow and black hazard tape is only to be used to mark the location/exclusion zone of CPD trees.

Schedule 4

Tree Hazard Mitigation Matrix: Identification, Assessment, Marking and Treatment

Assessment status	**Not Assessed In Fire Affected Area** (pre, during or post fire)	**Assessed And Deemed To Be Sound** (pre, during or post fire)	**Assessed** (pre fire)	**Assessed** (mostly pre-, occasionally during or post- fire)	**Assessed** (during or post fire)
Tree Type				HAZARD TREE	
	Not assessed	Appears sound	Potential Clear and Present danger (CPD): protection reliably assured.	Potential Clear and Present Danger (CPD): protection NOT reliably assured. OR Hazardous Tree	Clear & Present Danger (CPD)
Hazard Status	Unknown	Low	Currently low but vulnerable to rapid increase if affected by the fire or associated operations	Deemed to have, or presents evidence of increased hazard	Extreme
Marking Symbol	No mark	Sound, no mark	Yellow Dot (•)	Yellow Cross (**X**)	Yellow “**K**” and/or hazard tape exclusion area.

Assessment status	**Not Assessed In Fire Affected Area** (pre, during or post fire)	**Assessed And Deemed To Be Sound** (pre, during or post fire)	**Assessed** (pre fire)	**Assessed** (mostly pre-, occasionally during or post- fire)	**Assessed** (during or post fire)
Definition	Tree yet to be assessed	An assessed sound tree that is not currently hazardous and is not likely to become a CPD tree when exposed to fire or other disturbance associated with the incident (eg. wind gusts, machine damage).	A tree which in its current state does not appear hazardous, but may become a CPD tree if it catches alight or is impacted by wind or other fire-related disturbance. It has a high probability of surviving the fire intact based on the proposed protection measures and likely response resources available.	A tree which in its current state does not appear hazardous, but may become a CPD tree if it catches alight or is impacted by wind or other operational disturbance. It does NOT have a high probability of surviving the fire intact based on the proposed protection measures and likely response resources available. OR A tree which in its current state may in part or wholly fall and impact personnel in its potential impact zone (but is not considered likely to do so during the expected time frame of the current operation).	A tree or branch that is likely to fall within the expected timeframe of the current operation and impact personnel in its potential impact zone.

Assessment status	**Not Assessed In Fire Affected Area** (pre, during or post fire)	**Assessed And Deemed To Be Sound** (pre, during or post fire)	**Assessed** (pre fire)	**Assessed** (mostly pre-, occasionally during or post- fire)	**Assessed** (during or post fire)
Description		Tree appears 'sound', ie - no obvious defects which would significantly weaken the trunk or allow the entry of fire. No large dead branches or widow makers present.	Tree has: Exposed butt scars, OR Hard to reach elevated hollows, OR Small diameter and surrounded by accumulated heavy fuel.	Trees with a stem or branch diameter greater than 10cm above shoulder height and are assessed to be at increased risk of total or partial collapse based on (but not limited to) one or more of the following indicators: • Dead and/or decaying; • Suspended loose or broken branches; • Significant lean with a recent cause or indicators of failure; • >50% decrease in sound and solid cross section at any point in bole or major branch; • Evidence of longitudinal cracking, or a weak fork; • Evidence of its roots lifting, or an under cut or disturbed root system; • Tree cannot be effectively protected from catching alight and becoming subsequently weakened; • Other indicators of serious weakness based on local knowledge and conditions.	Tree is on fire, not able to be safely and reliably extinguished and will be weakened to failure point by fire, OR Tree has incurred severe structural damage from recently extinguished fire and appears very unstable, OR Tree has been impacted on by some other factor and appears likely to fail within the timeframe of the current operation (eg. backed into by bulldozer, damaged by nearby tree fall).

Assessment status	**Not Assessed In Fire Affected Area** (pre, during or post fire)	**Assessed And Deemed To Be Sound** (pre, during or post fire)	**Assessed** (pre fire)	**Assessed** (mostly pre-, occasionally during or post- fire)	**Assessed** (during or post fire)
Instruction to HT assessment crew	Tree has not been assessed and its condition is unknown. For avoidance of doubt, during or post fire all trees in this category should be considered potential CPD (“K”) trees.	Carefully check trees from both sides against criteria for hazardous and CPD trees. If in doubt regarding its soundness or ability to survive the fire, err on the side of fire fighter safety.	Mark with a Yellow Dot (•) provided the tree can reliably be protected from fire by measures and resources available (otherwise tree is to be considered as a potential CPD tree and marked accordingly). Tree may be worked under.	Mark with a yellow “X” for removal. If there is doubt regarding a tree being hazardous, err on the side of safety and mark for removal. Note: Small trees may burn out quickly. Trees may occasionally fall uphill particularly under the influence of strong winds.	Only mark if the tree is safe to approach, always establish an exclusion zone or reroute the control line.

Assessment status	**Not Assessed In Fire Affected Area** (pre, during or post fire)	**Assessed And Deemed To Be Sound** (pre, during or post fire)	**Assessed** (pre fire)	**Assessed** (mostly pre-, occasionally during or post- fire)	**Assessed** (during or post fire)
Instruction to fire crew	Approach trees with caution. If approaching tree to assess presents hazard to personnel, use the tape mark off system to identify as a CPD tree (ie “K” tree) and isolate as per DEPI pictorial guide. Assessments must be conducted on foot, not ‘drive by’.	Normal precautions, tree may be worked under.	**Pre-fire**: Clear around and protect from fire, normal precautions, ensure tree does not catch fire, tree may be worked under. Additional actions such as ground applied retardant or wetting down, pre-fire candling under controlled conditions, and intensive patrol may be requested. **Post-fire**: If protection fails and the tree catches alight, it should be fully extinguished as soon as possible, if safe to do so. If the tree cannot be reliably and effectively extinguished, and it threatens the work space/control line, it becomes a CPD tree and is treated accordingly.	Ensure tree removal as soon as practicable. Tree presents significant additional risks but is currently assessed as unlikely to fall during the current operation; may be worked under with caution following dynamic risk assessment during fire emergencies if necessary. Monitor condition to ensure tree has not caught alight or deteriorated to CPD. If tree has deteriorated reclassify to CPD and create exclusion.	Already too dangerous to work under, ensure taped-off exclusion zone for personnel and vehicles (unless specifically approved for this task) is established and maintained until tree falls or is removed.

Assessment status	**Not Assessed In Fire Affected Area** (pre, during or post fire)	**Assessed And Deemed To Be Sound** (pre, during or post fire)	**Assessed** (pre fire)	**Assessed** (mostly pre-, occasionally during or post- fire)	**Assessed** (during or post fire)
Instruction to plant operator or faller	Prohibit personnel entry into ‘not assessed’ areas for mop up/black out/patrol until hazard tree assessment and treatments have been implemented.	None (although tree removal may be required for other control line construction purposes).	Provide adequate width of mineral earth break around it to protect it from anticipated fire conditions. This must be achieved without damage to the tree (including its roots).	Remove provided the operator or faller deems it safe to do so.	Remove with extreme caution only when safety can be reliably assured. Wherever possible removal by machinery is preferred to hand falling.
General tree hazards	All trees present some degree of hazard, particular defects may be hard to see or identify so a degree of caution is always needed. Variable conditions such as increasing or gusty winds will change the overall level of risk and which trees are most dangerous.