THUNDERBIRD MINERAL SANDS PROJECT

TERRESTRIAL FAUNA ENVIRONMENTAL MANAGEMENT PLAN

PREPARED FOR:

THUNDERBIRD OPERATIONS PTY LTD

ThunderbirdOperations Pty Ltd

OCTOBER 2018

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EXECUTIVE SUMMARY

This Terrestrial Fauna Environmental Management Plan (FEMP) is submitted in accordance with Condition 6-1 of Ministerial Statement 1080 for the Thunderbird Mineral Sands Project (the Project) developed by Thunderbird Operations Pty Ltd. The FEMP is designed to be adaptive and will be updated over the life of the project (40+ years) as further information about conservation significant fauna within the Dampier Peninsula and the project area, and effectiveness of implemented management measures, is obtained.

Table 1 presents the purpose of this FEMP in the context of EPA objective for terrestrial fauna. Table 2 presents the environmental objectives stated in Condition 6-1 of Ministerial Statement 1080 that are required to be achieved through implementation of this FEMP.

Table 1: Purpose and Objective of this FEMP

Title of Proposal	Thunderbird Mineral Sands Project
Proponent	Thunderbird Operations Pty Ltd
Purpose of this Terrestrial Fauna Environmental Management Plan	Preparation of the FEMP is a requirement of Condition 6-1 of Ministerial Statement 1080. The purpose of this FEMP is to provide a framework to ensure that impacts on conservation significant terrestrial fauna, particularly the Greater Bilby and Dampier Peninsula Goanna, attributable to the project are minimised and impacts do not conflict with the EPA objective for terrestrial fauna.
EPA's Environmental Objective	Terrestrial Fauna: To maintain the representation, diversity, viability and ecological function at the species, population and community levels.

Table 2 FEMP Objectives

FEMP Objectives
Minimise impacts to the Greater Bilby and Dampier Peninsula Goanna within the mine site development envelope as defined in Figure 2 of Schedule 1 of Ministerial Statement 1080.
No material harm to the Greater Bilby population outside of the mine site development envelope as defined in Figure 2 of Schedule 1 of Ministerial Statement 1080.
No material harm to the Dampier Peninsula Goanna population outside of the mine site development envelope as defined in Figure 2 of Schedule 1 of Ministerial Statement 1080.

Corporate Endorsement

I hereby certify that to the best of my knowledge, the provisions within this Terrestrial Fauna Environmental Management Plan are true and correct and address the requirements of Condition 6-1 of Ministerial Statement 1080.

Name:	Stuart Pether	Signed:	
Designation:	Chief Operating Officer	Date:	24 October 2018

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1. CONTEXT, SCOPE AND RATIONALE

1.1 PROPOSAL

The Thunderbird Mineral Sands Project is a greenfields project and will comprise:

- Mining of heavy mineral sands over a 40 plus year period from the Thunderbird deposit. The initial rate of mining will allow excavation of a nominal 7.5 million tonnes per annum (Mtpa) of ore for the first four to five years, before increasing to a nominal 15 Mtpa of ore for the remainder of the Project life.
- Onsite primary and secondary processing of ore to produce a range of saleable mineral sands products (ilmenite, primary zircon, zircon concentrate, titano-magnetite and HiTi88 Leucoxene). Construction of processing facilities will be staged with production doubled to 15 Mtpa after approximately year five.
- Abstraction and reinjection of groundwater from the Broome Sandstone Aquifer to allow mining and supply ore processing needs.
- Development of infrastructure to support the project including power generation facilities, accommodation village, administration and maintenance buildings, internal roads, communications infrastructure, and waste storage and disposal facilities.
- Upgrade and extension of the existing pastoral road (Mt Jowlaenga Road) from the Great Northern Highway to form a 30 km Site Access Road.
- Transport of mineral sands products from the Mine Site via the Site Access Road and Great Northern Highway to Derby or Broome Ports for storage prior to export.
- Export of bulk mineral sands products from Derby Port via King Sound and packaged mineral product from Port of Broome to international customers.

Construction of the Project is scheduled to commence in 2018, with mining and production scheduled to commence in early 2019. The project is proposed to be fully operational in early 2019 with the first export of product anticipated by end of 2019.

1.2 LOCATION

The Project is located on the Dampier Peninsula within the west Kimberley region of Western Australia (Figure 1). The Project comprises two geographically separate locations, namely the Mine Site Development Envelope (including the Site Access Road) (Figure 2) and the Derby Port Development Envelope. Derby Port is an operational port and has been previously used for export of mineral products but is currently not being used for this purpose. King Sound is currently home to several aquaculture and pearling industries.

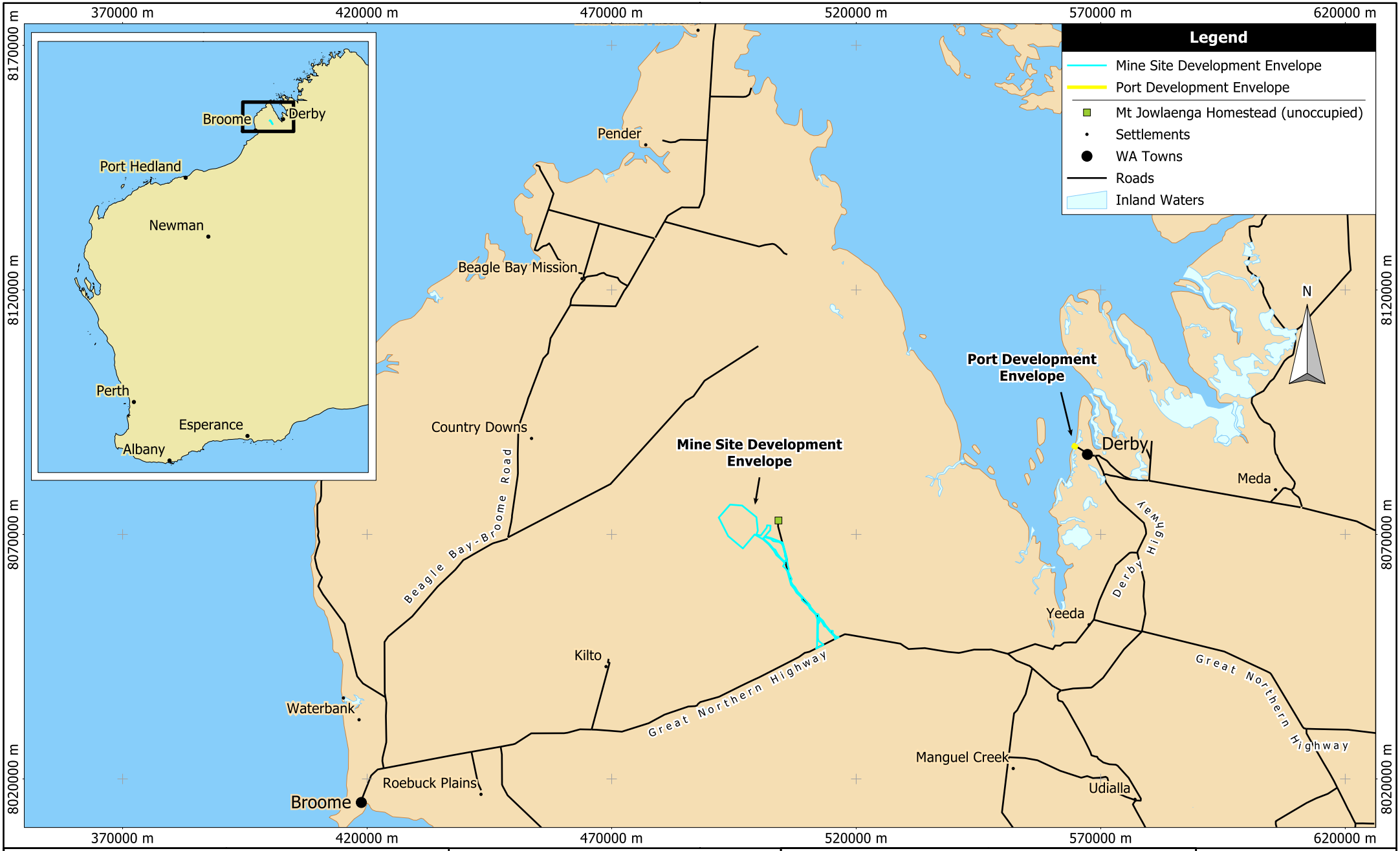
The Mine Site Development Envelope is located approximately 75 km west southwest of Derby and 95 km northeast of Broome (Figure 1). It is accessed from the Great Northern Highway via a proposed 30 km long Site Access Road.

The Mine Site Development Envelope is located within Mt Jowlaenga and Yeeda Pastoral Leases (H910623 and H649773), held by the Yeeda Pastoral Company Pty Ltd. An existing pastoral road that connects the Great Northern Highway to the abandoned Mt Jowlaenga Homestead will be upgraded to form part of the Site Access Road for the project. The Site Access Road intersects the Great Northern Highway approximately half way between Broome and Derby; the intersection is approximately 110 km to Derby and 100 km to Broome by road.

Several tenements are held by Thunderbird Operations for the Mine Site components of the Project. Thunderbird project tenements are detailed in Table 3 and are shown in Figure 2. This Terrestrial Fauna Environmental Management Plan applies only to the Mine Site Development Envelope.

Table 3: Thunderbird Mineral Sands Project Tenements

Tenement	Area (hectares)	Holder	Granted	Expiry
M04/459	4,525	Thunderbird Operations Ltd	25/09/2018	24/09/2039
L04/82	633	Thunderbird Operations Ltd	25/06/2018	26/06/2039
L04/83	219	Thunderbird Operations Ltd	25/06/2018	26/06/2039
L04/84	120	Thunderbird Operations Ltd	23/04/2015	22/04/2036
L04/85	237	Thunderbird Operations Ltd	23/04/2015	22/04/2036
L04/86	191	Thunderbird Operations Ltd	23/04/2015	22/04/2036



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Thunderbird Mineral Sands Project

Figure 1

Project Location

ThunderbirdOperations Pty Ltd

W:\Sheffield Resources\Approvals\PER\Drawings\PER Location Plan.map 15/08/2018 F1 Project Location Layout

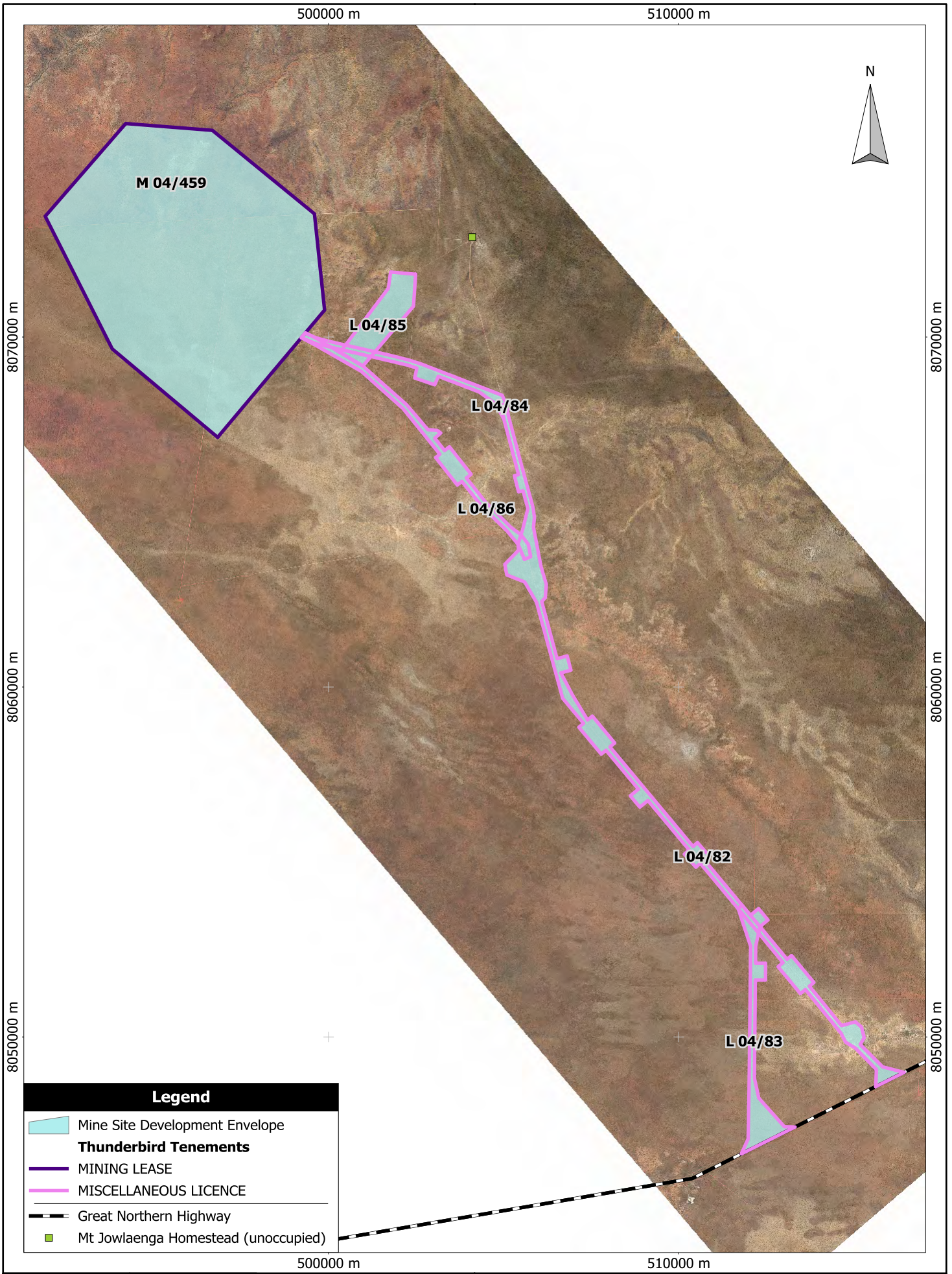

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Figure 2

Mine Site Development Envelope and Tenements

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1.3 KEY ENVIRONMENTAL FACTOR: TERRESTRIAL FAUNA

The EPA's objective for protection of terrestrial fauna is to maintain representation, diversity, viability and ecological function at the species, population and assemblage level.

Baseline assessments of fauna in the vicinity of the Mine Site Development Envelope identified that the Greater Bilby (*Macrotis lagotis*) utilises the area and surrounds. The Greater Bilby is a species of conservation significance, listed as Vulnerable under the *Environmental Protection and Biodiversity Conservation Act 1999* and the *Wildlife Conservation Act 1950*. The Dampier Peninsula Goanna (*Varanus sparnus*) was also recorded near, but not within the Mine Site Development Envelope (however records of *Varanus brevicauda* may have been previously incorrectly identified). This species is listed by the Department of Biodiversity Conservation and Attractions (DBCA) as a Priority 1 fauna species.

To ensure that the EPA's objective is achieved with respect to the Greater Bilby and Dampier Peninsula Goanna, this FEMP was developed.

The following environmental aspects of this proposal have potential to affect these terrestrial fauna:

- **Vehicle strike causing injury or death** - Greater Bilby and Dampier Peninsula Goannas within the Mine Site Development Envelope will be at risk of injury and/or death due to vehicle strike during road use and maintenance. This would be more likely along the Site Access Road and the road connecting the accommodation village and operational areas, particularly at night when the Greater Bilby is most active. Windrows along access tracks and other landforms comprising soft soils generated during construction may provide preferable habitat for bilbies and attract individuals to these areas. The likelihood of interactions between Greater Bilbies and vehicles would be more likely in these areas.
- **Fragmentation and loss of habitat resulting in displacement** - Fragmentation of fauna habitat from land clearing may lead to loss of individuals through competition and increased risk of predation, as affected individuals are required to relocate and compete and are more prone to predation by introduced predators which may themselves increase in numbers due to increased clearing.
- **Clearing activities causing injury or death** - Clearing activities can result in the injury and/or death of Greater Bilbies and Dampier Peninsula Goannas who may be crushed and or injured by heavy machinery whilst resting in underground burrows during daylight hours. The fauna may suffocate if their burrows are collapsed and they become buried.
- **Entrapment leading to injury or death** - Trenches, excavations, and water storage structures often have steep, slippery sides which prevent fauna, including Greater Bilbies and Dampier Peninsula Goannas which may fall into them, from escaping.
- **Increased predation causing injury or death** - Potential increase in introduced predator species (populations and number of species) through establishment of domestic waste disposal, clearing of native vegetation, creation of new tracks and roads and permanent water storage facilities may result in increased predation on the Greater Bilby and Dampier Peninsula Goanna by cats and/or dogs.
- **Altered fire regimes causing injury or death or loss of habitat** – The Kimberley region is subject to frequent burning, which has increased in intensity in recent years; either as a result of natural or deliberate events. Controlled burning conducted as part of pastoral activities will not be conducted on the same frequency or extent within the Mine Site Development Envelope as a result of implementation of the project. Due to the increased presence of people and machinery in the area, there is however an increased risk of accidental fires. The result of these changes is likely to be a reduction in widespread cool, controlled burns across the Mine Site Development Envelope and an increased risk of uncontrolled and hot burns for small areas within the Mine Site Development Envelope. Over the past few years the Kimberley region has seen a reduction in late season fires (hot fires).

- **Light and noise emissions disrupting nocturnal activities** - Development of the Project may result in an increase in light and noise emissions which could potentially result in changes to the Greater Bilby's nocturnal activities.
- **Radiation exposure causing injury or death** – Waste materials produced as a result of ore processing will be disposed of as part of backfilling of the mine void. Ore processing activities have potential to concentrate naturally occurring radioactive elements present within the deposit. Increased radiation levels in the rehabilitated mine area may subsequently impact fauna. If Project wastes contain sufficiently high concentrations of radionuclides near the surface, fauna may be potentially affected through external gamma-radiation, inhalation of radioactive material (dust and radon) and ingestion of contaminated vegetation or water.

1.4 REQUIREMENTS OF THE CONDITION

Specifically, this FEMP is submitted to satisfy the EPA and the Department of Environment and Energy (DoEE) that Thunderbird Operations has complied with the requirements of the relevant conditions under Ministerial Statement 1080. Table 4 contains the relevant conditions and the section of this FEMP that addresses the requirements of each condition. Thunderbird Operations are committed to undertaking a project that meets these objectives. This will occur through the application of management and monitoring measures detailed in this FEMP.

Table 4 Relevant Conditions and Where They are Addressed in this FEMP

Conditions		Section
Preparation and Timing		
6-1	Prior to the commencement of ground disturbing activities or as otherwise agreed in writing by the CEO, the proponent shall prepare and submit an Environmental Management Plan to the CEO, to demonstrate that the following environmental objectives will be met:	Section 2
(1)	Minimise impacts to the Greater Bilby within the mine site development envelope as defined in Figure 2 of Schedule 1.	Section 2 - Table 6
(2)	No material harm to the Greater Bilby population outside of the mine site development envelope as defined in Figure 2 of Schedule 1.	Section 2 - Table 7
(3)	No material harm to the Dampier Peninsula Goanna population outside of the mine site development envelope as defined in Figure 2 of Schedule 1.	Section 2 - Table 7
Plan Provisions		
6-2	The Environmental Management Plan shall specify the following management based provisions:	Section 2
(1)	Environmental objective/s, management actions, management targets, process for revision of management actions and reporting.	Section 2
6-3	The Environmental Management Plan shall be prepared in accordance with the Environmental Protection Authority's Instructions on how to prepare Environmental Protection Act 1986 *Part IV Environmental Management Plans*.	Section 2
Incident Requirements and Reporting		
6-5	In the event of failure to implement management actions, the proponent shall meet the requirements in Condition 4-5 (Compliance Reporting) and shall implement the measures outlined in the plan, including, but not limited to, actions and investigations to be undertaken, and reporting to the CEO, to enable the CEO to determine whether environmental harm has occurred.	Section 2.4
6-6	The proponent may review and revise the Environment Management Plan or any subsequently approved revisions.	Section 3
6-7	The proponent shall review and revise the Environmental Management Plan or any subsequently approved revisions, as and when directed by the CEO.	Section 3

1.5 RATIONALE AND APPROACH IN MEETING THE ENVIRONMENTAL OBJECTIVE

Results of baseline surveys and a number of assumptions and uncertainties inform the management approach for meeting the environmental objective. The identified management actions, management targets and proposed review and revision of management actions are aligned with the overall management approach.

1.5.1 Biology and Ecology

1.5.1.1 Biology

The Greater Bilby is the only surviving member of the Thylacornyidae family. The species is characterised by soft silky fur that is ash grey over most of the body, except the belly which is pure white to cream. The tail is distinctive, with the first 20% being the same colour as the upper-body, the central 40% being black and the distal 40% pure white. The forelimbs have three stoutly clawed toes (and two unclawed toes) that enable the animal to burrow effectively. The long snout is well equipped with sensory vibrissae. Mature males attain double the body mass of mature females (males 800 – 2,500g, females 600 – 1,100g); have longer canines and a noticeably enlarged forehead (Pavey 2006).

The Dampier Peninsula Goanna was described in 2014 when fauna surveys conducted by the West Australian Museum on the Dampier Peninsula identified unusual specimens of *Varanus brevicauda*. Subsequent morphological and molecular genetic appraisals identified a new species *Varanus sparnus. Varanus sparnus* possess a more elongate body, less robust head and limbs, distinctive scales on the front of the arms that are large, squarish and lacking surrounding granules and a plainer pattern and colouration. *Varanus sparnus* is slightly smaller than *Varanus brevicauda* in maximum body size, making it the smallest known Varanus; growing up to 16.3 grams and 23 cm long from snout to vent. It has short legs, an elongate body, a reddish brown back with scattered black spots and a ridged, circular and short tail.

1.5.1.2 Distribution

Once common throughout the arid and semi-arid regions of Australia, European settlement brought about changes to the Greater Bilby's habitat and as a result during the 20th century its range reduced significantly with the species now being absent from its previous southern and central range. Populations are now restricted to within the Tanami Desert of the Northern Territory, the Great Sandy and Gibson Deserts, parts of the Pilbara and Kimberley (near Broome) regions of western Australia and the clayey and stony soils of the Mitchell grasslands of southwest Queensland. Changes to the Greater Bilby's distribution have been attributed primarily to the introduction of predators such as cats and foxes, introduction of herbivores such as cattle, camels and rabbits, modification and destruction of habitat and changes to fire regimes, associated with European settlement.

Little is known about the Dampier Peninsula Goanna other than that genetic and morphological studies have identified it as a separate species from *Varanus brevicauda* which has been more widely observed in Western Australia, the Northern Territory and South Australia. Overall despite there being 116 recorded locations for *Varanus brevicauda* within Western Australian, there are relatively few *Varanus brevicauda* records on the Dampier Peninsula, with previous records restricted to the Thunderbird study area, the surrounding region of the James Price Point precinct and the Duchess Paradise study area south east of Derby, although it is currently unknown if the records of *Varanus brevicauda* are correct. The lack of records is likely attributed to a paucity of biological survey work utilising pitfall and funnel trap methods on the Dampier Peninsula. To date *Varanus sparnus* has been collected from four locations including the Thunderbird study area. The other three locations are at Coulomb Point some 85 km west of the Thunderbird study area.

1.5.1.3 Habitat and Behaviour

Greater Bilbies are largely solitary, widely dispersed and found in low numbers. The Greater Bilby is a nocturnal species. During daylight hours this species remains sheltered in burrows they construct to a depth of 2 – 3 m. At night they leave their burrows to forage and have been known to move up to 5 km in an individual night in search

of food (ABAS 2002). Responding to changes in food availability, Greater Bilby home ranges are extensive and variable (van Dyck and Strahan 2008). To accommodate these large home ranges, Greater Bilbies can utilise over 12 burrows concurrently (Southgate 1987).

The Greater Bilby has historically been recorded within a variety of habitat types that have included open Eucalyptus forest and woodlands in southwest Australia, tall shrublands and woodlands in semi-arid Australia, and hummock grasslands and sparse forblands in arid Australia (Pavey 2006).

Contemporary habitat utilisation was investigated in the mid-1980s; Southgate (1990) reported that a broad range of environments were still occupied by the Greater Bilby and recognised three major vegetation types:

- Open tussock grasslands (grasses and forbes) growing on uplands and hills.
- Mulga woodlands/shrublands (pure mulga and mixed stands of mulga/witchetty bush) growing on ridges and rises.
- Hummock grasslands growing on sand plains and dunes, drainage systems, salt lake systems and other alluvial areas.

In Western Australia, bilbies have been recorded from a variety of substrate and vegetation types. These align broadly with the habitats identified by Southgate (1990). Three primary landscape types can be identified:

- Laterite, silcrete or stony rises and uplands (residual landforms).
- Drainage lines including upland creek systems, calcareous areas and broad palaeodrainage systems (fluvial landforms).
- Flat or gently undulating plains and dune fields.

The prevalence and persistence of bilbies has been found to vary among these habitats and in response to the rainfall gradient. The availability of key foods and the prevalence of key introduced species were also found to vary with landform types.

In the north, where rainfall is higher, bilbies occupy residual, fluvial and sand plain landforms. In the southern part of the range, where rainfall is lower, it is evident that bilbies have become more restricted primarily to occupy residual and fluvial landforms (Cramer et al. 2017).

Given their predilection for habitats suitable for digging, it is possible that they would preferentially utilise soil landforms such as topsoil stockpiles and windrows that would be created if the Project was implemented.

It is possible that there is some alignment between habitat utilised by the Greater Bilby and Dampier Peninsula Goanna. However, given the low number of *V. sparnus* specimens that have been collected, little is known about the goanna's habitat preferences. Existing specimens were collected from habitats broadly described as Pindan Shrubland with sandy soils associated with alluvial or sandstone deposits (Doughty *et al*. 2014). Like the Bilby, this species regularly excavates and lives in burrows (Doughty et. al. 2014) and thus any soil substrate on the Dampier Peninsular able to be excavated could currently be considered as potential suitable habitat.

1.5.2 Results of Baseline Surveys

Five terrestrial fauna surveys have been undertaken by Ecologia for the Project over a four year period, as listed in Table 5. The latest survey specifically targeted the Greater Bilby and is provided in Table 5 (Ecologia 2016). These surveys covered an area of approximately 15,694 ha, which included the Mine Site Development Envelope (5,648 ha) and surrounds.

Table 5: Surveys Applicable to the Greater Bilby and Dampier Peninsula Goanna

Survey Title	Survey Time
Level 1 Flora and Fauna Assessment	June 2012
Level 2 Terrestrial and Subterranean Fauna Assessment	April and October 2013
Haul Road and Accommodation Village Flora and Fauna Assessment	May 2015
Targeted Greater Bilby Assessment	September 2015

1.5.2.1 Habitat at the Thunderbird Mineral Sands Project

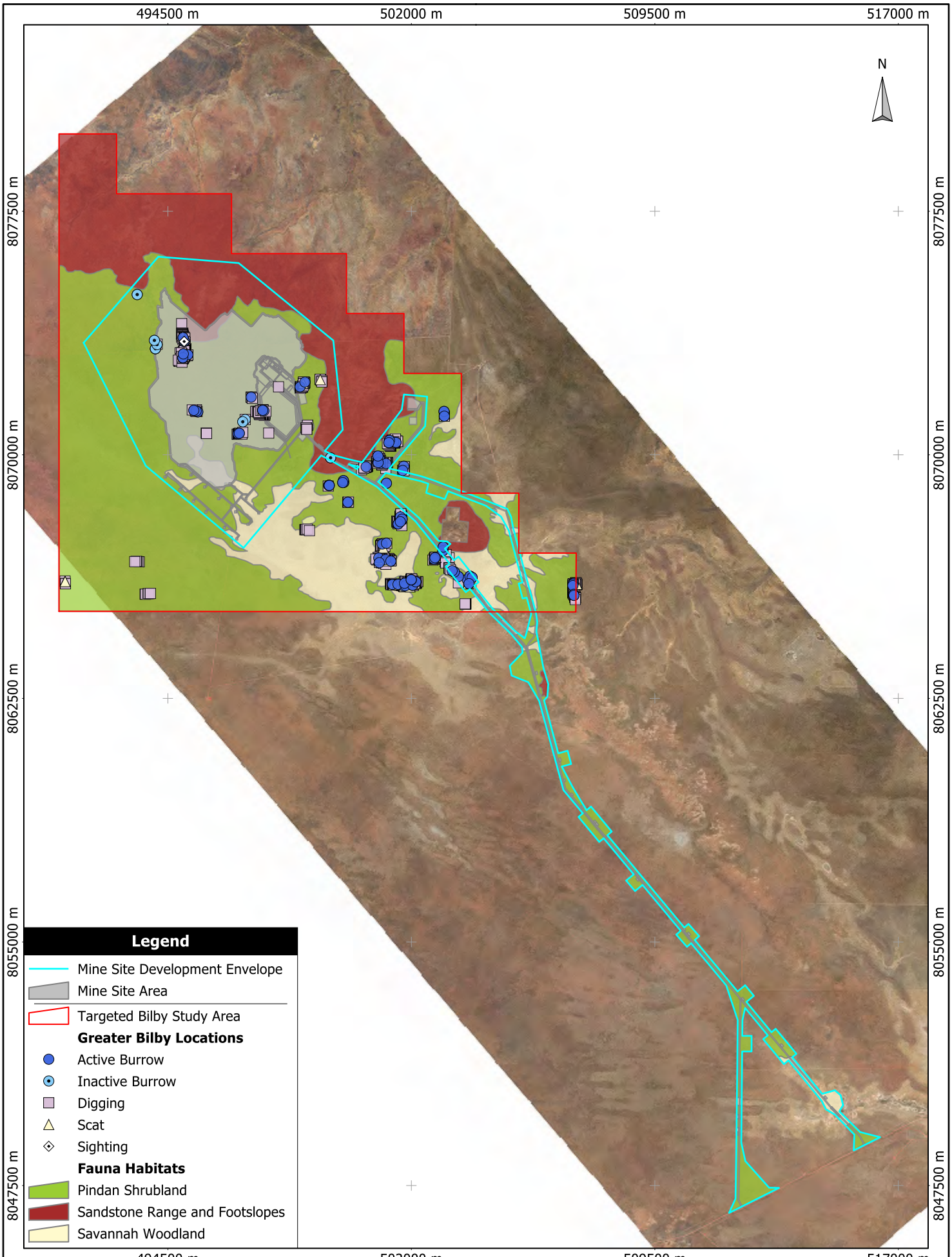
During the targeted Greater Bilby survey, Ecologia (2016) reported 754 records of Greater Bilby activity, evidenced by scats, diggings, inactive and active borrows (Appendix 1) (Figure 3). The majority of these records comprised diggings (670 records). Other evidence recorded included 25 scats, 17 active bilby burrows and 42 inactive bilby burrows. Greater Bilby presence was also confirmed at two active burrows using motion sensor cameras.

Scats observed during the targeted Greater Bilby survey underwent DNA analysis. The DNA extrapolation analysis results suggest the study area is likely to be supporting additional individuals (to the nine individuals confirmed through DNA analysis) at the time of surveying. It is estimated the Greater Bilby population within the study area at the time of the targeted survey was approximately 25 individuals, with this population likely to fluctuate according to seasonal and annual variations in rainfall, resource availability, fire history and feral animal populations.

In the broader region surrounding the Mine Site Development Envelope, the Greater Bilby has been reported within open woodland and open forest pindan vegetation types, with occurrence in pindan shrubland and other vegetation communities having a lower degree of preference (Southgate 2012 cited in Ecologia 2016). DBCA records show numerous records of the Greater Bilby within and surrounding the Mine Site Development Envelope (DBCA 2017).

During the targeted Greater Bilby survey, evidence of Greater Bilby occurrence was primarily recorded within the pindan shrubland vegetation type (Figure 3). More specifically, within the Mine Site Development Envelope, the Greater Bilby was recorded predominantly within dense, mature *Acacia tumida var. tumida* woodland micro-habitat. This micro-habitat appears to be influenced by fire age, with older fire age (>2 years) than surrounding areas. The dense, mature *Acacia tumida var. tumida* woodland micro-habitat forms a dense canopy layer, but relatively open ground cover, which is in contrast to surrounding areas which appear to have been burnt more frequently and are characterised by dense ground vegetation.

Twelve monitors (*Varanus brevicauda/Varanus sparnus*.) were collected during multiple baseline fauna surveys for the Thunderbird Mineral Sands Project (Figure 4). Of these, seven were collected in April 2013 and five were collected in October 2013. All specimens were collected prior to description of the new species *Varanus sparnus* in October 2014. Subsequent analysis of the one specimen from the baseline surveys vouchered at the West Australian Museum confirmed it was *Varanus sparnus.* This individual was recorded outside of the Mine Site Development Envelope (1.16 km south) and about 1.3 km from the southern boundary of the deposit. Of the other 11 monitors observed during baseline surveys, two were within the deposit area, one was adjacent to the borefield and the remaining eight were on the boundary of, or outside of the Development Envelope. Although limited information is available with regard to the habitat preferences of the Dampierland Goanna, this species has been reported to utilise Pindan Sands and Savannah Woodland habitats. Ten of the twelve Varanus individuals recorded in Thunderbird Project specific baseline studies were observed in Pindan Shrubland habitat with the remaining two observed in Sandstone Range and Footslopes. This habitat type is essentially the common Pindan vegetation of the region (Mattiske 2016). Given two disjunct location records exist approximately 85 km apart, and habitats occupied by the species are common between these locations, it is considered likely Varanus sparnus occurs throughout the Dampier Peninsula, wherever suitable sandy substrate habitat exists.



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Thunderbird Operations Pty Ltd
Thunderbird Mineral Sands Project

Figure 3

Greater Bilby Observation Records

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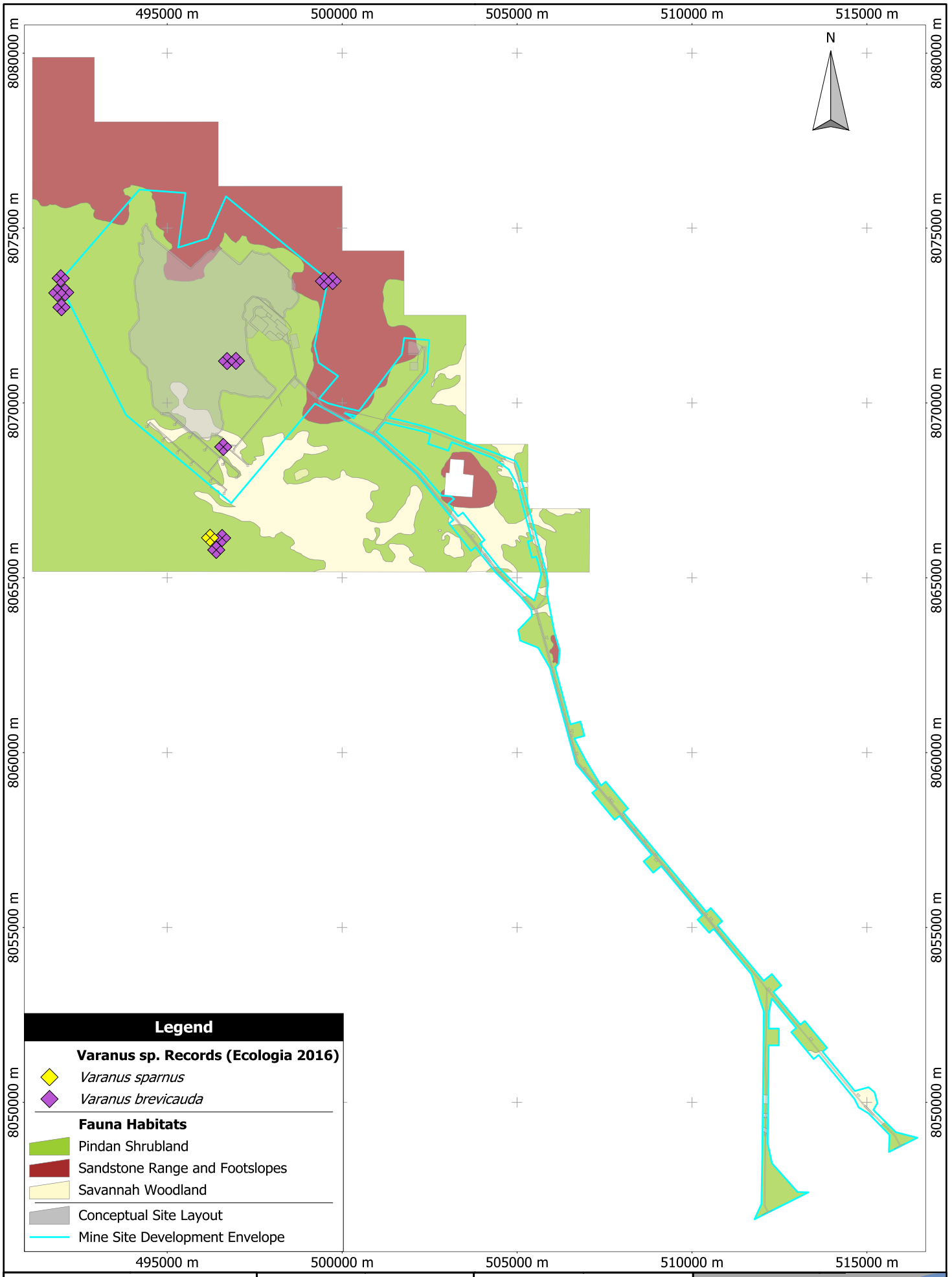

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0 5 km

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Thunderbird Mineral Sands Project

Figure

Varanus sp. Records

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1.5.3 Key Assumptions and Uncertainties

The Mine Site Development Envelope and surrounds have been subject to several investigations into terrestrial fauna including targeted studies for the Greater Bilby for the purpose of the PER. It is assumed that investigations and studies undertaken for the PER and management plans that have been developed have adequately:

- Mapped potential habitat within the Mine Site Development Envelope and immediate surrounds.
- Determined areas within the Mine Site Development Envelope where project activities will have minimal impact upon conservation significant fauna habitat and thus populations.
- Calculated total area of potential habitat loss (permanent, long term and short term).

Thunderbird has taken the precautionary approach and made the assumption that all of the Mine Site Development Envelope has potential to provide Greater Bilby and Dampier Peninsula Goanna habitat at some point within the 40+ year life of the Project. The highly mobile nature of the Greater Bilby and lack of knowledge of habitat preferences for the Dampier Peninsula Goanna makes it difficult to exclude areas within the Mine Site Development Envelope from being potential habitat. Some areas of the Development Envelope may be less preferred for use by the Greater Bilby based on substrate and absence or paucity of preferred food source plants. Preferences for the Greater Bilby are likely to be highly impacted by temporal changes to vegetation on a regional scale.

1.5.4 Management Approach

The management approaches discussed in this document are based and developed around the mitigation hierarchy of avoid, minimise, rehabilitate and off-set to ensure impacts to terrestrial fauna have been avoided or reduced to as low as reasonably practicable.

Management actions detailed in this FEMP have been specifically designed to ensure the Thunderbird Mineral Sands Project meets the environmental objectives for the environmental factor of Terrestrial Fauna and the relevant conditions of Ministerial Statement 1080. As such, they focus on the minimisation of impacts to the Greater Bilby within the Mine Site Development Envelope, and the avoidance of material harm to the Greater Bilby and the Dampier Peninsula Goanna outside the Mine Site Development Envelope.

Thunderbird has no direct control of activities off-tenure, and as a result, avoidance of material harm to the Greater Bilby and the Dampier Peninsula Goanna outside the Mine Site Development Envelope will be achieved through management actions within the Mine Site Development Envelope. Offsets will also contribute to the avoidance of material harm off-tenure. Risks and management actions were identified and prioritised using information gained from baseline surveys and other regional and local information within the public domain.

1.5.5 Rationale for Choice of Management Targets

Environmental criteria have been developed based upon baseline surveys undertaken between 2012 and 2015 as well as current scientific knowledge available. These studies identified a number of environmental parameters which are important to the conservation of terrestrial fauna species within the Dampier Peninsula, in particular the Greater Bilby.

It is recognised that the Project is located in an area that is currently used for pastoral activities (rangeland cattle grazing). This landuse will continue during the Project life and mine closure is aimed to return disturbed areas to the same pastoral land use. Pastoral activities are considered likely to influence survival and conservation of terrestrial fauna, including the Greater Bilby and Dampier Peninsula Goanna. Adverse impacts occur due to:

- Habitat destruction due to land clearing for pastoral infrastructure.
- Habitat degradation by introduced herbivores (cattle),

- Habitat degradation resulting from altered fire regimes.
- Mortality due to vehicle strike.
- Mortality due to introduced predator species (cats, dogs, foxes).

Site specific baseline studies have demonstrated that Greater Bilbies are coexisting with pastoral activities, (although the degree of influence of pastoralism on the known populations of Greater Bilbies in the area has not been determined) both within and in areas surrounding the Mine Site Development Envelope. Although there is little information available on existing Dampier Peninsula Goanna populations, given that rangeland cattle grazing is (and has historically been)one of the primary land uses throughout the broader region, it is likely that existing populations of this species are also co-existing with pastoral activities. Management actions, objectives and targets have taken into account the existing landuse recognising it will co-exist with the Project on a local and regional scale.

1.6 INDEX OF BIODIVERSITY SURVEYS FOR ASSESSMENT INFORMATION

Electronic data relevant to the Targeted Bilby Survey conducted as part of baseline investigations for the Project have been provided as a zip file at the time of submission of this document. The data package provided is consistent with IBSA requirements specified in EPA Instructions for preparing data packages for IBSA issued by the EPA in June 2018.

2. FAUNA MANAGEMENT PLAN PROVISIONS

This section identifies the legal provisions that Thunderbird proposes to implement to ensure the relevant conditions of Ministerial Statement 1080 are met with regard to the protection of the Greater Bilby and Dampier Peninsula Goanna.

It identifies management actions that will be implemented to mitigate and manage potential risks to these species, and management targets that will be used to measure the efficacy and performance of management actions. A monitoring framework for tracking performance against management targets is also included in this section, where relevant management targets are not met, management actions will be reviewed and where required adapted to meet the environmental objective. Proposed mechanisms for review and reporting during implementation are also included in this section.

2.1 FEMP OBJECTIVES

Condition 6-1 of Ministerial Statement 1080 specifies that the objectives of the FEMP are for Thunderbird to achieve the following:

- Minimise impacts to the Greater Bilby within the mine site development envelope as defined in Figure 2 of Schedule 1.
- No material harm to the Greater Bilby population outside of the mine site development envelope as defined in Figure 2 of Schedule 1.
- No material harm to the Dampier Peninsula Goanna population outside of the mine site development envelope as defined in Figure 2 of Schedule 1.

Within this FEMP, a number of management objectives have been developed to meet the requirements of the FEMP objectives specified in Ministerial Statement 1080. Management objectives have been identified to address potential impacts detailed in Section 2.1 of this FEMP. The purpose of management objectives is to define Thunderbirds aims in context with potential impacts identified in Section 1.3 of this FEMP. These contribute to achievement of the overall objectives of the FEMP.

2.2 MANAGEMENT OBJECTIVES, ACTIONS AND TARGETS

To achieve the FEMP objectives specified in Ministerial Statement 1080, a series of fit for purpose risk-based management objectives and actions have been developed and prioritised to ensure potential project related impacts on the Greater Bilby and the Dampier Peninsula Goanna are minimised and are considered acceptable. To ensure management actions are effective, measurable management targets have been identified. If management targets are met then impacts will be minimised and the overarching EPA's environmental objective for terrestrial fauna will be achieved.

Management objectives, actions and targets focussed on achieving the overall FEMP objectives are presented in Table 6 and Table 7. These focus the greatest management effort on proposal activities that have the highest likelihood of causing adverse impact on the species. The order of management objectives listed and the resultant management actions and targets is from highest to lowest management effort to achieve the overall FEMP objectives.

It is noted that Thunderbird has no direct control of activities outside of its Mining Act tenure, and as a result, avoidance of material harm to the Greater Bilby and the Dampier Peninsula Goanna outside the Mine Site Development Envelope will primarily be achieved through management actions within the Mine Site Development Envelope. Offsets will also contribute to the avoidance of material harm.

It is noted that the Project through land clearing activities has potential to impact on fauna habitat. This impact is anticipated to be minimised over time by rehabilitation. Management and monitoring of rehabilitation whilst addressed in this Plan, is addressed more comprehensively in the Greater Bilby Habitat Rehabilitation Plan required by Condition 9-1 of Ministerial Statement 1080. Management targets specific to rehabilitation documented in this FEMP are for those parameters considered most relevant to Greater Bilby habitat establishment, which should also benefit the Dampier Peninsula Goanna.

Table 6: Fauna Environmental Management Plan Provisions – FEMP Objective 1

Management Objective: Minimise the potential for vehicle strike causing injury or death to the Greater Bilby within the Minesite Development Envelope **Residual Risk: Medium** **Timing: Construction, operations and closure**			
Management Action	**Management Target**	**Monitoring**	**Reporting**
Speed limits implemented for Project areas with a maximum of 60 km applied to travel on the Site Access Road.	No Greater Bilby deaths due to vehicle strike attributable to the Project.	Speed record devices fitted in product transport haulage trucks.	• Internal Incident Reports • Land Survey Report • Regulatory Agency Notification of Incident Report • Annual Report (CAR)
Travel on the Site Access Road between dusk and dawn restricted to essential vehicles being product trucks or emergency vehicles.		Site entry records between dusk and dawn	
Project topsoil stockpiles not located within 5 m of Site Access Road		Survey data and aerial imagery	
Management Objective: Minimise the potential for land clearing activities to cause injury or death to the Greater Bilby within the Mine Site Development Envelope **Residual Risk: Medium** **Timing: Construction and operations**			
Management Action	**Management Target**	**Monitoring**	**Reporting**
Pre clearance surveys undertaken 2 weeks prior to land clearing	No Bilbies killed during land clearing activities due to direct strike.	Presence/absence of Greater Bilby usage of the area (burrows, scats, diggings)	• Greater Bilby Record Database • Quarterly DBCA Fauna Licence Submission • Regulatory Agency Notification of Incident Report • Annual Report (CAR)
Presence of Greater Bilbies in active burrows identified		Motion sensor cameras installed for active burrows within area to be cleared to determine if being used immediately prior to clearing.	
Inactive burrows to be manually collapsed at least 1 week prior to land clearing.		• Burrow location and status records • Date manual collapse undertaken.	
Greater Bilby capture and relocation program implemented 1 week prior to land clearing for active, occupied burrows.		• Greater Bilby capture and relocation Records • Greater Bilby Tracking Records • Greater Bilby Care Record	
Fauna spotter present during land clearing activities	No Bilbies killed during land clearing activities due to direct strike	• Presence or absence of Greater Bilby animals observed during land clearing • Health status of Greater Bilbies impacted by earth moving equipment during land clearing activities • Greater Bilby Care Record	

Management Objective: Minimise requirements for land clearing and associated loss/fragmentation of habitat that may displace Greater Bilbies **Residual Risk: Low** **Timing: Construction, operations and closure**			
Management Action	**Management Target**	**Monitoring**	**Reporting**
Clearing in accordance with internal Clearing Permit requirements	No clearing outside of approved clearing areas	Survey data and aerial imagery	• Clearing Register • Annual Report (CAR)
Minimise amount of active cleared areas	Clearing undertaken less than 1 month prior to proposed use	Survey data and aerial imagery	
Management Objective: Rehabilitate disturbed land to provide potential Bilby habitat within the Mine Site Development Envelope **Residual Risk: Medium** **Timing: Operations and closure**			
Management Action	**Management Target**	**Monitoring**	**Reporting**
Landform reinstated on completion of use of deposit area	Area of landform restoration per annum consistent with Annual Mine Plan	• Aerial photography • Survey data to map surface topography	• Rehabilitation Register • Annual Mine Plan • Annual Report (CAR)
Placement of overburden and topsoil over deposit areas	Soil bulk density in top 3 m consistent with pre mining measurements within 5 years	Soil bulk density measurement (pre mining, on completion of landform restoration, on completion of 1st wet season, after completion of subsequent dry season)	• Rehabilitation Register • Annual Report (CAR)
Land rehabilitated on completion of use of non-deposit areas	Area of rehabilitation consistent with Annual Rehabilitation Plan	• Aerial photography • Rehabilitation Monitoring (biannual - wet and dry season; species diversity, % cover, weed presence)	• Rehabilitation Register Annual Report (CAR)
Vegetation established via topsoil replacement, seeding and or planting	Vegetation consistent with pre-mining measurements within 5 years of landform restoration	• Rehabilitation Monitoring (biannual - wet and dry season; species diversity, % cover, weed presence) • Presence/absence of bilby usage of the area (burrows, scats, diggings)	• Rehabilitation Register • Bilby Record Database • Annual Report (CAR)

Management Objective: Minimise noise and light pollution within Mine Site Development Envelope **Risk: Low** **Timing: Construction, operations and closure**			
Management Action	**Management Target**	**Monitoring**	**Reporting**
Travel on the Site Access Road between dusk and dawn restricted to essential vehicles being product trucks or emergency vehicles.	No Greater Bilby deaths due to vehicle strike attributable to Project.	Site entry records between dusk and dawn	• Internal Incident Reports • Regulatory Agency Notification of Incident Report • Annual Report (CAR)
Lights placement minimises shine external to work areas	Light emissions contained to work areas	• Post Construction Inspection • Annual Inspection	
Equipment design compliant with relevant Australian Standards.	Compliance with industry requirements for noise emissions	• Post commissioning measurement • Annual measurement	
Management Objective: Minimise fauna entrapment leading to injury or death of Greater Bilby within the Mine Site Development Envelope **Residual Risk: Low** **Timing: Construction, operations and closure**			
Management -Action	**Management Target**	**Monitoring**	**Reporting**
Fauna egress installed in trenches, landfill, open excavations or water holding facilities.	No Greater Bilby deaths due to entrapment in open excavations, trenches, landfill or water holding facilities.	Daily water storage inspections.	• Incident Report • Regulatory Agency Notification of Incident Report • Annual Report (CAR)
Management Objective: Minimise exposure to radioactive materials that could result in injury or death of bilbies within the Mine Site Development Envelope **Residual Risk: Low** **Timing: Operations and closure**			
Management Action	**Management Target**	**Monitoring**	**Reporting**
Process wastes blended prior to in pit disposal and covered with overburden	Radiation levels at surface consistent with measured pre mining background levels.	Radiation Rehabilitation Monitoring (on completion of landform restoration, biannual thereafter for five years after rehabilitation was completed; Geiger counter (µSv/hr)).	• Rehabilitation Register • Incident Report • Annual Report (CAR) • Annual Radiation Monitoring Report to Department of Mines Industry Regulation and Safety (DMIRS)

Table 7: Fauna Environmental Management Plan Provisions – FEMP Objectives 2 and 3

Management Objective: Minimise changes to predator abundance that may adversely impact Greater Bilby Populations outside of the Mine Site Development Envelope **Residual Risk: Low** **Timing: Construction, operations and closure**			
Management Action	**Management Target**	**Monitoring**	**Reporting**
Fence domestic waste facilities within Mine Site Development Envelope	Predator attractants (e.g. uncovered waste and water sources) fenced to minimise accessibility to introduced predator species	• Monthly introduced predator species monitoring (presence/absence, species etc.) • Weekly infrastructure integrity inspections • Opportunistic observations	• Introduced predator species Inspection Form • Introduced predator species Eradication Form • Rehabilitation Register • Incident Report • Annual Report (CAR)
Project borrow pits constructed and rehabilitated to minimise permanent water holding ability	Minimise ponded water available in constructed landforms	• Post rehabilitation earthwork inspection • Post rainfall inspection • Opportunistic inspection	
Predator control program implemented within the Mine Site Development Envelope to target cats	Reduced observation of predators in project attractant areas (landfill, WWTP, water storage ponds and accommodation camp)	Monthly introduced predator species monitoring (presence/absence, species etc.)	
Management Objective: No net increase in fire frequency within Mine Site Development Envelope **Residual Risk: Low** **Timing: Construction, operations and closure**			
Management Action	**Management Target**	**Monitoring**	**Reporting**
Fire Fighting equipment maintained at the Project	Fire extinguishers and firefighting equipment and systems installed in Project area in compliance with relevant Australian Standards.	Quarterly Emergency Response Equipment Inspections	• Incident Report • Land Clearing Register • Hot Work Permit Register • Annual Report (CAR)
Project Emergency Response Personnel Trained in fire response	Emergency response team in place with demonstrated ability to respond to bush fire	Annual fire response training exercise	
Fire breaks installed and maintained	Fire breaks installed and maintained in compliance with project Annual Mine Plan	Aerial photographs Fire Break Records	
Hot Work Permit system implemented	No unplanned fires attributable to Project activities	Aerial photographs	

Management Objective: Minimise requirements for Project land clearing and associated loss/fragmentation of habitat that may displace Greater Bilbies and Dampier Peninsula Goanna **Residual Risk: Low** **Timing: Construction, operations and closure**			
Management Action	**Management Target**	**Monitoring**	**Reporting**
Clearing in accordance with internal Project Clearing Permit requirements	No clearing outside of approved clearing areas	Survey data and aerial imagery	• Clearing Register • Annual Report (CAR)
Minimise amount of active cleared areas	Clearing undertaken less than 1 month prior to proposed use	Survey data and aerial imagery	

2.3 MONITORING

It is recognised that monitoring will be required to determine whether the management actions are being undertaken and whether these are effective with respect to the relevant targets and objectives being achieved. Monitoring that will be undertaken for each management objective is documented in Table 6 and Table 7. This includes a mix of both quantitative monitoring programs, results of routine inspections and data collection programs that will provide the information required to evaluate achievement of the target.

Details about the more quantitative monitoring aspects contained in Table 6 and Table 7 are provided in the following sub sections.

2.3.1 Greater Bilby and Dampier Peninsula Goanna Presence Within Areas to be Cleared

To achieve the management objective of minimising the potential for land clearing activities causing injury or death to Greater Bilbies, a monitoring program has been developed. This will be an integral part of the pre-mining internal clearing processes. Whilst it is not a specific requirement of Ministerial Statement 1080, the presence of Dampier Peninsula Goanna within project areas to be cleared will also be monitored.

2.3.1.1 Greater Bilby

It is recognised that the Greater Bilby is a highly mobile species and utilisation of burrows can vary nightly. The presence of Greater Bilbies in mining cells planned to be cleared will be assessed two weeks prior to clearing being undertaken. This will be determined on a presence / absence basis considering evidence such as burrows, scats, and diggings. Monitoring will record:

- Burrow locations (GPS co-ordinates) and status (active or inactive).
- Scat locations (GPS co-ordinates) and status (fresh or old) and if samples are collected for DNA analysis.
- Digging locations (GPS co-ordinates) and status (fresh or old).

Where presence is observed, specifically burrows that appear to be active (fresh spoil, tracks or scats), motion sensor cameras will be deployed to determine if burrows are being actively used or not. If burrows are not being actively used, these will be manually collapsed at least two weeks prior to land clearing. Records will be kept of locations where motion sensor cameras were installed, date range for data collection, results of monitoring (i.e. Greater Bilby observed or not and how frequently) and date burrows were collapsed if no records were made of burrow use.

If burrows are found to be being actively used, a capture and release (relocation) procedure will be implemented with the aim of capturing individuals prior to entry of mechanised earth moving equipment. Thunderbird has worked closely with DBCA to develop an acceptable relocation procedure (Appendix 2). Discussions with DBCA indicate that they will require captured animals to be fitted with detection devices to allow monitoring of survival and dispersal post relocation. Appropriate data collection and management mechanisms will form part of the relocation procedure.

Land clearing will be undertaken using large scale mechanised earth moving equipment. Thunderbird will ensure that a Fauna Spotter is present during land clearing activities. The number of Fauna Spotters present will take into account the area and spatial extent of land to be cleared and the number of pieces of machinery to be used for the clearing recognising this may influence the likelihood of encountering fauna. The Fauna Spotter will meet the following requirements:

- Have appropriate training and experience in fauna handling techniques.
- Will hold a permit to handle and move significant fauna under Regulation 15 of the *Wildlife Conservation Act 1950*.

- Have suitable equipment to administer emergency care to injured and or displaced fauna.
- Have access to a care facility that can used to rehabilitate injured fauna. Thunderbird has established relationships with wildlife rehabilitation care organisations in Broome, who can provide care if required.

Fauna Spotters will monitor the following during land clearing:

- Presence or absence of Greater Bilbies during clearing.
- Number of individual Greater Bilbies impacted directly during clearing.
- Health status of any directly impacted Greater Bilbies.
- Actions taken to provide care for directly impacted Greater Bilbies (i.e. first aid, medical attention, and transfer to accredited carer).

2.3.1.2 Dampier Peninsula Goanna

Given that the Dampier Peninsula Goanna cannot be readily identified by easy to see morphological aspects in the field, it is not practical to monitor this species without invasive tissue sampling. Tissue sampling would cause an unreasonable amount of stress to this species and is therefore considered unacceptable from an animal ethics perspective. Despite this, the Fauna Spotter will monitor:

- The presence/absence of goannas during clearing.
- Number of individual goannas impacted directly during clearing.
- Health status of any goannas directly impacted animals.
- Actions taken to provide care for directly impacted goannas (i.e. first aid, medical attention, transfer to accredited carer).

In the instance of dead goannas being encountered during land clearing, Thunderbird will collect and lodge appropriate material for DNA analysis. This will provide additional scientific information about the abundance and distribution of the species.

2.3.2 Rehabilitation Monitoring

Rehabilitation of disturbed areas typically includes landform restoration and revegetation. The key landform restoration activities for the Project relate to filling of mine voids within the deposit area with blended process wastes and subsequent covering with overburden and topsoil.

Rehabilitation of land associated with the Project will include:

- Rehabilitation of areas used during construction phases of the Project. Typically this includes laydown areas, access tracks and borrow pits. This will typically occur within the first five years of Project commencement.
- Rehabilitation of deposit areas. This will occur progressively throughout the Project life with the deposit area containing a mosaic of individual mine cells having topsoil stripped, overburden removed, ore mined, process wastes deposited in mine voids, overburden and topsoil replaced and having vegetation re-established. The period of time between commencement of topsoil removal and landform restoration being completed is estimated to be about four years on average.
- Rehabilitation of long term project infrastructure areas. This will occur at the end of Project life i.e. post year 42 when long term infrastructure such as ore processing plants, roads, power generation, water supply and accommodation infrastructure is removed.

Rehabilitation to provide fauna habitat most relevant to the subject of this FEMP is within the deposit area. Management actions contained in Table 6 relate to success reconstruction of landform, placement of overburden and topsoil and vegetation reestablishment.
Monitoring of landform reinstatement will be via review of aerial photography and survey data. Results will be compared to the Annual Mine Plan to ensure the area of landform reinstated is consistent with the plan and the landform topography is consistent with pre mining landforms.

Reinstatement of the soil profile for the upper three metres is important recognising this is the maximum depth Greater Bilby burrows are found. The bulk density of reinstated soil profiles within individual mine cells will be measured and compared to pre mining measurements. Soil density monitoring will be undertaken for individual mine cells within the deposit area at the following frequency:

- Pre mining (i.e. less than 12 months prior to mining).
- On completion of landform restoration (less than 3 months after topsoil placement).
- On completion of the first wet season after land form restoration was completed.
- Annually thereafter for five years.

Soil density will be measured using a hand held penetrometer ("Perth Penetrometer" type) at surface and at 500 mm depth at a density of two locations per 200 x 100 m mine cell. The frequency of monitoring at individual sites will be determined based on progression towards short, medium and long term completion criteria. It is anticipated that as the age of rehabilitation increases, the need for bi annual monitoring will decrease.

It is recognised that Greater Bilbies are omnivorous and have habitat preferences related to plant species that provide food resources. Greater Bilbies select habitat types such as:

- Stands of particular Acacia species that harbour root-dwelling larvae (grubs).
- Particular grass species that provide food sources such as *Yakirra australiensis* and *Dactylobium radulans*, that provide seed and *Cyperus bulbosus* that provide bulbs.

It is suspected that given the Dampier Peninsula Goanna occupy similar habitats to the Greater Bilby, that this species has a fossorial habit and has been observed in Pindan habitats, which dominate the Dampier Peninsula. No specific vegetation types or habitats are known to limit conservation of the Dampier Peninsula Goanna. Monitoring of vegetation establishment in areas where landform restoration has been completed will include measurement of:

- Species diversity.
- Percentage cover.
- Weed presence.

Monitoring will be conducted biannually (i.e. wet and dry season) for each mine cell. Permanent monitoring sites will be established in each 200 x 100 m mining cell as progressive rehabilitation is completed. Results will be compared to information collected during baseline studies and pre mining data for each cell (i.e. analogue). The frequency of monitoring at individual sites will be determined based on progression towards short, medium and long term completion criteria. It is anticipated that as the age of rehabilitation increases, the need for bi annual monitoring will decrease.

2.3.3 Radiation Monitoring

Voids developed within the deposit area will be filled with blended process wastes, covered with overburden and topsoil. This process is termed landform restoration. Geochemical characterisation of mine and process wastes has considered the radiological characteristics of process wastes (Radiation Professionals 2016). The proposed void backfilling method, specifically blending of process wastes from primary and secondary processing and

covering of process wastes with overburden prior to topsoil placement will result in radiation levels within the restored landform being consistent with pre mining levels.

Radiation monitoring will be undertaken for individual 200 x 100m mine cells within the deposit area at the following frequency:

- Pre mining (i.e. less than 12 months prior to mining).
- On completion of landform restoration (less than 1 month after topsoil placement).
- Annually for two years post land form restoration.

Monitoring will be conducted using a Geiger counter to measure total radiation activity at the surface using a 100 by 100 m grid (1 sample per hectare). This will provide results in milliSieverts per hour (µSv/hr). Measurement of radiation activity levels will be undertaken prior to mining to provide a comparator for post mining results.

2.4 REPORTING PROVISIONS

2.4.1 Annual Reporting

Thunderbird will prepare Annual Environmental Reports (AERs) to be submitted to regulatory authorities. The format of these reports will be consistent with requirements stipulated by individual regulatory authorities.

A Compliance Assessment Report (CAR) will be submitted to the Environmental Protection Authority Services unit of DWER at an agreed date. The report will document compliance with conditions of approval including assessment of compliance with management plan requirements where management plans form part of approval conditions.

2.4.2 Exceedance Reporting

In the event that management targets are exceeded, the CEO of the OEPA will be notified within 7 days of identification of the exceedance.

2.4.3 Incident Reporting

In recognition of the conservation status of the Greater Bilby and the high degree of public interest in Greater Bilby conservation on the Dampier Peninsula, Thunderbird will report Greater Bilby deaths directly attributable to the Project. Relevant regulatory authorities (EPA, DBCA, DoEE and DMIRS) will be notified within 7 days of the death occurring.

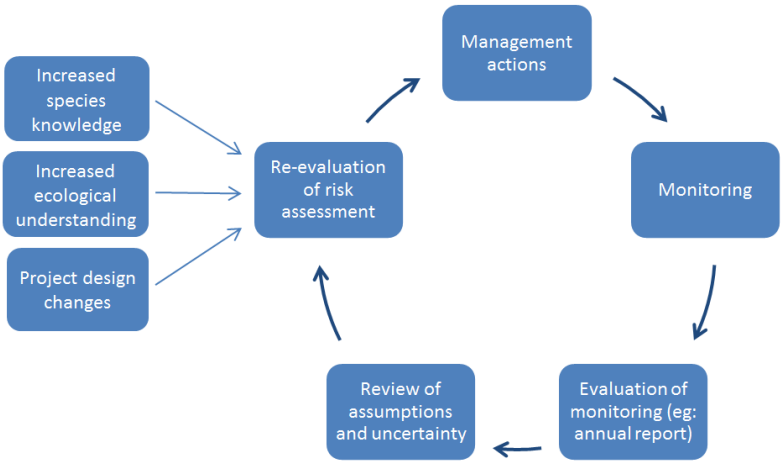
Given the Dampier Peninsula Goanna requires laboratory analysis for identification. If any goannas suspected to be *V. sparnus* are killed as a result of mining operations then goanna remains will be preserved and submitted for laboratory identification. If any impacted goannas are confirmed as *V. sparnus* then relevant regulatory authorities (EPA, DBCA and DMIRS) will be notified within 7 days of the identification.

3. ADAPTIVE MANAGEMENT

It is recognised that there is a level of scientific uncertainty surrounding the Greater Bilby in the Dampier Peninsula and the Dampier Peninsula Goanna, particularly in relation to abundance and distribution. This makes determination of residual impacts of implementing the Project on local or regional scales difficult with any degree of certainty. Given the 40+ year life of the Project, it is reasonable to expect that additional information will be gained on the species that may influence future management. For this reason it is important that the management approach for the Greater Bilby and Dampier Peninsula Goanna is adaptive.

Review processes for the FEMP will be based on formal dates after Project commencement and triggers such as:

- Monitoring results: If site specific monitoring program results indicate that management targets are not being achieved.
- Changes in knowledge: If additional information about the species use of the Mine Site Development Envelope or region is received that would better inform management approaches.
- Significant changes to Project design: The relevance and effectiveness of management measures would be considered.



Formal time periods for review of the FEMP will be:

- Annually for the first five years of Project life. After this period, the Project is anticipated to reach a steady state where construction has been completed and operational activities will have become standardised. The risk of unexpected impacts on the Greater Bilby and Dampier Peninsula Goanna after this period will be lower.
- Two yearly thereafter.

Reviews of the document will be undertaken in consultation with DBCA.

4. STAKEHOLDER CONSULTATION

Thunderbird have engaged in an extensive stakeholder consultation process during exploration, Project design and feasibility stages. This has included consultation specifically on environmental aspects including potential impacts to conservation significant fauna in the vicinity of the project. Initially this related to Greater Bilbies and a Preliminary Bilby Environmental Management Plan (BEMP) was developed to support the PER. Subsequently the EPA requested the scope of the BEMP was broadened to include other conservation significant species such as the Dampier Peninsula Goanna. During consultation the FEMP was discussed and draft copies provided to stakeholders for consideration. Table 8 lists those consulted about potential impacts to Greater Bilbies and Dampier Peninsula Goanna.

Table 8: Stakeholder Engagement

Stakeholder	Engagement Method	Actions
Department of Biodiversity Conservation and Attractions: • North West Regional Office • Scientific Branch • Environmental Management Branch	Meetings Site Visit (regional officers) Ecological reports supplied Draft FEMP and Bilby protocols supplied	Draft FEMP and protocols updated based on verbal and written feedback
Department of Environment and Energy	Site visit Phone and email correspondence Draft FEMP and Bilby protocols supplied	Offset package considered Feedback provided in discussions Draft FEMP and protocols updated based on verbal feedback
Department of Agriculture and Food	Meetings Greater Bilby fact sheet supplied Ecological reports supplied	
Department of Lands, Pastoral Lands Liaison Officer, Broome	Meetings Greater Bilby fact sheet supplied	
Malcolm Douglas Wildlife Park	Meeting Greater Bilby fact sheet supplied Draft BEMP supplied	Draft BEMP updated based on feedback (pre clearance survey considerations)
Kimberley Wildlife Carers and Associates (Jan Martin)	Meetings Greater Bilby fact sheet supplied Draft BEMP supplied	Draft BEMP updated based on feedback (inclusion of injured wildlife care provisions)
Native Animal Rescue Broome (Chris Mitchell)	Meetings Greater Bilby fact sheet supplied Draft BEMP supplied	Draft BEMP updated based on feedback (inclusion of injured wildlife care provisions)
Kimberley Pilbara Cattleman's Association (Catherine Marriott)	Meetings Greater Bilby Fact Sheet supplied	Project fact sheet specific to pastoralist prepared and supplied. Distributed to members by KPCA.
Yeeda Pastoral Company (Jack Burton)	Meetings Phone end email correspondence	Results of surveys provided
Rangelands NRM	Meeting Greater Bilby fact sheet supplied Draft FEMP supplied	
Derby Landcare	Meetings Greater Bilby fact sheet supplied	

Stakeholder	Engagement Method	Actions
Buru Energy (Kris Waddington)	Meetings Draft FEMP supplied	Draft FEMP updated based on feedback (consideration of pre clearance survey provisions and release programs).
Stuart Dawson (PhD candidate)	Meetings Draft BEMP supplied	Results of research considered in PER and BEMP
Alistair Winrow (Honours student)	Meetings Greater Bilby fact sheet supplied Draft FEMP supplied	
Robin Chapple MLC	Meetings	
Broome Chamber of Commerce and Industry (Board members)	Meetings Greater Bilby fact sheet supplied	
Environs Kimberley	Meetings Site Visit Ecological reports supplied Greater Bilby fact sheet supplied Draft BEMP supplied	
World Wildlife Fund (Broome) and Nyul Nyul Rangers	Meetings Ecological reports supplied Draft BEMP supplied	
Australian Conservation Foundation (Broome)	Meetings Ecological reports supplied Draft BEMP supplied	
Dr Bill Low (Low Ecological)	Phone and email correspondence	Previous management experience considered in PER and FEMP
Main Roads (Cape Leveque upgrade)	Phone and email correspondence Meetings Draft FEMP and Bilby Protocols supplied	Verbal feedback incorporated into FEMP and Bilby Protocols
Richard Southgate	Meetings Draft FEMP and Bilby Protocols supplied	Written feedback incorporated into FEMP and Bilby Protocols

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APPENDICES

APPENDIX 1: TARGETED GREATER BILBY ASSESSMENT (ECOLOGIA 2016)

JUNE 2016

Providing sustainable environmental strategies,
management and monitoring solutions
to industry and government.

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ENVIRONMENT

SHEFFIELD RESOURCES LTD
THUNDERBIRD PROJECT
TARGETED GREATER BILBY ASSESSMENT

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Document Status						
Rev	**Author**	**Reviewer/s**	**Date**	**Approved for Issue**		
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EXECUTIVE SUMMARY

Sheffield Resources Limited is undertaking biological surveys to support environmental impact assessment and environmental approvals for its Thunderbird Project. The Thunderbird Project study area (study area) is located approximately 70 kilometres west of Derby on the Dampier Peninsula and is approximately 148.8 km^2 in area, of which 17.23 km^2 is proposed disturbance area. Previous Level 1 and 2 vertebrate fauna surveys of the study area recorded the Greater Bilby (*Macrotis lagotis*). In order to gain a more comprehensive understanding of Greater Bilby occurrence, habitat utilisation and estimated size of the resident population within the study area, Sheffield commissioned *ecologia* to conduct a targeted Greater Bilby assessment.

The targeted Greater Bilby assessment was conducted by two zoologists over six days from the 22 to 27 September 2015. Prior to the field survey, secondary evidence search transects were selected to provide spatially representative and systematic coverage within the previously mapped pindan shrubland habitat type. Each transect was traversed by a zoologist, searching for secondary evidence signs of Greater Bilby (diggings, tracks, scats and burrows). Where active burrows were recorded in relatively close proximity to vehicle tracks (facilitating the collection of cameras at conclusion of field survey), motion cameras were established in an attempt obtain Greater Bilby burrow utilisation records. For a greater understanding of actual number of individuals present, DNA extraction and analysis of Greater Bilby scats was completed.

The Greater Bilby was recorded from numerous locations throughout the study area via secondary evidence in the form of diggings, scats, active burrows and motion camera records. A total of 26 scats were collected during the targeted assessment and subsequently underwent DNA extraction and analysis. Of the 26 scats collected, 15 produced viable amounts of DNA with 13 scats able to facilitate individual analysis. This analysis resulted in a total of nine individual Greater Bilbies being identified.

The DNA extrapolation analysis results suggest the study area is likely to be supporting additional individuals (to the nine individuals confirmed through DNA analysis) at the time of surveying. It is estimated the Greater Bilby population within the study area at the time of the targeted survey was approximately 25 individuals, with this population likely to fluctuate according to seasonal and annual variations in rainfall, resource availability, fire history and feral animal populations. When comparing the spatial occurrence of Greater Bilby in relation to location of proposed disturbance areas, it can be demonstrated that the Greater Bilby occurs both inside proposed mine disturbance areas and within close proximity to haul road disturbance areas. Overall, however, more Greater Bilby activity was recorded outside proposed disturbance areas. Using the estimate of 25 individuals, a home range of 3.69 km^2 per individual is calculated within the pindan shrubland habitat type.

The Greater Bilby was almost exclusively recorded from the pindan shrubland habitat type, specifically within the dense, mature *Acacia tumida* var. *tumida* woodland micro-habitat. This micro-habitat appears to be influenced by fire age, with older fire age (>2 years) then surrounding areas. The dense, mature *Acacia tumida* var. *tumida* woodland micro-habitat forms a dense canopy layer but relatively open ground cover, which is in contrast to surrounding areas which appear to have been burnt more frequently and are characterised by dense ground vegetation.

The Greater Bilby population status on Dampier Peninsula is not clear, however it has been suggested it is most likely a scattered population in low densities. Relatively few biological surveys have been completed on Dampier Peninsula, however three recent biological assessments have all recorded Greater Bilby, suggesting the species may be more common on Dampier Peninsula than previously thought. Due to the uncertainties regarding the status of the Dampier Peninsula population, the regional significance of the Greater Bilby population within the study area is difficult to determine. Using the estimated national Greater Bilby population of 10,000, should the study area contain 25 individuals, than the study area would contain 0.25% of the estimated national Greater Bilby population.

1 INTRODUCTION

1.1 PROJECT BACKGROUND

Sheffield Resources Limited (Sheffield) is an emerging Western Australian company, with significant mineral sands, nickel, talc and iron assets, all located within the state of Western Australia. Sheffield is undertaking biological surveys to support environmental approvals for their Thunderbird mineral sand project. The Thunderbird project study area (study area) is approximately 148.8 km^2 in area, of which 17.23 km^2 is proposed disturbance area. The study area located approximately 70 kilometres west of Derby on the Dampier Peninsula (Figure 1.1).

Sheffield has previously commissioned *ecologia* Environment (*ecologia*) to undertake a two-phase Level 2 terrestrial (vertebrate and SRE invertebrate) and subterranean fauna survey of the study area. Level 2 assessments were completed in 2014. An additional Level 1 survey was completed for infrastructure areas including haul road and proposed accommodation camp in May 2015.

Both the initial Level 2 vertebrate fauna survey and the more recent Level 1 survey recorded the Greater Bilby (*Macrotis lagotis*) in the study area. In order to gain a comprehensive understanding of Greater Bilby occurrence, habitat utilisation and resident population estimate within the study area, Sheffield commissioned *ecologia* to conduct a targeted Greater Bilby assessment.

1.2 LEGISLATIVE FRAMEWORK

Commonwealth and State legislation applicable to the conservation of native flora and fauna in Western Australia (WA) includes, but is not limited to, the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), the Western Australian *Wildlife Conservation Act 1950* (WC Act) and the *Environment Protection Act 1986* (EP Act). Section 4a of the EP Act requires that developments take into account the following principles applicable to native flora and fauna:

- **The Precautionary Principle:** Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;
- **The Principles of Intergenerational Equity:** The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations; and
- **The Principle of the Conservation of Biological Diversity and Ecological Integrity:** Conservation of biological diversity and ecological integrity should be a fundamental consideration of development projects.

The EPBC Act was developed to provide for the protection of the environment, particularly those aspects of the environment that are matters of national environmental significance, to promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources; and to promote the conservation of biodiversity. The EPBC Act includes provisions to protect native species (in particular to prevent the extinction and promote the recovery of threatened species) and to ensure the conservation of migratory species. In addition to the principles outlined in Section 4a of the EP Act, Section 3a of the EPBC Act includes the principle of ecologically sustainable development; that decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equity considerations.

The WC Act was developed to provide for the conservation and protection of wildlife in Western Australia. Under the WC Act, all native flora and fauna are protected in WA; however, the Minister may, via a notice published in the Government Gazette, declare a list of flora and fauna identified as likely to become extinct, or as rare, or otherwise in need of special protection. The current listing was gazetted on 2 December 2014.

1.3 GREATER BILBY DESCRIPTION

Conservation status: EPBC Act Vulnerable, WC Act Schedule 1 (Vulnerable), DPaW Vulnerable.

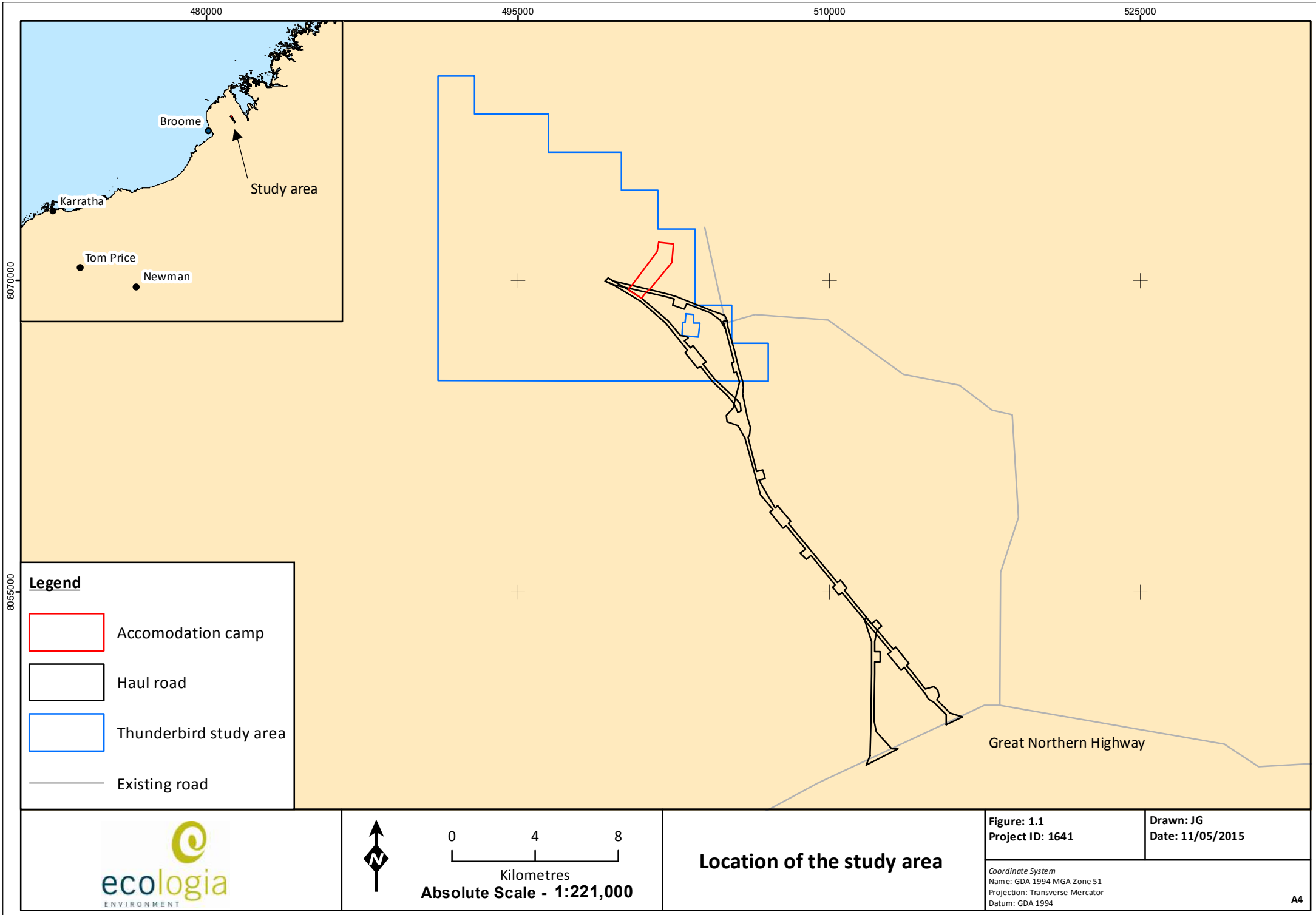
The Greater Bilby (*Macrotis lagotis*) formerly occurred over 70% of mainland Australia's arid and semiarid regions prior to European settlement (ABAS 2002). During the 20th century its range reduced significantly and is now absent from its previous southern and central range and restricted to northern Australia (Tyndale-Biscoe 2005). Woinarski *et al.* (2012) estimate the total Australian population size as 10,000 individuals, and is undergoing continual decline estimated to exceed 10% over the last three generations (12 years), that is likely to continue.

Greater Bilbies are currently patchily distributed through the Tanami, Great Sandy and Gibson Deserts, west to the Pilbara and north to Dampier Peninsula (Maxwell *et al.* 1996). Isolated populations also occur in south-west Queensland and to the north-east of Alice Springs. Greater Bilbies occur in a variety of habitats, including spinifex grassland, acacia shrubland, open woodland, fringes of salt lakes and cracking clays (Maxwell *et al.* 1996; Johnson 2008). Reasons for their population decline include predation by feral predators on both young and adult bilbies, competition from rabbits and livestock, reduced food as a result of changed fire regimes and drought (Maxwell *et al.* 1996; O'Malley 2006; Johnson 2008).

The Greater Bilby is a mainly solitary omnivorous marsupial and is the sole surviving species from the family Thylacomyidae, of which the Lesser Bilby (*Macrotis leucura*) has gone extinct (Tyndale-Biscoe 2005). As with all bandicoot species, the Greater Bilby are generalists in their diet and very effective opportunists, exploiting their environment by their wide choice of food in conjunction with fast growth and rapid reproduction, particularly when conditions are favourable (Tyndale-Biscoe 2005). Their typical diet consists of insects and larvae, seeds, bulbs, fruit and fungi (van Dyck and Strahan 2008).

Unlike other bandicoot species, the Greater Bilby constructs burrows where it shelters during the day. The burrows are up to two meters deep and descend in a spiralling direction with each individual animal utilising up to 12 burrows within its home range (ABAS 2002). Bilbies are strictly nocturnal and have been known to move up to five kilometres each night in search of food (Pavey 2006b). Home ranges are variable and temporary, with individuals responding to changes in food availability (van Dyck and Strahan 2008). Males, females and juveniles may all have overlapping home ranges, where densities in optimum habitat can be 12-16 individuals per km^2, however typically densities are 1-2 individuals per km^2 (Pavey 2006b). Estimates of short-term home ranges are relatively small, varying from 1.1 to 3.16 km^2, however females have been recorded with a home range as little as 0.18 km^2 (Pavey 2006a). Male home ranges and male-female home ranges overlap considerably, however overlap between females has not been recorded (Pavey 2006a).

The breeding season also reflects the opportunistic nature of this species, with Bilbies able to breed throughout the year whenever conditions are suitable (van Dyck and Strahan 2008). They are rapid breeders, with reproduction at faster rates than any other group of marsupials (Tyndale-Biscoe 2005).


480000
495000
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Broome
Study area
Karratha
Tom Price
Newman
Great Northern Highway
Legend
Accomodation camp
Haul road
Thunderbird study area
Existing road
N
0
4
8
Kilometres
Absolute Scale - 1:221,000
Location of the study area
Figure: 1.1
Project ID: 1641
Drawn: JG
Date: 11/05/2015
Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994
A4

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2 METHODOLOGY

2.1 GUIDING PRINCIPLES

This survey was undertaken as part of the Environmental Impact Assessment process in WA and is required to address the following government legislation and guidelines:

- EPA Guidance Statement No. 56: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (EPA 2002a);
- EPA Position Statement No. 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection (EPA 2002b);
- *Technical Guide - Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment* (EPA and DEC 2010); and
- Greater Bilby specific survey guidelines within *Survey guidelines for Australia's Threatened Mammals* (DSEWPaC 2011).

2.2 SURVEY TIMING

The targeted Greater Bilby assessment was conducted by two zoologists over six days from the 22 to 27 September 2015.

2.3 STUDY TEAM AND LICENCES

The targeted Greater Bilby assessment was planned, coordinated and executed by those listed in Table 2.1. The assessment was carried out under DPaW issued Regulation 17 License Number SF010517.

Table 2.1 – Study team

Project Staff			
Name	**Qualification**	**Role**	**Project role**
Shaun Grein	B. App. Sc; Grad. Dip. Nat Res.	Managing Director	QA and technical review
Matthew Macdonald	PhD	Principal Ecologist	QA and technical review
Bruce Greatwich	BSc.	Senior Zoologist	Project management, field survey and reporting
Sean White	BSc. (Hons)	Level 2 Zoologist	Field survey

2.4 GREATER BILBY SAMPLING METHODS

Greater Bilby sampling methods align with those recommended in the Commonwealth Department of the Environment guidelines (DSEWPaC 2011). Because traditional trapping methods can be unreliable in capturing Greater Bilbies, survey guidelines for the Greater Bilby focus on methods of determining presence/absence – these include secondary evidence signs (number of diggings, active burrows present) and activity captured on camera traps (DSEWPaC 2011). These methods were therefore used during this survey, and trapping was not conducted.

In the broader region of the study area, the Greater Bilby has been recorded in open woodland and open forest pindan habitats, and has also been recorded in pindan shrubland and other vegetation communities but with a lower degree of preference (Southgate 2012). Previous sampling and Greater Bilby records obtained during previous surveys of the Thunderbird study area, however, indicate that Greater Bilby predominantly occur locally in small, isolated patches of dense, mature *Acacia tumida* within the broader pindan shrubland habitat (*ecologia* 2014, 2015). This habitat was therefore targeted during survey activities, using both systematic and opportunistic methods.

2.4.1 Secondary evidence search transects

It was determined that traversing systematically spaced walking transects through the pindan shrubland habitat type would be the most effective sampling method to identify evidence of Greater Bilby activity. Other habitat types in the study area are not evidenced to be the preferred habitat of the Greater Bilby at Thunderbird (*ecologia* 2014, 2015), although isolated occurrences of the species in other habitats may exist on occasion.

Secondary evidence search transects were selected prior to the commencement of the field survey. Transects were selected to provide representative survey coverage within the previously mapped pindan shrubland habitat type. Each transect was spaced between 0.5-1 km apart and traversed by a zoologist searching for secondary evidence signs of Greater Bilby.

Secondary evidence searched for included diggings, tracks, scats and burrows. Where evidence was encountered, the immediately surrounding area (within 200 m radius) was searched in an attempt to record further evidence. Secondary evidence search transect locations are shown in Figure 2.2.

2.4.2 Camera trapping

Based on the habitats observed during surveying and the secondary evidence identified, motion-sensor camera trapping was also undertaken in order to detect the presence of the Greater Bilby (with capacity to detect other species of conservation significance if present). Camera trapping on active burrows that were located was completed using Reconyx HC500 Hyperfire motion cameras. All cameras are triggered by movement using highly sensitive, passive infra-red motion sensors that function both during the day and at night. Motion cameras were established on the entrance of active burrows that were located within relatively close proximity to vehicle tracks, allowing cameras to be collected at the conclusion of the field survey. Camera trap locations are shown in Table 2.2 and Figure 2.2. An example of camera trapping set up during the current field survey is shown in Figure 2.1.

Table 2.2 – Camera trap locations

Camera name	Easting	Northing	No. nights deployed
RC29	497065	8071777	3
RC16	497458	8071357	3
RC14	501767	8065957	5
RC32	502029	8065980	5
RC13	501663	8068089	4

GDA 94 Zone 51

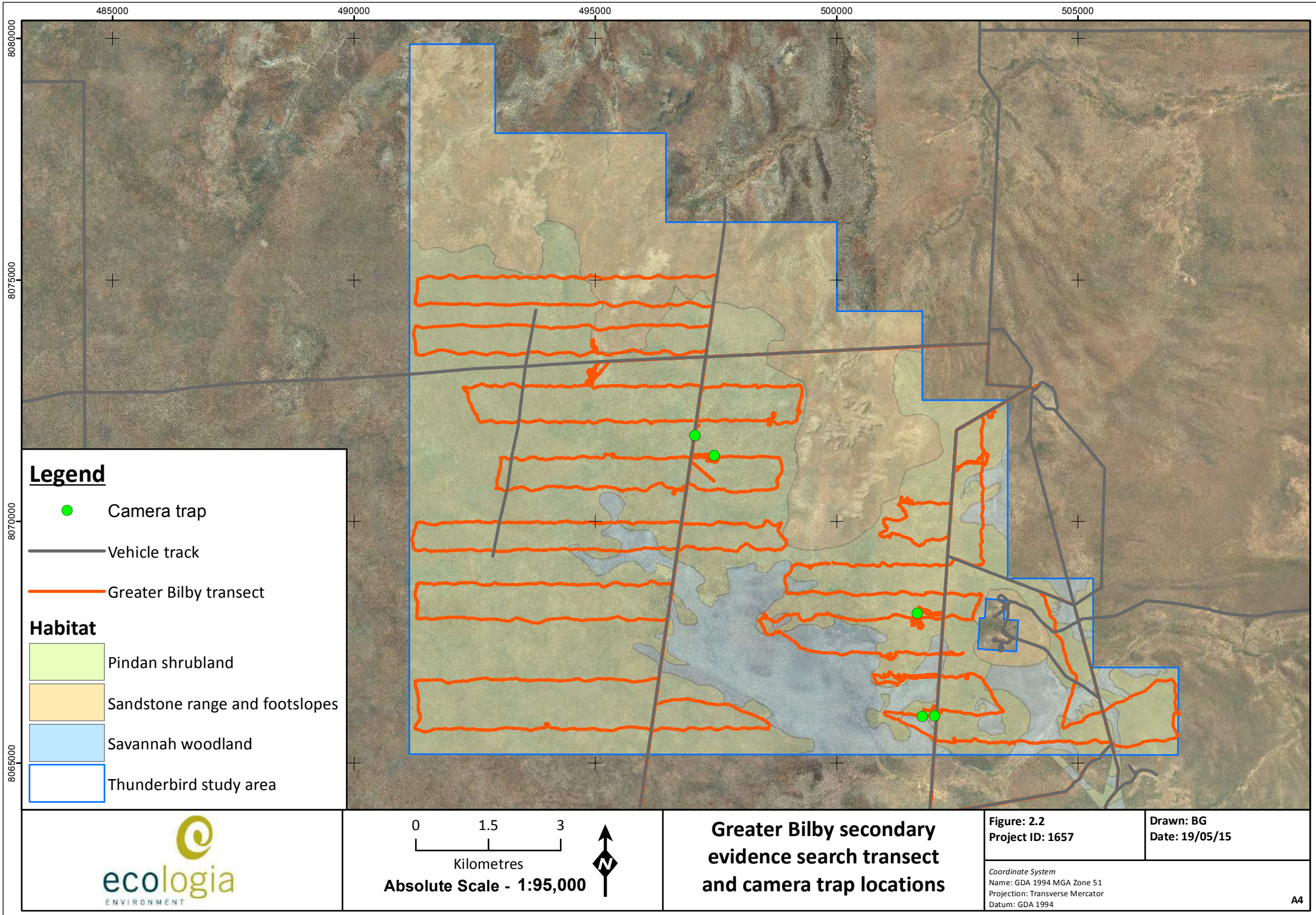
Figure 2.1 – Example of camera trap set on active Greater Bilby burrow

2.4.3 Scat collection and DNA analysis

To more accurately quantify the number of individuals present, DNA extraction and analysis was completed on Greater Bilby scats. This allowed for identification of individual Greater Bilbies.

When Greater Bilby evidence or burrows were encountered during transects, the surrounding area was searched in an attempt to find Greater Bilby scat. All attempts were made to find scat at each location where Greater Bilby evidence was recorded; this included sieving through spoil heap dirt associated with diggings, as scats are often produced in association with diggings. However, a number of sites where Greater Bilby evidence was recorded failed to yield any scat. Where a scat was recorded, the location was marked by GPS, with the scat scooped in to a vial using the lid to avoid contamination. Each vial contained silica gel to absorb moisture within the scat and prevent DNA degradation.

Scats were brought back to Perth, with DNA extraction and analysis completed by the Department of Parks and Wildlife (DPaW). Detailed scat extraction and analysis methodology is provided in the associated DPaW report (Appendix A).


485000
490000
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8070000
8065000
Legend
Camera trap
Vehicle track
Greater Bilby transect
Habitat
Pindan shrubland
Sandstone range and footslopes
Savannah woodland
Thunderbird study area
ecologia
ENVIRONMENT
0
1.5
3
Kilometres
Absolute Scale - 1:95,000
N
Greater Bilby secondary evidence search transect and camera trap locations
Figure: 2.2
Project ID: 1657
Drawn: BG
Date: 19/05/15
Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994
A4

3 RESULTS

3.1 GREATER BILBY RECORDS

The presence of the Greater Bilby in the study area was evidenced by 754 records of secondary evidence. These records comprised:

- diggings – e.g. as per Figure 3.1 – 670 records;
- scats – e.g. as per Figure 3.2 – 25 records/samples;
- active burrows – e.g. as per Figure 3.3 – 17 records; and
- inactive burrows – 42 records.

In addition, two direct records were obtained via the camera traps. In these cases, Bilbies were photographed entering and emerging from the active burrows monitored (two different burrows). The remaining three active burrows did not trigger the camera traps (Table 2.2).

Greater Bilby records from this targeted assessment, in addition to previous records from Level 1 and Level 2 assessments, and the proposed disturbance areas are shown in Figure 3.4 and in Appendix B.

Table 2.1 – Camera trap results

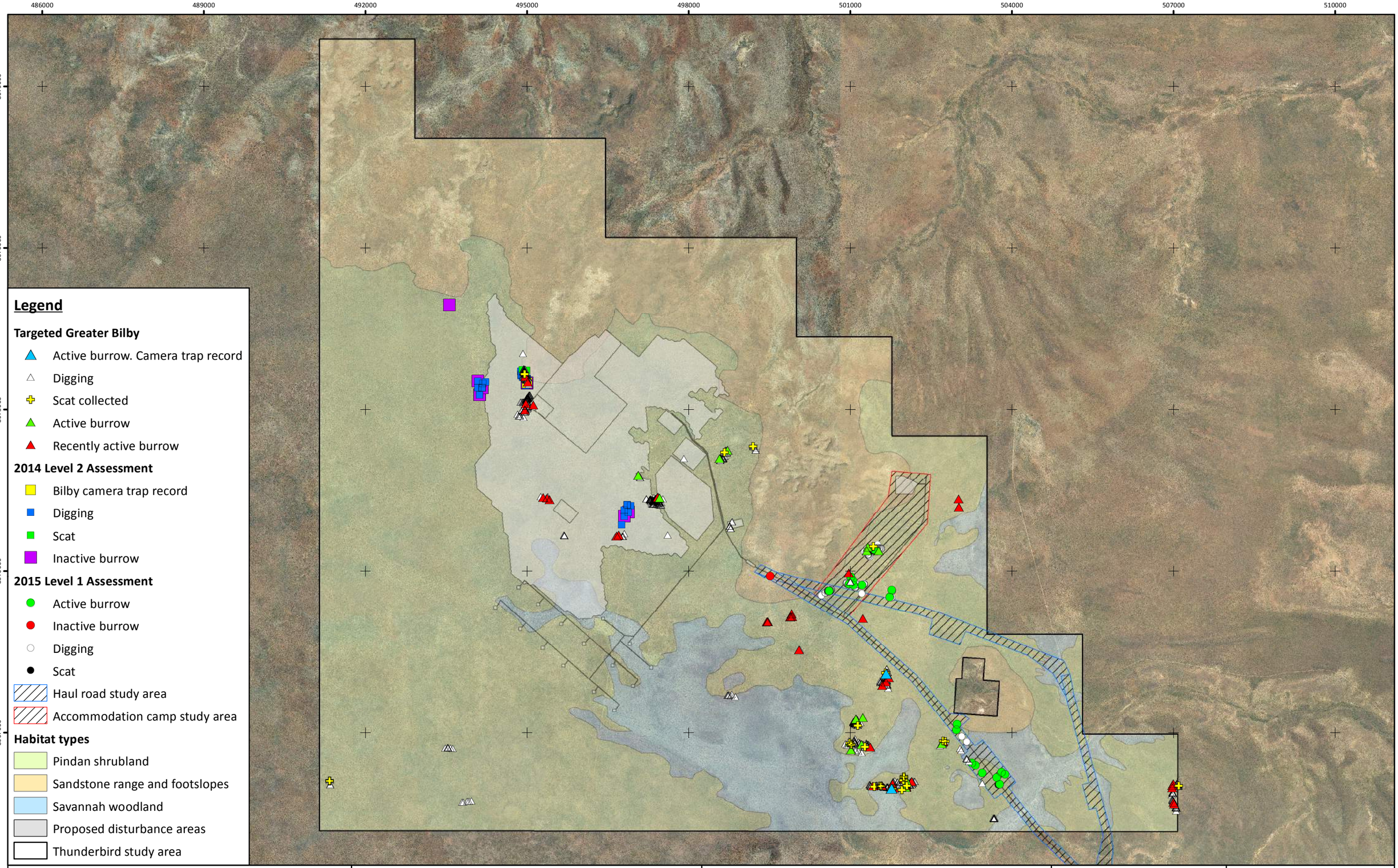
Camera name	Positioned at	Greater Bilby detected
RC29	Active burrow	NO
RC16	Active burrow	NO
RC14	Active burrow	YES
RC32	Active burrow	NO
RC13	Active burrow	YES

Figure 3.1 – A Greater Bilby digging recorded (51K 501090 mE 8067243 mN)

Figure 3.2 – A Greater Bilby scat recorded (51K 501656 mE 8068113 mN / BGS9)

Figure 3.3 – A Greater Bilby active burrow recorded (51K 0501663 mE 8068089 mN / RC13)

Figure 3.4 – A Greater Bilby recorded by camera trap (51K 0501663 mE 8068089 mN / RC13)



Legend

Targeted Greater Bilby

- Active burrow. Camera trap record
- Digging
- Scat collected
- Active burrow
- Recently active burrow

2014 Level 2 Assessment

- Bilby camera trap record
- Digging
- Scat
- Inactive burrow

2015 Level 1 Assessment

- Active burrow
- Inactive burrow
- Digging
- Scat
- Haul road study area
- Accommodation camp study area

Habitat types

- Pindan shrubland
- Sandstone range and footslopes
- Savannah woodland
- Proposed disturbance areas
- Thunderbird study area

ecologia ENVIRONMENT

0 1.5 3

Kilometres

Absolute Scale - 1:65,000

N

Previous and current Greater Bilby records

Figure: 3.5
Project ID: 1657

Drawn: MY
Date: 03/06/2016

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

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3.2 DNA SCAT ANALYSIS

At each location where Greater Bilby secondary evidence such as diggings was recorded, an attempt was made to locate fresh scat to be able to conduct DNA analysis. Despite these efforts, it was not possible to collect Greater Bilby scats at a number of sites, despite other forms of secondary evidence being present.

A total of 26 scat samples were collected during the targeted survey, which subsequently underwent DNA extraction and analysis (Table 3.1). One was identified as probably being from a macropod and did not respond to analysis (not included hereafter in datasets in this report), but the remaining 25 were identified as being from Greater Bilby (Appendix A).

Of the 25 scats collected, 15 produced viable DNA and 13 of these provided sufficient quantities of DNA to facilitate individual identification. The remaining two amplified successfully, but not at sufficient numbers of loci to allow for individual identification. A study currently being completed by the Department of Parks and Wildlife shows that the age of scats has an effect on amplification success rate (Appendix A); therefore, the scat samples that did not yield enough DNA or did not amplify at enough loci may simply have been too old for analysis.

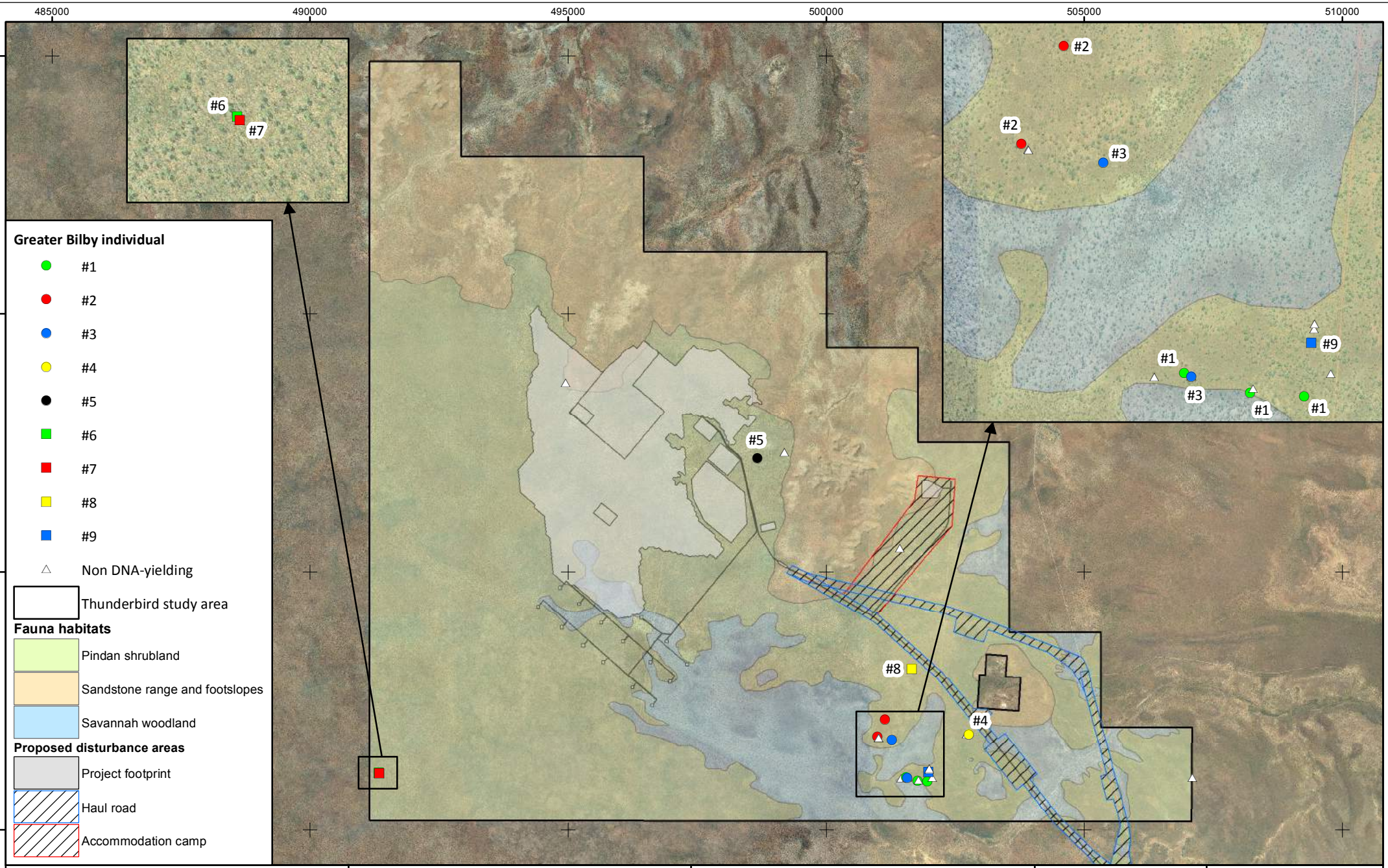
This analysis resulted in a total of nine individual Greater Bilbies being identified as occurring within the study area at the time of surveying (Figure 3.6).

Table 3.2 – Greater Bilby scat collection locations and DNA analysis results

Evidence	Scat ID	Sufficient DNA	Greater Bilby individual	Easting	Northing
Scat	BGS2	No	-	501446	8065999
Scat	BGS3	Yes	#1	501548	8066014
Scat	BGS4	No*	-	501573	8066002
Scat	BGS5	Yes	#3	501572	8066001
Scat	BGS6	Yes	#1	501775	8065945
Scat	BGS7	Yes	#1	501959	8065934
Scat	BGS8	No	-	502049	8066012
Scat	BGS9	Yes	#8	501656	8068113
Scat	BGS10	Yes	#2	501136	8067133
Scat	BGS11	Yes	#3	501271	8066734
Scat	BGS12	Yes	#2	500991	8066798
Scat	BGS13	No	-	501014	8066778
Scat	BGS14	No	-	501015	8066777
Scat	BGS15	No	-	494953	8073657
Scat	BGS16	No	-	501426	8070457
Scat	BGS17	No	-	501784	8065961
Scat	BGS18	Yes	#9	501982	8066117
Scat	BGS19	No	-	501993	8066164
Scat	BGS20	No	-	501995	8066181
Scat	Sws1	No*	-	502724	8066845
Scat	Sws2	Yes	#4	502759	8066841
Scat	Sws3	No	-	499192	8072315
Scat	Sws4	Yes	#5	498667	8072199
Scat	Sws5	Yes	#6	491331	8066102
Scat	Sws6	Yes	#7	491335	8066096

GDA 94 Zone 51

*DNA amplified but not in sufficient quantity to allow for individual identification



ecologia ENVIRONMENT

0 1.5 3
Kilometres
Absolute Scale - 1:95,000

N

Greater Bilby DNA scat analysis results

Figure: 3.6
Project ID: 1657

Drawn: MY
Date: 10/06/16

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

A4

4 DISCUSSION

4.1 OCCURRENCE OF GREATER BILBY WITHIN THE STUDY AREA

The current targeted Greater Bilby assessment, in conjunction with previous Thunderbird Project fauna assessments (*ecologia* 2014, 2015), has given a good understanding of spatial occurrence and activity levels of Greater Bilby in the study area. The DNA scat analysis has provided quantitative data as to the minimum number of individuals present at the time of the targeted survey.

The DNA analyses suggest the study area was supporting, at the time of surveying, at least nine individuals (unique individual animals confirmed through DNA analysis). The results of this assessment overall generally show that each of these uniquely identified individuals was associated with an isolated, discrete cluster of records of Greater Bilby activity (Figure 3.6).

As noted earlier (Section 2.4.3), efforts to locate scat were made at every area of Greater Bilby activity. However, at many locations where activity was recorded, no scats were available to collect (Figure 3.5). Given that individual clusters of activity were generally associated with unique individual animals in the cases where genetic identifications could be made, it is possible that locations where identifications could not be made are also associated with unique individuals. These would therefore be over and above the nine individuals conclusively identified during this assessment; based on this hypothesis, it is possible that the total number of individuals present in the study area at the time of the assessment was in the vicinity of 25 animals.

It is possible this is an underestimate; transects during this assessment were selected to provide representative coverage of the pindan shrubland habitat type in the study area, and were spaced 0.5-1 km apart (Figure 2.2). As a result of the width of the spaced transects, it is possible that Greater Bilby activity in some areas remained undetected at the time of surveying. Equally this may be an overestimate, due to difficulty in interpreting the age of secondary evidence that is not obviously fresh. The population is also likely to fluctuate according to seasonal and annual variations in rainfall, resource availability, predator presence and fire history (Section 4.2). Only a highly-intensive survey conducted over multiple seasons would produce an absolute, quantitative baseline estimate of the Greater Bilby population size in the study area..

When comparing the spatial occurrence of Greater Bilby in relation to location of proposed disturbance areas, it can be demonstrated that the Greater Bilby occurs both inside proposed mine disturbance areas and within close proximity to haul road disturbance areas (Figure 3.5). Overall, however, more Greater Bilby activity was recorded outside proposed disturbance areas (Figure 3.5). All individuals identified from DNA scat analysis were outside proposed disturbance areas (Figure 3.6), with only a single scat collected from inside the proposed disturbance area (despite numerous locations of secondary evidence), which did not yield DNA.

On the basis of existing habitat mapping and estimated Greater Bilby population number within the study area, an approximate home range of Greater Bilby within the study area can be estimated. Approximately 92.2 km^2 of pindan shrubland habitat type has been calculated to occur within the study area. Applying the estimate of 25 individuals, this equates to a home range of 3.69 km^2 per individual. This home range estimate is likely to be actually slightly lower, given Greater Bilbies preference towards micro-habitat within the study area (Section 4.2). This home range estimate is close to previous calculations of Greater Bilby short-term home ranges of 1.1 to 3.16 km^2 (Pavey 2006a).

4.2 HABITAT ASSOCIATION

As within the previous fauna assessments for the Thunderbird Project (*ecologia* 2014, 2015), the Greater Bilby was recorded predominately within the pindan shrubland habitat type (Figure 3.5), and more specifically within the dense, mature *Acacia tumida* var. *tumida* woodland micro-habitat

(Figure 4.1). This micro-habitat appears to be influenced by fire age, with older fire age (>2 years) then surrounding areas. The dense, mature *Acacia tumida* var. *tumida* woodland micro-habitat forms a dense canopy layer but relatively open ground cover, which is in contrast to surrounding areas which appear to have been burnt more frequently and are characterised by dense ground vegetation.

The intensity of fire also appears to have an important influence on suitability of habitat. A number of areas of dense, mature *Acacia tumida* var. *tumida* woodland were encountered that had been burnt by large scale fire and that result in the loss of *Acacia tumida* var. *tumida* plants (evident by lack of regeneration) (Figure 4.2). Burnt areas included patches where Greater Bilby evidence had been recorded previously. The regeneration process within these areas will consequently take longer and be unsuitable habitat for Greater Bilby in the short to medium term, than if lower intensity fires occurred. The potential benefits of fire to Greater Bilby are not well known, although Southgate and Carthew (2006) determined fire-promoted plant growth contributed significantly to the amount of dietary plant material, concluding spatial and temporal heterogeneity of fire age beneficial to Greater Bilby populations. Fire age and intensity is therefore likely to be an important local factor in determining suitability of habitat for Greater Bilby, with small scale and mosaic fire patterns likely to be of greatest benefit.

Figure 4.1 – Dense, mature *Acacia tumida* var. *tumida* within pindan shrubland

Figure 4.2 – Damage from high-intensity fire in dense, mature *Acacia tumida* var. *tumida* habitat

This assessment identified a strong Greater Bilby feeding association with *Acacia tumida* var. *tumida* plants. It was observed diggings were commonly made at the base of this plant species (Figure 3.1), with extractions of root dwelling larvae made from the roots. Shell casings of Witjuti grub larvae (*Endoxyla* spp.) was observed at the base of *Acacia tumida* var. *tumida* plants (Figure 4.3), suggesting Witjuti grubs as an important food source for the local Greater Bilby population.

Figure 4.3 – Example of Witjuti grub (*Endoxyla* spp.) larvae casing from the study area

4.3 GREATER BILBY OCCURRENCE ON THE DAMPIER PENINSULA

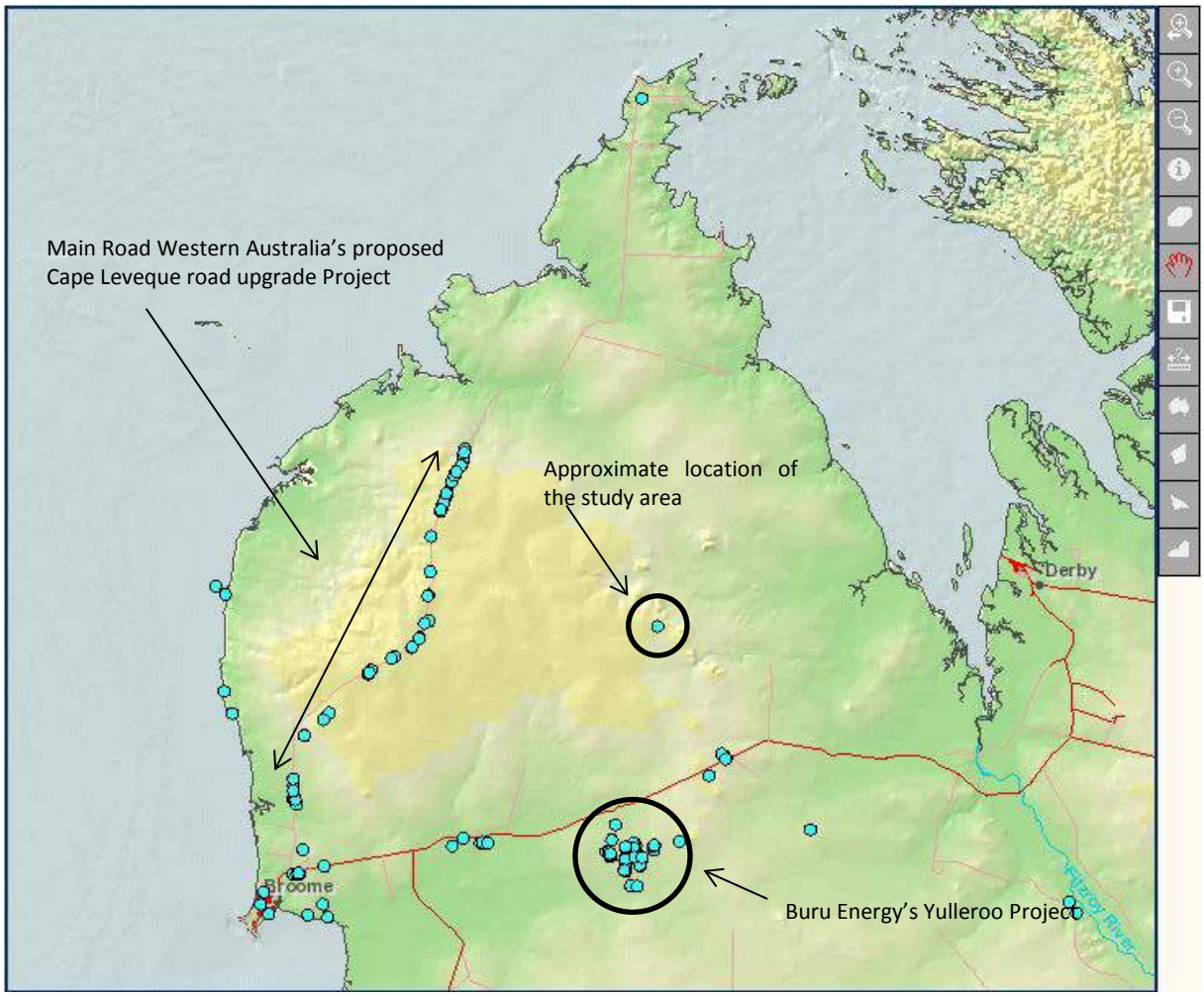
The Dampier Peninsula is a geographic region recognised as supporting a remnant, patchily distributed Greater Bilby population following the range contraction of this species in the early 1900's (Johnson 2008; Woinarski *et al.* 2012). The Greater Bilby population status on Dampier Peninsula is not clear, however Dr. Rick Southgate (GHD 2015) suggests it is most likely a scattered population in low densities. The northern edge of the Greater Bilby distribution (Dampierland and northern edges of the Great Sandy and Tanami Deserts) is thought to be of considerable importance to the conservation of the species, because it represents the only part of its range where populations can persist without the need of intensive management (Southgate 2012).

Relatively few biological surveys have been completed on Dampier Peninsula, however recent biological assessments including James Price Point (*ecologia* 2011), Buru Energy's Yulleroo Project (Ogburn 2013) and Main Road Western Australia's proposed Cape Leveque road upgrade Project (GHD 2013) all recorded Greater Bilby on the Dampier Peninsula. Previous records from NatureMap in relation to the study area are shown in Figure 4.4.

The impacts of development on Greater Bilby populations continue to be studied. Bilbies have been noted to be able to tolerate disturbance; however, it is important that indirect threats are also considered, in addition to the more obvious impacts of habitat removal (Southgate 2012).

Of particular importance in understanding Greater Bilby occupation of Dampier Peninsula are previous records associated with Main Road Western Australia's Cape Leveque road upgrade project (GHD 2013). These records can be seen in Figure 4.4, displayed as the linear collection of records west of the study area. The continued presence of Greater Bilby throughout the Cape Leveque road upgrade project area (approximately 100 km in length) suggests the Greater Bilby may be more common on the Dampier Peninsula then previously considered.

Due to the uncertainties regarding the status of the Dampier Peninsula population, the regional significance of the Greater Bilby population within the study area is difficult to determine. Using the estimated national Greater Bilby population of 10,000 (Woinarski *et al.* 2012), should the study area contain 25 individuals, then it is estimated that it would contain approximately 0.25% of the total national Greater Bilby population.



Source:(DPaW 2015)

Figure 4.4 – Previous Greater Bilby records on Dampier Peninsula

5 CONCLUSION

The main conclusions from this targeted Greater Bilby assessment of the Thunderbird study area are:

- The Greater Bilby was recorded in the Thunderbird study area. A total of 754 Greater Bilby records were obtained, comprising secondary evidence in the form of diggings, scats, active burrows and inactive burrows;
- Direct confirmation of the contemporary presence of the Greater Bilby in the study area was obtained, with camera traps detecting the species at two out of the five active burrows that were monitored using this technique.
- Of the 25 scats collected, 15 produced viable DNA with 13 of these providing DNA that amplified at a sufficient number of loci to facilitate individual identification. This analysis resulted in a total of nine individual Greater Bilbies being recognised as occurring within the study area at the time of surveying;
- Extrapolating DNA scat analysis results suggests the study area is likely to be supporting additional individuals at the time of surveying. It is estimated the local Greater Bilby population within the study area at the time of the targeted survey is approximately 25 individuals;
- The size of this population is likely to fluctuate according to environmental factors including, but not limited to, seasonal and annual variations in rainfall, resource availability, fire history and the size of sympatric feral animal populations;
- When comparing the spatial occurrence of Greater Bilby in regards to location of proposed disturbance areas, it can be seen Greater Bilby occurs inside proposed mine disturbance areas, and in close proximity to haul road disturbance areas. However, overall more Greater Bilby activity was recorded outside proposed disturbance areas;
- Using the estimate of 25 individuals, a home range of 3.69 km^2 per individual is calculated within the pindan shrubland habitat type. This home range estimate is likely to be actually slightly lower, given the Greater Bilbies preference towards the micro-habitat recorded within the study area. This home range estimate is close to previous calculations of Greater Bilby short-term home ranges of 1.1 to 3.16 km^2;
- As per previous fauna assessments of the Thunderbird Project, the Greater Bilby was recorded almost exclusively within the pindan shrubland habitat type, and more specifically within the dense, mature *Acacia tumida* var. *tumida* woodland micro-habitat. This micro-habitat appears to be influenced by fire age, with older fire age (>2 years) then surrounding areas;
- The Greater Bilby population status on Dampier Peninsula is not clear, however it has been suggested it is most likely a scattered regional population in low densities. Relatively few biological surveys have been completed on Dampier Peninsula, however three recent biological assessments have all recorded Greater Bilby on the Dampier Peninsula, suggesting the species may be more common on Dampier Peninsula than previously thought; and
- Due to the uncertainties regarding the status of the Dampier Peninsula population, the regional significance of the Greater Bilby population within the study area is difficult to quantify. Using the estimated national Greater Bilby population of 10,000 (Woinarski *et al.* 2012), and the estimated study area population of 25 individuals, then the study area may support up to 0.25% of the estimated total national Greater Bilby population.

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APPENDIX A DPAW GREATER BILBY SCATS ANALYSIS REPORT

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Science and Conservation Division

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Our ref: Bilb002
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Genotyping of bilby scats collected from Dampier Peninsula, Kimberley
Fiona Carpenter and Martin Dziminski

Ecologia provided 26 scat samples for genotyping, of which 25 were confirmed to be greater bilby (*Macrotis lagotis*) scats (Table 1). Sample BGS1 looked like a macropod scat and did not amplify. Samples were stored dry, at room temperature, in 30ml tubes, approximately 1/3-filled with silica gel beads, until DNA extraction was undertaken.

DNA extractions were undertaken on the 21 October 2015. Genomic DNA was extracted from scats using the Qiagen QIAamp Fast DNA Stool Mini Kit with some modifications from Piggott and Taylor (2003) to the recommended procedures included in the kit. DNA was screened using seven highly polymorphic microsatellite markers (Table 2). These were multiplexed into two polymerase chain reactions (PCR) using the Qiagen Multiplex PCR Plus Kit. PCR amplification was performed using cycling conditions modified from the Qiagen Multiplex PCR Plus Kit. The PCR product was then analyzed on an ABI3730XL Sequencer, sized using Genescan-500 LIZ internal size standard, and genotyped using Genemapper software (version 5.0.0).

Of the 25 supplied samples, 15 samples yielded DNA and 13 amplified at enough loci to include in identity analysis (Table 3). Genotyping using the seven loci identified nine distinct individuals present across the survey (Table 4). Overall the average genotyping success rate of 52 % was higher than the expected rate of 20-25 % from initial trials. A study that is currently being completed by Parks and Wildlife shows that age of scats has an effect on amplification success rate. The scats that did not yield DNA or did not amplify at enough loci to be included in identity analysis may have been too old.

Further analyses of these data can reveal the relatedness of individuals within these populations (for example if individuals are full- or half-siblings, or other levels of relatedness). When monitoring is completed at other sites across Western Australia and genetic data is available, population genetic analyses can be completed. These analyses can reveal isolation or connectivity between populations using gene flow and transfer. Furthermore, the data gained from these two monitoring sites can be used in distance analysis techniques to gain accurate measures of the numbers and densities of individuals within monitored populations.

Sincerely,
Dr Martin Dziminski.

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Table 1. Bilby scat samples supplied by Ecologia.

Ecologia ID	DPaW ID	
SWS1	KIM0001	
SWS2	KIM0002	
SWS3	KIM0003	
SWS4	KIM0004	
SWS5	KIM0005	
SWS6	KIM0006	
BGS1	KIM0007	Not bilby.
BGS2	KIM0008	
BGS3	KIM0009	
BGS4	KIM0010	
BGS5	KIM0011	
BGS6	KIM0012	
BGS7	KIM0013	
BGS8	KIM0014	
BGS9	KIM0015	
BGS10	KIM0016	
BGS11	KIM0017	
BGS12	KIM0018	
BGS13	KIM0019	
BGS14	KIM0020	
BGS15	KIM0021	
BGS16	KIM0022	
BGS17	KIM0023	
BGS18	KIM0024	
BGS19	KIM0025	
BGS20	KIM0026	

Table 2. Microsatellite markers used in PCR.

Locus	Primer set	Fluorescent label	Reference
Multiplex 1			
B02	BIL02	6-FAM	Moritz et al. (1997)
B17	Bil17intF	VIC	Moritz et al. (1997) and Smith et al. (2009)
B56	Bil56intF	PET	Moritz et al. (1997) and Smith et al. (2009)
Multiplex 2			
B55	BIL55	6-FAM	Moritz et al. (1997)
B22	BIL22	VIC	Moritz et al. (1997)
B41	BIL41intF	PET	Moritz et al. (1997) and Smith et al. (2009)
B63	BIL63	NED	Moritz et al. (1997)

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Table 3. Bilby scat samples successfully genotyped.	
Scats yielding DNA	Scats with enough loci amplified
KIM0001	KIM0002
KIM0002	KIM0004
KIM0004	KIM0005
KIM0005	KIM0006
KIM0006	KIM0009
KIM0009	KIM0011
KIM0010	KIM0012
KIM0011	KIM0013
KIM0012	KIM0015
KIM0013	KIM0016
KIM0015	KIM0017
KIM0016	KIM0018
KIM0017	KIM0024
KIM0018	
KIM0024	

Table 4. Individuals identified from scat samples.

Individual #	Sample
1	KIM0009
1	KIM0012
1	KIM0013
2	KIM0016
2	KIM0018
3	KIM0011
3	KIM0017
4	KIM0002
5	KIM0004
6	KIM0005
7	KIM0006
8	KIM0015
9	KIM0024

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APPENDIX B GREATER BILBY RECORDS FROM ALL THUNDERBIRD PROJECT SURVEYS

Evidence Type	Easting	Northing	Date
Greater Bilby Targeted Assessment (2015)			
Active burrow	501102	8067252	23/09/2015
Active burrow	500995	8066824	23/09/2015
Active burrow	501211	8066777	23/09/2015
Active burrow	501527	8070381	25/09/2015
Active burrow	501325	8070444	25/09/2015
Active burrow	501307	8070375	25/09/2015
Active burrow	502049	8066093	27/09/2015
Active burrow	501232	8067278	23/09/2015
Active burrow	501012	8066679	23/09/2015
Active burrow	502703	8066787	23/09/2015
Active burrow	498572	8072093	24/09/2015
Active burrow	498722	8072240	24/09/2015
Active burrow	497065	8071777	24/09/2015
Active burrow	497458	8071357	24/09/2015
Active burrow. Camera trap record	501767	8065957	22/09/2015
Active burrow	502029	8065980	22/09/2015
Active burrow. Camera trap record	501663	8068089	23/09/2015
Digging	507060	8066048	22/09/2015
Digging	507060	8066048	22/09/2015
Digging	507061	8066056	22/09/2015
Digging	507067	8066054	22/09/2015
Digging	507072	8066060	22/09/2015
Digging	507086	8066046	22/09/2015
Digging	507085	8066033	22/09/2015
Digging	507087	8066032	22/09/2015
Digging	507085	8066028	22/09/2015
Digging	507084	8066025	22/09/2015
Digging	507101	8066009	22/09/2015
Digging	507093	8066010	22/09/2015
Digging	507090	8066003	22/09/2015
Digging	507079	8066004	22/09/2015
Digging	507049	8066019	22/09/2015
Digging	507037	8066025	22/09/2015
Digging	506984	8066029	22/09/2015
Digging	506981	8066014	22/09/2015
Digging	506984	8065998	22/09/2015
Digging	506976	8065985	22/09/2015
Digging	506979	8065982	22/09/2015
Digging	506977	8065887	22/09/2015
Digging	506981	8065885	22/09/2015
Digging	506983	8065875	22/09/2015
Digging	506986	8065871	22/09/2015
Digging	506991	8065874	22/09/2015
Digging	506987	8065860	22/09/2015
Digging	506969	8065842	22/09/2015
Digging	506976	8065772	22/09/2015
Digging	506977	8065750	22/09/2015
Digging	506979	8065744	22/09/2015
Digging	506989	8065738	22/09/2015
Digging	506991	8065731	22/09/2015
Digging	506997	8065729	22/09/2015
Digging	506996	8065717	22/09/2015
Digging	507006	8065686	22/09/2015
Digging	507040	8065647	22/09/2015
Digging	507043	8065623	22/09/2015
Digging	507045	8065615	22/09/2015
Digging	507037	8065608	22/09/2015
Digging	507042	8065603	22/09/2015

Digging	507049	8065601	22/09/2015
Digging	507052	8065602	22/09/2015
Digging	507061	8065596	22/09/2015
Digging	507050	8065543	22/09/2015
Digging	501359	8066034	22/09/2015
Digging	501361	8066036	22/09/2015
Digging	501369	8066032	22/09/2015
Digging	501368	8066026	22/09/2015
Digging	501374	8066007	22/09/2015
Digging	501378	8066004	22/09/2015
Digging	501380	8066002	22/09/2015
Digging	501379	8065999	22/09/2015
Digging	501416	8066009	22/09/2015
Digging	501429	8066008	22/09/2015
Digging	501428	8066005	22/09/2015
Digging	501437	8066005	22/09/2015
Digging	501443	8065999	22/09/2015
Digging	501450	8065999	22/09/2015
Digging	501464	8066014	22/09/2015
Digging	501476	8066023	22/09/2015
Digging	501480	8066020	22/09/2015
Digging	501496	8066024	22/09/2015
Digging	501509	8066016	22/09/2015
Digging	501532	8066009	22/09/2015
Digging	501549	8066010	22/09/2015
Digging	501560	8066005	22/09/2015
Digging	501565	8066007	22/09/2015
Digging	501585	8066005	22/09/2015
Digging	501585	8066007	22/09/2015
Digging	501600	8066005	22/09/2015
Digging	501604	8065999	22/09/2015
Digging	501604	8065999	22/09/2015
Digging	501612	8065994	22/09/2015
Digging	501622	8065990	22/09/2015
Digging	501630	8065988	22/09/2015
Digging	501676	8065992	22/09/2015
Digging	501679	8065991	22/09/2015
Digging	501682	8065986	22/09/2015
Digging	501688	8065982	22/09/2015
Digging	501688	8065989	22/09/2015
Digging	501696	8065986	22/09/2015
Digging	501704	8065990	22/09/2015
Digging	501730	8065974	22/09/2015
Digging	501729	8065978	22/09/2015
Digging	501742	8065972	22/09/2015
Digging	501757	8065967	22/09/2015
Digging	501758	8065960	22/09/2015
Digging	501758	8065957	22/09/2015
Digging	501773	8065946	22/09/2015
Digging	501776	8065947	22/09/2015
Digging	501789	8065955	22/09/2015
Digging	501807	8065965	22/09/2015
Digging	501806	8065967	22/09/2015
Digging	501815	8065976	22/09/2015
Digging	501814	8065975	22/09/2015
Digging	501821	8065977	22/09/2015
Digging	501822	8065981	22/09/2015
Digging	501830	8065980	22/09/2015
Digging	501864	8065977	22/09/2015
Digging	501888	8065979	22/09/2015

Digging	501930	8065974	22/09/2015
Digging	501945	8065962	22/09/2015
Digging	502007	8065973	22/09/2015
Digging	502019	8065970	22/09/2015
Digging	502022	8065972	22/09/2015
Digging	502038	8065985	22/09/2015
Digging	502039	8065979	22/09/2015
Digging	502040	8065980	22/09/2015
Digging	502041	8065979	22/09/2015
Digging	502045	8065973	22/09/2015
Digging	502047	8065976	22/09/2015
Digging	502040	8065976	22/09/2015
Digging	502049	8065979	22/09/2015
Digging	502055	8065984	22/09/2015
Digging	502056	8065978	22/09/2015
Digging	502057	8066012	22/09/2015
Digging	502052	8066010	22/09/2015
Digging	502048	8066011	22/09/2015
Digging	502053	8066015	22/09/2015
Digging	501670	8068002	23/09/2015
Digging	501671	8068003	23/09/2015
Digging	501676	8067980	23/09/2015
Digging	501681	8067968	23/09/2015
Digging	501672	8067957	23/09/2015
Digging	501655	8067940	23/09/2015
Digging	501657	8067950	23/09/2015
Digging	501656	8067953	23/09/2015
Digging	501645	8067923	23/09/2015
Digging	501596	8067879	23/09/2015
Digging	501596	8067876	23/09/2015
Digging	501639	8067883	23/09/2015
Digging	501604	8067918	23/09/2015
Digging	501604	8067928	23/09/2015
Digging	501596	8067933	23/09/2015
Digging	501594	8067936	23/09/2015
Digging	501562	8067939	23/09/2015
Digging	501561	8067932	23/09/2015
Digging	501558	8067928	23/09/2015
Digging	501548	8067961	23/09/2015
Digging	501566	8067953	23/09/2015
Digging	501591	8067936	23/09/2015
Digging	501632	8067940	23/09/2015
Digging	501663	8067969	23/09/2015
Digging	501682	8067952	23/09/2015
Digging	501670	8067885	23/09/2015
Digging	501676	8067891	23/09/2015
Digging	501680	8067889	23/09/2015
Digging	501685	8067883	23/09/2015
Digging	501688	8067880	23/09/2015
Digging	501706	8067821	23/09/2015
Digging	501707	8068041	23/09/2015
Digging	501689	8068074	23/09/2015
Digging	501676	8068078	23/09/2015
Digging	501674	8068092	23/09/2015
Digging	501701	8068114	23/09/2015
Digging	501700	8068118	23/09/2015
Digging	501687	8068129	23/09/2015
Digging	501661	8068115	23/09/2015
Digging	501660	8068110	23/09/2015
Digging	501657	8068112	23/09/2015

Digging	501654	8068087	23/09/2015
Digging	501666	8068071	23/09/2015
Digging	501669	8068036	23/09/2015
Digging	501667	8068030	23/09/2015
Digging	498720	8067693	23/09/2015
Digging	498726	8067696	23/09/2015
Digging	498743	8067703	23/09/2015
Digging	498749	8067698	23/09/2015
Digging	498782	8067688	23/09/2015
Digging	498797	8067712	23/09/2015
Digging	498861	8067666	23/09/2015
Digging	501070	8067212	23/09/2015
Digging	501065	8067212	23/09/2015
Digging	501076	8067213	23/09/2015
Digging	501090	8067216	23/09/2015
Digging	501102	8067224	23/09/2015
Digging	501124	8067233	23/09/2015
Digging	501123	8067238	23/09/2015
Digging	501123	8067232	23/09/2015
Digging	501125	8067240	23/09/2015
Digging	501124	8067245	23/09/2015
Digging	501122	8067249	23/09/2015
Digging	501096	8067243	23/09/2015
Digging	501090	8067243	23/09/2015
Digging	501110	8067265	23/09/2015
Digging	501098	8067236	23/09/2015
Digging	501094	8067230	23/09/2015
Digging	501056	8067204	23/09/2015
Digging	501059	8067200	23/09/2015
Digging	501056	8067198	23/09/2015
Digging	501055	8067192	23/09/2015
Digging	501056	8067184	23/09/2015
Digging	501063	8067179	23/09/2015
Digging	501062	8067177	23/09/2015
Digging	501069	8067181	23/09/2015
Digging	501077	8067172	23/09/2015
Digging	501077	8067167	23/09/2015
Digging	501082	8067161	23/09/2015
Digging	501081	8067162	23/09/2015
Digging	501090	8067165	23/09/2015
Digging	501078	8067157	23/09/2015
Digging	501070	8067145	23/09/2015
Digging	501108	8067154	23/09/2015
Digging	501105	8067161	23/09/2015
Digging	501103	8067167	23/09/2015
Digging	501095	8067175	23/09/2015
Digging	501091	8067173	23/09/2015
Digging	501087	8067189	23/09/2015
Digging	501071	8067193	23/09/2015
Digging	501128	8067199	23/09/2015
Digging	501127	8067202	23/09/2015
Digging	501128	8067187	23/09/2015
Digging	501130	8067175	23/09/2015
Digging	501140	8067168	23/09/2015
Digging	501139	8067174	23/09/2015
Digging	501138	8067175	23/09/2015
Digging	501148	8067171	23/09/2015
Digging	501138	8067145	23/09/2015
Digging	501130	8067133	23/09/2015
Digging	501136	8067133	23/09/2015

Digging	501157	8067157	23/09/2015
Digging	501187	8067185	23/09/2015
Digging	501243	8067271	23/09/2015
Digging	501329	8066777	23/09/2015
Digging	501328	8066781	23/09/2015
Digging	501301	8066799	23/09/2015
Digging	501299	8066809	23/09/2015
Digging	501300	8066778	23/09/2015
Digging	501303	8066778	23/09/2015
Digging	501310	8066770	23/09/2015
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Recently active burrow	501999	8066145	27/09/2015
Recently active burrow	501995	8066155	27/09/2015
Recently active burrow	500970	8069964	25/09/2015
Recently active burrow	494961	8072990	25/09/2015
Recently active burrow	502728	8066833	23/09/2015
Recently active burrow	494976	8073107	25/09/2015
Recently active burrow	499455	8069061	23/09/2015
Recently active burrow	499898	8069152	23/09/2015
Recently active burrow	494968	8073609	24/09/2015

Recently active burrow	501368	8066727	23/09/2015
Recently active burrow	503007	8071336	23/09/2015
Recently active burrow	503016	8071190	23/09/2015
Recently active burrow	501233	8069124	23/09/2015
Recently active burrow	499918	8069152	23/09/2015
Recently active burrow	499907	8069205	23/09/2015
Recently active burrow	499884	8069146	23/09/2015
Recently active burrow	499468	8069060	23/09/2015
Recently active burrow	500046	8068540	23/09/2015
Recently active burrow	499471	8069057	23/09/2015
Recently active burrow	501661	8067941	23/09/2015
Scat BGS2 Bilby ID – Non DNA yielding	501446	8065999	27/09/2015
Scat BGS3 Bilby ID#1	501548	8066014	22/09/2015
Scat BGS4 Bilby ID – Non DNA yielding	501573	8066002	22/09/2015
Scat BGS5 Bilby ID#3	501572	8066001	22/09/2015
Scat BGS6 Bilby ID#1	501775	8065945	22/09/2015
Scat BGS7 Bilby ID#1	501959	8065934	22/09/2015
Scat BGS8 Bilby ID – Non DNA yielding	502049	8066012	22/09/2015
Scat BGS9 Bilby ID#8	501656	8068113	23/09/2015
Scat BGS10 Bilby ID#2	501136	8067133	23/09/2015
Scat BGS11 Bilby ID#3	501271	8066734	23/09/2015
Scat BGS12 Bilby ID#2	500991	8066798	23/09/2015
Scat BGS13 – Non DNA yielding	501014	8066778	23/09/2015
Scat BGS14 – Non DNA yielding	501015	8066777	23/09/2015
Scat BGS15 – Non DNA yielding	494953	8073657	24/09/2015
Scat BGS16 – Non DNA yielding	501426	8070457	25/09/2015
Scat BGS17 – Non DNA yielding	501784	8065961	27/09/2015
Scat BGS18 Bilby ID#9	501982	8066117	27/09/2015
Scat BGS19 – Non DNA yielding	501993	8066164	27/09/2015
Scat BGS20 – Non DNA yielding	501995	8066181	27/09/2015
Scat Sws1 – Non DNA yielding	502724	8066845	23/09/2015
Scat Sws2 Bilby ID#4	502759	8066841	23/09/2015
Scat Sws3 – Non DNA yielding	499192	8072315	24/09/2015
Scat Sws4 Bilby ID#5	498667	8072199	24/09/2015
Scat Sws5 Bilby ID#6	491331	8066102	27/09/2015
Scat Sws6 Bilby ID#7	491335	8066096	27/09/2015
Haul Road and Accommodation camp Level 1 survey (*ecologia* 2015)			
Scat	501573	8070421	13/05/2015
Scat	501449	8070406	13/05/2015
Active burrow	501452	8070397	13/05/2015
Active burrow	501769	8069648	14/05/2015
Active burrow	501734	8069517	14/05/2015
Active burrow	501060	8069737	14/05/2015
Active burrow	501051	8069815	14/05/2015
Active burrow	501011	8069889	14/05/2015
Active burrow	501222	8069733	15/05/2015
Active burrow	500978	8069759	14/05/2015
Active burrow	500606	8069630	15/05/2015
Digging	501261	8069764	14/05/2015
Digging	501261	8069767	14/05/2015
Digging	501259	8069761	14/05/2015
Digging	501258	8069748	14/05/2015
Digging	501227	8069724	14/05/2015
Digging	501219	8069740	14/05/2015
Digging	501216	8069742	14/05/2015
Digging	501203	8069755	14/05/2015
Digging	501128	8069761	14/05/2015
Digging	501129	8069756	14/05/2015
Digging	501114	8069750	14/05/2015

Digging	500956	8069749	14/05/2015
Digging	500934	8069766	14/05/2015
Digging	500926	8069776	14/05/2015
Digging	500933	8069786	14/05/2015
Digging	500934	8069790	14/05/2015
Digging	500621	8069649	14/05/2015
Digging	500649	8069649	14/05/2015
Digging	500647	8069651	14/05/2015
Digging	500642	8069641	14/05/2015
Digging	500638	8069647	14/05/2015
Digging	500620	8069648	14/05/2015
Digging	500629	8069630	14/05/2015
Digging	500624	8069628	14/05/2015
Digging	500617	8069627	14/05/2015
Digging	500594	8069611	14/05/2015
Digging	500592	8069613	14/05/2015
Digging	500581	8069620	14/05/2015
Digging	500568	8069633	14/05/2015
Digging	500584	8069642	14/05/2015
Digging	500584	8069638	14/05/2015
Digging	500594	8069634	14/05/2015
Digging	500594	8069636	14/05/2015
Digging	500600	8069636	14/05/2015
Digging	500468	8069541	14/05/2015
Digging	500536	8069590	14/05/2015
Digging	500540	8069599	14/05/2015
Digging	501499	8070386	14/05/2015
Digging	501496	8070400	14/05/2015
Digging	501502	8070417	14/05/2015
Digging	501497	8070418	14/05/2015
Digging	501511	8070434	14/05/2015
Digging	501529	8070422	14/05/2015
Digging	501544	8070419	14/05/2015
Digging	501552	8070430	14/05/2015
Digging	501565	8070424	14/05/2015
Digging	501575	8070418	14/05/2015
Digging	501577	8070411	14/05/2015
Digging	501488	8070363	14/05/2015
Digging	501478	8070364	14/05/2015
Digging	501471	8070370	14/05/2015
Digging	501474	8070377	14/05/2015
Digging	501452	8070386	14/05/2015
Digging	501460	8070390	14/05/2015
Digging	501452	8070402	14/05/2015
Digging	501444	8070408	14/05/2015
Digging	501440	8070400	14/05/2015
Digging	501428	8070412	14/05/2015
Digging	501426	8070409	14/05/2015
Digging	501406	8070403	14/05/2015
Digging	501389	8070395	14/05/2015
Digging	501374	8070395	14/05/2015
Digging	501406	8070446	14/05/2015
Digging	501415	8070448	14/05/2015
Digging	501783	8069629	14/05/2015
Digging	501781	8069632	14/05/2015
Digging	501733	8069530	14/05/2015
Digging	501740	8069517	14/05/2015
Digging	501758	8069498	14/05/2015
Digging	501777	8069510	14/05/2015
Digging	501213	8069580	14/05/2015

Digging	501097	8069683	14/05/2015
Digging	501087	8069688	14/05/2015
Digging	501096	8069697	14/05/2015
Digging	501099	8069701	14/05/2015
Digging	501096	8069712	14/05/2015
Digging	501049	8069748	14/05/2015
Digging	501037	8069780	14/05/2015
Digging	501044	8069795	14/05/2015
Digging	501048	8069798	14/05/2015
Digging	501048	8069830	14/05/2015
Digging	501024	8069893	14/05/2015
Digging	501006	8069888	14/05/2015
Digging	500980	8069821	14/05/2015
Digging	501006	8069811	14/05/2015
Digging	501013	8069801	14/05/2015
Digging	501000	8069771	14/05/2015
Digging	500960	8069749	14/05/2015
Digging	501369	8070264	14/05/2015
Digging	501350	8070271	14/05/2015
Digging	501347	8070279	14/05/2015
Digging	501334	8070295	14/05/2015
Digging	501330	8070296	14/05/2015
Digging	501327	8070303	14/05/2015
Digging	501323	8070308	14/05/2015
Digging	501290	8070326	14/05/2015
Digging	501263	8070350	14/05/2015
Digging	501321	8070418	14/05/2015
Digging	501372	8070394	14/05/2015
Digging	501396	8070387	14/05/2015
Digging	501416	8070384	14/05/2015
Digging	501424	8070373	14/05/2015
Digging	501438	8070372	14/05/2015
Digging	501438	8070381	14/05/2015
Digging	501446	8070388	14/05/2015
Digging	501445	8070392	14/05/2015
Digging	501508	8070488	14/05/2015
Digging	501462	8070400	13/05/2015
Digging	500977	8069946	13/05/2015
Scat	503748	8066030	14/05/2015
Active burrow	503721	8066163	14/05/2015
Active burrow	503450	8066252	14/05/2015
Active burrow	503322	8066391	14/05/2015
Active burrow	503257	8066429	14/05/2015
Active burrow	503807	8066263	14/05/2015
Active burrow	503872	8066222	14/05/2015
Active burrow	503775	8066033	14/05/2015
Digging	503165	8066826	14/05/2015
Digging	503071	8066928	14/05/2015
Active burrow	502969	8067046	14/05/2015
Active burrow	502980	8067161	14/05/2015
Inactive burrow	499512	8069908	15/05/2015
Level 2 Thunderbird Project Assessment (*ecologia* 2014)			
Digging	495011	8073550	22/10/2013
Digging	495005	8073572	22/10/2013
Digging	494999	8073578	22/10/2013
Digging	494994	8073571	22/10/2013
Digging	494978	8073558	22/10/2013
Digging	494918	8073595	22/10/2013
Digging	494891	8073627	22/10/2013

Digging	494889	8073642	22/10/2013
Digging	494885	8073708	22/10/2013
Digging	495002	8073513	22/10/2013
Digging	494992	8073488	22/10/2013
Digging	494985	8073445	22/10/2013
Digging	496862	8071229	22/10/2013
Digging	496862	8071232	22/10/2013
Digging	494999	8073486	22/10/2013
Digging	496881	8071087	22/10/2013
Digging	494116	8073268	22/10/2013
Digging	494166	8073394	22/10/2013
Digging	494085	8073523	22/10/2013
Digging	495000	8073487	22/10/2013
Digging	494169	8073407	22/10/2013
Digging	494180	8073485	22/10/2013
Digging	494230	8073512	22/10/2013
Digging	494086	8073400	22/10/2013
Digging	496756	8070856	22/10/2013
Digging	496804	8071125	22/10/2013
Digging	496807	8071018	22/10/2013
Scat	495015	8073510	19/10/2013
Scat	494911	8073733	19/10/2013
Scat	494996	8073723	20/10/2013
Digging	496928	8071212	22/10/2013
Digging	495019	8073532	22/10/2013
Active burrow. Camera rap record.	495001	8073488	22/10/2013
Inactive burrow	496881	8071087	19/10/2013
Inactive burrow	494116	8073268	10/04/2013
Inactive burrow	494166	8073394	10/04/2013
Inactive burrow	496807	8071018	20/10/2013
Inactive burrow	494085	8073523	20/10/2013
Inactive burrow	495000	8073488	20/10/2013
Inactive burrow	494116	8073268	20/10/2013
Inactive burrow	494166	8073394	20/10/2013
Inactive burrow	493555	8074935	11/04/2013

APPENDIX 2: GREATER BILBY DISTURBANCE PROTOCOLS (MBS 2018)