



mainroads
WESTERN AUSTRALIA

EPBC Act Compliance Report

Broome-Cape Leveque Road Upgrade, Western
Australia (EPBC 2013/6984)

Reporting period: 2 August 2021 to 1 August 2022

Report Compilation & Review	Name and Position	Date	Document Revision
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Reviewer	Senior Environmental Officer	13/10/22	Rev 0

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1 INTRODUCTION

The Cape Leveque Road is located in the Shire of Broome and runs from Broome Highway, east of Broome townsite, to the northern Dampier Peninsula for a length of approximately 200 kilometres (km) to the Ardyaloon (One Arm Point) Aboriginal community. The road is a main transport link, providing access for Aboriginal communities including Beagle Bay, Lombadina/Djarindjin, and numerous Aboriginal outstations. Other stakeholders include Country Downs pastoral station, pearling industries and several tourist destinations such as Kooljaman Resort and Cygnet Bay.

Various sections of the Cape Leveque Road have been upgraded to a sealed standard over the last ten years. Main Roads Western Australia (Main Roads) proposed to upgrade 77.6 km (Straight Line Kilometre (SLK) 25 to 102.6) of the unsealed section of the Cape Leveque Road (see Figure 1). The proposed upgrade involved construction of a new road generally parallel to the existing unsealed road. Road user safety and reduced maintenance are two of the key reasons for the proposed upgrade.

1.1 Approval under the *Environment Protection and Biodiversity Conservation Act 1999*

On 3 September 2013, the Department of Climate Change, Energy, the Environment and Water (DCCEEW) (then Department of Sustainability, Environment, Water, Population and Communities) received a referral under the EPBC Act from Main Roads (Main Roads Western Australia 2013) to upgrade the road between SLK 25 and 102.6.

On the 27 September 2013, Main Roads received formal advice from DAWE that the proposed upgrade was considered to be a 'controlled action' requiring assessment and approval under the EPBC Act. The proposed action was assessed at the Preliminary Documentation level of assessment.

Main Roads received approval from DCCEEW on the 6 July 2015 subject to a number of Conditions (EPBC 2013/6984). A copy of the Approval Notice is provided in Appendix 1.

1.3 Status of the Project

The Broome-Cape Leveque Road Upgrade Project (the Project) aims to both minimise the environmental footprint of works and maximise Aboriginal employment and local businesses for the communities of the Dampier Peninsula. Local engagement, participation and ownership is paramount to ensure social, environmental and economic opportunities are fully utilised.

Broome-Cape Leveque Road was opened to the public in December 2020. On 1 February 2022 Country Downs Station received 652 mm of rain within a 24 hour period, resulting in significant and extensive damage to a large section of Broome-Cape Leveque Road Upgrade Project. The most severe damage occurred between SLK 35 – 80, with extensive damage to the drainage network and across the project site. Repairs to the road are currently being undertaken and planned to be completed by December 2022. The flooding also caused considerable damage to rehabilitation as a result, revegetation works need to be reinstated and will be undertaken at the completion of the 2022 repairs.

Based in Beagle Bay, the Nyul Nyul Rangers continue to deliver specialised Greater Bilby Management, which delivers key components of the Project's Greater Bilby Management Plan. Pre-clearing Greater Bilby surveys by Traditional Owner Rangers are undertaken in accordance with the Project's Greater Bilby Management Plan. No active burrows requiring the relocation of Greater Bilbies were recorded during site this reporting period, nor were any individuals trapped nor sighted. Ecological expertise and specialised Greater Bilby services were provided by Dr Rick Southgate (Envisage Environmental Services).

No fauna underpasses were installed during the reporting period. Seven drainage culverts that also act as fauna underpasses were installed during previous reporting periods (Figure 2). The report on culvert monitoring by Dr Rick Southgate is attached (Appendix 2).

1.2 Purpose of this Report

This compliance report has been produced as required by Condition 3 of EPBC 2013/6984. Table 1 of this report outlines compliance with each approval condition over the 12 month period between 2 August 2020 and 1 August 2021 (the reporting period).

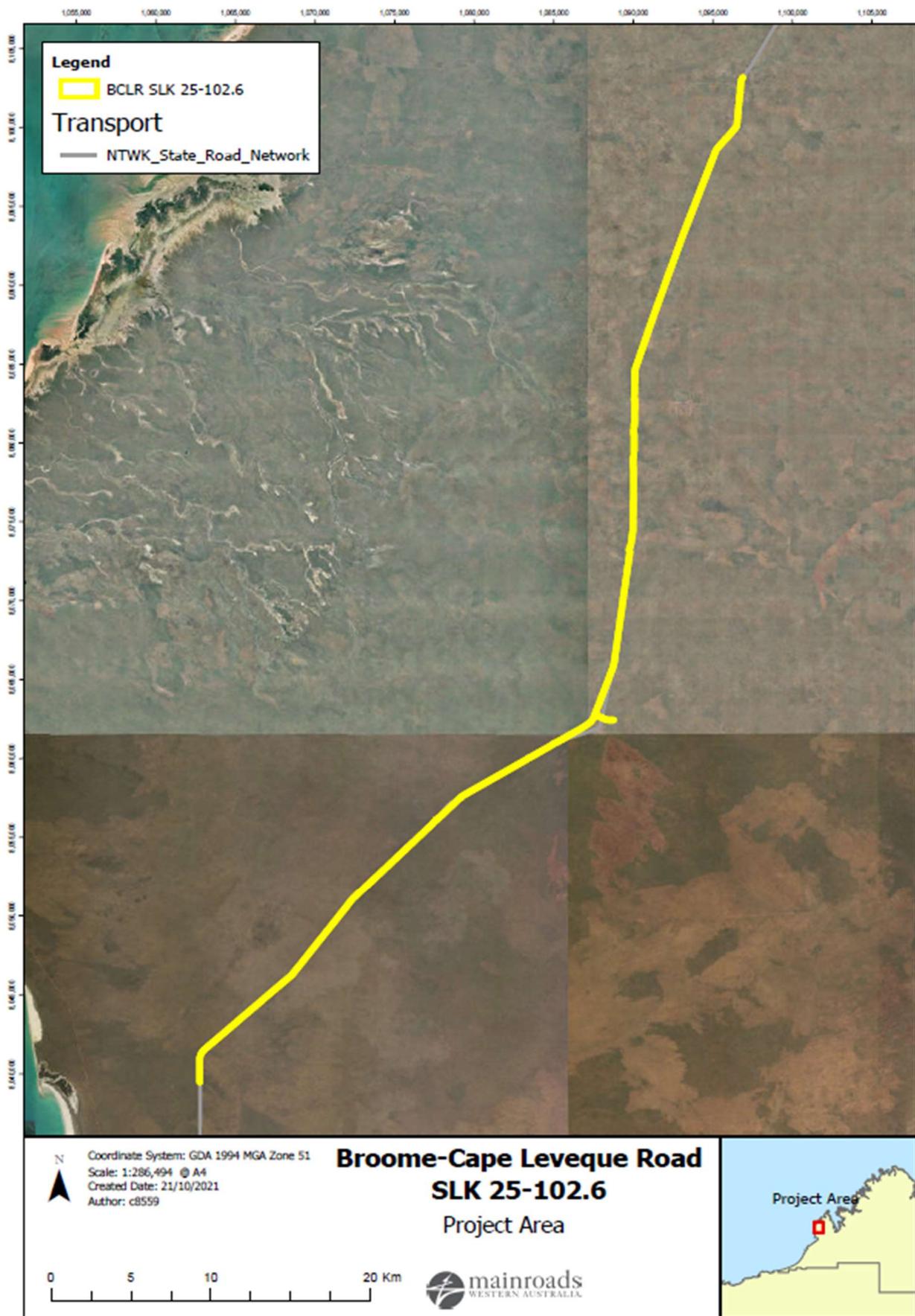


Figure 1. Project Area

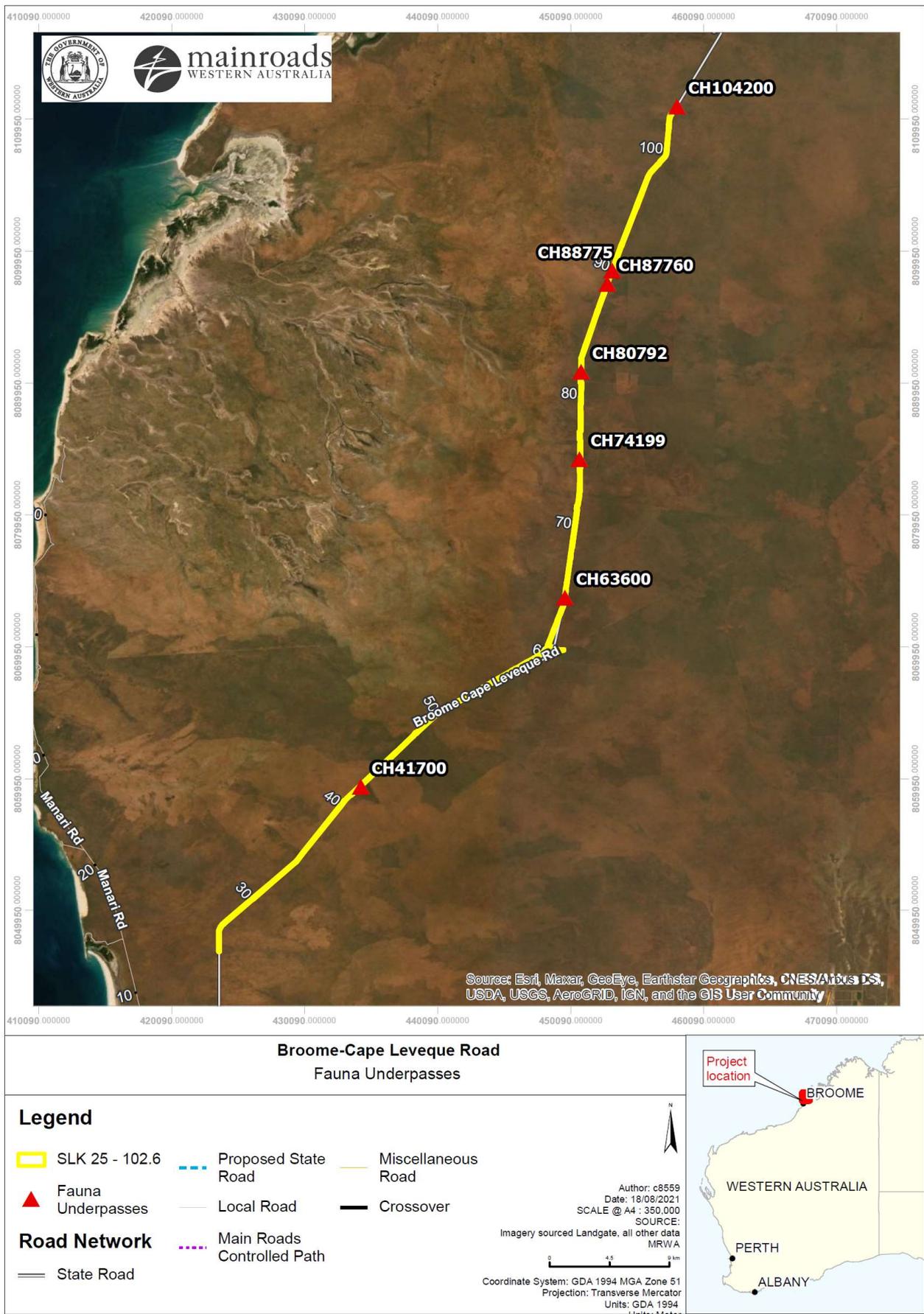


Figure 2: Fauna Underpasses

2 COMPLIANCE

Table 1: Compliance with Conditions of EPBC Approval 2016/7665

Condition Number	Condition	Status	Evidence/Comments
1	Within 10 days after the commencement of the action, the person taking the action must advise the Department in writing of the actual date of commencement.	Complete	<p>As per the definition of 'Commencement of Action' in EPBC 2013/6984, the Project commenced on 2 August 2017, with the clearing of small amounts of native vegetation for geotechnical investigations.</p> <p>The DotEE were advised of the Commencement of Action via a letter dated 9 August 2017.</p>
2	The person taking the action must maintain accurate records substantiating all activities associated with or relevant to the conditions of approval, including measures taken to implement the management plan required by this approval, and make them available upon request to the Department. Such records may be subject to audit by the Department or an independent auditor in accordance with section 458 of the EPBC Act, or used to verify compliance with the conditions of approval. Summaries of audits will be posted on the Department's website. The results of audits may also be publicised through the general media.	Compliant	Main Roads WA has maintained all records in accordance with this condition and legal obligations, under the <i>State Records Act 2000</i> (Western Australia).

Condition Number	Condition	Status	Evidence/Comments
3	<p>Within three months of every 12 month anniversary of the commencement of the action, the person taking the action must publish a report on their website addressing compliance with the conditions of this approval over the previous 12 months, including implementation of any management plans as specified in the conditions. The compliance reports must remain on their website for a minimum of 12 months (beginning on the date of publication). Non-compliance with any of the conditions of this approval must be reported to the Department at the same time as the compliance report is published. The person taking the action must continue to annually publish the report on their website addressing compliance with each of the conditions of this approval until such time as agreed to in writing by the Minister.</p>	Compliant	<p>This Report has been prepared pursuant to this condition and will be published on the Main Roads website. All previous reports remain available on the Main Roads website at: https://www.mainroads.wa.gov.au/community-environment/environment/construction-project-reports/Construction-Project-Reports-Main-Roads-Western-Australia¹.</p>
4	<p>The person taking the action must notify any non-compliance with this approval to the Department in writing within two business days of the person taking the action becoming aware of non-compliance.</p>	Not Applicable	<p>No non-compliances were recorded within the reporting period.</p>
5	<p>Upon the direction of the Minister, the person taking the action must ensure that an independent audit of compliance with the conditions of approval is conducted and a report submitted to the Minister. The independent auditor must be approved by the Minister prior to the commencement of the audit. Audit criteria must be agreed to by the Minister and the audit report must address the criteria to the satisfaction of the Minister.</p>	Not Applicable	<p>The Minister has not requested an independent audit of the Project.</p>

¹

Condition Number	Condition	Status	Evidence/Comments
6	<p>If the person taking the action wishes to carry out any activity otherwise than in accordance with the management plan as specified in the conditions, the person taking the action must submit to the Department for the Minister's written approval a revised version of that management plan. The varied activity shall not commence until the Minister has approved the varied management plan in writing. The Minister will not approve a varied management plan unless the revised management plan would result in an equivalent or improved environmental outcome over time. If the Minister approves the revised management plan, that management plan must be implemented in place of the management plan originally approved.</p>	Not Applicable	<p>No variations to the Management Plans specified in EPBC 2013/6984 have been implemented during the reporting period.</p>
7	<p>If the Minister believes that it is necessary or convenient for the better protection of listed threatened species and communities to do so, the Minister may request that the person taking the action make specified revisions to the management plan specified in the conditions and submit the revised management plan for the Minister's written approval. The person taking the action must comply with any such request. The revised approved management plan must be implemented. Unless the Minister has approved the revised management plan, then the person taking the action must continue to implement the management plan originally approved, as specified in the conditions.</p>	Not Applicable	<p>The Minister has not requested specific revisions to the Management Plans.</p>
8	<p>If, at any time after five years from the date of this approval, the person taking the action has not substantially commenced the action, then the person taking the action must not substantially commence the action without the written agreement of the Minister.</p>	Complete	<p>The Commencement of Action date was 2 August 2018, which is within 5 years of the date of approval (6 July 2015).</p>

Condition Number	Condition	Status	Evidence/Comments
9	<p>Unless otherwise agreed to in writing by the Minister, the person taking the action must publish the management plan referred to in these conditions of approval on their website. The management plan must be published on the website within one month of being approved. The person taking the action must notify the Department within five business days of publishing the management plan on their website, and the management plan must remain on their website for the period this approval has effect.</p>	Compliant	<p>All Management Plans referred to in EPBC 2013/6984 were published on Main Roads WA's website prior to the reporting period of this report and available at: https://www.mainroads.wa.gov.au/projects-initiatives/all-projects/regional/broome-cape-leveque-road</p>
10	<p>To ensure there is no decline in the local Greater Bilby population as a result of roadkill on the sealed Cape Leveque Road, the person taking the action must submit a Roadkill Monitoring and Adaptive Management Plan (RMAMP) for the Minister's approval. The RMAMP must provide sufficient detail (timing, effort and methodology) to detect the level of impact of roadkill on the local Greater Bilby population during the construction phase and operational phase. Commencement of the action must not occur unless the Minister has approved the RMAMP. The approved RMAMP must be implemented. The RMAMP must:</p> <p>a. be developed and endorsed by a suitably qualified ecologist and a linear infrastructure ecologist</p> <p>b. include survey methodology and effort to be implemented that are sufficient to determine the baseline local Greater Bilby population and the location of high density Greater Bilby areas</p> <p>c. include sufficient monitoring methodology and effort to determine baseline Greater Bilby roadkill rates on the unsealed Cape Leveque Road prior to commencement of the action</p>	Compliant	<p>The RMAMP was submitted for the Minister's approval prior to the reporting period. The Minister's approval was obtained on the 6 July 2015. The RMAMP has been implemented as per the 2021/2022 progress report (Appendix 3).</p> <p>Approval of the RMAMP by the Minister confirms compliance with the subsections of Condition 10.</p> <p>As per the approved RMAMP, the Roadkill Monitoring Report for 2021 was submitted to DCCEEW in March 2022 and is appended to this report (Appendix 3).</p>

Condition Number	Condition	Status	Evidence/Comments
	<p>d. include sufficient monitoring methodology to determine Greater Bilby roadkill rates on the sealed Cape Leveque Road during the construction phase and operational phase</p> <p>e. include appropriate Greater Bilby roadkill trigger values and adaptive management measures to be implemented should Greater Bilby roadkill trigger values be reached during the construction phase and operational phase</p> <p>f. include the requirement for ongoing monitoring and adaptive management measures until such time as it can be demonstrated that there is no decline in the local Greater Bilby population as a result of roadkill for three successive years</p> <p>g. include the requirement to provide a report on survey findings and effectiveness of adaptive management to the Department annually by 30 June each year following commencement of the action, until such time as it can be demonstrated that there is no decline in the local Greater Bilby population as a result of roadkill for three successive years.</p>		
11	<p>To minimise impacts to the Greater Bilby during the construction phase, the person taking the action must develop a Greater Bilby Induction Training and Awareness Program (GBITAP). The GBITAP must:</p> <p>a. be delivered to all employees and contractors prior to the commencement of the action and to any new employees and contractors arriving during the construction phase</p>	Compliant	A GBITAP has been developed in collaboration with the Nyul Nyul Ranger Group. Nyul Nyul Rangers are actively involved in the project and are key to management of the Greater Bilby.
	<p>a. be delivered to all employees and contractors prior to the commencement of the action and to any new employees and contractors arriving during the construction phase</p>	Compliant	The GBITAP is delivered at the commencement of each swing on site to ensure all new starters on the Project are compliant with the project specific environmental induction requirements.

Condition Number	Condition	Status	Evidence/Comments
	b. provide education on the appearance, characteristics and behaviour of the Greater Bilby sufficient to allow employees and contractors to accurately identify the species	Compliant	The GBITAP includes material on how to identify Greater Bilbies, as well as their behavioural characteristics.
	c. include maps of high density Greater Bilby areas	Compliant	The GBITAP and associated Environmental Induction provide details on the Project's Construction EMP which contains maps of high density areas.
	d. institute a signposted speed limit of no greater than 60 km/h, along with educational signage to increase awareness of Greater Bilby presence, at high density Greater Bilby areas and 200m either side of high density Greater Bilby areas to be observed by all employees and contractors	Compliant	Speed limit at all construction areas are limited to a maximum speed of 60km per hour. Speed limits are signposted with traffic control signage.
	e. include instructions on threats to the Greater Bilby and how to avoid or reduce impacts to the Greater Bilby through measures including, but not limited to, road awareness and waste management.	Compliant	The GBITAP and associated Environmental Induction provide details on the Project's Construction EMP which contains management measures that are communicated to personnel working on the road. Measures include waste management, roadkill and sighting reporting system.
12	To minimise impacts to the Greater Bilby as a result of onsite works during the construction phase, the person taking the action must ensure that a suitably qualified ecologist implements the <i>Cape Leveque Road Greater Bilby Relocation Protocol, October 2014</i> in conducting pre-clearance surveys and relocation of Greater Bilby individuals, if present. All Greater Bilby deaths must be recorded.	Compliant	Main Roads engaged the services of suitably qualified ecologists to manage the trapping and relocation program during the construction phase - Dr Malcolm Lindsay (Environs Kimberley).

Condition Number	Condition	Status	Evidence/Comments
13	To minimise impacts to the Greater Bilby of the sealed Cape Leveque Road during the operational phase, the person taking the action must ensure that the Cape Leveque Road upgrade is designed, constructed and maintained in a manner that minimises the potential for Greater Bilby roadkill from public use of the sealed road through avoidance, deterrence and increased visibility, including in particular:	Not Applicable	Works on the Broome-Cape Leveque Road should be completed in December 2022, following the flooding event in 2022. Once this work is completed, the location of signage, coloured pavement and rumble strips will be investigated. Results of these investigations will be reported in the next iteration of this annual compliance report.
	a. installation of signage educating the public of Greater Bilby presence at high density Greater Bilby areas and 200m either side of high density Greater Bilby Areas	Not Applicable	As above.
	b. the use of coloured pavement at high density Greater Bilby areas and 200m either side of high density Greater Bilby areas	Not Applicable	As above.
	c. the use of audible rumble strips at high density Greater Bilby areas and 50m either side of high density Greater Bilby areas.	Not Applicable	As above.
14	In order to minimise the potential of the proposed action to facilitate the increased spread of feral cats, foxes and weeds, the person taking the action must:	Compliant	Effective management of feral cats, foxes and weeds have been implemented.
	a. fence all standing pools of water resulting from the action	Compliant	All dams constructed have been fenced, and regular site inspections are undertaken to identify any unfenced standing pools of water that could attract feral animals.
	b. remove or fence all rubbish generated as a result of the action at the end of each working day	Compliant	All rubbish is appropriately contained in closed bins and removed off-site. All food waste is bagged for disposal. No feral animals have been recorded at rubbish disposal points.

Condition Number	Condition	Status	Evidence/Comments
	<p>c. weeds must be managed and controlled in accordance with the Cape Leveque Road Upgrade Revegetation Management Plan, October 2014.</p>	Compliant	No weeds have been recorded in the clearing area as of the reporting period.
15	<p>To offset the residual significant impact to the Greater Bilby, the person taking the action must ensure that the offsets program is undertaken by a suitably qualified ecologist, including:</p>	Compliant	The offset program is being undertaken and managed by the DBCA. A report of the program’s progress is attached at Appendix 4.
	<p>a. a baseline survey to determine the area of occupancy of the Greater Bilby and its threats on the Dampier Peninsula must be developed and undertaken in conjunction with DPaW and Traditional Owner Rangers. The survey must use established techniques and record signs of Greater Bilby, signs of introduced predators, habitat characteristics, fire history and grazing pressure. This baseline survey must be undertaken on SLK 90-102.6 prior to the commencement of the action. The baseline survey must be undertaken on SLK 25-90 prior construction occurring in SLK 25-90.</p>	Complete	<p>Baseline surveys have been undertaken.</p> <p>The DBCA, in collaboration with local Ranger groups and NGOs are currently undertaking occupancy surveys across the Dampier Peninsula which commenced in early 2017. Survey techniques were developed by the DBCA.</p> <p>Main Roads commissioned GHD Pty Ltd to undertake a baseline Greater Bilby Survey on the SLK 25 – 102.6 section between October and December 2015.</p>
	<p>b. an annual and ongoing survey must be developed and implemented in conjunction with DPaW and Traditional Owner Rangers. This survey must commence within six months of completion of the baseline survey and continue for at least two years, and monitor:</p> <p>i. at least four locations of the Greater Bilby population using DNA fingerprinting techniques</p> <p>ii. the population of introduced predators through the use of camera traps</p> <p>iii. grazing pressure, food resources and fire history.</p>	Compliant	The offset program is being undertaken and managed by the DBCA, who are implementing this with local Ranger groups (Appendix 4).

Condition Number	Condition	Status	Evidence/Comments
	<p>c. a threat management program must be submitted to the Minister for approval prior to implementation. The threat management program must be developed and implemented in conjunction with DPaW and Traditional Owner Rangers and must address either introduced predators, fire regimes or grazing pressure or a combination of these threats at high priority sites for the Greater Bilby. The threat management program must include an adaptive management component. Threat management must commence within one year of commencement of the action and continue for at least one year. At least \$120,000 is to be spent on direct threat abatement action per year of the threat management program</p>	Compliant	The Threat Management Plan was submitted to the Department prior to construction.
	<p>d. at a minimum, \$600,000 is to be provided to DPaW to enable development and implementation of the offsets program. Evidence of expenditure must be provided to the Minister within three months of the final payment</p>	Complete	As previously reported, Main Roads provided DBCA with the stated funds in two instalments. The final instalment was paid to the State Offset Fund on 10 May 2016 for release to DBCA once specific milestones are completed.
	<p>e. provision of information to the annual compliance report required by the conditions attached to this approval reporting on the survey findings, ongoing monitoring and effectiveness of adaptive management measures to address threats to the Greater Bilby, for the duration that the offsets program is implemented.</p>	Compliant	Results for the annual surveys and progress of the Dampier Peninsula Bilby Project offsets program is included in Appendix 4.

3 APPENDICES

Appendix 1	EPBC 2013/6984 Approval Notice
Appendix 2	Report of Greater Bilby Monitoring Works – Rick Southgate
Appendix 3	2021 Road Kill Monitoring Report
Appendix 4	DBCA Offsets Report: Evidence of Dampier Peninsula Bilby Project (Offset Program)

Appendix 1: EPBC 2013/6984 Approval Notice



Australian Government
Department of the Environment

Approval

Cape Leveque Road upgrade (SLK 25-102.6) Shire of Broome, Western Australia (EPBC 2013/6984)

This decision is made under sections 130(1) and 133 of the *Environment Protection and Biodiversity Conservation Act 1999*.

Proposed action

person to whom the approval is granted	Main Roads Western Australia
proponent's ABN	50 860 676 021
proposed action	To upgrade approximately 77.6 kilometres of Cape Leveque Road (SLK 25 – 102.6) within the Shire of Broome, Western Australia; as described in the referral received by the Department on 3 September 2013 [See EPBC Act referral 2013/6984].

Approval

Controlling Provision	Decision
Listed threatened species and communities (sections 18 & 18A)	Approved
Listed migratory species (sections 20 & 20A)	Approved

conditions of approval

This approval is subject to the conditions specified below.

expiry date of approval

This approval has effect until 31 December 2035.

Decision-maker

name and position	Dr Simon Banks Assistant Secretary Assessments (NSW/ACT) and Fuel Branch
signature	
date of decision	6 July 2015

Conditions attached to the approval

1. Within 10 days after the **commencement of the action**, the person taking the action must advise the **Department** in writing of the actual date of commencement.
2. The person taking the action must maintain accurate records substantiating all activities associated with or relevant to the conditions of **approval**, including measures taken to implement the management plan required by this **approval**, and make them available upon request to the **Department**. Such records may be subject to audit by the **Department** or an independent auditor in accordance with section 458 of the EPBC Act, or used to verify compliance with the conditions of **approval**. Summaries of audits will be posted on the **Department's** website. The results of audits may also be publicised through the general media.
3. Within three months of every 12 month anniversary of the **commencement of the action**, the person taking the action must publish a report on their website addressing compliance with the conditions of this **approval** over the previous 12 months, including implementation of any management plans as specified in the conditions. The compliance reports must remain on their website for a minimum of 12 months (beginning on the date of publication). Non-compliance with any of the conditions of this **approval** must be reported to the **Department** at the same time as the compliance report is published. The person taking the action must continue to annually publish the report on their website addressing compliance with each of the conditions of this **approval** until such time as agreed to in writing by the **Minister**.
4. The person taking the action must notify any non-compliance with this **approval** to the **Department** in writing within two business days of the person taking the action becoming aware of non-compliance.
5. Upon the direction of the **Minister**, the person taking the action must ensure that an independent audit of compliance with the conditions of **approval** is conducted and a report submitted to the **Minister**. The independent auditor must be approved by the **Minister** prior to the commencement of the audit. Audit criteria must be agreed to by the **Minister** and the audit report must address the criteria to the satisfaction of the **Minister**.
6. If the person taking the action wishes to carry out any activity otherwise than in accordance with the management plan as specified in the conditions, the person taking the action must submit to the **Department** for the **Minister's** written approval a revised version of that management plan. The varied activity shall not commence until the **Minister** has approved the varied management plan in writing. The **Minister** will not approve a varied management plan unless the revised management plan would result in an equivalent or improved environmental outcome over time. If the **Minister** approves the revised management plan, that management plan must be implemented in place of the management plan originally approved.
7. If the **Minister** believes that it is necessary or convenient for the better protection of listed threatened species and communities to do so, the **Minister** may request that the person taking the action make specified revisions to the management plan specified in the conditions and submit the revised management plan for the **Minister's** written approval. The person taking the action must comply with any such request. The revised approved management plan must be implemented. Unless the **Minister** has approved the revised management plan, then the person taking the action must continue to implement the management plan originally approved, as specified in the conditions.

8. If, at any time after five years from the date of this **approval**, the person taking the action has not **substantially commenced** the action, then the person taking the action must not **substantially commence** the action without the written agreement of the **Minister**.
9. Unless otherwise agreed to in writing by the **Minister**, the person taking the action must publish the management plan referred to in these conditions of **approval** on their website. The management plan must be published on the website within one month of being approved. The person taking the action must notify the **Department** within five business days of publishing the management plan on their website, and the management plan must remain on their website for the period this **approval** has effect.

Greater Bilby (*Macrotis lagotis*)

10. To ensure there is no decline in the **local Greater Bilby population** as a result of **roadkill** on the sealed **Cape Leveque Road**, the person taking the action must submit a Roadkill Monitoring and Adaptive Management Plan (RMAMP) for the **Minister's** approval. The RMAMP must provide sufficient detail (timing, effort and methodology) to detect the level of impact of **roadkill** on the **local Greater Bilby population** during the **construction phase** and **operational phase**. **Commencement of the action** must not occur unless the **Minister** has approved the RMAMP. The approved RMAMP must be implemented. The RMAMP must:
 - a. be developed and endorsed by a **suitably qualified ecologist** and a **linear infrastructure ecologist**
 - b. include survey methodology and effort to be implemented that are sufficient to determine the baseline **local Greater Bilby population** and the location of **high density Greater Bilby areas**
 - c. include sufficient monitoring methodology and effort to determine baseline Greater Bilby **roadkill** rates on the unsealed **Cape Leveque Road** prior to **commencement of the action**
 - d. include sufficient monitoring methodology to determine Greater Bilby **roadkill** rates on the sealed **Cape Leveque Road** during the **construction phase** and **operational phase**
 - e. include appropriate Greater Bilby **roadkill** trigger values and adaptive management measures to be implemented should Greater Bilby **roadkill** trigger values be reached during the **construction phase** and **operational phase**
 - f. include the requirement for ongoing monitoring and adaptive management measures until such time as it can be demonstrated that there is no decline in the **local Greater Bilby population** as a result of **roadkill** for three successive years
 - g. include the requirement to provide information to the annual compliance report required by the conditions attached to this **approval** reporting on survey findings, ongoing monitoring and effectiveness of adaptive management, until such time as it can be demonstrated that there is no decline in the **local Greater Bilby population** as a result of **roadkill** for three successive years.

11. To minimise impacts to the Greater Bilby during the **construction phase**, the person taking the action must develop a Greater Bilby Induction Training and Awareness Program (GBITAP). The GBITAP must:
 - a. be delivered to all **employees and contractors** prior to the **commencement of the action** and to any new **employees and contractors** arriving during the **construction phase**
 - b. provide education on the appearance, characteristics and behaviour of the Greater Bilby sufficient to allow **employees and contractors** to accurately identify the species
 - c. include maps of **high density Greater Bilby areas**
 - d. institute a signposted speed limit of no greater than 60km/hr, along with educational signage to increase awareness of Greater Bilby presence, at **high density Greater Bilby areas** and 200m either side of **high density Greater Bilby areas** to be observed by all **employees and contractors**
 - e. include instructions on threats to the Greater Bilby and how to avoid or reduce impacts to the Greater Bilby through measures including, but not limited to, road awareness and waste management.
12. To minimise impacts to the Greater Bilby as a result of onsite works during the **construction phase**, the person taking the action must ensure that a **suitably qualified ecologist** implements the *Cape Leveque Road Greater Bilby Relocation Protocol, October 2014* in conducting pre-clearance surveys and relocation of Greater Bilby individuals, if present. All Greater Bilby deaths must be recorded.
13. To minimise impacts to the Greater Bilby of the sealed **Cape Leveque Road** during the **operational phase**, the person taking the action must ensure that the **Cape Leveque Road** upgrade is designed, constructed and maintained in a manner that minimises the potential for Greater Bilby **roadkill** from public use of the sealed road through avoidance, deterrence and increased visibility, including in particular:
 - a. installation of signage educating the public of Greater Bilby presence at **high density Greater Bilby areas** and 200m either side of **high density Greater Bilby areas**.
 - b. the use of **coloured pavement at high density Greater Bilby areas** and 200m either side of **high density Greater Bilby areas**
 - c. the use of audible rumble strips at **high density Greater Bilby areas** and 50m either side of **high density Greater Bilby areas**.
14. In order to minimise the potential of the proposed action to facilitate the increased spread of feral cats, foxes and weeds, the person taking the action must:
 - a. **fence all standing pools** of water resulting from the action
 - b. remove or **fence all rubbish** generated as a result of the action at the end of each working day
 - c. manage and control weeds in accordance with the *Cape Leveque Road Upgrade Revegetation Management Plan, October 2014*.

Offsets

15. To offset the residual significant impact to the Greater Bilby, the person taking the action must ensure that the **offsets program** is undertaken by a **suitably qualified ecologist**, including:
- a. a baseline survey to determine the area of occupancy of the Greater Bilby and its threats on the Dampier Peninsula must be developed and undertaken in conjunction with **DPaW** and Traditional Owner Rangers. The survey must use established techniques and record signs of Greater Bilby, signs of introduced predators, habitat characteristics, fire history and grazing pressure. This baseline survey must be undertaken on SLK 90-102.6 prior to **commencement of the action**. The baseline survey must be undertaken on SLK 25-90 prior **construction** occurring in SLK 25-90.
 - b. an annual and ongoing survey must be developed and implemented in conjunction with **DPaW** and Traditional Owner Rangers. This survey must commence within six months of completion of the baseline survey and continue for at least two years, and monitor:
 - i. at least four locations of the Greater Bilby population using DNA fingerprinting techniques
 - ii. the population of introduced predators through the use of camera traps
 - iii. grazing pressure, food resources and fire history.
 - c. a threat management program must be submitted to the **Minister** for approval prior to implementation. The threat management program must be developed and implemented in conjunction with **DPaW** and Traditional Owner Rangers and must address either introduced predators, fire regimes or grazing pressure or a combination of these threats at high priority sites for the Greater Bilby. The threat management program must include an adaptive management component. Threat management must commence within one year of **commencement of the action** and continue for at least one year. At least \$120,000 is to be spent on direct threat abatement action per year of the threat management program
 - d. at a minimum, \$600,000 is to be provided to **DPaW** to enable development and implementation of the **offsets program**. Evidence of expenditure must be provided to the **Minister** within three months of the final payment
 - e. provision of information to the annual compliance report required by the conditions attached to this **approval** reporting on the survey findings, ongoing monitoring and effectiveness of adaptive management measures to address threats to the Greater Bilby, for the duration that the **offsets program** is implemented.

Definitions:

- a) **Approval:** The approval to take the approved action under section 133 of the EPBC Act.
- b) **Cape Leveque Road:** The approximately 77.6km length of Cape Leveque Road between SLK 25 and 102.6, illustrated in Attachment F of the referral, and any amendments.
- c) **Coloured pavement:** Pavement of a shade that improves the visibility of the Greater Bilby by increasing the colour contrast between the species and the road surface.
- d) **Commencement of the action:** The clearing of any vegetation or construction of any infrastructure, excluding fences and signage, associated with the proposed action.
- e) **Construction:** Includes any preparatory works required to be undertaken including clearing vegetation, the erection of any onsite temporary structures and the use of heavy duty equipment for the purpose of breaking the ground or laying sealed road.
- f) **Construction phase:** The time period from initial clearing of vegetation, breaking of ground or erection of onsite structures (whichever occurs first) until such time as the **Cape Leveque Road** upgrade is completed, all temporary onsite structures are removed and the road is open to the public and fully operational. The **construction phase** does not include regular road maintenance works.
- g) **Department:** The Australian Government Department administering the *Environment Protection and Biodiversity Conservation Act 1999*.
- h) **DPaW:** Western Australian Department of Parks and Wildlife and successor agencies.
- i) **Employees and contractors:** Refers to any Main Roads Western Australia employees or employees contracted by Main Roads Western Australia working onsite.
- j) **Fence:** Provision of a barrier sufficient to prevent access by feral cats and foxes.
- k) **High density Greater Bilby area:** Any 6ha area that includes or is immediately adjacent to the **proposed disturbance route**, containing three or more signs of Greater Bilby. Signs of Greater Bilby may include sightings (in person or via camera), active burrows, inactive burrows, diggings, scratching or scats.
- l) **Linear infrastructure ecologist:** Refers to an independent person, approved by the **Minister**, with relevant tertiary qualifications and a minimum of five years experience in the ecological impacts and management of linear infrastructure.
- m) **Local Greater Bilby Population:** The population size and distribution of Greater Bilby that is determined by a **suitably qualified ecologist** as likely to be impacted by the proposed action as derived from surveys conducted prior to referral and the baseline population surveys required by this **approval**.
- n) **Minister:** The Minister administering the *Environment Protection and Biodiversity Conservation Act 1999* and includes a delegate of the Minister.
- o) **Offsets program:** The program outlined in *Bilby (Macrotis lagotis) Offset Priorities for Dampier Peninsula Populations, West Kimberley, October 2014*, published as part of Preliminary Documentation on Main Roads Western Australia's website.
- p) **Operational phase:** The time period beginning at the completion of the **construction phase** and continuing for the life of the **approval**.

- q) **Proposed disturbance route:** The proposed new road route (including borrow pits) as illustrated in Attachment F of the referral, and any amendments.
- r) **Roadkill:** Vehicle(s) and/or equipment and/or machinery striking, colliding or crushing Greater Bilby in a manner that results in mortality to the Greater Bilby.
- s) **Rubbish:** Consumable or any other waste that may be attractive to feral cats and foxes.
- t) **Standing pool:** Pool of water greater than or equal to 2m² that has the potential to persist for greater than or equal to one week created by human activity.
- u) **Substantially commence:** As per **commencement of the action**.
- v) **Suitably qualified ecologist:** Refers to an independent person, approved by the **Minister**, with relevant tertiary qualifications and a minimum of five years experience in Australian mammal fauna surveys in the region.

Appendix 2: Report of Greater Bilby Monitoring Program Activities

Appendix 3: Report of Roadkill Monitoring 2021

Appendix 4: DBCA Report of Dampier Peninsula Bilby Project (Offset Program)

**REPORT ON BILBY MONITORING AND FAUNA UNDERPASS
USE ALONG THE BROOME-CAPE LEVEQUE ROAD
UPRADE IN OCTOBER 2021**

Dr Richard Southgate
Envisage Environmental Services
March 2022

Summary

A survey to determine the bilby activity and the use of fauna underpasses installed along the Broome-Cape Leveque Road (BCLR) upgrade was undertaken in October 2021 as part of the approval conditions required to be undertaken by Main Roads (Western Australia).

A survey protocol was developed to include activities identified in Greater Bilby Management Plan the that should be undertaken for a period of five years after the completion of the BCLR upgrade to address the conditions identified in the Clearing permit.

During the first year of survey in 2021, no sign bilby was detected at culvert sites or other sites sampled along the Broome - Cape Leveque Road upgrade.

Seven culverts were monitored using remote cameras and 19 plots were sampled using 2 ha sign plots along the BCLR. At each culvert between two and three cameras were deployed for a period of 45 days. Each 2 ha sign plot was searched for sign of target species for a period of 25 minutes once within the survey period.

A range of species were recorded at the entrance of a culvert including feral cats, dingoes, cattle and agile wallabies and several bird and reptile species. Feral cats were the only species likely to have travelled through a culvert under the road. Similarly, a range of species were recorded on the 2 ha plots sampled along the BCLR.

A revised monitoring protocol has been provided to implemented annually over the next four years.

Introduction

An upgrade and bitumenisation of the Broome-Cape Leveque Road has been conducted by Main Roads Western Australia (Main Roads). As part of the Project approval conditions, the development was assessed under both Federal and State Legislation and the Greater Bilby was identified as a threatened species occurring within the Project area. This species is considered vulnerable to extinction both nationally and in Western Australia. The species has declined by 70% nationally and wild populations are now restricted to the more northern and less productive parts of its former range (Fig. 1).

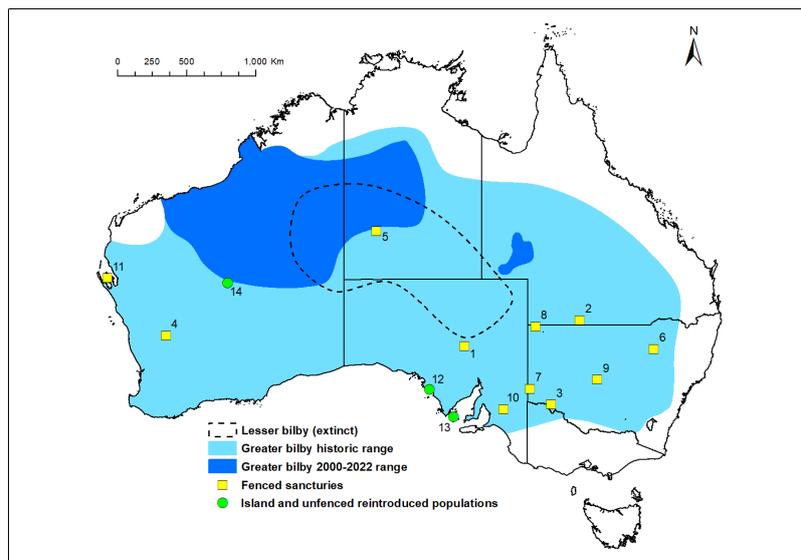


Fig. 1 Current and former Greater and Lesser Bilby distribution Reintroduced or introduced populations: 1 Arid Recovery, 2 Currawinya, 3 Mallee Cliffs, 4 Mt Gibson, 5 Newhaven, 6 Pilliga, 7 Scotia, 8 Sturt, 9 Yathong, 10 Yookamurra, 11 Peron, 12 Venus Bay, 13 Thistle Is, 14 Matuwa.

The Cape Leveque Road Greater Bilby Management Plan (Appendix 1) was developed in response to Project approval conditions and this outlined the activities that should be undertaken during and following completion of the upgrade. This included ongoing monitoring of the population for five years after a series of fauna underpasses were installed. The Management Plan also indicated that a series of fauna underpasses be inserted to reduce the risk of mortality to the Greater Bilby and other native fauna caused by vehicle traffic along the road.

For development of the Project, the following approvals were granted:

- DotEE 2015, EPBC 2013/6984 Approval under the EPBC Act.
- DER 2014, CPS 6078 Clearing Permit (CPS 6078/4 – 9 June 2020).

The Clearing permit CPS 6078/4 contained the following condition:

9(f) During the term of the permit, the Permit Holder shall implement a Greater Bilby (*Macrotis lagotis*) monitoring program that includes:

- (ii) Annual monitoring for a period not less than five years commencing within 12 months of the completion of the fauna underpasses identified under conditions 9(c) and 9(d), to assess the persistence of Greater Bilby (*Macrotis lagotis*) populations within 500 metres of the upgrade Cape Leveque Road, and the level of use and effectiveness of the fauna underpasses for Greater Bilby (*Macrotis lagotis*).

The aims of the monitoring program along the BCLR are to:

- establish whether bilbies, if assessed to be active in the vicinity of a culvert, make use the culverts to cross the roadway.
- determine the use of the concrete culverts by other fauna, particularly predators
- collect data on fauna use of different size culverts to enable a comparison with the findings of similar studies conducted in other regions
- assess if bilby activity remains evident at previously occupied locations along the BCLR
- provide a protocol for monitoring culverts that could be feasibly and repeatably applied each year over a five year period.

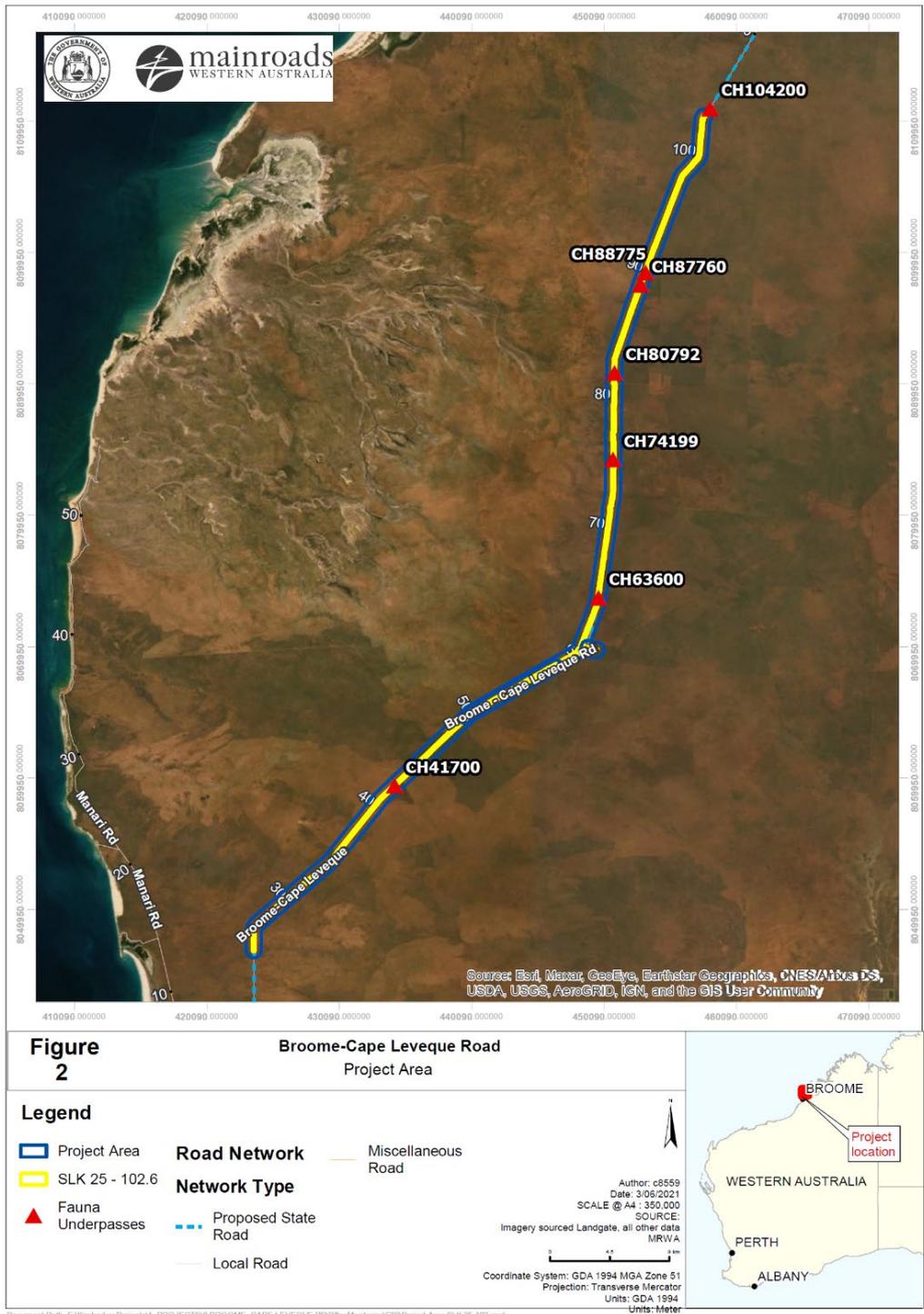
This report provides a description of a monitoring program implemented in 2021 and the results from the first year of monitoring. The strengths and weaknesses of the initial monitoring are considered. Based on these findings, a modified and streamlined the monitoring protocol for subsequent years is provided.

Project area

The Project area and underpass locations are shown in Fig. 2 and underpass coordinates are presented in Table 1. The Project area includes a 500 m corridor on either side of the upgraded BCLR (SLK 25-102.6) and seven fauna underpasses.

Table 1 Fauna underpass locations, culvert dimensions and condition

Underpass ID	Coordinates		Date Installed	Wide (m)	Height (m)
CH104200 (Cul67)	-17.085465°	122.605999°	18/11/2018	0.9	0.45 sand fill
CH88775 (Cul66)	-17.198170°	122.559802°	19/11/2018	0.9	0.3 open clean
CH87760 (Cul65)	-17.206832°	122.556499°	28/11/2018	0.9	0.3 sand fill
CH41700 (Cul61)	-17.550923°	122.380651°	19/09/2019	0.9	0.3 open clean
CH63600 (Cul62)	-17.421790°	122.525759°	05/09/2019	0.9	0.9 open clean
CH74199 (Cul63)	-17.327000°	122.536508°	22/08/2019	2 x 0.9	0.9 open clean
CH80792 (Cul64)	-17.267192°	122.537766°	28/07/2019	0.9	0.3 sand fill



Project rationale

The culvert monitoring project required building on previous monitoring along the BCLR and ensure the work was complementary and value adding to monitoring conducted by the Department of Biodiversity, Conservation and Attractions (DCBA) and Kimberley Minerals Ltd

(formerly Sheffield Resources Thunderbird Mineral Sands Project), Kimberley Land Council, Nyamba Buru Yawuru and Environs Kimberley and other organisations more broadly.

The culvert monitoring project also aimed to adopt the procedures used by other projects to monitor culvert use by fauna along other linear infrastructure. This would potentially enable direct and broader comparison of the findings.

Furthermore, the project aimed to involve and engage the services of local Ranger Groups. The Nyul Nyul Rangers have worked consistently with Main Roads on Bilby Surveys during the construction phase of the Broome-Cape Leveque Road.

1.1.1 Previous monitoring of the Greater Bilby along the BCLR

Bilby occurrence along the BCLR has been assessed primarily by searching for sign. Bilby presence can be validated if scats, specific diggings for root-dwelling larvae and clear track imprints can be detected at a site. This sign is necessary to locate because other species can produce digging and burrow activity similar to that produced by the bilby. This standardised sampling approach has been applied in most instances. That is, a search for track, scat and digging sign of a set of target species within a 2 ha plot (200 x 100 m) for 25 minutes (Moseby et al. 2009). At a site, a plot is located 30 m from an access track or road. A 100 m section in softer substrate along a track or road side gutter is also searched for sign. The data collected 'on plot' and 'along track' for each site are kept separate and used to identify situations where species are using habitat or using tracks or road primarily to traverse through an area. The age of sign is estimated and categorized as Fresh < 2 nights; Medium 3-7 nights, and Old >7 nights

Systematic monitoring of Bilby along the BCLR began in December 2012 when environmental consultants GHD monitored 14 locations. In October 2015, GHD sampled 101 plots using 2 ha plots spaced 1 km apart from SLK0-101. Sixteen of these plot locations were resampled in November and December by GHD. In September 2017, Environs Kimberley sampled eight locations. In May 2018, Biota environmental consultants conducted continuous sampling along the road from SLK0-25 and Nyul Nyul rangers were searched along the roadway SLK7-104. In both instances the edge of the roadway and vegetated areas were searched for bilby sign by multiple observers with similar search effort conducted when sampling 2 ha plot. Data from these continuous transects were extracted to correspond with plot locations. Envisage Environmental Services conducted further resampling of plots in July (n=29) and September (n=39) 2018. This survey history has resulted in some plots from SLK0-104 being sampled once and others up to seven times (**Appendix 1**).

Considering data collected since 2015, the 104 plot locations have been sampled on 269 occasions. Of these samples, bilby sign was detected on 27 occasions. No bilby sign was detected at 87% of plot locations. Thirty-nine plots were sampled once, 23 twice, 11 thrice, 14 four times and 17 five or more times (**Appendix 1**). At plots where bilby sign was detected, activity was not usually evident on a subsequent visit. That is, sign was infrequently detected when a site was resampled within a year or among different years. Consecutive bilby activity was recorded at only three on the 26 locations resampled on more than three occasions.

1.1.2 Monitoring of the Greater Bilby by DCBA

The DCBA has been applying the 2 ha sign-based monitoring technique and cameras to monitor the Greater Bilby and other fauna on the Dampier Peninsula, Southern Kimberley and Pilbara. Plots.

M. Dziminski and B. Greatwich (pers. comm., DCBA) indicated the use of one camera positioned on an active burrow and another positioned on a nearby access track was the standard approach they used to monitor a bilby colony and it would be valuable to apply the same technique if a bilby colony was encountered within the Project area.

1.1.3 Culvert monitoring in the Pilbara

Underpass use by fauna including the bilby has been investigated in the Pilbara along the railway line to Port Hedland (Harriet Davie pers. com., Roy Hill). Consultants from Ecoscape were contracted to implement the camera monitoring project. One camera was mounted on the roof of a culvert to document actual movement of fauna through the passage. Another was placed at the culvert entrance to document fauna passing by but not necessarily using a culvert. A third camera was set along a wildlife pad or track in habitat adjacent to the culvert to document the background composition of fauna. Three culvert sizes were examined (600-900, 900-1500 and 1500-3200 mm), with three replicates of each. Cameras were deployed for a period of 20 weeks with two periods of monitoring (wet and dry) over a period of four years. The target species for monitoring were primarily northern quoll, bilby and cat, fox and dingo. The data have still to be fully analysed. Preliminary results, provided only for feral cat, indicated five times as many cats were detected at the culvert mouth compared to traversing through the culvert, slightly less but roughly the same proportion were recorded in adjacent habitat as at the culvert mouth and none were recorded passing over the railway line. Quolls were detected using the culvert on a number of occasions but there was only one record of use by a bilby. Populations of both quoll and bilby were largely absent or very low abundance in the vicinity of the culverts. Overall, the Roy Hill study indicated the camera monitoring approach was effective in producing data to assess the use of culverts by different fauna. Further analysis is planned to examine the effect of culvert size and habitat on culvert use of different species.

2.0 The monitoring approach initially proposed for the BCLR Project area

2.1.1 Camera resources and deployment

It was proposed that profession grade remote cameras such as Reconyx or Scoutguard be deployed to monitor fauna passing the entrance of culverts placed within the culvert to document actual crossings by fauna and be set along a wildlife pad or track in habitat away for the main road but within 500 m of the culvert. Cameras were to be only set on one side of the culvert and where concealment of the cameras was best provided. Cameras were to be attached to brackets dyna-bolted the roof of a culvert or bolted to metal star pickets located along pads or at the entrance of culverts.

This configuration would require 21 cameras to monitor the seven culverts. MRWA held 11 remote cameras. It was proposed another 10 cameras be purchased because the quoted cost of hiring cameras was high and the annual monitoring needed to continue over a 5 year period. DCBA offered to provide the hire cameras as a contingency if some of the existing

cameras were found to be non-operational. Cameras were deployed in late October for a period of six weeks with the same configuration (height above ground, distance from target, trigger settings etc.) as used in the Roy Hill study (see **Appendix 2**).

2.1.2 Sign monitoring at culverts

At each culvert, it was proposed a plot be surveyed for sign on **both** sides of the road with each 2 ha plot positioned 30-50 m from the road edge with the long 200 m side extending perpendicular to the road. Adjacent to each plot, a search of a 100 m section in the soft sediments along the side of the road was also needed. The target species to record needed include bilby, feral cats, foxes, dingoes, cattle, donkeys, agile wallabies, spectacled hare wallaby, possums and kangaroos. Track age and abundance of activity for identifiable species needed to be recorded, and sign located 'on plot' and 'along road' needed to be identified separately. A data sheet was prepared to collect the data (see **Appendix 3**). This is similar to the 2 ha plot monitoring data sheet used by DCBA.

The 'on plot' and 'along track' approach provides an opportunity to detect bilby digging activity that may occur on plot and the imprints of predators and other fauna along the softer substrates in the roadside gutters. Monitoring a plot on either side of the road provided an opportunity to assess whether plot size was affecting detectability of different species and compare these detections with data collected by the cameras.

To satisfy the conditions requiring an assessment of the persistence of Greater Bilby (*Macrotis lagotis*) populations within 500 metres of the BCLR upgrade, it was proposed that a search beyond the end of the plot for 300 m (out and back) needed to be conducted at a single plot beside each culvert.

2.1.3 Sign monitoring at culverts

At the other (non-culvert) locations specified along the BCLR, it was proposed that only a single plot needed to be sampled at 20 locations where monitoring has been conducted previously. The side of the road with more open habitat or suitable bilby habitat should be selected. The location of sites previously sampled along the BCLR is shown in **Appendix 1**.

If bilby sign was detected on a plot or opportunistically along the BCLR, then the approach advocated by BCBA needed to be implemented with the placement of one camera at the entrance of an active burrow and another along a track to monitor other fauna.

3.0 The results of monitoring conducted in the BCLR Project area in 2021

The restriction of entry to WA because of Covid-19 meant the survey along the BCLR upgrade had to be managed remotely and some of the work had to be conducted by subcontracted consultants. This limited the set-up time and to some extent the ability to trouble-shoot implementation of the monitoring approach.

The camera setup was conducted over a two-day period by J. Meadham from Ecoscape environmental consultants. The Nyul Nyul Rangers were involved in some of the camera setup and also conducted the 2 ha plot monitoring at sites along the BCLR.

3.1.1 Camera deployment

Overall, 17 cameras were set at the seven culvert sites, 14 Reconyx HP and 3 Reconyx HF. At each site, one camera was set facing the entrance of a culvert and one or two cameras were set radially within 150 m of the culvert, facing along a track or wildlife pad. No cameras were mounted on the roof of the culvert. The coordinates for the location of each camera deployed are listed in **Appendix 4a**. The camera setup followed those used by in the Roy Hill study (see **Appendix 2**).

The cameras were deployed on the 25-26 October 2021 and retrieved on 9 December 2021 providing a potential operation period of 45 days. One camera deployed at Culvert 61 was destroyed in a bushfire that started on 17 November.2021 and burnt much of the Peninsula.

No sign of bilby was evident on the images captured. The frequency of other species detected is shown in **Table 2**. The camera monitoring recorded five mammal species, 16 bird species and three reptile species. (**Appendix 5**).

Feral Cat and Agile Wallaby were the two most frequently detected mammal species recorded at sites. Feral Cats were more than twice as likely of being detected at a culvert than on a wildlife pad in proximity to a culvert. Agile Wallabies showed the reverse trend.

Based on coat markings, the Cats detected at a site over the study period consisted of one or two individuals. With the absence of a camera mounted internally, it was not possible to determine the proportion of feral Cats that entered and moved through the culverts. The majority appeared tentative at the culvert entrance and were unlikely to have entered. A number of individuals made repeated visits to a culvert and one individual was detected on 20 separate days over the sample period and was most likely to have moved through the culvert. Both the large (900x900 mm) and smaller (900x450 mm) culverts were entered.

Dingoes were detected at two culvert sites, at the entrance to one culvert and at two radial sites near another culvert. Bullocks were detected at one culvert and a single rodent was detected by one the radially located cameras.

3.1.2 Sign monitoring at culverts

No sign-based monitoring was conducted at the culvert sites. This meant there were no 2 ha plots sampled including a search beyond the end of one plot for 300 m.

3.1.3 Track plot monitoring along the BCLR

Nineteen 2 ha plots were sampled once along the BCLR while the cameras were deployed. Only one plot (No. 15) was located within 200 m of culvert. The coordinates for the plot locations are listed in **Appendix 4b**

No bilby sign was detected at any of the sites sampled but the sign of five other mammal species was found (**Table 2**). Combining sign with an estimated age less than 7 days old detected 'on plot' with 'along road', Agile Wallaby sign was detected on 95% of sites, Dingo on 47 %, feral Cat on 11% and cattle on 37%. Old cattle sign >7 days was detected on an additional 37% of sites and old Donkey sign was detected on 16%. Interestingly, the sign of the above species was detected in slightly higher proportions 'on plot' compared to 'along road'.

No bilby colonies were encountered opportunistically along the BCLR during the survey period.

Table 1 Detection of cat, dog and agile wallaby from cameras set at culvert openings and set radially but within 150 m of a culvert. Naïve occurrence identifies whether a species was detected at least once at a camera site during the six week sample period. Daily occurrence identifies the number of times a species was recorded at a camera site during the sample period. The naïve* and daily* data represent the maximum activity detected from a radially located camera set near a culvert.

Cat	Culvert opening		Radially located	
	naïve occurrence	Daily occurrence	naïve* occurrence	daily* occurrence
CUL61	0	0		
CUL62	1	2	1	2
CUL63	1	3	1	2
CUL64	1	3	1	1
CUL65	1	3	1	1
CUL66	1	20	0	0
CUL67	1	2	1	1
sum	6	33	5	7

Dingo	Culvert opening		Radially located	
	naïve occurrence	Daily occurrence	naïve* occurrence	daily* occurrence
CUL61	0	0		
CUL62	1	2	4	8
CUL63	0	0	1	1
CUL64	0	0	0	0
CUL65	0	0	0	0
CUL66	0	0	0	0
CUL67	0	0	0	0
sum	1	2	5	9

Agile wallaby	Culvert opening		Radially located	
	naïve occurrence	Daily occurrence	naïve* occurrence	daily* occurrence
CUL61	0	0		
CUL62	1	2	4	8
CUL63	0	0	1	1
CUL64	0	0	0	0
CUL65	0	0	0	0
CUL66	0	0	0	0
CUL67	0	0	0	0
sum	1	2	5	9

Table 2 Species detected at plots sampled along the Broome - Cape Leveque Road. Presence or absence of sign (< 7 days old) of target species detected 'on plot' and ('on road').

Pot	Latitude	Longitude	Bilby	Dog	Cat	Cattle	Agile wallaby	Goanna	Bustard
1	-17.6728	122.2799	0	1 (1)	0	1 (1)	1 (1)	1 (1)	0
2	-17.6302	122.3016	0	1 (1)	0	1 (1)	1 (1)	0	0
3	-17.5722	122.3606	0	0	0	1 (1)	1 (1)	0	0
4	-17.5332	122.1002	0	1 (0)	0	0 (1)	0	0	0
6	-17.4888	122.4583	0	1 (1)	0	0 (1)	1 (1)	0	0
7	-17.4385	122.5101	0	0 (1)	0	1 (1)	1 (0)	0	0
8	-17.4244	122.5273	0	1 (0)	0	1 (0)	1 (0)	1 (0)	0
9	-17.3590	122.5353	0	0	0	0	1 (1)	0	0
10	-17.2780	122.5375	0	0	0	0	1 (1)	0	0
11	-17.2344	122.5404	0	0	0	0	1 (0)	0	0
12	-17.2175	122.5526	0	1 (0)	0	0	1 (1)	0	0
13	-17.1921	122.5622	0	0	0	0	1 (1)	0	1 (0)
14	-17.1241	122.5937	0	0	0	0	1 (1)	0	0
15	-17.1103	122.5992	0	0	0	0	1 (1)	0	0 (1)
16	-17.0986	122.0612	0	0	0	0	1 (1)	1 (0)	0
17	-17.0884	122.6064	0	1 (0)	1 (0)	0	1 (1)	0	0
18	-17.0504	122.6281	0	1 (0)	1 (0)	0	1 (0)	0	0
19	-17.0245	122.6523	0	0	0	0	1 (0)	0	0
20	-17.0234	122.7043	0	0	0	0	1 (0)	0	0

3.2 Discussion

The deployment of cameras and monitoring of sign plots was effective in identifying the composition and relative abundance of key target species and occurring along the BCLR. In addition, setting cameras both at a culvert and along wildlife pad enable assessing whether these landscape features were used equally by different species.

The monitoring of fauna at the culvert sites and additionally at sites along the BCLR indicated bilby activity within the Project area was very sparsely distributed or possibly absent. These findings correspond with the information provided by the Nyul Nyul rangers. No bilby activity had been encountered opportunistically along the BCLR by rangers in the previously 24 months (N. Hammagucci, pers comm.).

A variety of other mammal, bird and reptile species visited the culvert sites. Feral Cats were the only species detected that were likely to have traversed through a culvert.

While the cameras and sign plots were effective tools to monitor the fauna present and use of habitat features such as culverts within the study area, the monitoring protocol was not followed completely. Consequently, the findings could not address the conditions specified in the Clearing Permit unambiguously.

These shortcomings related to assessing:

- the level of use and effectiveness of the fauna underpasses
- the persistence of Greater Bilby (*Macrotis lagotis*) populations within 500 metres of the upgrade Cape Leveque Road

Unfortunately, the definitive use of culverts by bilbies (or any other fauna) as a wildlife underpass could not be assessed because cameras were not mounted on the roof of any of the culverts. To determine the use of culverts as a refuge or the proportion of traverses made by species visiting culvert it would be important to have camera placed within some of the culverts. The secure attachment of brackets suitable to fix cameras to the internal culvert wall and the suitability of the smaller (450 mm tall) culverts to take a camera and bracket will need to be investigated prior to further monitoring along the BCLR.

Additionally, some of the cameras facing the culverts were not positioned to capture the entire culvert opening, preventing a clear indication of culvert visitation. More care needs to be taken in placement of star-pickets to attach cameras (i.e. distance and position) in front of a culvert and the direction cameras are pointed. Test photos need to be taken to ensure suitable images are captured before cameras are left. Furthermore, some cameras produced excessive false triggers and were evidently not positioned facing south to minimise triggering by shadow/vegetation movement.

Evidently, a lack of clear communication resulted in the failure to conduct sign-based sampling at each culvert site and for searches to be conducted to a distance of 500 m from the BCLR. It is unlikely this omission would have affected the outcome of the monitoring in 2021 because of the evident scarcity of bilbies occurring on the Peninsula. However, more effort to determine whether bilbies are present within the vicinity of a culvert should be applied in future years.

While searching over a distance of 500 m from a culvert would increase the chance of encountering bilby sign, there is no rationale or explanation provided in the Clearance Permit or the Management Plan as to why searching perpendicularly from the BCLR would increase the chance of encountering bilby sign. Searching the same distance parallel to the road would most likely provide the same chance of encountering sign and be safer and easier logistically. Alternatively, this could be achieved by sampling two 2 ha plot, placed on either side of the road at a culvert.

4.0 Revised monitoring protocol for the BCLR Project area beyond 2021

Monitoring timing and duration

A monitoring period of six weeks needs to be maintained in the period October – December with cameras deployed at the start of this period and collected at the end. All plot monitoring at culverts and at other sites along the BCLR should be conducted within this six week period.

Sampling with 2 ha plots

The 2 ha 'off road' plot should be placed further than 30 m from the road edge and not include or straddle any part of the road. A separate 100 m 'on road' section should be sampled along the soft sediment occurring in the gutter beside the road adjacent to each plot. The data sheet supplied in **Appendix 2** needs to be applied to data. This includes the aiming to detect all target species each time a plot is sampled, aging of sign of species detected and recording site conditions.

- A each culvert, two plots require to be sampled with one on each side of the road (preferably with the long edge perpendicular to the road)
- Additionally, a single plot needs to be sampled at 20 sites along the BCLR preferably at locations where bilby activity has been recorded in previous years.

Sampling with cameras

Cameras need to be deployed on one side of the road at each culvert site where concealment is best provided. A single camera should be fixed:

- on the internal roof of each culvert where possible
- facing the entrance of a culvert
- along a wildlife pad or track in similar habitat but away from the main road but within 200 m of the culvert. Cameras were to be attached to brackets dyna-bolted the roof of a culvert or bolted to metal star pickets located along pads or at the entrance of culverts.

Each camera should be located in the same position used in the previous sampling period where possible (see the coordinates **Appendix 4**). New coordinates need to be recorded in decimal degree and degrees, minutes, seconds using a GPS if a new or slightly different camera location is used. The camera setup height and settings applied during each sampling period should follow those outlined in **Appendix 2**.

In addition, if bilby activity is detected on a plot or opportunistically along the BCLR, then the monitoring approach advocated by DCBA needs to be implemented. This involves the placement of one camera at the entrance of an active burrow and another along a track to monitor other fauna. Additional cameras may need to be sourced i.e. the cameras should not be drawn from those used while culvert monitoring is being conducted.

Appendix 1 The occurrence of bilby activity along the Broome-Cape Leveque Rd. Grey shading indicates when plots where resampled three times per year.

Spp s	<2012	GHD Dec-12	GHD Oct-15	GHD Nov-15	GHD Dec-15	EnvK Sep-17	Biota May-18	Nyul Nyul May-18	RS Jul-18	RS Sep-18
slk01	2002		0	0	0	0				
slk02			0							
slk03			0				1		0	0
slk04			0				0			
slk05			1	1	1		0			0
slk06			0							
slk07			0							
slk08			0							
slk09			0				1			0
slk10			0				0		0	0
slk11			0							
slk12			0				0			
slk13			0							
slk14			0							
slk15			0				0		0	0
slk16			0				1		0	0
slk17			0				1			1
slk18			0							
slk19			0							
slk20			0					0		0
slk21			0				1			0
slk22			0	0	0		1			0
slk23			0				1			0
slk24			1	1	1		0		0	0
slk25			0							
slk26			0							
slk27			0							
slk28			0							
slk29			0			0				
slk30		0	0	0	0					0
slk31			0							
slk32			0							
slk33			0							
slk34			0							
slk35		0	0							
slk36			0							
slk37			0							
slk38			0							
slk39			0	0	0			0		0
slk40			0							
slk41			0							
slk42			0							
slk43			0			0				
slk44			0							
slk45			0	0	0			0		0
slk46			0							
slk47			0							
slk48		1	0	0	0			0		0
slk49		0	0							
slk50			0							
slk51			0							
slk52			0							
slk53			0	0	0			0		0
slk54		0	0							
slk55			0							
slk56			0							
slk57			0							
slk58		0	0							
slk59			0							
slk60			0							
slk61		0	0							
slk62			1	0	0			0		0
slk63			0			0				

slk64		0					
slk65	1963	1	1	0		1	0
slk66		0					
slk67		0					
slk68		0					
slk69		0					
slk70	1963	0				0	0
slk71	1963	0	0	0		0	0
slk72		0				0	0
slk73		0				0	
slk74		0				0	0
slk75		0		0		0	
slk76		0				0	
slk77		0				0	
slk78		0				0	
slk79		0				0	0
slk80		0	0	1	0	0	0
slk81		0				0	0
slk82		0				0	
slk83		0				0	
slk84		0				0	
slk85		0				0	0
slk86		0				0	
slk87		0				0	0
slk88		0				0	0
slk89	1	0	0	0	0	0	0
slk90		0				0	0
slk91		0	0			0	
slk92	1987	0				0	
slk93	1987	0				0	
slk94		0				0	
slk95	0	0				0	0
slk96		0				0	0
slk97		0				0	1
slk98		0	0	1		1	0
slk99	0	0				0	0
slk100	0	1	1	1		0	0
slk101	0	0			0	0	
slk102	0	0				0	
slk103		0				0	0
slk104						0	0

Appendix 4a The coordinates for camera locations monitored along the BCLR in 2021

Underpass Id	Culvert&Camera	Location	Latitude	Longitude	Photos taken
CH41700	CUL61CAM1	Culvert opening	17.55200	122.37917	420
	CUL61CAM2	Radius	17.55158	122.37867	none, fire destroyed camera
CH63600	CUL62CAM1	Culvert opening	17.42214	122.52586	211
	CUL62CAM2	Radius	17.42186	122.52639	567
	CUL62CAM3	Radius	17.42211	122.52522	110
CH74199	CUL63CAM1	Culvert opening	17.32711	122.53664	162
	CUL63CAM2	Radius	17.32719	122.53778	567
	CUL63CAM3	Radius	17.32644	122.53494	26
CH80792	CUL64CAM1	Culvert opening	17.26756	122.53767	144
	CUL64CAM2	Radius	17.26842	122.53858	1632
CH87760	CUL65CAM1	Culvert opening	17.20747	122.55642	192
	CUL65CAM2	Radius	17.20683	122.55528	132
CH88775	CUL66CAM1	Culvert opening	17.19897	122.55961	201
	CUL66CAM2	Radius	17.19917	122.56036	57
CH104200	CUL66CAM3	Radius	17.19919	122.55833	30, Camera malfunctions after 17/11
	CUL67CAM1	Culvert opening	17.08628	122.60564	647
	CUL67CAM2	Radius	17.08717	122.60631	591

Appendix 4b The coordinates for plot locations monitored along the BCLR in 2021

Plot	Latitude	Longitude
2021_01	-17.67276	122.27990
2021_02	-17.63023	122.30164
2021_03	-17.57218	122.36060
2021_04	-17.53316	122.40019
2021_06	-17.48880	122.45830
2021_07	-17.43854	122.51008
2021_08	-17.42440	122.52727
2021_09	-17.35899	122.53527
2021_10	-17.27803	122.53753
2021_11	-17.23436	122.54040
2021_12	-17.21752	122.55256
2021_13	-17.19213	122.56224
2021_14	-17.12411	122.59372
2021_15	-17.11033	122.59923
2021_16	-17.09860	122.60116
2021_17	-17.08840	122.60640
2021_18	-17.05038	122.62810
2021_19	-17.02455	122.65234
2021_20	-17.02340	122.70431

Appendix 5 The species recorded from cameras set at sites along the five mammal species, 16 bird species and three reptile species.

	CUL61 CAM1 Culvert	CUL61 CAM2 Radius	CUL62 CAM1 Culvert	CUL62 CAM2 Radius	CUL62 CAM3 Radius	CUL63 CAM1 Culvert	CUL63 CAM2 Radius	CUL63 CAM3 Radius	CUL64 CAM1 Culvert	CUL64 CAM2 Radius	CUL65 CAM1 Culvert	CUL65 CAM2 Radius	CUL66 CAM1 Culvert	CUL66 CAM2 Radius	CUL66 CAM3 Radius	CUL67 CAM1 Culvert	CUL67 CAM2 Radius
bilby	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
cat			1		1	1	1		1	1	1	1	1	0		1	1
dingo			1	1	1												
agile wallaby				1	1		1	1		1	1	1	1		1		
mouse																	1
cow			1														
magpie											1		1				
magpie lark	1		1				1	1	1	1	1						
ww chough				1													
nightjar	1																
p butcher bird	1					1					1		1	1		1	
bower bird						1											
grey cronw babbler							1								1		
corvid	1					1						1				1	
willie wag tail			1						1				1		1	1	
rainbow be													1				
crested pigeon																1	
black kite				1													
bustard												1					
peaceful dove																	1
long-tailed finch	1																
wren																1	
goanna	1																
frill-necked lizard									1								
bearded dragon												1					1



mainroads
WESTERN AUSTRALIA

Roadkill Monitoring Report

Broome-Cape Leveque Road, Western Australia

SLK 25 – 102.6

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1 INTRODUCTION

The Broome-Cape Leveque Road (BCLR) is located in the Shire of Broome and runs from the Broome Highway, east of Broome townsite, to the northern Dampier Peninsula for a length of approximately 200 kilometres (km). The road is a main transport link, providing access for Aboriginal communities (including Beagle Bay, Lombadina/Djarindjin, Kooljaman and Ardyaloon/One Arm Point) and outstations, pastoral stations, pearling industries and tourist destinations.

Various sections of the BCLR have been upgraded to a sealed standard over the last ten years. Main Roads Western Australia (Main Roads) upgraded 77.6 km (Straight Line Kilometre (SLK) 25 to 102.6) of the unsealed section of the BCLR (Figure 1). The upgrade involved construction of a new road generally parallel to the existing unsealed road. Road user safety and reduced maintenance are two of the key reasons for the upgrade.

The road was widened to 8 m, the roadside batters were flattened and parking bays were installed at regular intervals to provide rest stop opportunities. The road was completed and officially opened in November 2020 (Main Roads, 2021).

1.1 Approval under the *Environment Protection and Biodiversity Conservation Act 1999*

On 3 September 2013, the Department of Agriculture, Water and the Environment (DAWE) (then Department of Sustainability, Environment, Water, Population and Communities) received a referral under the EPBC Act from Main Roads (Main Roads Western Australia 2013) to upgrade the road between SLK 25 and 102.6.

On the 27 September 2013, Main Roads received formal advice from DAWE that the proposed upgrade was considered to be a 'controlled action' requiring assessment and approval under the EPBC Act. The proposed action was assessed at the Preliminary Documentation level of assessment.

Main Roads received approval from DAWE on the 6 July 2015 subject to a number of Conditions (EPBC 2013/6984) (Appendix A).

1.2 Purpose of this Report

A Roadkill Monitoring and Adaptive Management Plan (RMAMP) (GHD, 2016) was produced as per Condition 10 of EPBC 2013/6984. As per Sections 2.5, 2.6 and 2.7 of the RMAMP, roadkill monitoring along the BCLR was required prior to commencement of construction, during construction and during operation of the road, respectively. This was required to determine if roadkill rates along the BCLR increased in response to the upgrade of the road or other factors.

As per Section 2.7 of the RMAMP, an annual Roadkill Monitoring Report is required for each monitoring cycle (GHD, 2016). As the BCLR was completed and opened in November 2020, this report is the first annual iteration of the Roadkill Monitoring Report, providing roadkill data for the first year of operations of the upgraded section (SLK 25 – 102.6).

For the purpose of this report, the monitoring period is considered to be November 2020 to October 2021 inclusive, however, monitoring data for the years preceding this monitoring period (i.e. monitoring data from pre-construction and construction) have also been included.

Results of the monitoring data will be reported in the 2021/2022 EPBC 2013/6984 Annual Compliance Report to DAWE and the 2022 CPS 6078 Annual Clearing Report to the Department of Water and Environmental Regulation (DWER).



Figure 1: Project Area

2 METHODOLOGY

Roadkill monitoring along the BCLR has been undertaken in accordance with requirements of the RMAMP (GHD, 2016).

Prior to construction, monitoring was required twice a week for a period of eight weeks. Monitoring was not to be undertaken on the same day each week but undertaken on any day within any given week. The following data was required to be collected:

- Date.
- Time.
- GPS location coordinates.
- Photographic evidence of the roadkill (where the species is not known) and all Bilbies, to assist with animal identification.
- A DNA sample of the Bilby (depending on the condition of the roadkill) to determine sex, and where possible, age.
- Any noteworthy circumstances including circumstances of injury death where relevant and known.
- Lunar cycle.
- Weather condition preceding the survey.

Any roadkill identified was also removed from the edges of the road to a distance of approximately 40 m. Monitoring was undertaken at a speed of 50 km/hr.

During construction, roadkill monitoring was undertaken using the same methodology listed as for pre-construction monitoring. Monitoring was undertaken twice a week.

During operation of the road, the RMAMP required monitoring, using the same methodology as listed above, as a minimum twice a week for sixteen weeks post-construction, then once a week for three months. This post-construction monitoring is then to be undertaken annually until such time that monitoring data can demonstrate there is no decline in the local Greater Bilby population as a result of roadkill on the BCLR for three successive years (GHD, 2016).

Weather and lunar cycle data were not recorded at the time of monitoring and have been included at the time of writing this report. Lunar cycle data was obtained from the Perth Observatory website (Perth Observatory, 2021) and weather data was obtained from the Bureau of Meteorology website (BoM, 2021).

2.1 Definitions

The following descriptions were used to define carcass condition.

- **Fresh:** Blood may be coagulated, but no odour (flies may be present).
- **Initial Decay:** Signs of insect activity (maggots), some odour.
- **Putrefaction:** Bloating of carcass, internal decomposition, strong odour.
- **Black Putrefaction:** Collapsed carcass, black flesh, strong, cheesy-butyric acid odour.
- **Dry Decay:** No soft tissue remaining, skeletal, dried connective tissues or skin remain.

3 RESULTS

3.1 2015 - Pre-Construction

In 2015 between the months of July and November, 31 roadkill individuals were recorded from 24 monitoring days (Table 1). These comprised 21 wallabies, two cats, two Southern Boobooks, two Northern Blue-tongue Skinks, one Corella, one snake, one Butcherbird and one cow. No Greater Bilby individuals were recorded. The majority of road kills appear to be located between SLK 60 – 83, however, they do not appear to be clustered and are spread along the road (Figure 2). Lunar cycle does not appear to influence level of roadkill.

Table 1: Roadkill Monitoring Results – 2015

YEAR	MONTH	DATE	SLK	SPECIES	CARCASS CONDITION	LONGITUDE	LATITUDE	COMMENTS	WEATHER	LUNAR CYCLE
2015	July	28	71.1	Wallaby	Black Putrefaction	122.533989	-17.36151		Sunny	Waxing Gibbous
2015	July	28	71.95	Cat	Dry Decay	122.535129	-17.353833		Sunny	Waxing Gibbous
2015	July	28	79.3	Snake	Dry Decay	122.537082	-17.288141		Sunny	Waxing Gibbous
2015	July	28	101.3	Butcherbird	Black Putrefaction	122.599327	-17.102133		Sunny	Waxing Gibbous
2015	July	28	63	Wallaby	Dry Decay	122.521753	-17.433764		Sunny	Waxing Gibbous
2015	August	6	16.65	Cat	Dry Decay	122.279399	-17.731392		Sunny	Last Quarter
2015	August	6	70.23	Wallaby	Dry Decay	122.534065	-17.361375		Sunny	Last Quarter
2015	August	6	70.67	Wallaby	Fresh	122.534565	-17.357355		Sunny	Last Quarter
2015	August	6	74.84	Wallaby	Black Putrefaction	122.536305	-17.320152		Sunny	Last Quarter
2015	August	11	16.23	Cow	Initial Decay	122.279444	-17.7425		Sunny	Waning Crescent
2015	August	11	57.73	Wallaby	Putrefaction	122.498611	-17.468056		Sunny	Waning Crescent
2015	August	11	63.00	Wallaby	Black Putrefaction	122.523333	-17.433612		Sunny	Waning Crescent
2015	August	11	63.06	Wallaby	Black Putrefaction	122.523333	-17.433056		Sunny	Waning Crescent

Broome - Cape Leveque Road

Roadkill Monitoring Report – November 2021

YEAR	MONTH	DATE	SLK	SPECIES	CARCASS CONDITION	LONGITUDE	LATITUDE	COMMENTS	WEATHER	LUNAR CYCLE
2015	August	11	70.38	Wallaby	Dry Decay	122.533888	-17.368056		Sunny	Waning Crescent
2015	August	20	77.67	Wallaby	Black Putrefaction	122.53695	-17.30115		Early fog, scattered clouds 0.2mm	Waxing Crescent
2015	August	20	88.21	Wallaby	Fresh	122.55579	-17.20892		Early fog, scattered clouds 0.2mm	Waxing Crescent
2015	August	28	78.8	Southern Boobook	Putrefaction	122.536984	-17.292426		Passing clouds	Waxing Gibbous
2015	August	28	72.6	Northern Blue-tongue Skink	Putrefaction	122.536639	-17.349065		Passing clouds	Waxing Gibbous
2015	August	28	51.5	Northern Blue-tongue Skink	Initial Decay	122.536639	-17.349065		Passing clouds	Waxing Gibbous
2015	September	3	61.72	Wallaby	Dry Decay	122.52112	-17.44111		Haze	Waning Gibbous
2015	September	10		NO ROADKILL FOUND					Passing clouds	Waning Crescent
2015	September	17	69.9	Wallaby	Fresh	122.53493	-17.35911		Sunny Passing clouds	Waxing Crescent
2015	October	6		NO ROADKILL FOUND					Passing clouds	Waning Crescent
2015	October	9		NO ROADKILL FOUND					Passing clouds	Waning Crescent
2015	October	13	57.09	Wallaby	Black Putrefaction	122.49293	-17.4701	40km of road received heavy rain	Partly sunny	New Moon
2015	October	16		NO ROADKILL FOUND					Scattered clouds	Waxing Crescent
2015	October	20	117.15	Wallaby	Black Putrefaction	122.701133	-17.022678		Passing clouds	First Quarter
2015	October	20	44.76	Wallaby	Fresh	122.399743	-17.533651		Passing clouds	First Quarter

YEAR	MONTH	DATE	SLK	SPECIES	CARCASS CONDITION	LONGITUDE	LATITUDE	COMMENTS	WEATHER	LUNAR CYCLE
2015	October	23	62.289	Wallaby	Dry Decay	122.52196	-17.43986		Overcast to scattered clouds	Waxing Gibbous
2015	October	23	62.411	Wallaby	Dry Decay	122.52215	-17.43877		Overcast to scattered clouds	Waxing Gibbous
2015	October	27		NO ROADKILL FOUND					Partly sunny	Full Moon
2015	October	29	88.38	Southern Boobook	Black Putrefaction	122.55575	-17.20926		Passing clouds	Waning Gibbous
2015	October	29	80.39	Corella	Black Putrefaction	122.53755	-17.27832		Passing clouds	Waning Gibbous
2015	November	3		NO ROADKILL FOUND					Passing clouds	Last Quarter
2015	November	6	75.78	Wallaby	Putrefaction	122.53654	-17.31969		Scattered clouds	Waning Crescent
2015	November	11		NO ROADKILL FOUND					Scattered clouds	New Moon
2015	November	13	70.7	Wallaby	Black Putrefaction	-17.364127	122.534578		Passing clouds	Waxing Crescent
2015	November	13	96.4	Wallaby	Black Putrefaction	-17.141744	122.582406		Passing clouds	Waxing Crescent
2015	November	18		NO ROADKILL FOUND					Haze Passing clouds	First Quarter
2015	November	19		NO ROADKILL FOUND					Haze Passing clouds	First Quarter
2015	November	25		NO ROADKILL FOUND					Partly sunny	Full Moon
2015	November	26		NO ROADKILL FOUND					Passing clouds	Full Moon



Figure 2: 2015 Roadkill Locations

3.2 2017 – Pre-Construction

In 2017 between the months of June and October, 13 roadkill individuals were recorded from 7 monitoring days (Table 2). These comprised five wallabies, two cats, one Black Headed Python, one Northern Blue-tongue Skink, one Euro, one raptor, one donkey and one Zebra Finch. No Greater Bilby individuals were recorded. The road kills are scattered along the length of the road and there does not appear to be any clusters of activity (Figure 3). Lunar cycle does not appear to influence level of roadkill.

Table 2: Roadkill Monitoring Results - 2017

YEAR	MONTH	DATE	SLK	SPECIES	CARCASS CONDITION	LONGITUDE	LATITUDE	COMMENTS	WEATHER	LUNAR CYCLE
2017	June	23	75.69	Wallaby	Fresh	122.53656	-17.320475			New Moon
2017	June	23	89.53	Cat	Dry Decay	122.559402	-17.199589			New Moon
2017	June	26	27.08	Wallaby	Fresh	122.28286	-17.645613	Blind corner - photo taken after moving	Waxing Crescent	
2017	July	10	94.28	Black Headed Python	Fresh	122.575183	-17.159644			Full Moon
2017	July	10	12.94	Wallaby		122.281919	-17.771962			Full Moon
2017	July	14	56.62	Wallaby		122.489108	-17.472096			Waning Gibbous
2017	July	14	103.38	Wallaby		122.605879	-17.085679			Waning Gibbous
2017	September	1	71.49	Northern Blue-tongue Skink	Fresh	122.535346	-17.3582		Cloudy 0.2mm	Waxing Gibbous
2017	September	1	51.08	Euro		122.443835	-17.49654		Cloudy 0.2mm	Waxing Gibbous
2017	October	4		NO ROADKILL FOUND						Waxing Gibbous
2017	October	26	113.01	Cat	Dry Decay	122.661757	-17.022675			First Quarter
2017	October	26	113.09	Bird - Raptor	Dry Decay	122.662535	-17.022598			First Quarter
2017	October	26	117.5	Donkey	Black Putrefaction	122.7014607	-17.014607			First Quarter
2017	October	26	104.6	Zebra Finch	Dry Decay					First Quarter

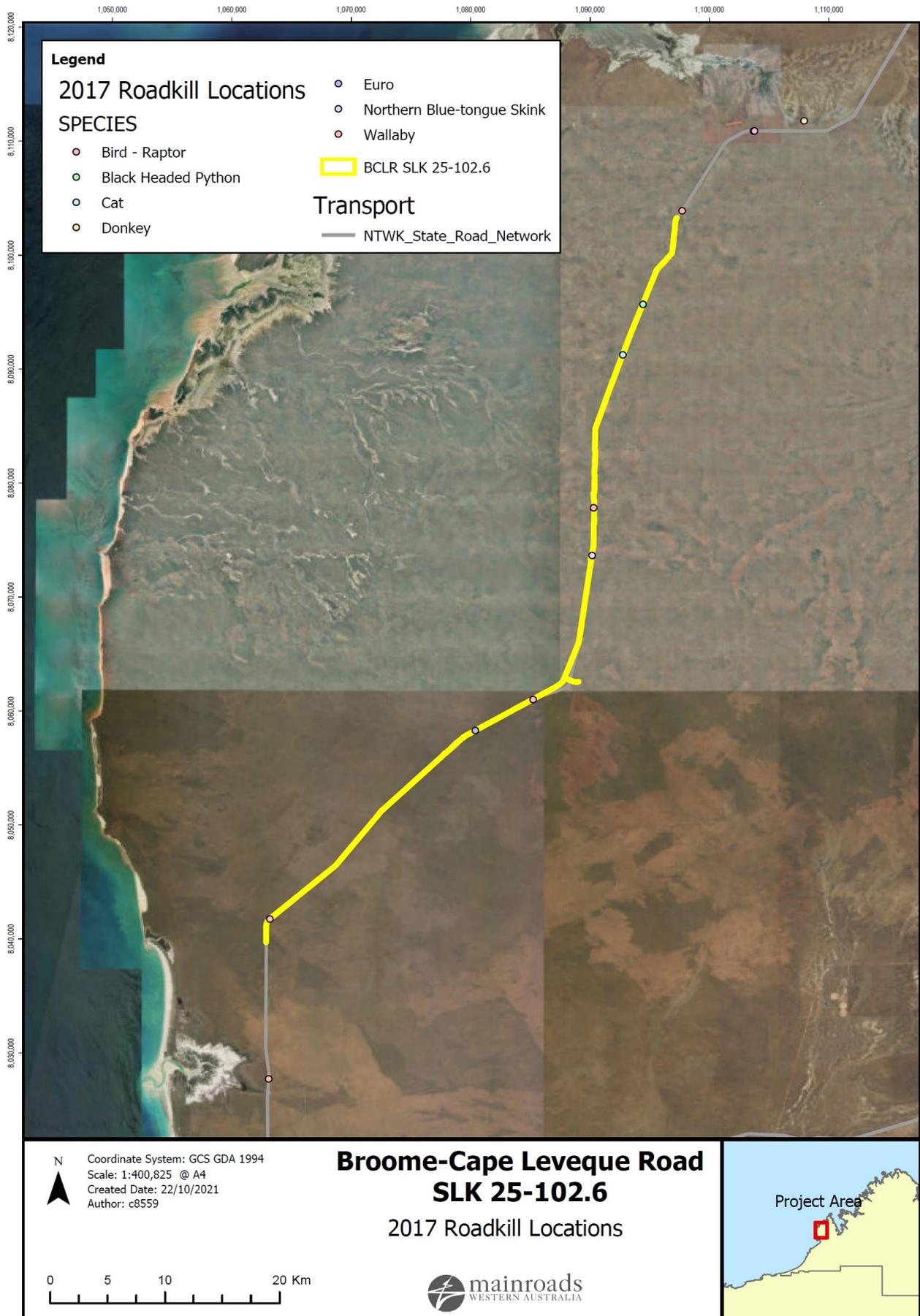


Figure 3: 2017 Roadkill Locations

3.3 2018 – Pre-Construction

In 2018, pre-construction of the BCLR (January – December), 47 roadkill individuals were recorded from 66 monitoring days (Table 3). These comprised 11 Agile Wallabies, seven wallabies, four Black Headed Pythons, four Southern Boobooks, three Stimson’s Pythons, two Dingos/dogs, two kites/falcons, one Euro, one Frogmouth, one raptor, one cow, one Bungarra, one Australian Bustard, one crow, one Carpet Python, one Butcherbird, one cat, one owl, one Wallaroo, one bird of prey (unknown) and one bull. No Greater Bilby individuals were recorded. The road kills appear to be spread along the length of the road (Figure 4). Lunar cycle does not appear to influence level of roadkill.

Table 3: Roadkill Monitoring Results – Pre-Construction 2018

YEAR	MONTH	DATE	SLK	SPECIES	CARCASS CONDITION	LONGITUDE	LATITUDE	COMMENTS	WEATHER	LUNAR CYCLE
2018	January	23	21.17	Euro	Black Putrefaction	122.279	-17.698		Hot 5.6mm	First Quarter
2018	March	21	3.16	Frogmouth	Fresh	122.27627	-17.8593	Sealed section, around from turnoff	Passing clouds	Waxing Crescent
2018	March	21	11.30	Dingo/Dog	Dry Decay	122.28101	-17.78662	LHS drain	Passing clouds	Waxing Crescent
2018	March	21	11.36	Raptor	Initial Decay	122.28107	-17.7861	Sealed. LHS	Passing clouds	Waxing Crescent
2018	March	21	60.23	Kite/Falcon	Fresh	122.51759	-17.45784	Straight unsealed section	Passing clouds	Waxing Crescent
2018	March	21	111.47	Black Headed Python	Dry Decay	122.64838	-17.02667	Sealed section	Passing clouds	Waxing Crescent
2018	April	9	53.73	Kite/Falcon	Fresh	122.46555	-17.48491	Sealed section		Last Quarter
2018	April	9	87.60	Cow	Dry Decay	122.55335	-17.21589	Straight unsealed section		Last Quarter
2018	April	9	49.49	Wallaby	Initial Decay	122.43105	-17.50378	Straight unsealed section		Last Quarter
2018	April	10	10.5	Southern Boobook	Fresh	122.28099	-17.79294	Sealed	Hot 0.2mm	Waning Crescent

YEAR	MONTH	DATE	SLK	SPECIES	CARCASS CONDITION	LONGITUDE	LATITUDE	COMMENTS	WEATHER	LUNAR CYCLE
2018	April	10	11.7	Southern Boobook	Fresh	122.28122	-17.78313	Sealed	Hot 0.2mm	Waning Crescent
2018	April	10	11.9	Stimson's Python	Initial Decay	122.28137	-17.78108	Sealed, moved off seal for pic id	Hot 0.2mm	Waning Crescent
2018	April	10	10.8	Bungarra	Fresh	122.28097	-17.79061	Sealed	Hot 0.2mm	Waning Crescent
2018	April	13	62.18	Black Headed Python	Initial Decay	122.52167	-17.44088	Unsealed		Waning Crescent
2018	April	13	10.39	Australian Bustard	Initial Decay	122.28102	-17.7948	Sealed		Waning Crescent
2018	April	13	7.62	Crow	Dry Decay	122.28119	-17.81977	Sealed		Waning Crescent
2018	April	23	0.9	Southern Boobook	Initial Decay	122.27545	-17.87925	Sealed		First Quarter
2018	May	1		NO ROADKILL FOUND						Full Moon
2018	May	4		NO ROADKILL FOUND						Waning Gibbous
2018	May	7	16.99	Black Headed Python	Fresh	122.27964	-17.73567	Unsealed		Last Quarter
2018	May	7	29.34	Carpet Python	Fresh	122.29893	-17.63251	Unsealed		Last Quarter
2018	May	9	9.09	Butcher Bird	Fresh	122.28108	-17.80655	Sealed		Last Quarter
2018	May	9	102.2	Cat	Initial Decay	122.60059	-17.09646	Unsealed		Last Quarter
2018	May	14		NO ROADKILL FOUND						New Moon
2018	May	17	83.43	Wallaby	Initial Decay	122.54042	-17.25137	Unsealed		Waxing Crescent
2018	May	21	77.16	Wallaby	Initial Decay	122.53683	-17.30737	Unsealed	Passing clouds	First Quarter
2018	May	25	97.76	Owl	Initial Decay	122.5876	-17.130085	Unsealed		Waxing Gibbous
2018	May	30	60.04	Walleroo	Initial Decay	122.51717	-17.45966	Unsealed, after bend	Scattered clouds	Full Moon

Broome - Cape Leveque Road

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YEAR	MONTH	DATE	SLK	SPECIES	CARCASS CONDITION	LONGITUDE	LATITUDE	COMMENTS	WEATHER	LUNAR CYCLE
2018	June	2		NO ROADKILL FOUND						Waning Gibbous
2018	June	5		NO ROADKILL FOUND						Last Quarter
2018	June	8	37.58	Stimson's Python	Fresh	122.35367	-17.58056	Unsealed		Waning Crescent
2018	June	12	80.86	Southern Boobook	Initial Decay	122.53.778	-17.27406	Unsealed		Waning Crescent
2018	June	14	83.41	Wallaby	Putrefaction	122.54059	-17.25159	Unsealed, drain		New Moon
2018	June	19		NO ROADKILL FOUND						First Quarter
2018	June	22		NO ROADKILL FOUND						Waxing Gibbous
2018	June	26		NO ROADKILL FOUND						Waxing Gibbous
2018	June	29	61.59	Black Headed Python	Initial Decay	122.52045	-17.44609	Unsealed		Full Moon
2018	June	29	60.88	Wallaby	Initial Decay	122.51895	-17.45222	Unsealed		Full Moon
2018	June	29	31.92	Wallaby	Black Putrefaction	122.31736	-17.61751	Unsealed		Full Moon
2018	July	2		NO ROADKILL FOUND						Waning Gibbous
2018	July	5	43.78	Wallaby	Black Putrefaction	122.24368	-17.94378	Unsealed		Last Quarter
2018	July	11		NO ROADKILL FOUND						Waning Crescent
2018	July	13		NO ROADKILL FOUND						New Moon
2018	July	16		NO ROADKILL FOUND						Waxing Crescent
2018	July	16	32.55	Agile Wallaby	Initial Decay	122.32194	-17.61375	Unsealed		Waxing Crescent
2018	July	20	1.24	Stimson's Python	Fresh	122.27468	-17.87627	Sealed		First Quarter
2018	July	20	14.14	Agile Wallaby	Fresh	122.2813	-17.76116	Unsealed		First Quarter

YEAR	MONTH	DATE	SLK	SPECIES	CARCASS CONDITION	LONGITUDE	LATITUDE	COMMENTS	WEATHER	LUNAR CYCLE
2018	July	20	71.28	Dingo/Dog	Dry Decay	122.5352	-17.36004			First Quarter
2018	July	30	56.99	Agile Wallaby	Initial Decay	122.49198	-17.47044			Waning Gibbous
2018	July	30	63	Agile Wallaby	Putrefaction	122.52337	-17.43371			Waning Gibbous
2018	July	30	69.82	Agile Wallaby	Initial Decay	122.53328	-17.37315			Waning Gibbous
2018	July	30	70.34	Agile Wallaby	Putrefaction	122.53394	-17.36848			Waning Gibbous
2018	July	30	71.54	Agile Wallaby	Fresh	122.53543	-17.3578			Waning Gibbous
2018	August	6	72.92	Bird of Prey	Fresh	122.53697	-17.34548			Waning Crescent
2018	August	6	67.41	Agile Wallaby	Putrefaction	122.53016	-17.39465			Waning Crescent
2018	August	9		NO ROADKILL FOUND						Waning Crescent
2018	August	13		NO ROADKILL FOUND						Waxing Crescent
2018	August	16		NO ROADKILL FOUND						Waxing Crescent
2018	August	20		NO ROADKILL FOUND						Waxing Gibbous
2018	August	23		NO ROADKILL FOUND						Waxing Gibbous
2018	August	31		NO ROADKILL FOUND						Waning Gibbous
2018	September	10		NO ROADKILL FOUND						New Moon
2018	September	13	52.23	Agile Wallaby	Initial Decay	122.45325	-17.49168	Unsealed		Waxing Crescent
2018	September	19		NO ROADKILL FOUND						Waxing Gibbous
2018	September	21		NO ROADKILL FOUND					Passing clouds	Waxing Gibbous

YEAR	MONTH	DATE	SLK	SPECIES	CARCASS CONDITION	LONGITUDE	LATITUDE	COMMENTS	WEATHER	LUNAR CYCLE
2018	September	25		NO ROADKILL FOUND						Full Moon
2018	September	27	65.8	Agile Wallaby	Initial Decay	122.52788	-17.40892	Unsealed	0.2mm	Waning Gibbous
2018	October	3		NO ROADKILL FOUND						Last Quarter
2018	October	9		NO ROADKILL FOUND					Passing clouds	New Moon
2018	October	10		NO ROADKILL FOUND						New Moon
2018	October	16		NO ROADKILL FOUND						First Quarter
2018	October	18		NO ROADKILL FOUND						Waxing Gibbous
2018	October	23		NO ROADKILL FOUND						Full Moon
2018	October	26		NO ROADKILL FOUND						Waning Gibbous
2018	October	30		NO ROADKILL FOUND					Scattered clouds	Last Quarter
2018	November	2		NO ROADKILL FOUND						Waning Crescent
2018	November	5		NO ROADKILL FOUND						Waning Crescent
2018	November	8		NO ROADKILL FOUND						New Moon
2018	November	12		NO ROADKILL FOUND						Waxing Crescent
2018	November	15		NO ROADKILL FOUND						First Quarter
2018	November	21		NO ROADKILL FOUND						Waxing Gibbous
2018	November	22	12.18	Bull	Fresh	122.28156	-17.77877	Sealed	Scattered clouds	Full Moon
2018	November	26		NO ROADKILL FOUND					Passing clouds	Waning Gibbous

YEAR	MONTH	DATE	SLK	SPECIES	CARCASS CONDITION	LONGITUDE	LATITUDE	COMMENTS	WEATHER	LUNAR CYCLE
2018	November	27		NO ROADKILL FOUND					Overcast	Waning Gibbous
2018	November	29		NO ROADKILL FOUND					Passing clouds	Last Quarter
2018	December	3		NO ROADKILL FOUND					Passing clouds	Waning Crescent
2018	December	11		NO ROADKILL FOUND						Waxing Crescent
2018	December	12	81.16	Agile Wallaby	Fresh	122.53772	-17.27142	Unsealed, pinkie alongside	Overcast	Waxing Crescent
2018	December	13		NO ROADKILL FOUND					Passing clouds	Waxing Crescent

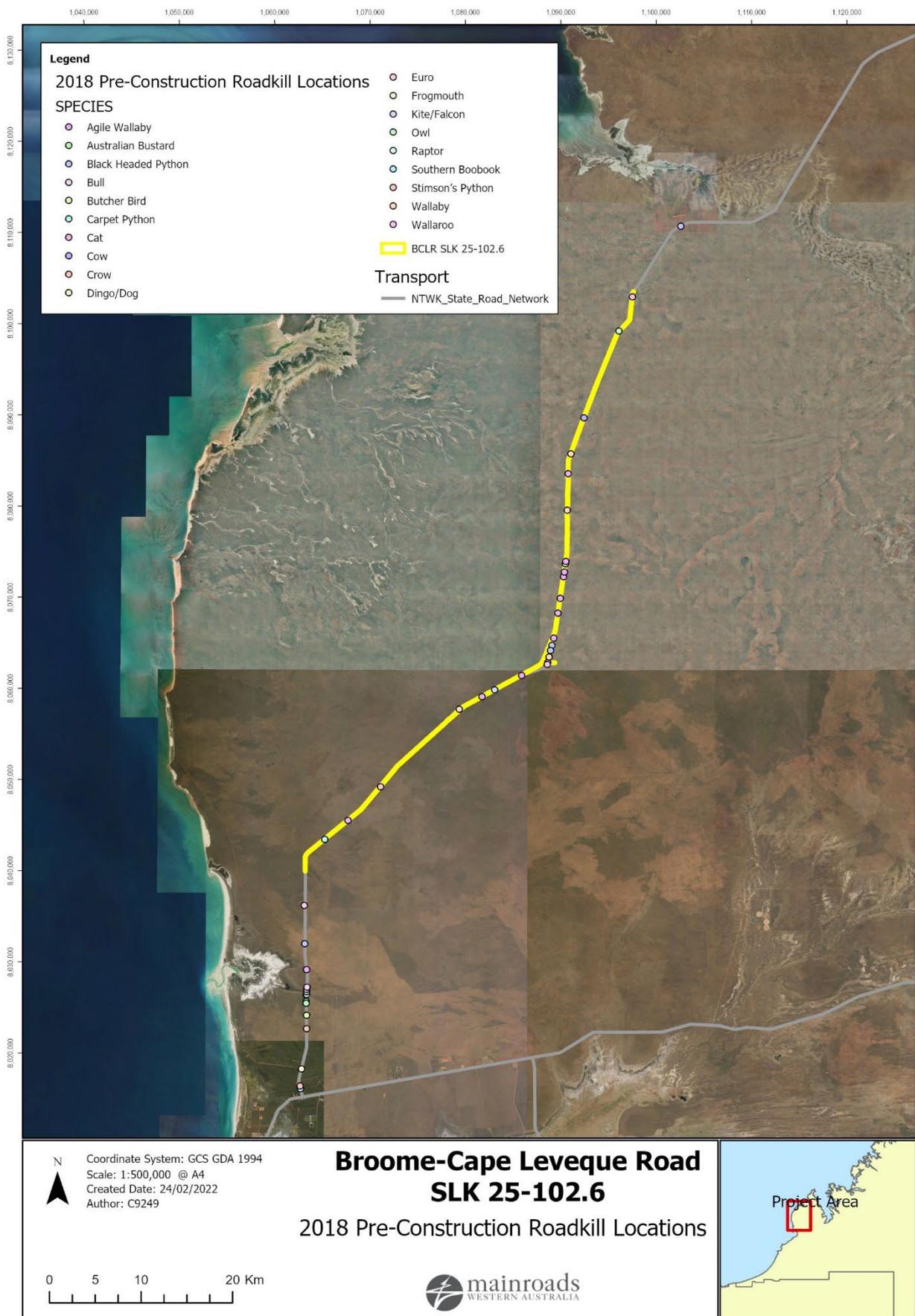


Figure 4: 2018 Pre-Construction Roadkill Locations

3.4 2018 – Construction

In 2018, during construction of the BCLR (June – December), 17 roadkill individuals were recorded from 43 monitoring days (Table 4). These comprised 13 Little Corellas, two birds of prey and two Agile Wallabies. No Greater Bilby individuals were recorded. The majority of road kills appear to be located between SLK 83 – 88, with Little Corellas being the most common species recorded within this section. There appears to be a small cluster of roadkill recordings at a bend in the road at SLK 83.6 (Figure 5). Lunar cycle does not appear to influence level of roadkill.

Table 4: Roadkill Monitoring Results – Construction 2018

YEAR	MONTH	DATE	SLK	SPECIES	CARCASS CONDITION	LONGITUDE	LATITUDE	COMMENTS	WEATHER	LUNAR CYCLE
2018	June	8		NO ROADKILL FOUND						Waning Crescent
2018	June	12		NO ROADKILL FOUND						Waning Crescent
2018	June	19		NO ROADKILL FOUND						First Quarter
2018	June	26		NO ROADKILL FOUND						Waxing Gibbous
2018	June	29		NO ROADKILL FOUND						Full Moon
2018	July	16	83.57	Little Corella	Initial Decay	122.54093	-17.25019	Unsealed		Waxing Crescent
2018	July	16	83.57	Little Corella	Initial Decay	122.54093	-17.25019	Unsealed (2 together)		Waxing Crescent
2018	July	16	87.3	Little Corella	Fresh	122.55221	-17.21852	Unsealed		Waxing Crescent
2018	July	23	83.56	Little Corella	Fresh	122.5407	-17.25021	Unsealed	0.2mm	Waxing Gibbous
2018	July	26	83.65	Little Corella	Fresh	122.54102	-17.24946	Unsealed		Full Moon
2018	July	26	84.1	Little Corella	Fresh	122.54235	-17.24565	Unsealed		Full Moon
2018	July	26	84.19	Little Corella	Fresh	122.54265	-17.24483	Unsealed		Full Moon
2018	July	26	85.53	Little Corella	Fresh	122.54673	-17.23349	Unsealed		Full Moon
2018	July	30	86.7	Little Corella	Fresh	122.55045	-17.22358	Unsealed		Waning Gibbous
2018	July	30	84.45	Bird of Prey	Fresh	122.54342	-17.24267	Unsealed		Waning Gibbous

YEAR	MONTH	DATE	SLK	SPECIES	CARCASS CONDITION	LONGITUDE	LATITUDE	COMMENTS	WEATHER	LUNAR CYCLE
2018	August	6	81.08	Little Corella	Fresh	122.53774	-17.27216	Unsealed		Waning Crescent
2018	August	6	86.37	Little Corella	Fresh	122.54941	-17.22639	Unsealed		Waning Crescent
2018	August	6	83.98	Little Corella	Fresh	122.54204	-17.24664	Unsealed		Waning Crescent
2018	August	6	83.72	Little Corella	Fresh	122.54129	-17.2489	Unsealed		Waning Crescent
2018	August	9		NO ROADKILL FOUND						Waning Crescent
2018	August	13		NO ROADKILL FOUND						Waxing Crescent
2018	August	16		NO ROADKILL FOUND						Waxing Crescent
2018	August	20		NO ROADKILL FOUND						Waxing Gibbous
2018	August	23		NO ROADKILL FOUND						Waxing Gibbous
2018	August	31		NO ROADKILL FOUND						Waning Gibbous
2018	September	10		NO ROADKILL FOUND						New Moon
2018	September	12	84.51	Bird of Prey	Initial Decay	122.54367	-17.24212	Unsealed		Waxing Crescent
2018	September	19		NO ROADKILL FOUND						Waxing Gibbous
2018	September	21		NO ROADKILL FOUND						Waxing Gibbous
2018	September	25		NO ROADKILL FOUND						Full Moon
2018	September	27		NO ROADKILL FOUND					0.2mm	Waning Gibbous
2018	October	3		NO ROADKILL FOUND						Last Quarter
2018	October	9		NO ROADKILL FOUND					Passing clouds	New Moon

YEAR	MONTH	DATE	SLK	SPECIES	CARCASS CONDITION	LONGITUDE	LATITUDE	COMMENTS	WEATHER	LUNAR CYCLE
2018	October	10		NO ROADKILL FOUND						New Moon
2018	October	16	81.74	Agile Wallaby		122.53838	-17.25723	Unsealed, with joey		First Quarter
2018	October	18	78.13	Agile Wallaby		122.53701	-17.29862			Waxing Gibbous
2018	October	23		NO ROADKILL FOUND						Full Moon
2018	October	26		NO ROADKILL FOUND						Waning Gibbous
2018	October	30		NO ROADKILL FOUND					Overcast to scattered clouds	Last Quarter
2018	November	2		NO ROADKILL FOUND						Waning Crescent
2018	November	5		NO ROADKILL FOUND					Overcast	Waning Crescent
2018	November	8		NO ROADKILL FOUND						New Moon
2018	November	12		NO ROADKILL FOUND						Waxing Crescent
2018	November	15		NO ROADKILL FOUND						First Quarter
2018	November	21		NO ROADKILL FOUND						Waxing Gibbous
2018	November	22		NO ROADKILL FOUND					Passing clouds	Full Moon
2018	November	26		NO ROADKILL FOUND					Passing clouds	Waning Gibbous
2018	November	27		NO ROADKILL FOUND					Overcast	Waning Gibbous
2018	November	29		NO ROADKILL FOUND					Passing clouds	Last Quarter
2018	December	3		NO ROADKILL FOUND					Passing clouds	Waning Crescent
2018	December	11		NO ROADKILL FOUND						Waxing Crescent

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YEAR	MONTH	DATE	SLK	SPECIES	CARCASS CONDITION	LONGITUDE	LATITUDE	COMMENTS	WEATHER	LUNAR CYCLE
2018	December	12		NO ROADKILL FOUND						Waxing Crescent

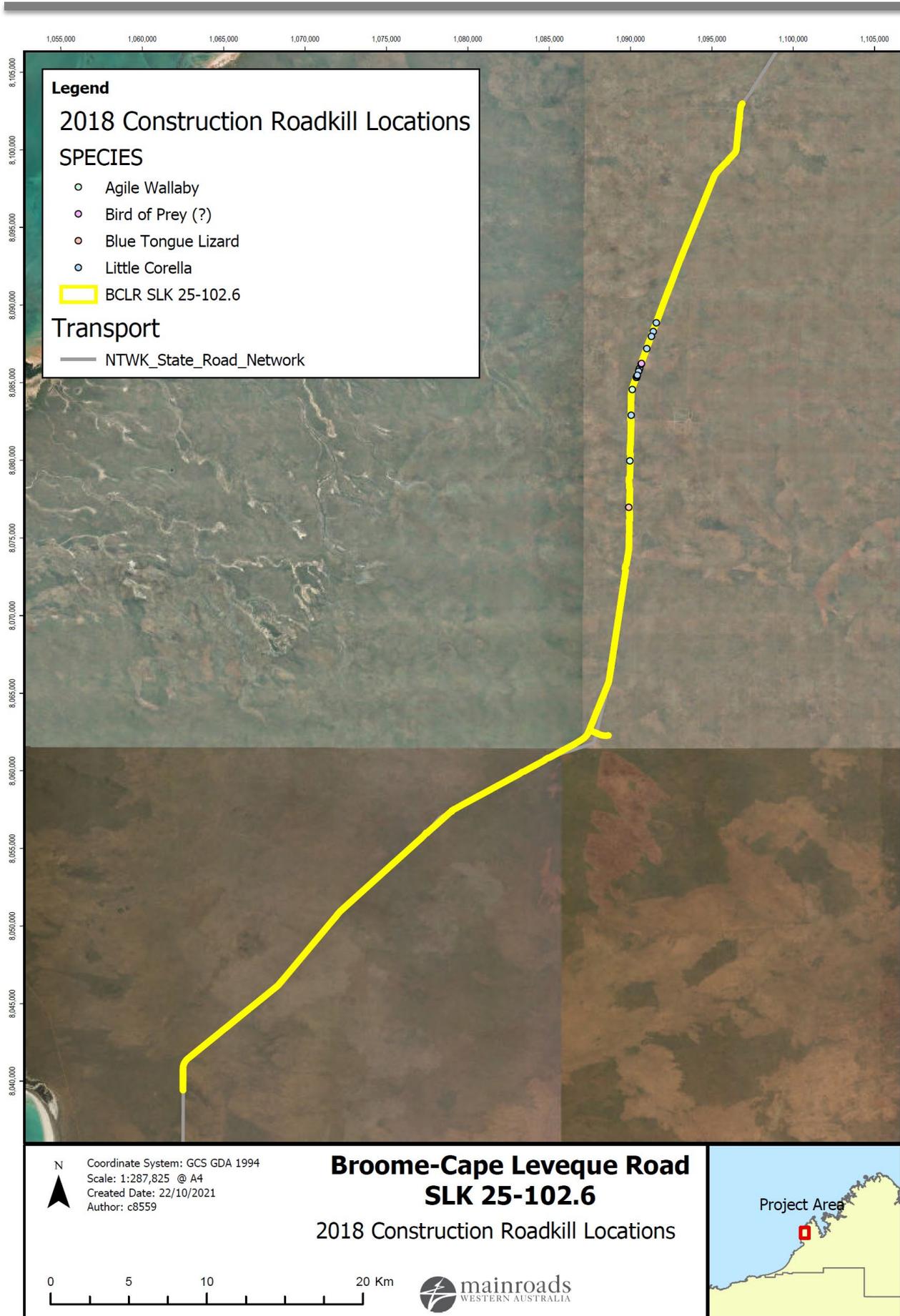


Figure 5: 2018 Construction Roadkill Locations

3.5 2019 – Construction

In 2019 between the months of April and December, 15 roadkill individuals were recorded from 64 monitoring days (Table 5). These comprised seven Agile Wallabies, three falcons, two wallabies, one Dingo, one Black Headed Python and one Brown Honey Eater. No Greater Bilby individuals were recorded. The road kills appear to be spread along the length of the road (Figure 6). Lunar cycle does not appear to influence level of roadkill.

Table 5: Roadkill Monitoring Results - 2019

YEAR	MONTH	DATE	SLK	SPECIES	CARCASS CONDITION	LONGITUDE	LATITUDE	COMMENTS	WEATHER	LUNAR CYCLE
2019	April	16	98.63	Agile Wallaby	Putrefaction	122.5929	-17.12493			Waxing Gibbous
2019	April	18	96.26	Agile Wallaby	Putrefaction	122.58168	-17.14298			Full Moon
2019	April	18	102.42	Agile Wallaby	Putrefaction	122.60137	-17.09304			Full Moon
2019	April	19		NO ROADKILL FOUND						Full Moon
2019	April	24	96.26	Agile Wallaby		122.58168	-17.142898			Waning Gibbous
2019	April	24	102.42	Agile Wallaby		122.60137	-17.09304			Waning Gibbous
2019	April	26		NO ROADKILL FOUND						Last Quarter
2019	April	27		NO ROADKILL FOUND						Last Quarter
2019	April	30		NO ROADKILL FOUND						Waning Crescent
2019	May	1		NO ROADKILL FOUND						Waning Crescent
2019	May	3		NO ROADKILL FOUND					Overcast	New Moon
2019	May	7		NO ROADKILL FOUND						Waxing Crescent
2019	May	10		NO ROADKILL FOUND					Passing clouds	Waxing Crescent
2019	May	13		NO ROADKILL FOUND					Scattered clouds	Waxing Gibbous
2019	May	17		NO ROADKILL FOUND						Full Moon

YEAR	MONTH	DATE	SLK	SPECIES	CARCASS CONDITION	LONGITUDE	LATITUDE	COMMENTS	WEATHER	LUNAR CYCLE
2019	May	21		NO ROADKILL FOUND					Overcast	Waning Gibbous
2019	May	23		NO ROADKILL FOUND						Waning Gibbous
2019	May	28		NO ROADKILL FOUND						Waning Crescent
2019	May	29		NO ROADKILL FOUND						Waning Crescent
2019	June	5		NO ROADKILL FOUND						Waxing Crescent
2019	June	9		NO ROADKILL FOUND						First Quarter
2019	June	11		NO ROADKILL FOUND						First Quarter
2019	June	13		NO ROADKILL FOUND						Waxing Gibbous
2019	June	18		NO ROADKILL FOUND						Full Moon
2019	June	20		NO ROADKILL FOUND					Overcast	Waning Gibbous
2019	June	24	51.51	Agile Wallaby	Putrefaction	122.4474	-17.4948			Last Quarter
2019	June	27		NO ROADKILL FOUND						Waning Crescent
2019	July	4		NO ROADKILL FOUND						Waxing Crescent
2019	July	10		NO ROADKILL FOUND						First Quarter
2019	July	10		NO ROADKILL FOUND						First Quarter
2019	July	10		NO ROADKILL FOUND						First Quarter
2019	July	15		NO ROADKILL FOUND						Full Moon
2019	July	25		NO ROADKILL FOUND						Last Quarter

YEAR	MONTH	DATE	SLK	SPECIES	CARCASS CONDITION	LONGITUDE	LATITUDE	COMMENTS	WEATHER	LUNAR CYCLE
2019	August	6		NO ROADKILL FOUND						First Quarter
2019	August	8		NO ROADKILL FOUND						First Quarter
2019	August	14	56.34	Agile Wallaby	Fresh	122.48679	-17.47339			Full Moon
2019	August	16		NO ROADKILL FOUND						Full Moon
2019	August	20		NO ROADKILL FOUND						Waning Gibbous
2019	August	23		NO ROADKILL FOUND						Last Quarter
2019	August	26		NO ROADKILL FOUND						Waning Crescent
2019	August	28	41.03	Falcon	Fresh	122.37427	-17.55674			Waning Crescent
2019	August	30		NO ROADKILL FOUND						New Moon
2019	September	3		NO ROADKILL FOUND					0.2mm	Waxing Crescent
2019	September	6		NO ROADKILL FOUND					Passing clouds	First Quarter
2019	September	10	100.95	Falcon	Fresh	122.59952	-1710606		Sunny	Waxing Gibbous
2019	September	10	100.95	Falcon	Fresh	122.59952	-1710606		Sunny	Waxing Gibbous
2019	September	12		NO ROADKILL FOUND						Waxing Gibbous
2019	September	17		NO ROADKILL FOUND					0.2mm	Waning Gibbous
2019	September	20		NO ROADKILL FOUND						Waning Gibbous
2019	September	24		NO ROADKILL FOUND						Waning Crescent
2019	September	26		NO ROADKILL FOUND						Waning Crescent

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YEAR	MONTH	DATE	SLK	SPECIES	CARCASS CONDITION	LONGITUDE	LATITUDE	COMMENTS	WEATHER	LUNAR CYCLE
2019	October	1		NO ROADKILL FOUND						Waning Crescent
2019	October	4		NO ROADKILL FOUND						First Quarter
2019	October	8	73.53	Dingo	Initial Decay	122.53694	-17.33997			Waxing Gibbous
2019	October	8	94.75	Black Headed Python	Fresh	122.57659	-17.15567			Waxing Gibbous
2019	October	12		NO ROADKILL FOUND					0.2mm	Full Moon
2019	October	14		NO ROADKILL FOUND						Full Moon
2019	October	18		NO ROADKILL FOUND						Waning Gibbous
2019	October	21	1008	Brown Honey Eater	Fresh	122.52613	-17.42062			Last Quarter
2019	October	23		NO ROADKILL FOUND						Waning Crescent
2019	October	25		NO ROADKILL FOUND						Waning Crescent
2019	October	29		NO ROADKILL FOUND						Waxing Crescent
2019	October	31		NO ROADKILL FOUND						Waxing Crescent
2019	November	5	71.05	Wallaby	Fresh	122.53465	-17.3621			First Quarter
2019	November	7		NO ROADKILL FOUND						Waxing Gibbous
2019	November	13		NO ROADKILL FOUND						Full Moon
2019	November	14		NO ROADKILL FOUND						Waning Gibbous
2019	November	19		NO ROADKILL FOUND						Last Quarter
2019	November	20		NO ROADKILL FOUND					Passing clouds	Last Quarter

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YEAR	MONTH	DATE	SLK	SPECIES	CARCASS CONDITION	LONGITUDE	LATITUDE	COMMENTS	WEATHER	LUNAR CYCLE
2019	December	7	62.500	Wallaby	Fresh					Waxing Gibbous

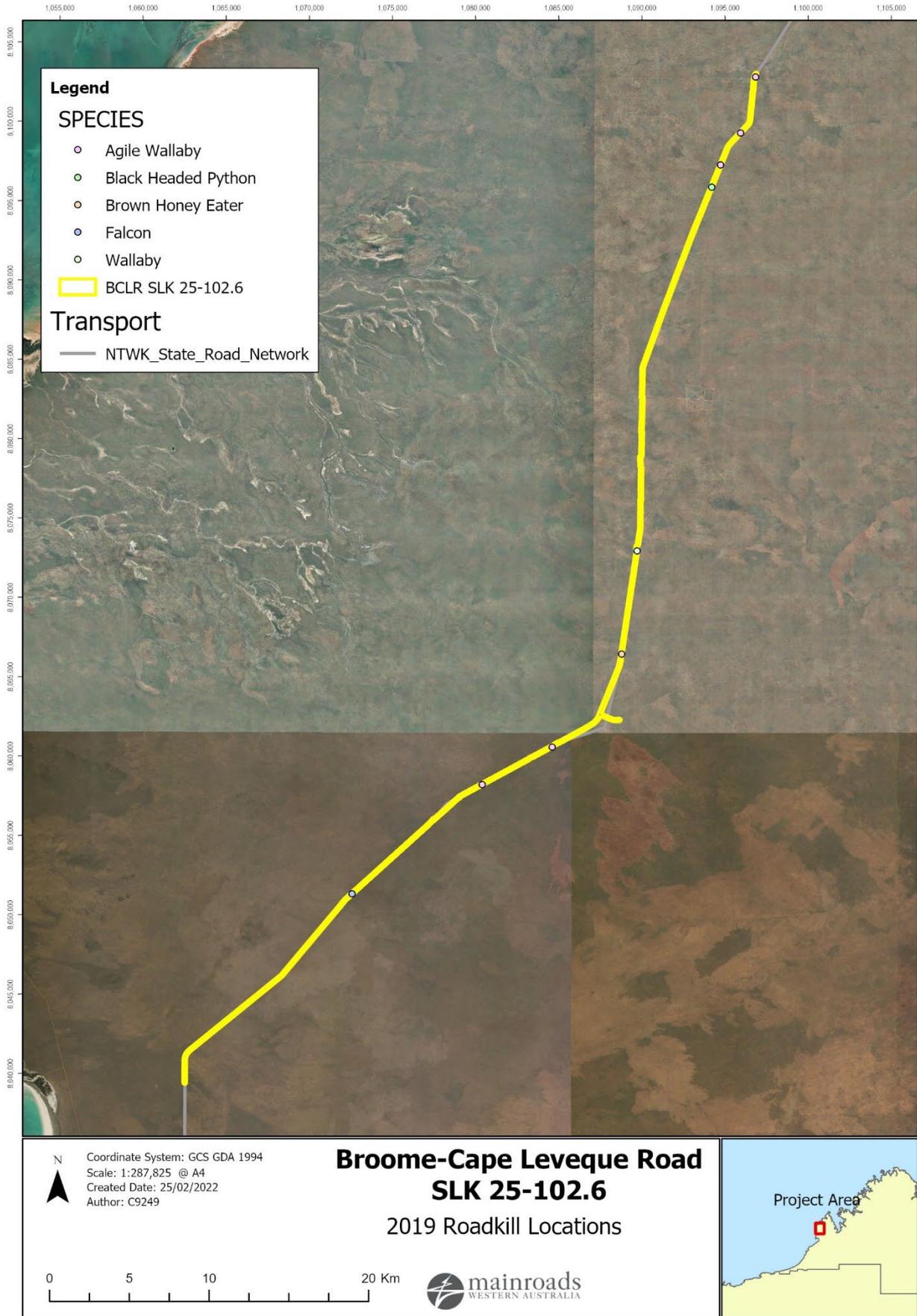


Figure 6: 2019 Roadkill Locations

3.6 2020 – Construction

In 2020 between the months of January and December, 13 roadkill individuals were recorded from 45 monitoring days (Table 6). These comprised seven Agile Wallabies, one Frilled Neck Lizard, three Bungarra (Sand Goanna), one Bird of Prey and one Black Head Python. No Greater Bilby individuals were recorded. The road kills appear to be spread along the length of the road (Figure 7).

One roadkill Greater Bilby was reported to Main Roads by a DBCA officer on 8 October 2020. The roadkill was recorded on 2 October 2020 on BCLR near the McGuigan Road turn off, approximately at SLK 5.3. The officer collected ear and tail tissue samples for DNA analysis for comparison against scat samples previously collected from the area. The officer noted the specimen was in poor condition at the time of recording with several birds of prey eating it. As the roadkill was recorded outside the monitoring area (SLK 25 – 102.6), this record does not trigger the Greater Bilby management conditions in the RMAMP.

Lunar cycle does not appear to influence level of roadkill.

Table 6: Roadkill Monitoring Results – 2020

YEAR	MONTH	DATE	SLK	SPECIES	CARCASS CONDITION	LATITUDE	LONGITUDE	COMMENTS	WEATHER	LUNAR CYCLE
2020	January	8		NO ROADKILL FOUND					Overcast	Waxing Gibbous
2020	January	21		NO ROADKILL FOUND					Overcast	Waning Crescent
2020	February	10		NO ROADKILL FOUND					Sunny	Full Moon
2020	February	24		NO ROADKILL FOUND					Sunny	Full Moon
2020	March	4		NO ROADKILL FOUND					Passing clouds	Waxing Gibbous
2020	March	10	73.98	Frilled Neck Lizard	Fresh	-17.33595	122.53682	Construction	Sunny	Full Moon
2020	March	10	65.42	Agile Wallaby	Fresh	-17.41228	122.52716	Construction	Sunny	Full Moon
2020	March	10	27.89	Bungarra	Fresh	-17.64097	122.28876	Construction	Sunny	Full Moon
2020	March	17		NO ROADKILL FOUND					Some clouds	Last Quarter
2020	March	24		NO ROADKILL FOUND						New Moon
2020	March	25		NO ROADKILL FOUND						New Moon

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2020	March	27		NO ROADKILL FOUND					Passing clouds	Waxing Crescent
2020	April	8		NO ROADKILL FOUND						Full Moon
2020	April	14		NO ROADKILL FOUND					Scattered clouds	Last Quarter
2020	April	21	3.99	Bungarra	Fresh	-17.85201	122.27793	Pre-construction		New Moon
2020	April	22		NO ROADKILL FOUND						New Moon
2020	May	12		NO ROADKILL FOUND						Waning Gibbous
2020	May	20		NO ROADKILL FOUND					Light rain, Overcast	Waning Crescent
2020	May	29		NO ROADKILL FOUND					Overcast	First Quarter
2020	June	2		NO ROADKILL FOUND						Waxing Gibbous
2020	June	12		NO ROADKILL FOUND						Last Quarter
2020	June	15	56.06	Agile Wallaby	Fresh	-17.47462	122.48457	Pre-construction Dinner Camp Bend		Waning Crescent
2020	June	17		NO ROADKILL FOUND						Waning Crescent
2020	June	18		NO ROADKILL FOUND						Waning Crescent
2020	June	26		NO ROADKILL FOUND						Waxing Crescent
2020	June	30		NO ROADKILL FOUND						Waxing Gibbous
2020	July	6		NO ROADKILL FOUND						Full Moon
2020	July	7		NO ROADKILL FOUND						Waning Gibbous
2020	July	15		NO ROADKILL FOUND						Waning Crescent

YEAR	MONTH	DATE	SLK	SPECIES	CARCASS CONDITION	LATITUDE	LONGITUDE	COMMENTS	WEATHER	LUNAR CYCLE
2020	July	22		NO ROADKILL FOUND						Waxing Crescent
2020	August	4		NO ROADKILL FOUND						Full Moon
2020	August	12	62.55	Agile Wallaby	Initial Decay	-17.43762	122.52254	Post-construction	Overcast	Last Quarter
2020	August	21		NO ROADKILL FOUND						Waxing Crescent
2020	August	27		NO ROADKILL FOUND						Waxing Gibbous
2020	September	3	2.01	Bird of Prey	Initial Decay	-1786949	122.27365	Pre-construction		Full Moon
2020	September	8		NO ROADKILL FOUND				Pre-construction		Waning Gibbous
2020	September	15		NO ROADKILL FOUND					Passing clouds	Waning Crescent
2020	October	2		NO ROADKILL FOUND					Passing clouds	Full Moon
2020	October	9	52.47	Agile Wallaby	Fresh	-17.49051	122.45523	Post-construction		Last Quarter
2020	October	14	3.04	Agile Wallaby	Fresh	-17.86035	122.27604	Post-construction		Waning Crescent
2020	October	21	22.21	Black Head Python	Fresh	-17.688755	122.2798			Waxing Crescent
2020	October	25	38.87	Agile Wallaby	Fresh	-17.5714	122.3611	Post-construction	Partly sunny	Waxing Gibbous
2020	November	10	56.03	Agile Wallaby	Black Putrefaction	-17.47459	122.48414			Waning Crescent
2020	November	23		NO ROADKILL FOUND						First Quarter
2020	November	26	4.2	Bungarra	Fresh	-17.85018	122.27839	Pre-construction		Waxing Gibbous
2020	December	9		NO ROADKILL FOUND					Overcast	Waning Crescent
2020	December	17		NO ROADKILL FOUND					Overcast	Waxing Crescent

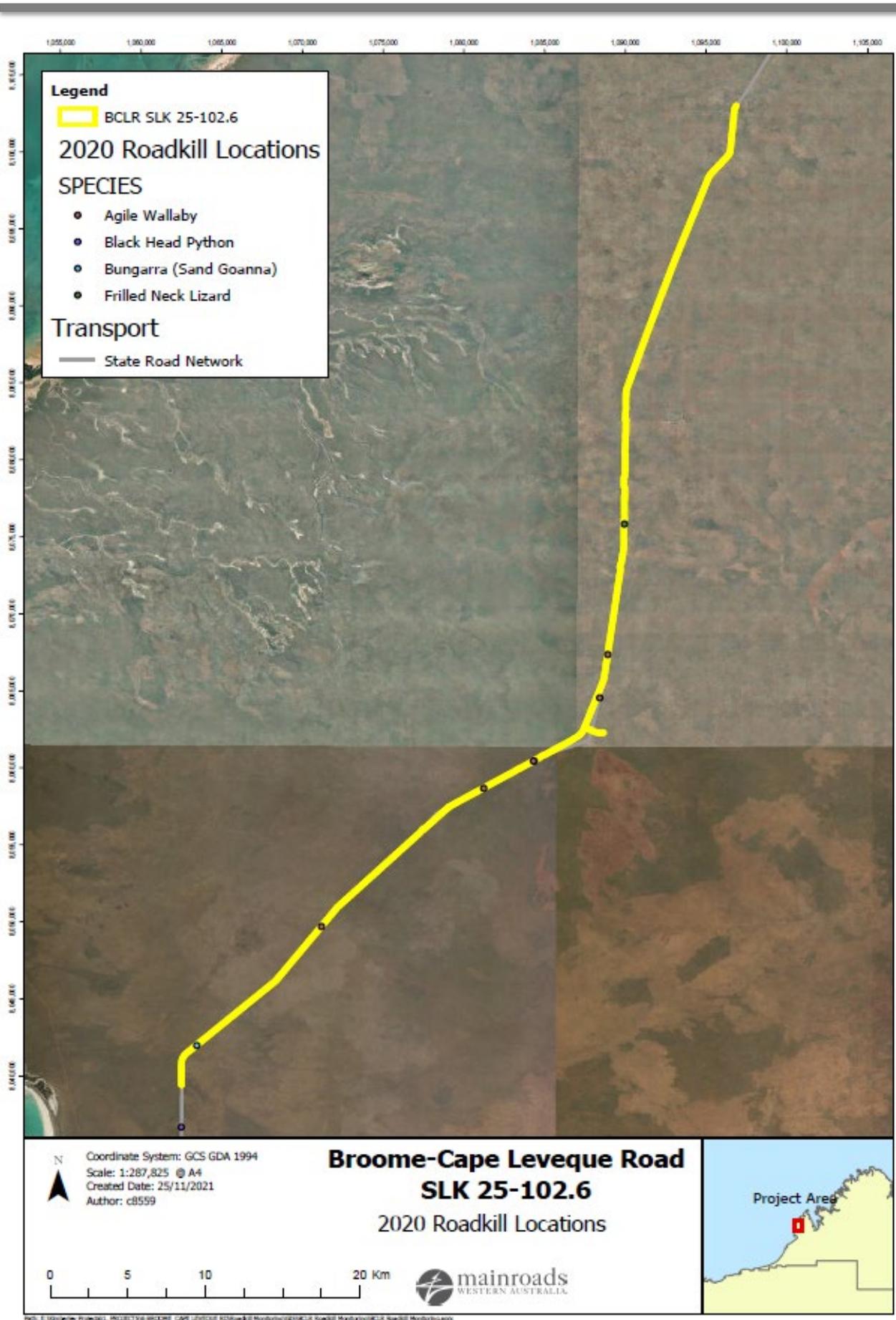


Figure 7: 2020 Roadkill Locations

3.7 2021 – Post Construction

In 2021 between the months of January and November, 30 roadkill individuals were recorded from 22 monitoring days (Table 7). These comprised 15 Agile Wallabies, four Birds of Prey, three Frilled Neck Lizards, two Cows, one Bungarra (Sand Goanna), one Top Notch Pigeon, one Black Head Python, one Bearded Dragon, one Brown Falcon and one Cat. No Greater Bilby individuals were recorded. The road kills appear to be spread along the length of the road (Figure 8). Lunar cycle does not appear to influence level of roadkill.

Table 7: Roadkill Monitoring Results - 2021

YEAR	MONTH	DATE	SLK	SPECIES	CARCASS CONDITION	LONGITUDE	LATITUDE	COMMENTS	WEATHER	LUNAR CYCLE
2021	January	4	93.41	Frilled Neck Lizard	Fresh	122.571926	-17.166823	Post-construction		Waning Gibbous
2021	January	4	92.03	Bird of Prey	Initial Decay	122.56734	-17.17866	Post-construction		Waning Gibbous
2021	January	4	91.98	Agile Wallaby	Putrefaction	122.5673	-17.17887	Post-construction		Waning Gibbous
2021	January	4	47.37	Bird of Prey	Initial Decay	122.41742	-17.51745	Post-construction		Waning Gibbous
2021	January	4	62.4	Agile Wallaby	Black Putrefaction	122.521966	-17.438809	Post-construction		Waning Gibbous
2021	January	4	64.23	Agile Wallaby	Black Putrefaction	122.52574	-17.422717	Post-construction		Waning Gibbous
2021	February	5		NO ROADKILL FOUND						Last Quarter
2021	February	23	79.56	Agile Wallaby	Initial Decay	122.53704	-17.285725			Waxing Gibbous
2021	February	23	99.36	Agile Wallaby	Fresh	122.598519	-17.116119			Waxing Gibbous
2021	March	11	29.31	Frilled Neck Lizard	Fresh	122.298773	-17.63255			Waning Crescent
2021	March	23	86.63	Agile Wallaby	Putrefaction	122.55017	-17.022399			Waxing Gibbous
2021	April	7	92.67	Agile Wallaby	Fresh	122.569615	-17.172969			Waning Crescent
2021	April	22	57.13	Cow	Initial Decay	122.493296	-17.46977			Waxing Gibbous
2021	May	7	25.62	Agile Wallaby	Fresh	122.2801	-17.65796			Waning Crescent
2021	May	21		NO ROADKILL FOUND						Waxing Gibbous

YEAR	MONTH	DATE	SLK	SPECIES	CARCASS CONDITION	LONGITUDE	LATITUDE	COMMENTS	WEATHER	LUNAR CYCLE
2021	June	2		NO ROADKILL FOUND						Last Quarter
2021	June	11	70.15	Agile Wallaby	Putrefaction	122.533524	-17.370079			New Moon
2021	June	22	47.12	Bungarra	Initial Decay	122.416027	-17.51903			Waxing Gibbous
2021	July	8	10.06	Top Notch Pigeon	Initial Decay	122.280994	-17.797799			New Moon
2021	July	19	97.31	Bird of Prey	Black Putrefaction	122.585348	-17.134264			Waxing Gibbous
2021	August	4	10.89	Cow	Fresh	122.2808	-17.79003		Passing clouds	Waning Crescent
2021	August	10	64.95	Agile Wallaby	Fresh	122.526563	-17.41658			Waxing Crescent
2021	August	23	4.59	Agile Wallaby	Fresh	122.27931	-17.84662			Full Moon
2021	September	6		NO ROADKILL FOUND						New Moon
2021	September	22	48.75	Bird of Prey	Initial Decay	122.42588	-17.50799			Full Moon
2021	October	1	27.51	Black Head Python	Initial Decay	122.2861	-17.6433			Waning Crescent
2021	October	29	95.64	Agile Wallaby	Black Putrefaction	122.57965	-17.14821			Last Quarter
2021	November	8	80.72	Agile Wallaby	Initial Decay	122.537812	-17.26721			Waxing Crescent
2021	November	8	86.19	Agile Wallaby	Black Putrefaction	122.54882	-17.22778			Waxing Crescent
2021	November	8	86.2	Agile Wallaby	Black Putrefaction	122.54884	-17.22773			Waxing Crescent
2021	November	8	85.94	Cat	Black Putrefaction	122.54801	-17.22997			Waxing Crescent
2021	November	8	81.3	Bearded Dragon	Fresh	122.537618	-17.270057			Waxing Crescent
2021	November	8	36.38	Brown Falcon	Fresh	122.346684	-17.588929			Waxing Crescent
2021	November	8	26.49	Frilled Neck Lizard	Fresh	122.280337	-17.650166			Waxing Crescent

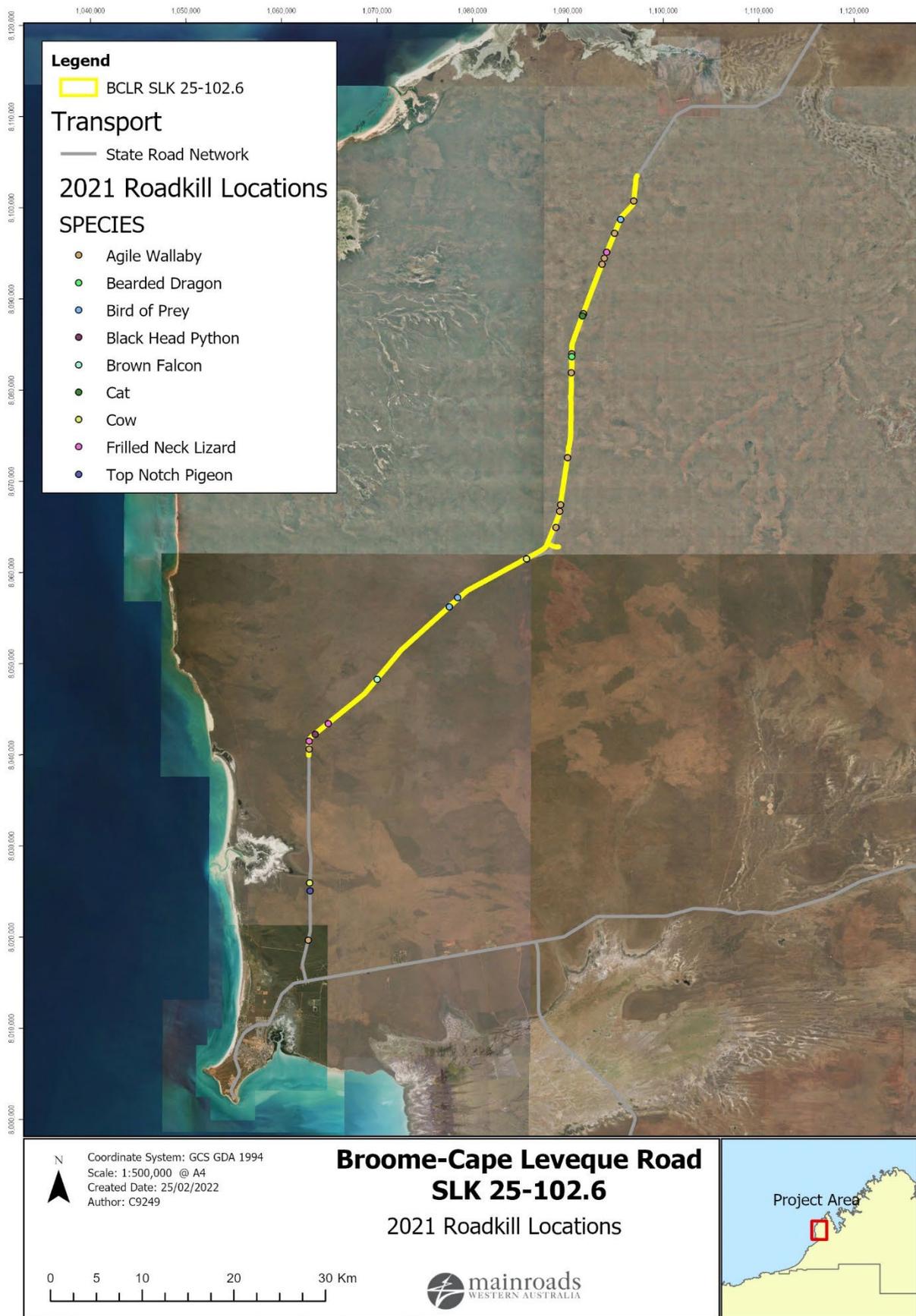


Figure 8: 2021 Roadkill Locations

4 DISCUSSION

In total 167 roadkill individuals from 350 monitoring days have been recorded on BCLR between SLK 25 and 102.6 and between the years of 2015 and 2021 (Table 8, and Figure 10 below):

Table 8. Roadkill individuals and monitoring days

Year	Phase	Individuals	Monitoring Days
2015		31	24
2017		13	7
2018 (P)	Pre construction	47	66
2018 (C)	Construction	18	44
2019		15	64
2020		13	45
2021	Post construction	30	22

Lunar cycle and weather patterns do not appear to impact the level of roadkill recorded on the BCLR.

Monitoring records from 2018 show a minor concentration of roadkill around SLK 83.6 during construction activities, however considering the species behaviour includes flocking and therefore an increased risk of multiple fatalities from one impact event, and the lack of any repetition of records at this location, it is considered that the distribution of roadkill along the entire road length appears random and not subject to any clusters or concentration points.

Pre-construction (2015-2018), the number of roadkill individuals recorded increased with greater monitoring effort, however, during the construction period (2018 – 2020) roadkill rates appeared to be significantly reduced compared to the monitoring effort (Figure 9). This can potentially be attributed to disturbance (noise and vibrations) from construction activities encouraging fauna to avoid the road and reduced signed speeds in construction areas encouraging motorists to drive with more care than usual. Post-construction (2021) when the road was opened fully to motorists, road kill rates appear to begin to return to the pre-construction road kill rates with increased monitoring effort, however, as only one monitoring period has occurred post-construction, continued monitoring will be required to determine if this is indeed the case.

No Greater Bilby roadkill individuals have been recorded on the BCLR during any of the monitoring periods. One Greater Bilby roadkill individual was recorded in 2020, however, as the record was outside the monitoring area, it does not trigger any Greater Bilby management conditions as specified in the RMAMP.

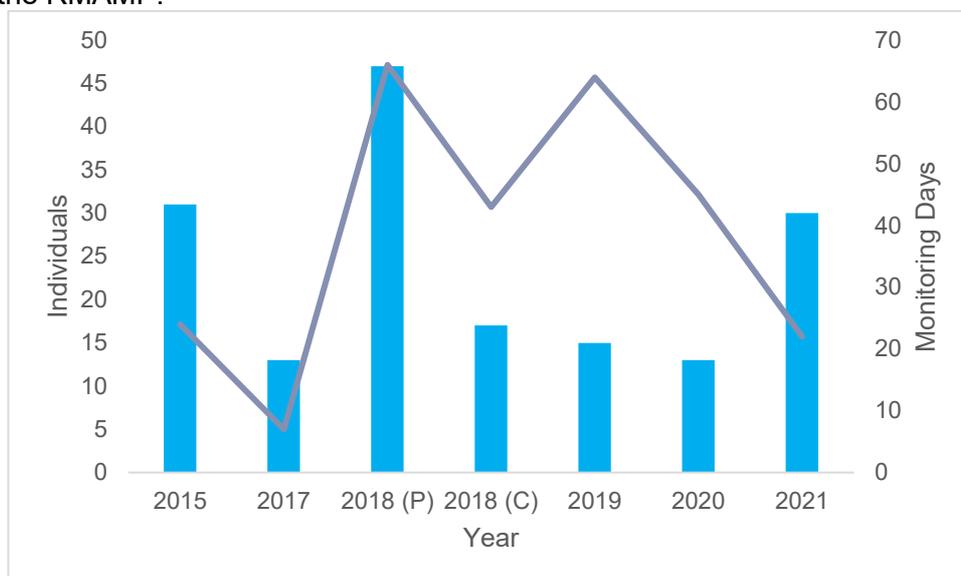


Figure 9: Roadkill Rates and Monitoring Effort

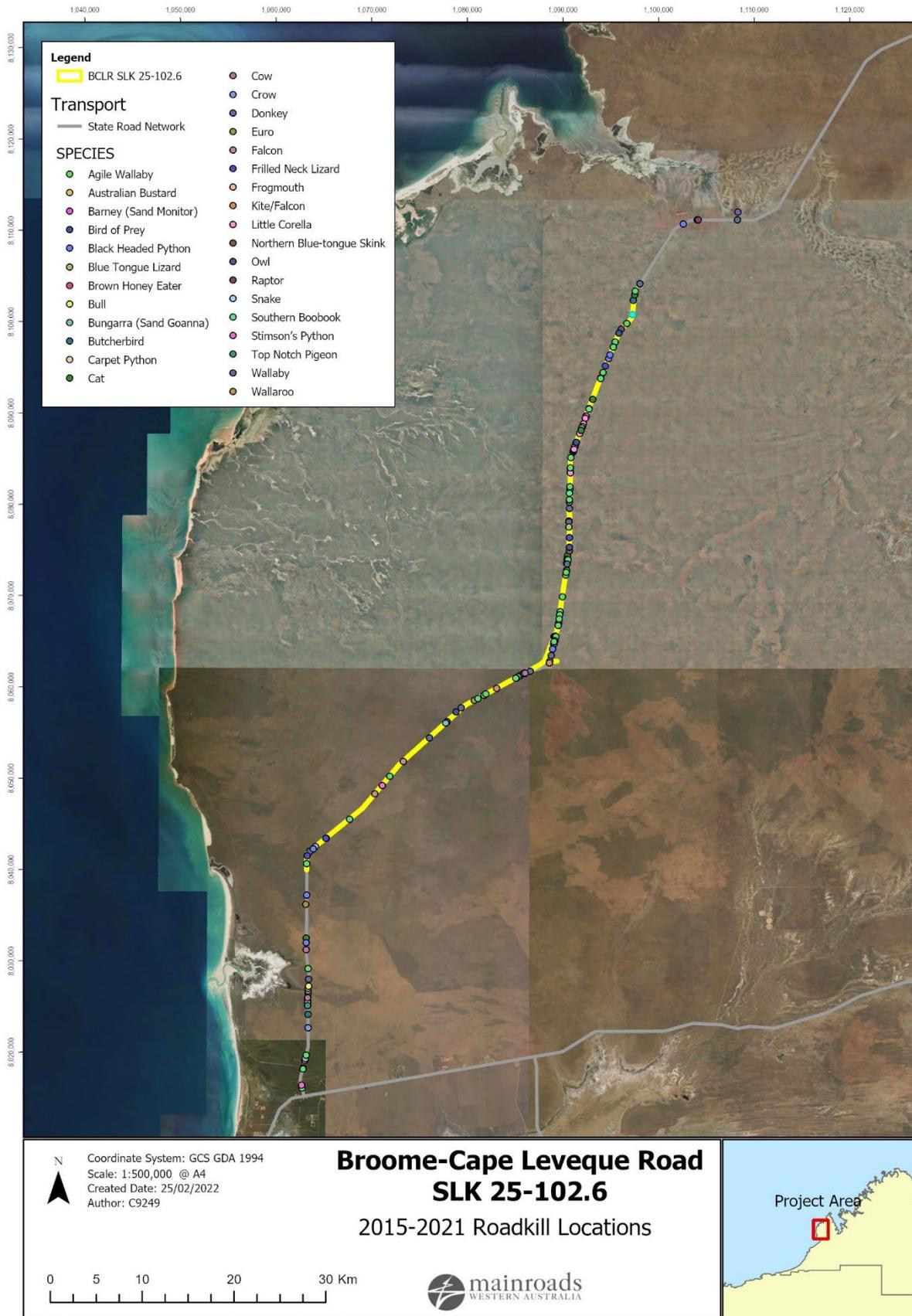


Figure 10: 2015 – 2021 Roadkill Locations

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6 APPENDICES

Appendix A: EPBC 2013/6984 Approval Notice



Australian Government
Department of the Environment

Approval

Cape Leveque Road upgrade (SLK 25-102.6) Shire of Broome, Western Australia (EPBC 2013/6984)

This decision is made under sections 130(1) and 133 of the *Environment Protection and Biodiversity Conservation Act 1999*.

Proposed action

person to whom the approval is granted Main Roads Western Australia

proponent's ABN 50 860 676 021

proposed action To upgrade approximately 77.6 kilometres of Cape Leveque Road (SLK 25 – 102.6) within the Shire of Broome, Western Australia; as described in the referral received by the Department on 3 September 2013 [See EPBC Act referral 2013/6984].

Approval

Controlling Provision	Decision
Listed threatened species and communities (sections 18 & 18A)	Approved
Listed migratory species (sections 20 & 20A)	Approved

conditions of approval

This approval is subject to the conditions specified below.

expiry date of approval

This approval has effect until 31 December 2035.

Decision-maker

name and position Dr Simon Banks
Assistant Secretary
Assessments (NSW/ACT) and Fuel Branch

signature

date of decision 6 July 2015

Conditions attached to the approval

1. Within 10 days after the **commencement of the action**, the person taking the action must advise the **Department** in writing of the actual date of commencement.
2. The person taking the action must maintain accurate records substantiating all activities associated with or relevant to the conditions of **approval**, including measures taken to implement the management plan required by this **approval**, and make them available upon request to the **Department**. Such records may be subject to audit by the **Department** or an independent auditor in accordance with section 458 of the EPBC Act, or used to verify compliance with the conditions of **approval**. Summaries of audits will be posted on the **Department's** website. The results of audits may also be publicised through the general media.
3. Within three months of every 12 month anniversary of the **commencement of the action**, the person taking the action must publish a report on their website addressing compliance with the conditions of this **approval** over the previous 12 months, including implementation of any management plans as specified in the conditions. The compliance reports must remain on their website for a minimum of 12 months (beginning on the date of publication). Non-compliance with any of the conditions of this **approval** must be reported to the **Department** at the same time as the compliance report is published. The person taking the action must continue to annually publish the report on their website addressing compliance with each of the conditions of this **approval** until such time as agreed to in writing by the **Minister**.
4. The person taking the action must notify any non-compliance with this **approval** to the **Department** in writing within two business days of the person taking the action becoming aware of non-compliance.
5. Upon the direction of the **Minister**, the person taking the action must ensure that an independent audit of compliance with the conditions of **approval** is conducted and a report submitted to the **Minister**. The independent auditor must be approved by the **Minister** prior to the commencement of the audit. Audit criteria must be agreed to by the **Minister** and the audit report must address the criteria to the satisfaction of the **Minister**.
6. If the person taking the action wishes to carry out any activity otherwise than in accordance with the management plan as specified in the conditions, the person taking the action must submit to the **Department** for the **Minister's** written approval a revised version of that management plan. The varied activity shall not commence until the **Minister** has approved the varied management plan in writing. The **Minister** will not approve a varied management plan unless the revised management plan would result in an equivalent or improved environmental outcome over time. If the **Minister** approves the revised management plan, that management plan must be implemented in place of the management plan originally approved.
7. If the **Minister** believes that it is necessary or convenient for the better protection of listed threatened species and communities to do so, the **Minister** may request that the person taking the action make specified revisions to the management plan specified in the conditions and submit the revised management plan for the **Minister's** written approval. The person taking the action must comply with any such request. The revised approved management plan must be implemented. Unless the **Minister** has approved the revised management plan, then the person taking the action must continue to implement the management plan originally approved, as specified in the conditions.

8. If, at any time after five years from the date of this **approval**, the person taking the action has not **substantially commenced** the action, then the person taking the action must not **substantially commence** the action without the written agreement of the **Minister**.
9. Unless otherwise agreed to in writing by the **Minister**, the person taking the action must publish the management plan referred to in these conditions of **approval** on their website. The management plan must be published on the website within one month of being approved. The person taking the action must notify the **Department** within five business days of publishing the management plan on their website, and the management plan must remain on their website for the period this **approval** has effect.

Greater Bilby (*Macrotis lagotis*)

10. To ensure there is no decline in the **local Greater Bilby population** as a result of **roadkill** on the sealed **Cape Leveque Road**, the person taking the action must submit a Roadkill Monitoring and Adaptive Management Plan (RMAMP) for the **Minister's** approval. The RMAMP must provide sufficient detail (timing, effort and methodology) to detect the level of impact of **roadkill** on the **local Greater Bilby population** during the **construction phase** and **operational phase**. **Commencement of the action** must not occur unless the **Minister** has approved the RMAMP. The approved RMAMP must be implemented. The RMAMP must:
 - a. be developed and endorsed by a **suitably qualified ecologist** and a **linear infrastructure ecologist**
 - b. include survey methodology and effort to be implemented that are sufficient to determine the baseline **local Greater Bilby population** and the location of **high density Greater Bilby areas**
 - c. include sufficient monitoring methodology and effort to determine baseline Greater Bilby **roadkill** rates on the unsealed **Cape Leveque Road** prior to **commencement of the action**
 - d. include sufficient monitoring methodology to determine Greater Bilby **roadkill** rates on the sealed **Cape Leveque Road** during the **construction phase** and **operational phase**
 - e. include appropriate Greater Bilby **roadkill** trigger values and adaptive management measures to be implemented should Greater Bilby **roadkill** trigger values be reached during the **construction phase** and **operational phase**
 - f. include the requirement for ongoing monitoring and adaptive management measures until such time as it can be demonstrated that there is no decline in the **local Greater Bilby population** as a result of **roadkill** for three successive years
 - g. include the requirement to provide information to the annual compliance report required by the conditions attached to this **approval** reporting on survey findings, ongoing monitoring and effectiveness of adaptive management, until such time as it can be demonstrated that there is no decline in the **local Greater Bilby population** as a result of **roadkill** for three successive years.

11. To minimise impacts to the Greater Bilby during the **construction phase**, the person taking the action must develop a Greater Bilby Induction Training and Awareness Program (GBITAP). The GBITAP must:
 - a. be delivered to all **employees and contractors** prior to the **commencement of the action** and to any new **employees and contractors** arriving during the **construction phase**
 - b. provide education on the appearance, characteristics and behaviour of the Greater Bilby sufficient to allow **employees and contractors** to accurately identify the species
 - c. include maps of **high density Greater Bilby areas**
 - d. institute a signposted speed limit of no greater than 60km/hr, along with educational signage to increase awareness of Greater Bilby presence, at **high density Greater Bilby areas** and 200m either side of **high density Greater Bilby areas** to be observed by all **employees and contractors**
 - e. include instructions on threats to the Greater Bilby and how to avoid or reduce impacts to the Greater Bilby through measures including, but not limited to, road awareness and waste management.

12. To minimise impacts to the Greater Bilby as a result of onsite works during the **construction phase**, the person taking the action must ensure that a **suitably qualified ecologist** implements the *Cape Leveque Road Greater Bilby Relocation Protocol, October 2014* in conducting pre-clearance surveys and relocation of Greater Bilby individuals, if present. All Greater Bilby deaths must be recorded.

13. To minimise impacts to the Greater Bilby of the sealed **Cape Leveque Road** during the **operational phase**, the person taking the action must ensure that the **Cape Leveque Road** upgrade is designed, constructed and maintained in a manner that minimises the potential for Greater Bilby **roadkill** from public use of the sealed road through avoidance, deterrence and increased visibility, including in particular:
 - a. installation of signage educating the public of Greater Bilby presence at **high density Greater Bilby areas** and 200m either side of **high density Greater Bilby areas**.
 - b. the use of **coloured pavement** at **high density Greater Bilby areas** and 200m either side of **high density Greater Bilby areas**
 - c. the use of audible rumble strips at **high density Greater Bilby areas** and 50m either side of **high density Greater Bilby areas**.

14. In order to minimise the potential of the proposed action to facilitate the increased spread of feral cats, foxes and weeds, the person taking the action must:
 - a. **fence** all **standing pools** of water resulting from the action
 - b. remove or **fence** all **rubbish** generated as a result of the action at the end of each working day
 - c. manage and control weeds in accordance with the *Cape Leveque Road Upgrade Revegetation Management Plan, October 2014*.

Offsets

15. To offset the residual significant impact to the Greater Bilby, the person taking the action must ensure that the **offsets program** is undertaken by a **suitably qualified ecologist**, including:
- a. a baseline survey to determine the area of occupancy of the Greater Bilby and its threats on the Dampier Peninsula must be developed and undertaken in conjunction with **DPaW** and Traditional Owner Rangers. The survey must use established techniques and record signs of Greater Bilby, signs of introduced predators, habitat characteristics, fire history and grazing pressure. This baseline survey must be undertaken on SLK 90-102.6 prior to **commencement of the action**. The baseline survey must be undertaken on SLK 25-90 prior **construction** occurring in SLK 25-90.
 - b. an annual and ongoing survey must be developed and implemented in conjunction with **DPaW** and Traditional Owner Rangers. This survey must commence within six months of completion of the baseline survey and continue for at least two years, and monitor:
 - i. at least four locations of the Greater Bilby population using DNA fingerprinting techniques
 - ii. the population of introduced predators through the use of camera traps
 - iii. grazing pressure, food resources and fire history.
 - c. a threat management program must be submitted to the **Minister** for approval prior to implementation. The threat management program must be developed and implemented in conjunction with **DPaW** and Traditional Owner Rangers and must address either introduced predators, fire regimes or grazing pressure or a combination of these threats at high priority sites for the Greater Bilby. The threat management program must include an adaptive management component. Threat management must commence within one year of **commencement of the action** and continue for at least one year. At least \$120,000 is to be spent on direct threat abatement action per year of the threat management program
 - d. at a minimum, \$600,000 is to be provided to **DPaW** to enable development and implementation of the **offsets program**. Evidence of expenditure must be provided to the **Minister** within three months of the final payment
 - e. provision of information to the annual compliance report required by the conditions attached to this **approval** reporting on the survey findings, ongoing monitoring and effectiveness of adaptive management measures to address threats to the Greater Bilby, for the duration that the **offsets program** is implemented.

Definitions:

- a) **Approval:** The approval to take the approved action under section 133 of the EPBC Act.
- b) **Cape Leveque Road:** The approximately 77.6km length of Cape Leveque Road between SLK 25 and 102.6, illustrated in Attachment F of the referral, and any amendments.
- c) **Coloured pavement:** Pavement of a shade that improves the visibility of the Greater Bilby by increasing the colour contrast between the species and the road surface.
- d) **Commencement of the action:** The clearing of any vegetation or construction of any infrastructure, excluding fences and signage, associated with the proposed action.
- e) **Construction:** Includes any preparatory works required to be undertaken including clearing vegetation, the erection of any onsite temporary structures and the use of heavy duty equipment for the purpose of breaking the ground or laying sealed road.
- f) **Construction phase:** The time period from initial clearing of vegetation, breaking of ground or erection of onsite structures (whichever occurs first) until such time as the **Cape Leveque Road** upgrade is completed, all temporary onsite structures are removed and the road is open to the public and fully operational. The **construction phase** does not include regular road maintenance works.
- g) **Department:** The Australian Government Department administering the *Environment Protection and Biodiversity Conservation Act 1999*.
- h) **DPaW:** Western Australian Department of Parks and Wildlife and successor agencies.
- i) **Employees and contractors:** Refers to any Main Roads Western Australia employees or employees contracted by Main Roads Western Australia working onsite.
- j) **Fence:** Provision of a barrier sufficient to prevent access by feral cats and foxes.
- k) **High density Greater Bilby area:** Any 6ha area that includes or is immediately adjacent to the **proposed disturbance route**, containing three or more signs of Greater Bilby. Signs of Greater Bilby may include sightings (in person or via camera), active burrows, inactive burrows, diggings, scratching or scats.
- l) **Linear infrastructure ecologist:** Refers to an independent person, approved by the **Minister**, with relevant tertiary qualifications and a minimum of five years experience in the ecological impacts and management of linear infrastructure.
- m) **Local Greater Bilby Population:** The population size and distribution of Greater Bilby that is determined by a **suitably qualified ecologist** as likely to be impacted by the proposed action as derived from surveys conducted prior to referral and the baseline population surveys required by this **approval**.
- n) **Minister:** The Minister administering the *Environment Protection and Biodiversity Conservation Act 1999* and includes a delegate of the Minister.
- o) **Offsets program:** The program outlined in *Bilby (Macrotis lagotis) Offset Priorities for Dampier Peninsula Populations, West Kimberley, October 2014*, published as part of Preliminary Documentation on Main Roads Western Australia's website.
- p) **Operational phase:** The time period beginning at the completion of the **construction phase** and continuing for the life of the **approval**.

- q) **Proposed disturbance route:** The proposed new road route (including borrow pits) as illustrated in Attachment F of the referral, and any amendments.
- r) **Roadkill:** Vehicle(s) and/or equipment and/or machinery striking, colliding or crushing Greater Bilby in a manner that results in mortality to the Greater Bilby.
- s) **Rubbish:** Consumable or any other waste that may be attractive to feral cats and foxes.
- t) **Standing pool:** Pool of water greater than or equal to 2m² that has the potential to persist for greater than or equal to one week created by human activity.
- u) **Substantially commence:** As per **commencement of the action**.
- v) **Suitably qualified ecologist:** Refers to an independent person, approved by the **Minister**, with relevant tertiary qualifications and a minimum of five years experience in Australian mammal fauna surveys in the region.



Biodiversity and
Conservation Science



Dampier Peninsula greater bilby (*Macrotis lagotis*) Main Roads offset project: Annual Progress Report 2021 – 2022

Harry Moore, Bruce Greatwich, Martin Dziminski, Ruth McPhail,
Fiona Carpenter and Lesley Gibson

In partnership with:



Annual Progress Report 2021 - 2022

June 2022

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April 2020

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This document is available in alternative formats on request.

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Summary

Over the last two centuries, the geographic range of the greater bilby (*Macrotis lagotis*) has contracted substantially, and the species is now restricted to a northern subset of its former distribution, part of which includes the Dampier Peninsula in the Kimberley region of Western Australia. In 2016, Main Roads WA provided funding for a three-year project to offset impacts to bilbies on the Dampier Peninsula as a result of the Cape Leveque Road upgrade (EPBC 2013/6984, CPS 6078/4). This project, coordinated by the Department of Biodiversity, Conservation and Attractions (DBCA), in partnership with traditional owner groups, aims to survey, monitor, and manage bilbies on the Dampier Peninsula, to improve our understanding of their occurrence, as well as what is required to ensure their persistence into the future.

An occupancy analysis of plot survey data collected from 70 sites across the Dampier Peninsula indicated bilby occupancy is relatively low and persisting bilby populations are isolated in small pockets in the south and central north of Dampier Peninsula. While factors related to vegetation type, substrate, and fire age did not explain patterns of bilby occurrence, bilby occurrence was significantly higher in the absence of feral cats.

Estimates of bilby abundance as derived from scat genotyping indicated both the Coconut Wells and Pio's Paddock populations are comprised of relatively few individuals, similar to other bilby populations in Western Australia where feral predator management does not occur. While little change in abundance has been observed in the Coconut Well's population over three years of sampling, a marked increase in abundance was observed in the Pio's Paddock population. Further monitoring is required in order to confirm this trend.

Analysis using data collected from camera trap surveys across 2020 – 2021 indicated feral cat occupancy was high across both Pio's Paddock and Coconut Wells bilby populations, while dingo occupancy was comparatively low, suggesting that feral cat management should be considered as part of ongoing bilby management on the Dampier Peninsula.

Implementation of prescribed burns at the impact bilby population monitoring site on Yawuru country (Pio's Paddock) was focussed along the northern boundary in 2021 and compliments fire management undertaken in 2020. These burns are likely to provide an important buffer for the Pio's Paddock bilby population against late dry season fire over the next several years. As part of late dry season emergency wildfire response in 2021, strategic advice was communicated through to Department of Fire and Emergency Services and the Pio's Paddock bilby population was successfully protected from wildfire impacts. DBCA staff also provided operational support for this wildfire suppression effort.

1 Introduction

Since European colonisation of Australia, the range and abundance of greater bilbies has contracted substantially (Southgate 1990; Bradley *et al.* 2015). The decline in bilbies has been attributed to a number of threats, which include predation by introduced cats and foxes (Paltridge 2002a; Bradley *et al.* 2015), changed and inappropriate fire regimes (Southgate and Carthew 2006; Southgate and Carthew 2007; Southgate *et al.* 2007; Bradley *et al.* 2015), and the degradation of bilby habitat through pastoralism, introduced herbivores, and clearing (Southgate 1990; Pavey 2006; Bradley *et al.* 2015; Department of Environment 2016).

The current distribution of the bilby is restricted to the Tanami Desert, Northern Territory (Johnson and Southgate 1990), the Great Sandy and Gibson Deserts, parts of the Pilbara and Kimberley in Western Australia (Friend 1990), and an outlying population between Boulia and Birdsville in south-west Queensland (Gordon *et al.* 1990). The Dampier Peninsula in the far northwest Kimberley comprises important bilby populations, due to widespread suitable sandy substrate and assumed lower past and present threat levels. The majority of the Peninsula is determined Native Title Claim and the bilby populations therein occur on lands owned or managed by Traditional Owner groups. Two Indigenous Protected Areas have been declared across part of Bardi Jawi, and Yawuru country. Several large pastoral stations operate in these areas, including Country Downs, Kilty, Roebuck Plains and Yeeda. Parts of the western and northern coastal edges of the Peninsula are popular with tourism and recreation.

As part of the Cape Leveque Road upgrade project (EPBC 2013/6984, CPS 6078/4), in 2016 Main Roads WA provided funding to offset impacts on local bilby populations, to undertake a three-year project coordinated by the Department of Biodiversity, Conservation and Attractions (DBCA). Key project activities are to survey, monitor and commence adaptive management of bilby populations to mitigate threats across the Peninsula.

The project aims to improve our understanding of the distribution, habitat preferences and threats to bilbies on the Peninsula, and to enable appropriate management to ensure the persistence of local populations. The purpose of the project is to monitor the occupancy and abundance of bilbies as well as key threatening processes on the Dampier Peninsula, while initiating on-ground actions to reduce the impacts from key threatening processes.

Primary components of this project are:

1. Defining the area of occupancy – through an array of 70 x 2 ha sign plots, surveyed four times and testing supplementary Remotely Piloted Aircraft (RPA) surveys across the Peninsula.
2. Population monitoring – of core populations monitored annually, involving genotyping individuals from scats collected along transects to measure abundance, occupancy from sign plots, predator occupancy from remote cameras, data on food resources, stock grazing pressure, introduced predators and fire regimes.
3. Management of threats – implementing management activities primarily in relation to fire.

The project partners with the following Traditional Owners and Ranger Groups; Nyul Nyul, Bardi Jawi, Nyikina Mangala and Yawuru Country Managers on a fee-for-service basis. The project builds on other DBCA coordinated bilby projects in the region and collaborates with WWF, Environs Kimberley and Rangelands NRM to contribute to the broader Kimberley Bilby program.

2 Defining the area of occupancy

2.1 Background

Managing threats to the Dampier Peninsula bilby population effectively requires the area within which they occur to first be defined. However, the scale and complexity of the Dampier Peninsula region, combined with the nomadic ecology of the species, is such that delineating the boundaries of this area requires a concerted search effort. In 2019, Nyul Nyul, Bardi Jawi, Nyikina Mangala Rangers and Yawuru Country Managers met this challenge by completing a total of 270 x 2 ha sign plot surveys across the Dampier Peninsula region, the details of which are discussed in previous annual reports (Dziminski *et al.* 2020).

Preliminary analysis revealed that as well as always being found in areas where the substrate of sand, soil, sandy clay, or sandy gravel is suitable for burrowing, there is an association with particular *Acacia* spp and *Senna* spp that bilbies use for food resources. At sites where bilbies are found, these *Acacia* spp typically form monospecific stands that provide resources in the form of cossid moth larvae (grubs) which is a major food resource for bilbies on the Peninsula. Bilbies have also been observed digging for termites in the late dry season.

Here, we run single and multi-species occupancy models to further investigate the influence of environmental factors as well as predator presence on bilby occupancy on the Dampier Peninsula.

2.2 Methods

2.2.1 Plot surveys

Bilby occupancy on the Dampier Peninsula was sampled across 70 x 2-ha sign plots. Collaborative planning sessions for sign plot locations was completed with Nyul Nyul, Bardi Jawi, Nyikina Mangala Rangers and Yawuru Country Managers. Sites were stratified according to fire frequency and sampled for the majority of plots four times each (with a small number of plots three times). At the time of field surveys, areas of Dampier Peninsula remained as undetermined Native Title Claim areas and it was inappropriate to conduct surveys in these areas. As a result, representative spatial coverage of plot surveys of Dampier Peninsula was unable to be obtained.

In addition to bilbies, 22 other animal taxa were detected on the plots, including feral predators and feral herbivores. Across the 270 x 2ha sign plots, cat sign was recorded at 70 plots, dingo at 54 plots, cattle at 184 plots and donkeys at 44 plots.

2.2.2 Occupancy analysis

Occupancy in the ecological sense, is commonly defined as the proportion of an area occupied by a given species. To measure bilby occupancy on the Dampier Peninsula, we used single-season occupancy models that account for imperfect detection (MacKenzie *et al.* 2002).

Data was first structured into the four occasions over which 2019 sampling took place. Next, detection histories for each site were assembled by denoting whether bilbies were detected or not detected over each of the four sampling occasions. Occupancy models were then formulated in terms of parameters ψ , (occupancy) and p (detectability), where ψ is the probability that site i is occupied by the species, and p is the probability of the species being detected at site i on night j , conditional upon its presence. The models assume detection of the species at sites is independent of species detections at other sites, that there are no false detections, and that occupancy remains constant over the sampling period.

Bilby presence has previously been shown to be influenced by factors including vegetation and fire history, as well as the presence of predators, and feral herbivores. As such, each of these were included as predictors for bilby occupancy. In addition, we included substrate (e.g., sand, clay) as a predictor for bilby detectability (i.e., the likelihood of bilbies being detected on a given plot survey, assuming they are present).

Occupancy models were fit using the unmarked package (Fiske and Chandler 2011) in R version 3.6.2 (R Core Team 2019). Model selection was conducted by first running a global model including all predictors, and then using the *dredge* function in statistical package *MuMIn* to determine which subset of predictors produce a model with the most parsimonious fit — model with lowest AIC value. This model was then used to estimate bilby occupancy and detectability across the Dampier Peninsula study area.

2.2.3 Survey effort

To measure the level of confidence that can be applied to survey effort used to determine bilby presence, cumulative nightly detectability curves were generated from detectability estimates using the following equation:

$$P = 1 - (1 - p_1) \times (1 - p_2) \times (1 - p_3) \dots (1 - p_n)$$

where P is the cumulative nightly detection probability, n is number of nights and p is the nightly detection probability. The minimum number of nights per site was then calculated, necessary to be 95% confident that the site is unoccupied:

$$N_{min} = \log(\alpha) / \log(1 - p)$$

where $\alpha = 0.05$ and confidence is equal to $1 - p$ (Kery 2002).

2.3 Occupancy Results

Bilbies were detected across 8.5% of all plot surveys (23/269) and 18.5% of all sites surveyed (13/70) (Figure 1). Feral cats were detected at 61.4% of sites, dingoes were detected at 54.2% of sites, and cattle were detected at 91.4% of sites.

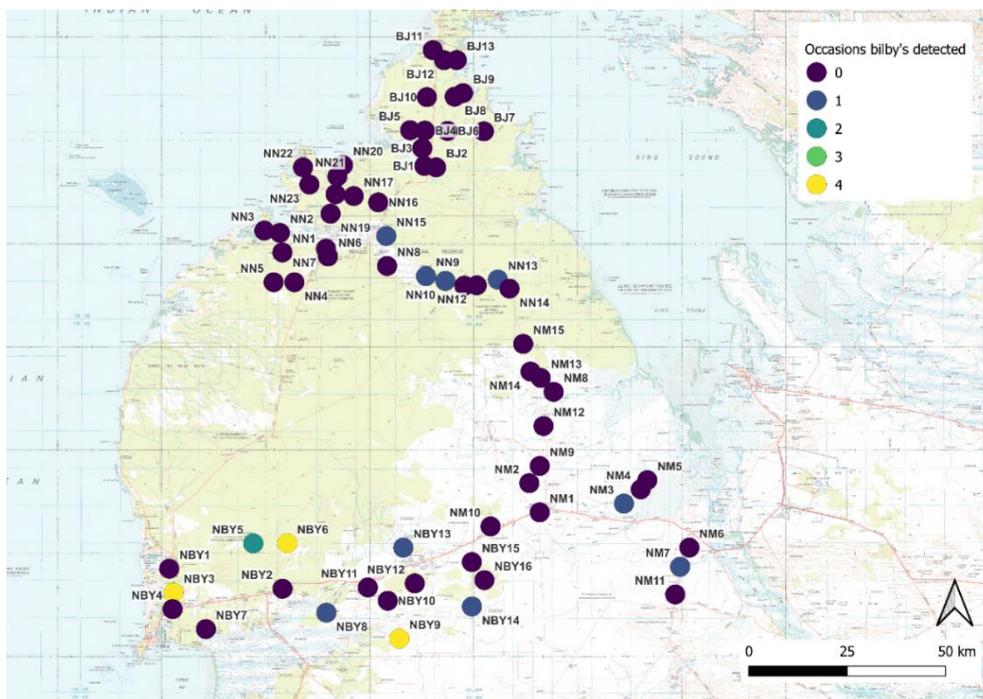


Figure 1 – Locations of 2ha plot surveys used to detect bilby presence across the Dampier peninsula. Point colours correspond to number of surveys where bilbies were detected.

2.3.1 Single species occupancy model

The most parsimonious occupancy model was the ‘null’ model – the model which included no predictor variables within either detectability or occupancy components of the model (Table 1, 2). This suggests the variable ‘substrate’ explained little variation in bilby detectability, and the variables ‘time since burnt’ and ‘vegetation structure’ explained little variation in bilby occupancy. Predicted occupancy derived from the null model was 0.24 (0.13-0.39), and detectability was 0.35 (0.20-0.53).

Table 1 – Models used to predict bilby occupancy and detectability on the Dampier Peninsula.

ρ (Int)	ψ (Int)	ρ - Substrate	ψ - Time since burnt	ψ - Vegetation structure	df	AICc	delta
-0.62	-1.17				2.00	132.41	0.00
-0.62	-1.09	+			3.00	132.82	0.40
-0.62	-7.76		+		4.00	136.41	4.00
-0.62	-6.19			+	4.00	136.48	4.07
-0.62	-6.73	+	+		5.00	136.93	4.52
-0.62	-8.43	+		+	5.00	136.98	4.57
-0.62	-13.85		+	+	6.00	140.75	8.34
-0.62	-10.96	+	+	+	7.00	141.37	8.95

Table 2 – The top model used predict bilby occupancy and detectability in the Pilbara.

Component	Predicted	SE	lcl	ucl
ψ	0.24	0.07	0.13	0.39
ρ	0.35	0.09	0.20	0.53

2.3.2 Multi-species occupancy model

Multi-species occupancy models indicated the likelihood of bilby occurrence is significantly higher at sites where feral cats are absent as opposed to sites where feral cats are present (Figure 2). Conversely, bilby occurrence was not significantly influenced by the presence of cattle or dingoes.

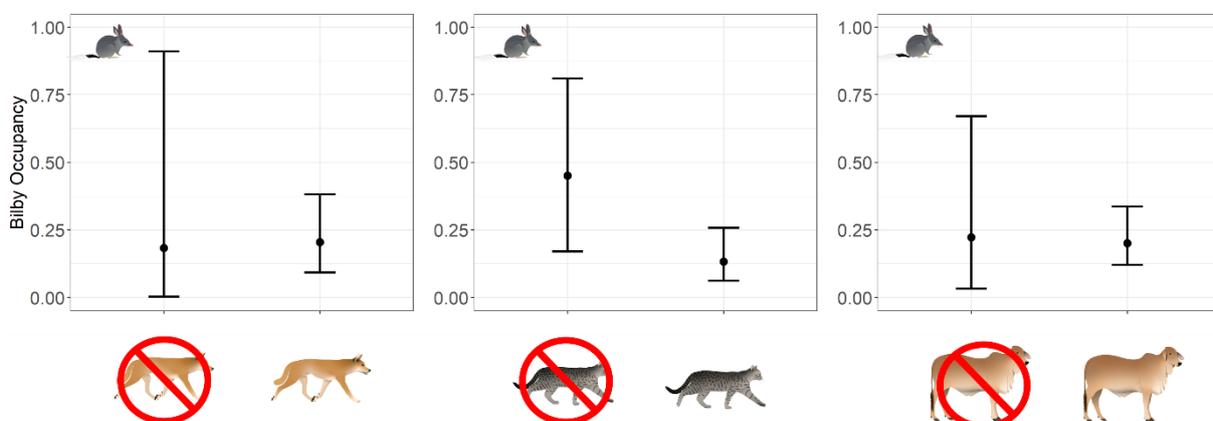


Figure 2 – Predicted occupancy on bilbies in presence and absence of dingoes, feral cats, and cattle.

2.3.3 Detection curve

Based on detectability as measured in Table 2, if bilbies are not detected at a site after four consecutive plot surveys (current survey protocol), one can be 82.2 % certain bilbies are absent from the site (Figure 3). This suggests a high level of confidence can be applied to plot survey results collected as part of 2019 sampling.

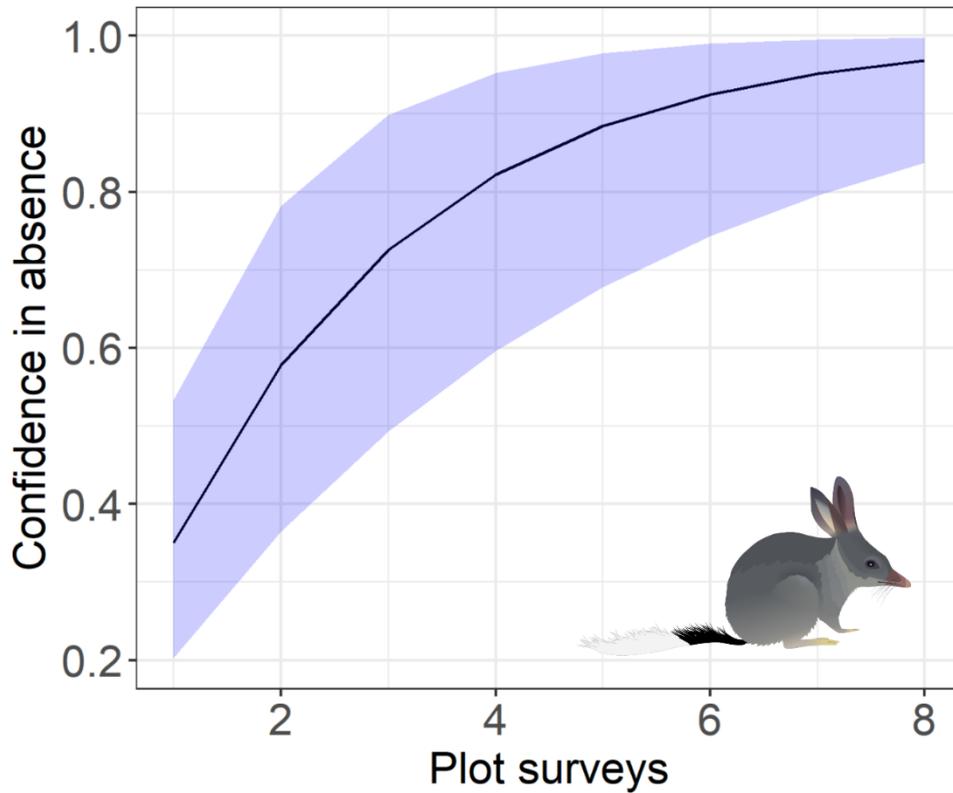


Figure 3 – Cumulative detectability curve for bilbies using 2 ha plot surveys on the Dampier Peninsula.

2.4 Discussion

Results suggest bilby occupancy across the Dampier Peninsula is low, and that active bilby populations are isolated to small pockets in the south and central north. Estimates of occupancy are comparable to those recorded in the nearby La Grange area ($\psi = 0.22$) (Dziminski *et al.* 2018), but lower than those recorded on Matuwa ($\psi = 0.32$) where regular feral cat baiting occurs (Lohr *et al.* 2021). Bilby occurrence did not appear to be explained by factors traditionally associated with bilby presence, such as substrate, vegetation type or fire age (Southgate *et al.* 2007; Pavey 2016; Lohr *et al.* 2021). This could potentially be explained by a number of factors, one of which is that in addition to the coarse scale environmental features, such as those included in our analysis, bilbies are also responding to fine scale features (e.g. specific combinations of food plants; Southgate *et al.* 2019) as well as landscape scale features (e.g. proximity to additional habitat patches, creek lines etc.), that could not be included in this analysis. It's also likely additional fire history attributes (fire frequency, burn patch size ect.) not included in this analysis could be influential. It is suggested future analysis investigate this possibility.

An alternative explanation for why occupancy models did not detect a significant influence of vegetation or fire-age on bilby occupancy is that the occurrence of bilbies is instead being primarily driven by the presence of predators — more specifically feral cats, a major threat to bilbies (Pavey 2016). Results from multi-species occupancy models provided some evidence in support of this theory, indicating the bilbies were almost three and a half times less likely to occur at sites where feral cats were detected as opposed to sites where feral cats were absent. These results align with the findings of previous studies, which indicate bilbies are frequently consumed by feral cats (Paltridge 2002b), and have been observed to decline in the presence of high feral cat densities (Southgate and Bellchambers 1994). From a management perspective, these findings suggest the addition of feral cat control to existing land management activities (fire management etc.) is likely to increase the persistence of bilbies on the Dampier Peninsula.

Results from the best occupancy model indicated that after four plot surveys we can be over 80% confident of bilby absence, if bilby activity has not yet been detected. This result provides further support for the use of 2ha plot surveys in verifying bilby presence (Southgate *et al.* 2019), and we recommend plot surveys remain the primary method by which bilby surveys are conducted.

3 Population monitoring

3.1 Background

Abundance monitoring to date has been undertaken at two populations: Coconut Wells in 2019, 2020 and 2021, and Pio's Paddock in 2020 and 2021, both on Yawuru. The monitoring was undertaken in partnership with the Yawuru Rangers. Abundance monitoring was undertaken following the procedures described in Dziminski *et al.* (2021). This report includes estimates of 2021 bilby abundance derived from bilby scat genotyping only. Estimates derived from spatially explicit capture-recapture (SECR) models remain pending.

3.2 Methods

3.2.1 *Sample collection*

Transects were positioned to sample population extents, ensuring access to start or end points from roads or tracks where available. Transects were traversed on foot to collect bilby scats. Each transect was sampled once. Individual bilbies deposit single or a small number of fecal pellets (usually 2–5) in a discrete group usually on top of, or within, the sand-spoil of food diggings. Bilby scats are difficult to age just by visual inspection.

Clearly decomposed or broken up scats were not collected. Most scats were found on top of, or within, the sand-spoil of a digging. Thus, the age of these scats was able to be assessed by examining the state of decomposition of the associated digging. If the digging was very eroded and weathered, indicating it was created probably >2 weeks prior, then the associated scats were not collected because the scats were less likely to yield DNA (Carpenter and Dziminski 2017). Collected scats were placed in labeled 30-ml plastic tubes, with approximately 33% filled with silica gel beads and a cotton wool ball, until DNA extraction. The silica gel ensured pellets remained dry because moisture degrades DNA. The cotton ball reduced rubbing of beads against pellets, which may remove bilby epithelial cells from the surface of the pellet, reducing available cells for DNA extraction.

Pellets in a group in contact with or very close to each other were considered to be from one individual and were stored in one vial. Pellets were scooped from the ground into the vial using the lid or a small stick, used only for the one sample to avoid cross-contamination. Vials with samples were transported in a cooler bag, kept out of the sun, and stored at room temperature until DNA extraction.

3.2.2 DNA extraction, PCR amplification and genotyping

The QIAGEN QIAamp DNA Stool Minikit (QIAGEN, Hilden, Germany) was used as per the manufacturer's protocol, with amendments as described by Carpenter and Dziminski (2017) with a single elution using 100 µL of buffer ATE. DNA samples were stored at -20°C until amplified using polymerase chain reaction (PCR).

PCR amplification was undertaken using eight bilby-specific polymorphic microsatellite markers (Moritz et al. 1997, Smith et al. 2009) amplified across two multiplexes with fluorescent labelled markers from the G5 filter set: multiplex 1 (B02 [6FAM], B17 [VIC], B56 [PET], and B66 [NED]) and multiplex 2 (B55 [6FAM], B22 [VIC], B41 [PET], and B63 [NED]; Moritz et al. 1997, Smith et al. 2009). PCRs were run as described in Carpenter and Dziminski (2017) with 2–4 µL of DNA used in a 12.5-µL reaction for each replicate. A minimum of two PCRs were performed for each scat sample. After comparison, where these samples provided a consensus result, further PCRs were not completed. For samples where alleles were not clear or were inconsistent, a third PCR was run to confirm the genotype of the individual. Where genotyping across all loci was not achieved from the initial PCRs, no further PCRs were undertaken for that sample, and the sample was eliminated from the dataset.

Plates containing PCR products were stored at -20°C until fragment analysis. PCR products were analysed on an ABI3730XL Sequencer and fragments sized using the Genescan LIZ 500 size standard (Applied Biosystems, Waltham, MA, USA). Alleles were scored using GeneMapper version 5 (Applied Biosystems). Results were reviewed manually to ensure consistent scoring of alleles and to confirm any genotyping errors such as the presence of false alleles (Bonin *et al.* 2004; Broquet and Petit 2004; Waits and Paetkau 2005) and allelic dropouts (Broquet and Petit 2004). An allele was considered to be a true allele when it was replicated at least twice across three PCRs. Allele matching was completed using the R package AlleleMatch (Galpern *et al.* 2012). Unclassified samples were examined and samples that matched multiple unique genotypes manually were excluded if they could not be matched or classified as new unique genotypes. Any remaining mismatched alleles were flagged and examined to determine genotyping errors. Genotypes identified along transects only provide information on the number of individuals detected specifically on transects, which requires further analysis to calculate the number of individuals within the extent of the population.

3.3 Results

A total of 51 bilby scat samples were collected along 21.71km of transects across the two surveyed populations (Table 3). Transects used to search for bilby scats are indicated in figures 4 and 5.

A total of 3 individual bilbies were identified from scats collected at the Coconut Wells population (Figure 5). Two of these individuals were identified as male, and one as female. Both male individuals were recorded as part of the 2020 abundance survey, but were not recorded as part of the 2019 abundance survey. The female individual has not been recorded as part of any previous surveys.

A total of 7 individual bilbies were identified from scats collected at the Pio's Paddock population, 2 of which were identified as males, and 5 of which were identified as females. One female was recorded as part of the 2020 abundance survey. No other individuals were recorded as part of any previous survey.

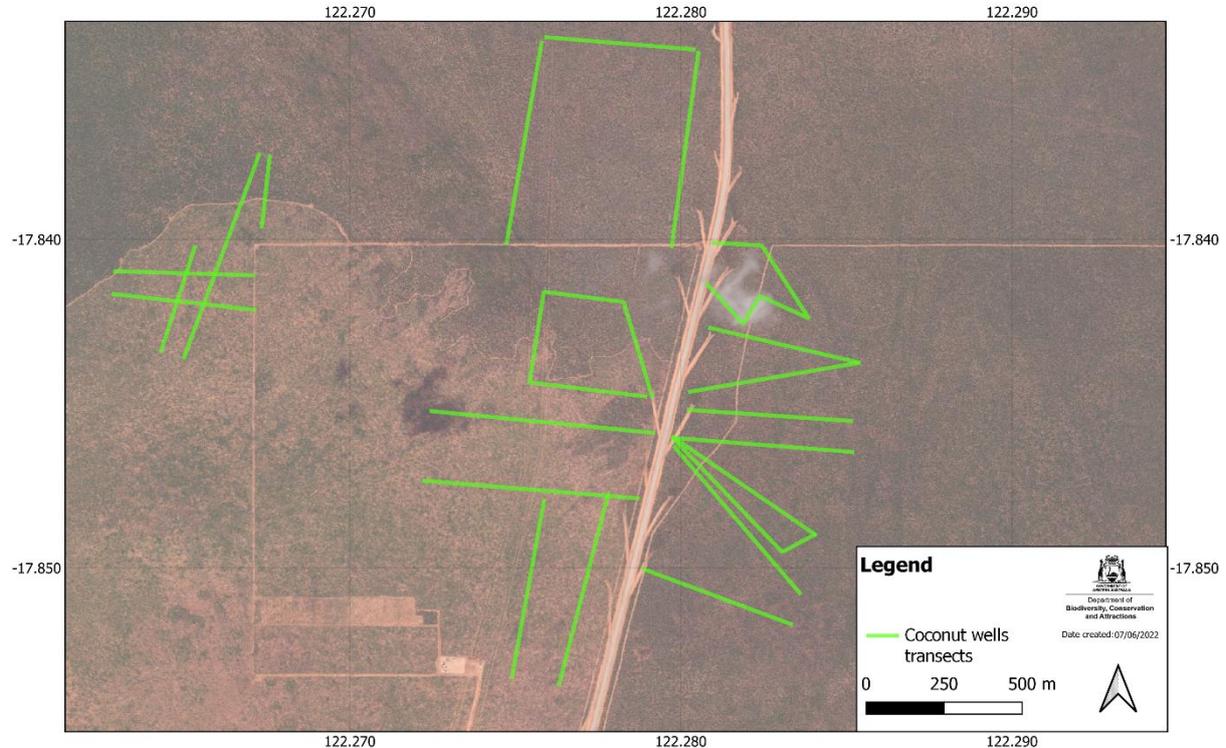


Figure 4 – Transects used to detect bilby scat in the Coconut Well's area on the Dampier peninsula.

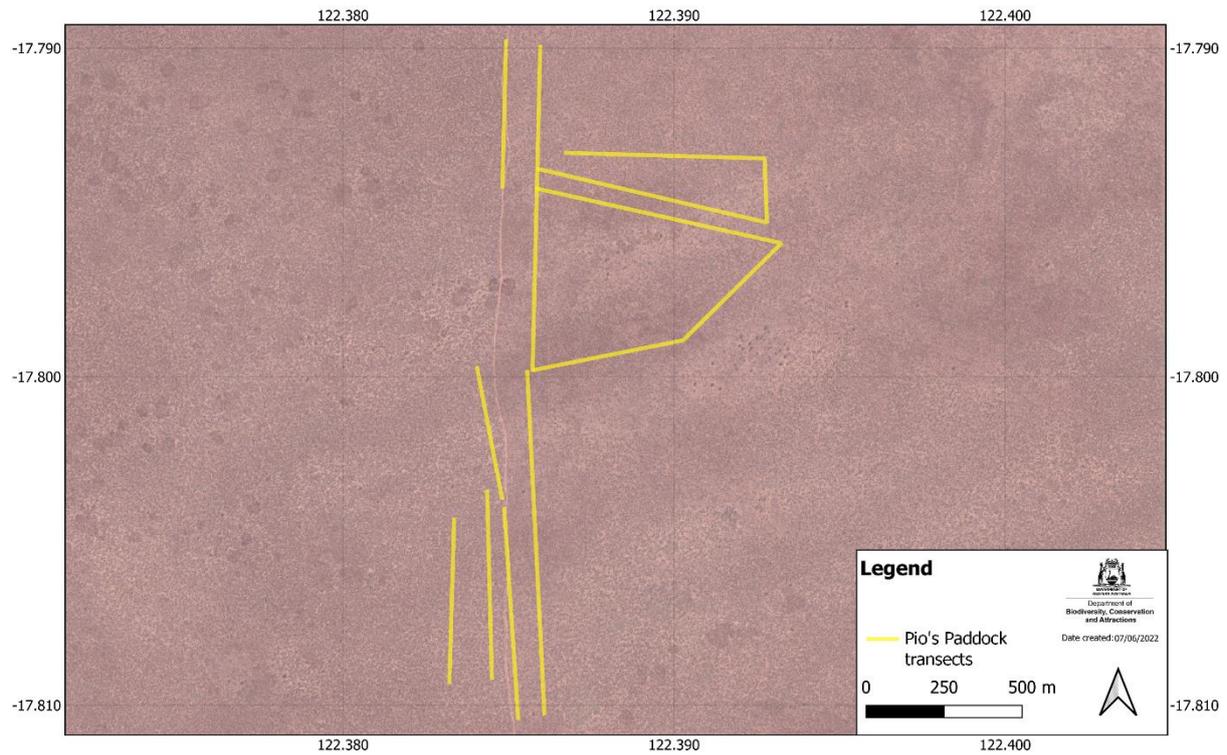


Figure 5 – Transects used to detect bilby scat in the Pio’s Paddock area on the Dampier peninsula.

Table 3 - Survey effort, scats collected, and individuals recorded at the Coconut Wells and Pio’s Paddock bilby populations in 2021.

Population	Transect surveyed (km)	Scats collected	Individuals recorded
Coconut Wells 2021	13.31	9	3
Pio’s Paddock 2021	8.4	42	7

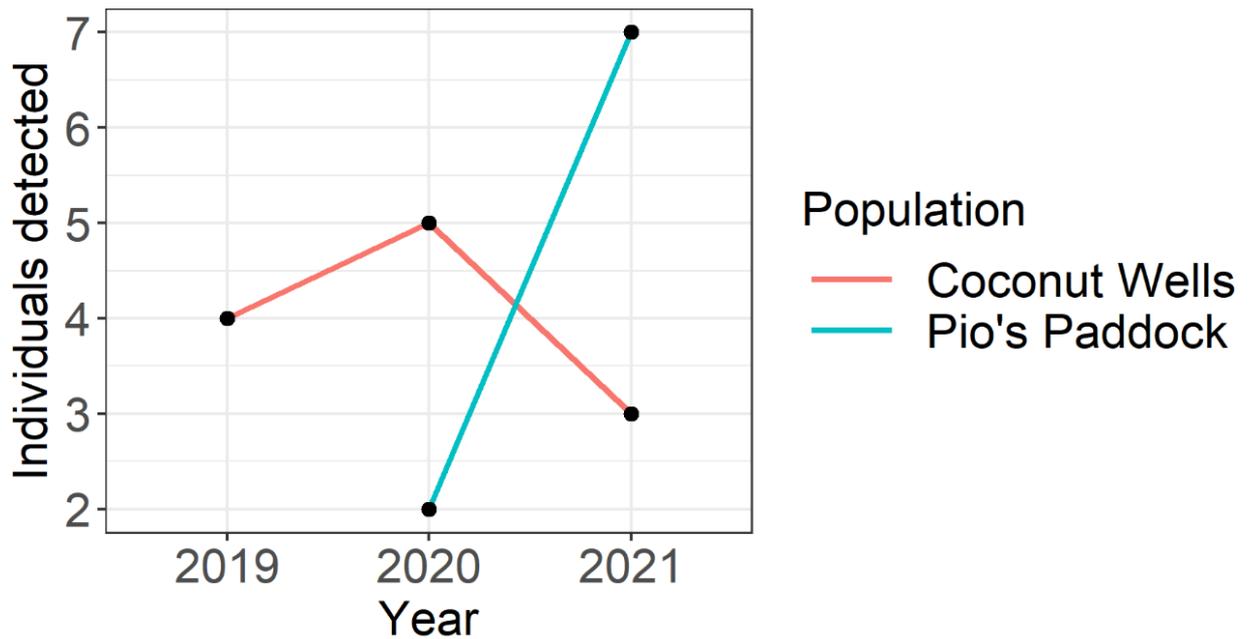


Figure 5 – Estimates of bilby abundance as derived from scat genotyping on the Dampier peninsula.

3.1 Discussion

Estimates of bilby abundance as derived from scat genotyping indicated both the Coconut Wells and Pio's Paddock populations are comprised of relatively few individuals. These estimates are comparable to those collected elsewhere in Western Australia, where feral predator baiting does not occur (Dziminski *et al.* 2021b).

While little change in abundance has been observed in the Coconut Wells population over three years of sampling, a marked increase in abundance was observed in the Pio's Paddock population. While it's possible this increase is related to fire management activities in the area, and subsequent emergence of important food plants, continued monitoring is required to confirm this trend. It's likely SECR analysis will provide further insight into changes in the Coconut Well's and Pio's Paddock over time. These results will be available within the coming weeks.

4 Predator monitoring

4.1 Background

Predation is recognised as a major threat to bilby populations across their range (Pavey 2016), particularly from feral cats (Moseby *et al.* 2011; Lollback *et al.* 2015), foxes (Johnson and Isaac 2009) and dingoes (Paltridge 2002b). To monitor occurrence of these predators in the vicinity of bilby populations studied as part of this project, a camera-trap monitoring program was established.

4.2 Methods

4.2.1 Camera traps

Predator occupancy was monitored via a network of remote sensing cameras deployed at Coconut Wells and Pio's Paddock bilby populations across 2020 and 2021 (Figure 6). A minimum of 5 cameras were deployed at each site in each year. Cameras were deployed for a minimum of 6 weeks. Cameras were positioned to observe vehicle tracks or face the entry of bilby burrows. Vehicle tracks provide movement corridors for invasive predators and their activity on tracks is often higher than off tracks (Raiter *et al.* 2018). Bilby burrows can also act as natural lures in the landscape, with many other prey species as well as bilbies inhabiting them, attracting predators that regularly visit these features in an often barren landscape (Hofstede and Dziminski 2017; Dawson *et al.* 2019).

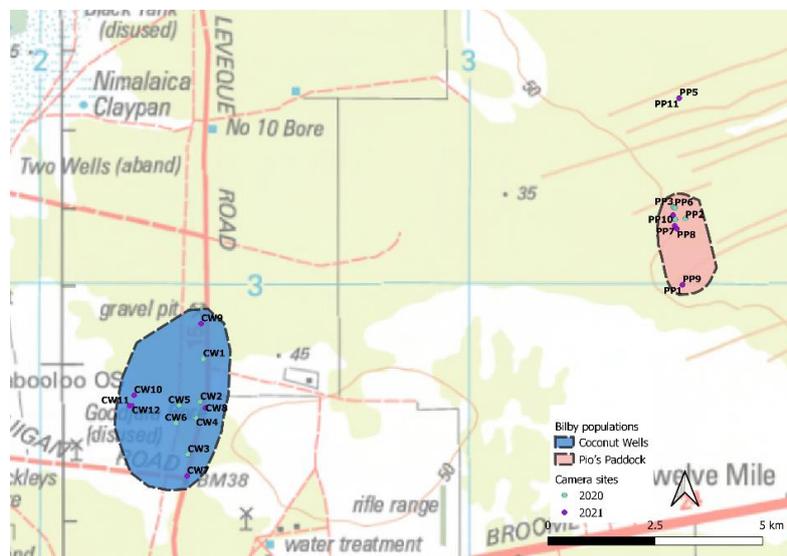


Figure 6 – Location of camera traps and Coconut Wells and Pio's Paddock bilby populations, used to monitor occurrence of predators including dingoes and feral cats.

4.2.2 Occupancy analysis

Data was first structured into one-week sampling occasions across 2020 and 2021. Detection histories for each site were then assembled by pooling detections for each site into a single measure of detection/non-detection for each sampling occasion. Occupancy models were then formulated in terms of parameters ψ , (occupancy) and p (detectability), where ψ is the probability that site i is occupied by the species, and p is the probability of the species being detected at site i on night j , conditional upon its presence. The models assume detection of the species at sites is independent of species detections at other sites, that there are no false detections, and that occupancy remains constant over the sampling period.

To test whether feral cat or dingo occupancy varied between the two bilby populations (Pio's Paddock, Coconut Wells), the variable 'Population' was included as a predictor for occupancy. Similarly, the variable 'Year' was also included to test if there was a difference in feral cat or dingo occupancy between years. The probability of detecting feral cats and dingoes was expected to vary depending on whether a camera was located on a track, or on a bilby burrow. As such, the variable 'location' (track or burrow) was included as a predictor for feral cat and dingo detectability.

Occupancy models were fit using the unmarked package (Fiske and Chandler 2011) in R version 3.6.2 (R Core Team 2019). Model selection was conducted by first running a global model including all predictors, and then using the *dredge* function in statistical package *MuMIn* to determine which subset of predictors produce a model with the most parsimonious fit — model with lowest AIC value. This model was the used to estimate feral cat and dingo occupancy and detectability across the two bilby populations.

4.2.3 Survey effort

To measure the level of confidence that be applied to survey effort used to determine feral cat and dingo presence, cumulative nightly detectability curves were generated for detectability estimates using the following equation:

$$P = 1 - (1 - p_1) \times (1 - p_2) \times (1 - p_3) \dots (1 - p_n)$$

where P is the cumulative nightly detection probability, n is number of nights and p is the nightly detection probability. The minimum number of nights per site was then calculated, necessary to be 95% confident that the site is unoccupied:

$$N_{min} = \log(\alpha) / \log(1 - p)$$

where $\alpha = 0.05$ and confidence is equal to $1 - p$ (Kery 2002).

4.3 Results

Sampling effort across 2020 and 2021 totalled 149 one-week sampling occasions (2020 = 71, 2021 = 78). Feral cats and dingoes were detected in 21% (31/149) and 9% (14/149) of all sampling occasions, respectively (Figure 7, Figure 10).

The most parsimonious model for feral cats included location (track, burrow) as a predictor for detectability, but included no predictors for occupancy (Table 4), indicating no difference in feral cat occupancy either between sampling years, or between sampling areas (Pio's Paddock, Coconut Wells). Results from this model suggested feral cats were almost three times more detectable using cameras located on tracks ($p = 0.36$, $0.23 - 0.51$) than cameras located on bilby burrows ($p = 0.13$, $0.07 - 0.22$) (Figure 8). After five sampling occasions, the cumulative probability of feral cat detections using cameras placed on tracks was 90%, but only 49% using cameras placed on bilby burrows (Figure 8, Figure 9). Predicted feral cat occupancy was 0.96 ($0.07 - 1$) across both sites.

The most parsimonious model for dingoes included no predictors for either detectability or occupancy, indicating there was no difference in dingo occupancy either between sampling years or sampling areas, and no difference in detection between cameras placed on bilby burrows or tracks. The probability of detecting dingoes within a given sampling occasion was 0.43 ($0.26 - 0.61$), assuming dingoes were present at a site. After five sampling occasions, the cumulative probability of dingo detection was > 90% (Figure 11). Predicted dingo occupancy was 0.22 ($0.09 - 0.43$) across both sites.

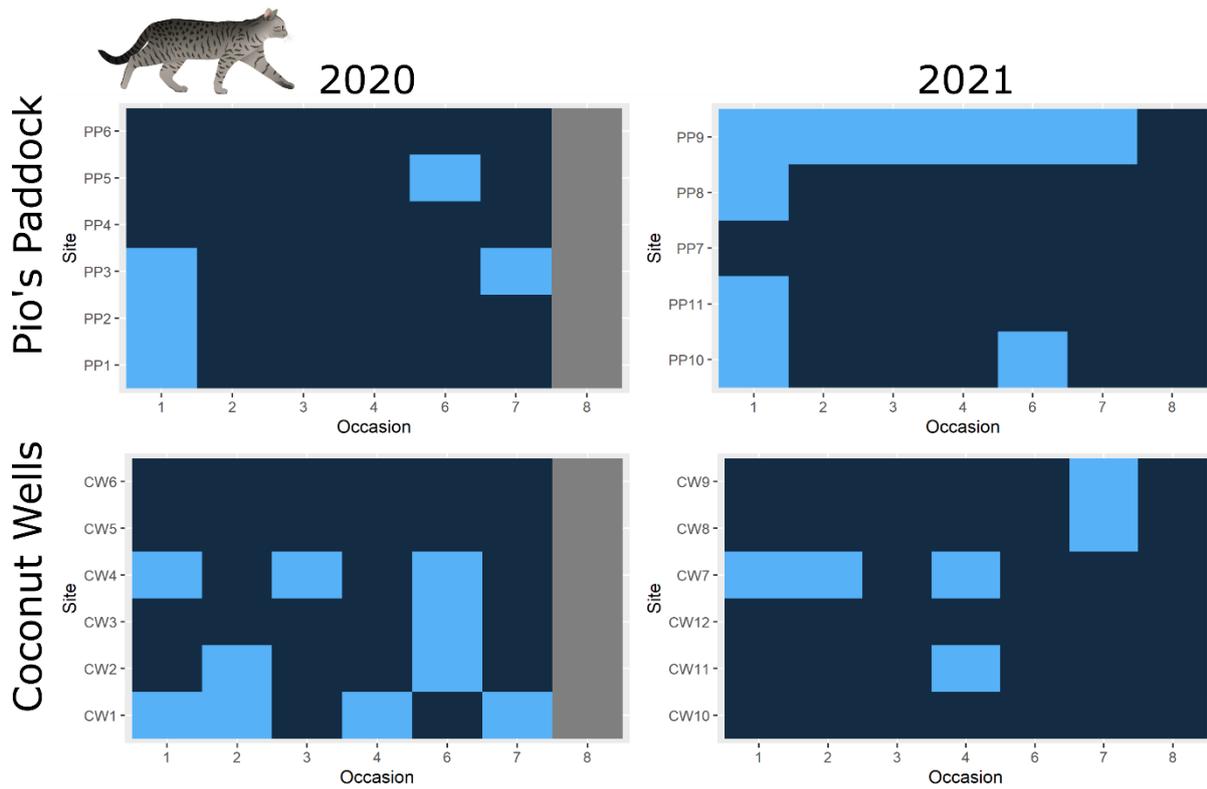


Figure 7 – Detection history of feral cats at Pio’s Paddock and Coconut Wells bilby populations on the Dampier Peninsula. Each sampling occasion is equivalent to one week of camera trap sampling.

Table 4 – Occupancy models used to predict feral cat occupancy and detectability at Pio’s Paddock and Coconut Wells bilby populations.

p(Location)	psi(Area)	psi(Year)	psi (Area:Year)	df	AICc	delta
+				3	148.95	0.00
+		+		4	151.38	2.42
+	+			4	151.55	2.60
+	+	+		5	154.09	5.14
				2	155.30	6.35
+	+	+	+	6	157.81	8.86
	+			3	157.85	8.89
		+		3	157.95	9.00
	+	+		4	160.79	11.84
	+	+	+	5	163.97	15.02

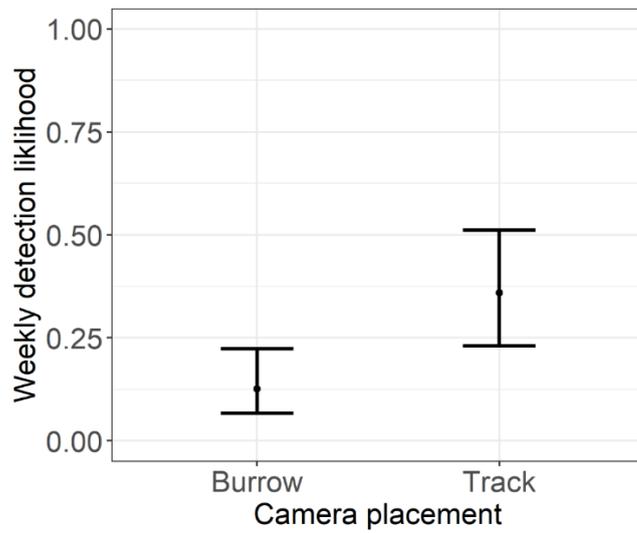


Figure 8 – Feral cat weekly detection likelihood using camera traps and Pio’s Paddock and Coconut Wells bilby populations.

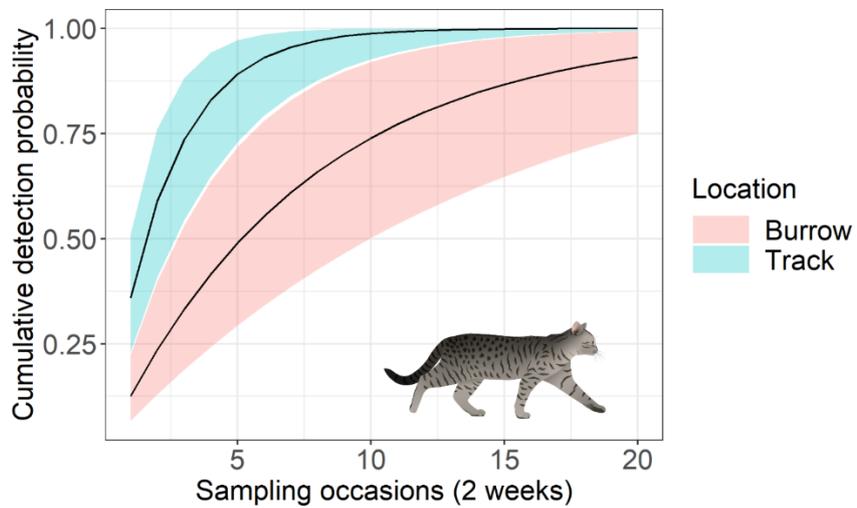


Figure 9 – Cumulative detection curves for feral cats using camera traps at Pio’s Paddock and Coconut Well’s bilby populations.

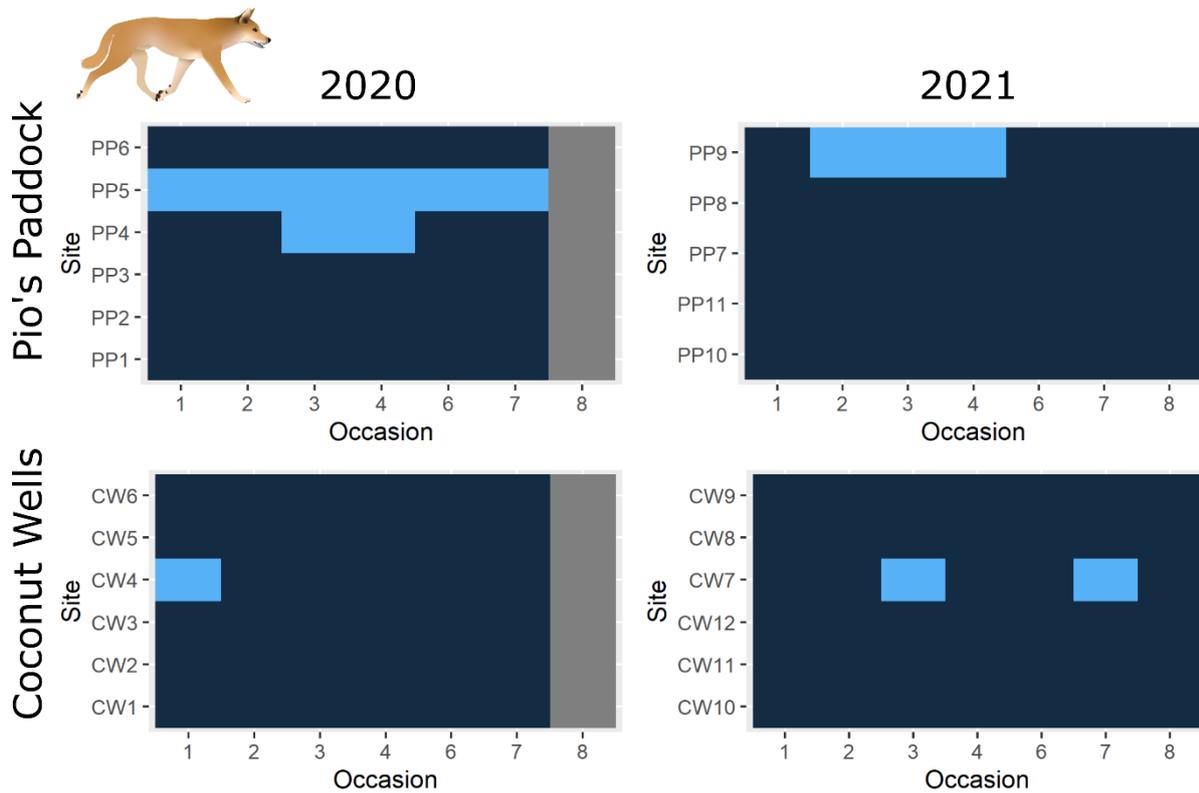


Figure 10 – Detection history of dingoes at Pio's Paddock and Coconut Wells bilby populations on the Dampier Peninsula. Each sampling occasion is equivalent to one week of camera trap sampling.

Table 5 – Occupancy models used to predict dingo occupancy and detectability at Pio's Paddock and Coconut Wells bilby populations.

p(Location)	psi(Area)	psi(Year)	psi (Area:Year)	df	AICc	delta
				3	63.22	0.00
+		+		4	66.08	2.85
+	+			4	66.09	2.87
+	+	+		5	69.31	6.09
				2	72.28	9.06
+	+	+	+	6	72.96	9.74
	+			3	74.56	11.34
		+		3	74.77	11.54
	+	+		4	77.36	14.14
	+	+	+	5	80.56	17.34

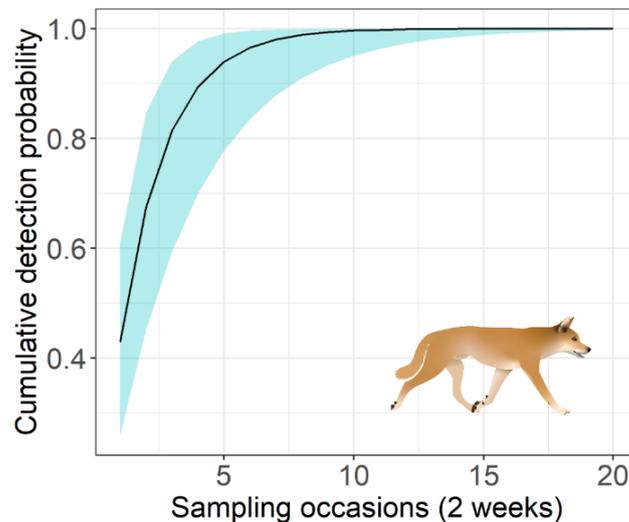


Figure 11 – Cumulative detection curve for dingoes using camera traps at Pio’s Paddock and Coconut Wells bilby populations

4.4 Discussion

Estimates based on camera traps across the 2020 – 2021 sampling period indicated feral cat occupancy was high across both Pio’s Paddock and Coconut Wells bilby populations, while dingo occupancy was comparatively low. Studies in other semi-arid parts of Australia have found feral cat occupancy to be comparable or higher than those recorded here (Comer *et al.* 2018; Dziminski *et al.* 2021a). For example, Doherty *et al.* (2021) found that feral cat occupancy in Charles Darwin Reserve was around 80% prior to the application of targeted baiting, while Johnston *et al.* (2012) estimated pre-bait feral cat occupancy was over 90%.

One potential explanation for high feral cat occupancy observed here could be the lack of topographic complexity in the study area. Hohnen *et al.* (2016) found feral cat occupancy declined with increasing ruggedness at a site in the Kimberley region, potentially due to reduced hunting success. It is also possible that high feral cat occupancy has in part been facilitated by the limited occurrence of dingoes – a larger and more dominant predator. For example, there is some evidence to suggest that dingoes can limit the activity (Wang and Fisher 2012) and even population size (Kennedy *et al.* 2012) of feral cats where they co-occur. However, high spatial overlap between the two species at both the Pio’s Paddock and Coconut Wells sites suggests it is unlikely dingoes are suppressing feral cats in this study.

Overall, the results suggest introduced predator management should be considered to better protect bilby populations on the Dampier Peninsula. Sustained introduced predator management has successfully facilitated the persistence and expansion of a bilby population translocated to Matuwa in the Goldfields region of Western Australia (Lohr *et al.* 2021).

5 Management of threats

The Dampier Peninsula Bilby Offset Project Threat Management Plan determined the highest threat for bilby populations on the Dampier Peninsula was the interaction between fire and introduced predators (Dziminski and van Leeuwen 2019). However, given that the scope and budget of the current project does not allow for the management of introduced predators, threat management focused on reducing the impacts of inappropriate fire regimes.

Management of fire will include:

- i. Establishing suitable firebreaks surrounding managed populations to prevent large wildfires destroying vegetation structure and food resources and allowing easy predator access within managed populations.
- ii. Implementing patch mosaic burning to create fire age heterogeneity, increasing habitat and resource diversity for bilbies.

As discussed above, two monitoring sites have been established: Coconut Wells (control) and Pio's Paddock (managed).

5.1 2020 fire management

In partnership with Nyamba Buru Yawuru (NBY), DBCA consulted and provided support to NBY to implement prescribed fire management actions in an attempt to mitigate wildfire impact to bilby populations in the Pio's Paddock management area. Ground burning took place on the 19 May 2020 and was completed along the length of the western side of this track in an attempt to create an effective fire scar to prevent late dry season wildfire passing into the management area. Aerial burning was conducted by NBY in liaison with the Department of Fire and Emergency Services (DFES). Burning took place along the eastern boundary, with further aerial burning completed along strategic flight lines working off existing fire scars internally within the cell of the management area.

Fire-take and effective scarring was variable, with some areas resulting in effective scarring and others unlikely to be an effective fire scar. This was attributed to vegetation and particularly grass cover and environmental conditions on the day of prescribed burns (low wind). Where fire take was achieved, fire behaviour was optimal for prescribed fire conditions, with low scorch height and low intensity. A total of approximately 62 hectares were burnt during ground burning operations and 514 hectares during aerial burn operations. These areas will offer fire age and vegetation heterogeneity within the landscape as preferred by bilbies and can be utilized to burn against in future prescribed fire operations.

5.2 2021 fire management

Fire management in 2021 focused on the northern boundary of Pio's Paddock where DBCA conducted aerial burning in the early dry season (June 2021). This work was undertaken with a strategic consideration to compliment fire management undertaken in 2020. The Broome region including this population monitoring site was threatened by late dry season wildfire in November 2021. As part of the emergency response for these wildfires, DBCA staff were able to successfully communicate the environmental values of this area to DFES staff. As a result of this and with operational on-ground wildfire suppression support from DBCA staff, the Pio's Paddock monitoring site was successfully protected from wildfire impacts (Figure 12, Figure 13).

As part of the 2021 October wildfires, a small area of the Coconut Wells monitoring site was impacted. This follows on from 2019 wildfire impacts which were more extensive at this site. As a result of the 2019 wildfire impact at Coconut Wells monitoring site, it is regarded as a control site where no direct fire management activities are being undertaken and hence the impacts of wildfire can be assessed on the bilby population that was present at this site.

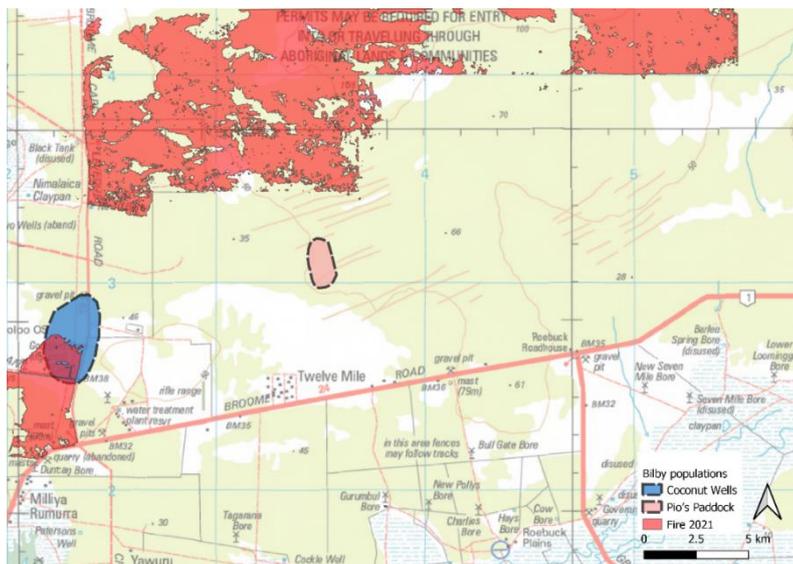


Figure 12 – 2021 wildfire suppression response between DFES and DBCA staff. Strategic advice and ground support from DBCA assisted in protecting the Pio's Paddock monitoring sites from wildfire impacts.



Figure 13 – Location of Coconut Wells and Pio’s Paddock bilby populations on the Dampier Peninsula. 2021 fire scar is marked in red.

5.3 2022 fire management

A yet to be executed prescribed burning plan for the Pio’s Paddock bilby population has been designed based on recent burns in the area. Proposed aerial burning and mineral earth fire break grading lines are indicated in Figure 14. Purple broken lines on the map represent proposed ignition lines and are an attempt at creating strategic fire scars to prevent late dry season wildfire, typically fuelled by strong south-easterly winds. Diagonal north-west/south-east direction burn lines have been proposed based on previous experience, which suggests this method to be more effective with the typical dry season south-easterly winds. The solid pink line represents tracks that will be graded to create fire breaks.

In addition to broad scale burning, finer scale ground burning is proposed in the area immediately surrounding the Pio’s Paddock population, particularly on the western side of the main track intersecting the area where bilbies are most active. The purpose of these burns is not for protection from wildfire, but rather to increase heterogeneity in surrounding burn ages, and promote emergence of important food plants for bilbies.

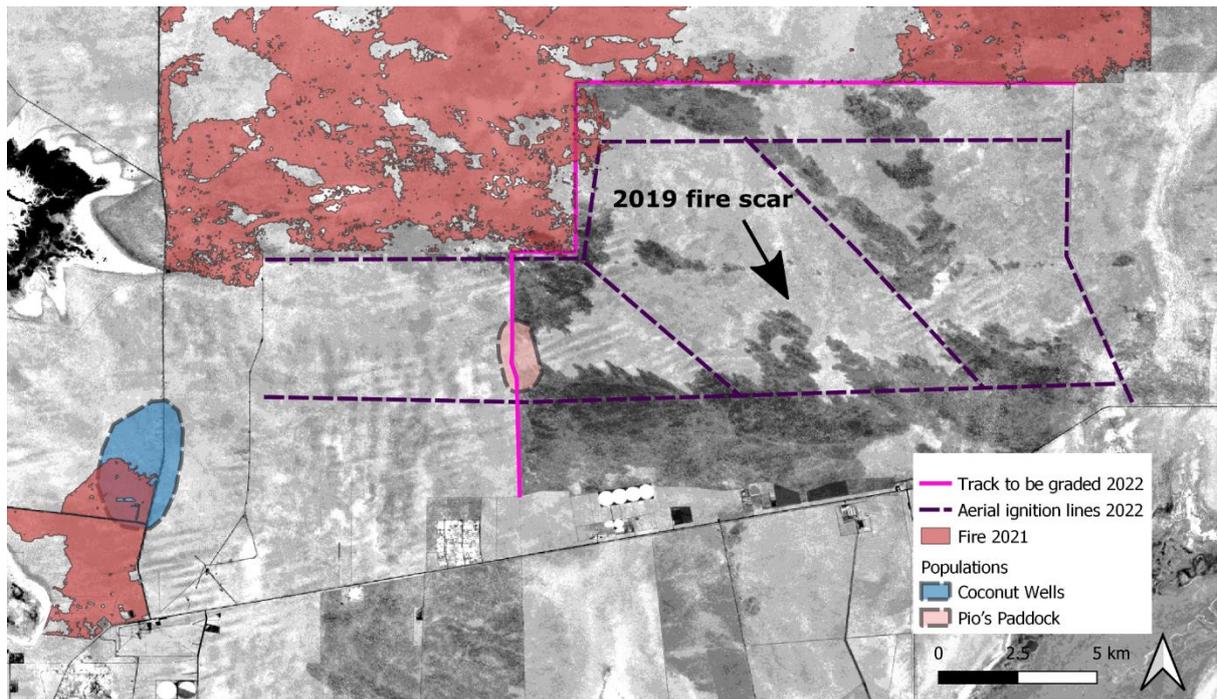


Figure 14 – 2022 burn plan for the Pio's Paddock bilby population. Satellite imagery indicates 2019 fire scars (dark regions), while red shading represents 2021 fire scar.

6 Presentations

In addition to the management activities described above, Indigenous rangers and DBCA staff have presented findings from this project at two events. The first event was a presentation to the Yawuru Registered Native Title Body Corporate (RNTBC) Land and Sea Subcommittee, which occurred in November 2021. The RNTBC Land & Sea subcommittee is responsible for the implementation, monitoring and evaluation of the Yawuru Indigenous Protected Area (IPA) Plan of Management (POM). In their presentation, rangers and DBCA staff described works proposed and completed as part of the Dampier Peninsula Main Roads Bilby Offset project to board members, and summarised key findings and achievements to date.



The second event (also November 2021) was a presentation to the Dampier Peninsula Fire Working Group. The Dampier Peninsula Fire Working Group aim to improve fire management practices on the Dampier Peninsula through working collaboratively with groups such as the Bardi Jawi, Nyul Nyul, Yawuru; pastoralists (Country Downs, Yeeda, Roebuck Plains) DBCA, the Kimberley Land Council, Main Roads, DFES and Sheffield Resources. DBCA and rangers from the main roads offset project presented current learnings to the group for Dampier Peninsula fire managers to consider and implement.

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