Biologic
ENVIRONMENTAL SURVEY

Havieron Project: Greater Bilby Monitoring 2022

Report to Newcrest Mining Limited

9 August 2023

Document Status				
Revision No.	Author	Review / Approved for Issue	Approved for Issue to	
			Name	Date
1	C. Proctor, A. Hutchison, R. Ellis	R. Ellis	N. Dixon	09/08/2023
2				
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Executive Summary

The Havieron Project Joint Venture (the Project) is a farm-in joint venture agreement between Newcrest Mining Limited (Newcrest) and Greatland Gold Ltd (Greatland), located approximately 45 kilometres (km) east of the Telfer Gold Mine (Telfer Mine) in the Great Sandy Desert. The Project Area (herein referred to as the Study Area) covers approximately 3,815.66 hectares (ha) and will be subject to a staged approvals approach. Current approvals support development of a boxcut and underground decline, with further approvals for the mine and associated infrastructure are expected to be progressed as required.

Previous baseline fauna surveys conducted by Biologic (2020) for the Project recorded the presence of greater bilby (*Macrotis lagotis*) within the Study Area. The species is currently listed as Vulnerable under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) and state Biodiversity Conservation Act 2016 (BC Act). To meet the Project's development and environmental approvals requirements, the Havieron Project bilby management plan (HPBMP) was developed to ensure potential impacts on the species are minimised where practicable. As part of the HPBMP, Newcrest has committed to undertaking annual monitoring of the occurrence of greater bilby within the Study Area.

Newcrest commissioned Biologic Environmental Survey Pty Ltd (Biologic) to undertake the second annual monitoring survey for greater bilby for the Project. The primary objective of the assessment was to continue the monitoring program established in 2021 to obtain data on the species presence and, where possible, abundance within the Study Area and to undertake the first bi-annual review of bilby habitat mapping within the Study Area.

The field survey was conducted from 20–27 October 2022 by Biologic Zoologists in collaboration with Ecological and Heritage Advisors representing the Traditional Owners of the Martu native title determination, which encompasses the Study Area. Methodology for the monitoring survey was developed following consultation with Department of Biodiversity, Conservation and Attractions (DBCA) bilby researchers (Dr Martin Dziminski and Dr Fiona Carpenter), to align with existing DBCA bilby monitoring methods and recommendations, as required by the HPBMP.

A total of sixteen monitoring sites were revisited and a further four new sites established during the current monitoring survey. Fifteen sites are located within the Study Area, with placement aiming to achieve a broad coverage, and a further five regional monitoring sites are located outside, but within 2 km, of the Study Area, to provide contextual data and act as control sites. Primary habitat within the Study Area is still fragmented due to widespread fires preceding the 2020 baseline survey; however, some post-fire regeneration is evident within the Study Area, with the extent of greater bilby primary habitat increasing 11.38% (353.36 ha) from 192.31 ha in 2020, to 545.67 ha during the current survey. Primary habitat within the Study Area is still predominantly located to the east; however, small patches of isolated primary habitat is now evident throughout most of the Study Area. The extent of primary habitat for bilby within the Study Area is likely to continue to increase over time as previously burnt areas regenerate and quality of habitat improves.

During the current survey, recent evidence of greater bilby was recorded for the first time since the Biologic (2020) baseline fauna survey. The species was recorded a total of 600 times within the Study Area during the current survey, comprising of 23 burrows (11 active and 12 inactive), 506 diggings (from 58 locations), 36 scats and 35 track records. Genotyping of scats collected during the field survey identified two unique individuals occurring within the Study Area; however, it is likely additional individuals occur. Based on assessment of age classes of scats and tracks recorded within the Study Area suggests multiple individuals of various age classes occur, with evidence of all three age classes (i.e. large male, female/small male and immature) present.

All known bilby burrows (n = 6) previously identified within the Study Area were visited and had evidence of recent bilby activity. A further six active burrows showing signs of recent use were located during the current survey. Long-term camera traps were placed at the burrow entrance of all 12 burrows to confirm usage by bilby, and/or assess burrow usage/ visitation by other species (including introduced predators which are likely to have an influence on the local bilby population. All data from the long-term camera traps deployed during the current survey will be included in the 2023 monitoring report.

Several factors were identified during the current survey which may influence the occurrence and abundance of greater bilby within the Study Area, including fire, mining/ exploration disturbance and feral predators. Signs of recent fires was recorded intermittently throughout the Study Area and regional monitoring sites, with several of the monitoring sites being recently burnt. These areas, however, still provide secondary (supporting) foraging and dispersal habitat, particularly when occurring in proximity to unburnt areas. Previously burnt areas are likely to be utilised more frequently as further post-fire regeneration occurs.

Exploration and mining activity within the Study Area has increased exponentially since the Biologic (2020) baseline fauna survey,. Although likely that individuals will move from an area temporarily while disturbance is occurring, there have been foraging and/or dispersal records of greater bilby within the disturbed areas of the Study Area previously during pre-clearance surveys for the Project. Additionally, the majority of greater bilby evidence recorded during the current survey were located only approximately 600m from current exploration and mining activity. Therefore, although mining disturbance may impact the species occurrence, greater bilby may still utilise the disturbed areas to forage an/or disperse, with occurrence and activity likely to increase as disturbances are reduced (i.e. drilling programs are completed). It is possible that the greater bilby population utilising the Study Area may become habituated to a level of disturbance over time as broader disturbance is reduced to mine operations, which is likely to be more confined.to a particular area.

The increase in feral predators recorded, particularly feral cat (*Felis catus*), is one of the most likely factors to impact greater bilby occurrence within the Study Area; however, the increase in dog/ dingo (*Canis lupus*) numbers may be beneficial for the greater bilby as the species is known to act as a tropic regulator and may assist in reducing and/or maintain lower abundance of feral cats locally. Additionally, Newcrest's feral cat management program initiated in 2022 is likely to be beneficial in reducing the potential threat for the local greater bilby population.

Despite no evidence of greater bilby occurrence being recorded during the 2021 monitoring survey, the results of the current survey indicate that the species is persisting locally. While it cannot be determined if the absence of the species during the 2021 monitoring survey was attributed to natural population movements and/or fluctuations, or other factors (i.e. feral predators, fire or mining/ exploration disturbance), the temporal continuation of the monitoring program is likely to provide greater insight into the species occurrence and abundance within the Study Area, and highlight influencing factors which may contribute to changes

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1 Introduction

1.1 Background

The Havieron Project Joint Venture (the Project) is a farm-in joint venture agreement between Newcrest Mining Limited (Newcrest) and Greatland Gold Ltd (Greatland), located approximately 45 kilometres (km) east of the Telfer Gold Mine (Telfer Mine) in the Great Sandy Desert (Figure 1.1). The Project Area (herein referred to as the Study Area) occupies tenement M45/1287 and is approximately 7.5 km by 5.5 km, and 3,815.66 hectares (ha) in size (Figure 1.1). The Project will be subject to a staged approvals approach, with curent approvals supporting development of a boxcut and underground decline up to approximately 400 meters (m) below ground level, a service road and supporting infrastructure (including waste rock landform) within the disturbance envelope. for the Project has commenced, with development of the decline currently in progress, following which, further approvals for the mine and associated infrastructure are expected.

Previous baseline fauna surveys undertaken for the Project recorded the presence of greater bilby (*Macrotis lagotis*) within the Study Area (Biologic, 2020). The species is currently listed as Vulnerable under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and state *Biodiversity Conservation Act 2016* (BC Act). To meet the Project's development and environmental approvals, the Havieron Project bilby management plan (HPBMP) was developed to ensure potential impacts on the species are minimised where practicable. As per the HPBMP, this will be achieved through the following management targets:

- Avoid clearing of bilby habitat, in particular primary habitat;
- minimise incidental mortality of bilby from clearing activity, entrapment, poor water quality consumption, vehicle strike or mining related fire;
- minimise increase in bilby fauna predation from the formation of water and food resources for predators;
- minimise decline in population due to dust, noise, artificial light and vibration;
- minimise decline in fauna habitat condition due to weeds or changed fire regimes.

As part of the HPBMP, Newcrest has committed to undertaking annual monitoring on the greater bilby within the Study Area. Data collected as part of the monitoring will contribute to a continuing dataset to monitor changes in the occurrence of the species in relation to the Project.

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Derby

Broome

Newman

Havieron

LEGEND

Study Area

Disturbance

Access Track

IBRA Region

Great Sandy Desert

IBRA Subregion

Mackay

McLarty

Biologic

Scale 1:30,000

0 0.5 1 Km

Coordinate System: GDA2020 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA2020 Created 12/04/2023

Port Hedland

Marble Bar

Nullagine

NEWCREST MINING LIMITED

Havieron Project Greater Bilby Monitoring 2022

Figure 1.1: Study Area and regional context

1.2 Objectives

The primary objective of this assessment was to continue the monitoring program established in 2021 to obtain data on the species presence and, where possible, abundance within the Study Area and to undertake the first bi-annual review of bilby habitat mapping within the Study Area to confirm extent of primary habitat. Data collected as part of the monitoring will contribute to a continuing dataset to monitor spatial and temporal changes in the occurrence of the species in relation to the Project. Specifically, the objectives of the survey are to:

- re-assess habitats within the Study Area to confirm primary and secondary classification for bilby;
- undertake the bilby population monitoring program in accordance with the 2021 annual monitoring, including:
    - sampling of established long-term monitoring sites within the Study Area and, where possible, regional areas established in 2021 (see below);
    - photo monitoring at established points at each monitoring site;
    - collection of monitoring site data, including habitat description and condition assessment;
    - collection of data on bilby presence (from direct and/or secondary evidence) and abundance (via collection of scats for post-field analysis); and
    - analysis of data and samples (i.e. scat genotyping) collected during the field survey.
- provide a report on completion of field survey and subsequent analyses detailing the methods and results of the monitoring survey; and
- meet Newcrest Environmental Policies and Standards.

Where possible (i.e. access permitted by tenement holders of non-Newcrest tenure), the monitoring program may also include visitation to regional monitoring sites established in 2021 and the addition of more regional sites in areas adjacent to the Study Area which may act as control sites to provide supporting contextual information on the species occurrence locally.

1.3 Compliance

This 2022 monitoring was carried out in a manner consistent with the following documents, consultation with the Department of Biodiversity, Conservation and Attractions (DBCA):

- DBCA (2017) Guidelines for surveys to detect the presence of bilbies, and assess the importance of habitat in Western Australia;
- DoE (2013) Significant impact guidelines 1.1: Matters of national environmental significance;
- DSEWPaC (2011) Survey guidelines for Australia's threatened mammals;
- Newcrest (2020) Havieron Project bilby management plan.

1.4 Greater Bilby (*Macrotis lagotis*)

1.4.1 Species Profile

The greater bilby is one of many Australian arid zone marsupial species that are within a 'critical weight range' (35–5,500 grams), which are often considered significant based on the high risk of decline and extinction (Johnson & Isaac, 2009). This is primarily attributed to predation by introduced foxes (*Vulpes vulpes*) and feral cats (*Felis catus*) (Johnson & Isaac, 2009). Greater bilbies are semi-fossorial and nocturnal, remaining in their burrows during the day and intermittently during the night for rest and refuge.

Throughout most of its range, the distribution of greater bilby is patchy and often occurs in low abundance (Southgate *et al.*, 2007). Greater bilby populations naturally occur as scattered solitary individuals or small groups (Smythe & Philpott, 1968; Southgate, 1990a), often occurring at a density of 1–2 individuals per km^2 and up to 12–16 individuals per km^2 in areas of optimal habitat (Southgate, 1987). Extant populations of the greater bilby occur in a variety of habitats; however, it is most often associated with landforms comprising level to low slope topography and light to medium soils, such as sand plains and sand dune habitats (Cramer *et al.*, 2017; Southgate, 1990b). It often occupies three main vegetation types within these habitats, open tussock grassland on uplands and hills, hummock grassland in plains and alluvial areas and occasionally mulga woodland/shrubland growing on ridges and rises (Southgate, 1990b). In general, the distribution of greater bilbies can be limited by the availability of suitable burrowing habitat, such as dunes where burrow excavation is easier (Moseby & O'Donnell, 2003), and are not found in predominantly rocky areas or mountains where they would be unable to dig suitable burrow systems or dig for food.

Typically the species will excavate several burrows within its home range and frequently move between them (Moseby & O'Donnell, 2003). Despite this, the species is not sedentary,

and a previously occupied area may be vacated for alternative areas, which is most likely attributed to resource depletion within the occupied area or as a response to predators (Southgate, 1987). Males will often occupy a much larger range with substantial overlap with other males, whereas females tend to occupy smaller areas with little overlap (Moseby & O'Donnell, 2003).

Greater bilbies are regarded as having low site fidelity and high mobility (Southgate *et al.*, 2007); males regularly moving distances of 2–3 km and up to 5 km between burrows over consecutive nights, while females tend to move up to 1.5 km (Southgate *et al.*, 2007). Home range of the species ranges between 1–3 km^2, averaging 3.16 km^2 for males and 0.18 km^2 for females (Moseby & O'Donnell, 2003). Variation in the species range is likely to be influenced by the presence and suitability of habitat and availability of resources (Southgate, 1987).

Greater bilby can forage broadly across habitats and can be highly mobile in response to resource availability, particularly in response to fire and post-fire regeneration (Southgate et al., 2007). Fire has been identified as an important process in the species ecology and occurrence, particularly due to many plant species that make up the species' diet or host prey species are fire-germinated species (Southgate, 1990b; Southgate & Carthew, 2007; Southgate & Carthew, 2006; Southgate et al., 2007). As such, the species is known to utilise mosaic habitats comprising unburnt areas and areas at various stages of post-fire regeneration, often primarily utilising unburnt areas but venturing into burnt areas during foraging and dispersal movements (Southgate & Carthew, 2007; Southgate & Carthew, 2006; Southgate et al., 2007). The utilisation of burnt areas however is often associated with post-fire regeneration of vegetation, which is heavily dependent on rainfall events to occur successfully (Southgate & Carthew, 2007). As rainfall throughout a large portion of the species distribution is relatively inconsistent and often associated with cyclonic activity to the north and northwest, the occurrence of rainfall and therefore timeframes during which habitat utilisation is likely to occur on a regular basis can be difficult to ascertain.

1.4.2 Previous Record within the Study Area

The species has previously been recorded within the Study Area on 274 occasions, 272 times during the Biologic (2020) baseline survey and twice during the previous monitoring survey (Biologic, 2022). Biologic (2020) survey records comprised four sightings from direct observation (camera trap captures) (Plate 1.1) and a further 268 times from secondary evidence. Secondary evidence records comprised 167 diggings (comprising 568 individual diggings;

Plate 1.2), eight burrows (including seven active and one inactive (at the time of survey; Plate 1.3), 39 scats (Plate 1.4), 24 series of tracks (Plate 1.5), two possible burrows and 28 possible diggings (Biologic, 2020). The two records observed during the previous monitoring survey (Biologic, 2022) comprised of two new inactive burrows. Records from both surveys occurred throughout the Study Area in Sand Plain and Sand Dune habitats.

The majority of recent diggings recorded during the Biologic (2020) survey occurred within unburnt areas in the northeast of the Study Area, in a relatively small linear area comprising open *Triodia* grassland with even cover of large mature *Triodia* hummocks and scattered *Acacia* shrubs. Within this area, all burrows were located at the base of *Acacia* shrubs or large *Triodia* hummocks, while diggings were concentrated in open areas between *Triodia* hummocks and were often clustered with multiple diggings occurring in close proximity to each other. Most records from other parts of the Study Area, primarily in recently burnt areas, comprised old and/or weathered diggings, often occurring singly (Biologic, 2020).

Plate 1.1: Greater bilby recorded from a camera trap during the Biologic (2020) survey

Plate 1.2: Greater bilby diggings recorded during the Biologic (2020) survey

Plate 1.3: Active greater bilby burrow recorded during the Biologic (2020) survey

Plate 1.4: Greater bilby scats recorded during the Biologic (2020) survey

Plate 1.5: Greater bilby tracks recorded during the Biologic (2020) survey

2 Methods

2.1 Approach

Methodology for the monitoring survey was developed following consultation with DBCA bilby researchers (Dr Martin Dziminski and Dr Fiona Carpenter) at the commencement of the monitoring program, to align with DBCA bilby monitoring methods and recommendations (Dziminski & Carpenter, 2016, 2017), as required by the HPBMP.

The field-based component of the monitoring comprised of three parts; the first assessing the species' presence or absence using standardised two-hectare (ha) plot searches. Where the species is detected, the second part comprised more thorough searches to map the extent of the species occurrence (primarily based on presence of diggings and/or burrows) in the vicinity; and the third part comprised targeted transects within the mapped area of extent to search for and collect bilby scats for genotyping, to determine the number of individuals present. Detailed descriptions of each method can be found in Section 2.5.2.

2.2 Survey Team and Licensing

The field survey was undertaken by Biologic Senior Zoologist Courtney Proctor and Zoologist Siobhan Paget, who collectively have more than 7 years' experience completing terrestrial fauna surveys throughout Western Australia, including targeted bilby surveys, pre-clearance surveys and monitoring projects. The field survey was undertaken collaboratively with Heritage and Ecological Advisors representing the Traditional Owners of the Martu native title determination, which encompasses the Study Area during the monitoring survey.

No DBCA issued fauna license was required to complete this survey. Biologic holds a current license to use animals for scientific purposes (License No. U244/ 2022-2024), administered through the Department of Primary Industries and Regional Development (DPIRD). This is enabled through Biologic's chosen animal ethics committee (AEC), Murdoch University. An application (RW3354/21) that covers the work conducted during this assessment has been submitted and approved by Murdoch University's AEC.

2.3 Survey Timing and Weather

The monitoring survey was completed over eight consecutive days from 20–27 October 2022. Observed weather conditions in the 12 months prior to and during the survey are shown in Figure 2.1, alongside long-term climatic data for Telfer Airport. It should be noted that some rainfall data for Telfer Airport is not available for the entirety of the 12 months prior to the surveys (February 2022) (BoM, 2022), and is therefore unlikely to accurately represent rainfall preceding the surveys. The specific reason for this data not being recorded is unknown (BoM, 2022). Supplementary rainfall data has been used from Meentheena weather station for February 2022.

In the 12 months prior to the survey, mean minimum and maximum temperatures recorded at Telfer Airport were similar to long-term averages for most months, though mean temperatures for some months fluctuated above and below long-term averages during (Figure 2.1). Where continuous monthly rainfall was recorded in the 12 months prior to the survey, rainfall was variable, with significantly higher rainfall recorded during the wet season compared to the long-term averages (BoM, 2022).

Observed temperatures at Telfer Airport during the survey were comparable to long-term averages; however, numerous days above long-term averages were recorded (Figure 2.1). During the survey, minimum daily temperatures ranged between 17.7–28.3°C and maximum temperatures between 34.7–40.8°C, compared to the long-term averages of 21.1°C and of 37.3°C for October respectively (Figure 2.1). A total of 1 mm of rainfall was recorded at Telfer Airport during the survey (Figure 2.1).

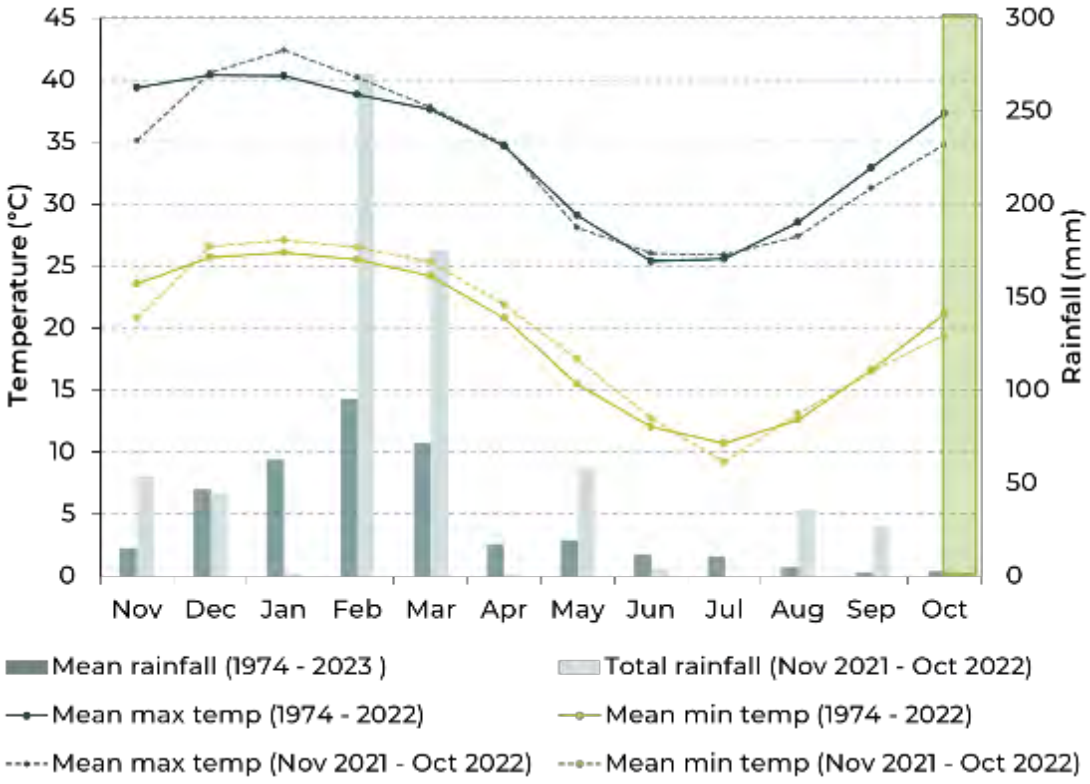

Figure 2.1: Long-term average and pre-survey climate data for the Study Area

Table 2.1: Daily climate data recorded at Telfer during the field survey (BoM, 2022)

Date	Temperature (°C)		Rainfall (mm)
	Minimum	Maximum	
20/10/2022	21	34.7	0.0
21/10/2022	28.3	38.4	0.0
22/10/2022	26.3	40.3	0.0
23/10/2022	24.5	40.2	0.0
24/10/2022	23.2	40.8	0.0
25/10/2022	21.9	39.6	1.0
26/10/2022	17.7	35.3	0.0
27/10/2022	21.3	36	0.0
Average/ Total	**23.0**	**38.0**	**1.0**

2.4 Monitoring Site Selection

A total of 12 monitoring sites were established within the Study Area during the 2021 monitoring survey (Table 2.2). During the current survey, an additional two sites were

established within the Study Area, with placement aiming to achieve a broad coverage of the Study Area (Table 2.2). Sites were selected to include a representative of all broad fauna habitats likely to support the species, in addition to including sites with variation in condition of habitats (i.e. burnt area which may have previously represented optimal habitat, and therefore may again in future).

In addition to the sites established within the Study Area, a further five regional monitoring sites were established outside (but within 2 km) of the Study Area during the 2021 monitoring survey, to provide contextual data and act as control sites (Table 2.2). During the assessment of one of the regional monitoring sites (VHBM-17) during the 2021 monitoring survey, several heritage artefacts were discovered by Martu Heritage and Ecological Advisors assisting with the survey (Table 2.2). As such, the site was not assessed during the current survey and a new regional site established further west from the original site. A further seven regional monitoring sites were initially proposed; however, due to their occurrence on tenure not managed by Newcrest, site access was not permitted, and sites were not accessible. Pending access approval, these sites may be established in future monitoring surveys to provide broader contextual data.

Table 2.2: Monitoring site information

Site ID	Location				Year Established	Species History/ Comments
	Site Type	Latitude	Longitude	Habitat Type		
VHBM-01	Regional	-21.7021	122.6076	Sand Plain	2021	
VHBM-02	Regional	-21.7112	122.6035	Sand Plain	2021	
VHBM-03	Regional	-21.7221	122.6140	Sand Plain	2021	
VHBM-04	Regional	-21.7391	122.6084	Sand Plain	2021	
VHBM-05	Study Area	-21.7076	122.6339	Sand Plain	2021	
VHBM-06	Study Area	-21.7070	122.6554	Sand Plain	2021	
VHBM-07	Study Area	-21.7134	122.6667	Sand Plain	2021	• Evidence of greater bilby recorded within vicinity (<100m) of site during baseline fauna survey Biologic (2020).
VHBM-08	Study Area	-21.7082	122.6817	Sand Plain	2021	
VHBM-09	Study Area	-21.7190	122.6771	Sand Plain	2021	• Evidence of greater bilby recorded within vicinity (<100m) of site during baseline fauna survey Biologic (2020).
VHBM-10	Study Area	-21.7161	122.6181	Sand Plain	2021	

Site ID	Location				Year Established	Species History/ Comments
	Site Type	Latitude	Longitude	Habitat Type		
VHBM-11	Study Area	-21.7184	122.6376	Sand Plain	2021	
VHBM-12	Study Area	-21.7247	122.6602	Sand Plain	2021	
VHBM-13	Study Area	-21.7301	122.6776	Sand Plain	2021	• Evidence of greater bilby recorded within vicinity (<100m) of site during baseline fauna survey Biologic (2020).
VHBM-14	Study Area	-21.7277	122.6226	Sand Plain	2021	
VHBM-15	Study Area	-21.7391	122.6267	Sand Plain	2021	• Evidence of greater bilby recorded within vicinity (<100m) of site during baseline fauna survey Biologic (2020).
VHBM-16	Study Area	-21.7372	122.6569	Sand Plain	2021	
VHBM-17	Regional	-21.6982	122.6315	Sand Plain	2021	• Evidence of greater bilby recorded within vicinity (<100m) of site during baseline fauna survey Biologic (2020). • Heritage artifacts

Site ID	Location				Year Established	Species History/ Comments
	Site Type	Latitude	Longitude	Habitat Type		
						recorded at site during 2021, site excluded from future surveys to minimise disturbance.
VHBM-18	Study Area	-21.7146	122.6742	Sand Plain	2022	• Site was established as a camera trap site only in 2021, revised to full monitoring site in 2022.
VHBM-19	Regional	-21.6974	122.6202	Sand Plain	2022	
VHBM-20	Study Area	-21.7486	122.6775	Sand Plain	2022	
VHBM-21	Study Area	-21.7448	122.6474	Sand Plain	2022	

2.5 Survey Methods

2.5.1 Habitat Assessment and Photo Monitoring

Habitat assessments were undertaken at all monitoring sites assessed during the current monitoring survey (Appendix A; Figure 2.2). Habitat assessments were completed to enable a temporal comparison of the condition, structure and quality of habitat with previous and future monitoring surveys.

Habitat assessments were conducted using methodology and terminology modified from the *Australian Soil and Land Survey Field Handbook* (National Committee on Soil and Terrain, 2009). The characteristics recorded during the habitat assessments were:

- site information, photo and location;
- landform: landform type, slope and relative inclination of slope;
- vegetation: leaf litter %, wood litter, hollow bearing trees, broad floristic formation;
- substrate: soil texture, bare ground, rock size, rock type, rock outcropping; and
- disturbance: time since last fire, evidence of weeds, grazing, or human disturbances.

To assist in documenting temporal changes at monitoring sites, a photo monitoring point was installed at each of the monitoring sites during the previous monitoring survey, or during the current survey for newly established sites. Each photo monitoring point was marked *in situ* with a star picket, with a site photo taken facing north-west from the star picket to providing a broad view of the representative habitat within the site (Appendix B).

2.5.2 Greater Bilby Habitat Mapping Review

Greater bilby habitat mapping was completed for the Study Area using the habitat assessments completed during the field survey, as well as high-resolution aerial imagery, vegetation, topographical, geology and soil mapping. Habitats were delineated into primary and secondary greater bilby habitat and mapped across the Study Area at a scale of approximately 1:20,000.

Following bilby habitat classifications defined in Biologic (2020), habitats mapped within the Study Area were assessed for the provision of critical habitat for the species (areas necessary "for activities such as foraging, breeding, roosting, or dispersal" as defined by DoE (2013)). Within this habitat types were assessed as providing primary habitat (i.e. critical habitat as per the definition above), or secondary habitat (i.e. supporting habitats not critical for foraging, breeding, roosting or dispersal, but may support such activities and/ or habitats of marginal suitability for such activities).

Greater bilby occurrence within the Study Area is primarily associated with Sand Plain and Sand Dune habitats where suitable burrowing substrates are present. Within these habitats, unburnt areas comprising relatively mature Triodia hummock grassland and open Acacia shrubland provide primary breeding, foraging and dispersal habitat for the species. Targeted Searches

At each monitoring site, a standardised two-hectare (ha) plot search (survey plot) was undertaken to search for evidence of bilby occurrence, as recommended by DBCA (2017) (Figure 2.2). Each survey plot was subjected to targeted searches for a minimum of 30 minutes and comprised searches for any secondary evidence for the species (i.e. burrows, diggings, tracks and scats, as described by Southgate *et al.* (2019)).

If evidence of bilby was recorded while undertaking searches within the survey plot, more thorough searches were undertaken over an expanded area to search for further evidence to define and map the approximate extent of the species' occurrence at the site. These searches primarily focused on diggings, which is often associated scat deposition. Searches followed the same approach to that implemented within survey plots, searching for evidence as described by Southgate *et al.* (2019).

Once the approximate extent of occurrence had been determined, targeted searches were undertaken along transects spaced approximately 100 m apart and extending just beyond the extent of occurrence. The primary purpose of targeted transects was to collect bilby scats for genotyping, to identify individuals occurring within the area. The total number of transects sampled for each area was dependent on the size and extent of the determined area of occurrence.

2.5.3 Long-term Burrow Camera Traps

All known bilby burrows within the Study Area were visited to assess if active at the time of the field survey. All burrows still in use (n = 6) had a long-term camera trap placed at the burrow entrance to confirm usage by bilby, and/or assess burrow usage/ visitation by other species, including feral cats and dogs (*Canis lupus*), which are likely to have an influence on the local bilby population. In addition, six new bilby burrows discovered during the current survey also had a long-term camera trap placed at the burrow entrance (Table 2.3; Figure 2.2; Plate 2.1). The long-term camera trapping of bilby burrows will capture any sporadic visitations by bilby and other species throughout the year. All data from the long-term camera traps deployed during the current survey will be incorporated into the 2023 monitoring report.

Table 2.3: Camera trap locations

Site	Latitude	Longitude	Date Deployed
VHBC-01	-21.7127	122.6660	24/10/2022
VHBC-02	-21.7138	122.6696	24/10/2022
VHBC-03	-21.7146	122.6742	24/10/2022
VHBC-04	-21.7152	122.6765	24/10/2022
VHBC-05	-21.7189	122.6770	23/10/2022
VHBC-06	-21.7180	122.6813	23/10/2022
VHBC-07	-21.7383	122.6234	26/10/2022
VHBC-08	-21.7387	122.6238	26/10/2022
VHBC-09	-21.7394	122.6247	26/10/2022
VHBC-10	-21.7399	122.6235	26/10/2022
VHBC-11	-21.7411	122.6220	26/10/2022
VHBC-12	-21.7403	122.6209	26/10/2022

Plate 2.1: Long-term camera trap placed at entrance of a bilby burrow during the current survey

457034 461034 465034

7600414 7597414 7594414

VHBM-19
VHBM-01
VHBM-02
VHBM-03
VHBM-04
VHBM-05
VHBM-06
VHBM-08
VHBM-10
VHBM-11
VHBM-12
VHBM-13
VHBM-14
VHBM-15
VHBM-16
VHBM-21
VHBM-20
VHBC-01
VHBC-02
VHBC-03
VHBC-04
VHBC-05
VHBC-06
VHBC-07
VHBC-08
VHBC-09
VHBC-10
VHBC-11
VHBC-12
VHBM-07
VHBM-18
VHBM-09
Havieron

LEGEND

- Study Area
- Disturbance
- Access Track
- Sample Site
- Regional Site
- Monitoring Site
- Study Area Site
- Long-term Camera Trap
- Monitoring Site
- Targeted Search

Biologic

Scale 1:30,000

0 0.5 1 Km

Coordinate System: GDA2020 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA2020 Created 12/04/2023

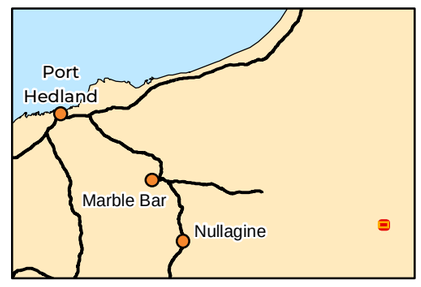

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Figure 2.2: Monitoring sites and sampling

2.5.4 Scat Genotyping

A total of 32 scats were collected from one site during the current survey (Table 2.4; Plate 2.2). Scats were analysed by DBCA with DNA extractions genotyped using a custom-designed multiplexed panel of single-nucleotide polymorphism (SNP) markers (n = 35 SNP loci) on a MassARRAY System. The sex of the individual from which the sample was obtained was determined using four custom-designed bilby sex-linked primers BRA included on the MassArray panel. Further details on specific methods used by DBCA can be found in Appendix E.

Table 2.4: Scat collection record

Site	Latitude	Longitude	Date Collected	Scat Age
VHBM-15	-21.7417	122.6219	25/10/2022	Fresh (<1mth)
VHBM-15	-21.7411	122.6221	25/10/2022	Fresh (<1mth)
VHBM-15	-21.7410	122.6222	25/10/2022	Fresh (<1mth)
VHBM-15	-21.7407	122.6225	25/10/2022	Recent (1 to 6mths)
VHBM-15	-21.7406	122.6225	25/10/2022	Fresh (<1mth)
VHBM-15	-21.7405	122.6213	25/10/2022	Fresh (<1mth)
VHBM-15	-21.7405	122.6234	25/10/2022	Fresh (<1mth)
VHBM-15	-21.7404	122.6234	25/10/2022	Fresh (<1mth)
VHBM-15	-21.7404	122.6234	25/10/2022	Fresh (<1mth)
VHBM-15	-21.7403	122.6239	25/10/2022	Fresh (<1mth)
VHBM-15	-21.7403	122.6209	25/10/2022	Fresh (<1mth)
VHBM-15	-21.7403	122.6213	25/10/2022	Recent (1 to 6mths)
VHBM-15	-21.7402	122.6237	25/10/2022	Fresh (<1mth)
VHBM-15	-21.7400	122.6243	25/10/2022	Fresh (<1mth)
VHBM-15	-21.7399	122.6226	25/10/2022	Fresh (<1mth)
VHBM-15	-21.7398	122.6222	25/10/2022	Fresh (<1mth)
VHBM-15	-21.7398	122.6221	25/10/2022	Recent (1 to 6mths)
VHBM-15	-21.7398	122.6222	25/10/2022	Fresh (<1mth)
VHBM-15	-21.7398	122.6222	25/10/2022	Fresh (<1mth)
VHBM-15	-21.7398	122.6222	25/10/2022	Fresh (<1mth)
VHBM-15	-21.7396	122.6225	25/10/2022	Fresh (<1mth)
VHBM-15	-21.7393	122.6248	25/10/2022	Fresh (<1mth)

Site	Latitude	Longitude	Date Collected	Scat Age
VHBM-15	-21.7392	122.6268	26/10/2022	Fresh (<1mth)
VHBM-15	-21.7390	122.6250	25/10/2022	Fresh (<1mth)
VHBM-15	-21.7387	122.6231	25/10/2022	Recent (1 to 6mths)
VHBM-15	-21.7385	122.6238	25/10/2022	Fresh (<1mth)
VHBM-15	-21.7385	122.6237	25/10/2022	Fresh (<1mth)
VHBM-15	-21.7385	122.6238	25/10/2022	Fresh (<1mth)
VHBM-15	-21.7382	122.6241	25/10/2022	Fresh (<1mth)
VHBM-15	-21.7382	122.6271	26/10/2022	Fresh (<1mth)
VHBM-15	-21.7382	122.6243	25/10/2022	Fresh (<1mth)
VHBM-15	-21.7381	122.6241	25/10/2022	Fresh (<1mth)

Plate 2.2: Greater bilby scats collected during the current survey

3 Results

3.1 Habitat Assessment and Photo Monitoring

Disturbances recorded throughout the Study Area and regional monitoring sites comprised of clearing for exploration activities, exploration drilling, road/access tracks, mining infrastructure/ activity and recent fire (Table 3.2). The majority of exploration and mining activity is located within the central and northern sections of the Study Area, with site VHBM-14 located the closest (110 m) to current disturbance. Signs of recent fires was also recorded intermittently throughout the Study Area and regional monitoring sites, including at three newly established monitoring sites (VHBM-18, VHBM-19 and VHBM-21). Disturbance details relating to each monitoring site are presented in Table 3.2 and discussed in Table 4.1.

3.2 Greater Bilby Habitat Mapping Review

Greater bilby is likely to occur throughout the Study Area, particularly within Sand Plain and Sand Dune habitats where suitable burrowing substrates are present. Within these habitats, unburnt areas comprising relatively mature *Triodia* hummock grassland and open *Acacia* shrubland provide primary breeding, foraging and dispersal habitat for the species.

Primary habitat for the greater bilby occurs sporadically throughout the Study Area, particularly in the eastern portion (Figure 3.1). Primary habitat within the Study Area is fragmentated due to fire; however, unseasonal rain over the last two years has aided in post-fire regeneration. Primary habitat within the Study Area has increased from 192.31 ha (5.31%) in 2020, to 545.67 ha (16.69%) in 2022 (Table 3.1), with additional areas of primary habitat mapped primarily in the southwestern portion of the Study Area during the current survey (Figure 3.1).

Table 3.1: Extent of primary and secondary greater bilby habitat within the Study Area

Year Assessed	Extent of Secondary Habitat		Extent of Primary Habitat	
	Area (ha)	Area (%)	Area (ha)	Area (%)
2020	3623.35	94.69	192.31	5.31
2022	3269.99	83.31	545.67	16.69
Change	-353.36	-11.38	+353.36	+11.38

Table 3.2: Habitat disturbance at each monitoring site

Site ID	Site Type	Disturbances			Distance and summary of disturbance	
		Fire	Road/ access track	Exploration/ mining activity	2021	2022
VHBM-01	Regional	-	x	-	Road/ access tracks approximately 220 m away.	No change from 2021.
VHBM-02	Regional	-	x	-	Road/ access tracks approximately 310 m away.	No change from 2021.
VHBM-03	Regional	-	-	-	No disturbance recorded. Road/ access tracks approximately 1,003 m away.	No change from 2021.
VHBM-04	Regional	x	-	-	Patches of recent fire through area. Mining activity/ infrastructure and road/ access track approximately 2,039 m away.	No change from 2021.
VHBM-05	Study Area	x	-	-	Patches of recent fire through area. Road/ access tracks approximately 200 m away.	No change from 2021.
VHBM-06	Study Area	-	x	x	Exploration drilling and road/ access track approximately 305 m away.	No change from 2021.
VHBM-07	Study Area	-	-	x	Exploration drilling approximately 210 m away.	Exploration drilling ceased nearby. Nearest active road/ access track located approximately 480m away.
VHBM-08	Study Area	-	-	-	No disturbance recorded. Road/ access track approximately 1,900 m away.	No change from 2021.

Site ID	Site Type	Disturbances			Distance and summary of disturbance	
		Fire	Road/ access track	Exploration/ mining activity	2021	2022
VHBM-09	Study Area	-	-	-	No disturbance recorded. Road/ access tracks approximately 638 m away.	No change from 2021.
VHBM-10	Study Area	-	x	-	Road/ access tracks approximately 247 m away.	No change from 2021.
VHBM-11	Study Area	x	x	-	Recent fire through area. Road/ access tracks approximately 215 m away.	No change from 2021.
VHBM-12	Study Area	-	x	x	Exploration drilling and road/ access track approximately 167 m away.	No change from 2021.
VHBM-13	Study Area	-	x	-	Road/ access tracks approximately 110 m away.	No change from 2021.
VHBM-14	Study Area	-	x	x	Mining activity/ infrastructure and road/ access track approximately 110 m away.	No change from 2021.
VHBM-15	Study Area	-	-	-	No disturbance recorded. Mining activity/ infrastructure and road/ access track approximately 900 m away.	No change from 2021.
VHBM-16	Study Area	x	-	-	Patches of recent fire through area. Mining activity/ infrastructure approximately 555 m away.	No change from 2021.
VHBM-17	Regional	x	-	-	Recent fire through area. Road/ access tracks approximately 740 m away. Heritage artifacts recorded at site during 2021, site excluded	-

Site ID	Site Type	Disturbances			Distance and summary of disturbance	
		Fire	Road/ access track	Exploration/ mining activity	2021	2022
					from future surveys to minimise disturbance.	
VHBM-18	Study Area	-	x	x	-	Patches of recent fire through area. Road/ access tracks approximately 740 m away.
VHBM-19	Regional	x	-	-	-	Patches of recent fire through area. Road/ access tracks approximately 500 m away.
VHBM-20	Study Area	-	-	-	-	No disturbance recorded. Road/ access track approximately 630 m away.
VHBM-21	Study Area	x	x	-	-	Patches of recent fire through area. Road/ access tracks approximately 120 m away.

457804
461804
465804
7600196
7597196
7594196
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LEGEND

Study Area

Greater Bilby Habitat

Biologic (2020)

Primary

Current Survey

Primary

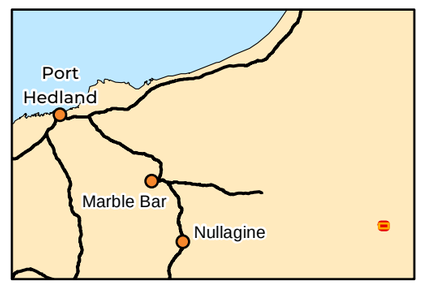
Secondary

Biologic

Scale 1:30,000

0 0.5 1 Km

Coordinate System: GDA2020 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA2020 Created 13/04/2023



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Havieron Project Greater Bilby Monitoring 2022

Figure 3.1: Greater bilby habitat

3.3 Targeted Searches

Evidence of greater bilby occurrence was recorded a total of 600 times within the Study Area during the current survey, comprising of 23 burrows (11 active and 12 inactive; Plate 3.1), 506 diggings (from 58 locations), 36 scats and 35 track records (Plate 3.2; Figure 3.2; Appendix D). Of the 11 inactive burrows recorded, nine of them were initially recorded during the Biologic (2020) survey and resurveyed to check for evidence of recent activity. Following Southgate (2005), assessment of age classes of scats and tracks recorded within the Study Area suggests multiple individuals of various age classes occur, with evidence of all three age classes (i.e. large male, female/small male and immature) present. The majority of evidence of greater bilby was found within the southwestern section of the Study Area, with an extent of occurrence from these records estimated to be 22.22 ha (Figure 3.2; Figure 3.3). All but one active burrow was located at the base of *Acacia* shrubs or large *Triodia* hummocks, while diggings were concentrated in open areas between *Triodia* hummocks and were often clustered with multiple diggings occurring in close proximity to each other (Figure 3.2; Appendix D).

Five other non-target species were recorded during the current survey, comprising three introduced mammal species (camel (*Camelus dromedarius*), dog/ dingo (*Canis lupus*) and cat (*Felis catus*)), one bird species (Australian bustard (*Ardeotis australis*)) and one reptile species (sand goanna (*Varanus gouldii*); Figure 3.2; Appendix D). Evidence of at least one introduced mammal species was recorded at all monitoring sites (Figure 3.2; Appendix D). Camel was recorded via secondary evidence (scats and tracks) at all 20 monitoring sites, while dog/ dingo was recorded at nine sites via secondary evidence (scats and tracks), and cat was recorded at 16 sites via secondary evidence (scats and tracks). An individual cat was also recorded using an inactive bilby burrow which has had a long-term camera trap deployed at it (VHBC-05) (Figure 3.2; Appendix D).

3.4 Scat Genotyping

Of the 32 scats collected during the current survey which were submitted for genetic analysis, a total of ten scats were successfully genotyped (Appendix E). Nine of the successful scats were fresh (<1 month old) and one scat was recent (1–6 months old). A total of two unique individuals were identified from of the ten scats genotyping was successful, comprising one male and one female (Appendix E). Both individuals were from VHBM-15, with eight scats attributed to the female and two scats attributed to the male. Although only two unique individuals were identified from genotyped scats, based on the assessment of age classes of tracks recorded within the Study Area and number of scats genotyping was unsuccessful, it is likely additional individuals occur within the Study Area.

Plate 3.1: Active greater bilby burrow recorded during the current survey

Plate 3.2: Greater bilby track recorded during the current survey

453798 458798 463798

7599552 7596552 7593552

Fauna Observed

Australian bustard
- Scat
- Track

Camel
- Scat
- Track

Cat
- Individual (alive)

Individual (dead)
- Scat
- Track

Dog
- Individual (alive)
- Track
- Scat

Greater Bilby
- Burrow (inactive)

Digging
- Track
- Burrow (active)
- Scat

Sand goanna
- Burrow (inactive)
- Digging
- Track

Havieron

LEGEND
- Study Area
- Disturbance
- Access Track

Biologic

Scale 1:35,000

0 0.5 1 1.5 Km

Coordinate System: GDA2020 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA2020 Created 12/04/2023

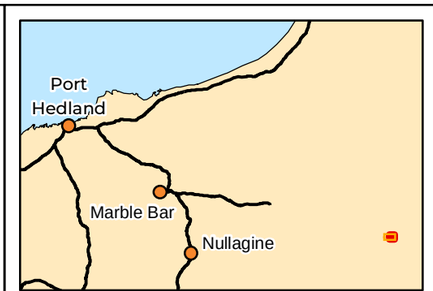

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Figure 3.2: Species recorded during targeted searches at monitoring sites

460521

460921

461321

7596179

7595929

7595679

LEGEND

Study Area

Extent of Occurrence

Access Track

Targeted Search

Fauna Observed

Greater Bilby

Burrow (active)

Digging

Scat

Track

Biologic

Scale 1:2,500

0 30 60 90 Meters

Coordinate System: GDA2020 MGA Zone 51

Projection: Transverse Mercator

Datum: GDA2020 Created 12/04/2023

Port Hedland

Marble Bar

Nullagine

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Havieron Project Greater Bilby Monitoring 2022

Figure 3.3: Greater bilby extent of occurrence

4 Discussion

4.1 Greater Bilby Presence and Abundance

Greater bilbies are highly cryptic and not easily observed (i.e. from direct observation of active individuals), and in addition are often sparsely distributed across big areas, with individuals capable of moving large distances across the landscape (DBCA, 2017). The observations of the species made during the current survey were the first recent records observed since the Biologic (2020) baseline survey. Although the records were concentrated within the southwestern portion of the Study Area during the current survey, the lack of observations elsewhere does not mean that greater bilbies will not use the other habitats of the Study Area in the future (DBCA, 2017). The variable and intermittent use of an area by the species at a local scale is evident by the concentrated records of the species in the southwest of the Study Area during the current survey and apparent lack of records in the northeast of the Study Area a concentration of records was previously recorded during the Biologic (2020) baseline survey,

Based on the different sized tracks observed during the current survey, it is likely that more than the two greater bilby individuals identified from scat genotyping are present within the Study Area. The species often occurs in low abundance (Southgate *et al.*, 2007), as populations naturally occur as scattered solitary or small groups (Smythe & Philpott, 1968; Southgate, 1990a). Groups of greater bilby often occur at a density of 1–2 individuals per km^2 and up to 12–16 individuals per km^2 in areas of optimal habitat (Southgate, 1987). Results from the long-term burrow camera traps and scat analysis will give a better estimation of greater bilby abundance within the Study Area.

Several factors were identified which may have an influence over the occurrence and abundance of greater bilby within the Study Area including feral predators, mining/ exploration disturbance and fire. Feral cats were recorded at 16 of the 20 monitoring sites during the current survey, having previously been recorded at ten of the 17 sites during the 2021 monitoring survey. Evidence of feral cats consisted mainly of tracks; however, one individual was recorded utilising one of the bilby burrows in the north of the Study Area. The number of dog/ dingo records has increased during the current monitoring survey compared to the 2021 monitoring survey. The increase in dog/ dingo numbers is likely to be beneficial for the greater bilby as the dog/ dingo population may help to control the feral cat population within the Study Area.

Exploration and mining activity within the Study Area has increased exponentially since the Biologic (2020) baseline survey, with additional tracks cleared, infrastructure constructed and development of the decline still in progress at the time of the current survey. During the Biologic (2020) baseline survey, the majority of greater bilby records were observed in unburnt primary habitat near sites VHBM-07 and VHBM-09 located in the northeast of the Study Area (Figure 2.2). Since the baseline survey, exploration activity within the north of the Study Area has increased, with a road/ access track and evidence of past exploration activity (cleared drill pad) located <100m from where greater bilby evidence was previously recorded.

Exploration and mining activity was similar between the current survey and the 2021 monitoring survey, with no new tracks or drilling occurring closer to any of the monitoring sites (Table 3.2), with majority of exploration activity still concentrated in the northern portion of the Study Area. The majority of greater bilby records observed during the current survey were located approximately 600m from the closest disturbance in the south of the Study Area. While this does not suggest disturbance resulting from the development of the Project has had no impact on the species at a local scale, it does indicate the species has persisted in the vicinity. Continuation of the annual monitoring program will further highlight the influence the Project's development and operation may have on the local population of the species.

The last factor which may influence the abundance of greater bilby is evidence of recent fire throughout the Study Area. Several of the monitoring sites consisted of areas that were recently burnt; however, these areas still provide secondary (supporting) foraging and dispersal habitat, particularly if the sites are in proximity to unburnt areas. Foraging and dispersal by the species is likely to occur more broadly across these habitats throughout the Study Area; however, utilisation of recently burnt areas is likely to be dependent on the overall condition and extent of post-fire regeneration occurring. These burnt areas are likely to be utilised more frequently as further regeneration occurs, particularly for foraging and may provide primary habitat in future. Utilisation of burnt areas for burrowing may not occur for a prolonged period until vegetation reaches the same maturity of the currently unburnt areas.

Although it is difficult to determine the age of vegetation within the unburnt areas within the Study Area, the size of the large *Triodia* hummocks present suggests the area has remained unburnt for a long period, at least 15–20 plus years following approximate age criteria defined in Burrows *et al.* (2014) and AFAC (2015). The true age of vegetation in desert regions, including *Triodia* grasslands, is difficult to ascertain as growth rates are highly variable and can be heavily influenced by environmental factors including rainfall, moisture, soil fertility and temperature (Bogusiak *et al.*, 1990; Casson & Fox, 1987; Gibson *et al.*, 2016; Wright *et al.*, 2014), therefore the age of unburnt vegetation within the Study Area, and timeframe in which burnt areas will regenerate to comparable structure is unknown. However, some post-fire regeneration within the Study Area is already evident, with the extent of primary habitat mapped increasing from 192.31 ha in 2020, to 545.67 ha during the current survey. The increase in primary habitat and post-fire regeneration throughout the Study Area is likely a result of the unseasonal rain which has occurred over the last two years within the broader region (BoM, 2022). Future monitoring surveys may record evidence of greater bilby within the remaining burnt monitoring sites as post-fire regeneration continues to occur. Further details on the potential factors that might impact on greater bilby occurrence and abundance can be found in Table 4.1.

Although no greater bilbies were recorded utilising the bilby burrows in the north of the Study Area during the current survey, disused bilby burrows have been found to be important structures for a range of species that use burrows as a permanent or short-term shelter (Hofstede & Dziminski, 2017). Typically the greater bilby will have several burrows excavated within its home range and frequently move between them, with periods of disuse variable and likely to be dependent on local foraging resources (Moseby & O'Donnell, 2003). The presence of feral cat within one of the northern bilby burrows is a likely factor as to why they are not currently occupied by the species; however, future monitoring surveys should resurvey known bilby burrows within the Study Area each year to check for usage.

Table 4.1: Factors potentially influencing greater bilby occurrence and abundance

Factor	Relevance	Potential impact on results
Feral predators	Previously occupied areas utilised by greater bilbies may be vacated for alternative areas as a response to feral predators (Southgate, 1987). Feral cats are a primary threat to many threatened species, with numerous examples of cats causing localised population declines (McGregor *et al.*, 2015; Risbey *et al.*, 1999).	**High**. During the initial baseline survey conducted by Biologic (2020), the only feral predator recorded was dog/ dingo from 64 records across the Study Area. Between the initial baseline survey and the 2021 monitoring survey, a cull of dog/ dingo numbers was performed around the Study Area. Dog/ dingo records increased during the current monitoring survey (recorded at nine monitoring sites), compared to the 2021 monitoring survey (recorded at two monitoring sites). However, the number of feral cat records also increased between monitoring years, with feral cat recorded at 16 monitoring sites during the current survey compared to ten monitoring sites during the 2021 monitoring survey. The increase in feral cat numbers is likely to have an impact on greater bilby occurrence within the Study, however the increase in dog/ dingo numbers may be beneficial for the greater bilby. A study by Southgate (2006) found that there was a positive association between bilby and dog/ dingoes, as a substantial part of the dog/dingo diet in the study was feral cats.
Mining and exploration disturbance	Noise, light and ground disturbance caused by exploration and mining activity may influence greater bilby occurrence.	**Moderate**. Potential disturbance from exploration and mine development activities including drilling and clearing can impact on the occurrence of greater bilby within the Study Area (particularly when mining activity is near bilby activity). Although likely that the species will move on from areas close to mining disturbance, there has been records of greater bilby in disturbed areas from bilby pre-clearance work within the Study Area (Biologic, 2021). The records found within disturbed areas likely represent an individual foraging/ dispersing. Disturbance details relating to each monitoring site are presented in Table 3.2.
Fire	Fire has been identified as an important process in greater bilby ecology and occurrence, particularly due to many plant species that make up the greater bilby diet (Southgate, 1990b; Southgate & Carthew, 2007; Southgate & Carthew, 2006; Southgate et al., 2007). Unburnt vegetation represents higher value	**Low**. Although there is evidence of recent fire throughout the Study Area, there are also scattered areas of unburnt vegetation throughout providing higher value habitat for the greater bilby. The species is known to utilise mosaic habitats comprising unburnt areas and areas at various stages of post-fire regeneration, often primarily utilising unburnt areas but venturing into burnt areas during foraging and dispersal movements (Southgate & Carthew, 2007; Southgate & Carthew, 2006; Southgate et al., 2007). The utilisation of burnt areas however is often associated with post-fire regeneration of vegetation, which is heavily dependent on rainfall events to occur successfully (Southgate & Carthew, 2007).

Factor	Relevance	Potential impact on results
	foraging and burrowing habitat for the species.	
Weather conditions	Greater bilbies move throughout the landscape in response to resource availability influenced by climatic conditions (Southgate, 1987; Southgate *et al.*, 2007).	**Low**. Weather conditions during the survey were comparable to long-term averages for that time of year. On one night during the survey a lightning storm accompanied by rain was experienced, however the storm was only mild. The weather conditions experienced during the survey were unlikely to have impacted the occurrence of greater bilby.
Previous rainfall	The amount of rainfall in preceding wet seasons can impact the availability of resources, which can in turn influence the distribution and abundance of the species.	**Negligible**. The higher-than-average rainfall in February and March preceding the monitoring survey would have had a beneficial impact on the food and habitat resources within the Study Area, especially aiding in post-fire regeneration, therefore unlikely to have affected the occurrence of greater bilby.
Breeding cycle	In environments where rainfall is low and often unpredictable, the greater bilby has been observed to breed throughout the year (Moseby & O'Donnell, 2003; Southgate *et al.*, 2000). However, the main drivers of breeding activity are habitat and climatic conditions (e.g. rainfall) that influence resource availability (Berris *et al.*, 2019).	**Negligible**. Breeding activity of the species is unlikely to have impacted the results of the monitoring survey. Limited information is known on the breeding biology of greater bilby, however whether the species was breeding or not during the monitoring survey is unlikely to impact on the ability to detect the species.

4.2 Survey Limitations

The EPA outlines a number of factors that can affect the adequacy of fauna surveys (EPA, 2020). These were assessed in relation to the current survey and no significant limitations were identified (Table 4.2).

Table 4.2: Survey limitations

Potential limitation	Applicability to this survey	Limitation to survey
Scope	The scope of the survey provided for the reassessment of habitats within the Disturbance Envelope to confirm primary and secondary classification for bilby and the implementation of the bilby monitoring program in accordance with the 2021 annual monitoring to obtain data on the species presence and, where possible, abundance within the Study Area, to meet requirement of the HPBMP.	No
Survey effort and completeness	A bilby monitoring survey and habitat reassessment was undertaken across the Study Area to meet the requirements of the HPBMP. The survey was completed with long term monitoring sites and photo monitoring points revisited and three new sites established through the Study Area (and in some regional areas) for future monitoring surveys.	No
Competency and experience of survey team	The field survey was undertaken by Senior Zoologist Courtney Proctor and Zoologist Siobhan Paget, who collectively have more than 7 years' experience completing terrestrial fauna surveys throughout Western Australia, including monitoring projects and surveys of similar scope or relevance, including previous baseline surveys and bilby pre-clearance surveys for the Project. Additionally, Heritage and Ecological Advisors representing the Traditional Owners of the Martu native title determination, which encompasses the Study Area, assisted with sampling, and provided traditional ecological knowledge of the Study Area and the fauna occurring within during the monitoring survey.	No
Efficacy of methods	The survey successfully applied monitoring techniques developed following consultation with DBCA bilby researchers (Dr Martin Dziminski and Dr Fiona Carpenter), to align with DBCA bilby monitoring methods and recommendations (Dziminski & Carpenter, 2016, 2017).	No
Timing of survey, weather, seasonality	The annual monitoring survey was completed in late October. There were no seasonal requirements within the HPBMP.	No
Disturbances (e.g. fire or flood)	No major disturbance occurred during or immediately prior to the survey. However, general mining activity occurred throughout the Study Area and may have impacted species presence. No recent fire has occurred in the Study Area and therefore this is not considered a limitation.	No
Availability of data and information	Previous baseline fauna surveys undertaken for the Project were available for review.	No

5 Conclusion

Recent evidence of greater bilby was recorded during the current survey for the first time since the Biologic (2020) baseline fauna survey. The species was recorded a total of 600 times within the Study Area during the current survey, comprising 23 burrows (11 active and 12 inactive), 506 diggings (from 58 locations), 36 scats and 35 track records. Based on the different sized tracks observed, it is likely that more than the two unique individuals identified from scat genotyping are present within the Study Area. Results from the long-term burrow camera traps will provide further information of greater bilby occurrence and possibly abundance within the Study Area. Recent evidence of greater bilby was primarily contained to the southwestern portion of the Study Area, compared to records concentrated in the northeast during the Biologic (2020) baseline fauna survey.

Primary habitat within the Study Area is still fragmented due to fire, however some post-fire regeneration within the Study Area is evident, with the extent of primary habitat mapped increasing from 192.31 ha in 2020, to 545.67 ha during the current survey. Primary habitat within the Study Area is still predominantly located to the east; however, small patches of isolated primary habitat is evident throughout the entire Study Area. It is likely that primary habitat for the species within the Study Area will continue to increase over time as previously burnt areas regenerate and the extent and quality of habitat improves.

Several factors were identified which may have an influence over the occurrence and abundance of greater bilby within the Study Area including fire, mining/ exploration disturbance and feral predators. Several of the monitoring sites consisted of areas that were recently burnt; however, these areas still provide secondary (supporting) foraging and dispersal habitat, particularly if the sites are in proximity to unburnt areas. These burnt areas are likely to be utilised more frequently as further regeneration occurs, particularly for foraging and may provide primary habitat in the future.

Since the Biologic (2020) baseline fauna survey, exploration and mining activity within the Study Area has increased exponentially. Although likely that the species will move on close to mining disturbance, there have been records of greater bilby within the disturbed areas from bilby pre-clearance works within the Study Area, likely representing an individual foraging/ dispersing. Additionally, the majority of greater bilby records observed during the current survey were located only approximately 600m from exploration and mining activity. Therefore, although mining disturbance may impact the species occurrence, greater bilby may still utilise the disturbed areas to forage and/or disperse and evidence could still be recorded during the monitoring surveys. It is possible that the local population may also become habituated to a level of disturbance over time with concentrated disturbance;

however, this is most likely to occur when broader disturbance (i.e. clearing and exploration) is less prominent and disturbance is reduced to mine operations, which is likely to be more confined compared to broader exploration activities. The monitoring program will further highlight the Project's influence on the species at a local scale as annual monitoring continues.

The increase in feral predators recorded (particularly feral cat) is one of the most likely factors to impact greater bilby occurrence within the Study Area. The increase in feral cat numbers is likely to have an impact on greater bilby occurrence within the Study Area; however, the increase in dog/ dingo numbers may also be beneficial for the greater bilby as the species is known to act as a trophic regulator and may reduce and/or maintain lower abundance of feral cats {Glen, 2007 #1098}. It is recommended that the availability of water and food resources for introduced species, particularly predators, be minimised as much as practicable (as outlined in the HPBMP) and the feral cat management program initiated by Newcrest in 2022 continue to be implemented within the Study Area to reduce the risk of

Despite no evidence of greater bilby occurrence being recorded during the 2021 monitoring survey, the results of the current survey indicate that the species is persisting locally. While the direct influence (i.e. whether natural population movements or contributed to by other factors such as feral predators or mining/ exploration disturbance) of this is unknown, temporal continuation of the monitoring program is likely to highlight influencing factors for the species' occurrence and abundance within the Study Area.

Future monitoring data will provide a better foundation for analysis of bilby population trends over time, particularly in relation to influencing factors, where they can accurately be identified (i.e. timeframes of particular disturbance of influencing factor occurring). The addition of more monitoring sites, particularly regional control sites, will increase the likelihood that the local population will be recorded, particularly when individuals may move to and from the Study Area seasonally, and provide more contextual data to compare the impact sites with. The data obtained from the monitoring program will continue to facilitate evaluation of potential impacts on the species as a result of the Project to ensure impacts are minimised to the maximum extent practicable.

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Appendix A: Monitoring site habitat assessments

Site ID	Coord.	Date	Habitat Type	Landform	Aspect	Slope	Soil Type	Soil Avail.	Veg. Litter	Dominant Veg. Type	Burrowing Suitability	Water present	Disturbances	Last Fire	Notes
VHBM-01	-21.7021, 122.6076	30/10/2021	Sand Plain	Sand Plain	Flat	Flat	Sand	Evenly Spread	Few Small Patches	Acacia Shrubland, Spinifex Hummock Grassland	Very High	None	Road/ Access Track	Moderate (3 to 5 yr)	
VHBM-02	-21.7112, 122.6035	30/10/2021	Sand Plain	Sand Plain	Flat	Flat	Sand	Evenly Spread	Few Small Patches	Acacia Shrubland, Spinifex Hummock Grassland	Very High	None	None Discernible	Old (6+ yr)	Patches of moderate fire
VHBM-03	-21.7221, 122.6140	30/10/2021	Sand Plain	Sand Plain	Flat	Flat	Sand	Evenly Spread	Few Small Patches	Acacia Shrubland, Spinifex Hummock Grassland	Very High	None	None Discernible	Old (6+ yr)	Patches of moderate fire
VHBM-04	-21.7391, 122.6084	29/10/2021	Sand Plain	Sand Plain	Flat	Flat	Sand	Evenly Spread	Few Small Patches	Scattered Eucalypts, Acacia Shrubland, Spinifex Hummock Grassland	Very High	None	None Discernible	Moderate (3 to 5 yr)	Patches of recent fire.
VHBM-05	-21.7076, 122.6339	29/10/2021	Sand Plain	Sand Plain	Flat	Flat	Sand	Evenly Spread	Few Small Patches	Acacia Shrubland, Spinifex Hummock Grassland	Very High	None	Road/ Access Track	Moderate (3 to 5 yr)	Patches of recent fire
VHBM-06	-21.7070, 122.6554	27/10/2021	Sand Plain	Sand Plain	Flat	Flat	Sand	Evenly Spread	Few Small Patches	Acacia Shrubland, Spinifex Hummock Grassland	Very High	None	None Discernible	Moderate (3 to 5 yr)	2ha plot targeting old growth
VHBM-07	-21.7134, 122.6667	27/10/2021	Sand Plain	Sand Plain	Flat	Flat	Sand	Evenly Spread	Many Small Patches	Acacia Shrubland, Spinifex Hummock Grassland	Very High	None	None Discernible	Old (6+ yr)	
VHBM-08	-21.7082, 122.6817	27/10/2021	Sand Plain	Sand Plain	Flat	Flat	Sand	Evenly Spread	Many Small Patches	Scattered Eucalypts, Acacia Shrubland, Spinifex Hummock Grassland	Very High	None	None Discernible	Old (6+ yr)	
VHBM-09	-21.7190, 122.6771	27/10/2021	Sand Plain	Sand Plain	Flat	Flat	Sand	Evenly Spread	Few Small Patches	Acacia Shrubland, Spinifex Hummock Grassland	Very High	None	None Discernible	Old (6+ yr)	
VHBM-10	-21.7161, 122.6181	28/10/2021	Sand Plain	Sand Plain	Flat	Flat	Sand	Evenly Spread	Few Small Patches	Acacia Shrubland, Spinifex Hummock Grassland	Very High	None	None Discernible	Moderate (3 to 5 yr)	
VHBM-11	-21.7184, 122.6376	26/10/2021	Sand Plain	Sand Plain	Flat	Flat	Sand	Evenly Spread	Few Small Patches	Acacia Shrubland, Spinifex Hummock Grassland	Very High	None	Road/ Access Track	Recent (0 to 2 yr)	
VHBM-12	-21.7247, 122.6602	26/10/2021	Sand Plain	Sandy/ Stony Plain	Flat	Flat	Sand	Evenly Spread	Few Small Patches	Acacia Shrubland, Spinifex Hummock Grassland	High	None	Road/ Access Track	Old (6+ yr)	Evidence of recent fire to the south
VHBM-13	-21.7301, 122.6776	26/10/2021	Sand Plain	Sand Plain	Flat	Flat	Sand	Evenly Spread	Few Small Patches	Acacia Shrubland, Spinifex Hummock Grassland	Very High	None	Road/ Access Track	Old (6+ yr)	
VHBM-14	-21.7277, 122.6226	30/10/2021	Sand Plain	Sand Plain	Flat	Flat	Sand	Evenly Spread	Few Small Patches	Acacia Shrubland, Spinifex Hummock Grassland	Very High	None	None Discernible	Old (6+ yr)	Patches of moderate fire
VHBM-15	-21.7391, 122.6267	29/10/2021	Sand Plain	Sand Plain	Flat	Flat	Sand	Evenly Spread	Few Small Patches	Acacia Shrubland, Spinifex Hummock Grassland	Very High	None	None Discernible	Moderate (3 to 5 yr)	

Site ID	Coord.	Date	Habitat Type	Landform	Aspect	Slope	Soil Type	Soil Avail.	Veg. Litter	Dominant Veg. Type	Burrowing Suitability	Water present	Disturbances	Last Fire	Notes
VHBM-16	-21.7372, 122.6569	28/10/2021	Sand Plain	Sand Plain	Flat	Flat	Sand	Evenly Spread	Few Small Patches	Acacia Shrubland, Spinifex Hummock Grassland	Very High	None	None Discernible	Old (6+ yr)	Fire scar runs through part of the 2ha plot
VHBM-17	-21.6982, 122.6315	29/10/2021	Sand Plain	Sand Plain	Flat	Flat	Sand	Evenly Spread	Few Small Patches	Acacia Shrubland, Spinifex Hummock Grassland	Very High	None	None Discernible	Recent (0 to 2 yr)	Site removed from future monitoring surveys due to heritage artefacts found
VHBM-18	-21.7145, 122.6742	27/10/2021	Sand Plain	Sand Plain	Flat	Low	Sand	Evenly Spread	Few Small Patches	Acacia Shrubland, Spinifex Hummock Grassland	Very High	None	None Discernible	Old (6+ yr)	Not a monitoring site, opportunistic camera trap site
VHBM-19	-21.6974, 122.6202	22/10/2022	Sandy Plain	Sandy Plain	Flat	Flat	Sand	Many Small Patches	Few Small Patches	Scattered Shrubs, Spinifex Hummock Grassland	High	None	None Discernible	Moderate (3 to 5 yr)	
VHBM-20	-21.7485, 122.6774	24/10/2022	Sandy Plain	Sandy Plain	Flat	Flat	Sand	Many Small Patches	Many Small Patches	Scattered Shrubs, Spinifex Hummock Grassland	Very High	None	None Discernible	Old (6+ yr)	
VHBM-21	-21.7448, 122.6474	24/10/2022	Sandy Plain	Sandy Plain	Flat	Flat	Sand	Many Large Patches	Few Small Patches	Scattered Shrubs, Spinifex Hummock Grassland	Very High	None	Road/ Access Track	Old (6+ yr)	

Appendix B: Photo monitoring point photos

Site ID	2021	2022
VHBM-01		
VHBM-02		
VHBM-03		
VHBM-04		

Site ID	2021	2022
VHBM-05		
VHBM-06		
VHBM-07		
VHBM-08		

Site ID	2021	2022
VHBM-09		
VHBM-10		
VHBM-11		
VHBM-12		

Site ID	2021	2022
VHBM-13		
VHBM-14		
VHBM-15		
VHBM-16		

Site ID	2021	2022
VHBM-17		NA
VHBM-18	NA	
VHBM-19	NA	
VHBM-20	NA	

Site ID	2021	2022
VHBM-21	NA	

Appendix C: Greater bilby records from current survey

Site	Location		Habitat	Record Type	Qty.	Comments
	Latitude	Longitude				
VHBC-08	-21.7387	122.6238	Sand Plain	Burrow (active)	1	
VHBC-09	-21.7394	122.6247	Sand Plain	Burrow (active)	1	
VHBC-10	-21.7400	122.6236	Sand Plain	Burrow (active)	1	Two entrances
VHBC-11	-21.7411	122.6220	Sand Plain	Burrow (active)	1	
VHBC-12	-21.7403	122.6209	Sand Plain	Burrow (active)	1	
VHBM-15	-21.7398	122.6222	Sand Plain	Burrow (active)	1	
VHBM-15	-21.7408	122.6226	Sand Plain	Burrow (active)	1	
VHBM-15	-21.7403	122.6209	Sand Plain	Burrow (active)	1	
VHBM-15	-21.7404	122.6239	Sand Plain	Burrow (active)	1	
VHBM-15	-21.7388	122.6240	Sand Plain	Burrow (active)	1	
VHBM-15	-21.7384	122.6271	Sand Plain	Burrow (active)	1	Lots of snake activity
VHBC-07	-21.7382	122.6234	Sand Plain	Burrow (active)	1	
VHBC-08	-21.7387	122.6238	Sand Plain	Burrow (active)	1	
No site	-21.7137	122.6693	Sand Plain	Burrow (inactive)	1	Caved in completely
No site	-21.7346	122.6262	Sand Plain	Burrow (inactive)	1	
VHBC-01	-21.7127	122.6660	Sand Plain	Burrow (inactive)	1	Burrow first recorded in 2020, revisited during current survey
VHBC-02	-21.7138	122.6696	Sand Plain	Burrow (inactive)	1	Burrow first recorded in 2020, revisited during current survey

Site	Location		Habitat	Record Type	Qty.	Comments
	Latitude	Longitude				
VHBC-03	-21.7146	122.6742	Sand Plain	Burrow (inactive)	1	Burrow first recorded in 2020, revisited during current survey
VHBC-04	-21.7152	122.6765	Sand Plain	Burrow (inactive)	1	Burrow first recorded in 2020, revisited during current survey
VHBC-05	-21.7189	122.6771	Sand Plain	Burrow (inactive)	1	Burrow first recorded in 2020, revisited during current survey
VHBC-06	-21.7180	122.6813	Sand Plain	Burrow (inactive)	1	Burrow first recorded in 2020, revisited during current survey
VHBM-07	-21.7126	122.6670	Sand Plain	Burrow (inactive)	1	Burrow first recorded in 2020, revisited during current survey
VHBM-07	-21.7131	122.6657	Sand Plain	Burrow (inactive)	1	Burrow first recorded in 2020, revisited during current survey
VHBM-07	-21.7127	122.6650	Sand Plain	Burrow (inactive)	1	Burrow first recorded in 2020, revisited during current survey
No site	-21.7344	122.6258	Sand Plain	Digging	5	Old diggings, within 10 square metres
No site	-21.7337	122.6279	Sand Plain	Digging	1	

Site	Location		Habitat	Record Type	Qty.	Comments
	Latitude	Longitude				
VHBM-15	-21.7385	122.6237	Sand Plain	Digging	6	Within 1 square metre
VHBM-15	-21.7400	122.6237	Sand Plain	Digging	1	
VHBM-15	-21.7398	122.6226	Sand Plain	Digging	6	Within 1 square metre
VHBM-15	-21.7398	122.6221	Sand Plain	Digging	20	Within 10 square metres
VHBM-15	-21.7399	122.6222	Sand Plain	Digging	5	Within 1 square metre
VHBM-15	-21.7407	122.6226	Sand Plain	Digging	15	Within 10 square metres
VHBM-15	-21.7410	122.6222	Sand Plain	Digging	5	Within 1 square metre
VHBM-15	-21.7410	122.6223	Sand Plain	Digging	2	Within 1 square metre
VHBM-15	-21.7417	122.6218	Sand Plain	Digging	2	Within 1 square metre
VHBM-15	-21.7396	122.6224	Sand Plain	Digging	15	Within 5 square metres
VHBM-15	-21.7396	122.6224	Sand Plain	Digging	15	Within 5 square metres
VHBM-15	-21.7387	122.6231	Sand Plain	Digging	3	Within 5 square metres
VHBM-15	-21.7385	122.6238	Sand Plain	Digging	9	Within 1 square metre

Site	Location		Habitat	Record Type	Qty.	Comments
	Latitude	Longitude				
VHBM-15	-21.7398	122.6223	Sand Plain	Digging	4	Within 2 square metres
VHBM-15	-21.7406	122.6225	Sand Plain	Digging	1	
VHBM-15	-21.7406	122.6225	Sand Plain	Digging	1	
VHBM-15	-21.7411	122.6221	Sand Plain	Digging	10	Within 10 square metres
VHBM-15	-21.7411	122.6214	Sand Plain	Digging	2	Within 2 square metres
VHBM-15	-21.7407	122.6211	Sand Plain	Digging	2	Within 1 square metre
VHBM-15	-21.7405	122.6213	Sand Plain	Digging	20	Within 10 square metres
VHBM-15	-21.7403	122.6210	Sand Plain	Digging	15	Within 10 square metres
VHBM-15	-21.7402	122.6214	Sand Plain	Digging	10	Within 15 square metres
VHBM-15	-21.7399	122.6219	Sand Plain	Digging	5	Within 5 square metres
VHBM-15	-21.7397	122.6220	Sand Plain	Digging	5	Within 10 square metres
VHBM-15	-21.7404	122.6238	Sand Plain	Digging	20	Within 15 square metres
VHBM-15	-21.7403	122.6239	Sand Plain	Digging	15	Within 10 square metres
VHBM-15	-21.7405	122.6242	Sand Plain	Digging	1	Attempted burrow

Site	Location		Habitat	Record Type	Qty.	Comments
	Latitude	Longitude				
VHBM-15	-21.7400	122.6243	Sand Plain	Digging	5	Within 5 square metres
VHBM-15	-21.7393	122.6247	Sand Plain	Digging	10	Within 15 square metres
VHBM-15	-21.7392	122.6249	Sand Plain	Digging	20	Within 15 square metres
VHBM-15	-21.7386	122.6241	Sand Plain	Digging	1	Attempted burrow
VHBM-15	-21.7382	122.6241	Sand Plain	Digging	10	Within 10 square metres
VHBM-15	-21.7386	122.6240	Sand Plain	Digging	10	Within 10 square metres
VHBM-15	-21.7416	122.6225	Sand Plain	Digging	1	
VHBM-15	-21.7403	122.6208	Sand Plain	Digging	10	Within 10 square metres
VHBM-15	-21.7402	122.6207	Sand Plain	Digging	5	Within 2 square metres
VHBM-15	-21.7407	122.6216	Sand Plain	Digging	5	Within 2 square metres
VHBM-15	-21.7408	122.6225	Sand Plain	Digging	5	Within 10 square metres
VHBM-15	-21.7406	122.6237	Sand Plain	Digging	5	Within 10 square metres
VHBM-15	-21.7400	122.6245	Sand Plain	Digging	6	Within 5 square metres

Site	Location		Habitat	Record Type	Qty.	Comments
	Latitude	Longitude				
VHBM-15	-21.7407	122.6247	Sand Plain	Digging	5	Within 5 square metres
VHBM-15	-21.7405	122.6234	Sand Plain	Digging	10	Within 5 square metres
VHBM-15	-21.7382	122.6246	Sand Plain	Digging	1	
VHBM-15	-21.7382	122.6243	Sand Plain	Digging	1	
VHBM-15	-21.7390	122.6250	Sand Plain	Digging	20	Within 5 square metres
VHBM-15	-21.7393	122.6248	Sand Plain	Digging	40	Within 20 square metres
VHBM-15	-21.7394	122.6270	Sand Plain	Digging	30	Within 20 square metres
VHBM-15	-21.7399	122.6268	Sand Plain	Digging	8	Within 1 square metre
VHBM-15	-21.7399	122.6267	Sand Plain	Digging	10	Within 10 square metres
VHBM-15	-21.7402	122.6265	Sand Plain	Digging	10	Within 10 square metres
VHBM-15	-21.7394	122.6263	Sand Plain	Digging	30	Within 20 square metres
VHBM-15	-21.7382	122.6272	Sand Plain	Digging	2	Within 2 square metres
VHBM-15	-21.7392	122.6266	Sand Plain	Digging	1	
VHBM-15	-21.7394	122.6230	Sand Plain	Digging	3	Within 5 square metres

Site	Location		Habitat	Record Type	Qty.	Comments
	Latitude	Longitude				
VHBM-15	-21.7397	122.6250	Sand Plain	Digging	20	Within 10 square metres
VHBM-15	-21.7407	122.6241	Sand Plain	Digging	3	Within 1 square metre
VHBM-15	-21.7385	122.6237	Sand Plain	Scat	1	Scat 10, Fresh (<1mth)
VHBM-15	-21.7399	122.6226	Sand Plain	Scat	1	Scat 1, Fresh (<1mth)
VHBM-15	-21.7398	122.6221	Sand Plain	Scat	1	Scat 13, Recent (1 to 6mths)
VHBM-15	-21.7398	122.6222	Sand Plain	Scat	1	Scat 14, Fresh (<1mth)
VHBM-15	-21.7407	122.6225	Sand Plain	Scat	1	Scat 31, Recent (1 to 6mths)
VHBM-15	-21.7410	122.6222	Sand Plain	Scat	1	Scat 9, Fresh (<1mth)
VHBM-15	-21.7411	122.6221	Sand Plain	Scat	1	Scat 11, Fresh (<1mth)
VHBM-15	-21.7417	122.6219	Sand Plain	Scat	1	Scat 28, Buried in sand, Fresh (<1mth)
VHBM-15	-21.7403	122.6209	Sand Plain	Scat	1	Scat 25, Fresh (<1mth)
VHBM-15	-21.7403	122.6213	Sand Plain	Scat	1	Scat 2, Recent (1 to 6mths)
VHBM-15	-21.7396	122.6225	Sand Plain	Scat	1	Scat 3, Fresh (<1mth)
VHBM-15	-21.7387	122.6231	Sand Plain	Scat	1	Scat 12, Recent (1 to 6mths)
VHBM-15	-21.7385	122.6238	Sand Plain	Scat	1	Scat 32, Fresh (<1mth)
VHBM-15	-21.7385	122.6238	Sand Plain	Scat	1	Scat 27, Fresh (<1mth)
VHBM-15	-21.7398	122.6222	Sand Plain	Scat	1	Scat 19, Fresh (<1mth)

Site	Location		Habitat	Record Type	Qty.	Comments
	Latitude	Longitude				
VHBM-15	-21.7398	122.6222	Sand Plain	Scat	1	Scat 23, Fresh (<1mth)
VHBM-15	-21.7398	122.6222	Sand Plain	Scat	1	Scat 29, Fresh (<1mth)
VHBM-15	-21.7406	122.6225	Sand Plain	Scat	1	Scat 5, Fresh (<1mth)
VHBM-15	-21.7405	122.6213	Sand Plain	Scat	1	Scat 21, Fresh (<1mth)
VHBM-15	-21.7403	122.6239	Sand Plain	Scat	1	Scat 26, Fresh (<1mth)
VHBM-15	-21.7402	122.6237	Sand Plain	Scat	1	Scat 6, Fresh (<1mth)
VHBM-15	-21.7400	122.6243	Sand Plain	Scat	1	Scat 30, Fresh (<1mth)
VHBM-15	-21.7382	122.6241	Sand Plain	Scat	1	Scat 24, Fresh (<1mth)
VHBM-15	-21.7404	122.6234	Sand Plain	Scat	1	Scat 20, Fresh (<1mth)
VHBM-15	-21.7404	122.6234	Sand Plain	Scat	1	Scat 17, Partially covered, Fresh (<1mth)
VHBM-15	-21.7405	122.6234	Sand Plain	Scat	1	Scat 8, Fresh (<1mth)
VHBM-15	-21.7381	122.6246	Sand Plain	Scat	1	Not collected, Recent (1 to 6mths)
VHBM-15	-21.7382	122.6243	Sand Plain	Scat	1	Scat 4, Fresh (<1mth)
VHBM-15	-21.7383	122.6240	Sand Plain	Scat	1	Not collected, Recent (1 to 6mths)
VHBM-15	-21.7381	122.6241	Sand Plain	Scat	1	Scat 16, Fresh (<1mth)
VHBM-15	-21.7390	122.6250	Sand Plain	Scat	1	Scat 18, Fresh (<1mth)
VHBM-15	-21.7393	122.6248	Sand Plain	Scat	1	Scat 22, Fresh (<1mth)
VHBM-15	-21.7392	122.6268	Sand Plain	Scat	1	Scat 15, Fresh (<1mth)

Site	Location		Habitat	Record Type	Qty.	Comments
	Latitude	Longitude				
VHBM-15	-21.7385	122.6268	Sand Plain	Scat	1	Not collected, degraded, Recent (1 to 6mths)
VHBM-15	-21.7382	122.6271	Sand Plain	Scat	1	Scat 7, Fresh (<1mth)
VHBM-15	-21.7375	122.6270	Sand Plain	Scat	1	Not collected, degraded, Recent (1 to 6mths)
No site	-21.7342	122.6278	Sand Plain	Track	1	Old track
VHBC-09	-21.7394	122.6247	Sand Plain	Track	1	
VHBM-15	-21.7399	122.6226	Sand Plain	Track	1	
VHBM-15	-21.7405	122.6224	Sand Plain	Track	1	
VHBM-15	-21.7407	122.6225	Sand Plain	Track	1	
VHBM-15	-21.7393	122.6226	Sand Plain	Track	1	
VHBM-15	-21.7391	122.6228	Sand Plain	Track	1	Multiple sets of tracks
VHBM-15	-21.7384	122.6235	Sand Plain	Track	1	
VHBM-15	-21.7382	122.6235	Sand Plain	Track	1	Multiple sets of tracks
VHBM-15	-21.7380	122.6234	Sand Plain	Track	1	
VHBM-15	-21.7397	122.6222	Sand Plain	Track	1	
VHBM-15	-21.7400	122.6222	Sand Plain	Track	1	
VHBM-15	-21.7396	122.6224	Sand Plain	Track	1	
VHBM-15	-21.7385	122.6243	Sand Plain	Track	1	
VHBM-15	-21.7392	122.6223	Sand Plain	Track	1	
VHBM-15	-21.7393	122.6224	Sand Plain	Track	1	

Site	Location		Habitat	Record Type	Qty.	Comments
	Latitude	Longitude				
VHBM-15	-21.7408	122.6244	Sand Plain	Track	1	
VHBM-15	-21.7402	122.6226	Sand Plain	Track	1	
VHBM-15	-21.7382	122.6246	Sand Plain	Track	1	
VHBM-15	-21.7381	122.6238	Sand Plain	Track	1	
VHBM-15	-21.7381	122.6233	Sand Plain	Track	1	
VHBM-15	-21.7376	122.6223	Sand Plain	Track	1	
VHBM-15	-21.7377	122.6223	Sand Plain	Track	1	
VHBM-15	-21.7381	122.6225	Sand Plain	Track	1	
VHBM-15	-21.7384	122.6228	Sand Plain	Track	1	
VHBM-15	-21.7384	122.6235	Sand Plain	Track	1	
VHBM-15	-21.7387	122.6246	Sand Plain	Track	1	
VHBM-15	-21.7388	122.6251	Sand Plain	Track	1	
VHBM-15	-21.7390	122.6250	Sand Plain	Track	1	
VHBM-15	-21.7392	122.6248	Sand Plain	Track	1	Multiple sets of tracks
VHBM-15	-21.7391	122.6242	Sand Plain	Track	1	
VHBM-15	-21.7387	122.6225	Sand Plain	Track	1	
VHBM-15	-21.7386	122.6224	Sand Plain	Track	1	
VHBM-15	-21.7396	122.6269	Sand Plain	Track	1	
VHBM-15	-21.7391	122.6268	Sand Plain	Track	1	

Appendix D: Species recorded during the current survey

Scientific Name	Common Name	VHBM-01	VHBM-02	VHBM-03	VHBM-04	VHBM-05	VHBM-06	VHBM-07	VHBM-08	VHBM-09	VHBM-10	VHBM-11	VHBM-12	VHBM-13	VHBM-14	VHBM-15	VHBM-16	VHBM-18	VHBM-19	VHBM-20	VHBM-21	Opportunistic
MAMMALS																						
CAMELIDAE																						
Camelus dromedarius	*Camel	S	S, T	S, T	T	S	T	T	T	T	T	S	T	T	T	T	S	T	S	T	T	
CANIDAE																						
Canis familiaris	*Dog/ dingo	T	T				T	T				T		T		S	S	T				IA, T
FELIDAE																						
Felis catus	*Cat	T		T	S, T	T	T	T		T		T	T	T	S, T	S, T		T	T	T	T	IA, ID, S, T
THYLACOMYIDAE																						
Macrotis lagotis	Greater bilby							BI								BA, D, S, T						BI, D, T
AVES																						
OTIDIDAE																						
Ardeotis australis	Australian bustard	T	T		T	T	T	T	S	T	S	S, T	S, T	T	S	S	T	T	T	T	T	
REPTILES																						
VARANIDAE																						
Varanus gouldii	Sand goanna	D	D	D	D	D	D	D	D, T	D	D	D	D	D	D	D, T	D	BI	D	D	D	

T = track, S = scat, D= digging, IA = individual alive, ID= individual dead, BA = burrow active, BI = burrow inactive

*Introduced

Appendix E: Scat genotyping results

Department of Biodiversity, Conservation and Attractions
GOVERNMENT OF WESTERN AUSTRALIA

Biodiversity and Conservation Science

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Ryan Ellis
Principal Zoologist
Biologic
Western Australia

Genotyping of bilby scats collected from Telfer area,, Western Australia.

Harry Moore, Kym Ottewell, Mel Millar

Background and field sampling

A total of 32 scat samples were submitted by Biologic in paper envelopes on Friday the 9th of December.

Laboratory analyses

Bilby scat samples were initially soaked and gently agitated in ~400 ul of SLP buffer to obtain sloughed cells from the surface of the scat. Supernatant from this mixture was transferred to tubes and genomic DNA extractions were completed using the Omega Bio-tek MagBind® Stool DNA 96 Kit (Omega Bio-tek, Norcross, GA, USA) as per the manufacturer's standard protocol. We eluted DNA in a final volume of 100 ul using a 50% dilution of the final elution buffer to reduce EDTA interference with MassArray typing. Samples were concentrated (60 ul DNA reduced to 30 ul) via vacuum centrifuge prior to analysis to improve genotyping results. DNA samples were genotyped using a custom-designed multiplexed panel of single nucleotide polymorphism (SNP) markers (n = 35 SNP loci) on the MassARRAY System (Agena BioScience) at the Australian Genome Research Facility, Brisbane (AGRF).

Molecular sexing of scat samples was carried out using four custom-designed bilby sex-linked primers BRA (Brandies 2021) included on the MassArray panel. To account for discrepancies in sex identification across scat samples, we followed guidelines established by Sun et al. (2021) for classification. Samples were classified as male if they exhibited successful amplification for at least two Y-linked markers and consistently showed the same sex identification across multiple scats. We defined likely sex as a set of scats with minimal variation between markers and/or scats. Predicted sex referred to a cluster of scats with significant discordance, and the selected sex represented the majority of results. Scats that demonstrated low to no amplification signal from sexing markers or were indistinguishable due to equal probabilities were classified as undetermined.

To improve the stringency of genotype matching, we removed samples and loci with amplification rates below 50% and 60% respectively. MassARRAY SNP results were processed in a custom R package 'ScatMatch'. designed to group scats based on genotype similarity, i.e. by the number of allelic mismatches between samples. A mismatch threshold of five was used given a clear separation was observed between the mismatch distributions of scats from the same individual and different individuals.

Results

Of the 32 supplied samples, ten samples yielded DNA and amplified at enough loci to include in identity analysis (Table 2). Genotyping using the 35 SNP loci identified two distinct individuals (One male, one female) (Figure 1, Table 2).

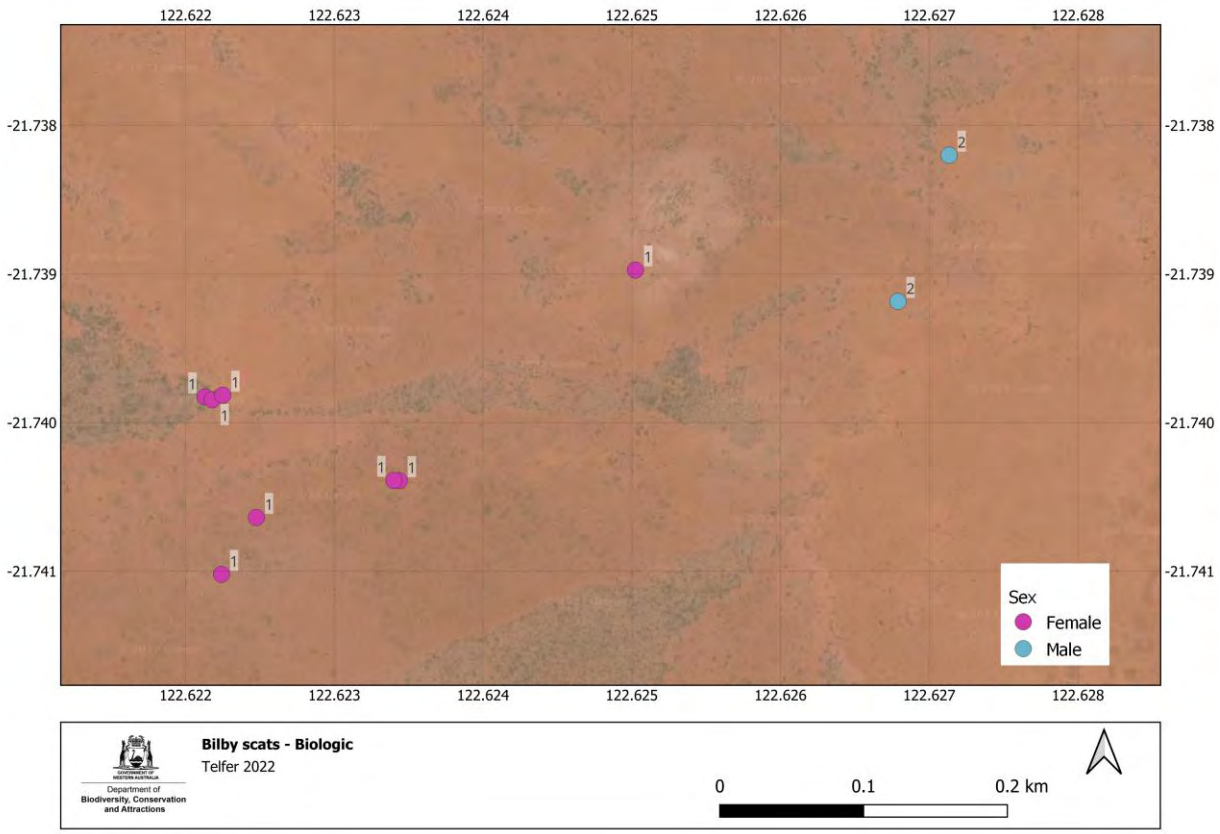

Figure 1 – Map indicating location of samples identified to the individual level. Labels indicate individual ID, and colours represent sex.

Table 1 – Successfully genotyped bilby scat samples.

Sample.No	Group	Latitude	Longitude	Sex
SC-02782	1	-21.7398	122.6221	F
SC-02783	1	-21.7398	122.6222	F
SC-02785	1	-21.741	122.6222	F
SC-02796	1	-21.7398	122.6222	F
SC-02797	1	-21.7406	122.6225	F
SC-02803	1	-21.7404	122.6234	F
SC-02804	1	-21.7404	122.6234	F
SC-02808	1	-21.739	122.625	F
SC-02812	2	-21.7392	122.6268	M
SC-02813	2	-21.7382	122.6271	M