Main Roads WA

Cape Leveque Road Upgrade

Greater Bilby Management Plan

October 2014

Table of contents

1. Introduction 1
   - 1.1 Background 1
   - 1.2 Objectives of the management plan 1
   - 1.3 Project area 1
   - 1.4 Limitations to management plan 2
2. Ecology of the Bilby 4
3. Potential threats to the Bilby from the Project 5
   - 3.1 Direct loss of habitat 5
   - 3.2 Injury and mortality during construction phase 5
   - 3.3 Other impacts during construction 5
   - 3.4 Mortality due to vehicle collision (road kill) 5
   - 3.5 Cumulative impacts of the Project 6
4. Management of impacts 7
   - 4.1 Approach 7
   - 4.2 Guiding documents and principles 8
   - 4.3 Project management 9
   - 4.4 Summary of impact management measures 9
   - 4.5 Design phase 10
   - 4.6 Construction phase 11
   - 4.7 Post- construction phase 12
5. References 22

Table index

Table 1 Summary of impact management measures. 9

Table 2 Impact management - design phase. 13

Table 3 Impact management - construction phase 15

Table 4 Impact management - post-construction (operational phase). 20

Appendices

Appendix A Figures

Appendix B Cape Leveque Road - Greater Bilby Handling and Relocation Protocols

1. Introduction

1.1 Background

Main Roads Western Australia (Mains Roads) commissioned GHD to undertake a targeted fauna survey of the Greater Bilby to assess the potential impacts associated with the Stage 3 improvement works along the Cape Leveque Road (SLK 25 to 102.6) in November 2012.

This study (GHD 2013) concluded the Project has the potential to significantly impact on the Greater Bilby (*Macrotis lagotis).* The Bilby is listed as Vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999 (EPBC* Act*)* and Vulnerable under the Western Australian *Wildlife Conservation Act 1950* (*WC* Act).

1.2 Objectives of the management plan

For the purpose of this management plan the 'Project' is defined as the upgrade of the unsealed section of the Cape Leveque Road between SLK 25 to 102.6. It is anticipated that construction of the new road will be undertaken by Main Roads in stages during the 2015- 2019 dry seasons (May to October), depending on available funding and whether environmental approval is given to proceed. The objectives of this Management plan are to:

- Minimise impact to individual Bilby and populations of the species within and adjacent to the Project area during construction and once the road is established (operational phase)
- Minimise impact to the habitat of the Bilby within and adjacent to the Project area during construction and operational phase
- Maintain connectivity for the Bilby either side of the Project area during the operation phase of the Project

1.3 Project area

The locality of the Project area is shown in Figure 1 (Appendix A). The Project area for this assessment lies between SLK 25 and SLK 102.6 on the Cape Leveque road. The proposed Impact area (area to be cleared for road construction) will include:

- The main road alignment (approximately 77.6 km long x 20-30 m wide), proposed to be located generally parallel to the existing alignment, which covers an area of 172.05 ha. This area includes an intersection and side road at SLK 58; approximately 2 km long x 20-30 m wide, totalling approximately 4 ha.
- 36 borrow pits which cover an area of 60.95 ha.
- Offshoot drains that will be located approximately every 170m. Each will cover an area of approximately 500m^2, totalling approximately 22 ha.
- Access tracks totalling approximately 5 ha.
- 20% contingency amount for any required additional works equalling 52 ha.

The proposed Impact area is 297 ha, with approximately 15 ha of overlap between the road alignments and proposed borrow pits. Main Roads will revegetate the temporary works areas, as well as land on part of the existing Cape Leveque Road, which will not be required for the new road. Areas to be revegetated are:

- Approximately 50% of the existing (to be redundant) Cape Leveque Road, totalling 38 ha
- 36 borrow pits, totalling 61 ha

- Temporary access tracks, totalling 5 ha

A total of 104 ha is therefore planned to be revegetated.

Previous project studies

This management plan draws information from various sources including relevant documents relating to legislation, publically available databases and previous studies by GHD and other consultants relevant to the Project area. These documents were also reviewed to understand the Project specific potential impacts to the Bilby and the implications resulting from clearing activities associated with the proposed Project. The documents reviewed included:

- GHD (2013) Report for Cape Leveque Road Targeted Greater Bilby Assessment
- GHD (2012) Report for Broome to Cape Leveque Road (Stage 3 SLK 12.7 – 102.6) Environmental Impact Assessment and Environmental Management Plan
- AECOM (2010) James Price Point LNG Precinct Access Road Environmental Impact Assessment and Environmental Management
- GHD (2007a) Report for Broome to Cape Leveque Road (Stage 3: SLK 12.7 102.6). Environmental Impact Assessment and Environmental Management Plan. Main Roads WA, Kimberley
- GHD (2007b) Report for Broome to Cape Leveque Road (Stage 3: SLK 12.7 - 102.6). Environmental Impact Assessment and Environmental Management Plan, November 2007 – Field Surveys and Desktop Assessment April 2012 – Updated Desktop Assessment. Main Roads Western Australia
- SKM (2012). Browse Bilby Review, Consolidated Information Relating to the Occurrence of the Bilby (*Macrotis lagotis*) in the Vicinity of the Browse LNG Precinct and Broadly on the Dampier Peninsular
- Southgate, R. (2012). Peer review of the Browse Bilby Review, a report detailing the consolidated information relating to the occurrence of the Bilby *Macrotis lagotis* near the proposed Browse LNG Precinct (close to James Price Point) and more broadly on the Dampier Peninsula. By Envisage Environmental Services
- Pavey, C. (2006). National Recovery Plan for the Greater Bilby Macrotis lagotis. Northern Territory Department of Natural Resources, Environment and the Arts

1.4 Limitations to management plan

This report has been prepared by GHD Pty Ltd (GHD) for Main Roads and may only be used and relied on by Main Roads for the purpose agreed between GHD and the Main Roads as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Main Roads arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Main Roads and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

2. Ecology of the Bilby

Taxonomy and conservation status

The Bilby is the sole remaining representative of the sub-family Thylacomyinae in the Bandicoot family and one of few medium sized (0.5 kg to 3.5 kg) terrestrial mammals remaining on mainland Australia. Many species in this 'critical weight range' have become extinct since European settlement of Australia.

Morphology

The Bilby shows sexual dimorphism with adult males reaching between 0.8 kg and 2.5 kg as compared to the smaller females at 0.6 kg to 1.1 kg. The Bilby has a distinctive appearance with long slender hind legs, small front limbs, a long tail, rabbit-like ears and a long snout. The animal has silky grey fur with a black and white tail.

Distribution and habitat

Bilbies are known to occur in the Dampierland Bioregion which encompasses the coastal areas from 80 Mile Beach north to Cape Leveque and east towards Derby. Records of the species in the Project area and in the vicinity of the Project area are show in Figures 2 and 3, Appendix A. Within the Dampierland Bioregion the Bilby occupies a wide variety of habitat types including Pindan woodlands and shrublands, dune systems and Salt-bush (*Halosarcia* spp) plains.

Bilbies are largely a solitary animal and usually spend the daytime in burrows. An individual Bilby may regularly utilize over a dozen burrows within its homerange. The species is highly mobile and have been recorded using burrows over 2 km apart on consecutive days. Studies on the homerange size of Bilbies range from 1 km^2 to over 3 km^2 (Pavey 2006;).

Diet

Bilbies are omnivorous and many food resources vary seasonally across the landscape. The Bilby is recognized as an ecosystem engineer as it often digs for food and this process creates variation in micro- habitat function.

Breeding

The Bilby can breed throughout the year and like many Australian arid-zone mammals can produce young quickly to take advantage of variation in arid conditions. Bilby gestation is 12 days long with live-born young spending 10 weeks in the mother's pouch and becoming independent at three months of age. Bilbies are sexually mature by six months of age. Bilbies can breed up to four times a year and one or two young are usually produced per litter (mean 1.94), however they can produce up to three young per litter (DSEWPaC 2013).

3. Potential threats to the Bilby from the Project

3.1 Direct loss of habitat

Pavey (2006) recognises in the national recovery plan for the Bilby that direct loss of habitat is a key threatening process. Clearing activities associated with the upgrade of the unsealed section of the Cape Leveque Road (proposed Impact area) is calculated to result in the permanent loss of up to 297 ha of Bilby habitat including foraging habitat and 13 recorded burrow sites within the proposed Impact area (GHD 2013). Furthermore, the construction of the road and associated infrastructure is anticipated to have a number of indirect consequences.

3.2 Injury and mortality during construction phase

During the construction phase of the Project habitat clearance may result in the injury or death of Bilbies and other fauna that would not otherwise occur in the absence of construction. The Bilby is susceptible to injury / death given its nocturnal, burrowing behaviour; as the Bilby generally spends daylight hours in their burrows. There is a risk that during construction, heavy machinery may crush active burrows and individuals inside may be injured or killed. Furthermore individuals may be unable to avoid construction machinery and be run over. If individuals do evade injury (from being crushed in burrows or run over) the initial displacement and lack of shelter will increase its likelihood of predation by both birds of prey and introduced predators.

3.3 Other impacts during construction

There are several other potential impacts to the Bilbies during the construction phase including:

- Increase traffic associated with construction may increase the incidence of road kill in the broader area
- Fire may result from construction activities
- Disruption to breeding cycles if breeding habitat is impacted
- Disruption to normal behavioural patterns from increased levels of activity in the area that could impact on dispersal, foraging and breeding opportunities for individual Bilbies

3.4 Mortality due to vehicle collision (road kill)

During the operation phase of the Project local wildlife populations may be reduced. Although the existing road will no longer be in use, the new road will create a new barrier to the movement of fauna, consequently increasing the likelihood of fauna and vehicle collisions. Furthermore, traffic along the road is likely to increase over time which will proportionally increase the occurrence of operational impacts due to:

- The increased accessibility created by the improved standard of the road allowing for safe access all year-around
- The likely increased levels of visitation (and therefore road use) from tourism and other activities in the region
- The likely increased speed at which the road users travel along the road due to improved road quality
- The potential for increased night time traffic due to improved road quality

3.5 Cumulative impacts of the Project

For this Project, clearing associated with the construction area would result in the loss of native vegetation and associated fauna habitat and fauna including Bilbies within that habitat. Furthermore the Project may also serve to reduce the functionality of the broader habitat in the area. The impact from the loss of habitat is likely to emerge slowly.

Specific impacts that are likely to lead to incremental losses are described in more detail below. The degree to which these potential impacts affect biodiversity and habitat values within the newly created fragments depends on a number of variables including distance between fragments, local environmental conditions, the species present and mitigation measures.

Habitat fragmentation

The proposed construction area would reduce the overall area of habitat available to the Bilby in the locality by up to 297 ha.

The existing road is likely to already contribute (albeit probably only to a minor degree) to the fragmentation of habitats within the surrounding landscape. The proposed road is likely to exacerbate existing fragmentation effects rather than divide a single area of habitat into two.

Barrier effects

The Project will create an additional barrier in the form of the new road. This new road is likely to exacerbate existing barrier effects as well as create new barrier effects as the road is likely to be more substantial (in terms of height, width and capacity). The barrier effects created by roads have two main implications: roads create meta-populations (e.g. where a road divides a larger population into smaller more isolated populations) and roads restrict or block the dispersal and/or re-colonisation process, which is often accentuated by road widening and / or increases in traffic volume (Forman and Alexander 1998) as may be the case for this Project.

Noise and light impacts

Anthropogenic disturbances such as artificial light and noise could increase as a result of this Project. Although it is difficult to gauge the extent of potential impacts, noise and light levels may impact on native fauna (Forman and Alexander 1998) including the Bilby.

Numerous noise studies have demonstrated either lower animal density and/or species richness near highways (Shaub et al. 2008; Dorrance et al. 1975; Forman et al. 2002; Reijnen et al. 1995; Reijnen et al. 1996; Rudolph et al. 1999), which suggests that noise is a major deterrent for wildlife. However, the Targeted Bilby Survey (completed by GHD December 2012) confirmed the presence of active burrows and diggings adjacent to the existing Cape Leveque Road alignment. The Project would most likely create increased anthropogenic impacts such as noise during the construction and operational phases; however it is difficult to gauge the extent of these potential impacts.

The type and level of noise is likely to increase (and peak) during the construction period. Night works are unlikely to be required. The overall increase in noise could potentially deter native fauna from using habitats adjacent to the road and some species of native fauna may abandon habitats adjacent to the road.

Fauna of most concern with regard to this Project are most likely native nocturnal species whose survival or success is dependent on darkness allowing them to avoid predators. It is understood the Project will not involve the addition of artificial street lighting and therefore will only be linked to vehicle related lighting. It is considered that the potential impacts associated with this form or artificial lighting would be minimal and infrequent to the Bilby.

4. Management of impacts

4.1 Approach

The EPBC Significant Impact Guidelines (DEWHA 2009) present a hierarchical series of measures to manage potential impacts in the early phases of Projects. There are not always opportunities to employ each of these impact management measures; however the Department of the Environment, Water, Heritage and the Arts (now Department of the Environment, Water, Heritage and the Arts (DSEWPaC)) presents a preferred order of opportunities to address these impacts (DEWHA 2009):

- Avoid impact completely
- Reduce the impact
- Manage the significance of the impact.

The key impacts potentially resulting from this Project are described in section 3 of this management plan.

Where impacts cannot be avoided or reduced then mitigation and management is recommended. Where the effectiveness and certainty of the measures used to avoid, reduce, mitigate or manage these potential impacts can be demonstrated the Projects' impact may be considered not significant[*1] under referral to DSEWPaC under the EBPC Act (DEWHA 2009).

This section of the Bilby Management plan will provide mitigation and management measures to address the impacts from the Project for each of the Project phases and these will be addressed as per:

- Design phase detailed in section 4.5
- Construction phase detailed in section 4.6
- Post- construction (the ongoing impacts from the road) detailed in section 4.7

This management plan should be used in conjunction with Main Roads specifications, a broad construction environmental management plan and other guiding documents listed in section 4.2.

The key measures used to avoid, then reduce, manage and mitigate the potential impacts to the Bilby from the Project are:

- Avoid and minimise habitat clearing that is not essential to the Project
- Incorporate fauna underpasses into road design
- Revegetate borrow pits and disturbed areas
- Manage ongoing impacts from road with appropriate signage and maintenance works.

[1]DSEWPaC defines a 'significant impact' is an impact which is important, notable, or of consequence, having regard to its context or intensity. Weather or not the Project is likely to have a significant impact depends on the sensitivity, value, and quality of the environment which may be impacted and the intensity, duration, magnitude and geographical extent of the impacts (DEWHA 2009).

4.2 Guiding documents and principles

There are several documents that have been reviewed during the development of this management plan relating to the impacts of roads on native fauna including:

- Review of Mitigation measures used to deal with the issue of habitat fragmentation (DSEWPaC 2006)
- Use of fauna passage structures on RTA roads; Summary report, Road Traffic Authority (RTA) (RTA 2009)
- Fauna sensitive road design, Volume 1; Past and existing Practices, Queensland Main Roads Department, 2002 (QMRD 2002)
- Fauna sensitive road design, Volume 2; Preferred Practices. Queensland Main Roads Department, 2010 (QMRD 2010).

Main Roads has developed a series of construction specifications that contribute to environmental management during road construction and construction works (MRWA 2012):

- 204- Environment
- 301 – Clearing
- 302 – Earthworks
- 303 – Pits and Quarries
- 304 – Revegetation and Landscaping
- 402 – Surface Drains and Levees
- 404 – Culverts
- 406 – Rock Protection
- 501 – Pavements
- 503 – Bituminous Surfacing
- 701- Road Lighting
- 707- Supply and Install of Message signs
- 903- Fencing

There are also several more general documents that have been developed to guide environmental management (MRWA 2012):

- Revegetation Planning and Techniques (Doc. No. 6707/031)
- Vegetation Placement within the Road Reserve (Doc. No. 6707/022)
- Main Roads Corporate Procedure; Environmental Guideline, Pits and Quarries
- Handbook of environmental practice for road construction and maintenance works through the Roadside Conservation Committee, Western Australia 2005 (RCC 2005).

The general guiding principles for these documents are:

- Best practice environmental management will be incorporated into the planning and undertaking of road management activities
- People involved in road management will be trained to protect the environment
- Communication and consultation will be undertaken with stakeholders
- Road management actions will comply with relevant laws that relate to the environment.

4.3 Project management

The management plan will be implemented by various stakeholders during the design, construction and post construction phases of the Project. Areas of responsibility are detailed in sections 4.5 - 4.7 and are likely to include:

- Main Roads (MR) Project management team
- Engineers and designers
- Site construction contractors and their staff
- Site Environmental Officer/s
- Ecologists.

4.4 Summary of impact management measures

Table 1 presents a concise summary of the management measures to be implemented and the key areas of responsibility. These management measures are presented in further detail within sections 4.5 - 4.7 and Table 3.

Table 1 Summary of impact management measures.

Project phase and key management measures
Key management measures in the **design phase** include: • Limit size of Project foot print • Fauna underpasses • Educational signage • Planning for fauna clearance and relocation.
Key management measures in the **construction phase** include: • Site inductions for operators/educate operator • Manage clearing extent • Pre-construction fauna clearance • Burrow Excavation • Relocation of Bilby • Monitoring of Relocated Bilby • Fire management • Limitations on night works • Weed management • Borrow pit management • Management of impacts from introduced fauna.
Key management measures in the **post-construction phase** include: • Rehabilitation of borrow pits and access tracks • Maintenance of underpasses • Monitoring of Bilbies.

4.5 Design phase

During the design phase of the Project fauna sensitive road design will be incorporated to reduce the potential impacts. Design principles will demonstrate avoidance and minimisation of impacts to the Bilby and its habitat. These management measures are presented in Table 2 along with the person/s responsible for ensuring that the measure is implemented.

Early education of the Project team of the issues relating to the Bilby and communication of these design measures to the Project team at an early stage of the Project will ensure all possible efforts are made to manage the potential impacts.

4.5.1 Fauna underpasses

Fauna underpasses will be incorporated into the design and installation of the drainage culverts planned for the road. Main Roads are proposing to install three dual barrel (1200 mm x 1200 mm) reinforced concrete box culverts and six single barrel (450 mm diameter) corrugated steel pipe culverts at separate locations along the proposed alignment. As the proposed road upgrade is still within the planning stage the final location of the drainage culverts may shift slightly once the waterways analysis and road design is complete.

The proposed location of the dual barrel (1200 mm x 1200 mm) box culverts that are being primarily installed and positioned for drainage, but will also facilitate movement of the Bilby are:

- SLK 64.5
- SLK 75.0
- SLK 98.5

The smaller single barrel (450 mm diameter) culverts are being installed for drainage at the following proposed locations:

- SLK 31.2
- SLK 36.0
- SLK 40.4
- SLK 54.2
- SLK 77.2
- SLK 81.5

Main Roads recognises the proposed drainage culverts (presented above) are unlikely to provide sufficient effective underpasses to mitigate the potential increased probability of vehicle strikes associated with the road upgrade. The smaller single barrel (450 mm diameter) culverts are unlikely to facilitate movement of Bilbys. To further mitigate the potential impacts of the road upgrade an additional three single barrel (1200mm x 1200mm) reinforced concrete box underpasses will be installed at locations where active burrows were identified to facilitate the movement of the Bilby. The locations of these underpasses are:

- SLK 48.5
- SLK 64.8
- SLK 89.0

The underpasses will have a ‘dry path’ or elevated sections to allow for all–weather dry passage. Fences to carrel fauna through the underpass may also be appropriate at some locations. Fencing should not impede drainage. Fencing the full length of the road is not

recommended due to the impracticability and the likelihood that a continuous fence would exacerbate barrier effects of the road.

Revegetation (with locally native species) around the underpasses could be undertaken to provide continuous habitat linkage to the broader habitat. However, revegetation of the road verge is not recommended as this increases likelihood of road kill and reduced the effectiveness of the road to act as a fire break (QMRD 2010; RTA 2009). No tall tree species should be used in this revegetation as this may provide perching stands for birds of prey. Main Roads document *Vegetation Placement within the Road Reserve (Doc. No. 6707/022)* will be considered during this process

Culverts and associated fencing will be maintained to ensure ongoing benefits to fauna. It is recommended that maintenance of the underpasses is undertaken at least bi-annually, preferably before and after the wet season (end of October and end of March).

4.6 Construction phase

The purpose of this section is to outline the management commitments that Main Roads will implement to address impacts to the Bilby during the construction phase of the Project. These management measures are detailed in Table 3.

Main Roads has developed a Greater Bilby Handling and Relocation Protocol (Appendix B) to avoid where possible, then minimise direct impacts to the Greater Bilby during the construction phase of the Project. The protocol addresses the following:

- Pre-construction surveys including procedures for the capture and handling of lactating females
- Burrow excavation procedures including search and excavation procedures when lactating females are captured
- Bilby relocation procedures, including for when lactating Bilby females are captured
- Monitoring programs for relocated fauna (during construction and post-construction phases).

4.6.1 Pre –construction fauna clearance

Bilbies are known to seasonally move through the landscape utilising a network of burrows and foraging areas as resource availability shifts. Thus it is inappropriate to re-align the proposed Project area to avoid burrows that were reported as active during previous field studies as it is just as likely that the Project would then disturb other burrows in the area. As such, pre-construction Bilby surveys will be conducted to avoid Bilby mortality.

Pre-clearance surveys will incorporate two steps:

1. a pre-clearing ground truthing, then
2. a staged trapping program which will progressively move ahead of the clearing immediately prior to the clearing actions.

Survey and handling protocols have been designed to minimise the impacts to the Bilby during the pre-clearance surveys. These protocols are detailed in Appendix B.

Only the suitably qualified ecologist will be responsible for trapping and handling animals. A suitably qualified ecologist would have sufficient experience undertaking pre-clearance fauna surveys, fauna relocation, and handling of Greater Bilby. The ecologist would hold all appropriate licences with DPaW (Ethics approval, regulation 15 and/or regulation 17) and be able to operate safely with the construction team. The ecologist would be the only person responsible for the handling of any fauna including the Greater Bilby.

4.6.2 Night work limitations

Bilby are a nocturnal species and typically will not emerge from a burrow until well after dark. It is anticipated that this Project will not require any night work for road construction activities. However, if night work is proposed then the following protocols need to be adhered to:

- A suitably qualified ecologist will undertake a 100 metre buffer search around the proposed work corridor identifying any active bilby burrows
- If active burrows are found within 50 meters of the road no night work is to be undertaken within 100 meters either side of that location along the work corridor (day work is permitted)
- If an active burrow is found between 50 and 100 meters of the road then works can be undertaken but monitoring of the burrow established via cameras and prints (activity) to establish if the individual/s are impacted
- If deemed that Bilby individuals are impact works are to stop and revert to day operations. If no impacts are perceived then operations to continue as normal, following but with the restrictions outlined here. The following points also need to be considered:
  - Minimum staff and vehicles used within the work corridor to reducing disturbance
  - Work restricted to set areas reducing vehicle movements
  - Night lighting restricted to work corridors (lights positioned high pointing down not across or angled) and not pointing into the vegetation reducing disturbance
  - Where possible reduced or muffled reverse beacons to reduce disturbance
  - A register set up for employees to record any observations of active Bilby in the night. This will include rough area (a GPS point preferred), time, direction and any other observations made.

4.6.3 Weed management

Weed management will follow methods stipulated in the Main Roads Revegetation and pit management plans and RCC 2005.

Weeds are among the most serious threats to Australia's natural environment and primary production industries (Australian Government 2013). Weeds can be exotic or native species that colonise and persist in ecosystems in which it they did not previously exist (Australian Government 2013). Weeds create major environmental impacts including resource competition and prevention of seedling recruitment of native plant species, alteration of geomorphological and hydrological cycles, changes in soil nutrients, fire regimes and the abundance of indigenous fauna, and genetic changes. Weeds are potentially dispersed through the construction of roads (RCC 2005).

Management aspects of weed control will include Identification, training, effective control techniques and will be incorporated into the construction phase of the Project. This will include vehicle hygiene and wash down protocols, restrictions to the movement of soil and vegetative materials from weed contaminated areas to non-weed contaminated areas.

4.7 Post- construction phase

Many of the impact management measures that are applied in the post-construction or operational phase of the Project are implemented during the design phase. Table 4 details the continuing impact management efforts for the Project.

Table 2 Impact management - design phase.

Management actions	Performance indicators	Monitoring	Responsible position for each action
Management objective - avoid and minimise impacts to the Bilby			
Limit size of Project foot print The clearing of vegetation and disturbance to habitat will be strictly limited to the smallest possible Project footprint. The extent of this clearing will be clearly detailed in documentation to support the construction phase. Bilbies will benefit because less habitat will be lost.	Design clearly identifies alignment and proposed clearing extent.	Design documentation to include alignment and proposed clearing extent.	MR Project Managers. MR Principle Design Engineers. MR Survey and Mapping Managers.
Fauna underpasses Incorporate fauna underpasses where practical within the design. Fauna underpasses are known to facilitate movement and maintain connectivity between habitats on either side of roads (QMRD 2002, 2010). Additional details are presented in section 4.5.1.	Three fauna underpasses will be incorporated into the culverts at identified Bilby use areas while an additional nine culverts will be positioned along the alignment primarily for drainage purposes but could be utilised by Bilby as required. Fauna underpasses will be built to facilitate Bilby movement, and recommended drainage design.	Design documentation to include location of underpasses and detail specifications	MR Project Managers. MR Principle Design Engineers. MR Survey and Mapping Managers.

Educational signage Signs along the road educating motorist to the presence of Bilbies may reduce the incidence of road kill. Signs will be placed within 1 km of major intersections where additional traffic enters the road. An example of a Bilby road sign (in Shark Bay Western Australia) is shown here. 	Signs are positioned along the road at every appropriate point.	Location of signage will be identified as part of the design. Signs will be installed prior to the finalisation of the Project and checked off by Contract managers.	MR Project Managers. MR Principle Design Engineers. Construction Contractors
Planning for fauna clearance and Bilby relocation During the construction phase Bilbies will be removed from the direct clearing path (as detailed in section 4.6.1). Planning for this will take place in the design phase to ensure the personal and equipment required is deployed to site ahead of schedule.	Obtain regulation 17 and regulation 15 licences from DPaW and seek clarification on the need for approval from an Animal Ethics Committee. Ensure suitably qualified Ecologist and MR Environmental Officers are available and appropriately informed for the Project. Preparation of equipment, materials and personnel for the artificial Bilby Burrows (detailed in Appendix B).	Monitoring of progression of permits and preparation will be undertaken by the MR Environmental Officer.	MR Project Managers. MR Environmental Officers Suitably qualified Ecologist[2]

[2] Suitably Qualified person would have experience in Fauna handling, hold all appropriate licence with DPaW (Ethics approval, regulation 15 and/or regulation 17) and by able to operate safely with the construction team.

.

Table 3 Impact management - construction phase.

Management Actions	Performance indicators	Monitoring	Responsible party
Management objective - minimise and manage impacts to the Bilby during construction of the road.			
Site inductions for operators/ educate operator Main Roads has documented the need for clear communication and education of environmental issues during road construction works. Site inductions will take place for all Project staff and contractors to highlight to potential risks to the Bilby and the broader environment. Any animals disturbed by works will be allowed to leave the site before any further works occur. Removal of any fauna from the Project area will only be undertaken by a designated and suitably qualified person. No native fauna (including venomous snakes) will be deliberately impaired or killed by construction personnel. No personnel will be permitted to feed or interact with native fauna while at the Project area.	No significant negative[3] interactions with Bilbies attributable to construction works. The Construction contractor(s) to report negative interactions with Bilbies to Main Roads within 24 hrs of incident.	Monitoring of all fauna interactions during construction will be undertaken by the MR Environmental Officer through: • Project personnel will be required to report any environmental incidences as per the Handbook of environmental practice (RCC 2005) • Any Bilbies injured or killed during the construction phase of the Project will be reported to the MR Environmental Officer as soon as practical who will then report the incident to DPaW Broome office.	MR Project management. MR Contract Managers. Construction contractors. MR Environmental Officers.

[3] Negative impacts include attracting, trapping, injuring and/or killing Bilbies.

Manage clearing extent The clearing of vegetation and disturbance to habitat will be strictly limited to the smallest possible Project footprint The extent of this clearing will be clearly communicated in documentation and accurately demarcated on-ground - Appendix B – Section 2.1.	All clearing and disturbance is within the pre-determined area as per the final design.	The clearing alignment will be monitored through: • Pre-start communication on details of area to be cleared that day. • Regular checks of the demarcation of clearing boundaries on the ground.	MR Contract Managers. MR Survey and Mapping Managers. Construction contractors. MR Environmental Officers.
Pre-construction fauna clearance. The details of the Pre-construction fauna clearance program are detailed in Appendix B – Section 2.2. All fauna trapping, searches and relocations will be undertaken by an experienced and appropriately licenced Ecologist.	No significant negative interactions with Bilbies attributable to construction works.	Results of all Fauna trapping, searches and relocations will be reported to the MR Environmental Officer and DPaW as required under regulation 17 and regulation 15 licences.	MR Project management MR Contract Managers. Construction contractors. MR Environmental Officers Suitably qualified Ecologist.
Burrow excavation Burrow excavation is to occur for all burrows active or otherwise within the Project Area. The protocols for burrow excavations are detailed in Appendix B – Section 2.3.	No significant negative interactions with Bilbies attributable to construction works.	Results of all burrow excavations will be reported to the MR Environmental Officer and DPaW as required under regulation 17 and regulation 15 licences.	MR Environmental Officers Suitably qualified Ecologist.
Relocation of Bilby The relocation of a Bilby commences from the time of capture and is completed when the Bilby is released into its new location. The protocols for Bilby relocation are detailed in Appendix B – Section 2.4.	No significant negative interactions with Bilbies attributable to construction works.	Results of all relocations will be reported to the MR Environmental Officer and DPaW as required under regulation 17 and regulation 15 licences.	MR Environmental Officers Suitably qualified Ecologist.

Monitoring of relocated Bilby To gauge success of the relocation of Bilby a monitoring program is required to assess its usefulness, and gain information to inform future Project in the region. The protocol for the monitoring of Bilby at release sites is detailed in Appendix B – Section 2.8.	No significant negative interactions with Bilbies attributable to construction works.	Results from the monitoring program of the release sites and all relocations will be reported to the MR Environmental Officer and DPaW as required under regulation 17 and regulation 15 licences.	MR Environmental Officers Suitably qualified Ecologist. MR Project management
Fire management Fire management during construction will follow methods stipulated in the Main Roads Revegetation and Pit Management Plans (MRWA 2007) and RCC 2005.	No fires are started through construction activities.	During construction, the work areas will be regularly inspected to access the implementation of the Main Roads Revegetation and Pit Management Plans.	MR Project management MR Contract Managers Construction contractors. MR Environmental Officers
Limitations of Night Work To reduce the likelihood of direct Bilby mortality from construction plant, construction work should not take place at night – Section 4.6.2.	No significant negative interactions with Bilbies attributable to construction works.	The Construction manager will ensure that night works are not conducted. Protocols for undertaking night work are outlined in Section 4.6.2 if this scenario is unavoidable.	MR Project management. MR Contract Managers. Construction contractors. MR Environmental Officers.
Weed Management Weeds are potentially dispersed through the construction of roads (RCC 2005). Various management aspects of weed control will be incorporated into the construction phase of the Project and these are detailed in Section 4.6.3 .	No new weed infestation associated with construction works.	Visual inspections for weed infestation shall be undertaken by MR Environmental Officer as part of routine site environmental inspections, including prior to and after clearing in any area. Monitor for establishment of new weed species.	MR Project management MR Contract Managers Construction contractors. MR Environmental Officers
Borrow pit management Borrow pits will be used to obtain soil for formation of the road during the construction phase. These	No significant impacts (erosion, weed dispersal and un-permitted	Visual inspections for borrow pit management undertaken by MR Environmental Officer as part of routine site environmental inspections.	MR Project management. MR Contract Managers.

pits will be managed in accordance with the Main Roads Environmental Guideline Pits and Quarries (MRWA 2007). These guidelines include recommendations on minimising the area to be disturbed, utilising existing tracks for access, weed control, how best to utilise top soil, erosion control and the rehabilitation procedure and monitoring. The management of borrow pits will extend into the post-construction phase in terms of: • On-going weed control as per the Main Roads Revegetation and pit management plans and RCC 2005 • Monitoring of weeds and erosion.	clearing) to result from construction.	Compliance with guidelines will be monitored by MR Environmental Officer.	Construction contractors. MR Environmental Officers.
Management of impacts from introduced fauna To ensure the impacts from introduce fauna species are not increased during the construction phase of the Project: • No pets, traps or firearms will be allowed on the Project area • Site personnel will be encouraged to record any sightings of native or feral fauna on the Project area • No personnel will be permitted to feed or interact with native fauna while at the Project area • All waste produced on site will be appropriately disposed of and stored in secure receptacles to prevent access by	No increase of impacts from introduced fauna to result from construction.	Compliance with this management plan will be monitored by MR Environmental Officer.	MR Contract Managers. Construction contractors. MR Environmental Officer.

native and introduced fauna. Waste will be collected, transported and disposed of by an appropriately licensed contractor on a regular basis.			

Table 4 Impact management - post-construction (operational phase).

Management Actions	Performance indicators	Monitoring	Responsible party
Management objective - minimise and manage the ongoing impacts to the Bilby from the road.			
Rehabilitation of borrow pits and access tracks Rehabilitation of borrow pits and access tracks in the post-construction phase will follow methods stipulated in the Cape Leveque Road Upgrade Revegetation Management Plan July 2014 (GHD 2014).	See Cape Leveque Road Upgrade Revegetation Management Plan July 2014 (GHD 2014).		
Maintenance of underpasses The ongoing effectiveness of the fauna underpasses will require regular maintenance which will be conducted in conjunction with other road maintenance activities; this will involve: • Ensuring the underpass is not blocked or impeded • Ensuring the fences (where erected) associated with the underpass are in working order	Underpasses are maintained as functional for the life of the Project.	Maintenance of the underpasses (culverts) would be undertaken least bi-annually, and preferably before and after the wet season (end of October and end of March).	MR Project management MR Contract Managers MR Environmental Officers MR Regional works and maintenance officers
Monitoring of Bilbies A post construction survey for the Bilby will be undertaken within 12 months after completion of the road works within the known and potential habitats documented in the targeted survey	Persistence of the Bilby within the broader area	Bilby surveys in the area will be undertaken annually for 5 years and monitoring will include: • Assessment of the level of use of the	MR Project management and in accordance with relevant EPBC and DPaW/ EPA standards and in consultation with a Suitably qualified Ecologist

report (GHD 2013). The aim of the survey would be to determine the persistence of the Bilby within the broader area and record the level of use of underpasses. This monitoring program would contribute to the body of knowledge about the species in the region, which in turn could contribute to species conservation. The monitoring program may be considered as part of an offsets package.		fauna underpasses. • Assessment of the presence of Bilbies within 500 m of the road. • Five years is recommended so that survey results can account for temporal and spatial shifts in population demographics (there may be re-colonisation of the road side habitat when construction phase is complete)	

5. References

AECOM (2010). James Price Point LNG Precinct Access Road Environmental Impact Assessment and Environmental Management.

Australian Government ; National Health and Medical research Council 2004. (Australia Government 2004)7th edition of the *Australian code of practice for the care and use of animals for scientific purposes*

Department of Sustainability, Environment, Water, Population and Communities. 2013. *Macrotis lagotis* in Species Profile and Threats Database, Department of Sustainability, Environment, Water, Population and Communities, Canberra. http://www.environment.gov.au/sprat.

Department of Environment, Water, Heritage and the Arts 2009, (DEWHA 2009) *Matters of National Environmental Significance, Significant Impact Guidelines 1.1*, Commonwealth of Australia.

DEWHA 2008; Van der Ree, R., Clarkson, D., Holland, K., Gulle, N., Budden, M., 2008. *Review of Mitigation measures used to deal with the issues of habitat fragmentation by major linear infrastructure* (DEWHA 2008). Report for Department of Environment, Water, Heritage and the Arts 2008,

Dorrance MF, Savage PJ, Huff DE 1975 Effects of snowmobiles on white-tailed deer. Journal of Wildlife Management 39, 563-569.

Environmental Protection Authority (EPA) and Department of Environment and Conservation (DEC) 2010. (EPA & DEC 2010) Technical Guide, Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment. Technical report for Environmental Protection Authority and Department of Environment and Conservation.

Forman, R. T. T. and Alexander, L. E. 1998. Roads and Their Major Ecological Effects. Annual Review of Ecology and Systematics 29, pp. 207-231

Forman RTT, Reineking B, Hersperger AM. 2002 Road traffic and nearby grassland bird patterns in a suburbanizing landscape. Environmental Management 29, 782-800.

GHD (2013). Report for Cape Leveque Road Targeted Greater Bilby Assessment. Main Roads WA, Kimberley.

GHD (2007a). Report for Broome to Cape Leveque Road (Stage 3: SLK 12.7 102.6). Environmental Impact Assessment and Environmental Management Plan. Main Roads WA, Kimberley.

GHD (2007b). Report for Broome to Cape Leveque Road (Stage 3: SLK 12.7 - 102.6). Environmental Impact Assessment and Environmental Management Plan, November 2007 – Field Surveys and Desktop Assessment April 2012 – Updated Desktop Assessment. Main Roads Western Australia.

Main Roads Western Australia (MRWA) 2005 (RCC 2005) Handbook of Environmental practice for road construction and maintenance work. Roadside Conservation Committee Western Australia. First Edition, 2005.

MRWA 2012 bhttp://mianroads.wa.gov.au/buildingroads/tenderpreparation/specifications/pages/specifications.aspx accessed on 06/03/2013

Pavey, C. (2006). *National Recovery Plan for the Greater Bilby Macrotis lagotis*. Northern Territory Department of Natural Resources, Environment and the Arts.

Queensland Main Roads Department, 2002; (QMRD 2002) *Fauna sensitive road design, Volume 1; Past and existing Practices*, Queensland Main Roads Department, 2002; 2002

Queensland Main Roads Department, 2010. (QMRD 2010) *Fauna sensitive road design, Volume 2; Preferred Practices*. Queensland Main Roads Department, 2010.

Reijnen R, Foppen R, ter Braak C, Thissen J 1995. (Reijnen *et al* 1995) *The effects of car traffic on breeding bird populations in woodland III. Reduction of density in relation to the proximity of main roads.* Journal of Applied Ecology 32, 187-202.

Reijnen R, Foppen R, Meeuwsen H 1996. . (Reijnen *et al* 1996) The effects of car traffic on the density of breeding birds in Dutch agricultural grasslands. Biological Conservation 75, 255-260.

RTA 2009; Carbery, K. Use of Fauna passage structures on RTA roads; Summary report. Roads and Traffic Authority, Surry Hills, NSW. 2009.

Rudolph. C, Burgdorf S, Conner. R, Schaefer. R. 1999. Preliminary evaluation of the impact of roads and associated vehicular traffic on snake populations in eastern Texas. (Eds GL Evink, P Garrett, and D Zeigler) pp. 129-136. (Florida Department of Transportation: Tallahassee).

SKM (2012). Browse Bilby Review, Consolidated Information Relating to the Occurrence of the Bilby (*Macrotis lagotis*) in the Vicinity of the Browse LNG Precinct and Broadly on the Dampier Peninsular.

Schaub, A., Ostwald, J., and Siemers, B. M. (2008). Foraging bats avoid noise. The Journal of Experimental Biology 211, 3174-3180.

Southgate, R. (2012). Peer review of the Browse Bilby Review, a report detailing the consolidated information relating to the occurrence of the Bilby *Macrotis lagotis* near the proposed Browse LNG Precinct (close to James Price Point) and more broadly on the Dampier Peninsula. By Envisage Environmental Services.

Appendices

Appendix A Figures

Appendix B Cape Leveque Road - Greater Bilby Handling and Relocation Protocols

Main Roads

Cape Leveque Road

Greater Bilby Relocation Protocol

October 2014

Table of contents

1. Introduction 1
   - 1.1 Guiding documents 1
   - 1.2 Justification for approach 1
   - 1.3 Summary of protocols 2
   - 1.4 Scenarios resulting in injury to animal 5
2. Handling and Relocation Protocols 5
   - 2.1 Demarcation of clearance area 5
   - 2.2 Site survey protocol 5
   - 2.3 Relocation and handling protocol 10
   - 2.4 Release of Greater Bilby into new sites – Protocol 13
   - 2.5 Data recording 14
   - 2.6 Monitoring programs for relocated fauna 15
3. References 18

Table index

Table 1. Summary of Greater Bilby Protocols for handling and relocation 3

Table 2. Step by step guide for Protocol 2.2.1 - Pre-clearance ground truthing 7

Appendices

Appendix A - Artificial burrow design

1. Introduction

This document is the Greater Bilby Handling and Relocation Protocol for the upgrade of the Cape Leveque Road (straight line kilometre (SLK) 25.00 to SLK 102.6) in the Shire of Broome. The purpose of this document is to detail the management commitments that Main Roads will implement to address impacts to the Greater Bilby during the construction and post-construction phase of the Project including:

- Greater Bilby burrow excavation protocols including search and excavation procedures when lactating females are captured
- Relocation protocols, including protocols for when lactating Greater Bilby females are captured
- Monitoring programs for relocated fauna

The aim of this Protocol is to avoid where possible, then minimise direct impacts to the Greater Bilby during the construction phase of the Project.

The information presented in this document has been prepared in conjunction with the Greater Bilby Management Plan (GHD 2014a) (GBMP) and addresses the key points outlined in the Department of Environmental Regulation (DER) letter (reference CPS 6078/1) to Main Roads regarding the need for management commitments to address impacts to the Greater Bilby.

1.1 Guiding documents

This relocation protocol has been developed with reference to several documents and guidelines including:

- The Australian Code of Practice for Care and Use of Animals for Scientific Purposes 2004 (8th edition)
- Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment (EPA and DEC 2010)
- Department of Parks and Wildlife (DPaW) Standard Operating Procedure (SOP) 9.2; Cage traps for live capture of terrestrial vertebrates (DEC 2009a).

1.2 Justification for approach

This protocol describes the methods to relocate individual Greater Bilby from the Project construction area immediately prior to construction. GHD Ecologists have extensive experience with trapping, translocation and relocation of the Greater Bilby and similar species. This knowledge has also been incorporated to this relocation protocol.

1.2.1 Translocation of Bilbies

There is no current literature available presenting the methods or outcomes of pre-fauna clearance undertaken for the Greater Bilby in road construction projects. However, Greater Bilby have been trapped and translocated to successfully establish populations in numerous conservation Projects around Australia including:

- Scotia Sanctuary (Western New South Wales)
- Arid Recovery (Roxby Downs, South Australia)
- Peron National park (Shark Bay Western Australia- Project Eden)
- Currawinya National Park (Central Queensland)

- Lorna Glen (Western Australia).

1.2.2 Relocation of similar species

The Southern Brown Bandicoots (*Isoodon obesulus*) (a similar species to the Bilby) have been relocated many times in the Perth area during road construction projects (including the recent Mandurah Entrance Road, Gateway Project, Roe Highway 7 and Forrest Highway). Post release monitoring of relocated Southern Brown Bandicoots has shown persistence at some sites (Harris, et al 2010).

Based on the previous successful translocations with Greater Bilby and relocations with Southern Brown Bandicoot, it is reasonable to predict that relocating Greater Bilby into adjacent habitat will not cause appreciable impacts to the species.

For the purpose of this protocol the following definitions are used:

A translocation is a process by which a species is transported and released into a new area of habitat, often where the species has previously occurred and has become locally extinct or occurs in low numbers.

A relocation of a species does not involve removing individuals from the current population extent and the distance between capture site and release site is likely to be within the individuals home range.

Where an active burrow is in the direct path of construction and trapping has occurred it will be hand excavated, animal caught (if present or not already trapped) and relocated. The below sections describe the process in greater detail.

1.3 Summary of protocols

Table 1 provides a summary of the protocols to be implemented, the timing, responsibilities and reporting requirements. The Table also provides a quick reference guide to the various aspects of the protocols, and next steps to be undertaken should a protocol be implemented.

Roles and responsibilities

The implementation of the Greater Bilby Protocol is reliant on a number of key roles including the following:

Construction Contractor – the construction contractor will provide the necessary information needed regarding the timing of the project.

MR Site Environment Officer – the role of the site environment officer is to assist the ecologist where needed and ensure all record keeping is maintained and provided to Main Roads and the relevant authorities where appropriate.

Ecologist – suitably qualified ecologist with experience undertaking pre-clearance fauna surveys, fauna relocation, and handling of Greater Bilby. The ecologist would hold all appropriate licences with DEC (Ethics approval, regulation 15 and/or regulation 17) and be able to operate safely with the construction team. The ecologist would be the only person responsible for the handling of any fauna including the Greater Bilby.

Table 1. Summary of Greater Bilby Protocols for handling and relocation

Protocol / aspect	Report section	Timing	Responsibility	Reporting requirements	Notification	Next steps
Demarcation of clearance area	2.1	Pre-construction before clearing	Site Environment Officer and Construction Contractor	Yes	Inform Ecologist	As soon as the area is demarcated then commence site survey protocols – 2.2.1
Site survey protocol						
Pre-clearance ground truthing	2.2.1	Pre-construction before clearing	Suitably qualified ecologist	Yes – section 2.6	Inform Site Environment Officer, Construction Contractor and Main Roads	If burrows are located the implement protocol - 2.2.2, then 2.3.1
Pre-clearance trapping program	2.2.2	Pre-construction before clearing	Suitably qualified ecologist	Yes – section 2.6	Inform Site Environment Officer, Construction Contractor and Main Roads	If Greater Bilby are captured then implement protocol – 2.4
Burrow excavation protocol						
Excavation guidelines	2.3.1	Pre-construction before clearing	Suitably qualified ecologist	Yes – section 2.6	Inform Site Environment Officer, Construction Contractor and Main Roads	If Greater Bilby are captured during excavation then implement protocol – 2.4
Relocation handling protocol						
Removing animals from traps	2.4.1	Pre-construction and during construction	Suitably qualified ecologist	Yes – section 2.6	Inform Site Environment Officer, Construction Contractor and Main	If Greater Bilby are captured during trapping then implement protocol –

					Roads	2.4.2 – 2.4.4
Hand restraint	2.4.2	Pre-construction and during construction	Suitably qualified ecologist	N/A	-	-
Storage and containment	2.4.3	Pre-construction and during construction	Suitably qualified ecologist	N/A	-	-
Transport and release	2.4.4	Pre-construction and during construction	Suitably qualified ecologist	Yes – section 2.6	Inform Site Environment Officer, Construction Contractor and Main Roads	If Greater Bilby are to be relocated to alternate site then implement protocol – 2.5.1 – 2.5.2
Release of Greater Bilby into new sites protocol						
Release site	2.5.1	Pre-construction and during construction	Suitably qualified ecologist	Yes – section 2.6	Inform Site Environment Officer, Construction Contractor, Main Roads and DPaW	-
Release of captured Greater Bilby	2.5.2	Pre-construction and during construction	Suitably qualified ecologist	Yes – section 2.6	Inform Site Environment Officer, Construction Contractor, Main Roads and DPaW	Following relocation of Greater Bilby to release sites monitoring protocols must be implemented – 2.7
Monitoring program – release sites						
Methods 1 and 2	2.7.1 – 2.7.2	During construction and Post-construction	Suitably qualified ecologist and Main Roads	Yes	Inform Site Environment Officer, Construction Contractor, Main Roads and DPaW	Pending outcomes of monitoring, implementation of site survey protocols may be required.

1.4 Scenarios resulting in injury to animal

1.4.1 Animals injured but euthanasia is not required

In circumstances where the animal is injured but the extent of injury does not warrant euthanasia then the animal will be gently restrained (for example in a clean calico bag within a sturdy cardboard box) and kept in a quiet dark location in an area less than 20 Degrees C (for example in an air-conditioned site office or in an air-conditioned car which must be kept running with air-conditioning on). As soon as possible the animal will be transported (in an air-conditioned car) to the closest wildlife career or Vet.

- Broome Vet - Frederick Street, Broome - (08) 9192 1319
- Broome Wildlife Care and Rescue - 0408 860 022.

1.4.2 Animal injured and euthanasia is required

Animals that are injured when captured will be assessed for level of injury and actions will follow the following Technical Guides:

- Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment. Technical report for Environmental Protection Authority and Department of Environment and Conservation (EPA & DEC 2010)
- 7th edition of the Australian code of practice for the care and use of animals for scientific purposes (Australia Government 2004).

2. Handling and Relocation Protocols

2.1 Demarcation of clearance area

Prior to clearing/ construction operations the Site Environment Officer and the Construction Contractor will mark out the clearing line and this will be checked by Main Roads to determine that it is clearly defined. The extent of this clearing will be clearly communicated in documentation and accurately demarcated on-ground.

2.2 Site survey protocol

Pre-clearance surveys will incorporate two steps: a pre-clearing ground truthing and a staged trapping program which will progressively move ahead of the clearing immediately prior to the clearing actions.

2.2.1 Pre-clearance ground truthing

The ground truthing will identify any burrows that are present within the clearing footprint in which will be targeted via the trapping program.

The Burrow will be assessed daily for five (5) days prior to clearing. Where prints are recorded at the burrow trapping for four (4) consecutive nights immediately prior to the clearing action must be undertaken. Where no prints or other Greater Bilby activity are recorded then the burrow will be excavated to ensure the burrow is not in use. Destruction of the burrow reduces the chances of Greater Bilby moving back between checking and clearing as well as identifies any other fauna species using the burrow. A GPS point will be recorded for all burrows and reported to Main Roads.

The ground truthing and clearing marking team (including the ecologist) will move in-front of the clearing operator by approximately 1 week to allow for full clearance of Greater Bilby incorporating a trapping element as required and excavation of burrows. If clearing is not undertaken within one week then the pre-clearing ground truthing will be repeated to ensure no Greater Bilby have moved into the operation area.

Where Greater Bilby activity is detected at the burrows a trapping regime will be employed as described in Section 2.2.2.

NOTE: - Once the corridor has been cleared, if any road construction activities are delayed for more than two (2) days then pre-clearance ground truthing must be repeated (following the procedure in Section 2.2.1). This is because Bilby are known to prefer freshly disturbed ground to dig burrows. The lack of disturbance via construction may allow Bilby to move back and utilise the site.

Table 2. Step by step guide for Protocol 2.2.1 - Pre-clearance ground truthing

Protocol task	Next steps
Step 1 - Ground truth the clearing footprint to identify any burrows that are present according to Protocol 2.2.1	If **no burrows** are found proceed with clearing see **Step 2** If burrows are found see **Step 3** However, if clearing does not occur within one week of the check then the site will need to be ground truthed again to ensure no use (repeat **Step 1**).
Step 2 - No Burrows found, clearing undertaken	Once the site has been cleared of vegetation if any road construction activities are delayed for more than two (2) days following site preparation works then pre-clearance ground truthing must be repeated (see **Step 1**).
Step 3 - Burrow/s are found	**If burrows are found** assess for use via visible prints. If prints / visible use **are not** recorded see **Step 4** If prints / visible use **are recorded** see **Step 5**
Step 4 - Burrow/s are found but not active	If located burrow is **deemed not active** proceed to Section 2.3.1, to excavate the burrow and clear the site of use.
Step 5 - Burrow/s are found and found active	If the located burrow is **deemed active** (via active prints present other visible use) proceed to the next protocol – Pre-clearance Trapping Program (Section 2.2.2).

Note: All tasks associated with this protocol must be performed by a suitably qualified ecologist

2.2.2 Pre-clearance trapping program

This section provides an overview of the trapping program for the Greater Bilby. It is recommended that the details of the trapping program, including the trap locations and sampling effort, timing, duration of the survey and design, be undertaken with regard to the Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment (EPA and DEC 2010).

The trapping program will occur immediately prior to clearing. Greater Bilby's are known to breed all year round when conditions are good, therefore if trapping is required it will possibly occur during a reproductive event. Given the potential for the Greater Bilby to breed all year round there is limited opportunity to avoid breeding events or plan construction phase around breeding seasons.

Trapping females with pouch young can increase the rate of death and / or injury, as the female can discard/evict their suckling young either in the trap or immediately after being released. This 'young –ejection' is a reasonably regular occurrence during marsupial trapping; experienced personnel will have the capacity to reduce the likelihood of it happening and avoid any permanent adverse impacts to individuals. Therefore, this protocol requires that the trapping program be undertaken by qualified personnel who have experience in trapping and relocating marsupials with young.

It is also recommend that trapping is avoided in extreme weather conditions (hot, cold or wet and/or strong winds) by planning ahead and monitoring long-range and daily weather forecasts.

Daily regime

Traps will be baited in the evening and left open over night to be checked early each morning (preferably prior to sun rise). They will then be closed during the day and reopened the following evening.

Trap type

It is recommended that wire cage traps (such as 'Sheffield' cage traps) with a treadle release mechanism (20 cm x 20 cm x 56 cm) are used for the trapping program, baited with universal bait (a mixture of peanut butter, rolled oats and sardines). Greater Bilby are known for being difficult to trap and hand excavating burrows is also required. See section 2.3 for excavating burrows.

Trap configuration

When a burrow is identified up to 20 cage traps will be utilised around the burrow entrance and surrounding habitat to try and capture the Greater Bilby. All areas of vegetation within the clearing footprint will be trapped, including all areas of woodlands, shrublands and grassland in association to a burrow. Only areas of open ground will be avoided. The location of each individual trap will be clearly marked with flagging tape and recorded via GPS to ensure the trap can be located quickly and accurately during the trap-clearing process.

Each cage trap must be covered (with thick shade cloth or hessian) and located within shady and protected area or covered with vegetation to minimise exposure (e.g. light, heat/cold, rain/water) of trapped animals. For additional advice on trap set up consult the DPaW SOP 9.2 Cage traps for live capture of terrestrial vertebrates (DEC 2009a).

Survey effort

The trapping program will be undertaken for a minimum of four nights immediately preceding the clearing action. At the completion of the trapping program the traps will be removed and any burrows excavated in accordance with section 2.3.1 burrow excavation protocol.

Greater Bilby live in a spiralling burrow which they dig up to 2 metres deep and generally in sandy soils. Typically Greater Bilby have multiple burrows within their home range and move between them as required following foraging resources. Greater Bilby burrows recorded by GHD (2013) were all in well drained sandy soils on open ground or within spoil heaps on the side of the existing track. Greater Bilby are known for being difficult to trap therefore excavating a burrow is recommended after trapping completed. Burrow excavation is to occur for all burrows active or otherwise. Reasons for excavating burrows include:

- If a burrow is active (presence of tracks) but no individuals have been trapped within the designated trapping period, the burrow requires excavating
- A lactating female has been trapped at a burrow with no juveniles present in the trap
- All burrows to be excavated to remove other species.

2.2.3 Excavation guidelines

No existing protocols can be found on the excavation of Greater Bilby burrows, however a number of DPaW SOP's can guide some of the processes involved in excavation including but not limited to DPaW SOP No. 9.6, Hand capture of wildlife (DEC 2009b), SOP 10.1, Animal handling/restraint using soft containment (DEC 2009c), SOP No. 10.2, Hand restraint of wildlife (DEC 2009d) and SOP No. 11.1 Transport and temporary holding of wildlife (DEC 2009e). The following protocols have been developed to assist in the capture of Greater Bilby (and other fauna) from within a burrow:

- Excavators will wear appropriate PPE including long pants, log sleeve shirt, eye protection, hat and gloves during burrow excavation to avoid injury
- Use blunt-nosed shovels or large garden trowels with caution
- Two individuals, each with a shovel is required
- To maintain sight of the burrow place a shovel (the handle) in/down the burrow entrance as far as possible
- Slice away the ceiling with the second shovel or trowel, remove sides and surrounding soils as required
- Continue to slide the first shovel down into the burrow chamber so the burrow is not lost during excavation
- Remove the soil with the second shovel or trowel as excavation proceeds and repeat
- Excavate the burrow slowly and carefully and stop often to see if a Bilby is within reach or the end of the burrow is visible (a torch maybe required). Be aware that other species maybe utilising the burrow
- Do not collapse the burrow ahead of the shovel or trowel inside the burrow. You will feel the shovel contact the other shovel with each stroke to avoid striking a Bilby. It may take up to several hours to excavate a Bilby burrow, depending on its length and other characteristics (i.e. roots, rocks)
- Always excavate the burrow to its absolute end

- If a fauna species is observed, identify the animal to at least group (i.e. snake, lizard, Bilby). The species then requires capturing as per the section on hand restraint. Hand capturing will be undertaken in line with DPaW SOP No. 9.6, Hand capture of wildlife (DEC 2009b).
- If a juvenile/s Bilby are captured and mother already captive then the juveniles will be reunited as soon as possible. This may involve direct insertion into the pouch and taping however this will be assessed at the time by the experienced zoologist. Additional information of this process is provided in SOP No. 14.1 Care of evicted pouch young (DEC 2009f)
- After excavating the burrow, fill it in the remaining hole
- Check the site the follow days up until clearing occurring as Bilby are known to burrow and dig in freshly disturbed areas. If no Bilby were captured at the burrow it could move back to the site over the period between excavation and the clearing process
- The excavation hole maybe large and up to 2 meters deep and classified as a confined space. Therefore the excavation will be dug not to create steep sides that may cause collapse points. A ramp will be dug for access at one end of the excavation. This potential confined space will be considered during safety preparation protocols.
- Note: Venomous species like snakes maybe present in burrows. The removal of these animals is discussed further in Section 2.4.

2.3 Relocation and handling protocol

The relocation of a Bilby commences from the time of capture and is completed when the Bilby is released into its new location.

2.3.1 Removing animals from traps

The techniques for removing animals from traps vary depending on the species involved and the experience and skills of the animal handler. It is recommended that animals be removed as efficiently as possible. The recommended guidance from the DPaW SOP 9.2 Cage traps for live capture of terrestrial vertebrates (DEC 2009a) states that animals will be encouraged to enter an appropriate handling bag for the species (see DPaW SOP 10.1, DEC 2009c) by placing the bag over the end of the trap and manipulating the door to the open position. Lifting cages with an animal inside will be avoided. Gentle encouragement via blowing on the animal, using light and dark or positioning of the animal handler's body toward the rear of the trap can help. Particular care will be taken for Bilby as they may eject pouch young if present (see DPaW SOP 14.1, DEC 2009f).

It is possible that a lactating female could be captured. This means that juveniles are either going to be in the cage with the mother or the juveniles were not trapped and have retreated down the burrow. If a female is captured and is lactating with no young present, the following will be undertaken:

- Secure the mother as per DPaW SOP 10.1, DEC 2009c
- Secure the mother into appropriate storage and containment (as per the heading storage and containment below)
- Between two people conduct two meter apart and diameter grid searches from the cage trap looking for any juveniles (more than likely the juvenile/s will be down the burrow). Disoriented young may want to not leave the mother and be hiding close by under grass tussocks or shrubs. If after a 20 meter diameter search (from the trap) no young area found undertake the following:

  - Inspect the burrow entrance for fresh prints (this may be difficult if the burrow is well used)
  - Proceed to dig up burrow to retrieve young as per section on burrow excavation
  - Once dug up, fill in if no juveniles found
  - If juveniles are found the size and number may determine when they are introduced back to the mother. This decision will be made by the experienced animal handler in line with DPaW SOP 10.1, DEC 2009c and DPaW SOP 14.1, DEC 2009f
  - Fill in the burrow once juveniles are removed
- If no juveniles are removed from the burrow after excavation then it is likely the young may naturally disburse. This means the young may have been close to disbursal age and moved on at will. The experienced animal handler may be able to gauge this by the size and elongation of the lactating females teats
- If the animal handler feels that these young maybe present in an area then all traps will remain open for an additional three (3) nights. Additional traps could be added to the immediate area where the female was captured because if the young return they are likely to investigate that trap/area first.

Venomous or dangerous animals such as snakes will be released with consideration given to the best possible escape route for both animal and personnel. The door can be propped open to allow the animal to leave when the animal is ready (DEC 2009a).

Collection of morphometrics

All interactions with animals captured during this relocation program will be humane and ethical. It is essential that the animal handler/s is experienced in working with Greater Bilby to ensure the relocation program present limited risks to the animals. The length of time spent handling animals will be restricted as much as possible. However to reduce the risk of death and injury to Greater Bilby (especially pouch young) it is essential to take some basic morphometric measurements of every individual captured. Traps will be checked prior to sunrise each day (or within 2 hours of sun rise at the latest). All individual Greater Bilby captured will:

- Immediately be removed from the trap into a soft handling bag, at this stage it is important to ensure there are no ejected pouch young in the trap or around the trap
- The sex of the animals will be the first thing checked and the animal will be contained within the handling bag during this process
- If the animal is a male then a general health check of the individual will take place looking for any signs of injury
- If the individual is a female with no pouch young then a general health check of the individual will take place including looking for any signs of injury and a diligent check of the trap and surrounds (including the bottom of the handling bag) for ejected pouch young will take place
- If the individual is a female with pouch young then the expert animal handler will consider the need to tape the pouch to prevent ejection during the relocation program (this will be based on a case-by case basis). In the instance where pouch young are ejected during the handling process the expert animal handler will consider options for re-inserting the young into the pouch or holding the young separately. The expert handler will know how to make this decision to achieve zero harm to the young with limited stress to the mother. This is also discussed further in DPaW SOP 14.1, (DEC 2009f).

After the basic morphometric have been checked the Greater Bilby will be stored and contained as described is section Storage and Containment. To ensure minimal stress to the animals they

will only be handled for as long as required to identify them and to collect any necessary measurements (usually no more than five minutes).

2.3.2 Hand restraint

If short-term restraint of animals is required during the trapping program (i.e. for transfer to a holding bag etc.) then it is recommended that the DPaW SOP 10.2 Hand restraint of wildlife be adhered to (DEC 2009d). This SOP provides general advice on suitable hand restraint techniques, however, training and supervision from experienced personnel in animal handling is required before a person may be considered competent. In the instance where Greater Bilby need to be transferred from bag-to-bag then an expert animal handler will be able to do this without the need for hand restraint.

Hand restraint will only be employed where absolutely necessary and it is unlikely that it would be required during this relocation program. Greater Bilby typically become still and appear less agitated and stressed when they are held or inspected in soft-dark handling bags (which ensure the animal is covered as much as possible). Furthermore, direct contact between handlers and the animals increase the risks of transferring oils and chemicals (such as those in sun-cream or insect repellent) to the animal.

If required, one of the recommended techniques for hand restraint of Greater Bilby is the two-handed hold, where both hands are used to hold the animal, usually one to restrain the head and the other to support the body and control the legs/tail. The head is held away from the body, and particularly the face, of the handler. It should be noted that Greater Bilby have fragile tails that can be broken or the skin sheath removed if roughly handled or handled by the tail (DEC 2009d).

If a female with pouch young is captured the expert animal handler will make decision on level of restraint and disturbance to that individual and young. More than likely, if the pouch young is secure within the pouch no handling would occur and animal go into storage. Where the pouch young is evicted then DPaW SOP 14.1, (DEC 2009f) will be followed.

During excavation of burrows particularly older systems a number of species could be encountered. Most of these species will be harmless (e.g. Northern Bluetongue, Black-headed Python), however some venomous snakes will also utilise burrows including Gwardar and Mulga Snake. Both these species are potentially dangerous to man and caution required when digging up a burrow. Additionally to remove these species from a burrow the handler will have been trained in venomous snake handling and have the appropriate equipment available (i.e. hoop bag, tongs and jig hook).

2.3.3 Storage and containment

All animals captured during the trapping program will need to be temporarily stored and contained until release. It is recommended that the soft containment methods described in the DPaW SOP 10.1 Animal handling/restraint using soft containment (DEC 2009c) be adhered to in order to ensure the appropriate soft containment method for the species of animal. Soft containment refers to the use of soft materials to contain the movement of animals to assist handling and restraint. It is recommended that clean large calico (or heavy cotton) bags be used for soft containment of the Greater Bilby (and other animals); ideally the bags will be dark in colour to reduce the amount of light stimulation to the animals.

The use of hessian bags for soft containment is not recommended as the hessian is known to irritate the eyes of many species. Once the animals are contained within the bags, the bags they will be stored in an area that is secured, dark, well ventilated, quiet and is less than 20°C. The animals contained within the bags will be stored individually within a crate or open topped

cardboard box so that any movement by the animals within the bag in contained (pet transport crates are ideal for this purpose).

Animals will not be held for longer than 12 hours unless it is absolutely necessary; if animals are to be held for longer than 12 hours they will be transferred into clean containment bags.

Where female Greater Bilby with pouch young are to be stored this will be done together to allow the infant to suckle as required.

2.3.4 Transport and release

It is recommended that captured animals in soft containment be transported to the appropriate release site previously identified in the region. The methodology and procedures for this ground transport are described in the DPaW SOP 11.1 Transport and temporary holding of wildlife (DEC 2009e), and will be adhered to. Animals will be transported within the cabin of a vehicle (i.e. not on the tray of a utility). The cabin of the transport vehicle will be below 20 degrees; particular care will be taken when stacking crates on top of each other and / or transporting animals in wagons where the air conditioning does not circulate to all parts of the cabin- additional ventilation may be required and shade may be required on windows to shelter the animals. Furthermore, when placing animals (within crates and bags) directly onto the floor of the cabin additional insulation will be layered on the floor to stop heat being transferred from gear box/ transmission, transfer-case and differential housing of the vehicle. (Even during short transfers radiant heat from vehicle's drive-train components has been known to kill animals during transport). The animals will be transported within the containment bags, within creates (as described the section Storage and Containment). Crates will be securely packed so they do not vibrate or move excessively during transport.

The release will take place within the pre-selected release site away from the edge of the habitat. The release will take place on dusk on the day that the animals were captured (that is, animals will be captured in the early morning, stored during the day, then released that evening).

2.3.5 Other species

Any species other than Greater Bilby's trapped in the cage traps will also be removed from the impact area and released following the appropriate DPaW SOPs.

2.4 Release of Greater Bilby into new sites – Protocol

2.4.1 Release site

The release site for Greater Bilby and other animals captured during the trapping program needs to be determined prior to the fauna inspection commencing. If applicable, consultation with the landholder of the release site regarding access and approval will be undertaken prior to the trapping program. The release site will be determined by an ecologist with appropriate knowledge and experience well before the relocation event. Key factors to be considered during the release site selection are:

- The release site will represent suitable habitat for the Greater Bilby
- The release site will not have extensive evidence of resident Greater Bilby (as establishment of new individuals will be more difficult where there is an established population)
- The release site will not have extensive evidence of feral predators (primarily cats, foxes and dogs)

- The release site will be within 1 km of the capture site so that the individual is not removed from its home range or its position in the local population
- The release site needs to be separated from the capture site to ensure that the Greater Bilby don't try to move back to their former home-range (which may result in the death of the animals by vehicle strike or predation).
- The release site will be larger than 10 ha (with a core area of 1 ha where artificial burrows are established) preferably with connectivity to other areas of habitat to facilitate establishment of the animals and allow for dispersal into other areas if suitable resources are not available
- The release site will have land tenure that ensures the habitat will remain intact for the foreseeable future
- Ideally the release site will be actively managed for conservation (i.e. with integrated pest management and fire control measures in place)
- Access to the release site must be approved by the landholder prior to the relocation event checked for physical/ logistical constraints (such as locked gates or over-grown tracks) prior to the relocation event
- The release site will have good access to allow on-going monitoring to occur
- The release site will have a series of artificial burrows established. The artificial burrows are a pre-dug burrow to a minimum of 1 metre deep (deeper if possible) dug at approximately 30 degrees. The hole is lined with a half cut PVC tube (35 to 45 mm PVC pipe diameter) into the ground so the roof of the hole is maintained and structurally sound
- A minimum of 6 artificial burrows within 1 hectare will be established at a release site. Artificial burrows will be created using the burrow design in Appendix A.

2.4.2 Release of captured Greater Bilby - new sites

When a Bilby is ready for release (late afternoon/early evening) the following protocols will be followed:

- An artificial Bilby burrow will be pre-selected as a release site (as described in the GBMP)
- The animal released into the burrow directly from the bag, the exception being that if a pouch young has been evicted then handling maybe required to re-deposit pouch young as per DPaW SOP 14.1, (DEC 2009f)
- A dark bag will be placed over the entrance of the artificial burrow and remain in place for 1 hour before removing. This will allow the Bilby to settle in the burrow
- Once the bag is removed after 1 hour the re location team leave the site to allow the Bilby to emerge in its own time
- A monitoring program will already be established and setup. This may involve cameras around the burrow and subsequent other burrows dug in the area to record activity of the relocated individual.

2.5 Data recording

2.5.1 Trapping and relocation

During the trapping and relocation program, the following data will need to be recorded:

- Location information of each trap
- All trapping data

- The species of animal
- The number of individuals caught
- The time and date
- The method of capture
- Morphometric data (including the sex of each individual Greater Bilby)

This information will be summarised and provided as a report to Main Roads.

2.5.2 Death or injury

Any deaths or injury to fauna during trapping program will be recorded and reported to the construction contractor and Main Roads. In the instance of death or injury to any animal captured during the program the relocation team will immediately assess to cause behind the injury/ or death and modify the procedures accordingly. If an effective way to eliminate the risk of additional deaths and injuries cannot be ascertained then the program will cease until the risk is addressed. Deaths and injuries will also need to be reported to DPaW under the condition of the Regulation 17 Licence as detailed under fauna returns.

2.5.3 Fauna returns

A condition of the Regulation 17 Licence to Take Fauna for Scientific Purposes requires that the licence holder submit fauna survey returns to the DPaW. This condition stipulates:

'Within one month of the expiration of this licence (or at such other time or times as the Director General may determine) the holder shall furnish to the Director General a return setting out in full detail the number of each species of fauna taken during the currency of the licence, the localities where the species was/were taken and the method of handling of such fauna and disposal of specimens. A copy of any paper or report resulting from this research will be lodged in due course with the Director General. In the case of consultants, a list of the fauna handled, the localities involved and a copy of the interpretive data prepared will be lodged.'

Following the completion of the Greater Bilby relocation program the contractor would be required to submit the fauna survey returns to the DPaW detailing all of the fauna species trapped during the trapping program. These returns must be submitted online to the following website: www.dec.wa.gov.au/fauna_returns.

Further information on the licensing requirements is available from the DPaW Wildlife Licensing Section.

2.6 Monitoring programs for relocated fauna

There are no examples of a Greater Bilby relocation program from road construction operation currently available. To gauge success of the relocation of Bilby a monitoring program is required to assess its usefulness, and gain information to inform future Projects in the region. Two methods are proposed to undertake monitoring of relocated Bilby.

Main Roads will commit to undertaking Method 1 (camera traps) as a minimum, and include Method 2 (radio-tracking) pending the outcomes of the pre-clearance trapping program. Camera traps as discussed in Method 1 would be used to compliment the radio-tracking program. Both methods would be undertaken at the release site where artificial burrows have been established within a pre-selected selected area. The methods are presented below:

2.6.1 Method 1

Method 1 employs non-evasive monitoring techniques including monitoring for prints and other signs of activity to establish presence. This method would incorporate 30 cameras traps to be deployed to monitor use around the release site:

- Sand pads will be established at each of the artificial burrows. Sand pads will be 2 x 2 meters (or a big as possible to fit into space). Sand pads will be checked daily and data recorded including prints present or other signs of activity (of all species), use of burrow and any evidence of digging activity
- Sand pads will be cleaned and smoothed after each check
- Assuming six (6) burrows - three cameras will be placed at each artificial burrow, one pointing at the burrow and the remaining two around it
- The remaining 12 cameras will be positioned around the 1 hectare release site. All cameras will remain un-baited so no predators are attracted into the site. Therefore captures of individuals will be opportunistic
- Cameras will remain operational for at least two weeks
- In order to identify individual Greater Bilby each animal will need be marked. To do this follow SOP No 12.9 Temporary marking of mammals, reptiles and birds (DEC 2009i)
- All data collected will be used to assess use of the area and artificial burrows and persistence if possible.

2.6.2 Method 2

Method 2 employs invasive monitoring including ground based radio-tracking devices to follow and locate Bilby in the land scape. This practice is widely used on Australian mammals including Bilby. Radio-tracking can be used to track movement, habitat use, activity patterns and survival of Bilby as described in greater detail in DPaW SOP No: 13.4, *Ground-based radio-tracking* (DEC 2009h). It involves attaching a radio-transmitter onto the neck or tail of the released individual, which emits pulses detectable by a receiver. The location of the animals can be calculated (without disturbing the individual) by triangulation of a set of directional signal records. The directional records of the subject animal can then be determined by using an antenna and located by homing in on the direction of the pulses.

By using this technique an animal can be kept under observation for long periods of time and its position in the survey area can be determined at regular intervals to determine survivorship and various aspects of its behaviour such as habitat use of burrow areas or daily movement patterns.

There are multiple variations of the type of tail and collar transmitters available and the most appropriate product will be selected based on consultation with experienced operators and approval by DPaW.

The attaching of radio-transmitters onto Greater Bilby needs to be undertaken by a suitably qualified ecologist who has previous experience in transmitters and requires specific approvals from DPaW. The following procedures will be followed:

- Approval from DPaW will be sought in the form of ethical approval and regulation 15 licence
- Prior to radio tracking the researcher will have all the appropriate gear including backups of transmitters, receivers, antennas, cables and batteries
- Knowledge of the area including accessibility, terrain, topography and landmarks

- Have all other general equipment ready and at hand (i.e. GPS, markers, notebooks, maps)
- On the day of capture of a Bilby fix the radio transmitter to the animal to be released as per DPaW SOP No: 13.4, Ground-based radio-tracking (DEC 2009h)
- Prior to release check that the unit is working and operational
- Release the animal as previously discussed into a pre-selected artificial burrow in the late afternoon or dusk. Cover the burrow with a dark cloth for 1 hour, remove and leave the site
- Commence radio tracking on day one after the relocation to avoid additional disturbances in the release area on the night of release. Operate system as per DPaW SOP No: 13.4, Ground-based radio-tracking (DEC 2009h)
- Conduct daily tracking every day for the first two weeks after release to ensure the individual has not moved back in to construction area
- Day-time radio tracking will aim to confirm the location of diurnal shelter points
- Conduct night time tracking at least every second night to ensure that the individual has actually moved (i.e. is not dead); this will not be necessary if a mortality function is included on the transmitter.
- Continue to radio track the animal/s for 2 weeks and then weekly until the construction phase is complete
- Bilbies need to be re-captured (employing the trapping protocols described above) to remove transmitters
- Compile all data and present to Main Road and assess data for inclusion into scientific community

3. References

Chambers, B and Bencini, R 2013, The Factors Affecting the Use of Fauna Underpasses by Quenda and Bobtail Lizards. Report to Main Roads Western Australia, October 2013.

Department of Environment and Conservation (DEC) 2009a, *Standard Operating Procedure (SOP) No. 9.2 Cage traps for live capture of terrestrial vertebrates*. Department of Environment and Conservation.

Department of Environment and Conservation (DEC) 2009b, *Standard Operating Procedure (SOP) No. 9.6, Hand capture of wildlife*, Perth, Department of Environment and Conservation.

Department of Environment and Conservation (DEC) 2009c, *Standard Operating Procedure (SOP) No. 10.1, Animal handling/restraint using soft containment*', Perth, Department of Environment and Conservation.

Department of Environment and Conservation (DEC) 2009d, *Standard Operating Procedure (SOP) No. 10.2, Hand restraint of wildlife*, Perth, Department of Environment and Conservation.

Department of Environment and Conservation (DEC) 2009e, *Standard Operating Procedure (SOP) No. 11.1 Transport and temporary holding of wildlife*, Department of Environment and Conservation.

Department of Environment and Conservation (DEC) 2009f, *Standard Operating Procedure (SOP) No. 14.1 Care of evicted pouch young*, Department of Environment and Conservation.

Department of Environment and Conservation (DEC) 2009g, *Standard Operating Procedure (SOP) No. 14.2, First Aid for animal*s, Perth, Department of Environment and Conservation.

Department of Environment and Conservation (DEC) 2009h, Standard Operating Procedure (SOP) No. 13.4, *Ground-based radio-tracking*, Perth, Department of Environment and Conservation.

Department of Environment and Conservation (DEC) 2009i, Standard Operating Procedure (SOP) *No. 12.9 Temporary marking of mammals, reptiles and birds*, Perth, Department of Environment and Conservation.

Ecologia-Environmental-Consultants (1995) Kwinana Freeway Wildlife Underpass Study Fauna Monitoring Program - Report to Main Roads Western Australia.

Environmental Protection Authority (2010) Technical Guide Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment EPA, Perth.

FerrAus, 2011, Report to support assessment under the Environment Protection and Biodiversity Conservation Act 1999, Referral 2011/6036. FerrAus Pilbara Project, Preliminary Documentation.

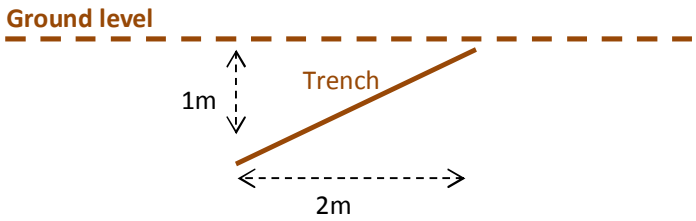
Harris, I. M., Mills, H. R. and Bencini, R. 2010, Multiple individual southern brown bandicoots (Isoodon obesulus fusciventer) and foxes (Vulpes vulpes) use underpasses installed at a new highway in Perth, Western Australia. Wildlife Research 37, pp.127–133.

Harris, I and Bamford, M, 2011, Roads and Wildlife; A Review of Purpose-Built Fauna Underpasses. Bamford Consulting Ecologists prepared for: City of Armadale, 10th July 2011

Appendices

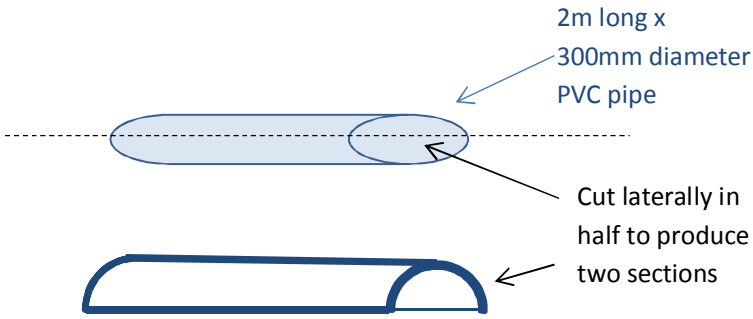
Appendix A - Artificial burrow design

Artificial Bilby burrow construction



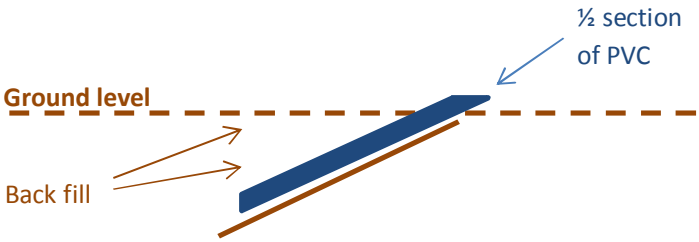
1. Dig a trench approximately 2m long that progressively gets deeper to approximately 1 m deep.

The trench only needs to be 300mm wide.



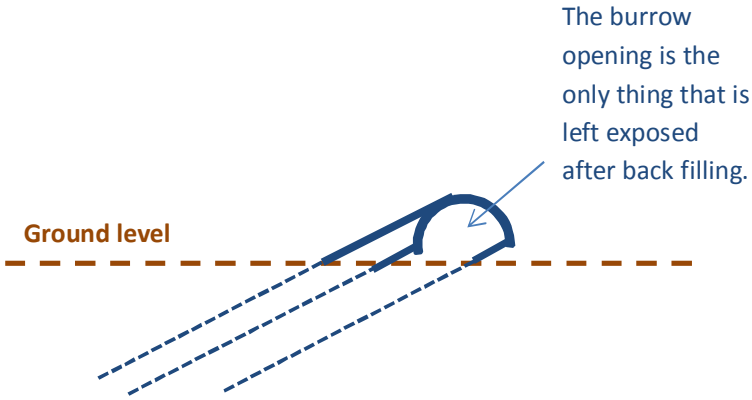
2. Cut a piece of 2 m long 300mm PVC pipe laterally to produce two half circle sections.

These sections should be pre- cut and available on site as required.



3. Burry the PVC pipe in the trench so that the pipe forms a roof and the dirt is the bottom of the burrow.

Make sure the top of the pipe is exposed above ground.



4. Back fill the trench on top of the pipe.

If Bilbies are captured during the pre-clearance trapping or during construction (and the individuals are suitable for re-location) then the Bilbies should be gently placed into an artificial burrow.

Burrows should be constructed as required.

Burrows should be made approximately 500m away from the point of capture, and away from the construction area.

Tools required on site;

Pre-cut PVC ½ sections

Post hole shovel

Mattocks

Crow bar

PPE

GHD

GHD House, 239 Adelaide Tce. Perth, WA 6004
P.O. Box 3106, Perth WA 6832
T: 61 8 6222 8222 F: 61 8 6222 8555 E: permail@ghd.com.au

© GHD 2014

This document is and shall remain the property of GHD. The document may only be used for the purpose for which it was commissioned and in accordance with the Terms of Engagement for the commission. Unauthorised use of this document in any form whatsoever is prohibited.

\\ghdnet\ghd\AU\Perth\Projects\61\31143\WP\143516.docx

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	G. Gaikhorst	C. Grabham		C. Grabham		25/07/2014
1	C. Grabham	D. Farrar		D. Farrar		16/10/2014

www.ghd.com

GHD

GHD House, 239 Adelaide Tce. Perth, WA 6004
P.O. Box 3106, Perth WA 6832
T: 61 8 6222 8222 F: 61 8 6222 8555 E: permail@ghd.com.au

© GHD 2014

This document is and shall remain the property of GHD. The document may only be used for the purpose for which it was commissioned and in accordance with the Terms of Engagement for the commission. Unauthorised use of this document in any form whatsoever is prohibited.

G:\61\31143\WP\143268.docx

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
2	G. Gaikhorst	C. Grabham		D. Farrar		27/07/14
3	C. Grabham	D. Farrar		D. Farrar		16/10/2014

www.ghd.com