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Kings Forest Koala Fire Management Plan

Prepared for Project 28

Andy Baker
Wildsite Ecological Services
PO Box 1172, MULLUMBIMBY
Phone: 0422 736 351
Email andybaker@wildsite.com.au
www.wildsite.com.au

Executive Summary

Regular fire is a natural component of the open forests of the Kings Forest area and plays an important role in maintaining koala habitat and food trees. However, the natural fire regimes of these forests have been disrupted by major landuse changes, posing a serious threat to the long-term viability of remnant koala populations. While large, high intensity canopy fires have the potential to eliminate koalas from extensive tracts of forest, fire is nonetheless essential for the maintenance of koala habitat, and long-term fire exclusion can lead to irreversible habitat decline and displacement.

The major fire-management issues threatening the koala in the Kings Forest area include, i) high intensity bush fires killing individual koalas, ii) peat fires that cause widespread collapse of koala habitat, and iii) fire exclusion resulting in the progressive decline and displacement of koala habitat. Conversely, high frequency fires were found to be a relatively minor issue.

The Plan outlines three management strategies, including i) Access and Strategic Fire Breaks, ii) Planned Burns, and iii) Monitoring & Adaptive Management.

The *Access and Strategic Firebreaks* strategy outlines actions required to identify and establish a network of fire containment infrastructure to better manage bush fire and planned burn operations in koala habitat.

The *Planned Burns* strategy outlines a planned burning program to maintain reduced fuel loads in order to reduce bush fire severity and assist fire suppression activities. Planned burning is the main strategy recommended for reducing bush fire hazard in koala habitat. Planned burns will also assist to maintain appropriate structure, floristics and function of koala habitat and related open ecosystems in the Kings Forest area.

The *Monitoring & Adaptive Management* strategy outlines actions to undertake monitoring and reporting to inform an adaptive management process which ensures best practices for fire management in koala habitat.

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List of Abbreviations and Prefixes

APZ	Asset Protection Zone
BC Act	NSW Biodiversity Conservation Act 2016 (BC Act)
BCD	Biodiversity Conservation Department
BFCC	Bush Fire Coordinating Committee
BFEAC	Bush Fire Environmental Assessment Code
BFMC	Bush Fire Management Committee
BFRMP	Bush Fire Risk Management Plan
DECCW	NSW Department of Environment, Climate Change & Water
DoE	Commonwealth Department of Environment
DPIE	Department of Planning, Industry and Environment
EMA	Environmental Management Area
EP&A Act	NSW Environmental Planning and Assessment Act 1979
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
FEZ	Fire Exclusion Zone
HR	Hazard Reduction
KFKPoM	Kings Forest – Koala Plan of Management
KFMP	Koala Fire Management Plan (this Plan)
KPoM	Comprehensive Koala Plan of Management
LMZ	Land Management Zone
NPWS	NSW National Parks and Wildlife Service
NSW	New South Wales
NSWFR	NSW Fire & Rescue
OEH	NSW Office of Environment & Heritage
RF Act	NSW Rural Fires Act 1997
RFS	Rural Fire Service NSW
SEPP	State Environmental Planning Policy
SEQ	Southeast Queensland
SFAZ	Strategic Fire Advantage Zone
TEC	Threatened Ecological Community
TSC	Tweed Shire Council

Part A
Basis for Management

1 INTRODUCTION

1.1 Plan Layout

This plan is broadly set out in three parts as follows:

- **Part A** of this Plan provides the background context for the management of fire in koala habitat.
- **Part B** maps the conservation values, fire history, fire-interval status and fire management priorities.
- **Part C** outlines the three main management strategies of the plan, including: i) Access & Strategic Fire Breaks; ii) Planned Burns; and iii) Monitoring & Adaptive Management

1.2 Background & Scope

Wildsite Ecological Services Pty Ltd (Wildsite) has been engaged by Project 28 Pty Ltd (Project 28) to prepare a Fire Management Plan for Koala habitat areas within the proposed Kings Forest Estate (**Map 1**). The proposed Kings Forest residential, commercial and golf course development south of Kingscliff includes considerable areas of koala habitat and associated native vegetation. A requirement of this development is the preparation of a *Bushfire Risk Management Plan* (BRMP). A specific requirement of the BRMP is to address Conditions 34 and 45(A)5 of the NSW Government Concept Plan approval (MP 08_0194) as follows:

Condition 34 Bushfire Risk Management Plan

The Bushfire Risk Management Plan (BRMP) shall be amended to address the following:

> *(1) Co-operative relations between neighbours to minimise the potential for wildfires and work towards fire frequencies and intensities that do not impact on Koala populations*
>
> *(2) Management actions required for future ongoing fire related Koala management in environmental protection zones.*
>
> *(3) The revised BRMP shall be endorsed by OEH prior to the issue of a construction certificate for civil works.*

Condition 45A Koala Plan of Management Update(s)

(5). *Bushfire Management*

> *a) specify site specific bushfire management measures, including the location of fire breaks and details of fuel reduction burns (i.e. frequency) required to facilitate the persistence of Koalas on-site.*

Additionally, the Kings Forest – Koala Plan of Management (KPoM) (JWA 2019) states that the revised Bushfire Management Plan should adopt (where relevant) the management approaches contained in:

- Tweed Coast Koala Fire Management Plan (Baker 2016b);
- Hazard Reduction Burn Guidelines for Koala Habitat on the Tweed Coast (Baker 2016a); and
- Far North Coast Bushfire Risk Management Plan.

The provisions of this Plan relate to fire management within all native vegetation (retained, restored and compensatory) within the site's Environmental Management Areas (EMAs; **Map 2**). Fire management provisions relating to the developed areas of the site are provided in (BFS(2020).

1.3 Tweed Coast Koala Fire Management Plan

The *Tweed Coast Koala Fire Management Plan* (Baker 2016b) identifies the main fire management issues affecting the Tweed Coast koala and outline strategies for the management of these issues.

The Plan identifies the major fire-management issues threatening the Tweed Coast koala, being:

1. high intensity bush fires
2. peat fires that cause widespread collapse of koala habitat
3. fire exclusion resulting in the progressive decline and displacement of koala habitat

The Plan outlines three management strategies relevant to the proposed Kings Forest Estate as outlined below.

1. *Access and Strategic Firebreaks* – outlines actions required to identify and establish new additions of on-ground fire infrastructure to better manage bush fire and planned burn operations in koala habitat.
2. *Hazard Reduction* – outlines hazard reduction (HR) program to maintain reduced fuel loads in order to reduce bush fire severity and assist fire suppression activities. HR burning is the main strategy recommended for reducing bush fire hazard in koala habitat. Periodic HR burns can also ensure the maintenance of appropriate fire regimes within koala habitat.
3. *Education, Monitoring & Research* - actions to engage private landowners in bush fire planning, increase community awareness of the important role of hazard reduction burning in bush fire safety and koala conservation, and undertake research to ensure best practices for fire management in koala habitat.

1.4 Hazard Reduction Burn Guidelines for Koala Habitat on the Tweed Coast

Hazard Reduction Burn Guidelines for Koala Habitat on the Tweed Coast (Baker 2016a) outline procedures to determine if a hazard reduction burn is needed, and also to minimise adverse impacts from HR burning on Koalas and their habitat, peat soils, fire-sensitive vegetation and cultural heritage values.

HR burns in koala habitat can i) reduce the risk of wildfires killing koala individuals, causing long-term koala habitat decline, and threatening human life and property, and ii) help maintain koala habitat by ensuring fires of appropriate frequency, intensity, severity and extent. However, it is essential that HR burns themselves, also avoid harming koala individuals and habitat, and other conservation values such as fire-sensitive vegetation and cultural heritage site.

The main purpose of the guidelines is to allow land managers to undertake hazard reduction burning within koala habitat with minimal impact on:

- koala individuals, canopy food resources and habitat condition, and
- fire-sensitive vegetation and items of cultural heritage.

1.5 Far North Coast Bushfire Risk Management Plan

The *Far North Coast Bushfire Risk Management Plan 2017* (BFRMP) sets out the types of work scheduled to deal with the risk of bush fires in the Tweed, Byron and Ballina LGAs. More specifically, the BFRMP:

- Identifies assets at risk of bush fire in the planning area (including communities, buildings, infrastructure, and also culturally and environmentally significant locations
- outlines strategies to protect these assets (ranging from community engagement to hazard reduction burns)

The BFRMP identifies several assets and treatments relevant to the Kings Forest estate (**Table 1**). Importantly, the koala population associated with Kings Forest is part of an endangered population under the BC Act (See section 1.9.3), however is not identified as an asset at risk from bushfire under the BFRMP. The provisions of the BFRMP should be updated to reflect the contemporary landuse planning changes associated with the Kings Forest estate, including relevant approval conditions.

Table 1. Assets, zones and treatments relating to Kings Forest as identified under the BFRMP.

Asset / Zone	Treatment strategy, action & responsibility
Private Forestry Plantations* (numerous polygons mapped as asset 76)	Property Planning: Prepare and implement regional fire plan (Private, FCNSW) ** this land use has now ceased*
Land Management Zone (All areas not specifically mapped as an APZ, SFAZ or FEZ are considered as LMZ)	As appropriate to achieve land management, e.g. heritage and/or fire protection e.g. broad scale mosaic burning objectives.
Olongburra frog habitat (unmapped)	Hazard Reduction: Implement appropriate fire regimes (TI CL, LGA, OEH, Private, RMS)

1.6 Kings Forest – Koala Plan of Management (KFKPoM)

The *Kings Forest – Koala Plan of Management* (JWA 2019) outlines the management of koala habitat and populations associated with the proposed Kings Forest Estate. The KFKPoM identifies that the proposal presents an 'increased risk of fire', specifically:

'through accidental ignitions and/or inappropriate or inadequate bushfire hazard management which allows fire to reach the canopy and either kill koalas or remove forage resources.'

The KFKPoM also provides that:

- The risk of high intensity fires should be reduced within koala habitat areas through controlled low intensity burns, or mechanical means if and where appropriate, and in accordance with an amended and approved Kings Forest Bushfire Risk Management Plan.
- The approved Kings Forest Bushfire Risk Management Plan will be consistent with the management strategies contained in the *Tweed Coast Koala Fire Management Plan (2016)*.
- High-intensity hazard reduction burns and wildfires that result in crown scorch or crown fires should be avoided.
- The proponent will be responsible for bushfire management in habitat areas until ownership is transferred
- Koala monitoring will be completed after bushfire events

The KFPOM identifies areas of native vegetation (retained and restored) and buffers that will not be developed, but managed for their environmental values as Environmental Management Areas (EMAs). The provisions of this

Plan relate to fire management within these EMAs; **Map 2**).

1.7 Planned Burn Guidelines: Southeast Queensland Bioregion

The Kings Forest Estate is located within the Southeast Queensland Bioregion (Thackway & Cresswell 1995) to which the *Planned Burn Guidelines: Southeast Queensland Bioregion* (SEQ Guidelines; NPRSR 2013) directly apply. Although, the Far North Coast Bushfire Management Committee uses the state-wide guidelines of (Kenny et al. 2004), the use of regionally specific guidelines is consistent with the provisions of the following:

1. *Tweed Coast Koala Fire Management Plan* (Baker 2016b)
2. *Hazard Reduction Burn Guidelines for Koala Habitat on the Tweed Coast* (Baker 2016a)
3. *Bush Fire Risk Management Planning Guidelines for Bush Fire Management Committees* (BFCC 2008).
4. *Northern Rivers Regional Biodiversity Management Plan* (Action 4.2.2; DECCW 2010):

   a) Investigate options for utilising the regional fire thresholds recommended by the Nature Conservation Council Hotspots Fire Project and the Southeast Queensland Fire and Biodiversity Consortium [NPRSR 2013]

   b) Recommendations should be used by regional bushfire management committees, DECCW [OEH] and Forests NSW.

5. *NPWS Fire Management Manual 2018 – 2019* (NPWS 2018), which states that:

   a) '*where more specific evidence-based biodiversity thresholds have been developed for a particular geographical area… these should be used instead*'.

The *SEQ Guidelines* have several advantages over the statewide guidelines given that they:

• are specific to the Northern Rivers region, reflecting the influence of the warm and wet climate on plant growth rates & lifespans and the influence of these on primary and secondary juvenile periods canopy closure

• reflect recent developments in the scientific understanding of the interplay between fire interval and biodiversity conservation, particularly that the absence of appropriate fire has been and is continuing to cause structural change towards more closed forests, resulting in an increase in fuel/fire hazard, open forest decline and a loss of biodiversity.

1.8 Plan Preparation

The preparation of this Koala Fire Management Plan (KFMP) has been based on detailed ecological assessment, comprehensive review of the latest literature relating to fire regime management for the maintenance of biodiversity values, and recommendations from Tweed Council (TC), Rural Fire Service (RFS), NSW Fire and Rescue (NSWFR) and Department of Planning, Industry and Environment (DPIE).

1.8.1 Aim and Objectives

The aim of this KFMP is to protect and conserve the population and habitat of koalas and other associated biodiversity values in the Kings Forest area through the restoration and maintenance of appropriate fire regimes.

The objectives are:

- to minimise impacts from unplanned wildfires through ecologically appropriate hazard reduction burns, and the establishment and use of wildfire suppression assets and strategies
- to maintain and improve habitat condition through the restoration of appropriate fire regimes

- to avoid adverse impacts from planned burns through burn planning, pre-burn surveys, appropriate burning strategies, post-fire monitoring and ongoing review and adaptation.

1.9 Legislative Context

1.9.1 Rural Fires Act 1997

Under the *Rural Fires Act 1997* (RF Act), public authorities and owners and occupiers of land have a duty to prevent bush fires occurring on or spreading from land under their management.

The RF Act facilitates a coordinated approach to fire planning and management within Fire Districts and Local Government Areas and infers responsibilities on Tweed Shire Council as a local authority. The Far North Coast Bush Fire Management Committee established under the RF Act consists of invited representatives from the NSW Rural Fire Service, Tweed Shire Council, Byron Shire Council, Ballina Shire Council, NSW Fire and Rescue Service, NSW Farmers Association, Forestry Corporation NSW, Nature Conservation Council NSW, NSW National Parks and Wildlife Service, Crown Lands, NSW Police, NSW Roads and Maritime, and Essential Energy. The Committee meets three times per year to discuss district fire planning issues including hazard reduction burning and bushfire management.

The Rural Fires Act 1997 includes the protection of the environment as one of its objectives by requiring activities "to be carried out having regard to the principles of ecologically sustainable development described in Section 6 (2) of the Protection of the Environment Administration Act 1991". In accordance with the Rural Fires Act 1997, Bush Fire Management Committees are required to have regard to these principles in carrying out any function that affects the environment.

1.9.1.1 FAR NORTH COAST BUSHFIRE RISK MANAGEMENT PLAN

Under the RF Act, Bush Fire Management Committees (BFMC) are responsible for the preparation of bush fire risk management plans (BFRMP). The Kings Forest estate is covered by the Far North Coast Bushfire Risk Management Plan (2010). The relevance of the BFRMP is outlined in **Section 1.5**.

1.9.1.2 NPWS FIRE MANAGEMENT STRATEGIES

Approximately 150 ha. of retained native vegetation that will be managed under this Plan, is contiguous with, and will ultimately be transferred to, Cudgen Nature Reserve. Currently, Cudgen Nature Reserve is subject to the provisions of two fire-related plans prepared by the NSW National Parks & Wildlife Service, including:

- Cudgen Nature Reserve Plan of Management (1998)
- Cudgen, Cudgera Creek, & Wooyung Nature Reserves Draft Fire Management Strategy (2012)

The relevant provisions of these plans are outlined in **Table 2**.

Table 2. NPWS fire-related plans relevant to the Kings Forest Estate.

Plan	Relevant Provisions
Cudgen Nature Reserve Plan of Management (1998)	• To manage fire on an ecological basis, except only where necessary to protect human life, property or the Reserve. • Manage fire consistent within fire thresholds (Kenny et al. 2004). • Encourage research into the ecological effects of fire in the Reserve, particularly the fire response of rare and threatened plant species. • Close contact and cooperation will be maintained with volunteer bush fire brigades, Council fire officers and State Forests of NSW. The NPWS will continue to actively participate in the Tweed Bush Fire Management Committee. • As far as possible fuel management will be carried out in cooperation with neighbours for mutual protection…" • The strategy identifies areas of koala habitat as 'long unburnt', 'too frequently burnt' and 'vulnerable to frequent fire'.
Cudgen, Cudgera	• Aim to minimise crown scorch to protect koalas

Creek, & Wooyung Nature Reserves Draft Fire Management Strategy (2012)	• Engage Tweed Valley Wildlife Carers to assist with post bush fire search for injured koalas. • The strategy identifies areas of koala habitat as 'long unburnt', 'too frequently burnt' and 'vulnerable to frequent fire'. • The strategy maps koala habitat metapopulation cells of Phillips et al. (2011)

1.9.2 Rural Fires and Environmental Assessment Legislation Amendment Act 2002

The *Rural Fires and Environmental Assessment Legislation Amendment Act 2002* amends the *RF Act* and several environmental assessment-related Acts. This Act provides for a *Bush Fire Environmental Assessment Code* (BFEAC: RFS 2006) that allows for a streamlined environmental assessment process for most hazard reduction works.

Section 2.7 of BFEAC states that: *If a development consent under the Environmental Planning & Assessment Act 1979 has been granted for the land on which the work is proposed and the consent allows for the provision of an asset protection zone or other bush fire protection measure and the proposed work is in accordance with the consent, a certificate is not required.* Whether the existing consent for the proposal satisfies this clause is currently being reviewed by DPIE (see Section 1.9.6).

1.9.3 Biodiversity Conservation Act 2016

The Koala is listed as Vulnerable under the *NSW Biodiversity Conservation Act* 2016 (BC Act) and the koala population associated with Kings Forest is part of an endangered population - *Koala population between the Tweed River and Brunswick River east of the Pacific Highway* – also listed under the BC Act. The BC Act primarily outlines an environmental impact assessment process to ensure that proposed activities do not adversely impact listed threatened species such as the koala. The biodiversity objectives of the BC Act (Section 3) with relevance to the impact of fire on koalas are outlined in **Table 3**.

Table 3. Biodiversity objectives of the BC Act with relevance to fire and koalas.

Objective	Relevance to the Tweed Coast koala
(d) to eliminate or manage certain processes that threaten the survival or evolutionary development of threatened species, populations and ecological communities,	High intensity, high frequency and low frequency bush fires threaten the survival of the koala. The BC Act should ensure rigorous assessment of all proposed activities which potentially increase these threats in koala habitat areas, including the activities which increase the likelihood of bush fire, or activities which reduce the likelihood of implementing hazard reduction burns (e.g. the placement of fire-sensitive infrastructure within fire-dependent vegetation).
(f) to encourage the conservation of threatened species, populations and ecological communities by the adoption of measures involving co-operative management.	This plan seeks to adopt measures involving co-operative management.

1.9.3.1 KEY THREATENING PROCESSES

As of June 2020, 39 key threatening processes are listed under the BC Act. Of these, two are relevant to fire and koalas, being:

- *High Frequency Fire Resulting in the Disruption of Life Cycle Processes in Plants and Animals and Loss of Vegetation Structure and Composition.*
- *Forest eucalypt dieback associated with over-abundant psyllids and Bell Miners*

The relevance of high frequency and eucalypt dieback to the Kings Forest koalas is outlined in **Section 3**.

Following amendments to Section 5A of the *Environmental Planning and Assessment Act* 1979 (EP&A Act) and Section 7.3 of the BC Act, any actions which lead to the operation or intensification of impacts of a listed key threatening process now require explicit consideration, in terms of whether they are likely to have a significant impact on koala populations.

Several additional threatening processes (not listed as KTPs) and related management actions are identified by DPIE with specific reference to inappropriate fire regimes **Table 4**.

Table 4. Additional threatening processes and actions relating to fire and koalas on the Kings Forest site.

Listed Value	Threats	Management Actions
Koala – threatened species	• Intense prescribed burns or wildfires that scorch or burn the tree canopy	• In association with relevant fire authorities and land managers ensure that koala populations and habitat areas are identified as assets for protection in fire planning tools. Develop Koala Fire Management Risk Plans with NSW Rural Fire Service, local councils and other land managers to identify fire management protocols that minimise impacts on koalas and their habitat.
Swamp Sclerophyll Forest Threatened Ecological Community	• Altered fire regimes: Low frequency fire can cause canopy closure, which shades out ground layer flora communities and fauna habitat. Too frequent fire can simplify ground layer vegetation through loss of flora species	• Assess and document the current fire frequency status in each management area by comparing time since fire with recommended fire intervals across the TEC. Determine the optimal fire frequency for each variant of the TEC and, based on findings, reinstate appropriate fire frequency across the TEC through the application of prescribed burns or fire suppression activities as appropriate. • Establish sites where canopy closure and ground layer plant communities can be monitored to determine fire thresholds.

1.9.4 Environment Protection & Biodiversity Conservation Act 1999

1.9.4.1 THREATENED SPECIES VALUES

Several threatened flora and fauna listed under the EPBC Act occur on the site (see Section 2.2).

1.9.4.2 NATIONAL KOALA CONSERVATION AND MANAGEMENT STRATEGY 2009–2014

While this strategy recognises the threat inappropriate fire regimes pose to the koala, it contains no provisions specifically relevant to fire and koalas.

1.9.5 Coastal Wetlands: SEPP (Coastal Management) 2018

Coastal wetlands of statewide significance (formerly SEPP 14 wetlands) are protected under the *State Environmental Planning Policy (Coastal Management) 2018* (the CM SEPP). The majority of retained vegetation within the Kings Forest Estate is mapped as Coastal Wetlands, or Proximity Areas for Coastal Wetlands, under this SEPP (**Map 5**).

Under the CM SEPP (clause 10), development consent is required for the 'clearing of native vegetation' within the meaning of Part 5A of the *Local Land Services Act 2013* (LLS Act). Under the LLS Act (clause 60c), 'clearing native vegetation' means any one or more of the following—

(a) cutting down, felling, uprooting, thinning or otherwise removing native vegetation,

(b) killing, destroying, poisoning, ringbarking or **burning** native vegetation.

1.9.6 Development Consent Pathway

Several potential consent pathways have been identified to allow full implementation of this KFMP. Firstly, the planned burning program proposed under this KFMP, may already be covered by existing consent for the development, which (a) contemplates these types of works within the environmental protection zones (which were previously mapped as '*Coastal Wetlands*' under SEPP 14 and now the CM SEPP) and (b) requires specific

amendments to the Bushfire Risk Management Plan to direct these works.

Alternatively, if an additional consent is required under the CM SEPP, clause 10 would normally require either a Designated Development Application (i.e. Environmental Impact Statement required) or a regular Development Application under the *Tweed Local Environment Plan* (TLEP) if the works are characterised as "environmental protection works".

The Department of Planning, Industry & Environment is providing advice on this (**Appendix E**).

2 CONSERVATION VALUES

2.1 Koala Values

Koala habitat on the Tweed Coast now occurs as fragmented remnants following extensive clearing for agriculture and residential development (Baker 2016b). Kings Forest and the adjacent Cudgen Nature Reserve now support one of the largest areas of remaining habitat and largest koala subpopulations on the Tweed Coast (Baker 2016b). The koala habitat in Kings Forest is shown in **Map 1** and **Table 5**.

Table 5. Extent of koala habitat within the study area by habitat class

Habitat / Vegetation Group	Hectares	% of total
Primary Habitat	34.6	25.4
Secondary Habitat (Class A)	96.0	70.5
Secondary Habitat (Class B)	5.6	4.1
TOTAL	136.2	100.0

2.2 Other Biodiversity Values

Koala habitat areas support a range of additional conservation values including high conservation value vegetation (**Map 3; Map 4**), as well as important habitat for other threatened flora and fauna species. It is important that fire management actions to maintain koala populations and habitat are also compatible with the conservation of these additional values. To determine the broad compatibility of fire management actions, these conservation values have been grouped by the general relationship of their habitat to fire, including: i) fire-dependent; ii) fire- independent, and iii) fire-sensitive.

The starting point for maintaining these conservation values in the landscape is to ensure fire-regimes are compatible with maintaining suitable habitat for each group. This Plan recommends planned burning within koala habitat areas in accordance with guidelines for the maintenance of associated vegetation groups, including excluding fire from adjacent rainforest habitats. The Plan assumes that active maintenance of existing vegetation types, is likely to be broadly consistent with the maintenance of the conservation values dependent on these habitats. However, it is beyond the scope of this plan to provide a comprehensive environmental impact assessment for individual management actions on each threatened species, and such an assessment should be undertaken at the time of seeking environmental approval for each management action.

2.2.1.1 FIRE-DEPENDENT CONSERVATION VALUES

Fire-dependent conservation values are those that are associated only with fire-dependent vegetation formations, such as grasslands, sedgelands, heathlands and dry, wet and swamp sclerophyll forest. These vegetation formations are widely recognised to be fire-dependent - requiring fire to maintain their floristic and structural composition, and their place in the landscape. Those values that rely on fire-dependent habitats alone are at least indirectly fire-dependent themselves. All fire-dependent conservation values associated with mapped koala habitat are outlined in **Table 6.**

The application of planned burns consistent with the maintenance of existing fire-dependent vegetation formations is likely to broadly compliment the maintenance of these fire-dependent conservation values.

Table 6. Fire-dependent conservation values.

Conservation Value	BC/SEPP	EPBC	Fire-dependent Habitat Association[1]
High Conservation Value Vegetation			
Freshwater Wetlands on Coastal Floodplains	EEC		Sedgelands and wet heathlands
Swamp Sclerophyll Forest on Coastal Floodplains	EEC		Swamp sclerophyll forests
Coastal Wetlands: SEPP (Coastal Management) 2018 - (formerly SEPP 14)	SEPP 2018		Swamp sclerophyll forests, sedgelands, fernlands and wet heathlands
Threatened Flora			
Southern Swamp Orchid (Phaius australis)	E1	E	Swamp and dry sclerophyll forest (Harden 1990; Bishop 2000).
Threatened Fauna			
Bush Stone-curlew (Burhinus grallarius)	E1		Nests in dry & swamp sclerophyll forests and woodlands.
Glossy Black-Cockatoo (Calyptorhynchus lathami)	V		Dry sclerophyll forest and woodland.
Grass Owl	V		Sedgelands and wet heathlands
Long-nosed Potoroo (Potorous tridactylus)	V	V	Dry, wet & swamp sclerophyll forest, heathlands.
Masked Owl	V		Dry eucalypt forests and woodlands
Olongburra Frog (Litoria olongburensis)	V	V	Swamp sclerophyll forests, sedgelands and wet heathlands.
Wallum Froglet (Crinia tinnula)	V		Swamp sclerophyll forests, sedgelands and wet heathlands (Barker et al. 1995).

1. Unless specified habitat associated data are sourced from DPIE threatened species profiles (DPIE 2020).

2.2.1.2 FIRE-SENSITIVE CONSERVATION VALUES

Fire-sensitive conservation values include those associated primarily with rainforest vegetation. While many rainforest species can survive intense bush fire, these species and their habitats are generally considered sensitive to recurrent fires, which can alter the habitat's floristic and structural composition. All fire-sensitive conservation values associated with mapped koala habitat are outlined in **Table 7.**

While intense bush fire can penetrate deeply into fire-sensitive habitats, lower intensity planned burns can be managed so as to avoid fire-sensitive habitats, and typically self-extinguish when they reach the boundaries of fire-sensitive vegetation types due to higher humidity and the absence of suitable understorey fuels. However, in the prolonged absence of fire, rainforest species often expand their range into adjacent fire-dependent forests, where they may be adversely affected by both bush fire and planned burning. These range expansions of fire-sensitive species into adjacent fire-dependent vegetation are cyclical and fluctuate with time since last fire. Fire management should aim to maintain unburnt refuge areas in the landscape for these values.

Table 7. Fire-sensitive conservation values.

Conservation Value	BC	EPBC	Fire-sensitive Habitat Association[1]
High Conservation Value Vegetation			
Littoral Rainforest	EEC[2]	EEC[2]	*Rainforest*
Threatened Flora			
Stinking Cryptocarya (Cryptocarya foetida)	V	V	*Rainforest*
White Lace Flower	V		*Rainforest and ecotones*
Threatened Fauna			
Nil recorded			

1. Unless specified habitat associated data are sourced from DPIE threatened species profiles (DPIE 2020).
2. An area of littoral rainforest occurs in Precinct 1 (Map 3), which the Major Project and EPBC Act approval processes resolved did not currently meet EEC mapping criteria (Adam McArthur, JWA Ecologist, personal communication, September 15, 2020). However, proposed restoration works are likely to result in the remnant meeting EEC criteria during the life of this plan.

2.2.1.3 FIRE-NEUTRAL CONSERVATION VALUES

Fire-independent conservation values include species which utilise either: i) *both* fire-sensitive and fire-dependent vegetation types, or ii) or vegetation types with no particular fire-relationship. Management should aim to maintain both fire-dependent and fire-sensitive habitats in the landscape. All fire-neutral conservation values associated with mapped koala habitat are outlined in **Table 8.**

Table 8. Fire-neutral conservation values.

Conservation Value	BC	EPBC	Fire-dependent/independent/sensitive Habitat Associations[1]
Threatened Flora			
Nil recorded			
Threatened Fauna			
Black Bittern (Ixobrychus flavicollis)	V		*Mangroves, swamp sclerophyll forests.*
Black-necked Stork (Ephippiorhynchus asiaticus)	E1		*Mangroves, vegetated swamps and open grassy woodland.*
Common Blossom-bat (Syconycteris australis)	V		*Roosts in littoral rainforest, and feeds in heathland and swamp sclerophyll forest.*
Common Planigale (Planigale maculata)	V		*Rainforests, dry sclerophyll forests, heathlands and grassy woodlands.*
Eastern Osprey (Pandion cristatus)	V		*Not associated to specific vegetation formation.*
Eastern Pygmy-possum (Cercartetus nanus)	V		*Rainforest, dry sclerophyll forest / woodland and heathland.*
Grey-headed Flying-fox (Pteropus poliocephalus)	V	V	*Rainforests, wet, dry and swamp sclerophyll forests and woodlands.*

Conservation Value	BC	EPBC	Fire-dependent/independent/sensitive Habitat Associations[1]
Pale-vented Bush-hen (Amaurornis moluccana)	V		*Rainforests, wet, dry and swamp sclerophyll forests, grasslands, heathlands.*
Yellow-bellied Sheathtail Bat	V		*Forages in most habitats across its very wide range, with and without trees*

1. Unless specified habitat associated data are sourced from DPIE threatened species profiles (DPIE 2020).

3 Koalas and Fire

3.1 Overview

Fire is a keystone ecological process within koala habitat and fossil evidence indicate that Eucalyptus, the preferred genus of koala feed tree, has coexisted with fire since the early Eocene (around 50 million years ago; Gandolfo et al. 2011). However, while regular fire is needed to maintain koala habitat, inappropriate fire regimes can adversely impact koalas and their habitat. The main fire management issues that affect koalas on the Kings Forest Estate and the wider Tweed Coast are detailed in the *Tweed Coast Koala Fire Management Plan* (Baker 2016b) and are summarised briefly here for context.

The most significant fire issues include:

- Large, high intensity bush fires killing individual koalas
- Dry-season fires that ignite peat soils and cause widespread collapse of canopy trees
- Fire exclusion resulting in koala habitat decline and displacement

3.1.1 High Intensity Bush fire

High-intensity canopy fires pose a serious threat to koalas, particularly in areas of fragmented habitat. High intensity canopy fires can cause death or injury of koalas (Lunney et al. 2004). Koalas which survive the initial canopy fire may still succumb to starvation following widespread canopy scorch (Melzer et al. 2000), or dog attack and road mortality as animals move in search of unburnt habitat (Matthews et al. 2007).

Resource depletion from intense bush fires is short-term for koalas, and individuals surviving in unburnt refuge areas, may recolonise burnt habitat and utilise resprouting trees within months of the fire for both food and shelter (Matthews et al. 2007). However, in fragmented habitat, high-intensity bush fires have the potential to eliminate koalas from isolated patches of koala habitat, and if the fragmentation limits koala movement across the landscape, repopulation of previously burnt areas after habitat recovery may be restricted or impossible.

Since reliable records began in 1978, bush fire has affected approximately 441 ha. (50%) of the Kings Forest estate. Over this period, bush fire has affected at least some portion of site around every 2-5 years. Four major bush fires were greater than 100 ha and affected extensive areas of koala habitat (**Table 9**). While there is no direct evidence of koala mortality from these bush fires, some mortality is assumed likely, and the loss of any individuals from the declining Tweed Coast koala population is believed to be unsustainable in the long-term (Baker 2016b).

Table 9. Large bush fires (>100 ha.) affecting koala habitat since 1978.

Year	Location	Affected Habitat
1982	North of Cudgen Lake	• 212 ha. including Swamp Mahogany, Paperbark and Swamp Box forest
1995	West of Cudgen Lake	• 150ha. including Paperbark, Swamp Mahogany & Blackbutt forest
2001	Northern end of Kings Forest Estate	• 166 ha. Paperbark and Swamp Mahogany forest
2009 (Dec)	West & north of Cudgen Lake	• 580 ha. Paperbark & Blackbutt forest complex. and over 200 hectares of adjacent habitat • Canopy scorch severe for approx. 70% of burn, and limited in the remainder

Importantly, large fires on the Tweed coast are often of variable burn intensity, and often contain areas of limited or no apparent canopy scorch over large areas (Baker 2016b), including approx. 30% of the 2004 Bogangar fire extent, and c. 70% of the 2014 Pottsville fire extent (**Figure 1**). So, while koala mortality associated with these large bush fires was potentially high, large areas of unburnt canopy are likely to have provided refuge and post-fire foraging resources for surviving individuals. Indeed, post-fire survey of the Pottsville wetlands reveals a relatively high levels of koala activity in recently burnt areas.

Large areas of koala habitat on Kings Forest have remained unburnt for over 25 years (**Map 6**) and are beyond threshold for fire (**Map 7**).

Figure 1. Relative extent of canopy scorch for Pottsville bush fire in 2014. Scorched canopy (grey areas) generally coincided with low canopy above dense heathy vegetation.

3.2 Peat Fires

Low lying vegetation communities subject to seasonal inundation often accumulate peat (partially decayed, densely packed organic matter) in their soils. During extended dry periods, lowered water tables allow the peat to dry and become vulnerable to ignition. Once ignited, peat fires can burn below the ground surface and in severe cases, extensive soil subsidence and / or burning of tree roots can cause widespread tree collapse.

In 2009, a large bush fire in Paperbark forests immediately to the south of the Kings Forest Estate resulted in peat fires that caused the widespread collapse of approximately 23 ha. of Paperbark forest (Baker 2016b) (**Figure 2**). This is likely to have seriously compromised the main koala linkage between the koala metapopulation on Kings Forest and those further south (**Figure 3**).

Reducing the risk of peat fires primarily involves the avoidance of bush fire or prescribed burns during extended dry periods when the dry peat layer is vulnerable to ignition. Bush fires are more likely to occur during extended dry periods, greatly increasing the likelihood of damaging peat fires. Accordingly, hazard reduction burns undertaken when the peat layer is protected by an elevated water table are advised to reduce fuel loads for dry season bush fires.

Figure 2. Widespread collapse of koala habitat (Paperbark forest) caused by peat fire in December 2009 on the western shore of Cudgen Lake (Baker 2016b).

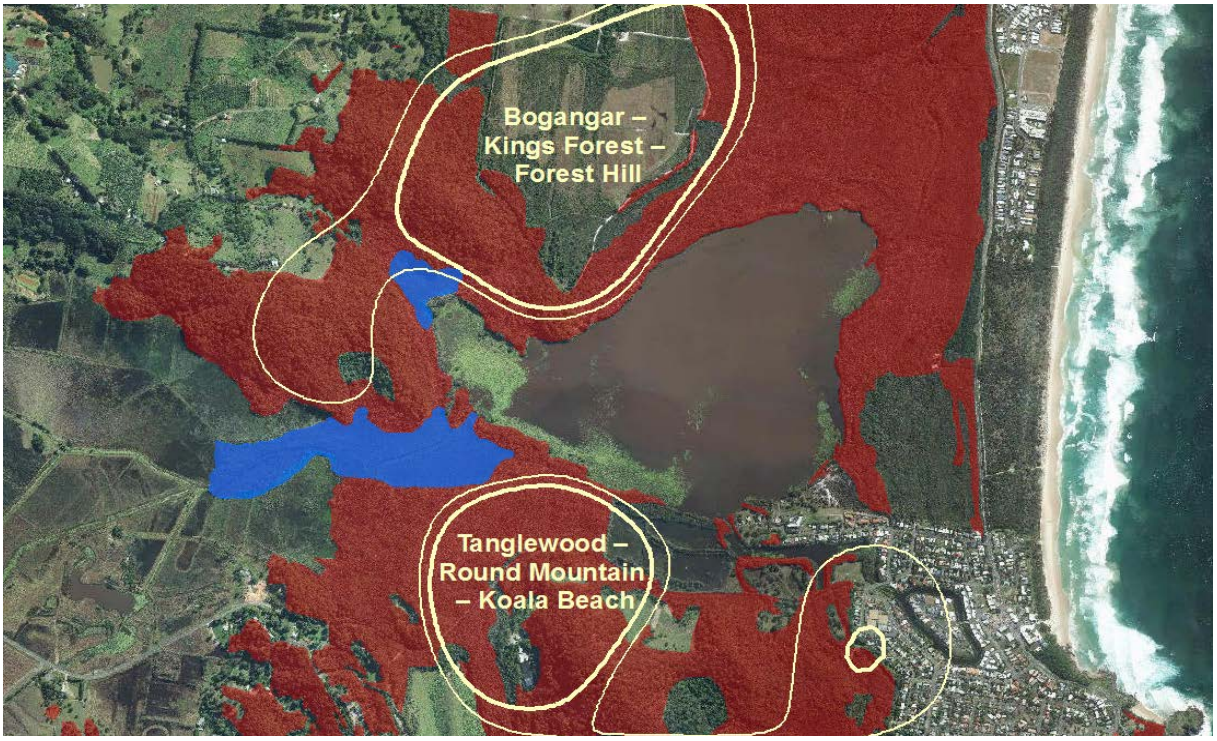


Figure 3. Collapse of koala habitat (blue) following 2009 peat fire has severely reduced connectivity between koala habitat areas (red) and two of the largest koala metapopulation cells (yellow lines) of the Tweed Coast (Baker 2016b).

3.3 Fire Exclusion (Low Frequency Fire)

3.3.1 Overview

Long-term fire exclusion is recognised to have several potentially severe consequences for koala conservation. Firstly, fires consume fuel, and the exclusion of fire is widely recognised to allow fuel accumulation, thereby increasing habitat flammability and maximising the likelihood of large, high intensity bush fires and high koala mortality. Conversely, on sites where fire exclusion allows rainforest expansion into the understorey, the developing rainforest strata can *reduce* community flammability through suppression of flammable understorey vegetation and accelerated litter decomposition. While reduced flammability may potentially reduce koala losses from bush fires, ongoing rainforest expansion would ultimately lead to the progressive decline and eventual displacement of koala habitat over large areas of the Tweed Coast.

The likelihood of these divergent consequences depends largely on the availability of surface and understorey layer fuels which fundamentally influence the ignitability and rate of spread of fires (Sullivan et al. 2012). With increasing time since fire, fuels in all layers continue to accumulate. However, a developing rainforest midstorey can suppress understorey fuel layers leading to reduced overall community flammability.

Finally, an intermediate fire exclusion pathway is possible, whereby areas of open forest avoid bush fires indefinitely, yet are also unable to support rainforest transition. While this may seem favourable to koala conservation, koala food trees require periodic fire for ongoing recruitment, and if fire does not facilitate recruitment within the lifespan of established plants or seed banks, local extinction will ensue.

3.3.2 Fuel Accumulation & Increased High Intensity Bush fires

Fire intensity and extent is largely governed by the volume and continuity of understorey vegetation, particularly surface fuels (i.e. leaf, twig & bark litter), near-surface fuels (i.e. grasses & low shrubs) and elevated fuels (i.e. tall shrubs). With increasing time since fire, these layers progressively accumulate fuel, increasing the likelihood of intense bush fires in fire-excluded vegetation. Fuel accumulation is most rapid in the decade after fire, although fuels in all layers can continue to increase for several decades (e.g. 22 years; Gould et al. 2008). By increasing the total fuel load, and allowing ongoing structural development of the fuel bed, fire exclusion increases the rate of spread, flame height and intensity of bush fires, as well as the number and distance of spot fires (Gould et al. 2008). The impact of high intensity bush fire on koalas are outlined in **Section 3.1.1.**

This relationship of increasing flammability with time since fire underpins the practice of hazard reduction burning, which is the primary tool for reducing the risk of high intensity bush fires worldwide. Hazard reduction burns are discussed further in **Section 3.4**

3.3.3 Habitat Decline & Displacement by Rainforest

While fire exclusion typically increases sclerophyll forest flammability, rainforest expansion into the forest understorey interrupts this process, ultimately reducing flammability through suppression of flammable shrubs and grasses (Hoffmann, Jaconis, et al. 2012; Baker et al. 2020), modified microclimate (Little et al. 2012) and accelerated litter decomposition (MacDermott et al. 2016). Continuing rainforest development and declining flammability trigger a cascade of positive feedback loops that can ultimately have irreversible impacts on koala habitat, including:

- suppressed recruitment of koala trees
- premature decline of established food trees
- the ultimate displacement of koala habitat

RAINFOREST TRANSITION & DECREASING FLAMMABILITY

Rainforest expansion into fire-excluded open forests occurs worldwide (Nowacki & Abrams 2008; Parr et al. 2012; Rosan et al. 2019) and is widely reported for high-rainfall regions throughout Australia (Gilbert 1959; Stanton et al. 2014; Krishnan et al. 2019). A general model of rainforest expansion recognises that rainforest trees often recruit into the understorey of open forests in the interval between fires, but regular fires prevent rainforest pioneers developing a dense midstorey (Ashton & Attiwill 1994; Bowman 2000; Murphy & Bowman 2012). With continuing fire exclusion, the developing rainforest midstorey shades out flammable ground layer vegetation (Baker et al. in press), thereby inhibiting further fires and enabling continued rainforest development (Williams 2000; Hoffmann, Geiger, et al. 2012).

The likelihood of a closed forest canopy forming and displacing the flammable understorey is a function of both fire frequency and tree growth rates. Any factor that promotes tree growth rates, such as increased water, nutrient or carbon dioxide availability, will increase the likelihood of rainforest trees recruiting, maturing and forming a closed stratum in the interval between fires. So too will any factor that increases the fire interval, such as topographic fire protection, suppression of bush fires or reduced anthropological burning (Murphy & Bowman 2012). Implicit in the model is the concept that if resources on a site are sufficient to support transition, then fire interval is the primary determinant of whether transition will occur.

With increasing time since fire, efforts to restore these sites may be complicated by encroaching rainforest trees that are no longer removed by reintroduction of fire alone, and the difficulties of reintroducing fire where flammable understoreys have been shaded out.

SUPPRESSED RECRUITMENT OF KOALA FOOD TREES

Many plant species within fire-dependent vegetation are dependent on fire for recruitment and can be driven to local extinction by fire exclusion. The reproduction and recruitment of many plant species is cued to coincide with the increased availability of resources, and the reduced competition within gaps of the post-fire environment (Whelan 2002). Gap-phase recruitment is a characteristic of most koala food trees (e.g. *Eucalyptus, Melaleuca* and *Lophostemon* spp.), and understorey removal and sun exposure of the bared soil in large gaps following fire is generally a prerequisite for the successful establishment of canopy replacing cohorts (Turton & Duff 1992; Ashton & Attiwill 1994).

Developing rainforest midstoreys are likely to further inhibit recruitment of koala food trees, by shading and reducing the likelihood of fire events necessary for their recruitment. However, even with a fire event, most rainforest species can survive complete top kill by intense bush fire (Campbell & Clarke 2006), and rapid regeneration of the rainforest midstorey after fire may directly compete with recruiting overstorey sclerophyll species, and may lead to suppressed or failed recruitment on sites with advanced rainforest midstorey development.

ACCELERATED DECLINE OF ESTABLISHED KOALA FOOD TREES

Long-term fire exclusion can cause profound changes in dry and moist eucalypt forest soils which negatively impact on tree health, including altered pH, Nitrogen and water availability and alteration of mycorrhizal and other microbial communities (Harvest et al. 2008; Close et al. 2009; Horton et al. 2013).

The development of a rainforest midstorey following fire-exclusion can further exacerbate these changes, and has been attributed to crown decline and premature mortality of dominant overstorey Eucalyptus trees (e.g. Ellis 1985; Harvest et al. 2008). Rainforest development typically modifies the soil physical and chemical environment, altering the competitive relationships between the midstorey and sclerophyll overstorey. The mechanisms accelerating crown decline include increased competition for soil water availability during droughts (Kirkpatrick & Marks 1985; Close et al. 2009) and locking up essential Phosphorous and/or cations in rainforest litter and midstorey biomass (Close et al. 2009).

While not identified in Baker (2016b) the recent and novel establishment of Bell Miner (Manorina melanophrys) colonies in coastal Tweed & Byron Shire (e.g. Uki, Yelgun, Brunswick Heads; A. Baker pers. obs.) signals a high potential for Bell Miner Associated Dieback (BMAD) as an emerging threat to koala habitat in Kings Forest. BMAD is listed as a Key Threatening Process under the BC Act and has caused the decline of tens of thousands of hectares of Euclaypt forest from south east Queensland to Victoria (Silver & Carnegie 2017). Long-unburnt open-forest with a dense mesic midstorey provides ideal nesting habitat for Bell Miners (Stone et al. 2008; Silver & Carnegie 2017).

POTENTIAL FOR RAINFOREST TRANSITION ON KINGS FOREST

While no research has assessed rainforest transition in the study area, high rainfall and widespread distribution of suitable soils and rainforest seed-source areas suggest that rainforest transition may be possible throughout many areas of fire-excluded koala habitat on the Tweed Coast. The potential for change in the region is indicated by recent vegetation mapping across the neighbouring Byron Shire, where since the 1990s, 35% of wet sclerophyll forest has transitioned to rainforest, and as much as 90% of dry sclerophyll forest understorey is now dominated by rainforest trees (BSC 2017).

Like Byron Shire, the study area's annual rainfall of >2000mm coincides with a rainfall threshold identified for far north Queensland, above which transition of coastal open forests to rainforest is ubiquitous after prolonged fire

exclusion (Russell-Smith et al. 2004; Stanton et al. 2014).

Secondly, all major soil types on the Tweed-Byron coast support rainforest in a range of topographic positions, including on exposed headlands, escarpments, and elevated sand dunes (TSC 2017). Furthermore, mixed regrowth co-dominated by rainforest trees and exotic mesophyllic trees such as Camphor Laurel (*Cinnamomum camphora*), Umbrella Trees (*Schefflera actinophylla*) and Privets (Ligustrum spp.), is widespread on formerly supporting open forest (TSC 2017), while examples of advanced rainforest midstorey development are common on richer sites such as at Duranbah and Tanglewood (Baker 2016b).

Finally, long-distance dispersal (>1 km) of rainforest seeds by frugivorous birds and bats is well documented on the far north coast of NSW (e.g. Date et al. 1996). Nearly 90% of all koala habitat on the Tweed Coast is located within 1500 meters of mapped rainforest vegetation (TSC 2017), and the diversity and abundance of frugivorous birds and bats in the study area is one of the highest in NSW (Milledge 1991).

3.4 High Frequency Fire & Hazard Reduction Burns

High frequency fire is listed as a key threatening process under the BC Act, and is specifically identified as having the potential to suppress regeneration of preferred food trees in the NSW *Recovery Plan for the koala* (DECC 2008). The continuing decline of koala populations is expected wherever recurrent bush fires remove a proportion of the breeding population at a rate faster than the time required for the loss to be replaced by successive koala generations and inflow from the wider metapopulation (Phillips et al. 2011).

Although bush fires are recurrent in the locality of Kings Forest, detailed fire history analysis (Baker 2016b) reveals that only 6.3% of koala habitat has been affected by *high frequency fire* since 1978. Furthermore, satellite imagery analysis showed that those areas affected by high frequency fire showed limited evidence of canopy scorch in one or both fires, reducing the likelihood of compounding impacts on koala mortality or temporary foraging resources.

Analysis of fire records shows that the extent of hazard reduction burning has been extremely limited on the Tweed Coast since at least 1978. During this period HR burns have only affected 2.6 ha (0.1%) of all koala habitat, no prescribed fires correlated to areas identified as being affected by high frequency fire, and there are no records of HR burns within the koala metapopulation cells of Phillips et al. (2011).

Review of fire history records for this Plan show that since 1978 within the Kings Forest site, there have been no hazard reduction burns and only a negligible extent of high frequency fire.

4 Current Fire Intervals

Fire Interval Status

A GIS analysis of fire interval status was undertaken which compared modern fire history for mapped native vegetation across the site with recommended (historic) fire intervals (NPRSR 2013) following the methods outlined in Baker (2016b p. 63). The fire classes assigned to mapped native vegetation (JWA 2019) are outlined in **Appendix A** and **Appendix B.**

Within the Kings Forest site approximately 118.0 ha. (53.9%) of koala habitat is currently beyond recommended burn intervals (i.e. overdue for fire; **Figure 4**; **Map 7**).

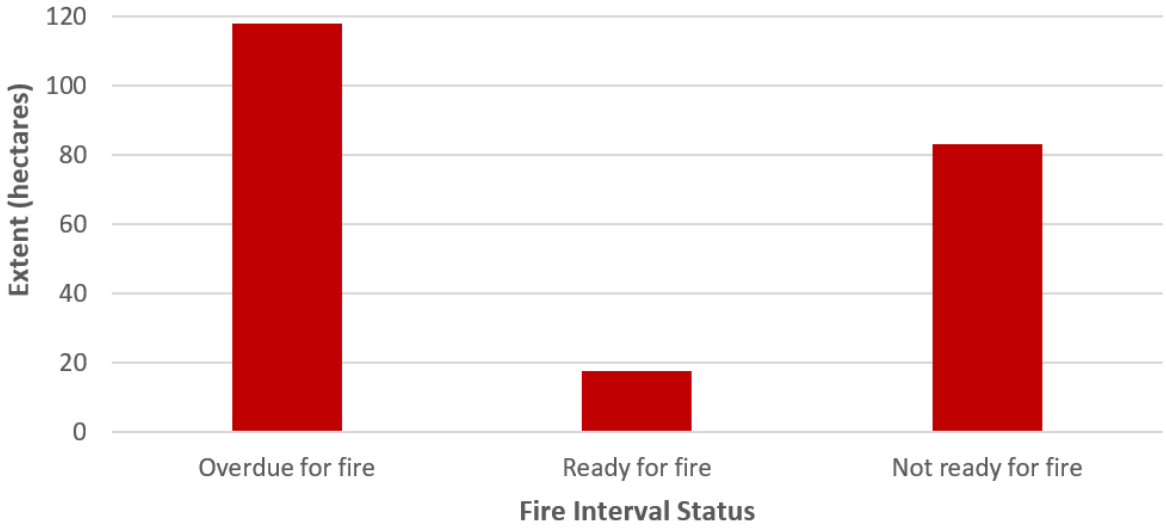
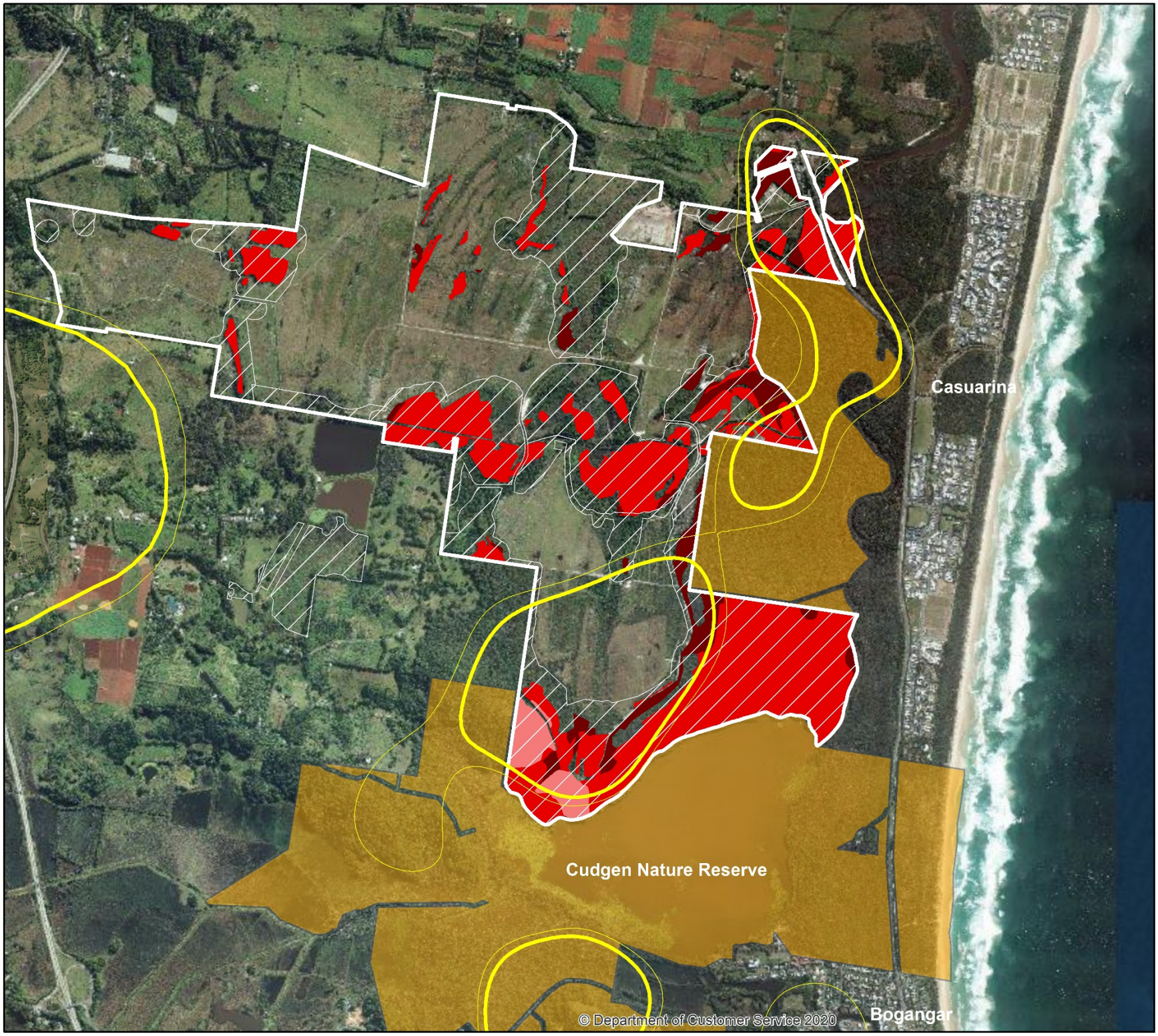


Figure 4. Fire interval status across all retained vegetation within the Kings Forest site.



KINGS FOREST KOALA FIRE MANAGEMENT PLAN

Map 1

Location & Context

N

Plan Area

- Kings Forest Estate
- Environmental Management Area (EMA)
- Nature Reserve

Koala Habitat

- Primary
- Secondary (Class A)
- Secondary (Class B)

Koala Metapopulations (Phillips et al. 2011)

- High activity
- Significant activity

Meters
0 250 500 1,000

Map Extent

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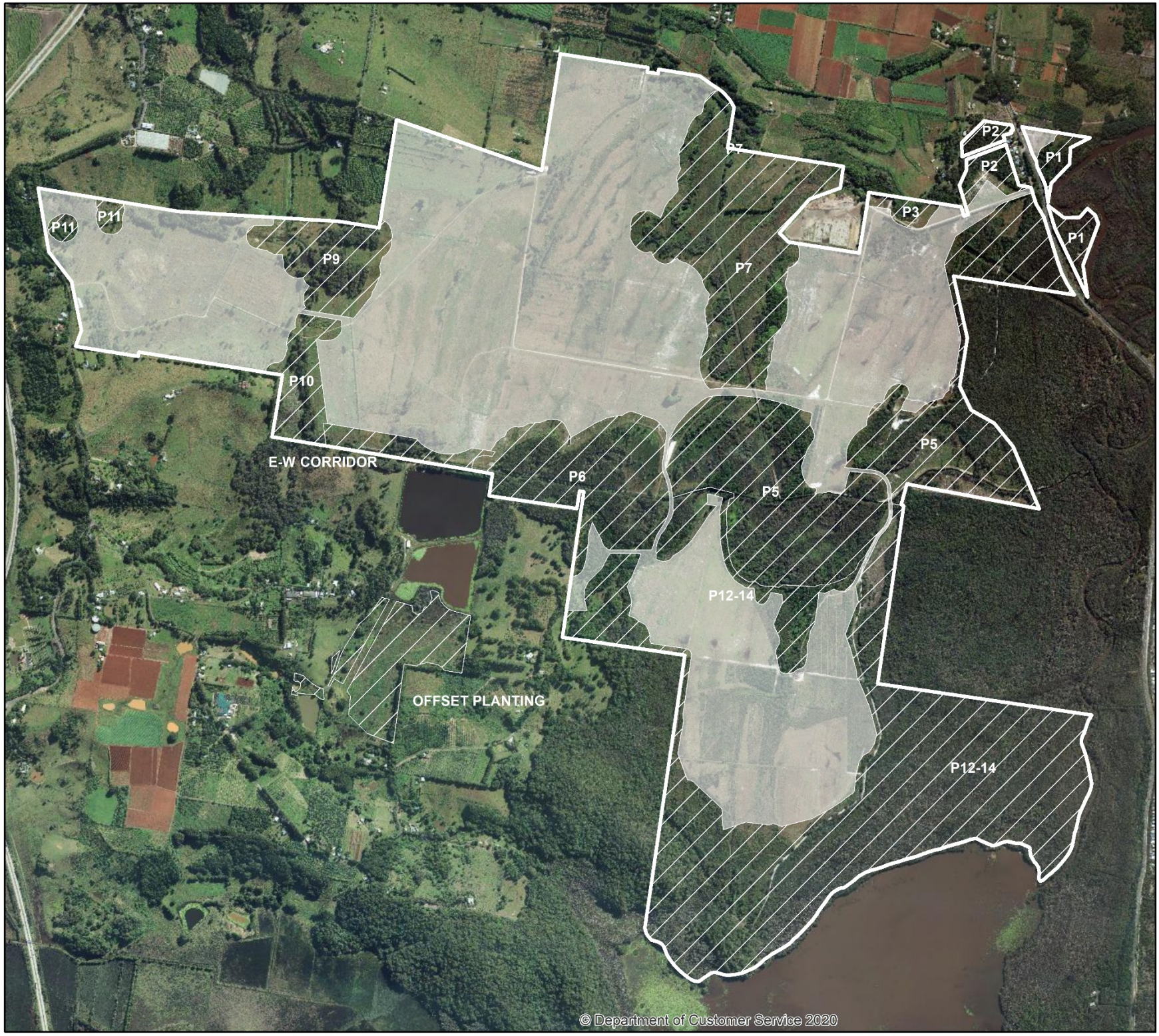

KINGS FOREST KOALA FIRE MANAGEMENT PLAN

Map 2

Environmental Management Areas (EMAs)

N

Environmental Management Area (EMA)

Developed lands

Meters
0 125 250 500 750 1,000

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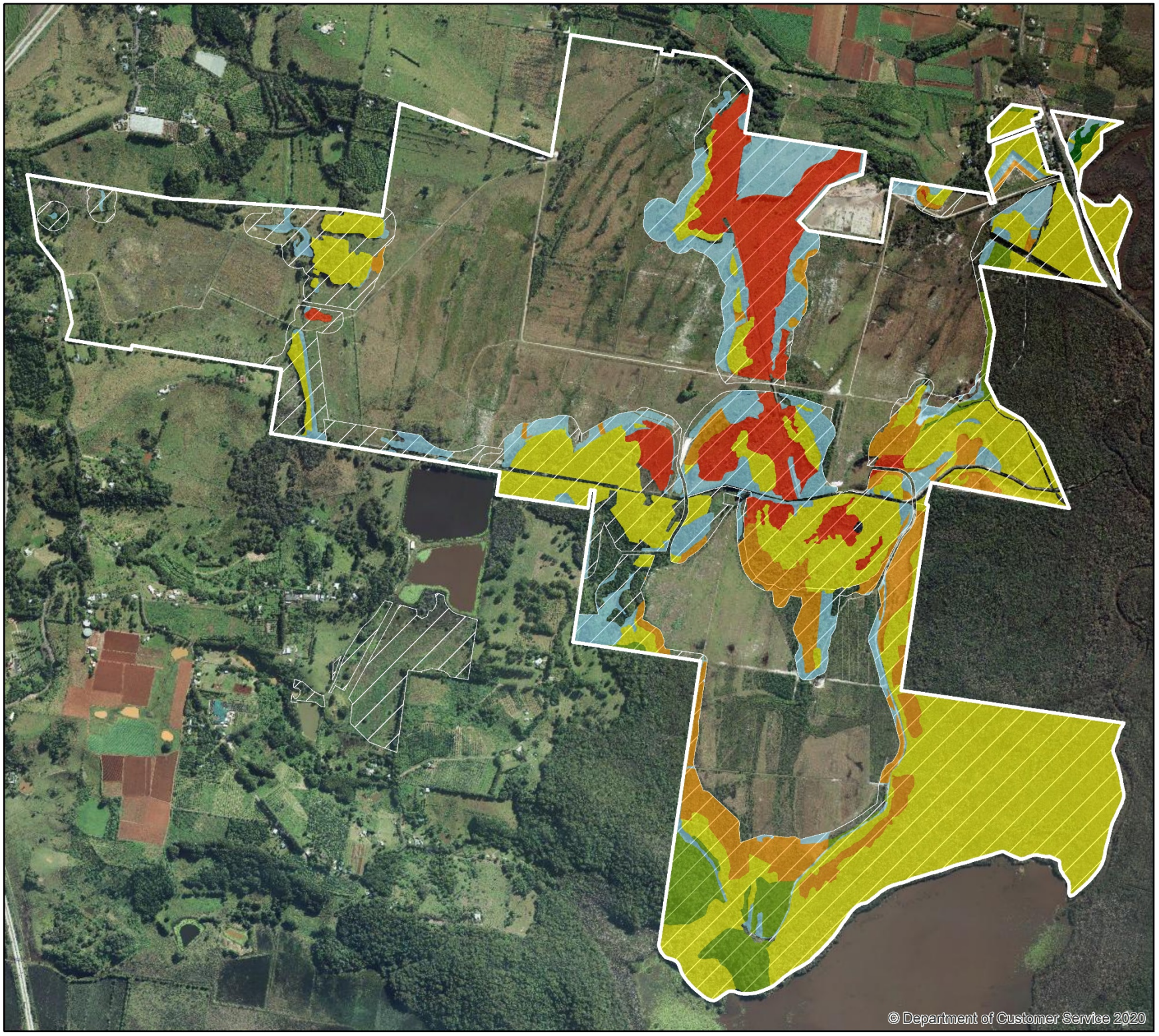

KINGS FOREST KOALA FIRE MANAGEMENT PLAN

Map 3

Existing Vegetatiom

- Rainforest
- Dry Open Forest
- Swamp Sclerophyll
- Heathland
- Freshwater Wetlands
- Highly Modified

N

Environmental Management Area (EMA)

Meters
0 125 250 500 750 1,000

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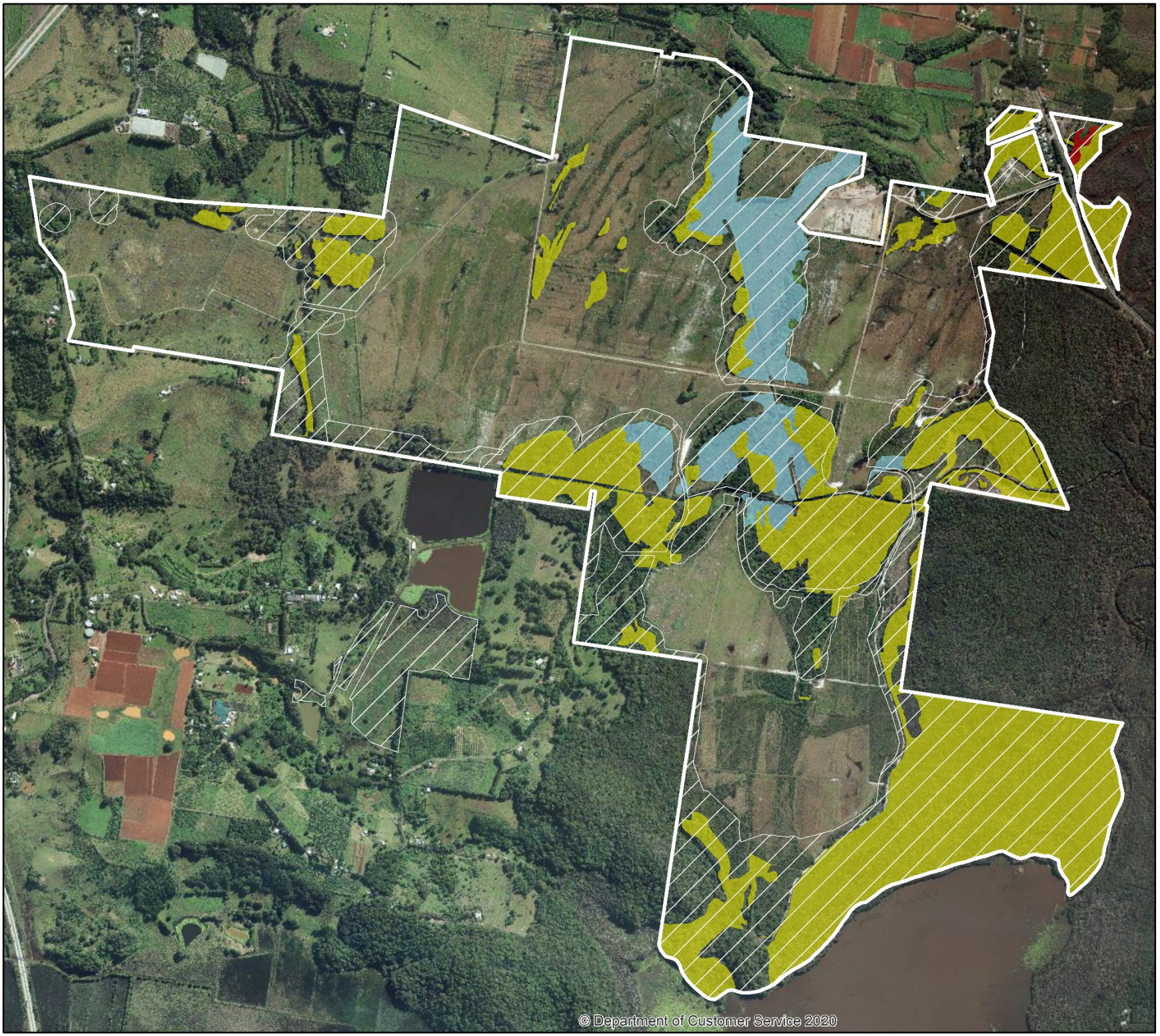

KINGS FOREST KOALA FIRE MANAGEMENT PLAN

Map 4

Threatened Ecological Communities (NSW)

- Freshwater Wetland
- Swamp Sclerophyll Forest
- Littoral Rainforest*
- Environmental Management Area (EMA)

N

**See Table 7 (Fire-sensitive conservation values)*

Meters
0 125 250 500 750 1,000

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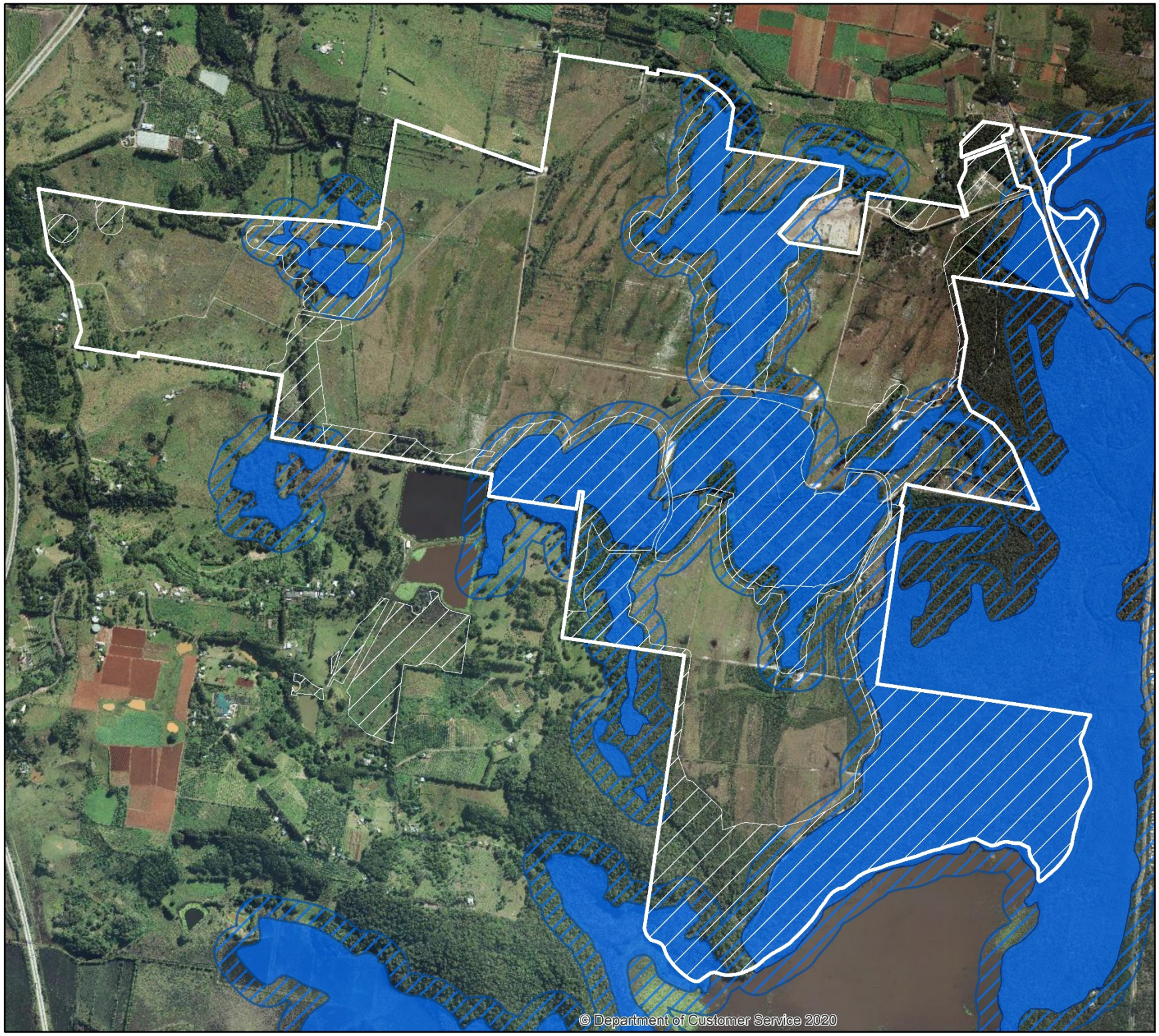

KINGS FOREST KOALA FIRE MANAGEMENT PLAN

Map 5

Coastal Wetlands

N

- Coastal Wetland
- Proximity Area
- Environmental Management Area (EMA)

Meters

0 125 250 500 750 1,000

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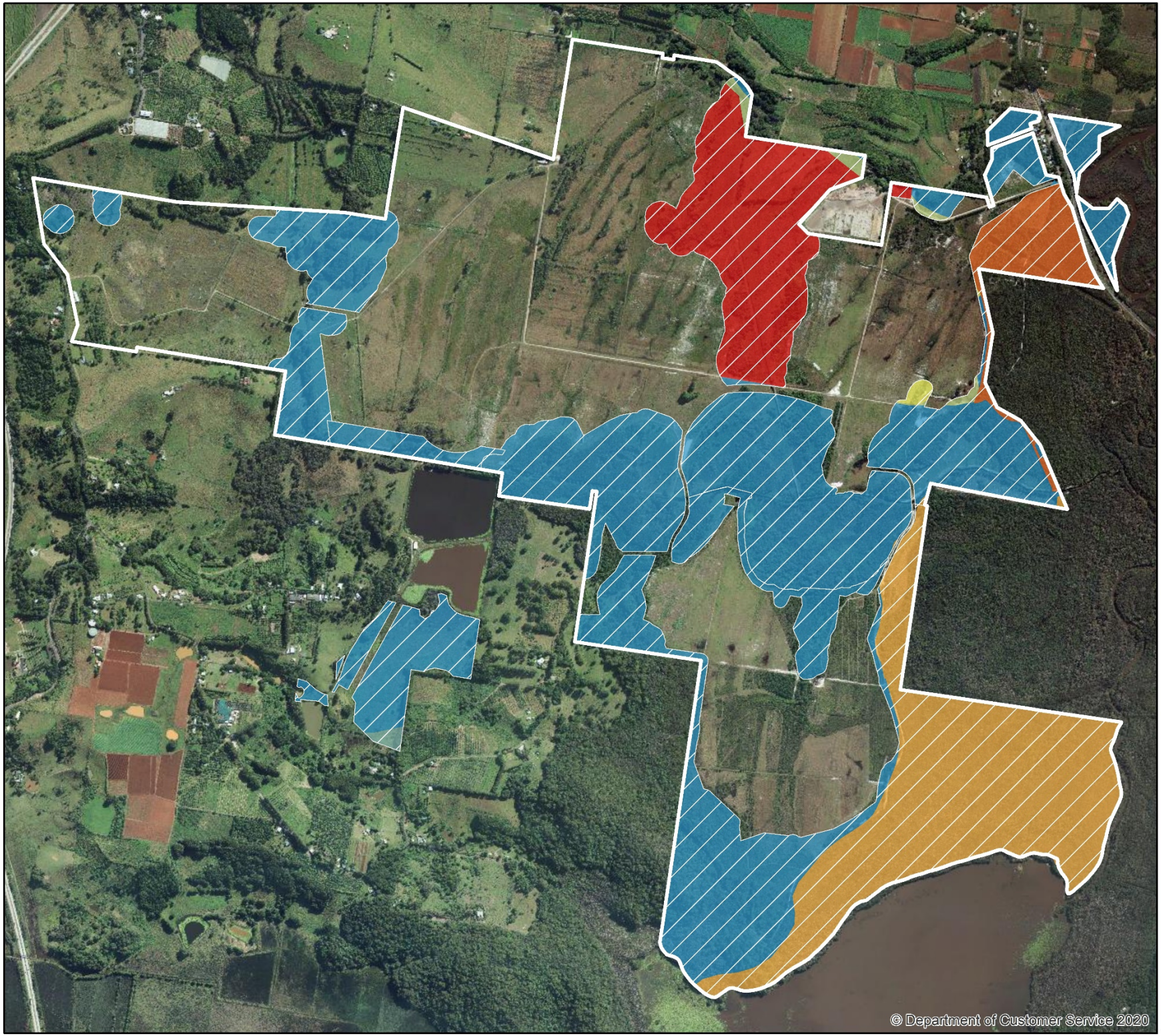

KINGS FOREST KOALA FIRE MANAGEMENT PLAN

Map 6

Fire History

N

Years since fire

- 2
- 8
- 11
- 16
- 19
- 24
- >25

Environmental Management Area (EMA)

Meters

0 125 250 500 750 1,000

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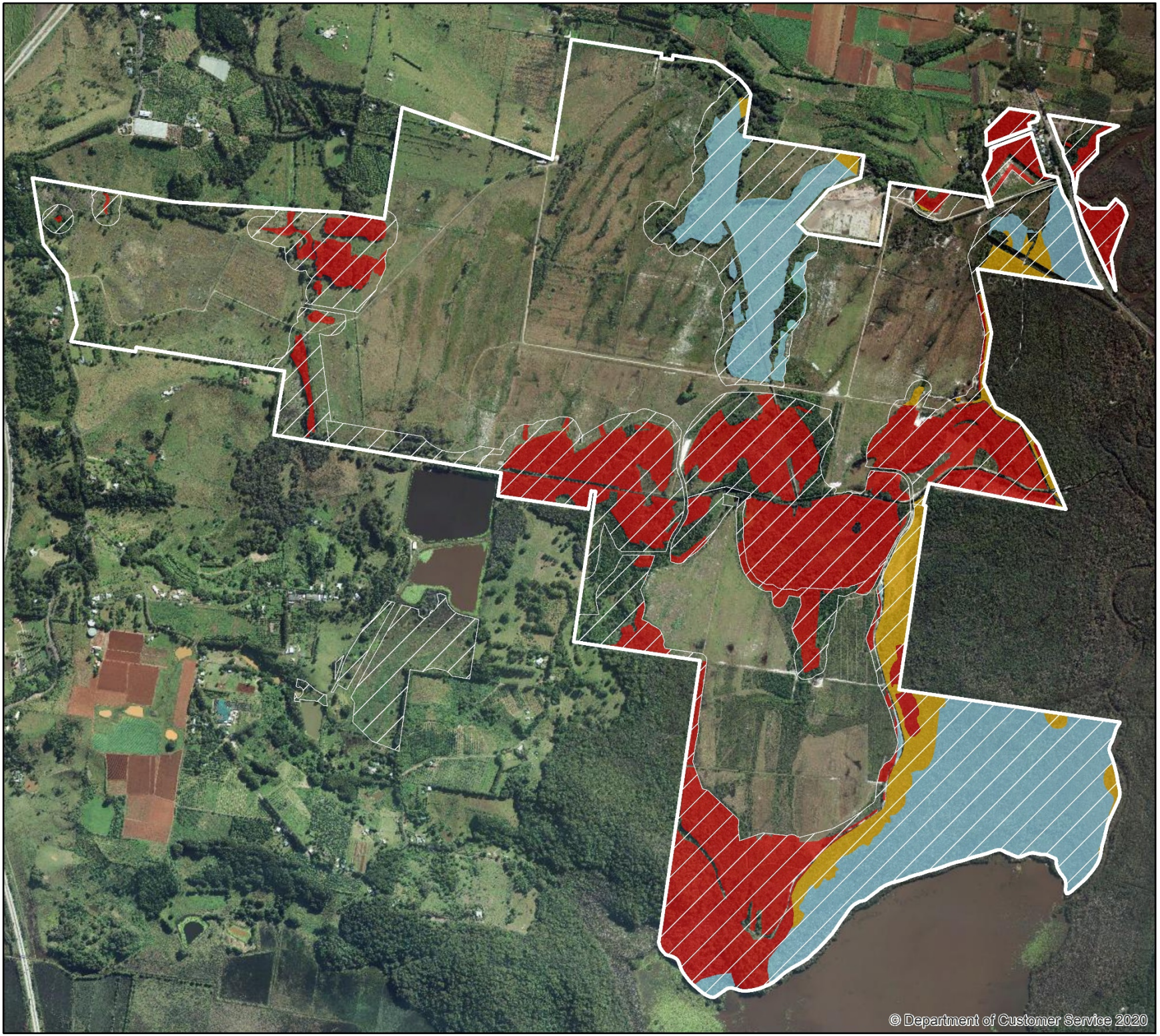

KINGS FOREST KOALA FIRE MANAGEMENT PLAN

Map 7

Fire Interval Status

N

- Overdue for fire
- Ready for fire
- Not ready for fire

Environmental Management Area (EMA)

Meters
0 125 250 500 750 1,000

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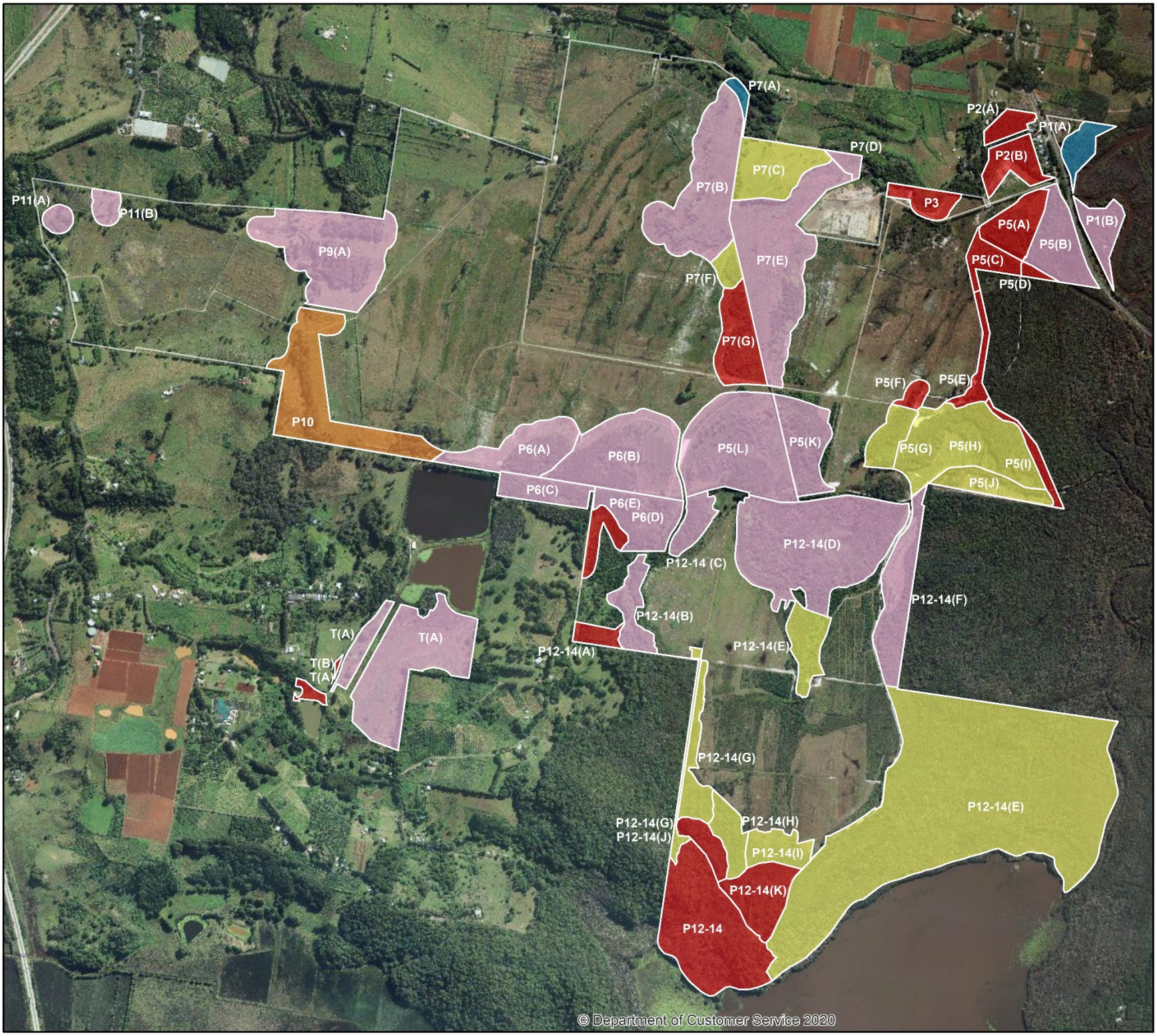

KINGS FOREST KOALA FIRE MANAGEMENT PLAN

Map 8

Proposed Burn Blocks & Fire Interval Targets

P7(E) Proposedl burn blocks

Recommended Fire Interval (years)

- 7-25
- 8-12
- 8-20
- 12-20
- No Fire

N

**Fire intervals are based on predominant vegetation class within each burn block*

SEQ Planned Burn Guidelines (NPRSR 2013)

Meters
0 125 250 500 750 1,000

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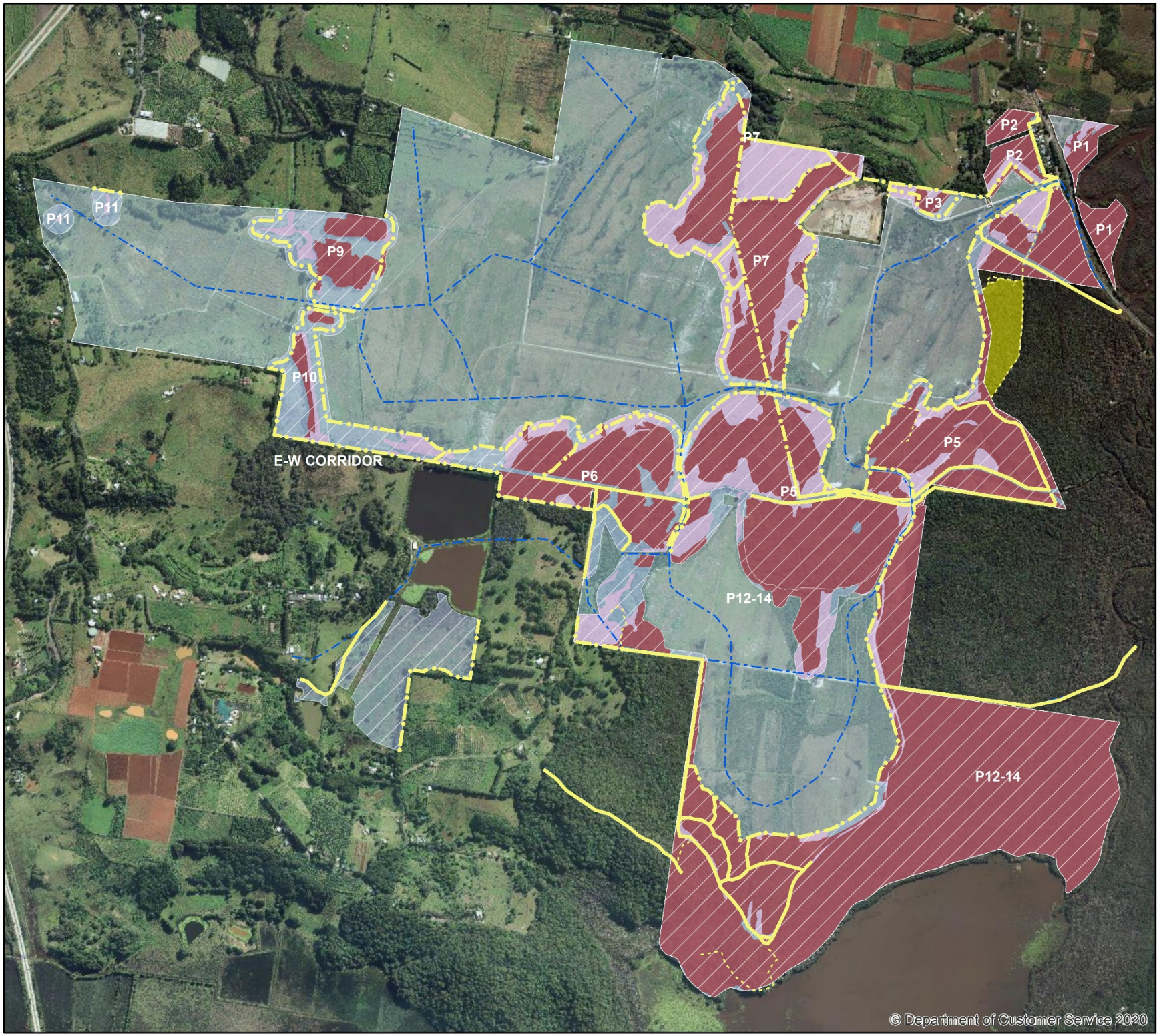

KINGS FOREST KOALA FIRE MANAGEMENT PLAN

Map 9

Burn Containment

N

Containment Lines

- Existing vehicle
- Existing walk / bike trail
- Proposed vehicle

Existing Vegetation Condition*

- Remnant vegetation
- Highly modified
- Cleared (now/proposed)

**Cleared or highly modified vegetation may provide opportunities for the establishment of new containment lines*

Miscellaneous

- Reticulation network
- Environmental Management Area (EMA)
- Strategic Fire Advantage Zone (NPWS)

Meters
0 125 250 500 750 1,000

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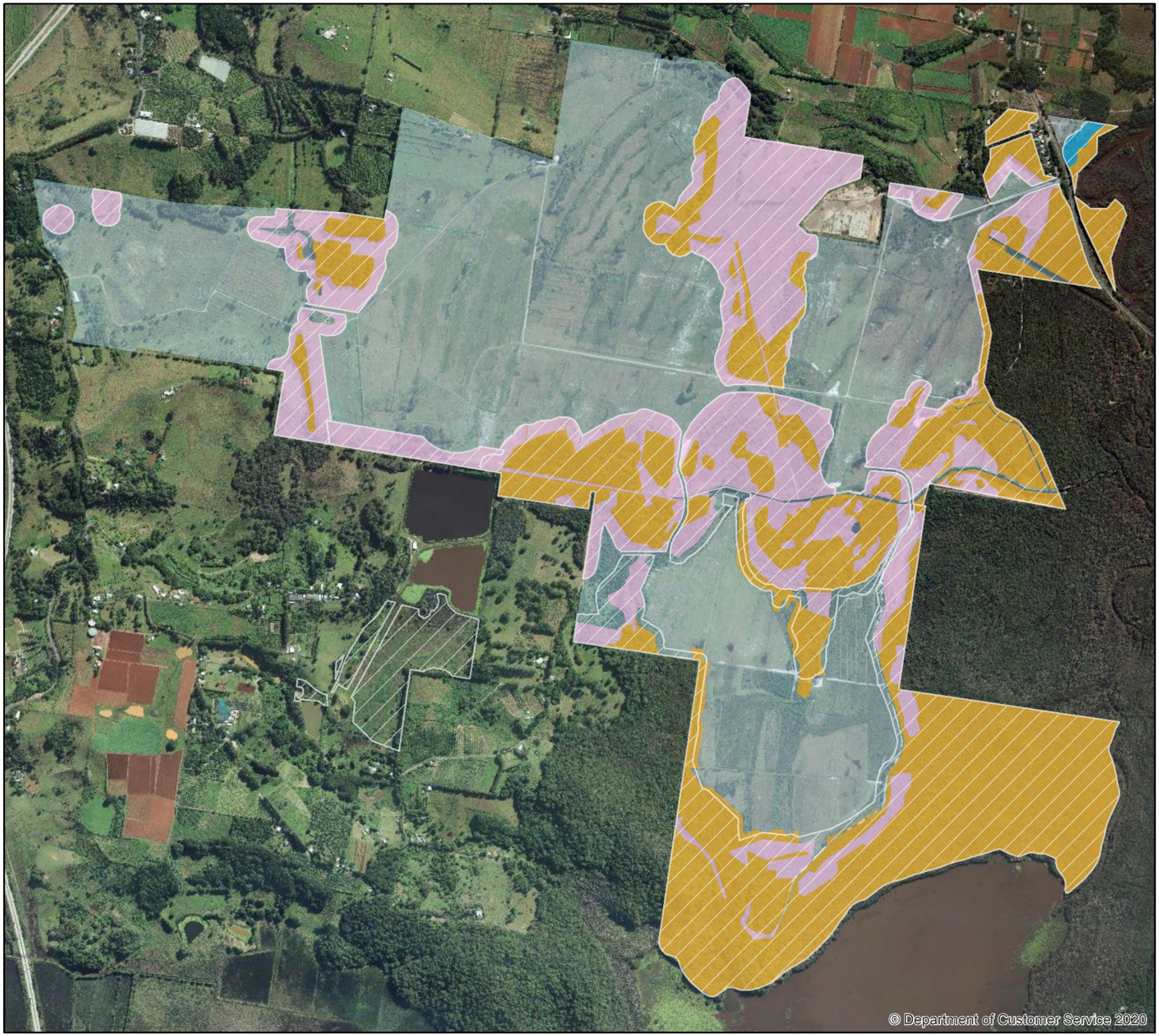

KINGS FOREST KOALA FIRE MANAGEMENT PLAN

Map 10

Fire-Sensitive Restoration Areas

N

Burn Constraints

- Retained vegetation (no establishment constraints)
- Restoration area (avoid establishment period)
- Fire-sensitive vegetation (never burn)

Environmental Management Area (EMA)

Meters
0 120 240 480 720 960

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KINGS FOREST KOALA FIRE MANAGEMENT PLAN

Map 11

Smoke-sensitive Assets

N

- Residential Areas
- Commercial Crops
- Pacifc Motorway
- Tweed Coast Road
- Overhead Powerlines
- Environmental Management Area (EMA)

Meters
0 250 500 1,000 1,500

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Part C
Management Strategies

Overview

The management of fire for the conservation of the koalas and their habitat on the Kings Forest site is outlined in the following three strategy areas:

A. ACCESS AND STRATEGIC FIREBREAKS

B. PLANNED BURNS

C. MONITORING & ADAPTIVE MANAGEMENT

Each strategy is outlined in the following manner:

BACKGROUND INFORMATION - Information which needs to be known in order to comprehend the subject and which provides a context for the outcomes, guidelines and actions.

DESIRED OUTCOMES - The desired condition of one or more specific attributes of the subject to be achieved by or before 2030.

EXISTING SITUATION - The current condition of the attributes referred to in 'Desired Outcomes'.

GUIDELINES AND POLICIES - Guidelines and policies to guide the change from the existing situation to the desired outcome.

ACTIONS - Actions needed to bring about the proposed change from the existing situation to the desired outcome.

A) ACCESS AND STRATEGIC FIREBREAKS

A.1 BACKGROUND INFORMATION

A network of access and strategic firebreaks in areas of fire-prone vegetation is crucial in allowing both suppression of bush fire and the implementation of planned burns. Fire trails and other containment strategies provide access to conduct planned burns and allow for the containment of planned burns, dividing larger vegetation blocks into smaller compartments, thereby allowing large areas to be safely and progressively burnt in stages.

The Kings Forest site has a range of existing and proposed accessways that could be used for fire management. These range from proposed public roadways and land management tracks, to informal access tracks established historically for the maintenance of drains, water mains and other land management purposes (**Map 9**). Those accessways that provide valuable access and strategic firebreaks should be identified and maintained as part of the formal fire access network for the site. Internal access trails (4m wide) will be provided along fauna fencing with gates at approx. 100m intervals (P2, P3, P5-7, P9, P10; **Map 9**). A Category 7 standard perimeter trail will is to be provided adjacent to lands proposed for transfer to the NPWS (P12-14; **Map 9**). Opportunities for additional access require urgent assessment in other retained and restored native vegetation areas.

Once established, compensatory planting areas will also be included in the planned burn program and it is essential that suitable fire management access be integrated into these plantings during their establishment.

Depending on their purpose, context and existing condition, some fire trails may only require periodic slashing for their establishment and maintenance (e.g. temporary containment lines within plantings areas), while others may require substantial design and construction to establish (e.g. new fire-trails across inundated areas).

Notwithstanding their value in fire suppression, fire trails may have adverse impacts on environmental values. Accordingly, where the establishment or upgrading of fire trails is proposed, this must be subject to appropriate impact assessment. While unauthorised access issues may be addressed by the installation of locked vehicle gates on some fire trails, the potential environmental management implications of additional trails may require consideration of alternative strategies for fire management in some cases.

One such alternative includes the use of 'Wet" strategic lines to help restrict fire movement, where fire trails are otherwise impractical. This type of strategic fire break would include a metal (or buried PVC) water line with metal risers and sprinklers which would be linked to either the reticulation network **Map 9** or that could be pressurised by fire-fighting vehicles during a fire event.

To ensure effective planning and implementation of fire management activities, knowledge of the location, condition and vehicle carrying capacity of fire trails is essential. To meet this objective the BFCC Fire Trails Policy (BFCC 2017) provides that all fire trails must be consistently classified, mapped and signposted on the basis of strategic importance and vehicle carrying capacity.

A.2 AIMS

By or before 2026, to have a comprehensive network of fire trails and strategic fire breaks established in and adjacent to both retained and restored areas of native vegetation.

A.3 EXISTING SITUATION

The existing Kings Forest fire trail network has evolved opportunistically, and needs considerable improvements to enable effective management of planned and unplanned fires.

Existing informal tracks in and adjacent to native vegetation could potentially be incorporated into the fire trail network.

Existing areas of cleared or highly modified vegetation, but which are proposed for revegetation works, provide opportunities for the establishment of new containment lines.

*Large areas of native vegetation have no internal fire trails or strategic firebreaks to support fire management activities, including: P12-14 EMA; P7 EMA; compensatory habitat plantings on the Turner site (**Map 9)**.*

*The proponent has agreed with NPWS to provide a Category 7 standard perimeter trail adjacent to lands proposed for transfer to the NPWS (P12-14; **Map 9**; **Appendix D**) (Damien Hofmeyer, NPWS Area Manager, personal communication, August 31, 2020).*

Existing and proposed water reticulation networks provide opportunities to establish permanent sprinkler lines as strategic fire breaks where fire trails are otherwise impractical.

A.4 GUIDELINES & SAFEGUARDS

*The proposed partitioning of vegetated blocks by containment lines is shown in **Map 8**.*

Proposed public roadways and Environmental Management Area perimeter tracks should be formally incorporated into the fire trail network as appropriate.

The construction, maintenance, classification, map depiction, and signage related to all fire trails is to be consistent with Fire Trails Policy of the Bush Fire Coordinating Committee (Policy No. 2/2007). The installation of signage consistent with this policy must avoid encouraging unauthorised access to access-restricted areas.

It is preferable for habitat areas to be bordered by well-defined and accessible vehicle tracks on all sides, but especially the edge along which most bush fire suppression activities are likely to be required.

Where possible all EMZs adjoining freehold lands should include a fire management trail that separates managed native vegetation and the adjoining freehold lands (see **Map 9**).

Burn blocks should be further subdivided in strategic locations using sprinkler lines or temporary mechanical containment lines where fire trails are otherwise impractical.

Containment lines may be placed between trees at ≥ 3m centres (mean) with minimal impact on compensatory planting areas.

The establishment or upgrading of any fire trails in locations subject to inundation must avoid any disruption to wetland hydrology.

The establishment or upgrading of any fire trails must be subject to appropriate environmental impact assessment.

A.5 ACTIONS

Investigate and implement the establishment of additional fire trails and strategic fire breaks that utilise existing or disused trails, highly disturbed areas and available static water supplies.

Liaise with NPWS in relation to water pipelines, levees and tracks within Cudgen NR which may be utilised as complementary fire trails and strategic fire breaks.

Undertake appropriate environmental impact assessments and obtain necessary approvals for significant access and strategic firebreaks works.

Ensure all existing and new fire trails are consistent with the BFCC Fire Trails Policy (1/2017 – Annex D) in terms of i) classification, ii) construction, iii) maintenance, iv) map depiction and v) signage.

Install locked gates on all fire trails not associated with fauna fencing (e.g. P12-14 EMA) where appropriate to prevent access for arson, dumping and recreational vehicle use.

Submit details of all new fire trails for inclusion in the Far North Coast BFMC Fire Trail Register.

Inspect and maintain all fire trails annually.

Create and implement an arson prevention program for Kings Forest estate, including the use fire trail gates, fencing, patrols, education, or signage as appropriate.

B) PLANNED BURNS

B.1 BACKGROUND INFORMATION

Planned burns are an essential tool to reduce the risk of bushfires and maintain the health and function of koala habitat and adjacent fire-dependant ecosystems. The rationale for planned burns in Koala habitat on the Tweed Coast is outlined in detail in the *Tweed Coast Koala Fire Management Plan* (Baker 2016b) and the *Hazard Reduction Burn Guidelines for Koala Habitat on the Tweed Coast* (Baker 2016a). The key aspects of this rationale and its application to the Kings Forest site is outlined below.

B.1.1 Rationale for Planned Burns

This Plan recommends that planned burns are the primary strategy for reducing the risk of high intensity bush fires impacting koala habitat on the Kings Forest site**.** The open-forest habitats of the koala are among the most fire-prone ecosystems on earth (Whelan 1995), and the incidence of fires in and around Kings Forest is the highest on the Tweed Coast. Thus, *total* fire-exclusion is an unrealistic and undesirable management goal. Attempts to exclude fire from these forests typically allow excessive accumulation of fuels, priming the koala habitat for catastrophic bush fire in extreme fire weather, thereby maximizing the likelihood of koala mortalities. Conversely, well-planned burns present a greatly reduced risk to individual koalas and their foraging resources. Low to moderate intensity planned burns are typically restricted to surface litter and understorey vegetation, with the canopy providing refuge for koalas and other arboreal mammals above the scorch height of the flames.

Hazard reduction burning is the primary tool for reducing the risk of high intensity bush fire worldwide, and provides an invaluable tool for reducing the likelihood of high intensity bush fire and peat fires within koala habitat. The overriding premise of hazard reduction burns is to pre-emptively reduce fuels under controlled conditions (e.g. mild weather and coordinated deployment of fire suppression resources), rather than allowing accumulated fuels to ignite under severe fire weather and cause severe and uncontrollable crown fires.

By reducing the load and vertical continuity of fuels, planned burns reduce the rate of spread, flame height and intensity of bush fires, as well as the number and distance of spot fires (Gould et al. 2008). Importantly, weather and fuel dynamics in Australian sclerophyll forests are conducive to regular high intensity fires, therefore hazard reduction burning can only realistically be expected to reduce rather than eliminate bush fire risk. Fuel in some vegetation communities can recover to a level capable of sustaining fire, albeit low intensity, within a few years of being burnt, especially in extreme fire weather. Accordingly, strategic HR burning aims to maintain a mosaic of low to moderate fuel levels across the landscape, increasing refugia for koalas during bush fires, while also facilitating improved bush fire suppression.

Planned burning also provides a crucial tool to minimise the likelihood of destructive peat fires. Bush fires typically occur during prolonged dry periods, which often also coincide with peat soils being exposed by lowered water tables. However, a planned burn may be used to reduce fuels above peat soils when they are protected by a high-water table, thereby minimising peat fire risk in subsequent fire seasons.

Fire is also a crucial ecological process in koala habitat, and planned burns play an important role in maintaining koala habitat condition by ensuring recruitment of koala food trees, preventing feed tree decline and maintaining appropriate forest structure (See **Section 3.3.3**).

Within koala habitat, well-planned and implemented burns provide an essential tool to:

- reduce koala mortality by reducing the intensity, extent and frequency of bush fire;
- reduce the likelihood of destructive peat fires;
- ensure ongoing recruitment of koala food trees;
- maintain an appropriate soil chemistry and microbiota for koala food trees; and
- prevent habitat displacement by rainforest transition.

B.1.2 Minimising risk to koalas

Although the primary objective for undertaking planned burns in koala habitat is to reduce koala mortality from high intensity bush fires, it is also essential that planned burns themselves avoid harming koala individuals and habitat. The critical factor is to avoid canopy scorch wherever koalas are present at the time of burning. This can be achieved by identifying areas of high risk, and managing these risks by fuel management, strategic burn tactics or exclusion from the burn area. Where these risks cannot be managed the burn should not proceed.

Koala Protection Guidelines have been developed specifically for the Tweed Coast (Baker 2016a) and these guidelines will be applied to all planned burns on the Kings Forest site to ensure minimal risk to koalas before during and after burn implementation.

The *Koala Protection Guidelines* outline a three-step process (Figure 5) that includes:

1. Identifying areas of **Canopy Scorch Risk** by comparing fuel hazard with canopy height.
2. Identifying **Koala Risk Areas** by determining koala activity within Canopy Risk Areas.
3. Managing the risk by mechanical fuel reduction, burn tactics or exclusion of area from burn.

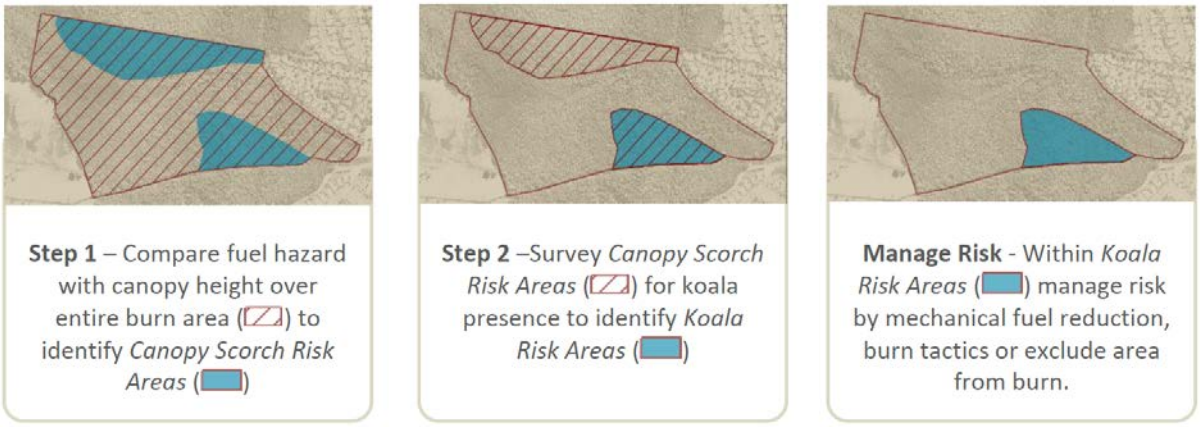


Figure 5. Overview of Koala Protection Guidelines of Baker (2016a).

B.1.3 Coordinating burns with revegetation works

Many of the environmental management areas (EMAs) requiring planned burns also contain compensatory koala habitat plantings and other revegetation works, and it is crucial that planned burns be coordinated with these fire-sensitive restoration areas (**Map 10**). Although revegetated areas will ultimately be subject to the same fire regime as adjacent remnant vegetation in the longer term, it is crucial that fire is withheld from revegetation areas during the initial establishment phase and until the plantings can survive fire and persist on the site either as adults or by seed. The challenge is protecting these plantings, while ensuring timely burns of the surrounding adjacent vegetation, much of which is currently overdue for fire (**Map 7**).

Experimental burns in young Eucalypt plantations (Lacey 2008; unpublished data) show that eucalypt saplings can survive fires of varying intensities at a relatively young age (**Figure 6**), including thin-barked species. The trials found that when exposed to *high* intensity fire, trees with a DBH > 6.5 cm typically survived, trees with a DBH 8-13 cm showed negligible effects and epicormic resprouting did not occur when crown scorch was below 75%. For *medium* intensity fires, effects were negligible for trees with DBH 5-9 cm. Therefore, given that planned fires on the Kings Forest site will typically be low-moderate intensity, koala feed tree plantings are likely to be resilient to the reintroduction of fire once trees reach a DBH of ≥ 10cm. And while complete crown scorch should be avoided, moderate crown scorch (where trees have been checked for the presence of koalas) and epicormic growth is desirable and will assist in the achieving appropriate open-forest structure in the long-term.

Figure 6. Experimental planned burn in commercial timber plantation in subtropical north-east NSW (Lacey 2008).

Planned burns must also be coordinated with the revegetation of heathland, fernland and sedgeland areas, and must ensure sufficient time after planting to allow plants to establish seed banks or be large enough to resprout. Review of the planting lists within the vegetation and weed management plans for the site (JWA 2020b; JWA 2020d)(JWA 2020a; JWA 2020b) indicate that 91% of planted species can resprout following fire and that the remaining 9% establish a seed bank capable of post fire recovery after approximately 5 years since planting (**Table 10**).

Table 10. Post-fire regenerative capacity of plants species used for revegetation works on Kings Forest Estate.

Regenerative Capacity	Species used in Plantings[1]
Resprouting (+/- seed bank)[2]	*Baeckea frutescens, Baeckea linifolia, Banksia aemula, Banksia oblongifolia, Banksia robur, Baumea articulata, Baumea rubiginosa, Boronia pinnata, Calytrix tetragona, Caustis recurvata var. recurvata, Gahnia sieberiana, Gleichenia dicarpa, Leptospermum liversidgei, Leptospermum semibaccatum, Leptospermum trinervium, Melaleuca nodosa, Phyllota phylicoides, Pteridium esculentum, Schoenus melanostachys, Sporadanthus interruptus, Triglochin procera, Xanthorrhoea fulva, Xanthorrhoea glauca, Allocasuarina littoralis, Coleocarya gracilis, Eurychorda complanata, Leptospermum juniperinum, Leptospermum polygalifolium subsp. cismontanum, Monotoca scoparia, Philotheca salsolifolia subsp. salsolifolia, Platysace lanceolata.*
Seed bank only (within 5 years)[2, 3]	*Banksia ericifolia, Dillwynia retorta, Sprengelia sprengelioides*

1 Species used in plantings (JWA 2020a; JWA 2020b)
2, 3 Regenerative capacity (OEH 2014; Baker unpub. data)

The avoidance of fire from fire sensitive restoration areas (**Map 10**) during the establishment phase can be achieved through three approaches:

1. Apply fire across entire EMA before any revegetation works are commenced.
2. Withhold all fire from the entire EMA (retained and planted vegetation) until all plantings within the EMA are mature enough to survive fire.
3. Withhold fire from revegetation areas only, but apply fire to adjacent retained vegetation within the EMA, as necessary. This may be achieved by separating plantings from burn areas using temporary containment lines, sprinklers or manual fuel reduction (e.g. brush cutting or raking around planted saplings) within planting areas.

B.1.4 Strategies for ensuring internal burn patchiness

Roadways, tracks and other unvegetated areas between individual vegetation blocks may provide impassable barriers to the movement and dispersal of some plant and animal species. So, it is essential that unburnt refuge areas are retained within each burn block to maximise the survival of biota during the burn, and their persistence and recolonisation of burnt areas post-burn. Several strategies are available to exclude fires from refuge areas within burn blocks, including:

- the use of temporary mechanical containment lines.
- wetting down areas of vegetation with hoses or permanent or temporary sprinkler lines.
- using natural or seasonal moisture differentials across the landscape.

B.1.5 Managing Smoke Impacts to Adjacent Assets

Smoke from either bush fire or planned burns can harm the health of the public, create a potential navigation hazard to road and air traffic, cause potential flashovers from overhead powerlines and potentially taint commercial food crops. Although planned burns prevent severe and extensive smoke pollution from large bush fires, it is crucial that even these reduced smoke emissions from planned burns are managed to minimise impacts on the public and other adjacent values.

Adjacent smoke sensitive values in the vicinity of Kings Forest estate are shown on **Map 11**, and include.

- Residential areas of Kings Forest, Casuarina, Salt and Bogangar
- Road traffic along the Pacific Motorway and Tweed Coast Road
- Air traffic from Coolangatta Airport
- The overhead powerline corridor running through P5 EMA
- Commercial banana, sweet potato and other intensive plant crops on volcanic soils to the north and south-west of the site

B.2 AIMS

By or before 2030, to have:

- a well-coordinated planned burning program operating throughout koala habitat areas and adjoining vegetation, and applying fire to ~10% of koala habitat per annum.
- at least 80% of koala habitat within recommended fire interval thresholds for ecological management.
- an enhanced network of 'strategic fire advantage zones' to protect both the community and the koala populations.

B.3 EXISTING SITUATION

Wildfires affect at least some portion of site around every 2-5 years.

No HR burns have been recorded on the site since 1978.

*Approx. 50% of koala habitat on the Kings Forest site is beyond fire-interval thresholds for biodiversity conservation and is likely to have high overall fuel hazard (**Map 7**).*

Existing fire-exclusion policies exacerbate the major fire management issues for koalas on the Kings Forest site, including high intensity bush fire, peat fire and habitat decline.

B.4 GUIDELINES & SAFEGUARDS

All planned burns are to be conducted in accordance with 'Hazard Reduction Burn Guidelines for Koala Habitat on the Tweed Coast' (Baker 2016a) including the application of *Koala Protection Guidelines to ensure minimal risk to koalas before during and after burn implementation.*

Planned burning should aim for a diversity of habitat age classes across koala habitat, and will be guided by the fire intervals outlined in Map 8.

Planned burning should aim to treat 7-10% per annum of fire-prone vegetation on the site in order to halve bush fire risk (Bradstock et al. 2012).

For each burn, patches of unburnt refugia must be:

- *retained for ~5% of each vegetation formation (e.g. heathland, swamp sclerophyll forest) within the burn block.*
- *burnt in the following year after the main fire to prevent excessive recruitment of saplings into the canopy.*
- *shifted with each successive burn, to ensure patches do not remain unburnt for more two or more consecutive fires.*

*To protect fire-sensitive restoration areas (**Map 10**), a minimum fire free establishment period will be maintained for 5 years since planting for treeless revegetation areas, and until trees reach a DBH of ≥ 10cm in forest plantings.*

Coordinating burns with revegetation works will be achieved through one of the following:

1. *Prioritising plantings in recently burnt areas*
2. *Burning the associated burn block prior to planting*
3. *Excluding recently planted blocks from burn areas through localised containment strategies (e.g. containment lines, sprinklers, manual fuel reduction).*

With specific reference to Stage 1, offset plantings proposed for P2, P5 and P12-14 EMAs (see Table 8 of KFKPoM) will need to be carefully coordinated with high priority burns as follows:

1. *prioritise burning of P2, P5 and P12-14 EMAs ahead of planting; or*
2. *in the unlikely event that burns cannot be completed in these EMAs within 5 years, then amend the KFKPoM Stage 1 plantings occur in the recently burnt P7, rather than the long unburnt P2, P5 and P12-14.*

B.5 ACTIONS

Undertake pre- and post-fire monitoring and management in accordance with Table 11 and relevant Management Plans (Vegetation, Threatened species, Feral animals).

Undertake appropriate environmental impact assessments and obtain necessary approvals of planned burn program.

Develop individual operational burn plans for individual burns as required. This will be done by qualified Fire Management Firm/s in collaboration with BCD/NPWS and TSC, with final plans likely approval by the relevant fire authority.

Implement planned burn program in coordination with other fire agencies and in accordance with the:

- *Planned Burn Strategy Guidelines; and*
- *'Hazard Reduction Burn Guidelines for Koala Habitat on the Tweed Coast'* (Baker 2016a).

Prioritise plantings where possible to occur in blocks that burnt in 2019 (P7B, P7C, P7E-G), and therefore not due for burning before 2026, to maximise tree establishment before being subject to initial burn.

Prioritise burns where possible that are overdue for burning (Map 7) before revegetation works, and then undertake plantings within first year after burn.

C) MONITORING & ADAPTIVE MANAGEMENT

C.1 BACKGROUND INFORMATION

C.1.1 Monitoring & Adaptive Management Framework

While planned burns are necessary to minimise the likelihood of high intensity fires in koala habitat, it is also important to monitor their effectiveness and long-term impacts on koala habitat. It is acknowledged that low intensity hazard reduction burns may not be of sufficient intensity to ensure recruitment of all species of koala food trees and other flora species of conservation significance (Auld and O'Connell 1991). Additionally, many sites in the study area have already undergone significant change following weed invasion and long periods without fire, and the response of these altered ecosystems to the reintroduction of fire is uncertain. To address these uncertainties, monitoring and adaptive management will be necessary to determine fire management strategies that best meet the objectives of protecting people and property, reducing the risk of injury or death to koalas, and ensuring the long-term conservation of koala habitat and other biodiversity values.

This Plan provides for ongoing monitoring and adaptive management to ensure planning and management are responsive to new information and changing circumstances. For example, while hazard reduction burns address many complimentary management objectives, it is essential that the effectiveness and long-term impacts of such management are regularly monitored. Such monitoring will assist the ongoing refinement of fire management strategies that best meet objectives for minimising the risk to people, property and koalas, whilst conserving koala habitat and associated plant and animal communities.

This Plan adopts the adaptive management procedures of other King's Forest Management Plans (e.g.). Adaptive management is an approach that involves implementing and monitoring management actions to learn which actions are most effective at achieving specified objectives. Comprehensive, long-term monitoring is central to the adaptive management approach, to provide robust evidence to support the continuation or refinement of management actions.

An adaptive management approach involves an integrated process of monitoring management actions, and then monitoring and evaluating the resulting structure, composition and function of the managed ecosystems as well as their overall fuel hazards. Where necessary management actions are adjusted to ensure the objectives of this KFMP are achieved.

Adaptive management strategies will be determined by the information provided in monitoring reports. Adaptive management strategies that may be required within this KFMP are as follows:

- Adjustment of the frequency, season or intensity of planned burns;
- Application of additional management interventions that may be required to ensure restoration or maintenance of ecosystem structure, composition and function; and
- Refinements to improve the efficiency and effectiveness of koala survey and hazard reduction procedures

Before the implementation of any adaptive management strategy a brief report is to be provided to Project 28 Pty Ltd and other relevant agencies detailing the proposed management actions and the predicted outcomes. The implementation must be approved by the relevant authority prior to implementation.

A network of monitoring sites will be established in both retained and restored vegetation throughout the site as part of routine vegetation and weed monitoring (JWA 2020a; JWA 2020b) and these will also be used for monitoring the planned burn program.

Fire-related monitoring has been divided into two classes, including :

1. Fire-related monitoring to be integrated other relevant Management Plans (Vegetation, Threatened species, Feral animals)
2. Fire-related monitoring unique to this KFMP

C1.2 Fire-related monitoring in relevant Management Plans

Pre- and post-fire monitoring should be integrated other Kings Forest management plans as outlined in Table 11.

Table 11. Fire-related monitoring for integration into other Kings Forest management plans.

Management Plan	Attributes to be Monitored[1]	Sampling Frequency[3]
Kings Forest Precincts 1 - 5 Vegetation and Weed Management Plan (JWA 2020a) *Kings Forest Precincts 6-14 Vegetation and Weed Management Plan* (JWA 2020b)	Cover and abundance of individual weed species	**Pre-burn**: ≤6-months prior to burn or use previous VMP annual report where available. **Post burn:** 3 -6 months after burn in accordance with VMP.
	Emerging post-fire weed infestations[2]	**Post burn:** 3 -6 months after burn in accordance with VMP.
Kings Forest Precincts 1 - 5 Threatened Species Management Plan (JWA 2020c) *Kings Forest Precincts 6-14 Threatened Species Management Plan* (JWA 2020d)	Cover and abundance of individual threatened plant species Abundance and/or activity of individual threatened fauna species	Annual monitoring and reporting in accordance with TSMP
Kings Forest Feral Animal Management Plan (JWA 2020e)	Abundance and/or activity of individual feral fauna species	**Pre-burn**: ≤6-months prior to burn or use previous feral animal annual report where available **Post burn:** 3 -6 months after burn in accordance with FAMP

[1]Data for each attribute is to be analysed with respect to recent fire history and the results presented in the annual monitoring report associated with the relevant Management Plans (Vegetation, Threatened species, Feral animals).

[2] Survey for emerging post-fire weed infestations will not use the standard monitoring site network, but will survey all road and track edges and any other historically disturbed areas with a high potential of environmental weed outbreaks. The survey is to be done by a suitably qualified Bush Regeneration Company and all significant infestations are to be integrated into the weed management program as a high priority.

[3] Post burn monitoring and survey is to also occur after any unplanned wildfires that occur within the site.

C 1.3 Fire-related monitoring unique to this KFMP

Monitoring and reporting will be undertaken to determine the effectiveness of planned burns to manage overall fuel hazard, maintain appropriate ecosystem structure, composition and function and maintain koala feed tree densities.

Monitoring will use the same sites established for the general vegetation management monitoring (JWA 2020a; 2020b) as shown in **Maps 1-3** below, including within retained habitat areas (Management Zones 2 and 3), compensatory habitat areas (Management Zones 4 and 5).

Monitoring will have three (3) focus areas, including:

1. Fuel Hazard
2. Ecosystem Structure
3. Koala Feed Tree Density

C 1.3.1. FUEL HAZARD

Fuel hazard assessments, including assessments of surface, near-surface, elevated and bark fuels, will be undertaken at each monitoring site using the *Overall Fuel Hazard Assessment Guide* (Hines et al. 2010). At each monitoring site, a 30m transect will be established as follows:

- the transect is to align with those used for vegetation and weed monitoring (JWA 2020a; JWA 2020b; **Appendix C**);

- the transect is to be centered on the permanent site marker, so that the transect extends 15m north and 15m south from the marker; and
- fuel hazard will be assessed at three (3) locations along the 30m transect (i.e. 0, 15, 30m).

C1.3.2 ECOSYSTEM STRUCTURE

Sampling of ecosystem structure will be undertaken at each monitoring site to quantify:

1. Understorey cover;
2. Overstorey cover; and

To measure ecosystem structure, a 30m transect will be established at each monitoring site as follows:

- the transect is to align with those used for vegetation and weed monitoring (JWA 2020a; JWA 2020b **Appendix C**); and
- the transect is to be centered on the permanent site marker, so that the transect extends 15m north and 15m south from the marker.

C1.3.2.1 Understorey Cover

Ground cover is to be sampled in $1m^2$ quadrat frames placed on the ground and using photographs taken:

- at six points, 5m apart, along the along the 30m transect described above (i.e. 0, 5, 10, 15, 20, 25, 30m);
- with the camera aimed vertically downward and positioned level and at a height sufficient to capture the outer edges of the of $1m^2$ quadrat frames.

Captured images are to be saved with a filename that includes site name, strata identifier (i.e. 'under'), distance along the transect in meters and date of capture (e.g. HR12_under_15m_01042022.jpeg). Images are to be analysed using appropriate software (e.g. Canopeo v 2.0; Oklahoma State University, Stillwater, USA) to determine fractional green canopy cover. Values are to be averaged over the six samples to give a single value for each site.

C1.3.2.2 Overstorey Cover

Overstorey cover is to be measured using hemispherical photographs taken:

- at six points, 5m apart, along the along the 30m transect described above (i.e. 0, 5, 10, 15, 20, 25, 30m);
- during even cloud cover to ensure delineation between canopy vegetation and sky;
- on a camera with a circular fisheye lens
- with the camera aimed vertically skyward and positioned level and at a height of 1 m above the ground.

Captured images are to be saved with a filename that includes site name, strata identifier (i.e. 'over'), distance along the transect in meters and date of capture (e.g. HR12_over_15m_01042022.jpeg). Images are to be analysed using appropriate software (e.g. Gap Light Analyzer v 2; Cary Institute of Ecosystem Studies, Millbrook, NY, USA) to determine canopy cover (e.g. leaf area index). Values are to be averaged over the six samples to give a single value for each site.

C1.3.3 KOALA FEED TREE DENSITY

Koala feed trees density is to be measured in a 20 x 20m quadrat, centered on the permanent marker for the site used for vegetation and weed monitoring (JWA 2020a; JWA 2020b; **Appendix C**). The diameter at breast height (DBH, 1.3 m above ground) of each koala feed tree in the quadrat is to be recorded in three DBH size classes (i.e. <10, 10 ≤ 30 and >30 cm). All stems are to be identified to species and tallied to quantify stem density (stems ha^{-1}).

C1.3.4 TIMING OF MONITORING VISITS

Monitoring rounds fall into two (2) classes:

1. Baseline Data Collection
2. Biennial Monitoring

Baseline data collection will quantify the existing fuel hazard and ecosystem structure prior to the commencement of construction. *Biennial monitoring* will continuously quantify fuel hazard and ecosystem structure as the vegetation responds to management actions over time.

C. 1.3.5 PERFORMANCE TARGETS AND CORRECTIVE ACTIONS

Performance indicators and targets are provided in **Table 12**. Corrective actions are provided that are to be implemented if performance targets are not met.

Table 12. Performance targets and corrective actions.

Performance Indicator	Target	Corrective Actions
Overall Fuel Hazard	Overall Fuel Hazard rating does not exceed 'high' over >50% of any environmental management area (EMA)	Where overall fuel hazard fails to meet performance criteria, discussions with BCD and TSC shall be initiated by the proponent or their consultants to consider adjustments to the planned fire strategy while ensuring the maintenance of ecologically sustainable fire intervals.
Overstorey cover	Overstorey cover in forests does not exceed 70% over more than 20% of any environmental management area (EMA). Overstorey cover in sedge/fernland does not exceed 30% over more than 20% of any environmental management area (EMA).	Where overstorey cover fails to meet performance criteria, discussions with BCD and TSC shall be initiated by the proponent or their consultants to consider adjustments to the planned fire strategy being used or other management interventions that may assist to reset appropriate structure.
Understorey cover	Understorey cover does not fall below 25% over more than 20% of any environmental management area (EMA), excluding areas that have been burnt in the last 12 months.	Where understorey cover fails to meet performance criteria, discussions with BCD and TSC shall be initiated by the proponent or their consultants to consider adjustments to the planned fire strategy being used or other management interventions that may assist to reset appropriate structure.
Koala Feed Tree Density	The density of koala feed trees <10cm DBH remains relatively stable (or increases) within each EMA over time.	Where koala feed tree density fails to meet performance criteria, discussions with BCD and TSC shall be initiated by the proponent or their consultants to identify likely factors leading to the decline of koala feed tree density and consider adjustments to the planned fire strategy being used or other management interventions that may assist to maintain feed tree density.
Fire interval status	The extent of areas overdue for fire is less than: o 40% for all EMAs combined, and 90% for each individual EMA after 5 years of burn program commencement o 10% for all EMAs combined, and 10% for each individual EMA after 10 years of burn program commencement	Where fire interval status fails to meet performance criteria, discussions with BCD and TSC shall be initiated by the proponent or their consultants to identify and address any impediments for the timely implementation of planned burns throughout the project area.

Performance Indicator	Target	Corrective Actions
Access and strategic fire breaks[1]	o Relevant works completed and maintained during the Establishment Period[2] o Assets maintained in condition suitable for handover to Tweed Shire Council or NSW BCD[3]	o Completion of works to the satisfaction of the consent authority o Follow up maintenance as necessary to the satisfaction of the consent authority

Notes:

[1] *See Implementation table for details of works involved*

[2] *"Establishment period" means the period during which initial environmental repair, restoration and monitoring works required by the relevant approved environmental management plan(s) are undertaken. The establishment period ends when the works meet the establishment period performance criteria, as defined by the relevant approved environmental management plans, to the satisfaction of the Secretary.*

[3] *"Maintenance period" means the period of environmental management and monitoring works commencing immediately after the end of the establishment period.*

C.1.3.6 REPORTING

Baseline Planned Burn Monitoring Report

Subsequent to the completion of baseline vegetation monitoring, a report will be prepared outlining the results of the survey and relevant analyses. The report will be provided to the Commonwealth DoE, NSW DPI&E, NSW BCD and TSC and form the baseline for future monitoring.

Biennial Planned Burn Monitoring Report

A biennial Planned Burn Monitoring Report will be prepared which discusses the results of the monitoring of planned burn actions and responses against the Monitoring Performance Criteria identified in Section 4. The information provided in the report should include, but not necessarily be limited to:

- A summary of all planned burn actions undertaken in the last 24 months;
- A map showing planned burns undertaken in the previous 24 months;
- A map outlining the current fire interval status across all EMAs;
- A presentation of the results of the particular monitoring event/s;
- A detailed discussion of the results of each particular monitoring event including pre and post fire comparisons where appropriate;
- A detailed comparison with the baseline parameters and with previous survey data, as appropriate;
- A statement of compliance with the Monitoring Performance Criteria identified in Section 4;
- Any problems since the previous inspection (delays to burn implementation, decline in koala feed tree density, wildfires etc.) and what effects these issues have had on the burn program, fuel hazard and ecosystem structure in affected areas;
- Success or failure of measures implemented to rectify previously identified problems;
- Measures to be taken to rectify new problems;
- A discussion of any new research (seek advice annually from TSC and BCD) that may trigger adaptive management procedures; and
- Adaptive management procedures to ensure that the management plan remains relevant and effective.

Each annual Planned Burn Monitoring Report will be submitted to TSC and the NSW DPI&E (including NSW BCD).

C.2 AIMS

By or before 2030, to have:

- improved understanding of the effectiveness and long-term impacts/benefits of the planned burning program on the koala and associated biodiversity values, and
- improved the planned burning program through ongoing review and adaptive management.

C.3 EXISTING SITUATION

Many aspects of ecological fire management, such as the appropriate fire regimes required for ongoing recruitment of koala food trees, are not well understood.

C.4 GUIDELINES & SAFEGUARDS

Monitoring will follow the guidelines included in **Section C1.3.**

C.5 ACTIONS

Map and date all planned burn and wildfire perimeters in a GIS database within three months of each event, to allow the long-term management and monitoring of burn frequency, season and extent across the site.

Undertake baseline monitoring and reporting in accordance with **Section C1.3.**

Undertake biennial monitoring and reporting in accordance with **Section C1.3.**

Ensure relevant Kings Forest management plans include fire-related monitoring actions as per **Table 11***.*

Undertake pre- and post-fire monitoring and management in accordance with Table 11 and relevant Management Plans (Vegetation, Threatened species, Feral animals).

7 Implementation Schedule

7.1 Introduction

Specific management actions outlined in Part C will be triggered and completed at the different phases of the development. The implementation schedules provided below (Table 13, Table 14 and Table 15) summarise all management strategies by development stage and identify the associated management actions, timing, responsibilities and performance measures. Indicative budgets have also been provided for works associated with this KFMP where appropriate.

Performance indicators and targets for the proposed rehabilitation strategy to be achieved during the 'establishment period' and 'maintenance period' of the project (as defined within the Project approval MP08_0194) are contained in **Table 12**. Corrective actions are also provided that are to be implemented if performance targets are not met.

7.2 Development Phases

Management actions outlined in this KFMP will be implemented in three (3) phases:

- Pre-construction Phase – The pre-construction phase of the development refers to all preliminary works required to be completed prior to commencement of construction.
- Construction Phase - The construction phase of the development refers to works commenced or completed during construction of the development.
- Operation Phase - The operational phase of the development will commence post construction and after registration of the plan/s of subdivision for each precinct and will continue in perpetuity.

The specific management actions to be implemented during each of these phases are detailed in Table 13, Table 14 and Table 15 below.

7.3 Roles and Responsibilities

The successful implementation of this KFMP requires a number of key personnel / entities to complete various roles. A summary of key personnel / entities and their responsibilities for the management actions identified in in Table 13, Table 14 and Table 15 below includes:

Proponent

Project 28 Pty Ltd is the Proponent for the works as the approval holder.

Construction Manager

The Construction Manager (to be appointed) is a representative of the project team (typically the project engineer) and is responsible for coordinating the project consultants and construction contractor.

Principal Contractor

The Principal contractor (to be appointed) is responsible for the management of all activities involved in the construction phase of the development.

Site Supervisor

The Site Supervisor is a representative of the Principal Contractor (to be appointed) and responsible for overseeing all pre-clearing, clearing and construction activities are undertaken in accordance with this KFMP and subsequent environmental management documentation.

Ecological Consultant

For the purposes of this KFMP means a qualified ecological consultant with appropriate training and at least ten (10) years of experience in: undertaking environmental impact assessment of planned burns; GIS mapping and analysis; flora and fauna survey.

Fire Management Contractor

For the purposes of this KFMP means a suitably qualified Fire Management Contractor that has demonstrable experience in bushfire management and prescribed burning the South East Queensland Bioregion. It is noted that the Fire Management Contractor must hold the necessary licenses and approvals. The engaged Fire Management Contractor will be responsible for planning, coordinating and implementing planned burns on the site.

7.4 Implementation Table – Pre-construction Phase

Table 13. Fire Management Strategies – Pre-construction phase.

Management Strategy	Management Action	Responsibility	Performance Measure	Indicative Budget[1]
Access & Strategic Fire Breaks	*Investigate the establishment of additional fire trails and strategic fire breaks that utilise existing or disused trails, highly disturbed areas and available static water supplies.*	Fire Management Contractor	Plan developed that identifies all suitable access and strategic fire break opportunities and provides detailed specifications to enable their establishment	$20, 000
Access & Strategic Fire Breaks	*Liaise with NPWS in relation to water pipelines, levees and tracks within Cudgen NR which may be utilised as complementary fire trails and strategic fire breaks.*	Fire Management Contractor	All available access and strategic fire break opportunities on Cudgen NR identified and agreement obtained from NPWS to implement identified measures	$3, 000
Access & Strategic Fire Breaks	*Undertake appropriate environmental impact assessments and obtain necessary approvals for significant access and strategic firebreaks works.*	Qualified Ecological Consultant	All environmental impact assessment requirements completed and required environmental approvals are obtained	Subject to advice on final approval pathway and associated environmental impact requirements
Planned Burns	*Undertake appropriate environmental impact assessments and obtain necessary approvals of planned burn program.*	Qualified Ecological Consultant	All environmental impact assessment requirements completed and required environmental approvals are obtained	Subject to advice on final approval pathway and associated environmental impact requirements
Planned Burns	*Develop individual operational burn plans for individual burns as required.*	Fire Management Contractor	Operational burn plans developed as required	$25, 000 / yr
Planned Burns[2]	*Pre- and post-fire monitoring and control in accordance with Table 11.*	Qualified Ecological Consultant	Consistent with performance targets in the relevant Management Plans (Vegetation, Threatened species, Feral animals)	See relevant Management Plans
Planned Burns	*Implement planned burn program in coordination with other fire agencies and in accordance with the:* *• Planned Burn Strategy Guidelines; and* *• 'Hazard Reduction Burn Guidelines for Koala Habitat on the Tweed Coast' (Baker 2016a).*	Fire Management Contractor	All vegetation within appropriate fire interval thresholds in accordance with the requirements of the KFMP.	$100,000 / yr

Management Strategy	Management Action	Responsibility	Performance Measure	Indicative Budget[1]
Planned Burns	*Prioritise plantings where possible to occur in blocks that burnt in 2019 (P7B, P7C, P7E-G), and therefore not due for burning before 2026, to maximise tree establishment before being subject to initial burn.*	Qualified Ecological Consultant / Bush Regeneration Company	Blocks P7B, P7C, P7E-G are planted by 2022 and planted areas are resilient to initial post-planting burn from 2027 onwards.	$1, 500 Rehabilitation costs already captured in relevant VMPs
Monitoring & Reporting	*Undertake baseline monitoring and reporting in accordance with Section C1.3.*	Qualified Ecologist	Baseline planned burn surveys and reports completed in accordance with Section C1.3. Reports provided to relevant government agencies.	$109 000
Monitoring & Reporting	*Ensure relevant Kings Forest management plans include fire-related monitoring actions as per Table 11.*	Qualified Ecological Consultant	Fire-related monitoring actions integrated into relevant management plans.	$2, 000

[1] *Pre-construction works assumed to be completed during the Establishment Period. "Establishment period" means the period during which initial environmental repair, restoration and monitoring works required by the relevant approved environmental management plan(s) are undertaken. The establishment period ends when the works meet the establishment period performance criteria, as defined by the relevant approved environmental management plans, to the satisfaction of the Secretary. See Project Approval for details.*

[2] *Post burn monitoring and survey is to also occur after any unplanned wildfires that occur within the site.*

7.5 Implementation Table - Construction Phase

Table 14. Fire Management Strategies –Construction phase

Management Strategy	Management Action	Responsibility	Performance Measure	Indicative Budget[1]
Access & Strategic Fire Breaks	*Implement the establishment of additional fire trails and strategic fire breaks that utilise existing or disused trails, highly disturbed areas and available static water supplies.*	Principal contractor	All additional access and strategic fire break infrastructure installed and operational	Subject to arrangements with Principal Contractor
Access & Strategic Fire Breaks	*Ensure all existing and new fire trails are consistent with the BFCC Fire Trails Policy (1/2017 – Annex D) in terms of i) classification, ii) construction, iii) maintenance, iv) map depiction and v) signage.*	Principal contractor	All fire trails are consistent with the BFCC Fire Trails Policy (1/2017 - Annex D)	Subject to arrangements with Principal Contractor
Access & Strategic Fire Breaks	*Install locked gates on all fire trails not associated with fauna fencing (e.g. P12-14 EMA) where appropriate to prevent access for arson, dumping and recreational vehicle use.*	Construction Manager	Locked gates installed on all fire trails	Subject to arrangements with Principal Contractor
Access & Strategic Fire Breaks	*Submit details of all new fire trails for inclusion in the Far North Coast BFMC Fire Trail Register.*	Fire Management Contractor	All new fire trails are included on the Far North Coast BFMC Fire Trail Register.	$1 500
Access & Strategic Fire Breaks	*Create and implement an arson prevention program for Kings Forest estate, including education and signage as appropriate.*	Principal contractor / Community Liaison Officer	Arson prevention program developed and implemented	$10, 000
Planned Burns	*Implement planned burn program in coordination with other fire agencies and in accordance with the:* *• Planned Burn Strategy Guidelines; and* *• 'Hazard Reduction Burn Guidelines for Koala Habitat on the Tweed Coast' (Baker 2016a).*	Fire Management Contractor	All vegetation within appropriate fire interval thresholds in accordance with the requirements of the KFMP.	$100,000 / yr
Planned Burns	*Prioritise burns where possible that are overdue for burning (Map 7) before revegetation works, and then undertake plantings within first year after burn.*	Qualified Ecological Consultant / Fire Management	Planting areas are resilient to initial post-planting burns.	$3, 000 Rehabilitation costs already captured in relevant VMPs

Management Strategy	Management Action	Responsibility	Performance Measure	Indicative Budget[1]
		Contractor / Bush Regeneration Company		
Planned Burns[2]	*Pre- and post-fire monitoring and control in accordance with Table 11.*	Qualified Ecological Consultant	Consistent with performance targets in the relevant Management Plans (Vegetation, Threatened species, Feral animals)	See relevant Management Plans
Monitoring & Reporting	*Map and date all planned burn and wildfire perimeters in a GIS database within three months of each event, to allow the long-term management and monitoring of burn frequency, season and extent across the site.*	Qualified Ecological Consultant	All fires mapped into GIS database within two months of occurrence	$7 000 / yr
Monitoring & Reporting	*Undertake ongoing monitoring and reporting in accordance with Section C1.3.*	Qualified Ecological Consultant	Ongoing planned burn monitoring program and reports completed in accordance with Section C1.3. Reports provided to relevant government agencies.	$66 500 / yr

[1] *Construction works assumed to be completed during the Establishment Period. "Establishment period" means the period during which initial environmental repair, restoration and monitoring works required by the relevant approved environmental management plan(s) are undertaken. The establishment period ends when the works meet the establishment period performance criteria, as defined by the relevant approved environmental management plans, to the satisfaction of the Secretary. See Project Approval for details.*

[2] *Post burn monitoring and survey is to also occur after any unplanned wildfires that occur within the site.*

7.6 Implementation Table - Operational Phase

Table 15. Fire Management Strategies –Operational phase

Management Strategy	Management Action	Responsibility	Performance Measure	Indicative Budget[1]
Access & Strategic Fire Breaks	*Inspect and maintain all fire trails annually.*	Construction Manager	All fire trails maintained in accordance with the BFCC Fire Trails Policy (1/2017 – Annex D)	$10,000 / year
Planned Burns	*Implement planned burn program in coordination with other fire agencies and in accordance with the:* *• Planned Burn Strategy Guidelines; and* *• 'Hazard Reduction Burn Guidelines for Koala Habitat on the Tweed Coast' (Baker 2016a).*	Fire Management Contractor	All vegetation within appropriate fire interval thresholds in accordance with the requirements of the KFMP.	$100,000 / year
Planned Burns	*Map and date all planned burn and wildfire perimeters in a GIS database within three months of each event, to allow the long-term management and monitoring of burn frequency, season and extent across the site.*	Ecologist	All fires mapped into GIS database within two months of occurrence	$7 000 / yr
Planned Burns[2]	*Pre- and post-fire monitoring and control in accordance with Table 11.*	Qualified Ecological Consultant	Consistent with performance targets in the relevant Management Plans (Vegetation, Threatened species, Feral animals)	See relevant Management Plans
Monitoring & Reporting	*Undertake ongoing monitoring and reporting in accordance with Section C1.3.*	Qualified Ecologist	Ongoing planned burn monitoring program and reports completed in accordance with Section C1.3. Reports provided to relevant government agencies.	$66 500 / yr

[1] *Operational phase works assumed to be carried out during the Maintenance Period. "Maintenance period" means the period of environmental management and monitoring works commencing immediately after the end of the Establishment Period. See Project Approval for details.*

[2] *Post burn monitoring and survey is to also occur after any unplanned wildfires that occur within the site.*

8 References

Ashton, D.H., & Attiwill, P.M. 1994. Tall open-forests. *Australian vegetation*

Baker, A.G. 2016a. *Hazard Reduction Burn Guidelines for Koala Habitat on the Tweed Coast*. Wildsite Ecological Services, Mullumbimby, NSW.

Baker, A.G. 2016b. *Tweed Coast Koala Fire Management Plan*. Wildsite Ecological Services, Mullumbimby, NSW.

Baker, A.G., Catterall, C., Benkendorff, K., & Fensham, R.J. Rainforest expansion reduces understorey plant diversity and density in open forest of eastern Australia. *Austral Ecology* n/a:

Baker, A.G., Catterall, C.F., Benkendorff, K., & Zylstra, P.J. 2020. Too little, too late? Fire exclusion triggers positive feedbacks to reinforce shifts from open to closed forests in south-eastern Australia. *Manuscript in preperation.*

Barker, J., Grigg, G., & Tyler, M. 1995. A field guide to Australian frogs.

BFCC. 2008. *POLICY 1/2008 - Bush Fire Risk Management Planning Guidelines for Bush Fire Management Committees*. Bush Fire Coordinating Commitee, Sydney.

BFCC. 2017. *POLICY 1/2017 - Fire Access & Fire Trails*. Bush Fire Coordinating Commitee, Sydney.

BFS 2020 *Bushfire Management Plan For Proposed Residential / Commercial Development Kings Forest Stage 1.* Report prepared for Project 28 Pty Ltd by Bush Fire Safe Pty Ltd, McClean.

Bishop, A. 2000. *Field guide to the orchids of New South Wales and Victoria*. UNSW Press.

Bowman, D.M.J.S. 2000. *Australian rainforests: islands of green in a land of fire*. Cambridge University Press, Cambridge, UK ; New York, NY, USA.

Bradstock, R.A., Cary, G.J., Davies, I., Lindenmayer, D.B., Price, O.F., & Williams, R.J. 2012. Wildfires, fuel treatment and risk mitigation in Australian eucalypt forests: Insights from landscape-scale simulation. *Journal of Environmental Management* 105: 66–75.

BSC. 2017. *Byron Shire Vegetation Cover (GIS layer): Byron All Stages Shirewide Veg_18May17*. Byron Shire Council, Mullumbimby, NSW.

Campbell, M.L., & Clarke, P.J. 2006. Response of montane wet sclerophyll forest understorey species to fire: evidence from high and low intensity fires. In *Proceedings of the Linnean Society of New South Wales*, p. 63. Linnean Society of New South Wales.

Close, D.C., Davidson, N.J., Johnson, D.W., Abrams, M.D., Hart, S.C., Lunt, I.D., Archibald, R.D., Horton, B., & Adams, M.A. 2009. Premature Decline of Eucalyptus and Altered Ecosystem Processes in the Absence of Fire in Some Australian Forests. *The Botanical Review* 75: 191–202.

Date, E.M., Recher, H.F., Ford, H.A., & Stewart, D.A. 1996. The conservation and ecology of rainforest pigeons in northeastern New South Wales. *Pacific Conservation Biology* 2: 299–308.

DECC. 2008. *Recovery plan for the koala (Phascolarctos cinereus)*. Department of Environment and Climate Change NSW, Hurstville, NSW.

DECCW. 2010. *Northern Rivers Regional Biodiversity Management Plan*. Department of Environment, Climate Change and Water, Hurstville, NSW.

DPIE. 2020. *Threatened Species Profiles*. NSW Department of Planning, Industry and Environment, Hurstville, NSW.

Ellis, R.C. 1985. The relationships among eucalypt forest, grassland and rainforest in a highland area in north-eastern Tasmania. *Austral Ecology* 10: 297–314.

Gandolfo, M.A., Hermsen, E.J., Zamaloa, M.C., Nixon, K.C., González, C.C., Wilf, P., Cúneo, N.R., & Johnson, K.R. 2011. Oldest Known Eucalyptus Macrofossils Are from South America. *PLOS ONE* 6: e21084.

Gilbert, J.M. 1959. Forest succession in the Florentine valley, Tasmania. In *Papers and proceedings of the Royal Society of Tasmania*, pp. 129–152.

Gould, J.S., McCaw, W., Cheney, N., Ellis, P., & Matthews, S. 2008. *Field Guide: Fire in Dry Eucalypt Forest: Fuel Assessment and Fire Behaviour Prediction in Dry Eucalypt Forest*. CSIRO PUBLISHING.

Harden, G.J. 1990. Flora of New South Wales. Vols 1–4. *New South Wales University Press: Kensington*

Harvest, T., Davidson, N.J., & Close, D.C. 2008. Is decline in high altitude eucalypt forests related to rainforest understorey development and altered soil bacteria following the long absence of fire? *Austral Ecology* 33: 880–890.

Hines, F., Victoria, Fire and Adaptive Management Branch, Victoria, & Department of Sustainability and Environment. 2010. *Overall fuel hazard assessment guide*. Fire Management Branch, Dept of Natural Resources and Environment, East Melbourne, Vic.

Hoffmann, W.A., Geiger, E.L., Gotsch, S.G., Rossatto, D.R., Silva, L.C.R., Lau, O.L., Haridasan, M., & Franco, A.C. 2012. Ecological thresholds at the savanna-forest boundary: how plant traits, resources and fire govern the distribution of tropical biomes (F. Lloret, Ed.). *Ecology Letters* 15: 759–768.

Hoffmann, W.A., Jaconis, S.Y., Mckinley, K.L., Geiger, E.L., Gotsch, S.G., & Franco, A.C. 2012. Fuels or microclimate? Understanding the drivers of fire feedbacks at savanna-forest boundaries. *Austral Ecology* 37: 634–643.

Horton, B.M., Glen, M., Davidson, N.J., Ratkowsky, D., Close, D.C., Wardlaw, T.J., & Mohammed, C. 2013. Temperate eucalypt forest decline is linked to altered ectomycorrhizal communities mediated by soil chemistry. *Forest Ecology and Management* 302: 329–337.

JWA. 2019. *Kings Forest – Koala Plan of Management*. Report prepared for Project 28 Pty Ltd by James Warren and Associates Ecological Consultants, Eight Mile Plains.

JWA. 2020a. *Kings Forest Precincts 1 - 5 Vegetation and Weed Management Plan*. Report prepared for Project 28 Pty Ltd by James Warren and Associates Ecological Consultants, Eight Mile Plains.

JWA. 2020b. *Kings Forest Precincts 6-14 Vegetation and Weed Management Plan*. Report prepared for Project 28 Pty Ltd by James Warren and Associates Ecological Consultants, Eight Mile Plains.

JWA. 2020c. *Kings Forest Precincts 1 - 5 Threatened Species Management Plan*. Report prepared for Project 28 Pty Ltd by James Warren and Associates Ecological Consultants, Eight Mile Plains.

JWA. 2020d. *Kings Forest Precincts 6 - 14 Threatened Species Management Plan*. Report prepared for Project 28 Pty Ltd by James Warren and Associates Ecological Consultants, Eight Mile Plains.

JWA. 2020e. *Kings Forest Feral Animal Management Plan*. Report prepared for Project 28 Pty Ltd by James Warren and Associates Ecological Consultants, Eight Mile Plains.

Kenny, B., Sutherland, E., Tasker, E., & Bradstock, R. 2004. *Guidelines for ecologically sustainable fire management*. NSW National Parks and Wildlife Service, Hurstville.

Kirkpatrick, J.B., & Marks, F. 1985. Observations on drought damage to some native plant species in eucalypt forests and woodlands near Hobart, Tasmania. In *Papers and Proceedings of the Royal Society of Tasmania*, pp. 15–21.

Krishnan, V., Robinson, N., Firn, J., Applegate, G., Herbohn, J., & Schmidt, S. 2019. Without management interventions, endemic wet-sclerophyll forest is transitioning to rainforest in World Heritage listed K'gari (Fraser Island), Australia. *Ecology and Evolution* 9: 1378–1393.

Lacey, P. 2008. *Fire Note: Burning Under Young Eucalypts*. Bushfire CRC.

Little, J.K., Prior, L.D., Williamson, G.J., Williams, S.E., & Bowman, D.M.J.S. 2012. Fire weather risk differs across rain forest-savanna boundaries in the humid tropics of north-eastern Australia. *Austral Ecology* 37: 915–925.

Lunney, D., Gresser, S.M., Mahon, P.S., & Matthews, A. 2004. Post-fire survival and reproduction of rehabilitated and unburnt koalas. *Biological Conservation* 120: 567–575.

MacDermott, H.J., Fensham, R.J., Hua, Q., & Bowman, D.M.J.S. 2016. Vegetation, fire and soil feedbacks of dynamic boundaries between rainforest, savanna and grassland. *Austral Ecology*. doi: 10.1111/aec.12415

Matthews, A., Lunney, D., Gresser, S., & Maitz, W. 2007. Tree use by koalas (*Phascolarctos cinereus*) after fire in remnant coastal forest. *Wildlife Research* 34: 84.

Melzer, A., Carrick, F., Menkhorst, P., Lunney, D., & John, B.S. 2000. Overview, Critical Assessment, and Conservation Implications of Koala Distribution and Abundance. *Conservation Biology* 14: 619–628.

Milledge, D. 1991. A survey of the terrestrial vertebrates of coastal Byron Shire. *Australian Zoologist* 27: 66–91.

Murphy, B.P., & Bowman, D.M.J.S. 2012. What controls the distribution of tropical forest and savanna? *Ecology Letters* 15: 748–758.

Nowacki, G.J., & Abrams, M.D. 2008. The demise of fire and "mesophication" of forests in the eastern United States. *BioScience* 58: 123–138.

NPRSR. 2013. *Planned Burn Guidelines: Southeast Queensland Bioregion of Queensland*. Department of National Parks, Recreation, Sport and Racing, Brisbane.

NPWS. 2018. *Fire Management Manual 2018 - 2019*. NSW National parks & Wildlife Service, Hurstville, NSW.

OEH. 2014. *NSW Flora Fire Response Database (Version 2.1)*. Ecosystem Management Science Branch, Office of Environment & Heritage (NSW), Hurstville, NSW.

Parr, C.L., Gray, E.F., & Bond, W.J. 2012. Cascading biodiversity and functional consequences of a global change-induced biome switch. *Diversity and Distributions* 18: 493–503.

Phillips, S., Hopkins, M., & Shelton, M.L. 2011. *Tweed Coast Koala Habitat Study.* Report to Tweed Shire Council. Biolink Ecological Consultants, Uki, NSW.

RFS. 2006. *Bushfire Environmental Assessment Code for NSW*. NSW Rural Fire Service, Lidcomb, NSW.

Rosan, T.M., Aragão, L.E.O.C., Oliveras, I., Phillips, O.L., Malhi, Y., Gloor, E., & Wagner, F.H. 2019. Extensive 21st-Century Woody Encroachment in South America's Savanna. *Geophysical Research Letters* 46: 6594–6603.

Russell-Smith, J., Stanton, P.J., Whitehead, P.J., & Edwards, A. 2004. Rain forest invasion of eucalypt-dominated woodland savanna, Iron Range, north-eastern Australia: I. Successional processes. *Journal of Biogeography* 31: 1293–1303.

Silver, M., & Carnegie, A.J. 2017. *An independent review of bell miner associated dieback*.

Stanton, P., Stanton, D., Stott, M., & Parsons, M. 2014. Fire exclusion and the changing landscape of Queensland's Wet Tropics Bioregion 1. The extent and pattern of transition. *Australian Forestry* 77: 51–57.

Stone, C., Kathuria, A., Carney, C., & Hunter, J. 2008. Forest canopy health and stand structure associated with bell miners (Manorina melanophrys) on the central coast of New South Wales. *Australian Forestry* 71: 294–302.

Sullivan, A., McCaw, L., Gomes Da Cruz, M., Matthews, S., & Ellis, P. 2012. *Fuel, Fire Weather and Fire Behaviour in Australian Ecosystems*. CSIRO Publishing.

Thackway, R., & Cresswell, I.D. 1995. An Interim Biogeographic Regionalisation for Australia: a framework for establishing the national system of reserves, Version 4.0. *Australian Nature Conservation Agency, Canberra* 88:.

TSC. 2017. *Tweed LGA Vegetation 2012. VIS_ID 3912 (GIS layer)*. Tweed Shire Council, Murwillumbah.

Turton, S.M., & Duff, G.A. 1992. Light environments and floristic composition across an open forest-rainforest boundary in northeastern Queensland. *Australian Journal of Ecology* 17: 415–423.

Whelan, R.J. 2002. Managing fire regimes for conservation and property protection: an Australian response. *Conservation Biology*

Whelan, R.J. 1995. *The Ecology of Fire*. Cambridge University Press, Cambridge.

Williams, P.R. 2000. Fire-stimulated rainforest seedling recruitment and vegetative regeneration in a densely grassed wet sclerophyll forest of north-eastern Australia. *Australian Journal of Botany* 48: 651.

9 Appendices

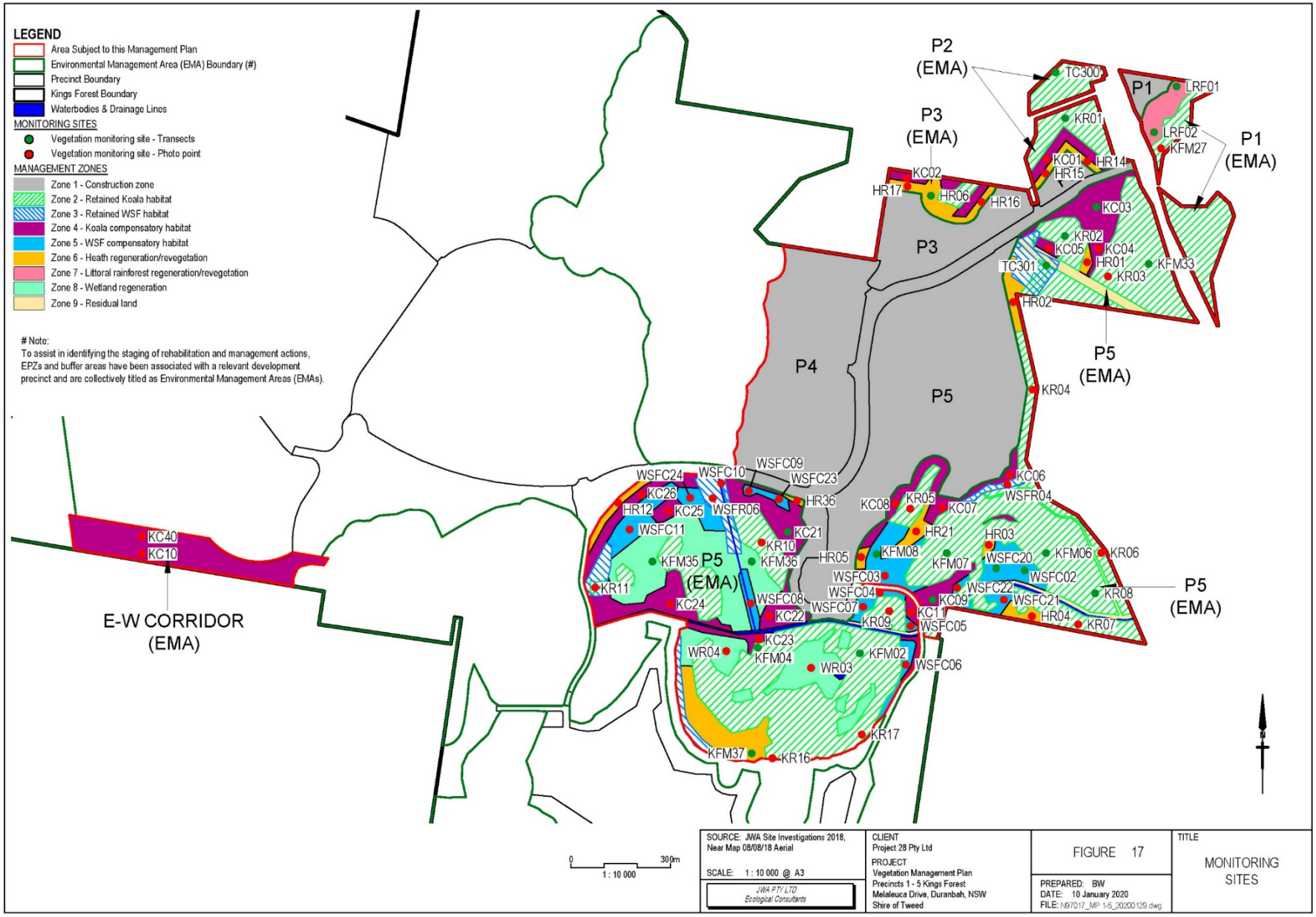
Appendix A. Recommended fire intervals for mapped vegetation types outlined in KFKPoM (JWA 2019).

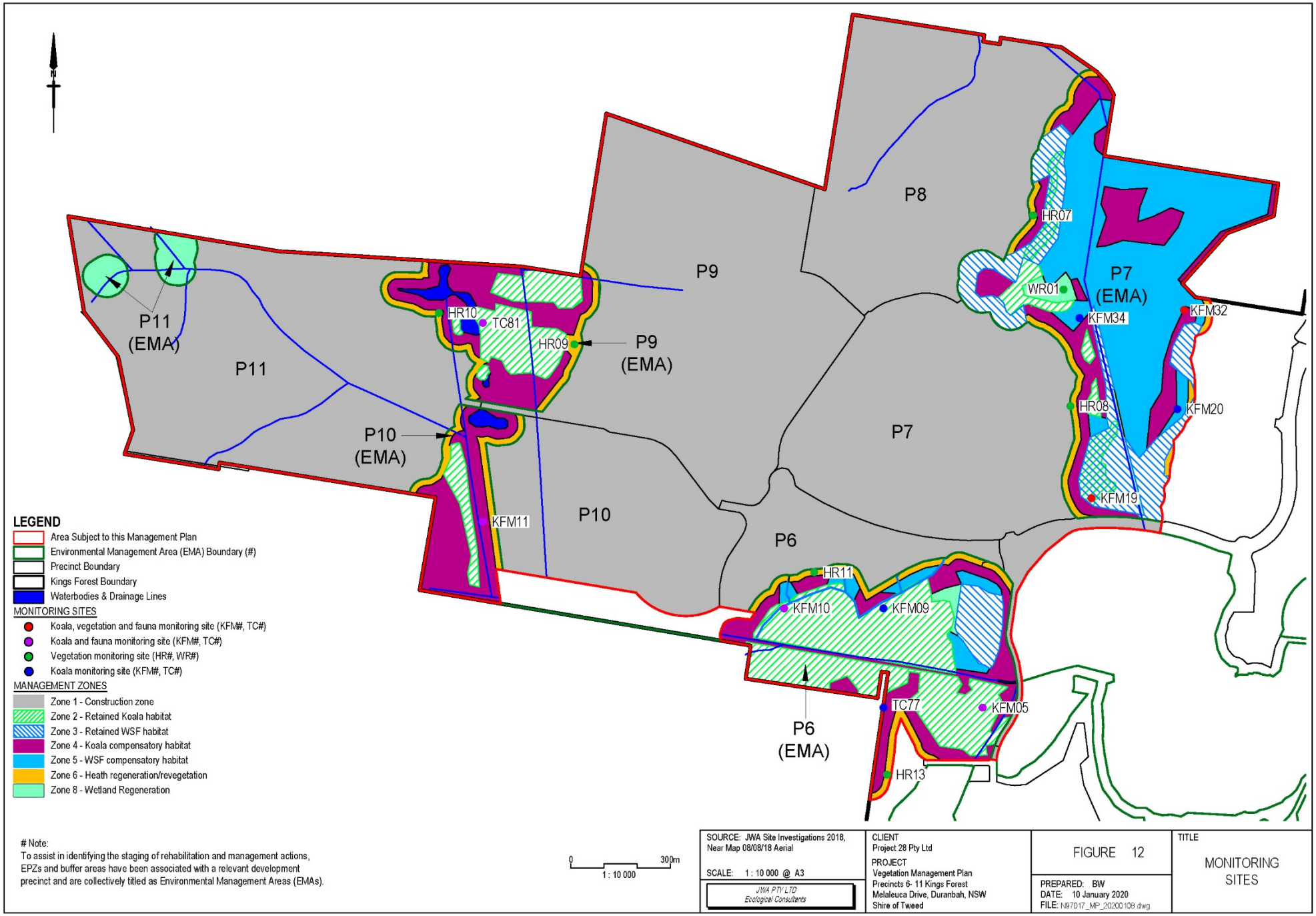
Mapped Community	Vegetation Structure	Fire Class
2(a) Freshwater Wetlands Seepage Swamp; 2(b) Freshwater Wetlands Ponds; 2(c1) Freshwater Wetlands Sedgeland; 2(c2) Freshwater Wetlands Sedgeland with exotic pines	Freshwater Wetlands	Melaleuca Communities (Sedge/Fern) - **12-20 yrs**
3(a1) Heathland & Shrubland Dry heath; 3(a2) Heathland & Shrubland Dry heath with exotic pines; 3(b1) Heathland & Shrubland Wet heath; 3(b2) Heathland & Shrubland Wet heath with exotic pines; 3(d) Heathland & Shrubland Regen wet-dry heath; 3(e) Heathland & Shrubland Regen wet-dry heathland with pine	Heathland	Heathland - **8-20 yrs**
4(a) Swamp Sclerophyll Forest red gum paperbark; 4(b) Swamp Sclerophyll Swamp mahogany; 4(c) Swamp Sclerophyll Scribbly gum swamp mahogany; 4(d) Swamp Sclerophyll Swamp box; 4(e) Swamp Sclerophyll Paperbark; 4(g1) Swamp Sclerophyll Paperbark with rainforest; 4(g2) Swamp Sclerophyll Paperbark with rainforest & Camphor; 4(h) Swamp Sclerophyll Paperbark swamp mahogany; 4(i) Swamp Sclerophyll Swamp sclerophyll heathland with exotic pines; 4(j1) Swamp Sclerophyll Regen paperbark; 4(j2) Swamp Sclerophyll Regen paperbark with exotic pines; 4(k) Swamp Sclerophyll Regen swamp mahogany	Swamp Sclerophyll - Eucalypt (non-melaleuca)	Open forests and woodlands (Shrubby) - **7-25 yrs**
5(a) Dry to Moist Open Forest Blackbutt wet-dry; 5(b) Dry to Moist Open Forest Blackbutt tallowwood; 5(c) Dry to Moist Open Forest Blackbutt grass; 5(d) Dry to Moist Open Forest Scribbly; 5(e1) Dry to Moist Open Forest Regen Scribbly; 5(e2) Dry to Moist Open Forest Regen Scribbly with exotic pines	Dry Open Forest	Open forests and woodlands (Shrubby) - **7-25 yrs**
6(a) Rainforest Littoral	Rainforest	Rainforest – **no fires**

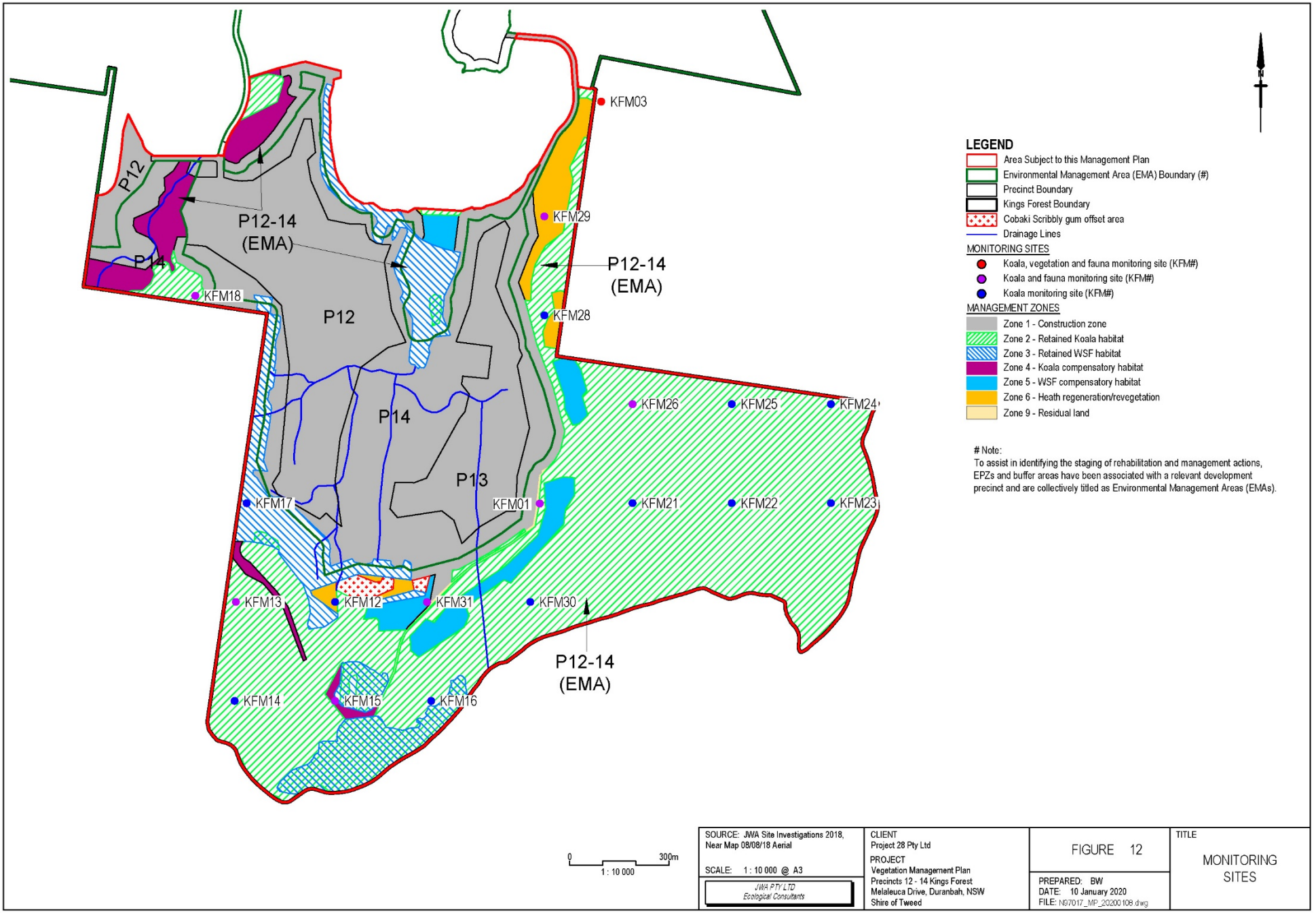
Appendix B. Recommended fire intervals for restored vegetation as outlined in VMP management zones (JWA 2020a; 2020b).

VMP Management Zone	Management Intent	Vegetation Structure	Fire Class
Zone 2 - Retained Koala Habitat Management	To protect, restore (through assisted natural regeneration) and provide for the ongoing maintenance of retained koala habitat	• Dry open forest • Swamp sclerophyll forest	Open forests and woodlands (Shrubby) – **7-25 years** Melaleuca Communities (Sedge/Fern) – **12-20 years** **See* **Appendix A** *for more detailed classification of mapped retained vegetation*
Zone 3 - Retained WSF Habitat Management	To protect, restore (through assisted natural regeneration) and provide for ongoing maintenance of retained WSF habitat	• Wet heathland • Fernland • Sedgeland	Heathland – **8-20 years** Melaleuca Communities (Sedge/Fern) – **12-20 years** **See* **Appendix A** *for detailed classification of mapped retained vegetation*
Zone 4 – Koala Compensatory Habitat Management	To create and maintain additional koala habitat through assisted regeneration and revegetation works	• Dry open forest • Swamp sclerophyll forest	Open forests and woodlands (Shrubby) – **7-25 years** Melaleuca Communities (Sedge/Fern) – **12-20 years**
Zone 5 – WSF Compensatory Habitat Management	To create and maintain additional WSF habitat through assisted regeneration and revegetation works	• Wet heathland • Fernland • Sedgeland	Heathland – **8-20 years** Melaleuca Communities (Sedge/Fern) – **12-20 years**
Zone 6 – Heath Regeneration/Revegetation Management	To protect and maintain retained heathland To create and maintain additional heathland through assisted regeneration and revegetation works	• Dry Heathland • Wet Heathland	Heathland – **8-20 years**
Zone 7 - Littoral Rainforest Regeneration/Revegetation Management	To protect and maintain retained littoral rainforest To create and maintain additional littoral rainforest through assisted regeneration and revegetation works	• Rainforest	Rainforest – **no fire**
Zone 8 – Wetland Regeneration Management	To protect and maintain retained wetlands To create and maintain additional wetlands through assisted regeneration and revegetation works	• Wet heathland • Fernland • Sedgeland	Heathland – **8-20 years** Melaleuca Communities (Sedge/Fern) – **12-20 years**
Cobaki Scribbly gum offset area	To convert regenerating heathland to heathy Scribbly Gum forest	• Dry open forest	Open forests and woodlands (Shrubby) – **7-25 years**

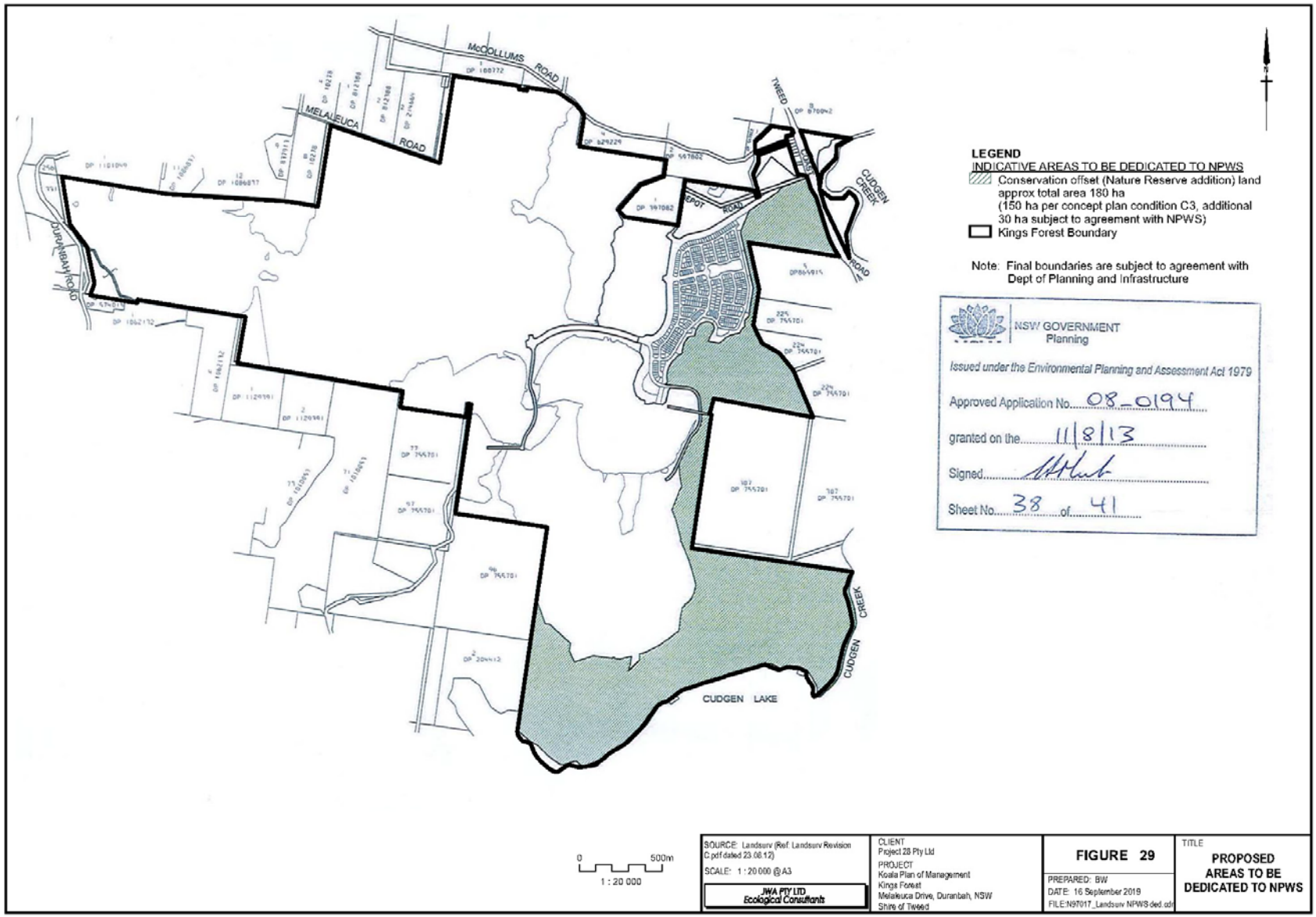
Appendix C. Monitoring site locations (JWA 2020a; JWA 2020b)




P11 (EMA)
P11
P9
P9 (EMA)
P8
P7 (EMA)
P7
P10 (EMA)
P10
P6
P6 (EMA)
HR10
TC81
HR09
HR07
WR01
KFM34
KFM32
HR08
KFM20
KFM19
KFM11
HR11
KFM10
KFM09
TC77
KFM05
HR13
LEGEND
Area Subject to this Management Plan
Environmental Management Area (EMA) Boundary (#)
Precinct Boundary
Kings Forest Boundary
Waterbodies & Drainage Lines
MONITORING SITES
Koala, vegetation and fauna monitoring site (KFM#, TC#)
Koala and fauna monitoring site (KFM#, TC#)
Vegetation monitoring site (HR#, WR#)
Koala monitoring site (KFM#, TC#)
MANAGEMENT ZONES
Zone 1 - Construction zone
Zone 2 - Retained Koala habitat
Zone 3 - Retained WSF habitat
Zone 4 - Koala compensatory habitat
Zone 5 - WSF compensatory habitat
Zone 6 - Heath regeneration/revegetation
Zone 8 - Wetland Regeneration
Note:
To assist in identifying the staging of rehabilitation and management actions, EPZs and buffer areas have been associated with a relevant development precinct and are collectively titled as Environmental Management Areas (EMAs).
0
300m
1 : 10 000
SOURCE: JWA Site Investigations 2018, Near Map 08/08/18 Aerial
SCALE: 1 : 10 000 @ A3
JWA PTY LTD Ecological Consultants
CLIENT
Project 28 Pty Ltd
PROJECT
Vegetation Management Plan
Precincts 6- 11 Kings Forest
Melaleuca Drive, Duranbah, NSW
Shire of Tweed
FIGURE 12
PREPARED: BW
DATE: 10 January 2020
FILE: N97017_MP_20200108.dwg
TITLE
MONITORING SITES


KFM03
KFM29
KFM28
KFM18
KFM26
KFM25
KFM24
KFM17
KFM01
KFM21
KFM22
KFM23
KFM13
KFM12
KFM31
KFM30
KFM14
KFM15
KFM16
P12
P14
P13
P12-14
(EMA)
P12-14
(EMA)
P12-14
(EMA)
LEGEND
Area Subject to this Management Plan
Environmental Management Area (EMA) Boundary (#)
Precinct Boundary
Kings Forest Boundary
Cobaki Scribbly gum offset area
Drainage Lines
MONITORING SITES
Koala, vegetation and fauna monitoring site (KFM#)
Koala and fauna monitoring site (KFM#)
Koala monitoring site (KFM#)
MANAGEMENT ZONES
Zone 1 - Construction zone
Zone 2 - Retained Koala habitat
Zone 3 - Retained WSF habitat
Zone 4 - Koala compensatory habitat
Zone 5 - WSF compensatory habitat
Zone 6 - Heath regeneration/revegetation
Zone 9 - Residual land
Note:
To assist in identifying the staging of rehabilitation and management actions, EPZs and buffer areas have been associated with a relevant development precinct and are collectively titled as Environmental Management Areas (EMAs).
0
300m
1 : 10 000
SOURCE: JWA Site Investigations 2018, Near Map 08/08/18 Aerial
SCALE: 1 : 10 000 @ A3
JWA PTY LTD
Ecological Consultants
CLIENT
Project 28 Pty Ltd
PROJECT
Vegetation Management Plan
Precincts 12 - 14 Kings Forest
Melaleuca Drive, Duranbah, NSW
Shire of Tweed
FIGURE 12
PREPARED: BW
DATE: 10 January 2020
FILE: N97017_MP_20200108.dwg
TITLE
MONITORING SITES

Appendix D. Indicative Areas to be Dedicated to NPWS.



Appendix E. Consent Advice from the NSW Department of Planning, Industry and Environment.

To be inserted upon receipt.