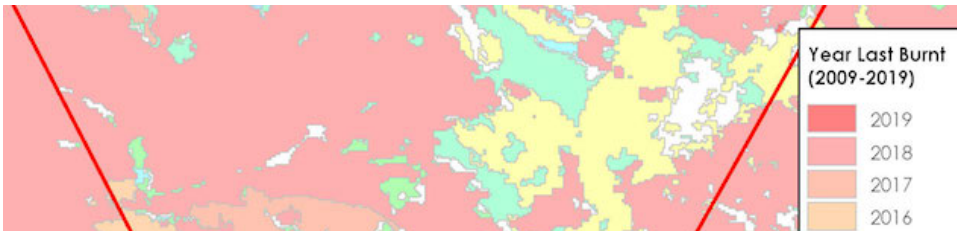
Biota Environmental Sciences

The Asian Renewable Energy Hub

Nyangumartamil wangal pa janyja

Asian Renewable Energy Hub



Fire Management Strategy

February 2020

The Asian Renewable Energy Hub
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Fire Management Strategy

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1.0 Introduction

1.1 Proposal Background

NW Interconnected Power Pty Ltd ('the proponent') is seeking to develop the Asian Renewable Energy Hub ('the proposal'). The proposal is to construct and operate a large-scale wind and solar renewable energy proposal at a site approximately 220 km east of Port Hedland and 270 km southwest of Broome, in the north west of Western Australia (Figure 1.1).

The proposal consists of the following components (Figure 1.2):

- **Wind Turbines** – Up to 1,743 wind turbines with each turbine being up to 260 m tall from ground to the top limit of the highest blade tip.
- **Photovoltaic (PV) Solar Panels**– 2,000 MW worth of solar PV capacity that will be divided into 37 x 55 MW modules, each of which will be up to 180 ha in size, placed adjacent to a step-up substation.
- **HVDC Converter Station** – An HVDC converter station will convert the AC current generated onsite into DC current, so that it can be exported from the site.
- **Overhead/Underground Transmission Line** – Up to 50 m tall pylons spaced every 450 m along the transmission corridor. The transmission cables will be undergrounded before reaching the coast and buried below the foredune and beach.
- **Offshore Transmission Lines** – The four HVDC transmission cables will be buried along the offshore cable route to the edge of State waters.
- **Site Tracks** – Up to 1,514 km of site access tracks will be constructed, linking the wind turbines and other infrastructure. The track alignments will be cleared to a width of 15 m, and a compacted gravel surface approximately 10 m wide will be completed in the centre to assist with operations and fire management.
- **Onsite electrical infrastructure** – Up to 37 step-up substations will be distributed over the site, together with overhead power lines connecting the turbines to the substations and the substations to the converter station.
- **Onsite Operational Compound and Control Centre** - A site compound and control centre will be established to provide a base for construction and operations personnel.

1.2 Scope

The scope of this document is to develop a strategic framework for fire management for the proposal, and addresses the spatial scope of the full development envelope for the proposal (Figure 1.1).

This document outlines strategies that will mitigate risk from bushfire to four values:

- proposal workforce;
- proposal infrastructure;
- surrounding land-holders and land-users; and
- fauna and flora (biodiversity) occurring within the development envelope.

Finally, the minimisation of impacts of construction land clearing activities upon populations of the Threatened species the Bilby (*Macrotis lagotis*) and the Black-flanked Rock Wallaby (*Petrogale lateralis*) through application of managed fire regimes is proposed, during both construction and operational phases.

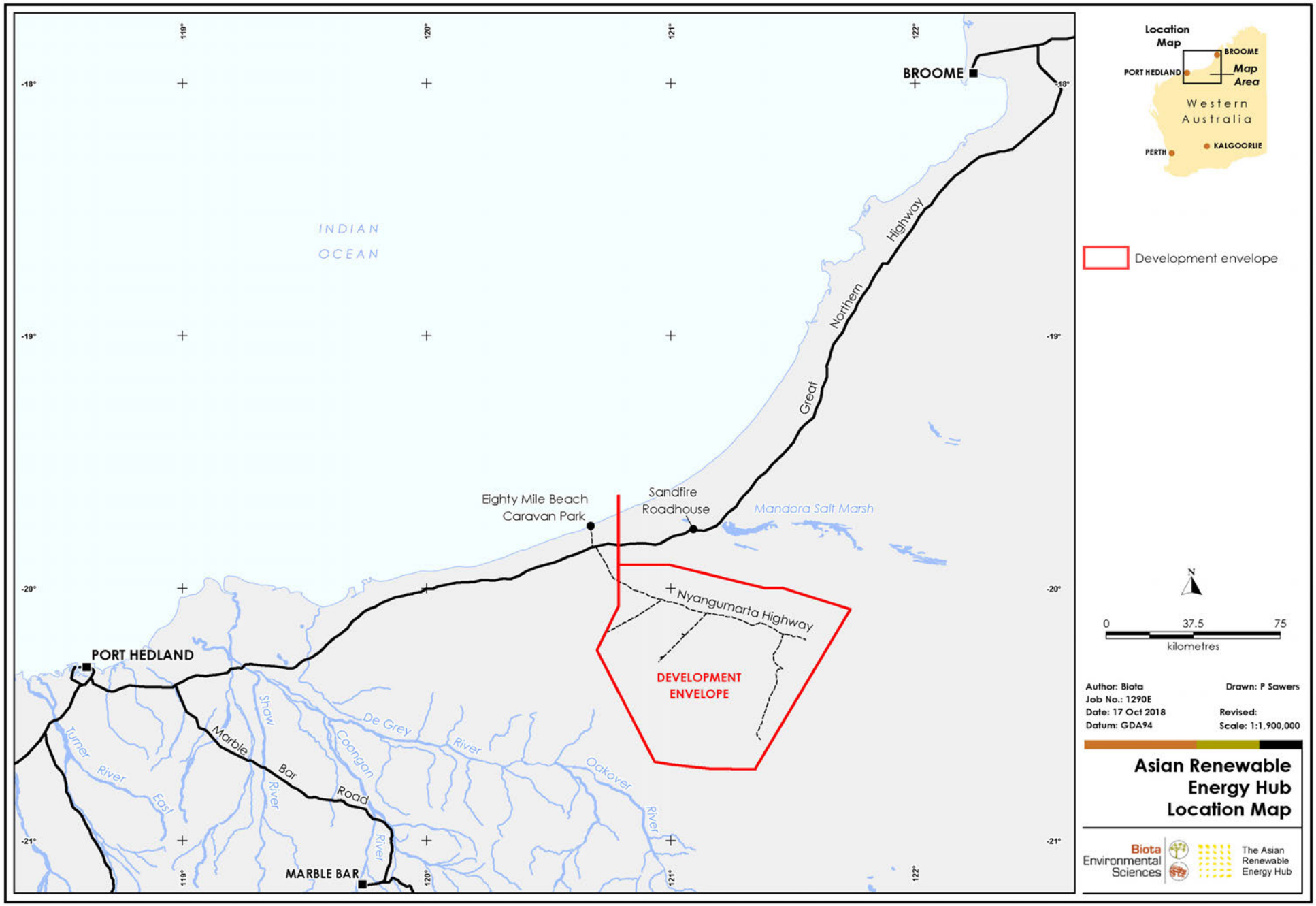

Figure 1.1: Location map for the proposal.

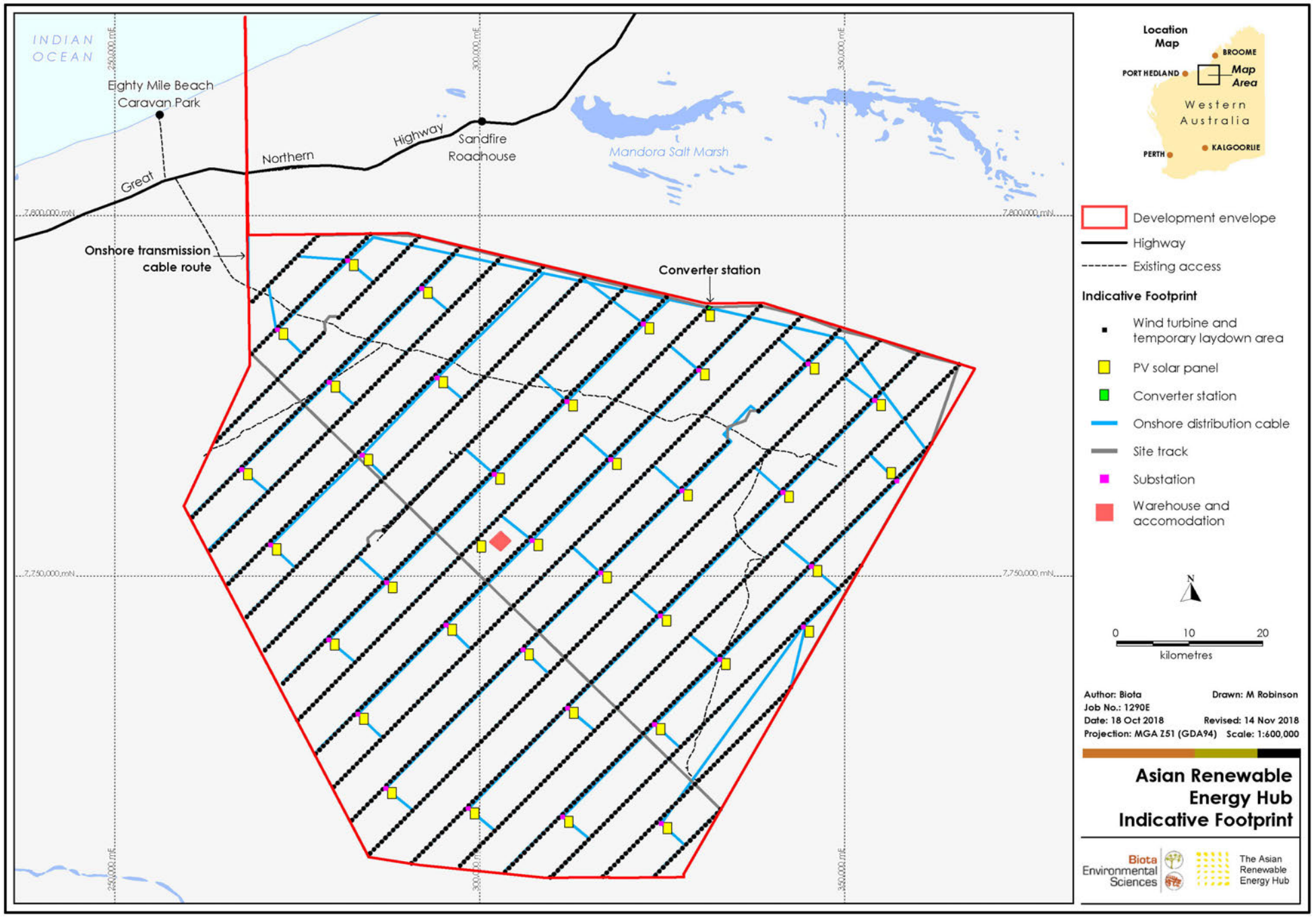

Figure 1.2: Proposal development envelope, footprint and conceptual design.

1.3 Definitions

The following terms are used in this document:

Development envelope - The spatial extent that encompasses all the physical elements of the proposal.

Footprint - The area of ground disturbance arising from the current indicative design of the proposal.

Significant - An impact or level of change is considered to be significant for the purposes of this document in accordance with the relevant criteria of EPA (2018a), with consideration to the:

a. values, sensitivity and quality of the environment which is likely to be impacted;
b. extent (intensity, duration, magnitude and geographic footprint) of the likely impacts;
c. consequence of the likely impacts (or change); and
d. resilience of the environment to cope with the impacts or change.

2.0 Background

2.1 Land Use

Existing land use both within the development envelope and in adjoining areas is a key consideration for fire management. The majority of the proposed proposal infrastructure is located within the Shire of East Pilbara, with the cable export route passing through the Shire of Broome (Figure 2.1). The development envelope that will accommodate the proposed proposal is entirely Unallocated Crown Land, except for the cable export route, which would traverse an existing pastoral lease. While there are no live mineral exploration permits inside the site boundary, exploration license applications have recently been filed which cover the majority of the proposal site area. There are currently no pastoral or other relevant land uses within the development envelope.

The offshore section of the cable route passes through State Waters vested as the Eighty Mile Beach Marine Park (Figure 2.1). The closest conservation estate to the development envelope is the recently vested Walyarta Conservation Park, situated to the immediate north (R52387; Figure 2.1). This Conservation Park was announced after the development of the proposal, and the boundaries were drawn right up to the boundaries of the development envelope. Both reserves are managed by the Department of Biodiversity Conservation and Attractions (DBCA).

The entire development envelope lies within the Nyangumarta Native Title Claim area (Figure 2.2). Native title holders (Nyangumarta people) may exercise their rights to implement land management actions within the development envelope, including fire management, cultural site protection and fauna and flora exploitation and management.

2.2 Spinifex Fire Ecology

The development envelope is dominated by *Triodia* spp. ('spinifex') hummock grasslands and Acacia shrub steppes (Biota 2018a). Hummock grasses are very flammable, and even light or discontinuous vegetation can support high levels of fire behaviour under suitable weather conditions.

Fire regimes in the western deserts were actively managed by Aboriginal people for thousands of years, ending abruptly in the mid 1900s (Burrows and Christensen 1991). Desert people used fire continuously but with a high level of control, resulting in high-density time-since-fire vegetation mosaics. While large fires could still spread under extreme conditions, the mosaic patchwork of vegetation ages ensured that the size and intensity of large fires was reduced. Fauna could re-colonise burnt areas from nearby un-burnt areas. Areas in early-stage regrowth following fire were rich in plant and animal resources used by Aboriginal people and by some fauna species.

Fire directly kills and destroys plants and animals, and destroys fauna habitat. The size and intensity of a fire determines the long-term outcome for local fauna populations. This can range from insignificant (little or no impact from a small local fire) to catastrophic, where large, intense fires burn vast areas of country (sometimes millions of hectares) in single fire events. While fire is required for some plants and vegetation communities to regenerate, and recently burned areas are favoured by some fauna species, large fires erase time-since-fire heterogeneity from the landscape (Burrows et al. 2009).

Large areas of similar-aged vegetation will then have a similar vulnerability to burning in the future. Lack of vegetation diversity reduces fauna diversity and the resilience of the system to respond to future disturbance (such as fire, flood and weed invasion).

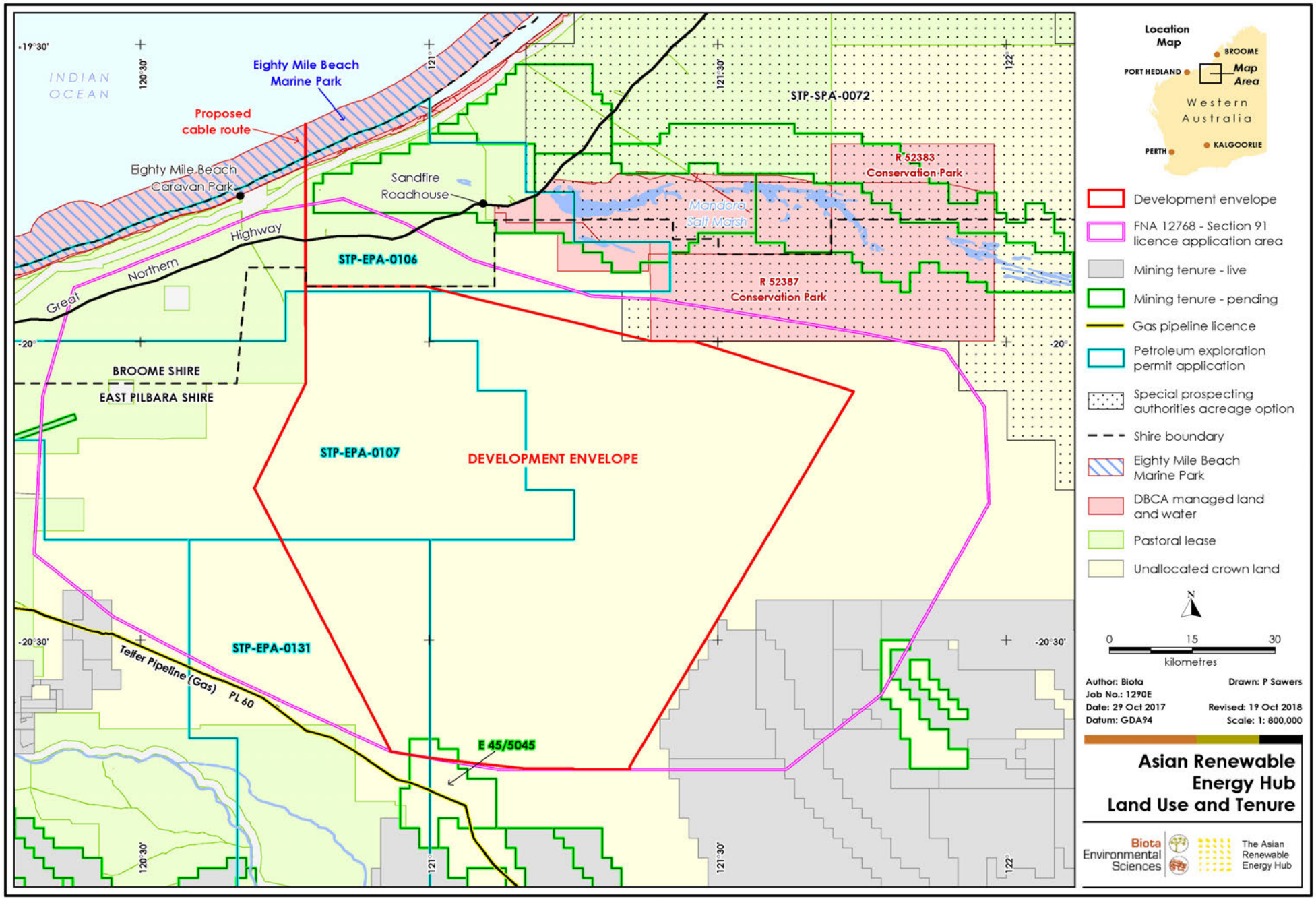

Figure 2.1: Land use and tenure.

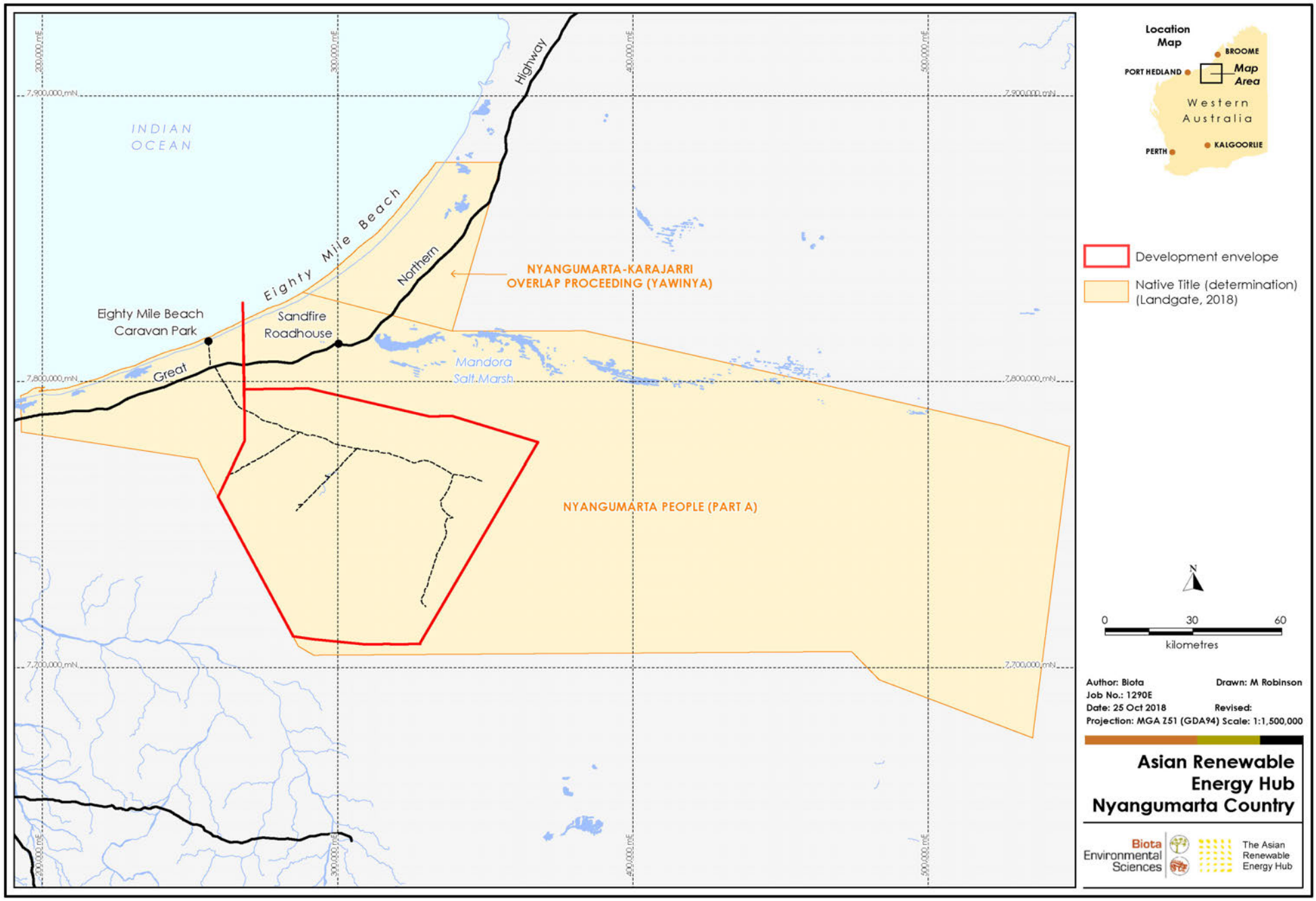

Figure 2.2: Native title claim areas.

2.3 Spinifex Bushfire Behaviour

Burrows et al. (2006) describe the behaviour of fires burning in hummock grassland environments of the western deserts of Western Australia.

Bushfire intensity and rates of spread are determined by fuel quantity and quality, and by weather, primarily wind. Spinifex grassland biomass increases linearly with time and approach a steady state after approximately 20 years (Burrows et al. 2006). Discrete hummock clumps do not generally contact each other for many years after germination (with growth rates determined by effective rainfall). A discontinuous fuel environment of individual hummocks forms which, although flammable, are separated from each other by a bare or low-fuel barrier. The width of this barrier decreases over time as clumps grow in size.

For fire to spread it must cross the gaps between clumps. As clumps grow larger the wind speed required to cross to adjacent clumps decreases. Under extreme weather conditions (low relative humidity, high temperatures, high wind speed), even light spinifex fuels will carry fire.

In spinifex hummock grasslands, fire behaviour is mainly determined by wind – a fire will mostly spread in the direction of the prevailing wind. Fire will burn against a wind when fuel is continuous. Dense and continuous fuels often grow in linear features like creeks or road windrows, or in very old spinifex growing under favourable conditions.

2.4 Relevance of Fire to the Proposal

Fire is the major ecological process occurring within the development envelope. Bushfire can harm personnel and damage infrastructure, and large fires may seriously affect local biodiversity values. Although the development envelope is large, a single fire event could impact upon a significant proportion of the development envelope. Fires originating in or passing through the development envelope may also impact on other land users, owners and environments adjacent to the development envelope. However, the risks associated with bushfire can be mitigated by implementing a fire management program.

This document advocates managing fire to reduce the risk of impacts upon threatened fauna and landscape biodiversity values in general, during the construction and operations phases.

2.5 Fire History

The fire history for the development envelope was assessed from remote-sensed historical fire scar data sourced from the Northern Australian Fire Information (NAFI) project [1].

A ten-year fire history for the development envelope was compiled showing pre-development bushfire events from 2009-2019 (Figure 2.3). This recent fire history shows a pattern of episodic large fires occurring, with very little of the development envelope being longer than 10 years since it was last burnt (Figure 2.3 A). The two-year period of 2017-2018 saw 66% of the development envelope burn (436,139 ha) (Figure 2.3 A), parts of the development envelope have also burnt twice or three times in the past decade (Figure 2.3 B). These events currently occur in an unplanned and uncontrolled manner, with bushfires ignited by lightning strikes or occasionally through human activity.

[1] http://www.firenorth.org.au/nafi3/

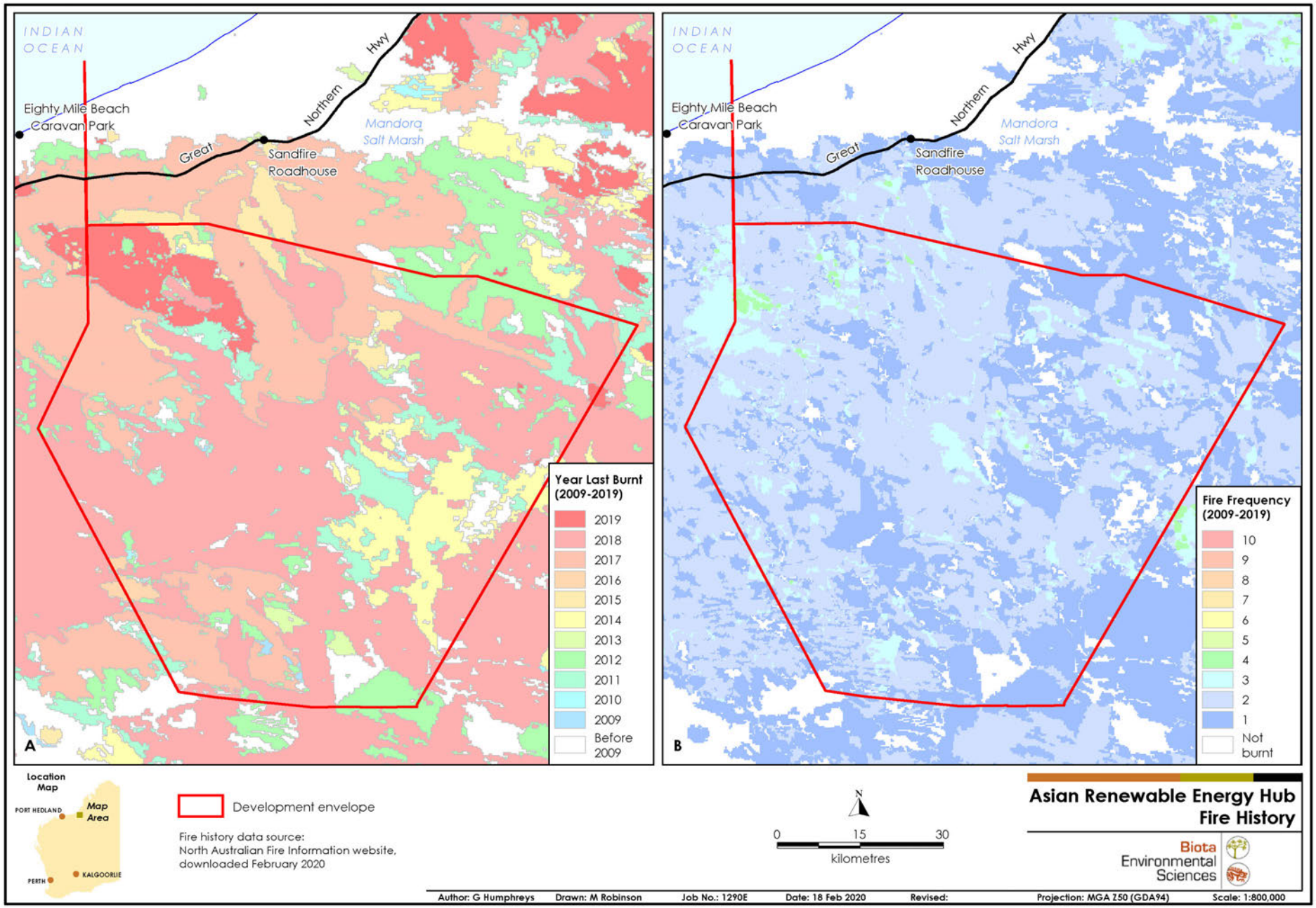

Figure 2.3: Fire history of the development envelope, showing A) year in which areas last burnt, and B) the number of years in the last decade areas in which areas burned (data source: http://www.firenorth.org.au/nafi3/).

2.6 Bushfire Behaviour and Intensity

Fire behaviour in natural spinifex vegetation in the western deserts was described by Burrows et al. (2006), over ranges of values shown in Table 2.2. These are the only values published from environments similar to those of the development envelope, and are likely to be representative.

Table 2.1: Environmental parameters measured by Burrows et al. (2006) while characterising bushfire behaviour and characteristics in the western desert spinifex grasslands of Western Australia.

Variable	Mean	Range
Wind Speed (km / h)	15	4 - 36
Temperature (°C)	31	19 - 50
RH (%)	14	5 - 48
Fuel quantity (t / ha)	7	2 - 14
Fuel Cover (%)	38	9 - 65
Fuel Height (cm)	25	18 - 37
Fuel Profile Moisture (%)	18	12 - 31
Rate of Spread (m / h)	842	0 – 5,520
Flame height (m)	1.4	0 - 5
Fire Intensity (kW / m)	3.515	0 – 19.111

Burrows et al. (2006) found that fire rates of spread and intensity were predicted most accurately by wind speed, fuel quantity and fuel moisture content. Temperature and relative humidity were not very significant, although other factors will affect fire behaviour (e.g. ground slope).

Burrows et al. (2018) developed models for predicting rates of spread for spinifex fires (m/h) burning in fuels of various ages since last fire. Table 2.2 shows rates of spread for fire burning in vegetation of 6 -10 years old. Note that rates of spread of nearly 6.5 kilometres per hour are possible in moderate spinifex fuels. A bushfire could traverse the entire development envelope within a day under strong wind conditions. Conversely, fires will not spread at all under even moderate wind conditions if moisture content is high. The prescription process assesses fuel characteristics and estimates the wind and humidity conditions required for a particular burn outcome.

Table 2.2: Bushfire rates of spread (metres per hour) in spinifex fuels between 6-10 years old and under various wind speed and percentage of fuel moisture content (Burrows et al. 2018).

	Wind Speed (km/hr)						
Moisture Content (% wt)	**10**	**15**	**20**	**25**	**30**	**35**	**40**
35	0	0	0	0	0	190	960
30	0	0	0	0	520	1,290	2,060
25	0	0	100	840	1,620	2,390	3,160
20	0	390	1160	1,940	2,720	3,490	4,260
15	0	1,490	2,270	3,040	3,820	4,590	5,360
10	1,810	2,590	3,370	4,140	4,920	5,690	6,460

For protection of people and infrastructure, fire intensity (as radiant heat flux; kW/m^2) is the critical variable. This is determined from the available fuel quantity and rate of spread of the fire.

A radiant heat flux of 3 kW/m^2 is considered safe for fire-fighters on foot and wearing standard PPE. Table 2.3 shows the likely impacts of radiant heat flux on materials and humans (Standards Australia 2009).

Table 2.3: Effects of radiant heat flux on humans and various materials (Australian Standards 3959-2009).

Radiant Heat Flux (kW/m^2)	Phenomenon
1	Solar radiation on clear sunny day.
3	Routine exposure during fire-fighting on foot (with PPE)
4	Pain to human after 10 – 20 seconds
10	Pain to humans after 10 seconds
15	Human skin blisters within 6 seconds
20	Pain to humans in 2 seconds, second degree burns in 4 seconds
29	Wood ignites after prolonged exposure
42	Cotton fabric ignites after 5 seconds (no flame)
52	Fibre-board ignites after 5 seconds
55	Timber ignites after 10 seconds

Given measured vegetation fuel loads and weather conditions, head-fire radiant heat flux levels for different fuel-free buffers can be estimated. On this basis, buffers of between 20 to 50 metres are likely to be sufficient for most fires likely to impact the development envelope. With a prescribed fire program, risks to humans can be significantly reduced.

2.7 Experience Elsewhere

Landscape-scale fire management is practised throughout Australia. In the spinifex hummock grasslands of the Pilbara and western deserts, large-scale fire management is implemented by state government organisations, such as the Department of Biodiversity, Conservation and Attractions (DBCA), the Department of Fire and Emergency Services, and by non-government organisations such as the 10 Deserts Proposal, and Kanyirninpa Jukurrpa (the land and culture organisation of the Martu people) and pastoral enterprises. Indigenous fire programs are now successfully applied on broad geographic scales.

Potential partnerships with such organisations are possible for prescribed landscape-scale burning programs within the development envelope, and this will be pursued in the implementation of this strategy.

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3.0 Infrastructure and Personnel Protection

Large fires can be deadly to people, destructive to infrastructure, and damaging to the environment. Proposal workforce will be at risk in any areas where flammable vegetation grows close to work areas. Bushfires do not respect tenure, and a fire originating on or passing through the development envelope could also seriously impact adjacent landholders (personnel, stock and property) and the public.

Because of the nature of the vegetation throughout the development envelope, it is impossible to exclude fire from the site. The vegetation within the development envelope will eventually burn. By implementing a fire management program the proponent can influence when fires will occur, and their size and intensity. This dramatically reduces risk to personnel and infrastructure, and achieves good environmental outcomes. A prescribed burning program will also enable a dramatic reduction in risk from un-planned bushfires.

A fire management programme also offers strong possibilities for collaborative partnerships with traditional owner and relevant government agencies.

3.1 Construction Phase Workforce

During the construction phase a large workforce (up to 2,000 people at a time) will be working across the development envelope. A bushfire may approach work areas and, depending on fuel and weather characteristics, construction areas may be considered at high risk of bushfire impacts.

The construction workforce will be located on site for approximately a decade, during which time they will develop some familiarity with the location and environment. However, it may still be assumed that:

- Workers will be dispersed over a wide geographical area at isolated work sites. This will increases the likelihood of bushfire impacting upon personnel and increase response or evacuation times.
- A large proportion of the workforce will have low experience and knowledge of bushfire, especially in desert spinifex environments.
- Personnel unfamiliar with the fire characteristics of spinifex vegetation often under-estimate the intensity and rate of spread of spinifex fires. Spinifex clumps will burn when green (although less readily than when dry), and fires can spread quickly (Table 2.2). Sand dune landforms may reduce direct observation of an approaching fire.
- Personnel may attempt to escape a fire by vehicle or on foot. This is dangerous, especially when the location of other fire fronts is unknown. Dense smoke creates extreme hazards for driving, which can compound a bushfire incident with subsidiary incidents (such as vehicle crashes or missing persons) within the fire area.

Two primary management measures can be employed mitigate bushfire risks:

1. Basic bushfire safety and awareness training will be mandatory for all site personnel (this is not bushfire responder training). Basic bushfire safety and awareness training for all site personnel will emphasise situational awareness and safe protocols for seeking shelter in the event of a bushfire emergency.
2. Implementation of a selective prescribed burning program within the development envelope, both during construction and operations, to minimise the risk of unplanned, large and intense fires.

It should be noted that direct attack fire suppression of bushfires in these environments can be difficult or impossible, considering the scale of the fires and the topography of the area (sand ridges).

The prescribed burning program will result in a series of low-fuel areas across the development envelope, preventing the spread of large bushfires and reducing risk to site personnel and biodiversity values (Section 4.0).

3.2 Operations Phase Workforce

The operational workforce will be smaller that the construction workforce (approximately 400 personnel), and they will develop a level of familiarity and knowledge of the development envelope and its environment over time. It is expected that a permanent on-site emergency response team will be in place, with appropriate training and a direct role in bushfire emergency response.

Familiarity with the development envelope will not, however, completely remove risk to personnel from bushfire. All operational personnel will receive basic bushfire safety and awareness training, as for the construction workforce.

The prescribed burning program commenced during construction will be implemented throughout the operational life of the proposal, to provide protection from large bushfires. The methods and biodiversity focus of the program would change with the shift to operations. However, given that ground disturbance will be complete and the proposal track network will then exist, the development envelope will be well established to deploy fire management operations (see Section 5.0).

3.3 Other Stakeholders

Other stakeholders that may be affected by bushfire either originating from within or passed through the development envelope include:

- adjacent pastoral leases, including personnel, stock and infrastructure;
- indigenous community members of surrounding Native Title lands;
- government agencies involved in managing public infrastructure (such as Main Roads Western Australia for the Northwest Coastal Highway);
- roadhouse operators on the Northwest Coastal Highway;
- travellers on the Northwest Coastal Highway and the Nyangumarta Highway (Kidson Track); and
- Walyarta Conservation Park (DBCA and Nyangumarta native title holders).

Most of these stakeholders are relatively low-risk regarding bushfire impact. However, given the potentially high consequences (fatalities or destruction of facilities) caused by bushfire, the risk must be considered during fire management planning.

The most effective mitigation for most of these risks includes an ongoing prescribed burning regime within the development envelope.

3.4 Surrounding Land Users

Lands surrounding the development envelope is almost entirely undeveloped areas of natural vegetation. This vegetation is similar to that of the development envelope itself, and is susceptible to bushfire. There are few management activities undertaken in the areas near the proposal. However, given the recent determination of native title (Nyangumarta Claim; Figure 2.1 in Section 2.1) and establishment of Nyangumarta community ranger teams, this may change during the proposal construction period.

As a major land user within the Nyangumarta claim area, it is likely that Nyangumarta people will seek to engage with the proponent regarding fire and other land management programs. We are aware that the Nyangumarta are currently undertaking pilot aerial burning programs in the locality and are a potential partner in the delivery of the fire management program.

The Walyarta Conservation Park is managed by the DBCA, including management of fire for similar reasons to those outlined in this document: protection of life, property and environmental values. Given the strong similarity in aims, potential collaboration in fire management exists between the proposal and both Nyangumarta and DBCA. Collaboration may allow economies of scale and shared mobilisation of fire management assets. Any planning undertaken for the development envelope will seek compatibility with existing fire management plans for the Walyarta CP or for Nyangumarta lands.

3.5 Proposal Infrastructure

The proposal will involve the development of a large array of ground facilities and infrastructure, which will be widely distributed throughout an environment that is highly susceptible to bushfire. Protection of such facilities and infrastructure will depend upon two passive-protection strategies:

1. Maintenance of low- or bare-fuel zones around all buildings and infrastructure; and
2. Implementation of a prescribed burning program across the development envelope, to decrease the risk and impact of large and hot bushfires.

Minimum setback distances for facilities are regulated by local government requirements. Where fuels are particularly dense, wider fuel control areas are required. Radiant heat flux levels generated by bushfires can be estimated from fuel quantities and likely weather conditions. Heat flux levels in moderate spinifex fuels are likely to be considerably less than those developed by the calculator tool for ‘shrublands’ and ‘scrub’ vegetation, meaning the separation distances provided in Table 3.1 are conservative. It is currently considered that a 50 m setback is adequate to protect staff from most spinifex fires in the development envelope (see also Table 2.3).

Table 3.1: Radiant heat flux (kW/m^2) calculations derived from the Bushfire CRC bushfire calculator tool, for shrubland and scrub vegetation. A level of 3 kW/m^2 is considered safe for fire-fighters in standard bushfire PPE.

Fuel Type	Separation distance from fuel			
	25 m	**50 m**	**75 m**	**100 m**
Shrublands	9.27	3.71	1.95	1.17
Scrub	14.0	5.6	2.93	1.76

Note that narrower 'fire breaks' are not effective in preventing fire spread under windy conditions. 'Firebreak' tracks allow vehicle access only, and would probably not stop fire moving across the development envelope. This also applies to the road network within the development envelope. A 15m wide road will not stop the spread of fire under lively weather conditions, though it may effectively do so under mild conditions burning prescription.

4.0 Management Species and Communities

4.1 Vegetation

None of the vegetation types present with the main part of the development envelope are considered to be of conservation significance. The cable export corridor crosses the Eighty Mile Beach Land System Priority Ecological Community (PEC) (Biota 2018a). All of the vegetation types found in the vast majority of the development envelope are spinifex hummock grasslands that are adapted to periodic burning. The species composition of any particular area within this extent at a given time is likely to be largely determined by the time since fire.

A variety of different fire ages will firstly increase the diversity of vegetation types in the area. Floristic composition of these communities will then change with time since fire, approaching a mature composition several years after last burn.

Grazing pressure from feral herbivores may degrade vegetation recovery post-fire. There was, however, no evidence of donkey or goat being recorded as present in the development envelope during all of the fauna and flora field work undertaken for the proposal over a two-year period (Biota 2018b, 2018a, 2018c). Camels were present, but apparently only at relatively low density: tracks were periodically sighted, mainly in the west of the development envelope, but not in large numbers, and only a few actual individuals were sighted over the course of all the field surveys. Therefore, the existing data suggest feral herbivore grazing may not be a significant factor in post-fire vegetation recovery.

4.2 Fauna

The development envelope contains a fauna typical of the western deserts and coastal pindan sandplains (Biota 2018b). Survey data indicate 176 species of vertebrate (77 reptiles and frogs, 68 birds, and 31 mammals). Fire will directly or indirectly impact most of these species, and a large percentage of the total fauna may be considered fire sensitive in that they rely upon intact spinifex clumps or other vegetation for critical resources.

A prescribed burning program within an area as large as the development envelope will also have significant benefits to other fauna. A diversity of time-since-fire vegetation offers the greatest diversity of resource and habitat types, supporting diverse fauna communities at the landscape scale.

4.3 Bilby

Bilby (*Macrotis lagotis*), a Threatened fauna species, was confirmed from the development envelope by Biota (2018b). While vulnerable to disturbance, most species of conservation significance are able to escape construction activities and land clearing if undisturbed habitat remains nearby. However, family groups of Bilby shelter during the day within burrow systems, and disturbance to ground containing occupied burrows would probably kill the occupants. Such ground disturbance for the proposal can be broadly categorised as:

1. Linear: access tracks, turbine pads, cable trenching; and
2. Larger polygons: solar arrays, substations and the control compound.

Construction impacts on Bilby will be mitigated as set out in the proposal Environmental Management Plan (EMP). Disturbance areas will be assessed by drone-based imagery (flight path specifications as per research conducted by DBCA to identify Bilby foraging activity centres, M. Dziminski, DBCA, pers. comm. 2019) (Biota 2019)), and/or traversed by zoologists experienced in identifying Bilby sign prior to civil works. Direct management measures will then be implemented for any burrows identified within clearing disturbance areas.

If no evidence of Bilby is found within the search area then no further management actions are necessary.

If Bilby burrows are found in linear disturbance areas such as tracks, and the burrow is not currently occupied then it will be decommissioned. Bilby use multiple burrows, and the animal must be occupying another burrow outside the clearing area (Biota 2019).

Large non-linear areas of disturbance may contain all of the burrows used within a Bilby activity centre. In this case, unoccupied burrows can be decommissioned. Trapping and translocation of individuals is the minimum contingency measure for the proposal in this scenario (as set out in the EMP; (Biota 2019), but this is problematic as they may be stressed and injured, and trapping may not capture all occupants. Locating all of the occupied burrows within these large areas would be laborious, with no guarantee that individuals were not missed. Alternative management measures are needed.

Bilby are known to move around in the landscape over time, and fire history is a key driver in this (Cramer 2016). Figure 4.1 shows examples of the relationship between Bilby records from the development envelope and time since last fire, indicating that records of current activity come from suitable landform and substrate habitats that are approximately five to six years since last burn. This is consistent with other findings, where Bilby have been found to utilise habitats that are regenerating from fire, particularly when adjoining habitat patches are longer time since burnt, and where rainfall has driven the recruitment of *Acacia* spp. and other food resources.

There is some evidence that Bilby respond to fire by moving away from burrows located within recently burnt areas, establishing new residence burrows in nearby unburnt vegetation (Southgate and Carthew 2007, Southgate et al. 2007, Cramer et al. 2016, Dziminski and Southgate 2017). Other recent observations, however, also indicate that Bilby may remain active in burnt areas for a period of at least a fortnight before relocating (M. Dziminski, DBCA, pers. comm. 2019), and that the scale of the burn relative to other suitable vegetation nearby may be a factor in their successful relocation.

Prescribed burns which make the planned disturbance area unattractive to Bilby should encourage them to move into adjoining unburned areas. These areas will have been subject to smaller controlled burns with enough lead time to ensure that they are suitable habitat. A pilot study will be conducted in advance of the commencement of construction, involving prescribed burns and monitoring of Bilby activity and response to validate this approach (see Section 5.1). The timeframes prior to clearing in larger polygons with resident Bilby will be more fully determined by that study, but if such areas were burned under prescribed conditions 2 to 12 months before earthworks commenced, then resident Bilby should move to nearby unburned areas of suitable fire age.

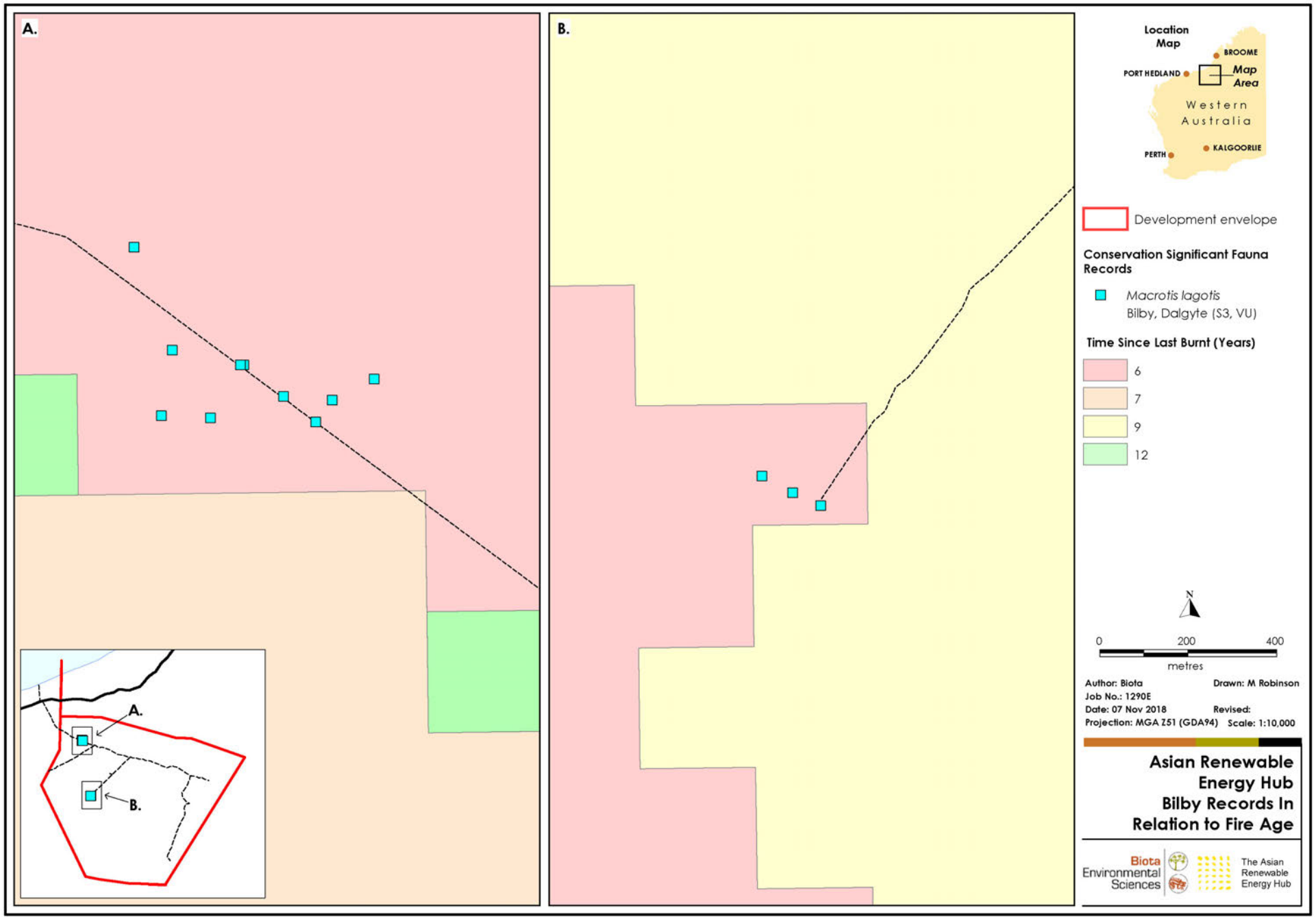

Figure 4.1: Relationship between Bilby records and fire history within the development envelope.

Fire management planning will aim to retain or create blocks of adjoining habitat in the 5-6 year post-fire age, which are likely to be optimal for the species. This would occur within each of the ~15,000 ha blocks of habitat defined by the proposal's access track network. A local scale mosaic of differing fire age habitat is created within each management block, nested within the larger scale context of overall managed fire ages across the development envelope. Habitat heterogeneity seems to be a critical resource requirement for Bilby (Cramer et al. 2016), so creating these mosaics of differing fire age within the development envelope should benefit this species, as well as improving overall long-term ecological resilience and reducing the risk of large scale fire events.

4.4 Black-flanked Rock Wallaby

Black-flanked Rock Wallaby (*Petrogale lateralis*), a Threatened species, are not usually thought to be especially vulnerable to fire (Alicia Whittington, Peter Kendrick pers. comm.). This is partly due to the fire-protected rocky landscape features they live in. Observations during the Biota (2018b) field survey support this in the development envelope, with the habitat surrounding one rock wallaby habitat burnt between survey phases, but with rock wallaby still being recorded at the location months after the burn occurred.

However, a large, intense bushfire can significantly impact on rock wallaby populations if critical vegetation is burnt. If this occurs during a long dry period, then wallaby populations may find foraging close to rock piles impossible, leaving them more vulnerable to predation if they extend their foraging zone further from shelter.

Specific consideration will be given to rock wallaby populations in the planning of fire management. A specific fire program will not be developed for rock wallaby conservation, rather that any implementation of prescribed burning will include the objective of avoidance of the rock piles where rock wallaby are known to occur. This species will benefit from the overall application of prescribed fire across the development envelope through the decrease in frequency of very large bushfires.

4.5 Other Species

The only other species of conservation significance where fire ecology is relevant is the Spectacled Hare-wallaby (*Lagorchestes conspicillatus*, Priority 3 species), which was only identified from the development envelope from a single track and may be at low abundance (Biota 2018b). This species relies on larger, long-unburnt spinifex hummocks for shelter. The establishment of habitat areas more than 10 years unburnt (Management Actions, Section 8.1), will benefit this species compared to the current unmanaged fire regime.

No other vertebrate species are considered to be particularly susceptible to bushfire. Of the remaining listed species known from the area (Biota 2018b), none are considered to be at specific risk from a prescribed fire program.

5.0 Prescribed Burn Strategy

5.1 Pre-Construction Prescribed Burning Pilot Study

A pre-construction pilot study of prescribed burning will be undertaken to develop proof of concept, at least 36 months prior to construction earthworks beginning. This will be used to test burn prescriptions, treat initial construction target areas, and to determine whether the predictions regarding Bilby response to recent fire are supported.

The planning, design and implementation of this trial will be conducted in collaboration with DBCA, the Nyangumarta Rangers and other key stakeholders and specialists, and will involve:

1. Confirmation of a study site representing a larger disturbance polygon within Zone 1 of the construction schedule (Figure 5.1) . This is the first area where construction clearing will commence, and Bilby activity was recorded in this area during baseline surveys (Figure 4.1);
2. documentation of the extent of Bilby activity within the site prior to the implementation of the pilot study's prescribed burns (following methods detailed in Section 7.1.1);
3. identifying and mapping of vegetation fire age within the study site, both from sources such as NAFI, on-ground traverses and mapping from newly acquired digital imagery, including the assessed time-since-fire age of areas with current Bilby activity;
4. preparation of fire prescriptions specific to the site following the format provided in Appendix 1 (Spread Index of between 1 - 4), with the objective of creating a range of fire age patches in areas adjoining the Bilby activity extent, taking into account the existing vegetation fire ages;
5. prescribed burning of the study site itself including documenting the characteristics and outcomes of each ignition (see Appendix 1);
6. monitoring of Bilby activity and changes in distribution and activity in the period following prescribed burning (Section 7.1.1); and
7. implement advance burning in areas adjoining the study site consistent with the requirements of the Fire Management Plan (in preparation) and prescriptions, including documenting the characteristics and outcomes of each ignition (see Appendix 1).

The data from the pilot study will be used to validate the approach of fire-mediated management as a means of moving Bilby from the larger extent components of the proposal footprint, and for establishing the overall fire management regime for the proposal.

5.2 Construction Phase Prescribed Burning

At the broader scale, a burning program will be developed across the development envelope, with the objective of effectively creating a mosaic of fire age vegetation, beginning up to 5 years ahead of construction earthworks. This would be presented for specific areas in the Fire Management Plan. Operational fire planning, including annual burn plans and prescriptions, will be continually updated for the proposal during pre-construction, construction and operations phases.

The anticipated staging of the proposal construction is shown in Figure 5.1, giving a guide to the timing of advance prescribed burning for each management zone of the development envelope.

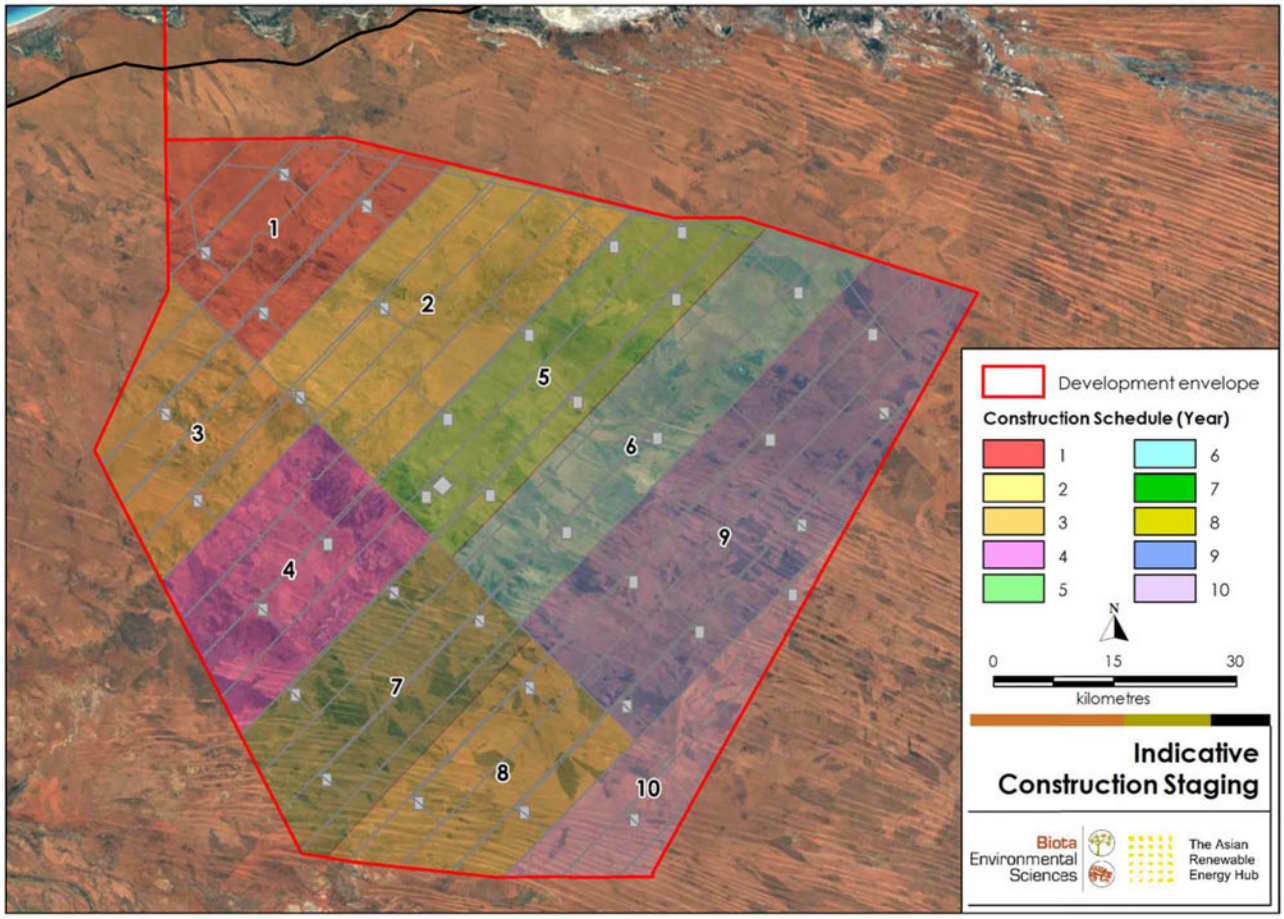

Figure 5.1: Indicative construction staging within the development envelope.

The scale of burning within the construction areas indicated above are determined by the burn prescription that is applied. The prescription is written to achieve the desired burn outcome – for instance to remove vegetation from around construction areas for workforce safety. In that example, a prescription is developed to allow ignition within future larger polygons such as solar arrays (by aerial or ground ignition) which will burn for 1-3 hours before self-extinguishing (due to local weather conditions). A prescription template that will be used for the spinifex-dominated habitats of the development envelope is provided in Appendix 1.

Prescriptions are developed to suit the desired burning outcomes. These would include workforce safety, removal of vegetation, fauna management or general ecological management (these may be combined into single prescriptions where outcomes are aligned). Detailed fire management arrangements will be presented in the Fire Management Plan, to be developed and continuously updated during the life of the proposal. Operational planning will take local fire history, weather and other matters into consideration when implementing individual prescribed burns. Generally, no more that 10% of a fire management area (construction staging areas, Figure 4.2) would be burned in one year. In this instance, a construction area (e.g. Area 1 in Figure 4.2) will include several different prescribed burns, depending upon the outcomes and timing desired.

5.3 Operations Phase Prescribed Burning

Given the long-term tenure of the proposal, the fire management program will be continued for life of operation. This would include continuation of the biodiversity monitoring program, including information feedback into refinement and improvement of the program.

The benefits for both bushfire risk mitigation and wildlife management will be profound. The monitoring which will be employed to measure this is discussed in Section 7.0.

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6.0 Implementation Methods

6.1 Development and Implementation Team

The proponent has assembled a team of experienced ecologists, land managers and bushfire specialists to assist in the preparation of the Fire Management Strategy. These form the foundation for a steering group that will oversee implementation of fire management actions, ecological monitoring, reporting and continuous improvement feedback. The fire management steering group includes:

- Dr Peter Kendrick (previously with DBCA in the Pilbara Region and on Barrow Island, from 1989-2018, with a background in conservation land management and threatened fauna monitoring, including collaboration with traditional owner groups);
- Roy Teale (30 years' experience in arid zone ecology, including ARC linkage grant research relating to fire and threatened fauna);
- Garth Humphreys (30 years' experience in arid zone ecology and environmental management);
- Roger Armstrong (previously DBCA's Principal Fire Planner, Senior Environmental Manager and District and Section Manager for several decades); and
- Alexander Tancock (Managing Director, NWIP, representing the proponent).

It is proposed that a prescribed burning program be undertaken in collaboration with Nyangumarta Rangers and DBCA. Both of these organisations are key stakeholders to be engaged with by the proponent, and will be invited to join the steering group once the proposal Ministerial Approval is received. Other stakeholders including adjoining land managers and research scientists from elsewhere within Australia who may be invited to join the steering group, or kept apprised of progress and the outcomes of ongoing implementation and monitoring.

6.2 Pre-construction Phase

Both aerial and ground ignition techniques are routinely used to put fire into such areas across arid and semi-arid Australia.

6.2.1 Aerial Burning Program

The proposal is to be constructed over a large area, within which there are few roads or tracks. Existing tracks at present are not aligned to the proposal's infrastructure.

Burn prescriptions suitable for aerial ignition, defining suitable weather conditions and fuel characteristics for a high probability of success (low rates of spread during and self-extinguishing at night) are applied, using well established principals (Burrow et al. 2006, 2009, 2018; Burrows and Christensen 1991). Spread Indexes of between 1 to 4 will be prescribed (Appendix 1).

An aerial burning program will be implemented before commencement of construction, to allow testing of proof of concept. This will allow the specifics of implementation techniques to be trialled, and burn prescriptions to be tested and refined.

Aerial ignition can be implemented efficiently and is the most cost-effective option for the development envelope. It is possible that this proposal could be incorporated into other Pilbara or southern Kimberley programs to maximise efficiencies and shared learning, through collaboration with other land management bodies (DBCA, Nyangumarta).

6.2.2 Ground Burning Program

Ground ignition can be very effective where access is possible. Follow-up ground burning can supplement aerial burning if required. Given the lack of vehicle access, ground operations would need careful consideration before implementation.

6.3 Construction Phase

It is probable that aerial burning will be the primary implementation method during the construction period. Under appropriate prescription conditions, the entire program could be achieved within a few days, guided by the Fire Management Plan for each specific management area.

6.4 Operations Phase

The proposal fire management program will be implemented for the duration of the proposal, guided by the Fire Management Plan. Details of program implementation would be developed as experience is gained during the pre-operations burning program. Ground ignition will likely become more important as the proposal track network is developed.

6.5 Traditional Owner Partnerships

A collaborative prescribed burning program will require careful planning and implementation in respect of training, competency and equipment, with the agreement and involvement of the Nyangumarta traditional owners. It is likely that Nyangumarta Rangers would be directly involved. This group undertakes land management roles on their traditional country, and fire management is a key land management function. It is understood that the Nyangumarta Rangers have commencing aerial burning trials in their traditional lands.

7.0 Monitoring

7.1 Fauna

7.1.1 Bilby Pilot Study

Pre- and post-fire monitoring of Bilby activity and burrow distributions would be necessary to test the concept of fire-mediated relocation of Bilby populations (Section 5.1). This will be achieved during the pilot study (Section 5.1) by:

1. Targeted searches prior to the burn within the trial area to document the extent of current Bilby activity, recording currently active burrows, fresh scat records, automatic camera records and current foraging evidence. Drone-captured imagery will be used to identify areas of Bilby activity;
2. Collecting data on both vegetation and habitat, and existing Bilby activity, in habitat areas adjoining the planned burn trial area ahead of trial burns;
3. Establishment of an automatic camera network before and after the prescribed burn, to collect data on Bilby movement records during dispersal. This would target active Bilby burrows located prior to the burn;
4. Repeated follow up monitoring of previously active burrows and foraging areas within the burned area with cameras and/or drone imagery, to determine if Bilby are no longer present; and
5. Repeated targeted searches and equivalent monitoring in the suitable unburnt habitat adjoining the trial area, to determine if Bilby activity has increased compared to the baseline.

Assuming the data from the pilot study support the use of fire-mediated relocation of Bilby, similar monitoring protocols for Bilby would be implemented for the larger polygons of the proposal footprint (solar arrays, substations and control compound).

7.1.2 Black-flanked Rock Wallaby

Standardised visual observations will provide sufficient data to monitor the persistence of local populations. This will be supplemented by searches for fresh scat material and the deployment of automatic cameras during periods when prescribed burns have occurred in areas within 2 km of known rock wallaby habitat.

7.1.3 Other Fauna

Monitoring of the wider vertebrate faunal assemblage will test the assumptions made regarding the positive ecological impacts of a prescribed burning program.

Standard pit-fall trap lines will be established in habitats of differing fire age, including baseline sampling of the trial burn area prior to burning. Sampling effort, methods and timing will be consistent across sites to leave fire history as the primary environmental variable to the extent possible. Standard layouts will be utilised, comprising of a single row of eight pitfall traps arranged as alternating 20 litre buckets and 150 mm diameter x 600 mm deep PVC tubes, spaced at approximately 20 m intervals and connected with an 80 m length of 300 mm high fly wire fence.

Changes in the post-fire fauna assemblage over time will be compared against data from sites of varying fire age, to provide quantification of changes to community structure over time following burning (see Section 7.4).

7.1.4 Feral Fauna

Feral fauna may also be benefited by fire in the landscape, and recently burnt areas offer limited shelter to many native species. Pilot study monitoring (Section 7.1.1) will also collect data both pre- and post-burn activity of feral fauna. This will be used to assess any local changes in distribution and density of feral fauna activity, including scats, tracks and other sign.

The proposal EMP requires development of a feral fauna control programme in liaison with DBCA (Biota 2019). Data from monitoring feral fauna activity around the prescribed burns will inform this programme.

7.2 Flora and Vegetation

Monitoring of flora and vegetation will be used to test assumptions made regarding the ecological impacts of a prescribed burning program.

Systematically collected flora and vegetation data from sites of varying fire age will also provide valuable covariate data for monitoring of Bilby and other significant species.

Long term monitoring quadrats will initially be established in existing vegetation of differing fire ages. Initially, time since fire will be inferred from NAFI fire age mapping (Figure 2.3), with this to be refined once areas have been subject to prescribed burning, where age since fire is precisely known. Sites will be chosen to sample representative habitats within each management zone, to cover the range of times since fire and vegetation types present. It is anticipated that a minimum of 10 quadrats per management zone would be established and monitored on an annual basis, sampled within two months of a major rainfall event (>100 m in 24 hours), or by April of each year in the event that this criterion is not met. The final number of quadrats within each management zone will be a function of the vegetation types and fire ages actually present, and determined by the lead botanist undertaking the monitoring, following these guiding principles.

Quadrats will be assessed in accordance with the relevant technical guidance documents (e.g. Clarke 2009; EPA 2016a). The methodology for each flora monitoring site will comprise:

- Standard quadrats of a 50 m x 50 m square (or equivalent area of 2,500 m^2);
- All quadrats will be established using measuring tapes and an optical square, and permanently marked at each corner point; coordinates for each corner point will be recorded;
- Vegetation types will be described at the NVIS association Level V (or below, if appropriate);
- A digital photograph of each quadrat will be taken from a standard corner;
- Vegetation condition will be assessed according to the condition scale of Trudgen (1988);
- Common vascular flora species will be identified in the field; voucher samples will be collected of all other species for further identification and vouchering (where necessary);

- Estimated size and structure of spinifex hummocks will be recorded as a key parameter; and
- Standardised drone imagery will be captured for each quadrat, including LIDAR assessment of vegetation distribution and volume.

Floristic data will form the primary basis for objective analysis and tracking of vegetation composition over time since fire (see Section 7.4).

7.2.1 Weeds

There will be increased risk of weed establishment post-fire, including potential novel introductions during fire implementation and construction / operations phases.

The pilot study area (Section 7.1.1) will be monitored for weeds one month and three months post-burn, with an additional monitoring phase following one month after a major rainfall event (>100 mm in 24 hours), if neither of the first phases follows rain. This will involve searches of the burn extent, particularly on track margins or other earthworks areas, to identify any newly established weeds.

As per the EMP for the proposal (Biota 2019), any such new establishments will be subject to control and follow up monitoring measures. An equivalent protocol will be followed for future burns to be conducted more widely during the construction period.

7.3 Fire History Mapping

Monitoring of fire history will continue for life of proposal. This can be efficiently maintained by annual acquisition of satellite data, with fresh fire scars mapped onto preceding maps. Assuming the facility continues, the NAFI proposal data[2] that have been utilised in the compilation of this document will also be incorporated into broader scale monitoring.

7.4 Analysis and Reporting

Ecological data from the monitoring program would be analysed using current best practice methods, with results reported annually during construction and operations. It is planned that *mvabund* [3] will be utilised in RStudio [4] to analyse the faunal assemblage and floristic data sets against known and inferred fire age and rainfall as environmental predictor variables. Both ecological community and individual species responses can be tested for significant relationships to predictor variables through this method of multivariate analysis.

Subject to the data collected on Bilby, the application of spatially explicit capture recapture (SECR) to model density in areas of differing fire age (and post-prescribed fire) will also be explored. Occupancy modelling approaches, such as that used by Dzminski et al. (2019) will also be introduced into the monitoring programme to examine larger scale use of the development envelope habitats.

[2] http://www.firenorth.org.au/nafi3/
[3] https://besjournals.onlinelibrary.wiley.com/doi/10.1111/j.2041-210X.2012.00190.x
[4] https://rstudio.com

The findings of each year's monitoring would be used to inform and refine the prescribed burning implementation methods for following years, and to adjust the monitoring program itself to ensure it provides for continuous improvement during the life of the operation.

8.0 Summary of Objectives and Management Actions

8.1 Objectives of this Fire Management Strategy

As set out in earlier sections, this fire management strategy has multiple objectives, which are consolidated and summarised in conclusion below:

1. The protection of proposal personnel and infrastructure from wildfires, during pre-construction, construction and operations phases of the proposal.
2. Minimise the impact of ground disturbance on any Bilby that may be resident within disturbance polygons at the time of construction.
3. Mitigate the risk of large hot fires affecting habitat relied upon by colonies of the Black-flanked Rock Wallaby.
4. Develop and implement a detailed Fire Management Plan, consistent with this overarching Fire Management Strategy. Specific burn objectives to be achieved in consultation with DBCA and using procedures outlined in the prescription template in Appendix 1.
5. Conduct prescribed burns following the prescriptions, with the overall objective of creating and maintaining a mosaic of differing fire ages within each management zone of the development envelope, provisionally comprising by area: 10% <1 year since burn; 20% 2-3 years; 20% 3-5 years; 20% 5-7 years; 20% 7-10 years and 10% exceeding 10 years since last burnt.
6. Monitor for and mitigate any proposal-induced increase in feral fauna and weed establishment that occurs as a result of prescribed burning.
7. Monitor key species and ecological communities over time in response to prescribed burns to provide feedback to refine detailed fire management planning.
8. Collaborate with traditional owners, adjacent land managers and other stakeholders in delivering a sustainable mosaic of differing fire age habitat across the landscape of the development envelope.

8.2 Revision Process

A review of this Fire Management Strategy will be undertaken internally at key project milestones, comprising:

- Completion of the Bilby Pilot Study;
- Triennially during the construction period; and
- Triennially during operations.

Aspects of the strategy that will be reviewed include changes to deployment methods, effectiveness of fire prescription templates, monitoring methods / frequency, reporting frequency, refinements to management measures based on feedback regarding their implementation, any incorporation of any emergent or changing environmental issues at the site and management responses.

An example of the latter would be the current assessment that feral herbivores appear unlikely to create undue pressure on revegetation post-fire (Section 4.1); should monitoring data indicate that this is becoming an issue, then management measures will be developed and implemented to control feral herbivores, consistent with the principles of adaptive management and continuous improvement.

8.3 Organisational Overview of this Fire Management Strategy

Figure 8.1 illustrates the relationship between this document, the over-arching Fire Management Strategy, and other components of the project's fire management, including the detailed Fire Management Plans and prescriptions to be prepared for each management zone and the relationship by which related monitoring data will be used to inform future reviews and adaptive management.

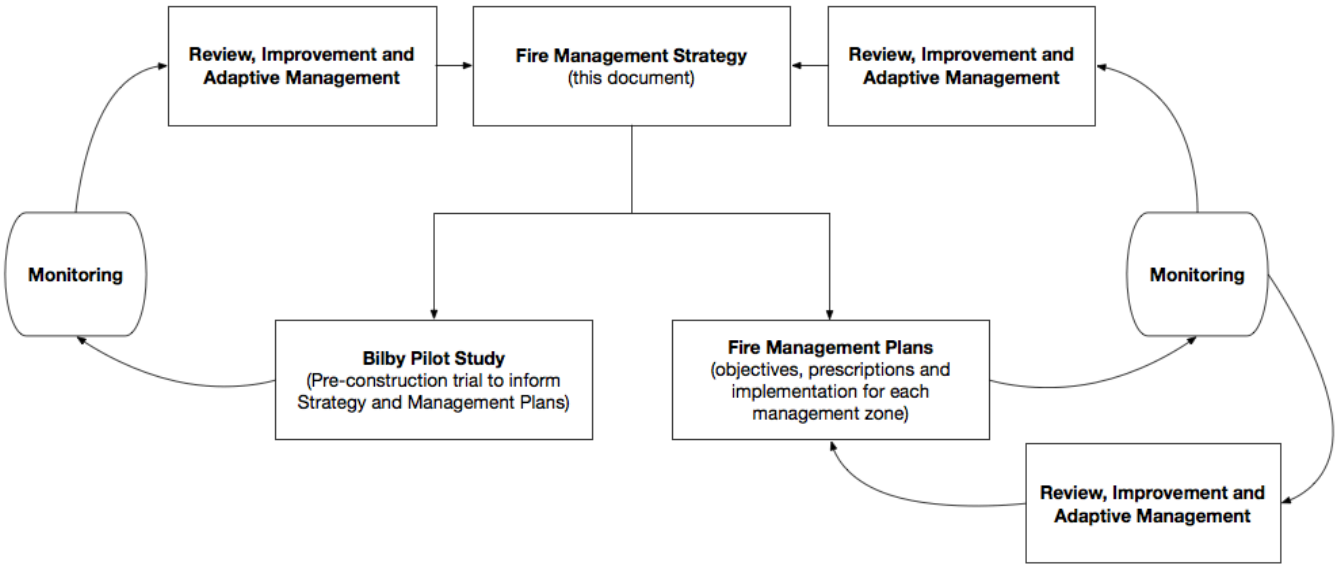

Figure 8.1: Relationship between elements of this Fire Management Strategy.

8.4 Summary of Management Actions

A summary of the management provisions to be implemented are presented in the management-based provisions structure provided for by EPA (2018b) (Table 7.1).

Management objectives identified here relate to the EPA's environmental objective for each relevant factor, the management actions designed to meet these objectives, and management targets aimed to assess the effectiveness of management actions, consistent with the proposal EMP (Biota 2019). Monitoring and reporting approaches used to assess the effectiveness of the management actions in meeting management-based objectives are also presented.

Table 8.1 details the management objectives, associated actions and targets for the key environmental factors relevant to fire. Consistent with the approach recommended by EPA (2018b), the management provisions are detailed in tabular format, setting out objectives, actions and monitoring.

Table 8.1: Management-based provisions for Fire Management Strategy.

Key Environmental Factors: Terrestrial Fauna; Flora and Vegetation
EPA Objective: To protect terrestrial fauna and flora and vegetation so that biological diversity and ecological integrity are maintained.

Key Environmental Values	Key Impacts and Risks	Outcome	Management Actions	Management Target	Monitoring	Reporting
Flora and vegetation	Risk of proposal-induced bushfires.	No significant risk of fire starting as a result of construction activities.	1. Design and implementation of a fire management plan within the development envelope for the construction phase of the proposal, consistent with the proposal fire management strategy. 2. Implementation of controlled procedures for spark generating activities. 3. Implementation of a fire emergency response plan prepared to the satisfaction of the Shire of East Pilbara and FESA.	Minimise the risk of unplanned proposal-induced fires.	Construction activity monitoring with detailed fire management planning, controlled procedures and reporting of any incidents related to bushfires. **Responsibility**: construction contractors. **Frequency/Timing**: ongoing during construction phase.	Compliance reporting against detailed fire management planning and controlled procedures.
	The long-term presence of the site access tracks, partitioning vegetation into blocks and thereby altering fire regimes within the development envelope (in terms of frequency, extent, intensity), leading to consequent changes in vegetation structure and floristic compositions.	Improve landscape scale habitat quality, heterogeneity and resilience compared to current unmanaged fire regime.	4. Design and implementation of a fire management plan for the construction and operational life of the proposal, consistent with the framework and objectives of the proposal fire management strategy. 5. Design and implementation of a biodiversity monitoring program, consistent with the methods and objectives of the proposal fire management strategy.	Active management of fire regime with the aim of enhancing biodiversity and protecting infrastructure.	Compliance with detailed fire management planning and analysis of ecological monitoring data. **Responsibility**: environmental representative. **Frequency/Timing**: pre-construction, during construction and annually during operation. Requirement and effectiveness reassessed after implementation of five years of mosaic burning.	Compliance reporting against detailed fire management planning
	Risk of weed introduction and spread post-prescribed burn	No new weed species or increase in the distribution of existing weeds as a result of prescribed burns.	6. Implement weed hygiene and control to prevent the establishment of new weed populations within the development envelope during prescribed burns. 7. Conduct weed monitoring of newly burned areas, consistent with the proposal fire management strategy 8. Follow up control measures to eradicate any weed populations that become established after prescribed burns.	Minimise the risk of the introduction or spread of weeds within the development envelope as a result of fire management.	Results of weed monitoring **Responsibility**: environmental representative. **Frequency/Timing**: pre-construction, during construction and annually during operation. Requirement and effectiveness reassessed after implementation of five years of mosaic burning.	Compliance reporting against detailed fire management planning and environmental management plan.

Key Environmental Values	Key Impacts and Risks	Outcome	Management Actions	Management Target	Monitoring	Reporting
Terrestrial fauna	Risk of proposal-induced bushfires.	No significant risk of fire occurrence as a result of construction activities.	1. Design and implementation of a fire management plan within the development envelope for the construction phase of the proposal.	Minimise the risk of unplanned proposal-induced fires.	Construction activity monitoring with detailed fire management planning, controlled procedures and reporting of any incidents related to bushfires. **Responsibility**: construction contractors. **Frequency/Timing**: ongoing during construction phase.	Compliance reporting against detailed fire management planning
	The long-term presence of access tracks altering fire regimes within the development envelope (in terms of frequency, extent, intensity) and consequent changes to habitats, and local abundance and distribution of species responsive to fire ecology	Improve landscape scale habitat quality, heterogeneity and resilience compared to current unmanaged fire regime.	2. Design and implementation of landscape-scale detailed fire management planning for the operational life of the proposal, in consultation with DBCA and other stakeholders 3. Design and implementation of biodiversity monitoring programme to measure the effectiveness of the detailed fire management planning and provide feedback.	Active management of fire regime with the aim of enhancing biodiversity and protecting infrastructure protection.	Compliance with detailed fire management planning and analysis of ecological monitoring data. **Responsibility**: environmental representative. **Frequency/Timing**: pre-construction, during construction and annually during operation. Requirement and effectiveness reassessed after implementation of five years of mosaic burning.	Compliance reporting against detailed fire management planning
Black-flanked Rock-wallaby.	Changes to fire regimes that reduce landscape heterogeneity and increase risk of extensive or very hot fires.	No significant population decline of Black-footed Rock-wallaby attributable to changed fire regimes.	4. Design and implementation of detailed fire management planning for the operational life of the proposal, in consultation with DBCA and other stakeholders, that excludes large hot fires from Black-footed Rock-wallaby habitat. 5. Design and implementation of biodiversity monitoring programme to measure the effectiveness of the fire management plan and provide feedback.	Provide continuous feedback to fire management for long-term maintenance of Black-footed Rock-wallaby populations.	Monitor response (e.g. behaviour, persistence) of Black-footed Rock-wallaby post fire. **Responsibility**: site environmental representative with potential for Aboriginal community involvement. **Frequency/Timing**: in consultation with prescribed fire management practices. Adaptively review and reassess management.	Biodiversity monitoring programme.
	Increased risk of feral fauna spread, particularly fox and cat; known predators of the species.	No significant population decline of Black-footed Rock-wallaby attributable to increased feral fauna predation.	6. Implementation of a targeted fox and cat monitoring and control programme.	Minimise and avoid feral predation impact on Black-footed Rock-wallaby populations.	Annual survey for fox presence within core habitat areas. Baiting in consultation with the DBCA if fox populations establish. **Responsibility**: feral animal control specialists. **Frequency/Timing**: Once annually or as required depending on outcome of surveying.	Annual compliance report (or as required).

Key Environmental Values	Key Impacts and Risks	Outcome	Management Actions	Management Target	Monitoring	Reporting
Bilby	Changes to fire regimes that reduce landscape heterogeneity and increase risk of extensive or very hot fires.	No significant population decline of Bilby attributable to changed fire regimes.	7. Design and implementation of landscape-scale detailed fire management planning for the operational life of the proposal, in consultation with DBCA and other stakeholders 8. Design and implementation of biodiversity monitoring programme to measure the effectiveness of the fire management plan and provide feedback.	Improvement of landscape heterogeneity and resilience through re-establishment of a mosaic of fire age habitat units to benefit the Bilby (<66% of the development envelope less than 2 years since last burnt, with creation of the range of other fire age habitats detailed in Section 8.1, Objective 5).	Monitor response (e.g. behaviour, persistence) of Bilby post fire. **Responsibility**: site environmental representative with potential for Aboriginal community involvement. **Frequency/Timing**: in consultation with prescribed fire management practices. Adaptively review and reassess management.	Biodiversity monitoring programme.
	Potential direct loss of individual Bilby during construction.	No significant mortality of individual Bilby attributable to construction activities.	9. Implementation of prescribed burning to manage any Bilby occurring within large clearing polygons (solar arrays, substations and control compound) ahead of construction via behavioural ecology, in consultation with DBCA. 10. Pre-clearing targeted survey and contingency management to confirm effectiveness, in consultation with DBCA.	Minimise potential for direct loss of individual Bilby.	Targeted pre-clearance survey. **Responsibility**: site environmental representative with potential for Aboriginal community involvement. **Frequency/Timing**: immediately prior to construction activities.	Pre-clearance targeted Bilby survey report.
	Increased risk of feral fauna spread, particularly foxes.	No significant population decline of Bilby attributable to increased feral fauna predation.	11. Implementation of a targeted feral fauna monitoring and control programme, in consultation with DBCA.	Minimise and avoid feral predation impact on Bilby populations.	Annual survey for fox presence within suitable habitat areas. Baiting in consultation with the DBCA if fox populations establish. **Responsibility**: feral animal control specialists. **Frequency/Timing**: Once annually or as required depending on outcome of surveying.	Annual compliance report (or as required).

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9.0 References

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Appendix 1: Example Fire Prescription Template

BURN IMPLEMENTATION PLAN: Spinifex Grasslands

BURN NAME:		BURN LOCATION:		BURN NO:	

AREA (ha):	PERIMETER/LENGTH (km):
SEASON/YEAR:	FUEL AGE:
SHIRE:	PROHIBITED PERIOD:
SHIRE:	PROHIBITED PERIOD:
FORECAST ZONE FOR BURN*:	
VEGETATION TYPE(S): 1) (%) 2) (%) 3) (%)	

*Refers to weather forecasting zone

BURN PURPOSE

This is a high-level description of the hoped-for outcomes of the burn. E.g. adding a new fire age into the prescription area to enhance the mosaic; or removing vegetation to a radius of not less than a defined radius around a bilby location

BURN OBJECTIVES

OBJECTIVE	**SUCCESS CRITERIA (as observable immediately post burn)**
BIODIVERSITY CONSERVATION OBJECTIVES: e.g. Maintaining the post-burn presence of high value fauna species within the managed area.	CRITERIA
PROTECTION / SAFETY OBJECTIVES: e.g. Removal of high risk fuels around work sites and trafficked access	CRITERIA
VEGETATION MANAGEMENT OBJECTIVES: e.g. Burning no more than 10% of vegetation in a burn cell	CRITERIA
KNOWLEDGE / RESEARCH: e.g. Observing and measuring rates of spread of fire in different fuel densities	CRITERIA

RISK APPRECIATION

DESCRIPTION OF HIGH VALUES/RISKS ADJACENT TO THE BURN:
Personnel, dwellings, buildings
Biodiversity values
Community assets
Commercial assets
Access limitations
Smoke impacts
Fuels
other

RISK TREATMENTS APPLIED

Personnel safety	
Protection of community assets	
Protection of built assets	
Protection of biodiversity assets	
Protection of commercial values	
Protection of utilities	
Other	

DESIRABLE BURNING CONDITIONS FOR SPINIFEX

After Burrows et al. (2018) – Development and validation of a model for predicting fire behaviour in spinifex grasslands of arid Australia

DESIRABLE OUTCOME			DESIRABLE IGNITION CONDITIONS			DESIRABLE FIRE BEHAVIOUR		IGNITION PATTERN
Veg Type % of Total burn area	Desirable mean burnt patch size (ha)	Resultant % that will be burnt	Wind speed (kph)	Temp (^{0}C)	RH (%)	Spread Index	ROS (m/hr)	
	2-10	15-20	12-15	20-25	25-35	1-2	500 -1,000	300x1000
	10-50	20-35	15-20	25-30	15-25	2-4	1,000 – 1,500	200x1000

EDGING PLAN

EDGE DESCRIPTION OF LOCATION	DESIRABLE SEASON	STRATEGIES	FUEL TYPES	DESIRED ROS	DESIRABLE WIND DIRECTION & SPEED

AREAS TO BE EXCLUDED FROM BURN

DESCRIPTION	LOCATION	HOW WILL FIRE BE EXCLUDED

PRE-DETERMINED SUPPRESSION STRATEGIES

IN THE EVENT OF AN ESCAPE:
Consider sensitive species and communities, adjoining fuel loads, areas where new track construction is acceptable and where indirect attack is more appropriate, feasibility of aerial suppression, location of existing tracks suitable as control lines etc).

SIGN MANAGEMENT PLAN

Identification of roads and trails associated with burn

ROAD NAME	**ROAD TYPE** (e.g. highway, local sealed road, dirt track)	**SPECIAL TRAFFIC CONSIDERATIONS** (e.g. high volume of trucks and sedans)

Sign Layout (Show on Plan)

Sign Placement and Removal Dates

ROAD NAME	**SIGN TYPE**	**DATE INSTALLED**	**DATE REMOVED**

Sign Inspection and Surveillance Diary

DATE SIGNS INSPECTED	**TIME OF INSPECTION**	**COMMENTS**	**OFFICER INSPECTING**

PRESCRIBED BURN BRIEFING

The Briefing notes section to be filled out by both the prescribing officer for issues/actions for D.O.B. identified in pre planning and the person presenting the briefing for current information (e.g. forecast weather, activities near burn etc.).

OVERVIEW OF BURN	**BRIEFING NOTES**
Description of Burn Area	
Burn Objectives	
Fuel ages within and surrounding burn	
Access around burn	
Areas where fire is to be excluded	
Values in/adjacent to the burn	
Current Weather	
Forecast Weather	
IMPLEMENTATION	**BRIEFING NOTES**
Organisational Structure	
Divisions & Sectors	
Strategies (sequence of lighting)	
Tactics (edging & core lighting etc)	
Task and Resource Allocation	
Aircraft operations	
Water Points/ sources	
Time constraints & deadlines	
Diaries, Record Keeping	
SAFETY	**BRIEFING NOTES**
Known Hazards and Safety Issues	
Traffic Management	
PPE	
COMMUNICATIONS	**BRIEFING NOTES**
Radio Channels	
Reporting - To whom, detail required and frequency	
LOGISTICS	**BRIEFING NOTES**
Ground Support, Catering arrangements	

FIRE BEHAVIOUR OBSERVATIONS

TIME OF OBSERVATION	**VEG/FUEL TYPE**	**ESTIMATED ROS**	**ESTIMATED FLAME HT (RANGE)**	**FLAME LENGTH (RANGE)**	**STRIP & SPOT SPACING (M X M)**	**EVIDENCE OF SPOTTING (DISTANCE?)**

WEATHER OBSERVATIONS

Available from ☐ Automatic Weather Station OR ☐ Field Observations

TIME	CLOUD COVER (X/8)	TEMP (ºC)	RH (%)	WIND			FUEL MOISTURE		
				Direction	Speed	Gusts	Predicted	Actual	Estimate

BURN EVALUATION SUMMARY

BURN OBJECTIVES	SUCCESS CRITERIA	EVALUATION*	RATIONALE
Biodiversity Conservation Objectives:			
Protection / Safety Objectives:			
Vegetation Management Objectives:			
Knowledge / Research Objectives:			

* MET - COMPLETELY, SOMEWHAT, NOT AT ALL

LESSONS LEARNT
