Contextual information and management of potential impacts on conservation significant fauna during the development and operations of the British Hill mine

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Front Cover: Malleefowl (*Leipoa ocellata*) and Chuditch (*Dasyurus geoffroii*)

EXECUTIVE SUMMARY

IMD Gold Mines Ltd, using Blue Cap Mining Ltd as the project managers, is proposing to reopen the British Hill mine (i.e. project area). An earlier vertebrate fauna assessment for IMD Gold Mines Ltd for the same site indicated that Malleefowl and Chuditch were present and would be impacted by development in the project area. The consequence is that a referral under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) would be required if potential impacts on either of these two species is significant.

Additional background information will be required if a referral is to be submitted, and this includes more information on the presence and abundance of Malleefowl in the project area. Active and recently active Malleefowl mounds are typically used as a proxy for assessing the relative abundance of Malleefowl, so these have been recorded in the project area.

This report provides ecological (e.g. breeding cycle, habitat preferences, etc) information on Chuditch and Malleefowl, and information on their abundance in the adjacent area. It also provides information on four historical referrals for adjacent mining areas so that potential impacts on Malleefowl and Chuditch might be better understood in the context of the EPBC Act.

Chuditch could be impacted, as they are potentially present in the project area. It is unclear whether Malleefowl are still present in the project area, but there has been no breeding activity in the last 5-10 years. Western Brush Wallabies are still likely to be in the project area and will almost certainly move once vegetation clearing commences, so any impacts will be low.

The presence of Chuditch and Malleefowl in areas adjacent to the British Hill mine site means that any impacts on these species is likely to be low when considered in a bioregional context, as the number of individuals for each species potentially impacted by the mining development and operations will be small in the context of the regional population in adjacent areas. For Malleefowl, there is no evidence of recent breeding activity within the project area, and there is only one old, and unusable mound in the development envelop.

Implementing three minimising and mitigating actions (i.e. minimising the vegetation that is cleared, implementing an ongoing wild dog / dingo and feral cat reduction program and rehabilitating project areas at the completion of the project) will result in a net-positive gain or increase in the abundance of Malleefowl and Chuditch and a neutral impact on Western Brush Wallabies in and immediately adjacent to the project area. Therefore, the implementation of the management actions should result in no significant impact on conservation significant species listed under the EPBC Act and a net-positive benefit to these species.

TABLE OF CONTENTS

Tables

Plates

Figures

1 INTRODUCTION

1.1 Background

Terrestrial Ecosystems (2016) undertook a Level 1 vertebrate fauna assessment of the British Hill site for IMD Gold Mines Ltd. This assessment included a site survey using camera traps and an investigation of known Malleefowl mounds. The project area for this assessment included parts of tenements M77/1256 and L77/223 ('project area'). The project area is located approximately 72km south, south east of Southern Cross and had an area of 424.7ha.

Twenty-five camera traps were deployed on 22 November 2016 and retrieved on 6 December 2016. Non-reward pods containing a lure of peanut butter, oats, sardines and mulie oil were used to attract fauna. The purpose of the camera traps was to detect the possible presence of Chuditch, Malleefowl and other conservation significant species in the project area.

Based on the results of the camera trapping and field work in 2016, a referral under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) would be required if the proposed vegetation clearing and mine operations will impact significantly on either of these species.

The presence of Chuditch and Malleefowl require some additional information before a referral under the EPBC Act can be prepared. An understanding of the relative abundance of Malleefowl in the project area is required, and this is typically best estimated by the presence of recently active breeding mounds. The relative abundance of Chuditch can be estimated from the camera trapping data. To determine whether the proposed vegetation clearing, mine development and operation is potentially a significant impact on these two species, the abundance of these two conservation significant species in adjacent areas is required along with an understanding of the species ecology. Western Brush Wallabies, a Priority 4 species with the Department of Biodiversity, Conservation and Attractions (DBCA), were also recorded in the project area. and are therefore included in this assessment although they are not listed under the EPBC Act.

The mine is owned by IMD Gold Mines Ltd and Blue Cap Mining Ltd is the project manager.

The objectives of this assessment and report are to:
- provide ecological (e.g. breeding cycle, habitat preferences and movement distances and patterns) information on Chuditch and Malleefowl;
- provide an indication of the abundance and distribution of Chuditch and Malleefowl in and around the area for the proposed British Hill mine site;
- provide information on the number and status of Malleefowl mounds in the proposed British Hill mine project area; and
- to assess potential impacts on conservation significant species and how these impacts might be minimised and mitigated, and the resulting residual impact if these actions were implemented.

1.2 Scope of works

This project had the following five tasks for the project area (Figure 1):

Task 1

Woinarski *et al*. (2014) indicated there are records of Chuditch between 1993 and 2012 in all directions from the British Hill site, so British Hill is within its extant geographic distribution for this marsupial. However, Woinarski *et al*.'s (2014) mapping is not at a suitable scale to determine proximity of these records to the project area.

Malleefowl are known to be present in low densities in areas adjacent to the British Hill mine in suitable habitat (Parsons *et al*. 2008, Garnett *et al*. 2011), so it would be anticipated there will be other records in the vicinity of British Hill, presuming that these areas have been surveyed.

We have therefore acquired all Chuditch and Malleefowl records from the DBCA threatened species database within a 150km radius of the British Hill project area. As the project area is on the boundary of wheatbelt and goldfields habitat types, a 150km radius is appropriate to assess both regions. These data provide an indication of other known populations and the geographic distribution of Chuditch and Malleefowl within the vicinity of the project.

Task 2

Terrestrial Ecosystems undertook a search of the Chuditch and Malleefowl literature focusing on their breeding cycle, habitat preferences, etc. A summary of this information is provided as background information upon which a referral can be prepared, and environmental offsets can be negotiated if that is appropriate.

Task 3

Terrestrial Ecosystems' has reviewed the relevant information for Western Area's project at Forrestania and Kidman Resource's / Covalent Lithium Pty Ltd project at Earl Grey (~30km south-east). These referrals were considered relevant because when a single Chuditch was recorded in Western Area's Flying Fox project area, it was not deemed a Controlled Action (EPBC 2006/2904), however, development at the Spotted Quoll nickel sulphide open cut mine was deemed a Controlled Action based on the presence of Chuditch and other conservation significant species (EPBC 2008/4443). Kidman Resources also received a Controlled Action based on the presence of Chuditch and Malleefowl in the proposed disturbance area at its Mt Holland project area. We have also reviewed the subsequent research that was undertaken in the project area by the DBCA using environmental offset funds.

Task 4

Aerial photography has been acquired for the project area and LiDAR algorithms were used to search for Malleefowl mounds, and visual searching high-definition aerial photography using a similar methodology to that described in Thompson *et al*. (2015) has also been undertaken to locate potential Malleefowl mounds.

Task 5

Assessing potential impacts on conservation significant species, providing minimising and mitigating actions for these potential impacts, and determining residual impacts, if any, when these actions are implemented.

1.3 Background information from previous investigations

1.3.1 Fauna habitat types

Terrestrial Ecosystems (2016) reported the project area supported the following six board fauna habitats:

- tall shrubs on a sandy substrate (Plates 1 and 2);
- scattered trees over tall shrubs with a pebbly or stony clay substrate (Plates 3 and 4);
- hill or rocky outcrop on a pebbly or stony clay substrate (Plate 5 and 6);
- eucalypt woodland with a scattered understorey of shrubs (Plates 7 and 8);
- eucalypt woodland with an understorey of shrubs and smaller trees on a red sandy substrate (Plates 9 and 10); and
- highly disturbed or rehabilitated areas (Plates 11 and 12).

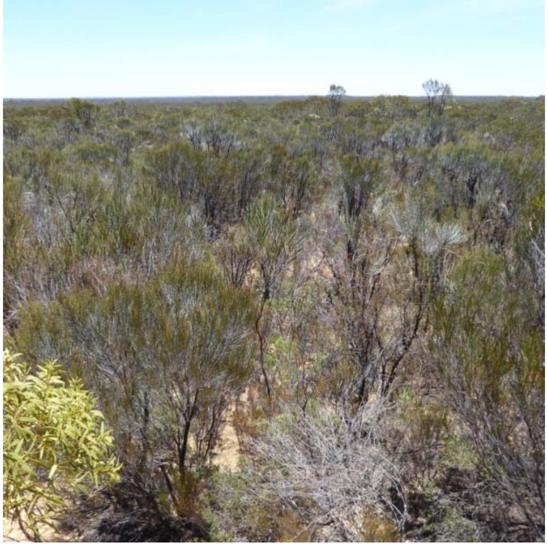
Plate 1. Tall shrubs on a sandy substrate


Plate 2. Tall shrubs on a sandy substrate


Plate 3. Scattered trees over tall shrubs on a pebbly or stony clay substrate


Plate 4. Scattered trees over tall shrubs on a pebbly or stony clay substrate

Plate 5. Hill or rocky outcrop with a pebbly or stony clay substrate

Plate 6. Hill or rocky outcrop with a pebbly or stony clay substrate

Plate 7. Eucalypt woodland with a scattered understorey of shrubs

Plate 8. Eucalypt woodland with an understorey of shrubs and smaller trees on a red sandy substrate

Plate 9. Eucalypt woodland with an understorey of shrubs and smaller trees on a red sandy substrate

Plate 10. Eucalypt woodland with an understorey of shrubs and smaller trees on a red sandy substrate

Plate 11. Highly disturbed or rehabilitated areas **Plate 12. Highly disturbed or rehabilitated areas**

1.3.2 Camera trap results

Table 1 shows the species recorded on the 25 camera traps in 2016. Chuditch (*Dasyurus geoffroii*) were recorded on 13 of the 25 camera traps (Plates 13 and 14), and all of these images were recorded in the southern section of the project area. It is likely that this mammal is concentrated around the hill in the south-east corner and forages widely around that area. Malleefowl (*Leipoa ocellata*) were recorded on five of the 25 camera traps (Plates 15 and 16), and four of these were on the sand plain and one near the rocky hill. Western Brush Wallabies (*Notamacropus irma*) were recorded on six of the 25 camera traps (Plates 17 and 18) and were spread across the project area but were predominantly on the sand plain.

There were two feral cats (*Felis catus*) in the project area – a black cat and a tabby cat (Plate 19). A single dingo / wild dog (*Canis lupus*; Plate 20) was recorded at one location on the sand plain. Gould's sand goannas (*Varanus gouldii*), emus (*Dromaius novaehollandiae*), Brush Bronzewings (*Phaps elegans*) and red kangaroos (*Osphranter rufus*) were common in the project area.

Plate 13. Chuditch **Plate 14. Chuditch**

Plate 15. Malleefowl

Plate 16. Malleefowl

Plate 17. Western Brush Wallaby

Plate 18. Western Brush Wallaby

Plate 19. Feral cat

Plate 20. Dingo/wild dog

Table 1. Results of the camera trapping survey

Camera #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Emu	x	x	x				x	x	x		x					x	x		x		x	x	x	x	
Brush Bronzewing		x		x				x	x	x			x	x							x				
Chuditch						x			x	x	x	x	x	x	x	x		x		x		x	x		
Western Brush Wallaby	x	x					x								x						x	x			
Red Kangaroo	x	x	x					x													x				x
Currawong				x										x											
Gould's Goanna				x	x			x		x						x		x							
Malleefowl	x					x										x				x		x			
Cat	x		x		x			x														x			
Dingo						x																			
Grey Shrike Thrush																		x					x		
Southern Scrub Robin									x																

x recorded as an image

1.4 Results

1.5 Task 1

Data on the location of Malleefowl and Chuditch has been acquired from the DBCA and has been plotted to Figures 2 and 3.

A radius of 150km around the project area encompassed a large area west of the project area that has been cleared for many years for agriculture. Within the agricultural area there are many remnant plots of native vegetation. Some of these are small and within farms, others are in much larger conservation reserves. To the east of the project area, the land is largely uncleared and forms part of the Great Western Woodland (Department of Environment and Conservation 2010).

Malleefowl pre-2016 records

There is an abundance of historical Malleefowl records to the west of the British Hill mine (Figure 2). Many of the early records are in areas that are now under agriculture, but others are in bushland reserves and remnant vegetation that are scattered throughout the farmland. There is no obvious clustering of these records, suggesting that Malleefowl were widely dispersed in the area to the west before the native vegetation was cleared and they have retreated to remnant patches of vegetation as land clearing has progressed. There are many fewer historical records to the east of British Hill, and this almost certainly reflects the lack of survey effort in this area, as these areas provide suitable habitat for Malleefowl.

Malleefowl Post 2016 records

There is an abundance of Malleefowl records post 2016 south of the project area and a small number of records to the west of the British Hill mine site (Figure 2). This almost certainly reflects the survey work undertaken by Western Areas and Kidman Resource's / Covalent Lithium Pty Ltd.

There are two interpretations of these data:

- the Malleefowl are predominantly in a north-south corridor that runs from British Hill mine south past the Western Areas' Forrestania mining operations, or
- Malleefowl are relatively abundant in the bushland south and east of British Hill mine, and these areas have yet to be surveyed.

The later explanation is probably the most reasonable interpretation, given the abundance of suitable Malleefowl habitat in areas either side of the higher density of Malleefowl records (Figure 2).

Malleefowl current situation

These data would suggest that Malleefowl are widespread in the uncleared areas of native vegetation to the south and east of the British Hill mine site. The primary reason for a reduction in the Malleefowl population compared to what originally existed would be predation by wild dogs, foxes and feral cats (Frith 1962a, Priddel and Wheeler 1994, Benshemesh and Burton 1999), given that the other major reported threats (e.g. vegetation clearing, habitat fragmentation, grazing) are not generally applicable in this area (Benshemesh 2007).

Chuditch pre-2015 records

There are scattered records of Chuditch to the north, west and south of the British Hill mine site, but few to the east (Figure 3). Chuditch have been recorded as far east as Norseman (DBCA threatened species database).

Chuditch post-2015 records

There is an abundance of records for Chuditch to the south of the British Hill mine site, and this almost certainly reflects the survey work undertaken by Western Areas and Kidman Resource's / Covalent Lithium Pty Ltd (Figure 3).

Chuditch are essentially nocturnal, wary, secretive and are typically not observed when walking through an area of bushland. The advent and wide use of camera traps and targeted trapping programs has resulted in multiple records for this species around the mine sites south of the British Hill mine site.

Chuditch current situation

As with Malleefowl, Chuditch would have been widely disperse in the bushland around the British Hill mine site. Vegetation clearing for agriculture (Department of Environment and Conservation 2012) would have resulted in the death and displacement of Chuditch from large sections of the cleared wheatbelt to the west of the British Hill mine site. In the relatively undisturbed bushland to the north, east and south of British Hill mine site, the primary threats to Chuditch would be wild dogs, foxes and feral cats (Morris *et al*. 2000, Department of Environment and Conservation 2012).

Implication for potential impacts of the British Hill mine on Malleefowl and Chuditch

Chuditch and Malleefowl have largely disappeared from the cleared agriculture areas. Malleefowl are now mostly recorded in the remnant patches of bushland in the agricultural area.

Chuditch and Malleefowl are likely to be widely dispersed in the bushland to the south, east and north of the British Hill mine site, and the most significant threat to their abundance would be predation by wild dogs, foxes and feral cats. A sustained reduction in wild dog, fox and feral cat populations, even at a local scale, should result in a local increase in the population.

1.6 Task 2

A literature search on the ecology of Malleefowl and Chuditch has been undertaken and is summarised below.

Malleefowl (*Leipoa ocellata*) – Vulnerable under the EPBC Act and the WA *Biodiversity Conservation Act 2016*

Malleefowl is a relatively large, mostly terrestrial bird that tends to be sedentary, nesting in the same general area year-after-year with little sexual dimorphism and belonging to the family Megapodiidae or the mound builders (Frith 1962a, Priddel and Wheeler 2003).

Its range has contracted, particularly in the agricultural regions (Benshemesh 2007, Parsons *et al*. 2008). Density of these birds is generally highest in areas of higher rainfall and on more fertile soils (Frith 1962a, Copley and Williams 1995, Benshemesh 2007) and where shrub diversity is greatest (Woinarski 1989) .

Malleefowl spend most of their time on the ground, and will generally only fly when disturbed, to escape predators or to roost (Frith 1962b).

Habitat and mounds

Malleefowl are now primarily found in semi-arid and arid shrublands and low woodlands dominated by mallee (*Eucalyptus* sp.) on a sandy substrate in the more temperate areas (Frith 1962b, Benshemesh 2007). Grazed areas generally have lower densities of Malleefowl (Benshemesh 2007).

Parsons *et al*. (2008) reported that for WA, the distribution of Malleefowl in the Wheatbelt is influenced be lower rainfall, dense mallee and associated shrubland, and the presence of large remnant patches of native vegetation on lighter sandy soils with a gravel content, an abundance of ground litter and abundance of food shrubs.

A sandy or gravelly substrate and abundance of leaf litter are requirements for the construction of the birds' incubator mounds (Frith 1959, 1962a) . Malleefowl mounds are typically 60-90cm high and 3.7m wide, however, there is considerable variability in the size, which is often influenced by how often the mound has been used (Jones and Goth 2008). Malleefowl frequently reuse existing mounds (Priddel and Wheeler 2003) by raking more material from the surrounding area each year on to the existing mound, with the consequence that some of the older mounds are higher than 100cm and wider than 5m.

Habitat critical for Malleefowl is found in the semi-arid to arid zone in shrublands and low woodlands dominated by mallee and associated habitats such as Broombush (*Melaleuca uncinata*) and Scrub Pine (*Callitris verrucosa*) (Frith 1962a, Benshemesh 2007). In Western Australia, they are also found in some shrublands dominated by acacia, and occasionally in woodlands dominated by eucalypts such as Wandoo (*E. wandoo*), Marri (*Corymbia calophylla*) and Mallet (*E. astringens*). Malleefowl are mostly found in scrubs and thickets of mallee (*Eucalyptus* spp.), *Melaleuca lanceolata* and *Acacia linoiphylla* in Western Australia (Johnstone and Storr 1998).

Feeding

Benshemesh (2007) and others (Harlen and Priddel 1992, Kentish and Westbrooke 1993, Reichelt and May 1997) reported Malleefowl as generalist feeders, with a diet that includes seeds, flowers, fruit, herbs and invertebrates, and it varies based on seasons and what is locally available. In the Little Desert area of Victoria, for example, Malleefowl diet consisted of multiple species of flowering plants, fungi and invertebrates (Reichelt and Jones 2008) and they fed on flowers, buds, seeds and the foliage. The diet of chicks is similar to adults (Frith 1959).

These birds typically forage on the ground for potential food items.

Breeding

Breeding occurs annually if conditions are suitable (Frith 1959). Egg laying begins in September and lasts until late summer, with a single egg laid every 5-7 days. Incubation is about 60 days and 15-25 eggs are laid with approximately 80% hatching (Frith 1959, Benshemesh 2007) . Chicks hatch and dig their way out of the mound and are left to fend for themselves. Within a couple of days of hatching they can fly small distances. Mortality of chicks is high, with up 80% occurring in the first 10 days after hatching (Priddel 1989, Priddel and Wheeler 1990, Benshemesh 2007). Chicks generally hatch from November through to March.

Clutch size and thus the duration of the breeding period varies from year-to-year and breeding may not occur at all in years when rainfall is low. In mid-west WA, breeding activity is influenced by winter rainfall (Frith 1959) and in the occasional years when winter rainfall is very low, breeding activity can be non-existent or very low. Insufficient rain prevents organic matter in the centre of the mound from decomposing at a rate sufficient to generate enough heat to incubate the eggs (Frith 1956). Therefore, mound usage is variable from year-to-year. Further, density of the canopy cover is an important feature associated with high breeding densities (Frith 1962a, Benshemesh 2007) and it is this dense mallee vegetation that can make ground searches for Malleefowl mounds difficult.

The presence of active or recently active nest mounds provides an indication of the presence and relative abundance of Malleefowl in the area.

Threats

Major threats to Malleefowl are vegetation clearing for agriculture, population fragmentation, predation by foxes, wild dogs and feral cats, grazing by goats and probably sheep, rabbits and an overabundance of kangaroos and the introduction of weeds (Garnett *et al*. 2011, Birdlife International 2016) .

Fire is a very serious threat as they don't fly well or for long-distances, and even if they escape the fire, a burnt terrain appreciably increases their exposure to predation. A fragmented habitat can exacerbate this problem as birds have nowhere to move to after a fire when the habitat becomes less favourable. Fires also reduce the available litter for mound building.

Management actions

The National Recovery Plan for Malleefowl (Benshemesh 2007) indicated management actions necessary to conserve the species included: predator control, fire management, control of herbivores. including rabbits are effective management measures. Malleefowl do well in large-predator-proof enclosures.

Western Quoll or Chuditch (*Dasyurus geoffroii*) - Vulnerable under the EPBC Act and the WA *Biodiversity Conservation Act 2016*

The Chuditch is a medium-sized, arboreal-terrestrial dasyurid that is carnivorous/insectivorous and nocturnal (Serena and Soderquist 2008). Its range has declined since European settlement, and is now restricted to the south-west of Western Australia, mostly in the Jarrah forest, but they are also in the Fitzgerald River National Park and the Ravensthorpe Range (Orell and Morris 1994, Woinarski *et al*. 2014). It has recently been relocated to other historical sites in Australia

Geographic distribution

Formally known from over 70% of Australia, the Chuditch now has a patchy distribution throughout the Jarrah forest and mixed Karri/Marri/Jarrah forest of south-west WA (Department of Environment and Conservation 2012, Woinarski *et al*. 2014). The DBCA (2012) estimated there were less than 10,000 Chuditch in 2007, with 75% of these occurring in the eucalypt forest and woodlands, and mallee heath and shrublands of the south-west and south coast (Plate 21).

Plate 21. Distribution of Chuditch (taken from Department of Environment and Conservation 2012; p5)

Habitat

The Department of Environment and Conservation (2012) described habitat critical to their survival including forest, mallee shrublands, woodland and desert. The densest populations have been found in riparian jarrah forest. Chuditch require adequate numbers of suitable den and refuge sites (horizontal hollow logs or earth burrows) and enough prey biomass (large invertebrates, reptiles and small mammals) to survive.

It dens in hollow logs and burrows and has also been recorded in tree hollows and cavities (Serena and Soderquist 2008), therefore, key aspects of the Chuditch habitat requirements are denning opportunities, prey availability and activity area size (Department of Environment and Conservation 2012).

Activity area

In the Jarrah forest, male Chuditch have a home range of up to 15km^2 and for females 3-4km^2 (Serena and Soderquist 2008). The core activity area of females, as defined by denning sites, do not overlap but they do for males (Serena and Soderquist 1989b). Serena and Soderquist (1989b) reported core activity areas along the Murray River, WA being 55-120ha for females and about 438ha for males. For most of the time, individuals live a solitary life. In a semi-arid area near Forrestania, under-estimates of home range size (because of inadequate GPS fixes) was 189ha (range 174-202ha) for females and 2,125ha (range 662–3,522ha) for males. The estimated density of Chuditch at Forrestania was 0.039 individuals km^{-2}, which was lower than at Dwellingup at 0.11 individuals km^{-2}, Batalling at 0.34 individuals km^{-2} and Julimur at 0.68 individuals km^{-2} (Rayner *et al*. 2012).

They can travel long distances and have large home ranges, even when they are abundant (Department of Environment and Conservation 2012, Cannella and Henry 2017).

Diet

Chuditch has a generalist diet which includes mammals, birds, reptiles, invertebrates and plant material (Rayner *et al*. 2012, Woinarski *et al*. 2014). Foraging is undertaken on the ground and in an arboreal environment.

Their diet consists of mostly insects, but they will eat mammals, birds and lizards if they can be caught (Serena *et al*. 1991). They will also scavenge for food and eat carrion (Department of Environment and Conservation 2012).

Chuditch are known to enter work areas, probably in search of food that has not been adequately secured.

Breeding

Litters are born from May to September, with most appearing in June to July. For nine weeks the young are left in the den while the female goes in search of food and they are first seen outside the den at about 17 weeks (Soderquist and Serena 2000). Young are weaned by 22-24 weeks (Serena and Soderquist 2008) in late October and early November.

In the Jarrah Forest along the Murray River, denning sites were all ground burrows (Serena and Soderquist 1989a). Of the 22 dens located by Serena and Soderquist (1989a), six were in the base of a tree with entrances located under large surface roots, five followed root channels exposed under remnants of burnt rotting stumps, one was under a large boulder and others were either abandoned rabbit burrows or not associated with a particular surface feature.

Threats

Major threats are listed as habitat alteration due to vegetation clearing, frequent fires and predation by foxes and cats (Morris *et al*. 2008, Department of Environment and Conservation 2012).

Chuditch are rarely found in highly disturbed or fragmented habitats, so agriculture, mining, housing development can all impact on the presence and abundance of Chuditch (Department of Environment and Conservation 2012). Fires also alter the density and quality of habitat (e.g. loss of denning sites, protective cover) and can reduce prey availability (Department of Environment and Conservation 2012), so fire can have a reoccurring impact.

Western Brush Wallaby (*Notamacropus irma*) - Priority 4 species with DBCA

Western Brush Wallabies was recorded by Terrestrial Ecosystems (2016) in the project area. This is a small wallaby (7-9kg) that is endemic to the south-west corner of Western Australia. Christensen (Christensen 2000) described its optimum habitat as open forest or woodland, particularly favouring rather open, seasonally wet flats with low grasses and open, scrubby thickets. This is not the habitat in the project area, which is mostly thickest of shrubs.

There are no robust measures of abundance; however, the species is relatively common, particularly where fox control is in place (Woinarski and Burbidge 2016), as there abundance was significantly reduced until widespread fox control was implemented in state forests and conservation estate; it seems likely that foxes preyed on juveniles.

Woinarski and Burbidge (2016) reported no major threats to this species, which contradicted their early statement that they were being predated on by foxes. Woinarski *et al*. (2014) reported foxes, habitat loss and fragmentation, in appropriate fires and vehicle impact were the threats to this species.

1.7 Task 3 - Relevant Chuditch and Malleefowl referrals under the EPBC Act

The following four referrals under the EPBC Act are relevant to the British Hill project area:

- Flying Fox T5 and water pipeline, referred by Western Areas NL, EPBC ref: 2006/2904;
- Spotted Quoll open cut mine, referred by Western Areas – EPBC ref: 2008/4443;
- Cosmic Boy Haul Road, referred by Western Areas NL – EPBC 2011/6003; and
- Earl Grey lithium mine, referred by Kidman Resources – EPBC ref: 2017/7950.

Each of these referrals is discussed below.

1.7.1 Flying Fox T5 and water pipeline

This application was for the further development of the underground nickel resource at the Flying Fox mine, T5 deposit and the construction of a 40km buried pipeline for Western Areas project near Forrestania.

Flying Fox mine is approximately 450km east of Perth, 80km east of Hyden and 160km south of Southern Cross. The T5 was an extension of an existing development and no additional infrastructure was required. The water pipeline required the clearing of 29.3ha of native vegetation.

The referral documentation indicated potential impacts on vertebrate fauna included an active Malleefowl mound within 200m of the pipeline route and one within 130m of a drill pad for a bore. Chuditch were reported in the vicinity of the areas to be cleared and one individual was recorded near the Flying Fox operations. Biota Environmental Sciences (2007) concluded that one individual did not constitute a matter of national environmental significance, based on advice from Dr Peter Mawson, the then Senior Zoologist with the Department of Conservation and Land Management.

Western Areas offered the following management strategies to minimise and mitigate impacts on Chuditch and Malleefowl:

- increased site awareness;
- protecting potential habitat sites;
- a feral animal control program;
- workforce and site restrictions; and
- monitoring programs.

The Commonwealth Minister for the Environment's decision was the proposed action was not a Controlled Action.

1.7.2 Spotted Quoll open cut mine

The Spotted Quoll mine is approximately 450km east of Perth, 80km east of Hyden, 160km south of Southern Cross and 6km south of the existing Flying Fox mine. An additional 120ha was applied for to facilitate mine development and infrastructure, however, existing tracks, roads and disturbance of land meant the clearing permit envelop was 257ha.

The referral application indicated that no Malleefowl or Malleefowl mounds were found in or near the proposed clearing envelop. One Chuditch was recorded in Phase II of an inventory survey conducted at Flying Fox in October 2005, one was recorded in Phase II in May 2006 and again in Phase IV in November 2006, and all animals were caught at the same trapping location (i.e. FR13).

The Commonwealth Minister for the Environment decided the action was a Controlled Action, with approval to proceed subject to the following conditions:

- preparation and implementation of a Species Conservation Management Plan (the Malleefowl Conservation Plan) and undertaking surveys in accordance with the approved Malleefowl Conservation Plan; and
- preparation and implementation of a Species Conservation Management Plan (the Chuditch Conservation Plan) and undertaking surveys in accordance with the approved Chuditch Conservation Plan.

1.7.3 Cosmic Boy Haul Road

Western Areas proposed to develop a haul road between the Spotted Quoll Open Pit operations and the Cosmic Boy processing plant. The haul road would be 15.8km long and 13-20m wide, 5.7km of which followed an existing track that was 3m wide. The total disturbance area was 41.12ha, including borrow pits, with 38.61ha to be cleared.

A report by Keith Lindbeck and Associates (2011) indicated that there were no active Malleefowl mounds within the areas surveyed for the road, however, there were old mounds within 500m of the proposed haul road.

The Keith Lindbeck and Associates (2011) report indicated that no Chuditch were recorded in the area to be impacted but refugia suitable for Chuditch was present, and vegetation outside the proposed haul route supported habitat favourable to Chuditch, so the proposed disturbance was unlikely to alter the conservation status of Chuditch.

The Commonwealth Minister for the Environment decided the action was a Controlled Action and approved of the proposed action subject a research program and a management plan for Carnaby's Black-Cockatoo, but nothing relevant to Malleefowl or Chuditch.

1.7.4 Research resulting from environmental off-sets at the Western Areas mines at Forrestania

Rayner *et al.* (2012)) trapped (4,138 trap-nights) Chuditch between February and July 2009 to calculate population density, home range size and diets. Density was estimated to be 0.039 Chuditch km^{-2}. Mean maximum distance females moved between refuges was 1.5km and for males 7.9km. Home ranges, using the asymptotes for GPS fixes were achieved for one male and one female, but calculated home ranges using the available data to calculate the minimum convex polygon was 189ha for females and 2125ha for males.

Home ranges for males had large overlaps, but females maintained an exclusive core home range. Heath and woodland areas were used equally, and logs were the most frequently used refuge. Diets consisted mostly of invertebrates, but vertebrate remains were also found in most Chuditch. Vertebrates in stomach contents included house mice, echidna, kangaroos and pygmy possum, and for reptiles the thorny devil, bearded dragon and *Tiliqua* sp..

1.7.5 Earl Grey Lithium Mine

The Earl Grey Lithium Mine is located 105km south-southeast of Southern Cross and proposed an open cut mine and on-site processing plant for lithium. The project area is 610ha of which 245ha was already disturbed area.

Eighteen Chuditch were trapped in the project area (10 adults and 8 dispersing young), of which 16 were in the development envelop. One hundred and one camera traps were deployed, 44 of which recorded Chuditch in a variety of habitat types.

It was proposed that pre-clearing capture-and-release program would minimise, although not entirely avoid impacts on Chuditch. The assessment considered the proposed action posed a relatively low risk to Chuditch and offered environmental gains associated with rehabilitation of historic disturbance, contribution to knowledge through monitoring programs and opportunities to conserve fauna through feral animal monitoring and control.

Five Malleefowl were sighted during the field survey, four active and 17 inactive mounds were recorded in the study area. One bird was sighted in the development envelop, along with, one active and eight inactive mounds. With a feral animal management program (i.e. fox and cat control) and with ongoing monitoring the proponent argued to proposed development posed a relatively low risk to Malleefowl.

The Commonwealth Minister for the Environment decided the action was a Controlled Action. No conditions have been announced.

Covalent Lithium, the new mine owner, has applied to change the person undertaking the action from Kidman Resources Ltd to Covalent Lithium Pty Ltd and this has been was approved (6/9/2018). An application to vary the proposal was submitted by Covalent Lithium and a minor works application was submitted to the EPA in February 2019.

1.8 Task 4 - Malleefowl in the project area

Arvista was engaged by Blue Cap Mining Ltd (Blue Cap) to provide an aerial photogrammetry and LiDAR survey of the British Hill mine site and the access corridor located approximately 40km south of Marvel Loch, WA. The aerial photography was acquired using unmanned aerial vehicles (UAVs) and covered a total area of 440ha (Figure 1).

1.8.1 Methodology – aerial surveys

Ground surveys were undertaken on 7 January 2020 and the aerial data acquisition between 7–9 January 2020 by Arvista. Thirty-seven ground control targets were marked and surveyed on the site to enable geo-referencing of the aerial survey data. The ground control was surveyed in GDA94 MGA zone 50 / AHD, relative to a point that was established based on a long-duration (7.5hr) static Global navigation satellite system (GNSS) observation, since the SSM G77-8 was unable to be located. Processing of the static GNNS data on the Geoscience Australia AusPos service provided base station co-ordinates to an accuracy of <20mm, and height was checked to a nearby benchmark (HS87) with a difference of 3mm.

1.8.2 Aerial surveying equipment and data acquisition parameters

Photogrammetry

Unmanned aerial vehicle (UAV)	DJI Inspire 2
Camera	Calibrated X4S
Global navigation satellite system (GNSS)	Airgon Loki PPK survey-grade GNSS fitted to UAV, with Topcon Hiper 2 base station
Flight Height	120 m above ground level

LiDAR

UAV	DJI Matrice 600
Sensor	NextCore RN50
GNSS	Integrated
Flight Height	45m above ground level

1.8.3 LiDAR searches for Malleefowl mounds

The Malleefowl mounds were detected based on relative height and other geometric features. A ground surface-filtering algorithm was used to classify point cloud from LiDAR into ground and non-ground points. Subsequently, a digital elevation model (DEM) was produced from grounds points. Within the DEM, areas which are higher than surrounding areas are detected by a blob detection image morphology operation and results are regarded as candidates for Malleefowl mounds. Features including size, shape and height relative to neighbours are calculated for each candidate and with non-likely candidates (i.e. those with features inconsistent with typical mounds are filtered out). The remaining results are classified as 'potential mounds' for visual interrogation.

1.8.4 Searching aerial photogrammetry for Malleefowl mounds

Following the completion of the photogrammetry processing, Arvista were able to generate pairs of images over the full survey area suitable for viewing in stereo vision software by Blue Cap's fauna consultants (Terrestrial Ecosystems). Viewing the imagery in stereo provided the user with a 3D view, enabling the Malleefowl mounds to be identified more easily.

Arvista provided the software and hardware to enable the stereo viewing, and support to Terrestrial Ecosystems to develop a method of inspecting the entire survey area in a methodical manner.

1.8.5 Results – aerial surveys

Twelve potential Malleefowl 'mounds' were located using LiDAR and ten were found in the search of photogrammetry (Table 2; Figure 4).

Table 2. Potential mounds located in LiDAR and photogrammetry searches (UTM Zone 50)

Mound #	Easting	Northing
1	746076	6474328
2	747319	6473373
3	747322	6472960
4	746936	6472479
5	746473	6472872
6	746333	6473765
7	747333	6474451
8	747031	6474692
9	745595	6473587
10	746508	6474033
11	745868	6473270

Mound #	Easting	Northing
12	747293	6474350
13	747689	6474694
14	747551	6474659
15	747342	6474645
16	746690	6473562
17	746594	6474604
18	746483	6474626
19	746260	6474408
20	747223	6473506
21	748421	6475441
22	749019	6476028

1.8.6 Methodology – field work

Between 24-25 February 2020, Drs Scott Thompson and Cara Sambell undertook an inspection of all potential Malleefowl mounds located during the LiDAR and the search of photogrammetry for the project area (see Table 2).

This investigation included visiting each potential Malleefowl mound and categorising it according to the national Malleefowl monitoring program's classification system (Hopkins nd) as described below and shown in Plates 22-27.

Profile 1 (crater rim apparent) – this is the typical mound shape but is inactive and without any accumulated vegetation in the crater.

Profile 2 (mound dug out) – this is a recently fully dug out mound with steep sides to the crater, with the base forming a box like structure with the sides normally 20-30cm deep. Sometimes litter has been raked into windrows in readiness to be placed in the mound

Profile 3 (mound filled if litter) – this mound contains litter in the crater and is the next construction stage after profile 2. It should be apparent where litter has been raked into the mound.

Profile 4 (active mound with no crater) – this active mound is closed, and dome shaped.

Profile 5 (mound with crater and often a peak at the centre) – this is an active mound that is being opened or closed.

Profile 6 (disused or extinct mound) – this mound has not been used for some time and weathering and erosion have 'flattened' the original mound.

Plate 22. Profile 1 (crater rim apparent)

Plate 23. Profile 2 (mound dug out)

TERRESTRIAL ECOSYSTEMS


Plate 24. Profile 3 (mound filled if litter)


Plate 25. Profile 4 (active mound with no crater)

Plate 26. Profile 5 (mound with crater and often a peak at the centre)

Plate 27. Profile 6 (disused or extinct mound)

Data collected for each potential Malleefowl mound listed in Table 2 included:

- diameter of the mound;
- height of the mound above ground level surface;
- diameter of the crater; and
- depth of the crater.

The composition of each potential mound was recorded using the following:

- Substrate type (organic matter, stone, gravel, sand etc);
- Outer surface of the mound;
    - crust;
    - moss;
    - herb;
    - debris;
    - shrub; and
    - tree;
- Inner surface of the mound:
    - crust;
    - moss;
    - herb;
    - debris;
    - shrub; and
    - tree.

Signs of activity and use based on the presence of scats, footprints, feathers, eggshell, goanna diggings, litter raked. If footprints or scats were present, the species was recorded.

Mound surrounds – for a 50m radius around the mound, a succinct description was provided of the vegetation.

Photographic images were recorded for each potential mound.

1.8.7 Results – field work

Plates 28-49 show images of the 22 potential Malleefowl mounds identified in the searches using LiDAR and aerial photogrammetry.

There were no active or recently active Malleefowl mounds, nor were any footprints of Malleefowl or Malleefowl seen during the site visit. Mounds 2–7, 11 and 13 were recognisable as inactive Malleefowl mounds. The remaining 'mounds' were either anthropogenic disturbances, an abundance of rocky material near the surface or bare ground devoid of trees. Mounds 2 and 3 have not been used for 5-10 years but may be reusable, mounds 6, 7 and 13, although they had the form of a Malleefowl mound had vegetation growing in the mound, so were unusable.

The only mound in the development envelop is mound #6, and this is a very old mound never to be used again because of the vegetation growing in the mounds (see Plate 33). Mound 13 is just outside the project area access track, and this is an old mound, which is unlikely to be re-used. All other mounds are between the development envelop and the project area boundary.

Descriptive information about each of the mounds inspected is provided in Appendix A.


Plate 28. 'Mound' 1


Plate 29. Malleefowl mound 2


Plate 30. Malleefowl mound 3


Plate 31. 'Mound' 4


Plate 32. 'Mound' 5


Plate 33. Malleefowl mound 6

Plate 34. 'Mound' 7

Plate 35. 'Mound' 8

Plate 36. 'Mound' 9

Plate 37. 'Mound' 10

Plate 38. 'Mound' 11

Plate 39. Malleefowl mound 12


Plate 40. 'Mound' 13


Plate 41. 'Mound' 14


Plate 42. 'Mound' 15


Plate 43. 'Mound' 16

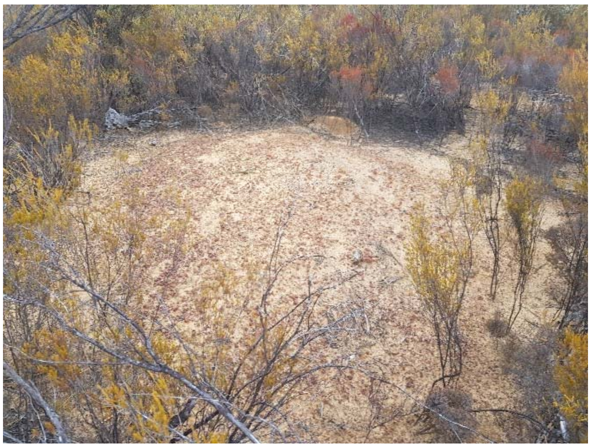
Plate 44. 'Mound' 17


Plate 45. Malleefowl mound 18

Plate 46. ‘Mound’ 19 **Plate 47.’Mound’ 20**

Plate 48. ‘Mound’ 21 **Plate 49. ‘Mound’ 22**

1.9 Discussion

1.9.1 Malleefowl

Malleefowl were recorded in the project area by the Terrestrial Ecosystems (2016) using a camera trapping survey. Western Botanical recorded two Malleefowl mounds during the flora and vegetation assessment of the British Hill mine site in 2016. Both of these mounds were inspected by Terrestrial Ecosystems (2016). One was very old, but the other was better formed, and could be used again. Tracks of Malleefowl were recorded on disused vehicle tracks in the sand plain section in the north-west corner.

No active or recently active Malleefowl mounds were found in the project area in the 2020 survey, so there may be a few transient Malleefowl in the project area, and if present, then they are not breeding in the area and have not bred in the area for many years. Feral cats and dingoes / wild dogs in the project area are likely to be predating on Malleefowl.

Malleefowl are present in adjacent areas. There are recent records (i.e. post 2016) of multiple active mounds and birds to the south of the project area, and although the bushland to the north and east has not been surveyed, much of the habitat in this area would support Malleefowl, so they are likely to be present in this area. Therefore, if Malleefowl are present in the project area, their numbers are probably low and they have not bred in the project area for 5-10 years, and they represent a very small fraction of the number of Malleefowl in the native vegetation in the surrounding area. This means that any impacts on this species is likely to be low when considered in a bioregional context, as the number of Malleefowl potentially impacted by the mining development and operation will be a very small fraction of the population in adjacent areas.

1.9.2 Chuditch

The last record of Chuditch in the project area was from the camera trap survey by Terrestrial Ecosystems (2016). It is likely that Chuditch are still present in the project area, retreating to the rocky area and foraging widely. Their abundance is likely to fluctuate annually, as males typically die after the breeding season and females mostly live to produce two litters.

The DBCA threatened species data indicates there is an abundance of Chuditch around the Mt Holland and Forrestania project areas and then there are a small number of scattered records mostly in the agricultural area. It is highly probable that they are also present in the native bushland to the east of the project area but have not been recorded in these areas due to a lack of survey effort.

Therefore, Chuditch are widespread in areas adjacent to the British Hill mine site, particularly to the bushland to the east and south. This means that any impacts on this species by the proposed British Hill mine are likely to be low when considered in a bioregional context, as the number of Chuditch potentially impacted by the mining development and operation will be a very small fraction of the population in adjacent areas.

2 IMPACT ASSESSMENT

This impact assessment will consider threats and potential impacts on Malleefowl, Chuditch and Western Brush-Wallaby, the management and mitigating actions that will be implemented, discuss how these actions reduce potential impacts, and then we provide an indication of the residual impacts.

Below, impacts and the associated minimisation and mitigation actions have been quantified for a localised population, and then discussed in the context of a mitigation hierarchy.

2.1 Mitigation hierarchy

Rio Tinto's (2014) illustration (Plate 50) adequately describes the mitigation hierarchy.

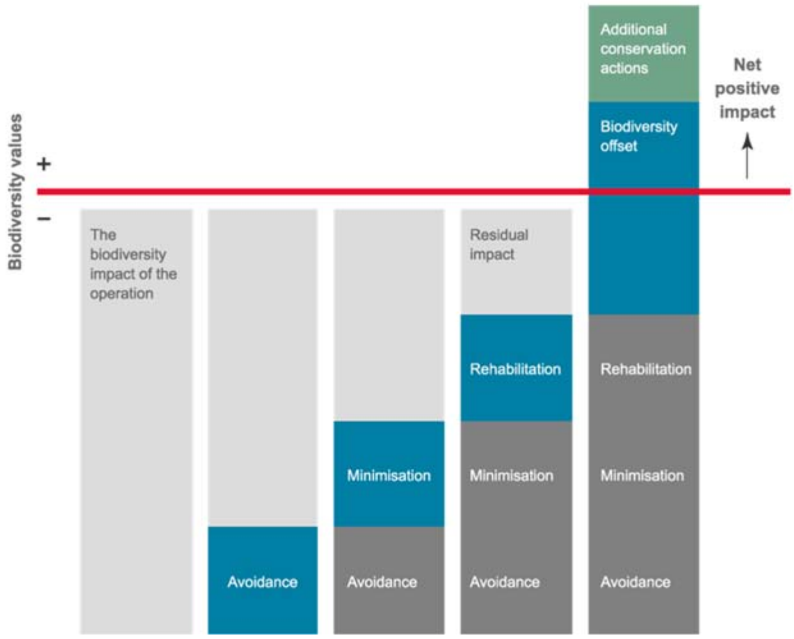

Plate 50. Mitigation hierarchy (Rio Tinto 2014)

Minimisation, mitigation and rehabilitation strategies can partially reduce the severity of an impact, or completely offset an impact or can provide a net positive impact. For example, a wild dog, fox and feral cat reduction program can result in a significant increase in the abundance of local fauna, and in particular, conservation significant fauna, increasing the local population beyond pre-development levels; this increase in a population as a direct result of this management action would be considered a net positive impact.

2.2 Quantification of impacts and minimisation and mitigation actions

To quantify the interaction between the impacts and the minimisation / mitigation / rehabilitation strategies proposed, a scoring system and criteria shown in Table 3 have been used.

Table 3. Quantification criteria for impacts and minimisation / mitigation / rehabilitation strategies for a localised population[1,2]

Extent of impact or effectiveness of the minimisation / mitigation / rehabilitation strategy[1]	Score
>80% loss of individuals over a period of five years	-5
60-80% loss of individuals over a period of five years	-4
40-60% loss of individuals over a period of five years	-3
20-40% loss of individuals over a period of five years	-2
10-20% loss of individuals over a period of five years	-1
-10 to + 10% change in the abundance of fauna over a period of five years	0
10-20% increase in the number of individuals over a period of five years	+1
20-40% increase in the number of individuals over a period of five years	+2
40-60% increase in the number of individuals over a period of five years	+3
60-80% increase in the number of individuals over a period of five years	+4
>80% increase in the number of individuals over a period of five years	+5

[1] Assumes that the current vertebrate fauna population is at a suboptimal level, mostly because of predation.

[2] For the purposes of this impact assessment a 'localised population' refers to a population of Malleefowl and Chuditch that would at some time include the project area as part of their home range.

2.3 Malleefowl

2.3.1 Threats to Malleefowl

Benshemesh (2007) and Birdlife International (2016) reported threats to Malleefowl as:

- vegetation clearing, loss of habitat from grazing by introduced herbivores and raised salinity levels leading to habitat loss and fragmentation;
- predation by foxes and feral cats, as they both predate on chicks and foxes are known to dig up mounds containing eggs;
- fires resulting in medium-term loss of foraging and breeding habitat;
- climate change resulting in reduced rainfall and a loss or reduction in the opportunity to successfully incubate eggs in decomposing vegetation in mounds; and
- vehicle impact, particularly on roadside verges where birds fed on spilt grain.

Malleefowl were once abundant in the WA Wheatbelt prior to vegetation clearing for agriculture. Vegetation clearing for agriculture also opened adjacent bushland to predators, and in the south-west of WA, Malleefowl often only persist in isolated remnant patches of native vegetation. Sheep and other herbivores (e.g. goats, kangaroos) grazing in remnant vegetation removes or thins the undergrowth, and they also compete with Malleefowl for herbaceous foods and can cause changes to the structure and floristic diversity of foraging habitats (Benshemesh 2007).

Malleefowl and their eggs are vulnerable to predation by wild dogs, foxes, and newly hatched chicks are also vulnerable to wild dogs, foxes, cats and raptors (Priddel and Wheeler 1990, 1997, Benshemesh and Burton 1999, Benshemesh 2007, Lewis and Hines 2014).

Fires kill Malleefowl and remove the vegetation from Malleefowl habitat displacing these birds into other areas which are often unsuitable (Woinarski 1999, Benshemesh 2007) . Fires mostly occur during the breeding season, and even if the birds are not killed by the fire, they will generally not return to an active mound in a burnt area that is exposed to predators and where there is little protection from adjacent vegetation, with the consequence that the eggs are not successfully incubated.

Malleefowl have little road sense and are prone to being hit on roads by vehicles as they are slow to move. In agricultural areas, Malleefowl can feed on grain dropped on the side of roads and are vulnerable to predation and vehicle strikes. Malleefowl could be injured or killed by vehicle strikes on the access road to the mine.

Malleefowl will move to adjacent areas when vegetation clearing commences, so there will be an initial impact as individual birds are displaced, and until each displaced bird establishes a new home range. This displacement may expose these individuals to higher levels of predation as they could be unfamiliar with the habitat.

2.3.2 Recovery plan

The approved recovery plan for Malleefowl (Benshemesh 2007) includes the following recovery strategies:

- habitat protection via reserves, conservation parks, etc and limiting vegetation clearing;
- fire management to restrict hot and intensive burns across large areas;
- fencing native vegetation to restrict grazing activity by herbivores;
- habitat rehabilitation, revegetation and increasing habitat connectivity;
- predator control;
- captive breeding programs, re-introductions and supplementation;
- promotion of Malleefowl-friendly agriculture practices; and
- research (e.g. distribution, population dynamics, habitat requirements, etc) and population monitoring.

The number of Malleefowl in the project area is unknown, but it is likely to be nil or low as there has been no recorded breeding activity for 5-10 years. Based on the location of Malleefowl mounds assessed (i.e. an old one that is unusable in the development envelop, one outside the project area and the remainder between the development envelop boundary and the project boundary), the proposed mining operations are likely to impact on any breeding activity, and it is likely there will only be infrequent and incidental observations of Malleefowl in the vicinity of mining observations.

2.3.3 Avoidance and mitigation

If Malleefowl are present in the project area, minimising vegetation clearing, particularly in areas of high-density vegetation will limit impacts. Malleefowl will potentially cross the access road and will be at risk of collisions with light vehicles and trucks.

A wild dog, fox and feral cat reduction program will be implemented on an ongoing basis. An appropriate number of meat baits containing 1080 will be dispersed around the project area. The frequency and distribution of baits and other detail of the program will be provided in the vertebrate fauna management plan. However, baits will be deployed along existing tracks within a radius of 10km around the mine site. It is anticipated that this will significantly reduce the number of dingoes / wild dogs and any foxes in the general area.

Three Felixers (Read *et al*. 2019; also see https://thylation.com) will be deployed around the project area on an ongoing basis to euthanase feral cats. These Felixers will be moved monthly to new locations, and it is anticipated that the abundance of feral cats within 12 months will drop to zero and remain at that level while the euthanasia program is in place.

Speed limits will be implemented on the access road and around the mine to reduce the potential for Malleefowl to be struck by a vehicle.

Rehabilitating areas once mining activity has ceased with the specific intention of creating suitable habitat for Malleefowl (e.g. areas of dense understorey with suitable fed plants, surface pebbles, plenty of leaf litter, etc) will assist this species in the long-term.

2.3.3.1 Monitoring Malleefowl abundance

All management programs will be informed and evaluated with appropriate data. The abundance of Malleefowl will be monitored within 1km of the project area using camera traps. The baseline monitoring will be undertaken before vegetation clearing and earthworks are undertaken for mine site development. Subsequent monitoring will be undertaken every two years, using the same protocols. A before-after-control-impact (BACI) design will be used in the monitoring and evaluation program.

Summary of threats, mitigation and level of impacts

The following quantified summary of threats, mitigation and level of impact only considers impacts and mitigation relating to mining activities and excludes impacts that were present before the mining project commenced.

Significant threats and impacts associated with the mining program	Impact score	Mitigation	Impact score	Residual impact
• Fire • Vegetation clearing • Vehicle collisions on the access road	-1 -1 -1	• Fire management plan • Fox and feral cat reduction program • Rehabilitation of fauna habitats	+1 +3 +1	+2

2.4 Western Quoll or Chuditch

2.4.1 Threats to Chuditch

Smith *et al*. (2004), Glen *et al*. (2009), Morris *et al*. (2008) and the then Department of Environment and Conservation (2012) reported predation and competition for food by and with feral cats and foxes, and Smith *et al*. (2004), Morris *et al*. (2008) and the then Department of Environment and Conservation (2012) also listed vegetation clearing and habitat fragmentation, particularly riparian vegetation and the removal of suitable den logs and den sites, mortality from poisoning, shooting and vehicle collisions as the factors that have contributed to a reduction in the Chuditch population. Morris *et al*. (2008) and the then Department of Environment and Conservation (2012) also indicated that more frequent and extensive fires resulted in a medium-term loss of Chuditch habitat.

Most Chuditch are likely to attempt to move when vegetation clearing commences. This displacement will be an initial impact until each displaced individual establishes a new home range. This short-term displacement may expose these individuals to greater predation pressure as they could be unfamiliar with their new home range. Chuditch retreating to hollow logs, tree hollows and holes in the ground may be lost during the vegetation clearing process because they are unable to escape. The increased habitat fragmentation may impact on their movement and dispersal through the landscape and foraging areas.

Chuditch could be injured or killed attempting to cross the access track into site. Therefore, speed limits will be implemented on the access road and around the mine to limit the potential for Chuditch to collide with a vehicle.

2.4.2 Recovery plan

The recovery plan (Department of Environment and Conservation 2012) for Chuditch indicates that the proposed recovery actions are:

- retain and improve habitat critical for their survival;
- determine impacts of feral cats and feral cat controls on Chuditch;
- continue, expand and improve baiting of foxes and feral cats;
- determine population abundance and distribution of Chuditch populations;
- establish reference sites for monitoring Chuditch population abundance to evaluate the effectiveness of fox and cat control;
- undertake and monitor translocations to increase the extent of occurrence; and
- increase public awareness through community education and enforcement of regulations.

It is likely that 10-15 Chuditch will be directly affected by the proposed vegetation clearing, construction and mining operations, but this number will vary depending on the time of the year that these activities are taking place, as adult males typically die after the breeding seasons (i.e. April – May) and young join the population in October - November.

TERRESTRIAL ECOSYSTEMS

2.4.3 Avoidance and mitigation

Minimising vegetation clearing, particularly in areas of relatively high vegetation density and rocky areas will limit impacts. Chuditch will potentially cross the access track and will be at risk of collisions with light vehicles and trucks. Speed limits will therefore be implemented on the access road and around the mine to limit the potential for Chuditch to collide with a vehicle.

A wild dog, fox and feral cat reduction program will be implemented on an ongoing basis. An appropriate number of meat baits containing 1080 will be dispersed around the project area. The frequency and distribution of baits and other details of the program will be provided in the vertebrate fauna management plan. However, baits will be deployed along existing tracks within a radius of 10km around the mine site. It is anticipated that this will significantly reduce the number of dingoes / wild dogs and any foxes in the general area.

Three Felixers (Read *et al*. 2019; also see https://thylation.com) will be deployed around the project area on an ongoing basis to euthanase feral cats. These Felixers will be moved monthly to new locations, and it is anticipated that the abundance of feral cats within 12 months will drop to zero and remain at that level while the euthanasia program is in place.

Rehabilitating areas once mining activity has ceased with the specific intention of creating suitable habitat for Chuditch (e.g. retreat sites in hollow logs and rock piles, areas of dense understorey, etc) will provide suitable habitat for Chuditch in the long-term.

2.4.3.1 Monitoring Chuditch abundance

All management programs will be informed and evaluated with appropriate data. The abundance of Chuditch will be monitored within 1km of the project area using camera traps. The baseline monitoring will be undertaken before vegetation clearing and earthworks are undertaken for mine site development. Subsequent monitoring will be undertaken every two years, using the same protocols. A before-after-control-impact (BACI) design will be used in the monitoring and evaluation program.

Summary of threats, mitigation and level of impacts

The following quantified threats, mitigation and level of impact only considers impacts and mitigation relating to mining activities and excludes impacts that were present before the mining project commenced.

Significant threats and impacts	Impact score	Mitigation	Impact score	Residual impact
• Fire • Vegetation clearing • Vehicle collisions on the access track and during mine operations	-1 -1 -1	• Fire management plan • Fox and feral cat reduction program • Trapping and relocation plan prior to and during vegetation clearing • Rehabilitation of fauna habitats	+1 +2 +1 +1	+2

2.5 Western Brush Wallaby

2.5.1 Threats

Woinarski *et al*. (2014) and Woinarski and Burbidge (2016) reported threats to Western Brush Wallabies as predation by foxes, habitat loss and fragmentation, inappropriate fire regimes and vehicle impacts. Christensen (2000) suggested the fox was a major predator, particular of joeys, and Woinarski and Burbidge (2016) reported that Western Brush Wallaby numbers have increased in areas of fox control.

The Western Brush Wallaby will readily move into adjacent areas once vegetation clearing commences, and there is adequate foraging habitat in adjacent areas. As the activity area for this species is quite large, for most individuals this will mean an adjustment to their home range, so impacts are likely to be short-term and not significant. Further fragmentation of their habitat will also restrict their movement.

It is anticipated that Western Brush Wallabies will be infrequently encountered on the access track to the mine and will therefore be at risk of collisions with light vehicles and trucks. Speed limits will be implemented on the access road and around the mine to limit the potential for Western Brush Wallabies to collide with a vehicle.

Loss of habitat and habitat fragmentation will impact on this species by reducing areas in which they can feed and limit movement between areas, which are particularly important in time of fire or reduced feeding resources.

2.5.2 Avoidance and mitigation

The potential impact associated with vegetation clearing can be reduced by minimising areas of native vegetation to be cleared and rehabilitating areas once they are no longer required. A fire management plan should stop, restrict and reduce the impact of fires around the project area.

A wild dog, fox and feral cat reduction program will be implemented on an ongoing basis. An appropriate number of meat baits containing 1080 will be dispersed around the project area. The frequency and distribution of baits and other detail of the program will be provided in the vertebrate fauna management plan. However, baits will be deployed along existing tracks within a radius of 10km around the mine site. It is anticipated that this will significantly reduce the number of dingoes / wild dogs and any foxes in the general area.

All management programs will be informed and evaluated with appropriate data. The abundance of Western Brush Wallaby will be monitored within 1km of the project area using camera traps. The baseline monitoring will be undertaken before vegetation clearing and earthworks are undertaken for mine site development. Subsequent monitoring will be undertaken every two years, using the same protocols. A before-after-control-impact (BACI) design will be used in the monitoring and evaluation program.

Summary of threats, mitigation and level of impacts

This summary of threats, mitigation and level of impact only considers impacts and mitigation relating to mining activities and excludes impacts that were present before the mining project commenced.

Significant threats and impacts	Impact score	Mitigation	Impact score	Residual impact
• Fire • Vegetation clearing • Vehicle collisions on the access road	0 -1 -1	• Fire management plan • Fox and feral cat reduction program	0 +2	0

2.6 Summary of threats and impacts and mitigation strategies

Table 4 provides a summary and quantification of the significant threats and impacts on the vertebrate fauna and avoiding, minimising and mitigating strategies that British Hill will adopt to address these impacts.

Table 4. Significant threats and impacts on the vertebrate fauna that the British Hill has some capacity to avoid, mitigate or minimise

Species	Status	Threats and impacts	Impact score	Mitigation	Impact score	Residual impact
Malleefowl (*Leipoa ocellata*)	Vu	• Fire • Vegetation clearing • Vehicle collisions on the access road	-1 -1 -1	• Fire management plan • Fox and feral cat reduction program • Rehabilitation of fauna habitats	+1 +3 +1	+2
Chuditch (*Dasyurus geoffroii*)	Vu	• Fire • Vegetation clearing • Vehicle collisions on the access track and during mine operations	-1 -1 -1	• Fire management plan • Fox and feral cat reduction program • Trapping and relocation plan prior to and during vegetation clearing • Rehabilitation of fauna habitats	+1 +2 +1 +1	+2
Western Brush Wallaby (*Notamacropus irma*)	P4	• Fire • Vegetation clearing • Vehicle collisions on the access road	0 -1 -1	• Fire management plan • Fox and feral cat reduction program	0 +2	0

Vu Vulnerable
P Priority species recorded by DBCA

Table 4 indicates that with the described management actions there will be a net-positive benefit for Malleefowl and Chuditch, and no impact on Western Brush-Wallaby.

3 MITIGATION

3.1 Vertebrate fauna management plan

The British Hill proposed mine site supports multiple vertebrate fauna, and in particular conservation significant species. It is therefore important that mine management accepts responsibility for the long-term management, protection and mitigation of impacts on the vertebrate fauna. A vertebrate fauna management will be prepared, implemented and regularly updated based on the best available information (i.e. at least annually). The vertebrate fauna management plan will cover the entire operations and will describe the management practices associated with vegetation clearing and infrastructure development, and ongoing mining operations.

The plan will document the feral and pest animal control programs that will be implemented and the success or otherwise of these programs based on appropriate monitoring.

This plan will have specific and measurable objectives, triggers for specific actions and the specific actions that will be implemented as and when required. The plan will also detail a biannual vertebrate fauna monitoring program to measure the health and relative abundance of conservation significant vertebrate fauna species and will use a BACI design. The monitoring program will utilise the relevant aspects of the existing monitoring program, so that the data already available might be used in a long-term dataset. The plan will detail the adaptive management processes to be implemented by the mine's management.

3.2 Wild dog, fox and cat reduction

The most significant threats to vertebrate fauna in the British Hill proposed mine site, in particular, conservation significant fauna species is the abundance of wild dogs and feral cats, and possibly foxes, and vegetation clearing.

Broad-landscape scale baiting programs for wild dogs, foxes and feral cats have been undertaken with mixed success. The two primary problems with broad-scale aerial baiting programs are uncontrolled uptake of baits by non-target species and unpredictable ambient weather conditions prior to and during the distribution of the bait. For example, Dundas *et al.* (2014) reported that 99% of 1080 baits laid to control foxes in the northern Jarrah Forest and monitored by camera traps were taken by non-target species and in a field trial to compare the efficacy of Eradicat and Curiosity baits in the Cape Arid National Park and Nuytsland Nature Reserve inappropriate weather resulted in poor bait uptake due to reduced bait attractiveness/palatability (Algar *et al.* 2011). In the British Hill proposed mine site, non-target species such as *Varanus gouldii* (Sand Goanna), *Tiliqua rugosa* (Bobtail lizard), *Tiliqua occidentalis* (Western Blue-tongue Lizard), *Corvus coronoides* (Australian Raven), emus (*Dromaius novaehollandiae*) and *Strepera versicolor* (Grey Currawong) would potentially take most of the meat based baits, unless they are buried and deployed in the cooler months when reptiles are no longer surface active.

Wild dog and cat, and any foxes present in the area, will be significantly reduced as a result of this baiting program will also enable some recovery of small mammal and reptile populations, and a shift toward the original functional ecosystems in the project area.

Burying 1080 meat baits reduces the bait uptake by non-targeted species such as ravens, currawongs and goannas. A well planned and implemented program should have a significant impact on wild dog numbers, however, it is possible that a reduction in the wild dog population will result in the increased impact of cats (i.e. meso-predator release) on native fauna (Zavaleta *et al.* 2001). It is therefore important that a concurrent cat reduction program is implemented.

Three Felixers (Read *et al*. 2019; also see https://thylation.com) will be deployed around the project area on an ongoing basis to euthanase feral cats. These Felixers will be moved monthly to new locations. It is anticipated that the abundance of feral cats within 12 months will drop to zero and remain at that level while the euthanasia program is in place.

The abundance of Chuditch, Malleefowl and Western Brush Wallabies will be monitored within 1km of the project area using camera traps and a BACI design. The baseline monitoring will be undertaken before vegetation clearing and earthworks are undertaken for mine site development. Subsequent monitoring will be undertaken every two years, using the same protocols.

3.3 Fire management plan

A fire management plan is required, as altered fire regimes in conjunction with habitat fragmentation and predation by introduced predators have had a significant impact on the vertebrate fauna in the British Hill tenements.

4 RESIDUAL AND NET POSITIVE IMPACTS

The presence of Chuditch and Malleefowl in areas adjacent to the British Hill mine site means that any impacts on these species is likely to be low when considered in a bioregional context, as the number of individuals for each species potentially impacted by the mining development and operation will be a very small fraction of the population in adjacent areas. For Malleefowl, there is no evidence of recent breeding activity within the project area, and there is only one old, and unusable mound in the development envelop.

With the implementation of the mitigation program proposed above and using the scoring system proposed for impact and mitigation strategies (Table 3) the residual or net positive impacts for each of the species are summarised in Table 5.

Table 5. Residual or net positive impacts on conservation significant species

Species	**Status**	**Residual or net positive impact**
Malleefowl (*Leipoa ocellata*)	Vu	+2
Chuditch (*Dasyurus geoffroii*)	Vu	+2
Western Brush Wallaby (*Notamacropus irma*)	P4	0

The primary mitigation strategy that has resulted in lowering the residual impact for most conservation threatened fauna is the wild dog, fox and cat management programs.

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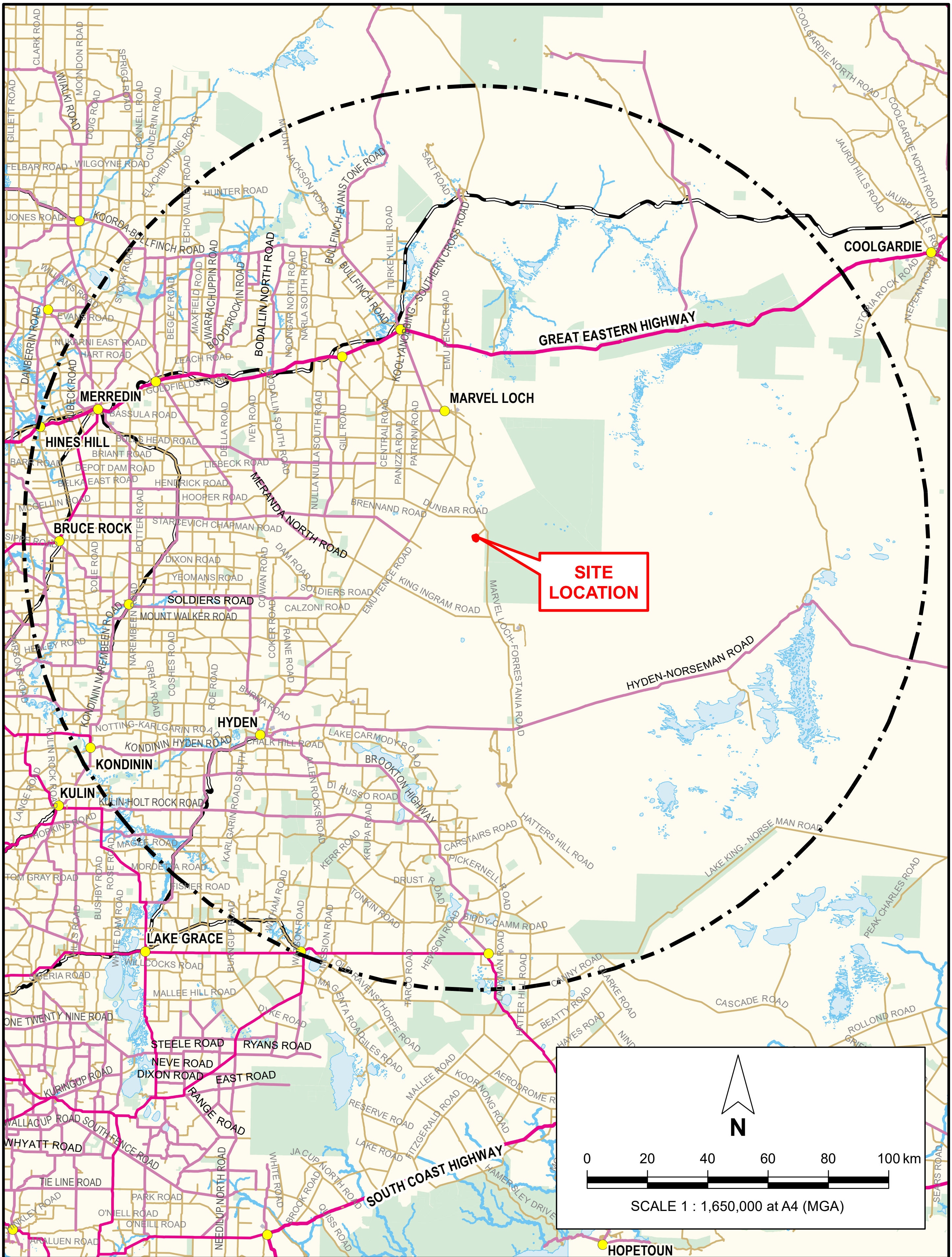
Figures

Contextual information for potential impacts on Malleefowl and Chuditch at British Hill



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TERRESTRIAL ECOSYSTEMS

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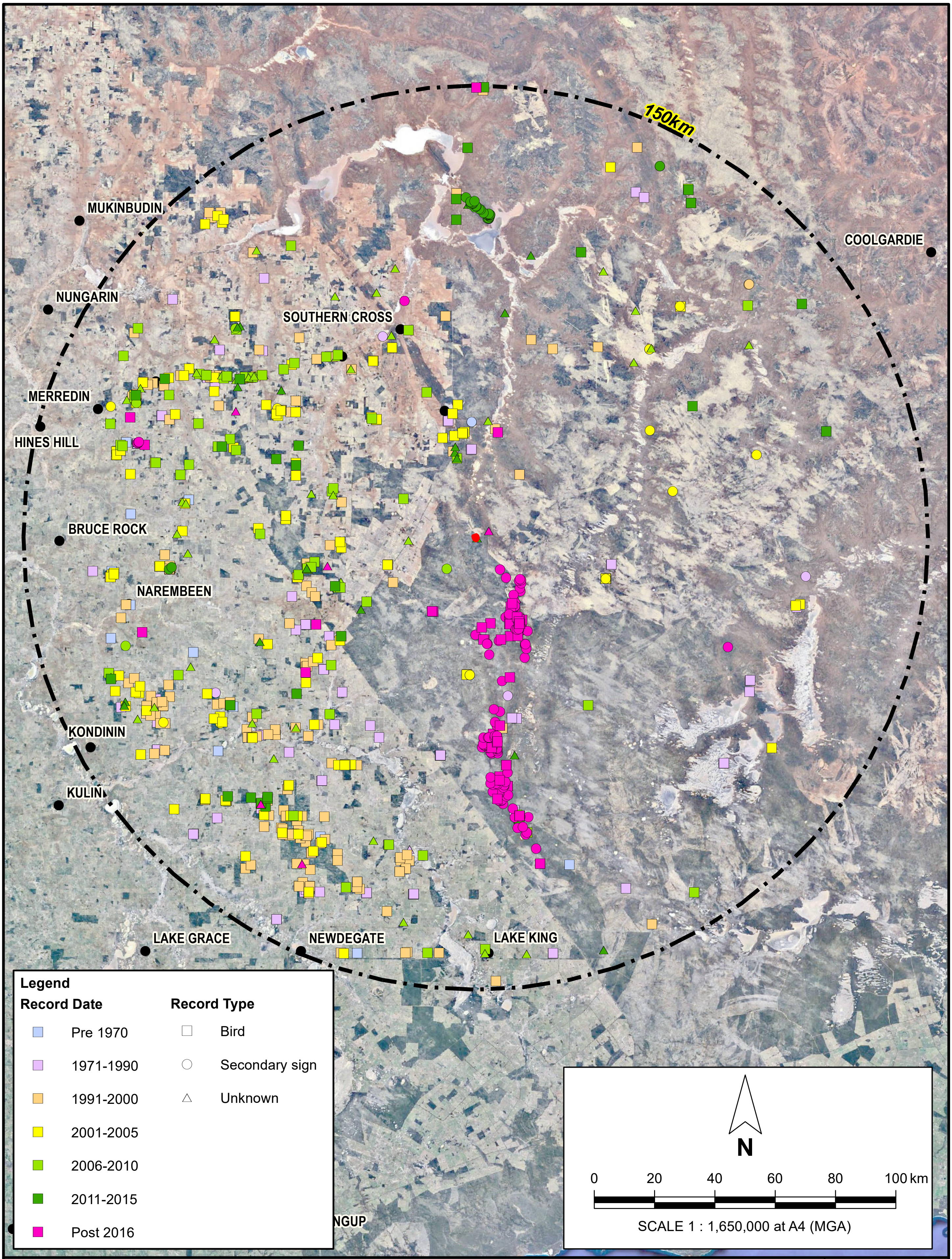
CHUDITCH AND MALLEEFOWL CONTEXTUAL INFORMATION
BRITISH HILL

REGIONAL LOCATION

Figure 1

Job: 2019-0091



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TERRESTRIAL ECOSYSTEMS

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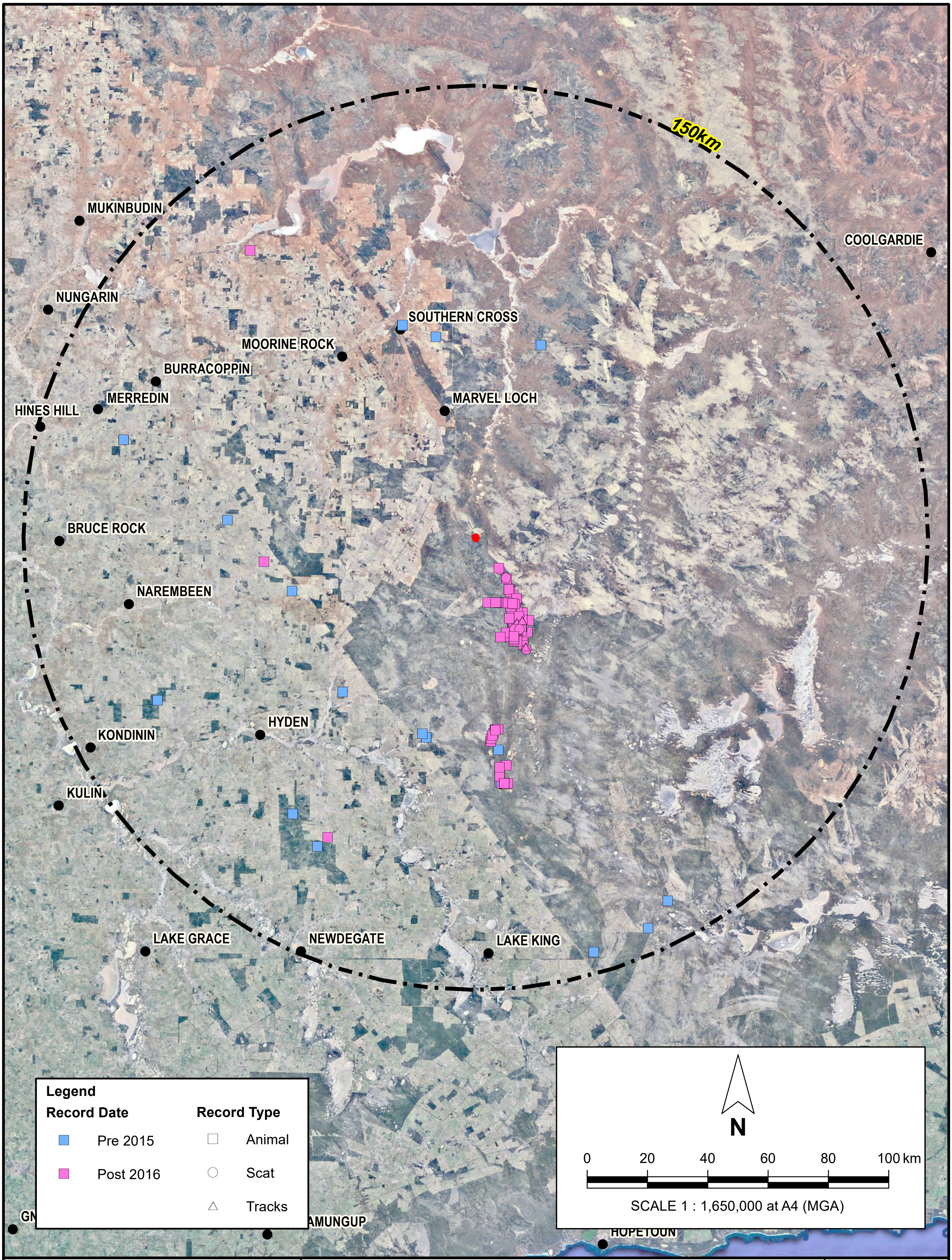
CHUDITCH AND MALLEEFOWL CONTEXTUAL INFORMATION
BRITISH HILL

MALLEEFOWL RECORDS FOR A RADIUS OF 150KM AROUND THE PROJECT AREA

Figure 2

Job: 2019-0091



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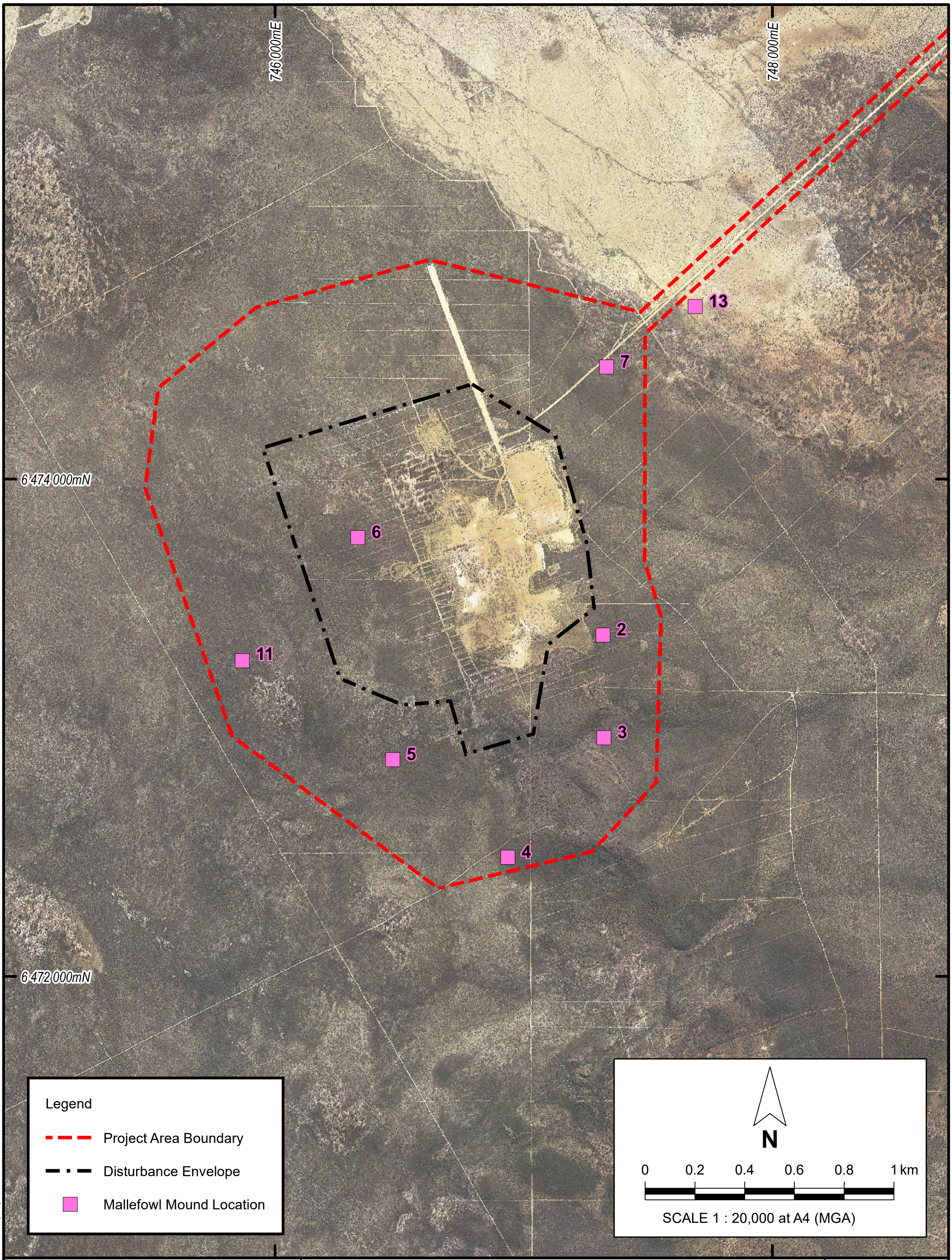
CHUDITCH AND MALLEEFOWL CONTEXTUAL INFORMATION
BRITISH HILL

CHUDITCH RECORDS FOR A RADIUS OF 150KM AROUND THE PROJECT AREA

Figure 3

Job: 2019-0091



TERRESTRIAL ECOSYSTEMS

Drawn: G. Thompson

Date: 13 Mar 2020

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CHUDITCH AND MALLEEFOWL CONTEXTUAL INFORMATION
BRITISH HILL

LOCATION OF MALLEEFOWL MOUNDS

Figure 4

Job: 2019-0091

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Appendix A

Contextual information for potential impacts on Malleefowl and Chuditch at British Hill

Descriptive information about the mounds inspected

Info required	Comments
#	1 - nothing
Easting	746076
Northing	6474328
Mound profile	
Diameter of the mound	
Height of the mound above ground level surface	
Diameter of the crater	
Depth of the crater	
• Substrate type (organic matter, stone, gravel, sand etc)	
• Outer surface of the mound: o crust o moss o herb o debris o shrub o tree	
• Inner surface of the mound: o crust o moss o herb o debris o shrub o tree	
Signs of activity and use (i.e. scats, footprints, feathers, eggshell, goanna diggings, litter raked)	
Mound surrounds	
Photograph	

Info required	Comments
#	2
Easting	747319
Northing	6473373
Mound profile	
Diameter of the mound	7.5m
Height of the mound above ground level surface	800mm
Diameter of the crater	3900mm
Depth of the crater	550mm
• Substrate type (organic matter, stone, gravel, sand etc)	Stony
• Outer surface of the mound: o crust o moss o herb o debris o shrub o tree	Crust, shrubs on the outer edges
• Inner surface of the mound: o crust o moss o herb o debris o shrub o tree	Crust
Signs of activity and use (i.e. scats, footprints, feathers, eggshell, goanna diggings, litter raked)	None
Mound surrounds	Thicket
Photograph	Yes

Info required	Comments
#	3
Easting	747322
Northing	6472960
Mound profile	
Diameter of the mound	5.2m
Height of the mound above ground level surface	500mm
Diameter of the crater	900mm
Depth of the crater	500mm
• Substrate type (organic matter, stone, gravel, sand etc)	Stone
• Outer surface of the mound: o crust o moss o herb o debris o shrub o tree	Crust
• Inner surface of the mound: o crust o moss o herb o debris o shrub o tree	Crust
Signs of activity and use (i.e. scats, footprints, feathers, eggshell, goanna diggings, litter raked)	No
Mound surrounds	Thickets, gravelly stone
Photograph	Yes

Info required	Comments
#	4
Easting	746936
Northing	6472479
Mound profile	
Diameter of the mound	7m
Height of the mound above ground level surface	500mm
Diameter of the crater	1800mm
Depth of the crater	250mm
• Substrate type (organic matter, stone, gravel, sand etc)	Stone
• Outer surface of the mound: o crust o moss o herb o debris o shrub o tree	Crust
• Inner surface of the mound: o crust o moss o herb o debris o shrub o tree	Crust/shrubs/trees
Signs of activity and use (i.e. scats, footprints, feathers, eggshell, goanna diggings, litter raked)	None
Mound surrounds	Very thick shrubland
Photograph	Yes

Info required	Comments
#	5
Easting	746473
Northing	6472872
Mound profile	
Diameter of the mound	9m
Height of the mound above ground level surface	500mm
Diameter of the crater	
Depth of the crater	
• Substrate type (organic matter, stone, gravel, sand etc)	Stone
• Outer surface of the mound: o crust o moss o herb o debris o shrub o tree	Crust
• Inner surface of the mound: o crust o moss o herb o debris o shrub o tree	Crust, trees and shrubs
Signs of activity and use (i.e. scats, footprints, feathers, eggshell, goanna diggings, litter raked)	None
Mound surrounds	Very dense shrubs
Photograph	Yes

Info required	Comments
#	6
Easting	746333
Northing	6473765
Mound profile	
Diameter of the mound	8.2m
Height of the mound above ground level surface	2.3m
Diameter of the crater	~ 800mm
Depth of the crater	750mm
• Substrate type (organic matter, stone, gravel, sand etc)	Stone
• Outer surface of the mound: o crust o moss o herb o debris o shrub o tree	Crust
• Inner surface of the mound: o crust o moss o herb o debris o shrub o tree	Crust, trees/shrubs growing
Signs of activity and use (i.e. scats, footprints, feathers, eggshell, goanna diggings, litter raked)	None
Mound surrounds	Acacia thicket
Photograph	Yes

Info required	Comments
#	7
Easting	747333
Northing	6474451
Mound profile	
Diameter of the mound	9m
Height of the mound above ground level surface	250mm
Diameter of the crater	
Depth of the crater	
• Substrate type (organic matter, stone, gravel, sand etc)	Stony
• Outer surface of the mound: o crust o moss o herb o debris o shrub o tree	Crust with trees
• Inner surface of the mound: o crust o moss o herb o debris o shrub o tree	Crust with trees
Signs of activity and use (i.e. scats, footprints, feathers, eggshell, goanna diggings, litter raked)	None
Mound surrounds	Acacia thicket and organic matter
Photograph	Yes

Info required	Comments
#	8 – spoil pile
Easting	747031
Northing	6474692
Mound profile	
Diameter of the mound	
Height of the mound above ground level surface	
Diameter of the crater	
Depth of the crater	
• Substrate type (organic matter, stone, gravel, sand etc)	
• Outer surface of the mound: o crust o moss o herb o debris o shrub o tree	
• Inner surface of the mound: o crust o moss o herb o debris o shrub o tree	
Signs of activity and use (i.e. scats, footprints, feathers, eggshell, goanna diggings, litter raked)	
Mound surrounds	
Photograph	Yes

Info required	Comments
#	9 – Mallee tree only
Easting	745595
Northing	6473587
Mound profile	
Diameter of the mound	
Height of the mound above ground level surface	
Diameter of the crater	
Depth of the crater	
• Substrate type (organic matter, stone, gravel, sand etc)	
• Outer surface of the mound: o crust o moss o herb o debris o shrub o tree	
• Inner surface of the mound: o crust o moss o herb o debris o shrub o tree	
Signs of activity and use (i.e. scats, footprints, feathers, eggshell, goanna diggings, litter raked)	
Mound surrounds	
Photograph	Yes

Info required	Comments
#	10 – large pile of dirt
Easting	746508
Northing	6474033
Mound profile	
Diameter of the mound	
Height of the mound above ground level surface	
Diameter of the crater	
Depth of the crater	
• Substrate type (organic matter, stone, gravel, sand etc)	
• Outer surface of the mound: o crust o moss o herb o debris o shrub o tree	
• Inner surface of the mound: o crust o moss o herb o debris o shrub o tree	
Signs of activity and use (i.e. scats, footprints, feathers, eggshell, goanna diggings, litter raked)	
Mound surrounds	
Photograph	Yes

Info required	Comments
#	11
Easting	745868
Northing	6473270
Mound profile	
Diameter of the mound	5m
Height of the mound above ground level surface	150mm
Diameter of the crater	1200mm
Depth of the crater	250mm
• Substrate type (organic matter, stone, gravel, sand etc)	Stony with vegetation
• Outer surface of the mound: o crust o moss o herb o debris o shrub o tree	Crust
• Inner surface of the mound: o crust o moss o herb o debris o shrub o tree	Crust
Signs of activity and use (i.e. scats, footprints, feathers, eggshell, goanna diggings, litter raked)	None
Mound surrounds	Very thick shrubs
Photograph	Yes

Info required	Comments
#	12 – nothing but mallee thicket
Easting	747293
Northing	6474350
Mound profile	
Diameter of the mound	
Height of the mound above ground level surface	
Diameter of the crater	
Depth of the crater	
• Substrate type (organic matter, stone, gravel, sand etc)	
• Outer surface of the mound: o crust o moss o herb o debris o shrub o tree	
• Inner surface of the mound: o crust o moss o herb o debris o shrub o tree	
Signs of activity and use (i.e. scats, footprints, feathers, eggshell, goanna diggings, litter raked)	
Mound surrounds	
Photograph	Yes

Info required	Comments
#	13
Easting	747689
Northing	6474694
Mound profile	
Diameter of the mound	6.2m
Height of the mound above ground level surface	400mm
Diameter of the crater	2.6m
Depth of the crater	440mm
• Substrate type (organic matter, stone, gravel, sand etc)	Stony gravel
• Outer surface of the mound: o crust o moss o herb o debris o shrub o tree	Crust
• Inner surface of the mound: o crust o moss o herb o debris o shrub o tree	Crust
Signs of activity and use (i.e. scats, footprints, feathers, eggshell, goanna diggings, litter raked)	None
Mound surrounds	Burnt sandplain
Photograph	Yes

Info required	Comments
#	14 – pile of sand
Easting	747551
Northing	6474659
Mound profile	
Diameter of the mound	
Height of the mound above ground level surface	
Diameter of the crater	
Depth of the crater	
• Substrate type (organic matter, stone, gravel, sand etc)	
• Outer surface of the mound: o crust o moss o herb o debris o shrub o tree	
• Inner surface of the mound: o crust o moss o herb o debris o shrub o tree	
Signs of activity and use (i.e. scats, footprints, feathers, eggshell, goanna diggings, litter raked)	
Mound surrounds	
Photograph	Yes

Info required	Comments
#	15 - nothing
Easting	747342
Northing	6474645
Mound profile	
Diameter of the mound	
Height of the mound above ground level surface	
Diameter of the crater	
Depth of the crater	
• Substrate type (organic matter, stone, gravel, sand etc)	
• Outer surface of the mound: o crust o moss o herb o debris o shrub o tree	
• Inner surface of the mound: o crust o moss o herb o debris o shrub o tree	
Signs of activity and use (i.e. scats, footprints, feathers, eggshell, goanna diggings, litter raked)	
Mound surrounds	
Photograph	Yes

Info required	Comments
#	16 – cleared drilling site
Easting	746690
Northing	6473562
Mound profile	
Diameter of the mound	
Height of the mound above ground level surface	
Diameter of the crater	
Depth of the crater	
• Substrate type (organic matter, stone, gravel, sand etc)	
• Outer surface of the mound: o crust o moss o herb o debris o shrub o tree	
• Inner surface of the mound: o crust o moss o herb o debris o shrub o tree	
Signs of activity and use (i.e. scats, footprints, feathers, eggshell, goanna diggings, litter raked)	
Mound surrounds	
Photograph	Yes

Info required	Comments
#	17 – spoil pile
Easting	746594
Northing	6474604
Mound profile	
Diameter of the mound	
Height of the mound above ground level surface	
Diameter of the crater	
Depth of the crater	
• Substrate type (organic matter, stone, gravel, sand etc)	
• Outer surface of the mound: o crust o moss o herb o debris o shrub o tree	
• Inner surface of the mound: o crust o moss o herb o debris o shrub o tree	
Signs of activity and use (i.e. scats, footprints, feathers, eggshell, goanna diggings, litter raked)	
Mound surrounds	
Photograph	Yes

TERRESTRIAL ECOSYSTEMS

Info required	Comments
#	18 – bare dirt in thicket
Easting	746483
Northing	6474626
Mound profile	
Diameter of the mound	
Height of the mound above ground level surface	
Diameter of the crater	
Depth of the crater	
• Substrate type (organic matter, stone, gravel, sand etc)	
• Outer surface of the mound: o crust o moss o herb o debris o shrub o tree	
• Inner surface of the mound: o crust o moss o herb o debris o shrub o tree	
Signs of activity and use (i.e. scats, footprints, feathers, eggshell, goanna diggings, litter raked)	
Mound surrounds	
Photograph	Yes

Info required	Comments
#	19- nothing
Easting	746260
Northing	6474408
Mound profile	
Diameter of the mound	
Height of the mound above ground level surface	
Diameter of the crater	
Depth of the crater	
• Substrate type (organic matter, stone, gravel, sand etc)	
• Outer surface of the mound: o crust o moss o herb o debris o shrub o tree	
• Inner surface of the mound: o crust o moss o herb o debris o shrub o tree	
Signs of activity and use (i.e. scats, footprints, feathers, eggshell, goanna diggings, litter raked)	
Mound surrounds	
Photograph	Yes

Info required	Comments
#	20 – nothing, machine turn around tracks
Easting	747223
Northing	6473506
Mound profile	
Diameter of the mound	
Height of the mound above ground level surface	
Diameter of the crater	
Depth of the crater	
• Substrate type (organic matter, stone, gravel, sand etc)	
• Outer surface of the mound: o crust o moss o herb o debris o shrub o tree	
• Inner surface of the mound: o crust o moss o herb o debris o shrub o tree	
Signs of activity and use (i.e. scats, footprints, feathers, eggshell, goanna diggings, litter raked)	
Mound surrounds	
Photograph	Yes

Info required	Comments
#	21 – Bare patch of sand
Easting	748421
Northing	6475441
Mound profile	
Diameter of the mound	
Height of the mound above ground level surface	
Diameter of the crater	
Depth of the crater	
• Substrate type (organic matter, stone, gravel, sand etc)	
• Outer surface of the mound: o crust o moss o herb o debris o shrub o tree	
• Inner surface of the mound: o crust o moss o herb o debris o shrub o tree	
Signs of activity and use (i.e. scats, footprints, feathers, eggshell, goanna diggings, litter raked)	
Mound surrounds	
Photograph	Yes

Info required	Comments
#	22 – Road spoil pile
Easting	749019
Northing	6476028
Mound profile	
Diameter of the mound	
Height of the mound above ground level surface	
Diameter of the crater	
Depth of the crater	
• Substrate type (organic matter, stone, gravel, sand etc)	
• Outer surface of the mound: o crust o moss o herb o debris o shrub o tree	
• Inner surface of the mound: o crust o moss o herb o debris o shrub o tree	
Signs of activity and use (i.e. scats, footprints, feathers, eggshell, goanna diggings, litter raked)	
Mound surrounds	
Photograph	Yes