Roads & Maritime

Microbat Management Plan Sections 1 and 2

Woolgoolga to Ballina Pacific Highway upgrade

September 2014

UPR	*Description*	*Date Issued*	*Issued By*	*Reviewed By*
2149-1049	Version 1	29/08/2014	VJS	AG, DSA, DGH
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Introduction

1.1 Project Overview and Background to the Plan

The Pacific Highway Upgrade Program is a joint commitment by the Australian and New South Wales governments to improve the standard and safety of the Pacific Highway between Hexham and the Queensland border.

The Woolgoolga to Glenugie Pacific (W2G) Highway upgrade project (referred to hereafter as W2G or the Project) is part of the broader Woolgoolga to Ballina Pacific Highway upgrade project, for which an Environmental Impact Statement (EIS) has been prepared (NSW Roads and Maritime Services, 2012). The Project was approved under the NSW *Environmental Planning and Assessment Act 1979* on 24 June 2014 and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* on 14 August 2014.

W2G extends over approximately 31 km from the northern end of the Sapphire to Woolgoolga Pacific Highway upgrade (S2W) to the Glenugie Pacific Highway upgrade. It is broken up into two sections as follows:

- Section 1 extends from the southern tie-in north of the Arrawarra interchange (Chainage 0) to Chainage 16,500 within the existing 3.4 km Halfway Creek Pacific Highway upgrade.
- Section 2 extends from Chainage 16,500 within the Halfway Creek Pacific Highway upgrade to the southern extent of the new northbound carriageway within the Glenugie Pacific Highway upgrade at Chainage 31,400.

This Microbat Management Plan relates to both Sections 1 and 2.

GeoLINK was engaged by the Arup Parsons Brinckerhoff Joint Venture (APBJV) on behalf of NSW Roads and Maritime Services (RMS) to undertake targeted microbat surveys of existing drainage structures (culverts and bridges) associated with the Project. As such, in accordance with Section 5.3.5 of the Threatened Mammal Management Plan (TMMP) (RMS, 2013), the survey results have triggered the requirement for a Project Specific Bat Management Plan which provides details regarding provision of artificial roosting structures, exclusion procedures prior to demolition works and monitoring procedures. Artificial roosting structures are only considered necessary for high or medium conservation/ habitat value drainage structures that require removal or disturbance as part of the Project. Low conservation/ habitat value drainage structures of similar value to those requiring demolition are locally common and/ or would be duplicated by culverts and bridges on the new highway upgrade. The categorisation of conservation/ habitat values was based on survey results in relation to potential microbat roosting habitat, species and evidence of usage present as well as representativeness of each drainage structure.

1.2 Pre-construction Surveys

Microbat surveys were originally undertaken by GeoLINK in November 2013. Large-footed Myotis has two breeding events per season in Northern NSW (Lloyd *et al*., 1999; Van Dyck and Strahan, 2008; Churchill, 2008). November was chosen to maximise detection of breeding activity as it coincides with the first breeding event of the season (Lloyd *et al*., 1999; Van Dyck and Strahan, 2008). A total of 71 culverts were surveyed within Section 1 in November 2013 and a total of 58 culverts (including the Bebo Arch crossing at Glenugie Creek) and two bridges (Halfway Creek Bridge and Wells Crossing Bridge) were surveyed within Section 2 in November 2013.

Upon completion of the November 2013 surveys, 34 drainage structures within Sections 1 and 2 were assigned to the high, medium or low-medium conservation/ habitat value categories. These 34 drainage structures were surveyed again on 11 February 2014, coinciding approximately with the second Large-footed Myotis birthing event of the breeding season.

Pre-construction winter surveys were recommended by Schulz (2013) as part of the TMMP peer review. These surveys aim to address seasonal variations in microbat roost behaviour and in particular, identify important winter roost sites (e.g. for threatened bentwing-bats). Winter (June to mid-August) surveys therefore targeted all identified drainage structures categorised in GeoLINK's summer 2013-14 surveys in the high, medium and low-medium conservation/ habitat value category, and low conservation/ habitat value drainage structures where evidence of microbat usage was recorded.

Based on the results of summer 2013-14 surveys, a total of 24 structures within Section 1 and 16 structures within Section 2 were identified as low (with evidence of microbat usage), low-medium, medium or high conservation/ habitat value and therefore re-surveyed in winter 2014. Following the winter 2014 surveys, the conservation/ habitat value of the surveyed drainage structures were re-assessed in order to re-assign the low-medium conservation/ habitat value category drainage structures into low or medium. This plan applies to four structures within Section 1 and four structures within Section 2 that were categorised as high or medium conservation/ habitat value following assessment of data collected during summer 2013-14 and winter 2014.

Characteristics of the high, medium and low conservation/ habitat value categories are provided in Table 1.1.

Table 1.1 Drainage Structure Conservation/ Habitat Value Categories

Conservation/ Habitat Value *Category*	*Criteria*
High	▪ Known to provide breeding habitat for threatened species (i.e. Large-footed Myotis); or ▪ Known to provide non-breeding roosting habitat for large numbers (ie. >50) of threatened species (e.g. known to support large numbers of bentwing-bats over winter); or ▪ Supports one or more of the federally listed Large-eared Pied Bat.
Medium	▪ Does not satisfy high conservation/ habitat value category; ▪ Provides non-breeding roosting habitat for small numbers (ie. <50) of threatened species; or ▪ Medium to large guano accumulations and/ or stains present indicative of the occurrence of moderate numbers of microbats or medium to long-term usage (threatened/ non-threatened status unknown); or ▪ Potentially suitable for breeding Large-footed Myotis. For example, access under bridge/ into culvert >500 mm diameter, presence of large cavities (e.g. >20 mm wide and >100 mm deep), directly adjacent to/ over open water, low inundation susceptibility; or ▪ Supports protected cavities providing good potential long term roosting habitat; however, no bats or evidence of roosting bats present; and/or ▪ In proximity to open surface water, however provides mainly exposed roosting opportunities (e.g. cavities <50 mm deep, or rough concrete), offering limited potential for breeding roosting; and/or ▪ Supports a breeding colony of non-threatened microbats.

Conservation/ Habitat Value *Category*	*Criteria*
Low	▪ Does not satisfy high or medium conservation/ habitat value categories; and ▪ Individual microbats or very small numbers of non-breeding microbats (e.g. <5) present; or ▪ Small guano accumulations and/ or stains present indicative of the occurrence of small numbers of microbats or short-term usage; or ▪ Provides mainly exposed roosting opportunities (e.g. cavities <50 mm deep, or rough concrete) offering limited potential for use as breeding habitat; or ▪ Not in proximity to open water. Roosting habitat of similar value locally is common and would be duplicated by culverts and bridges on the new highway upgrade.

1.3 Purpose and Objectives

This management plan outlines the proposed management measures to be implemented for the subject microbats and their habitat and provides a program for monitoring of the effectiveness of these measures. The objective of the management plan is to provide measures that minimise impacts to microbats associated with the Project. More specifically, the management plan aims to:

- reduce the potential for injury or death to microbats as a consequence of the proposed works by discouraging microbats from occupying the subject drainage structures at the time of the construction works;
- provide temporary alternative habitat for excluded microbats during the proposed works; and
- provide permanent replacement habitat within the drainage structures for microbats.

This Project Specific Microbat Management Plan details:

- Alternative roosting habitat designs, locations and timing of installation;
- Methods and timing of monitoring pre, during and post construction;
- Exclusion techniques and management; and
- Provisions for an Ecologist experienced in microbat management to provide detailed input that is specific for each drainage structure at the time of works during construction phases.

The plan covers pre, during and post-construction (operational) phases of the Project and applies to the eight drainage structures within Sections 1 and 2 that have previously been categorised as high or medium conservation/ habitat value structures.

1.4 Management Structures and Plan Updates

This management plan has been presented using an adaptive management approach based on firstly identifying specific goals for management, implementation of management measures followed by monitoring of the performance of these measures against the goals and identified thresholds. As a final step the monitoring would evaluate the effectiveness of the management measures using identified thresholds for performance and implementing corrective actions to improve mitigation where required.

To ensure the success of this approach the management goals presented in the plan have been based on the following SMART principles:

- Specific
- Measurable
- Achievable
- Results-based
- Time-based

This Microbat Management Plan has been prepared in consultation with RMS and the NSW Environment Protection Authority (EPA). General responsibilities for environmental management would be outlined in the project specific Construction Environment Management Plan (CEMP) and CEMP sub plans including the Flora and Fauna Management Plan (FFMP). These management plans would be prepared prior to the commencement of construction. RMS and the Contractor for this Project would be responsible for implementing the measures in this Microbat Management Plan and this would include the engagement of suitably qualified specialists to undertake and oversee surveys and monitoring activities where necessary.

2 Subject Species and their Roosts

2.1 Subject Species

Four target threatened species were identified in the TMMP and are listed in Table 2.1. Of these, the Large-footed Myotis (*Myotis macropus*) is the only target species known to utilise drainage structures as maternity roosting habitat.

Table 2.1 Target Threatened Microbat Species

Scientific Name	*Common Name*	*Legal Status*		*Roosting Habitat Requirement*	*Project Records**
		TSC Act	*EPBC Act*		
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	Typically requires sandstone escarpments (or occasionally volcanic rock types) to provide roosting habitat that is adjacent to higher fertility sites which are used for foraging. Roosting has also been observed in disused mine shafts, caves, overhangs and disused Fairy Martin (*Hirundo ariel*) nests. It also possibly roosts in the hollows of trees. The structure of primary nursery roosts appears to be very specific, ie. arch caves with dome roofs with indentations DoE (2014).	Not recorded. However, one record occurs within a 10 km radius of the Project (RMS, 2012).
Miniopterus australis	Little Bentwing-bat	V	-	Caves, tunnels, tree hollows, abandoned mines, stormwater drains, culverts, bridges and sometimes buildings (OEH 2012). Maternity colonies are restricted to specific maternity caves (predominantly limestone) (Van Dyck and Strahan, 2008).	Known from eight drainage structures in Section 1 and five in Section 2 (GeoLINK, 2014a, 2014b). No maternity roost sites are known or likely within the Project footprint. 221 records within a 10 km radius of the site (RMS, 2012).
Miniopterus schreibersii	Eastern Bentwing-bat	V	-	Caves are the primary roosting habitat, but also use derelict mines, storm-water tunnels, buildings and other man-made structures (OEH, 2012; Van Dyck and Strahan, 2008).	Known from two drainage structures within Section 2 (GeoLINK 2014b). No maternity roost sites are known or likely within the Project footprint.

Scientific Name	*Common Name*	*Legal Status*		*Roosting Habitat Requirement*	*Project Records**
		TSC Act	*EPBC Act*		
					20 records within a 10 km radius of the site (RMS, 2012).
*Myotis macropus**	Large-footed Myotis	V	-	Caves, mines, tree hollows, aqueduct tunnels and under bridges/ culverts and in dense vegetation (the latter in the tropics) in the vicinity of bodies of slow-flowing or still water (Van Dyck and Strahan, 2008).	One individual known from drainage structure 16 within Section 1 (GeoLINK, 2014a) and a larger colony from drainage structure 25 within Section 2 (GeoLINK, 2014b). 29 records within a 10 km radius of the site (RMS, 2012).

Notes:
TSC Act = NSW Government *Threatened Species Conservation Act 1995*.
EPBC Act = Australian Government *Environment Protection and Biodiversity Conservation Act 1999*.
V: Vulnerable under Schedule 2 of the TSC Act
Project records are based on review of RMS 2012, and GeoLINK 2014a, 2014b.

2.2 Microbat Roosting Habitat Features

Culvert roost features observed within Sections 1 and 2 include:

- Culvert cell joins: Ranged in habitat value from minor hold points providing exposed roosting opportunities, to deep protected cavities caused by cell dislodgment and subsequent erosion of road substrate above. Cell joins were present in most drainage structures.
- Culvert cell lift holes: Varied from minor hold points providing exposed roosting opportunities, to deep protected earth cavities. Present mainly in the larger (>500 mm diameter) reinforced concrete pipe (RCP) culverts and one reinforced concrete box culvert (RCBC); drainage structure 25.
- Rough concrete on the culvert obvert: Provide exposed roosting opportunities and were common mainly in RCBC.
- Presence of mud bird nests: Welcome Swallow (*Hirundo neoxena*) and mud dauber wasp nest may provide mostly exposed (non-breeding) roosting opportunities.

Bridge roost features included:

- Cavities between concrete planks/ segments: Provide habitat ranging from protected (though somewhat shallow) cavities to exposed roost points.
- Cavities around piers/ headstocks: Provide mainly exposed roosting opportunities.
- Rough concrete, concrete ledges and concrete angles: Provide exposed roosting opportunities.
- Cavity behind approach span: Provide culvert like roost features, with the concrete ledges and angles providing roost points.
- Blocked scuppers: approximately 100 mm diameter, approximately 500 mm deep, some angled, some vertical.

2.3 Subject Drainage Structures

Details of the subject drainage structures are provided in Table 2.2 and their locations are shown in Illustration 2.1.

Table 2.2 Subject Drainage Structures

Section	*Chainage*	*Reference No. (Identification)*	*No. of Cells*	*Width (RCBC only) (mm)*	*Height or Dia. (mm)*	*Length (m)*	*Feature Type*	*Action*	*Conservation/ Habitat Value*
1	13,310	46 (Boney's Creek)	2	3000	3000	18	RCBC	Replace	High
1	13,850	49	1	2400	2100	15	RCBC	Replace	Medium
1	15,950	66	3	3300	2400	41	RCBC	Retain	High
1	16,000	67	1	-	1200	40	RCP	Retain	Medium
2	20,665	25 (Halfway Creek Culvert)	4	3000	2400	15	RCBC	Replace	High
2	21,000	Halfway Creek Bridge	-	-	-	-	Bridge	Replace	Medium
2	29,360	32 (Bebo Arch)	1	9000	3000	26	ARCH	Extend	High
2	30,160	40	1	1500	1500	16	RCBC	Retain	High

As indicated above, five of the eight structures that have been assessed as high or medium conservation/ habitat value would be directly impact by the Project. The three drainage structures to be retained would be incorporated into the monitoring program to provide control sites. The distance of works to the drainage structures to be retained are as follows:

- Drainage structure 40: works located 660 m south.
- Drainage structure 66: works located 15 m south (works comprise a turn-around bay which would involve embankment work and sealing).
- Drainage structure 67: works located 80 m south (works comprise the same turn-around bay as noted above).

2.4 Impacts to Microbats

The Project is anticipated to have the following potential impacts on microbats:

- Loss of roosting and breeding habitat;
- Loss of foraging habitat and reduced prey abundance;
- Reduced breeding output;
- Habitat fragmentation; and
- Injury/ mortality to individuals from construction works.

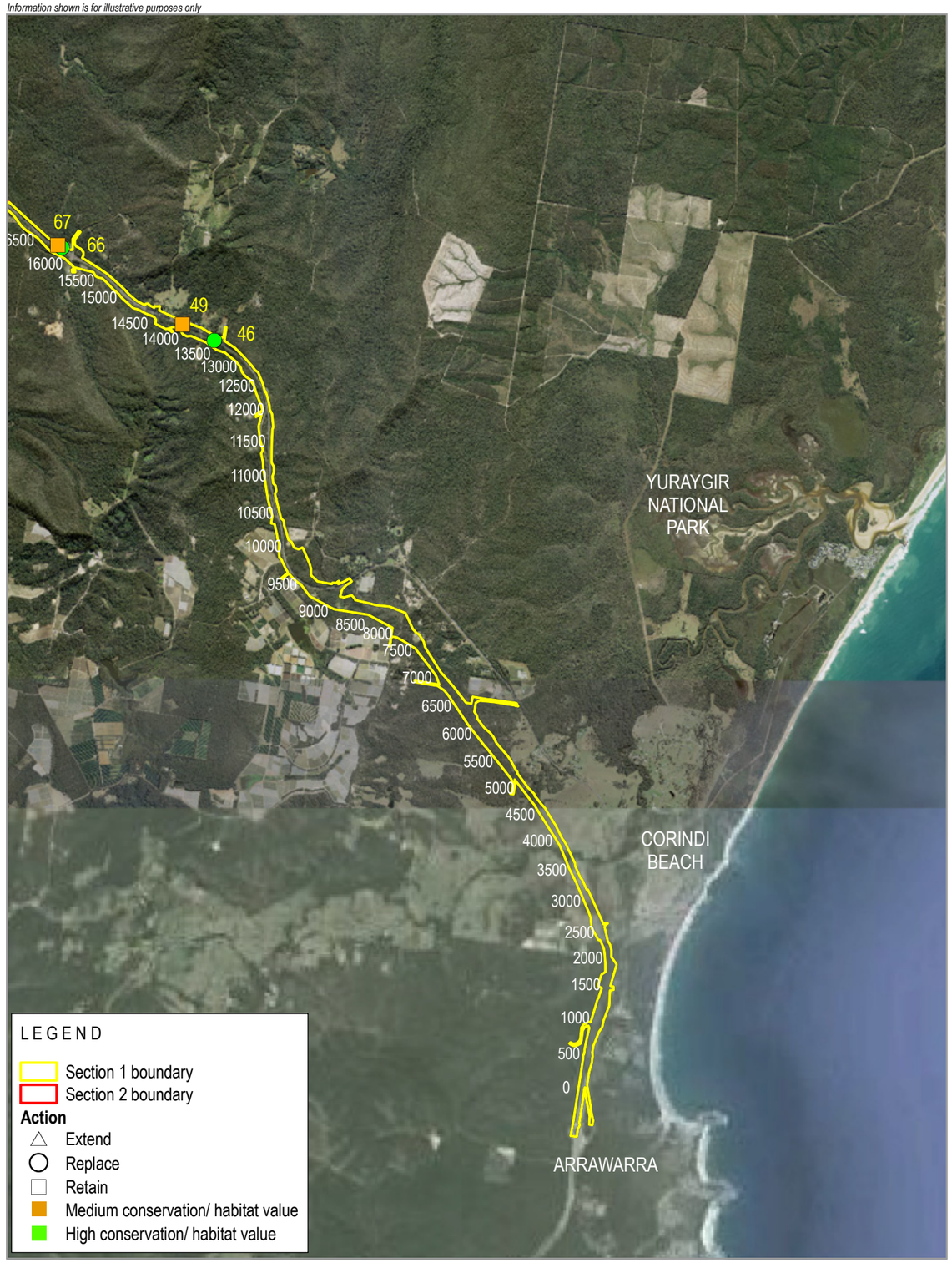
2.5 Goals for Management

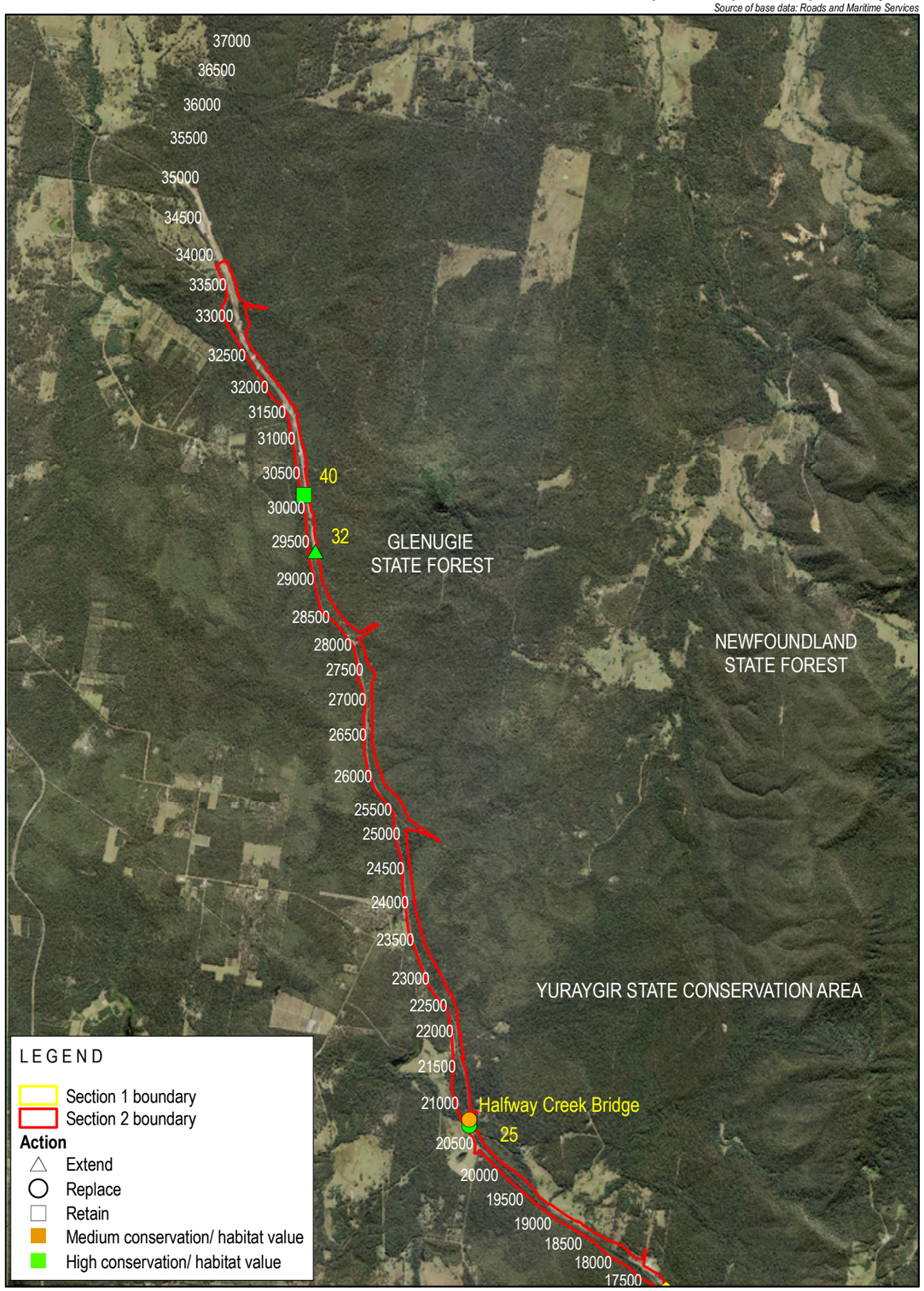
The main goals for management are as follows:

- Low number of injuries/ mortality to roosting microbats from construction activities;
- Provide replacement roosting habitat within the newly constructed drainage structures; and
- Observe uptake, breeding and persistent use of replacement roosting habitat.

Information shown is for illustrative purposes only

Drawn by: GJM Checked by: RE Reviewed by: VJS Date: August 2014
Source of base data: Roads and Maritime Services





0 1.5 km

North

GeoLINK environmental management and design

W2G Pacific Highway Upgrade Microbat Management Plan: Sections 1 and 2
2149-1052

Subject Drainage Structures

Illustration 2.1

3 Management Measures

3.1 Overview

In general, management measures involve the following main components:

1. Temporary replacement habitat;
2. Exclusion of bats;
3. Creation of permanent cave-dwelling roost habitat within newly constructed drainage features;
4. Monitor; and
5. Implement corrective actions.

3.2 Temporary Replacement Habitat

3.2.1 Bat Box Installation

Bat boxes provide alternate roost habitat for microbats (specifically Large-footed Myotis) that are excluded from their current roost as a result of the Project and are regarded as a temporary measure provided prior to and during construction until roosts within their preferred habitat is replaced (ie. gaps in culverts and bat boxes beneath bridges/ in culverts etc). If microbats inhabit the bat boxes however, they would be left in place post-construction. Installation of bat boxes would be undertaken or supervised by an Ecologist with experience with microbats. Bat boxes that are attached to trees would be installed so as to not impeded sap flow. Each bat box would be given a unique identification number and the location accurately recorded.

3.2.2 Bat Box Design

Variation is required in the design of boxes being used at any one location. Boxes of different designs would increase the chances of uptake, address seasonality and thermoregulatory considerations and address the fact that bats are known to regularly change roost locations.

The following designs are recommended:

- Large (four-chambered) hanging bat boxes (refer to Plate 3.1);
- Light weight concrete bat boxes;
- Lattice style bat boxes (refer to Plate 3.2); and
- Tree mounted bat boxes (least preferred due to behaviour and habitat preferences of cave-dwelling microbats). If tree mounted bat boxes are installed, these must be in close proximity to water if not over hanging water.

Bat boxes can be tailor made or sourced from Hollow Log Homes (http://www.hollowloghomes.com) or similar company that can ensure a robust structure.

If bat boxes are custom made they need to meet the following criteria:

- Constructed of hardwood or marine grade ply;
- Re-enforced with bracing;
- Variable width gaps (2-6 cm);
- Removable (able to be relocated to new drainage structures);
- Roughed/ grooved timber;
- Different length landing pads; and
- Gaps at the top of the wedges/ slats to allow bats to move between the cavities.

Based on previous observations of microbat behaviour, lattice style boxes are recommended as they can allow for larger colonies and therefore increased ability to thermoregulate and breed. A lattice style bat box is recommended for use beneath the Halfway Creek Bridge.

3.2.3 Bat Box Placement

Placement of bat boxes is critical to their successful uptake. The most important feature is proximity to water. The bat boxes need to be above or as close to water as possible. The location of bat boxes needs to satisfy the following criteria:

- Shaded location overhanging >100 mm of surface water;
- >2 m above ground (ideally 3-4 m unless directly over a deep, permanent water body);
- Recipient tree considered robust and in good health;
- On land outside the Project clearing limits; and
- Within RMS road reserve or adjacent private land with an agreement.

The lattice style bat box to be erected beneath Halfway Creek Bridge would be placed beneath the southern span, as close to water as possible, near a bridge pylon in low light, safe from predators.

At least one temporary bat box would also be installed in the subject drainage structures to be replaced in order to give bats the opportunity to familiarise themselves with the new bat box structures thereby potentially enhancing uptake following exclusion. These bat boxes would then be moved to a predetermined location during exclusion.

Where no suitable trees occur in proximity to water, a length of timber or wire/ rope system would be erected between two trees over a waterway (refer to Plate 3.2). The bat box can then be attached to hang from this structure.

Plate 3.1 Hanging bat boxes over water (Source: V. Silver)

Plate 3.2 Hanging lattice style bat box over water (Source: N. Williams)

3.2.4 Timing of Bat Box Installation

It is important that time is provided for microbats to recognise the presence of the bat boxes and the potential roosting opportunity they offer prior to microbat exclusion being implemented. Therefore, every attempt would be made to maximise the time between installation of bat boxes and exclusion of microbats from the subject drainage structures. It is preferable to install bat boxes up to 12 months in advance to give microbats time to locate and 'accept' the new structures as a viable roost.

Timing of bat box instalment relative to exclusion and demolition would be recorded. The duration of the lead time would be evaluated and communicated should this appear to be a factor influencing uptake of bat boxes.

Table 3.1 provides approximate timing of construction, bat box installation and exclusion.

Table 3.1 Approximate Timing

Section	*Chainage*	*Reference No./ ID*	*Timing of Works*	*Timing of Bat Box Installation*	*Timing of Exclusion*
1	13,310	46 (Boney's Creek)	Vegetation clearing: approximately April/ May 2015. Half of the new culverts would be installed late 2015 (ie. extend northern embankment and move traffic to the one side whilst works occur on the other side). Traffic would then be switched and existing culverts would then be demolished and the remaining half of new culverts installed mid 2016.	September – October 2014	Between mid-April and end of May 2015 or between late August and early October 2015.
1	13,850	49			
2	20,665	25 (Halfway Creek Culvert)	Vegetation clearing: approximately April/ May 2015. The new southern Halfway Creek Bridge approach would be constructed blocking off the western end of the existing Halfway Creek Culvert late 2015. The existing Halfway Creek Bridge would be demolished and the existing culverts filled with grout late 2016.		Early October 2014.
2	21,000	Halfway Creek Bridge			Between mid-April and end of May 2016 or between late August and early October 2016.
2	29,360	32 (Bebo Arch)	Works directly adjoining the Arch would be avoided during the Large-footed Myotis breeding season (ie. no works between early October and mid-April), if Large-footed Myotis are present. Further consultation would take place with EPA if works are proposed during this period.		N/A

3.2.5 Numbers of Bat Boxes

Based on surveys undertaken in November 2013, February 2014 and July 2014, numbers of bat boxes required at each of the subject drainage structures to be replaced or extended are provided in Table 3.2. These calculations acknowledge that surveys have only been undertaken in two seasons over one year therefore a 15% safety factor has been added. They also assume occupation by 15 microbats per wedge in a four-chambered bat box.

Table 3.2 Number of Bat Boxes Required

Section	*Chainage*	*Reference No./ ID*	*Number of Bat Boxes*
1	13,310	46 (Boney's Creek)	9
1	13,850	49	2
2	20,665	25 (Halfway Creek Culvert)	4
2	21,000	Halfway Creek Bridge	2
2	29,360	32 (Bebo Arch)	9*

* Works at the Bebo Arch involve extension of the arch and therefore exclusion is not proposed. Bat boxes have been recommended however as a safeguard in case bats leave the existing structure during construction. Based on previous experience, it is not expected that microbats would leave the roost however they may get flighty, especially if large numbers are present. The recommended number of bat boxes however uses a reduced rate.

3.2.6 Bat Boxes and Nest Box Management Plans (Biosis 2014, Ecosure 2014)

Bat boxes provided under this microbat management plan are regarded as additional items to the nest box management plans for Sections 1 (Biosis 2014) and Section 2 (Ecosure 2014).

3.2.7 Blind Culvert

An experimental structure in the form of a blind culvert is recommended near Halfway Creek Culvert. This structure is recommended to provide an alternate roost for Little Bent-wing Bats who prefer concrete structures (pers. obs). The blind culvert would comprise the following:

- 2.4 m long CPC;
- 1.2 m diameter;
- positioned horizontally;
- blocked at one end;
- covered with compacted soil for insulation and to avoid scouring;
- invert grooved to collect water;
- close to water source;
- entrance open to a south-westerly aspect to reduce amount of light and wind entering;
- fitted out with concrete blocks (refer to Plate 3.9 and 3.10) or a recessed chamber (refer to Section 3.4.5 and Plate 3.13).

This culvert could be installed pre-construction or in the early stages of construction to maximise compensation.

3.3 Roost Exclusion

Exclusion of microbats from roost sites would only be necessary at the subject drainage structures requiring direct works (ie. replacement or extension). Within Section 1, these are drainage structures 46 and 49. Within Section 2, these are drainage structures 25 and Halfway Creek Bridge.

3.3.1 Timing of Exclusion

Exclusion of microbats from the subject drainage structures is required to enable construction works to be undertaken at any time of the year. If microbats were not excluded, works on the subject drainage structures would need to be undertaken outside the typical breeding period for the Large-footed Myotis (breeding between early October to mid-April) and also avoid over-wintering periods for Little and Eastern Bent-wing Bats. This would limits works to approximately September and May of each year which is impractical.

The exclusion component of this Microbat Management Plan must only occur the season before works at each subject drainage structure between late August and early October or between mid-April and end of May which would avoid the breeding season and overwintering periods for subject microbats. Furthermore, planned roost exclusion would not occur during forecast periods of heavy rain (>20 mm in 24 hours according to the Bureau of Meteorology).

Large-footed Myotis is the only target species known to utilise drainage structures as maternity roosting habitat. The potential for injury and death to Large-footed Myotis would be much higher during the breeding period due to the presence of dependant young and/ or juveniles. Dependant young are less likely to vacate the roost and there is a high risk that juveniles would be abandoned in the roost by adults.

Exclusion devices would need to be periodically monitored for effectiveness in excluding bats, especially following flood events.

3.3.2 Exclusion Methodology for Culverts

Roost exclusion would involve the Project Ecologist inspecting the roost prior to the dusk fly-out to identify if microbats are present and where they are roosting. Exclusion devices would then be installed in culvert cells confidently identified as being bat free.

For culvert cells with small numbers of bats (<15) that are able to be captured, the Project Ecologist would capture and later release the microbats at dusk as detailed in Section 3.6.1, once the exclusion devices are installed.

Culvert cells with medium to large numbers of roosting bats (or that are unable to be confidently identified as bat free) would then be inspected one hour after the first bat emerges (to ensure the peak activity associated with emergence has passed), by an Ecologist with microbat experience to confirm that no microbats are present. Once this is confirmed, exclusion devices would be deployed. Exclusion structures would be deployed gradually (ie. one cell each night, or specific sections of Halfway Creek Bridge) to encourage bats to find roosting sites elsewhere, limiting the number of bats 'caught short' and potentially roosting in inappropriate locations. Exclusion structures that allow bats to exit but not re-enter would be used at roost sites where small numbers of bats that have not flown out and cannot be captured by the Ecologist remain or where it is not possible to confidently identified the roost site as bat free due to the roost cavity structure.

Exclusion devices comprise a combination of the following depending on the specific habitat features at each site:

- Plastic sheeting;
- Gap filler or expandable foam;
- Plywood secured with adhesive (ie. liquid nails);
- One-way flap (for small cracks, fissures or lifting holes).

The plastic sheeting exclusion option comprises a thick, slippery plastic sheet attached to the headwall to exclude bats (refer to Plate 3.3). An example of suitable plastic sheeting previously been used for this purpose is 'Enviroguard' sourced from Burwell Technologies: http://www.burwell.com.au/catalogue/containmentscreen/Enviroguard. Care needs to be taken to ensure bats cannot land on the headwall and crawl along the concrete and under the exclusion device. One disadvantage of plastic sheeting is that it obstructs the fly-way however it is effective in excluding microbats from all crevices within the drainage structure.

Gap filler or expandable foam, would need to completely fill the gap therefore would only be suitable for gaps <5 cm deep. Where this cannot be achieved (i.e. due to an obscure cavity), ply-wood secured with adhesive or one-way plastic flaps would be installed. One disadvantage of gap filler (or equivalent) is that microbats can still grip the foam and use it as an exposed hold point.

Plywood secured with adhesive (ie. liquid nails) is an effective way of excluding bats from large gaps or those that are along a straight surface such as within a RCBC or bridge (refer to Plate 3.4). This method can be used in conjunction with gap filler and is best utilised in areas where the size of the gap exceeds the working limit of the gap filler.

Installation of the one-way flap involves attaching a plastic shield over the exit hole/ gap, extending at least 80 mm from the hole to ensure a non-grip surface (Temby 2012). Then hang a flap of plastic sheeting over the exit point, so that bats can leave but not re-enter. If there is to be a significant delay between exclusion and proposed works, re-inspect the one-way plastic flaps 72 hours after installation with torch and endoscope and decommission with expandable foam or equivalent. One-way plastic flaps would be used where a cavity cannot be fully inspected.

It should be noted that Shultz (2013) also recommends that all abandoned Fairy Martin nests should be destroyed if unoccupied at the time of planned exclusion.

There are advantages and disadvantages for each exclusion methodology therefore the Project Ecologist would recommend which of the above listed exclusion methodologies would be used at each site at the time of exclusion. If exclusion is not effective, a thermal imaging camera or night vision scope would be used to observe bats to determine where the breach is occurring. Actions would be undertaken to remedy any breaches or improve the methodology (eg. temporary installation of a string of lights inside the cells).

The Project Ecologist would inspect the exclusion devices and drainage structure on the morning after exclusion to ensure microbats are not roosting in vulnerable locations. The bat boxes would also be inspected at this time to check if microbats relocated to these structures.

Plate 3.3 Plastic sheeting at Binna Burra (Source: V Silver)

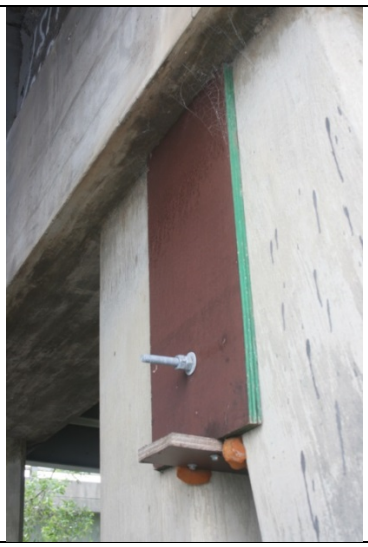


Plate 3.4 Plywood, liquid nails and expandable foam beneath Mororo Bridge (Source: D. Andrighetto)

3.3.3 Exclusion Methodology for Halfway Creek Bridge if Microbats are Present

Exclusion of microbats from Halfway Creek Bridge would preferably commence following completion of works on the new Halfway Creek Culvert and/or the new Halfway Creek Bridge, however this depends on timing of construction. Timing of exclusion must be in accordance with that outlined in Section 3.3.1.

The methodology would initially involve blocking crevices, scuppers and gaps using the methodologies listed in Section 3.3.2 (ie. plywood and liquid nails, gap filler and one-way valves) and progress to plastic sheeting, if required (refer to Plates 3.5 and 3.6). An example of a suitable plastic sheeting previously been used for

this purpose is 'Enviroguard' sourced from Burwell Technologies: http://www.burwell.com.au/catalogue/containmentscreen/Enviroguard. The Project Ecologist would guide this procedure. The northern approach would be excluded first as surveys to date have indicated that this side is least preferred. Exclusion devices would be installed during the daytime where low numbers (<20)/ no microbats are present (refer to Table 3.3).

Table 3.3 Exclusion Process for Halfway Creek Bridge if Large Numbers of Microbats are Present

Exclusion Steps		
Task	*Responsibility*	*Procedure*
Monitor bat boxes in adjacent habitat	Project Ecologist	▪ Check bat boxes in adjacent habitat to determine if occupied or not. This information is important to determine if excluded microbats then relocate to these structures.
Observe fly-out	Project Ecologist	▪ Watch from bank (using binoculars).
Install exclusion devices	Project Ecologist with assistance from Contractor	▪ Starting on the northern span, gradually exclude bats from the bridge to encourage microbats into the boxes. Dependent upon the number of microbats present, this may be undertaken over two-three nights however staged exclusion is not required if no or only small numbers (<20) of bats are present.
Monitor exclusion devices	Project Ecologist	▪ Watch from bank to see if microbats return (using binoculars, spotlight and/or thermal imager). ▪ Note if bats were able to re-gain access. ▪ Identify where breaches occur. ▪ Check for microbats roosting in unsafe areas as a result of exclusion. ▪ On final night of exclusion, remove microbats roosting in unsafe (exposed) areas and place in bat boxes.
Modify exclusion devices (if required)	Contractor under guidance of Project Ecologist	▪ Wrap sections in plastic.
Confirm exclusion successful	Project Ecologist	▪ Check bat boxes in adjacent habitat to determine if excluded microbats relocated to these structures. ▪ Physical inspection for microbats on the day before and the morning of demolition work.
Relocate lattice style bat box from Halfway Creek Bridge to newly constructed replacement Halfway Creek Bridge following its completion	Project Ecologist with assistance from Contractor	Depending on timing of exclusion (undertaken between late August and early October or between mid-April and end of May) there may be a delay between exclusion and relocation of the bat box. ▪ Pre-drill holes in the newly constructed Halfway Creek Bridge with chem-set bolts in place ready to receive the bat box structure. ▪ Cover the openings of the existing bat box to be removed with a breathable material (eg. geofabric/ hessian). ▪ Gently transport the bat box to its new location (positioned as close to water as possible, in a corner of the bridge low light safe from predators).

Plate 3.5 Exclusion Option – Plastic wrap bridge (Source: A. Lloyd)

Plate 3.6 Exclusion - Plastic over scuppers (Source: D. Andrighetto)

3.4 Create Permanent Cave-dwelling Roost Habitat

A series of 'in culvert' design modifications are proposed for the replacement drainage structures to promote and replace insitu habitat. For each subject drainage structure, the alterative roosting habitat provided would have a minimum carrying capacity of the existing structure. These features are essential at the subject high and medium conservation/ habitat value drainage structures however are also recommended elsewhere where new drainage structures provide good microbat roost opportunities.

3.4.1 Maximum Jointing Gaps

Microbats were frequently observed roosting in jointing gaps of RCBCs and CPCs during surveys within W2G Sections 1 and 2 undertaken in summer and winter 2014 for the Project. These ranged in habitat value from minor hold points providing exposed roosting opportunities, to deep protected cavities. Cell joins were present in most drainage structures. It is therefore recommended to replicate this situation and ensure that all CPCs and RCBC in the vicinity of medium and high conservation habitat structures are laid with maximum jointing gap allowance (as specified by manufacturer).

3.4.2 Bat Boxes within Drainage Structures

Following completion of works on the new drainage structures, bat boxes would be installed. The bat boxes that were erected in adjacent vegetation prior to exclusion would be moved into the drainage structures only if microbats have not taken to these boxes. If microbats have occupied the boxes in adjacent habitat, then these would remain insitu and new boxes would be installed within the drainage structures. It is essential that the identification number of the bat boxes that are retained insitu and those that are relocated are accurately recorded.

A bat box (approximately 30 cm x 40 cm) within a RCBC (ranging between 2.4 m x 3 m to 3 m x 3 m) would occupy approximately 1 % of the cross sectional area of the RCBC. As such, it is assumed that the bat boxes would have a negligible impact on the hydraulic function of the drainage structure.

A variety of designs are once again proposed to increase the chances of uptake. These include:

- Hanging four-chambered bat boxes with bash plate to deflect any debris and reduce damage during a flood event (refer to Plates 3.7 and 3.8);
- Light weight concrete blocks (Hebel) with holes drilled to create cavities (refer to Plates 3.9 and 3.10); and
- Lattice style bat boxes (refer to Plate 3.11 and 3.12).

Plate 3.7 Bat boxes with bash plate beneath Myott Bridge (Source: A. Lloyd)

Plate 3.8 Installation of bat boxes beneath Mororo Bridge (Source: D. Andrighetto)

Plate 3.9 Light weight concrete blocks with drill holes, microbat visible in chamber (Source: N. Williams)

Plate 3.10 Light weight concrete blocks with drill holes secured beneath bridge (Source: N. Williams)

Plate 3.11 Lattice style bat box beneath Myott Bridge (Source: A. Lloyd)

Plate 3.12 Lattice style bat box under bridge (Source: N. Williams)

3.4.3 Roughed Concrete Obvert

Microbats were frequently observed roosting on areas of rough concrete on the obvert of RCBCs and CPCs during surveys within W2G Sections 1 and 2 undertaken in summer and winter 2014 for the Project. It is acknowledged that these areas provide exposed roosting opportunities however were common throughout. In order to minimise impacts to flow regimes, roughed concrete would be implemented in the middle third of the drainage structure for a width of approximately 30 cm. Several options are available to roughen obverts of replacement CPCs and RCBCs:

- Sponge the obvert during manufacturing;
- Spray the obvert with a sand/ cement mixture;
- Paint on a sand/ cement/ epoxy mixture;
- Sandblast the obvert of the drainage structure;
- Apply shotcrete.

3.4.4 Lift Holes

Culvert cell lift holes vary from provision of minor hold points providing exposed roosting opportunities, to deep protected earth cavities. It is recommended that lift holes are not capped or filled.

3.4.5 Recessed Chambers

A recessed chamber in the form of a manufactured man hole would provide bats with a well-insulated replacement cavity that would provide a safe roosting location. Recessed chambers are only recommended within CPCs, this is due to structural reinforcing being compromised within the obvert of a RCBC. The recessed chamber would be located approximately one third of the way through the culvert at the outlet end (as pools of water are often present at the outlet rather than inlet). The CPC would have a pre-fabricated hole the size of the man hole (chamber) and would be fitted with four-chambered hanging bat boxes (refer to Plate 3.13).

Plate 3.13 Recessed Chamber with Bat Boxes (Source: V. Silver)

3.4.6 Fauna Underpasses

The Project design includes fauna underpasses to allow for safe passage of fauna crossing the Pacific Highway. Although these fauna underpasses have not specifically targeted microbats, it is recommended that bat boxes be installed and design modifications such as lay pipes/ box cells with maximum jointing gap (as specified by manufacturer) be included at these locations. This design feature is important to cater for flyways of low-wing loading bat species (in particular Little Bentwing Bat and Large-eared Pied Bat) which are unlikely to traverse the open space created by the upgraded highway footprint (Shultz, 2013). Fauna underpasses also need to allow for open airspace above furniture to be free of obstacles.

3.4.7 Bridge Roost Features

Bridge roost features would replicate those currently being utilised by microbats where possible. This would include maximising cavities between concrete planks/ segments and around piers/ headstocks and replicating areas of rough concrete, concrete ledges and concrete angles.

3.4.8 Maintenance

Shultz (2013) recommends that RMS employees and contractors be educated and advised not to remove disused Fairy Martin nests or mud dauber wasp nests on the ceiling and sides of culverts or bridges post construction as these provide roosting habitat for at least three of the cave-dwelling bat species. Contractors need to ensure that flyways under bridges and water bodies are not obstructed and bat boxes are not disturbed.

3.4.9 Summary of Management Measures

As previously noted, provision of a variety of types of replacement habitat would increase the chances of uptake by microbats. Furthermore, the alterative roosting habitat provided would have a minimum carrying capacity of the existing structure. Table 3.4 summarises the management measures required at each of the subject drainage structures.

Table 3.4 Summary of Permanent Cave-dwelling Roost Habitat

Section	*Chainage*	*Ref. No./ ID*	*Management Measures*
1	13,310	46	▪ Install nine bat boxes in adjacent vegetation.
			▪ Exclusion as per Section 3.3.
			▪ Roughened concrete obvert.
			▪ Maximum jointing gaps (as per manufacturer's specifications). Note: The alterative roosting habitat provided would require a minimum carrying capacity of the existing structure. Existing culvert has 12 cell joints.
			▪ Unused bat boxes from surrounding vegetation would be relocated within the drainage structure once construction is complete. At least nine bat boxes (combination of lattice, concrete blocks and hanging bat-boxes) positioned within the new culvert.
			▪ Monitoring.
1	13,850	49	▪ Install two bat boxes in adjacent vegetation.
			▪ Exclusion as per Section 3.3.
			▪ Roughened concrete obvert.
			▪ Maximum jointing gaps (as per manufacturer's specifications).
			▪ Unused bat boxes from surrounding vegetation would be relocated within the drainage structure once construction is complete. At least two bat boxes (combination of lattice, concrete blocks and hanging bat-boxes) positioned within the new culvert.
			▪ Monitoring.
2	20,665	25 (Halfway Creek Culvert)	▪ Install four bat boxes in adjacent vegetation.
			▪ Exclusion as per Section 3.3.
			▪ Install temporary lattice style bat box under the southern span of existing Halfway Creek Bridge prior to the commencement of construction.
			▪ Install blind culvert as per Section 3.2.7 prior to construction or during the early stages of construction.
			▪ Roughened concrete obvert.
			▪ Maximum jointing gaps (as per manufacturer's specifications).
			▪ Unused bat boxes from surrounding vegetation would be relocated within the drainage structure once construction is complete. At least four bat boxes (combination of lattice, concrete blocks and hanging bat-boxes) positioned within the new culvert.
			▪ Monitoring.
2	21,000	Halfway Creek Bridge	▪ Install two bat boxes in adjacent vegetation.
			▪ Exclusion as per Section 3.3.
			▪ Maximise cavities between concrete planks/ segments and around piers/ headstocks.
			▪ Replicate areas of rough concrete, concrete ledges and concrete angles.
			▪ Relocate lattice style bat box under new Halfway Creek Bridge.
			▪ Unused bat boxes from surrounding vegetation would be relocated within

Section	Chainage	Ref. No./ ID	Management Measures
			the drainage structure once construction is complete. Install bat boxes (combination of lattice, concrete blocks and hanging bat-boxes) under new Halfway Creek Bridge
			▪ Monitoring.
2	29,360	32 (Bebo Arch)	▪ Install nine bat boxes in adjacent vegetation.
			▪ Maximum jointing gaps (as per manufacturer's specifications).
			▪ Restrict pedestrian access to the existing arch (limited to essential entry only); ▪ No vehicular access beneath the existing arch; ▪ Sandbag water within the existing arch to trap water (which is an essential requirement for microbats) for the duration of construction; ▪ Install a temporary barrier in the form of a series of geofabric/ plastic sheets on the end of the arch between the works area and the microbats which is to be extended to be lowered during daily works and raised prior to dusk daily; ▪ Ensure the fly-way beneath the arch is not obstructed at night; ▪ Ensure water flow is re-instated following completion of works; and ▪ Works directly adjoining the Arch would be avoided during the Large-footed Myotis breeding season (ie. no works between early October and mid-April), if Large-footed Myotis are present. Further consultation would take place with EPA if works are proposed during this period.
			▪ Monitoring.

3.5 Mitigation Measures

3.5.1 Environmental Work Method Statements

Environmental Work Method Statements (EWMS) would be prepared for all construction activities potentially impacting fauna (including microbats). The EWMS would provide an opportunity to assess any risks to fauna (including microbats) from the works and to incorporate mitigation measures into work methodologies to minimise the potential for impacts. Where an EWMS identifies risks to fauna, the Project Ecologist would be consulted to provide input where necessary.

3.5.2 Inductions

An environmental induction would be prepared and delivered to all personnel involved with the construction stage works. Relevant points to be delivered in this induction in relation to microbat management are as follows:

- Presence on site (identification and potential habitat);
- Education on the potential of microbats to carry disease and that any microbat found during the works would be reported immediately to the Project Ecologist and would not be handled by an untrained or unvaccinated person;
- Clearing/ pre-clearing requirements;
- Maintenance of fly-ways;
- Location of and instructions not to disturb bat boxes or artificial roost habitat;

- Requirements for works to cease within 100 m of any unexpected microbats detected within drainage structures until authorisation has been given for works to commence from the Environmental Manager/ Project Ecologist; and
- Requirements for works to cease if microbats take flight from drainage structures during daylight hours until authorisation has been given for works to commence from the Environmental Manager/ Project Ecologist.

3.5.3 Pre-work Microbat Inspections

A suitably qualified Ecologist would undertake checks for microbats prior to works on each subject drainage structure as outlined in Table 3.5.

Table 3.5 Pre-work Microbat Inspection Methodology

Procedure				
Action	*Timing*	*Responsibility*		*Procedure*
Pre-work microbat inspection	One day prior to starting work on the subject drainage structure and on the day of work.	Project Ecologist/ Contractor		Check the drainage structure for the presence of microbats.
Mitigation Steps				
Outcome of inspections	*Response*	*Timing*	*Responsibility*	*Steps/ Notes*
Bats not present	Proceed with work.	-	Contractor	-
Bats present	Contact Environmental Manager/ Project Ecologist and decide: ▪ avoid microbat/s by working elsewhere; ▪ exclude after dusk fly-out; or ▪ remove microbat/s.	Prior to any work	RMS site supervisor/ Project Ecologist to remove microbat/s	Handling of microbats only in accordance with s132c licence and Section 3.6.1.

3.5.4 Site Specific Management Measures for Bebo Arch (Chainage 29,360)

The following management measures would be implemented at the Bebo Arch which is proposed to be extended:

- Restrict pedestrian access to the existing arch (limited to essential entry only);
- No vehicular access beneath the existing arch;
- Sandbag water within the existing arch to trap water (which is an essential requirement for microbats) for the duration of construction;
- Install a temporary barrier in the form of a series of geofabric/ plastic sheets on the end of the arch between the works area and the microbats which is to be extended to be lowered during daily works and raised prior to dusk daily;
- Ensure the fly-way beneath the arch is not obstructed at night;
- Ensure water flow is re-instated following completion of works; and
- Works directly adjoining the Arch would be avoided during the Large-footed Myotis breeding season (ie. no works between early October and mid-April), if Large-footed Myotis are present. Further consultation would take place with EPA if works are proposed during this period.

3.5.5 Site Specific Management Measures for Drainage Structure 66 (Chainage 15,950)

Drainage structure 66 is located approximately 15 m north of works to construct a turn-around bay. Site specific management measures are therefore required for this site:

- Restrict pedestrian access to the drainage structure;
- Project Ecologist to have input into the EWMS for this specific site;
- If bats are taking flight during daylight hours, cease works within 50 m of the subject drainage structure and contact the Project Ecologist. The Project Ecologist would advise if bat boxes, exclusion devices or alternative measures are required.

3.6 Contingency Measures

3.6.1 Capturing and Releasing Healthy Microbats

The following methodology would be implemented if microbats are unexpectedly found in a drainage structure during works where microbats have not been excluded.

All handling of microbats would be undertaken by a qualified and vaccinated Ecologist experienced in handling bats. The Ecologist must hold an Animal Care and Ethics Committee approval and a NPWS Scientific Licence for handling native flora and fauna.

The Project Ecologist would have spare bat boxes on hand to accommodate for unexpected finds of more than ten microbats. The Project Ecologist would nominate a suitable location for the bat box to be positioned.

If less than ten microbats are encountered, the microbats would be housed in small cloth bags. Bags containing bats would be hung in a cool, dry place off the ground and out of the direct sun. Bats of the same species would be housed together with no more than three in any one bag. Large bats (head and body 80-95 mm) would not be grouped with smaller bats (head and body <75 mm) as some larger species predate on smaller species. The Ecologist is responsible for releasing the bats in the evening at the site of capture.

3.6.2 Injured or Dead Microbats

If bats are unexpectedly injured during works the Project Ecologist would carefully remove the bat with a cloth bag. With a gloved hand encased within the cloth bag, gently pick up the bat and then turn the bag inside out to free the gloved hand and capture the bat. The bag would be tied off at the entrance and hung in a cool, shaded sheltered location.

The local wildlife carer group would be contacted immediately for collection of any injured bat/s captured. Options for treatment and future release would be decided at the discretion of the wildlife carer. Any costs for treatment would be the responsibility of the contractor.

If a dead or injured microbat is found during the works, the Works Supervisor and Project Ecologist must be notified immediately.

All dead microbats would be collected and retained for the Project Ecologist. The Ecologist would lodge bodies with the Australian Museum as specimens for future research and study.

3.6.3 Adaptive Procedures

It is not desirable to design a rigid plan when dealing with fauna related issues. Animals can display unpredicted or unexpected behaviour and therefore management plans such as this need to adaptable to deal with a range of potential outcomes. The procedures of this plan may be adapted in response to factors such as pace of the works, or results of inspections. Modifications to the exclusion procedure may be undertaken, for example, minor modification may be required to the exclusion devices to improve their success. The aim is to facilitate the identification of the best course of action for the particular situation, including time and logistical constraints, as well as the biological constraints posed by the micrbats.

4 Monitoring Program

4.1 Monitoring Objectives

Monitoring of bat boxes, artificial habitat and design modification components would be undertaken to determine the effectiveness of the artificial habitat in terms of providing alternative microbat roosting habitat and compensating of the roosting habitat losses from the Project at high and medium conservation/ habitat value drainage structures. It would also provide useful information on breeding, age class and therefore population dynamics and population survival post-construction. The information would be useful for future RMS projects involving exclusion of microbats and provision of alternative habitat.

4.2 Pre-construction Monitoring

In accordance with the TMMP (RMS 2013) and peer review (Shultz 2013), pre-construction microbat monitoring surveys have been undertaken in summer 2013-14 (November 2013 and February 2014) and winter (July-August 2014) to provide baseline data relating to current usage of drainage structures by microbats within Sections 1 and 2 of the Project. This information has been utilised during the preparation of this Microbat Management Plan.

4.3 Timing

Monitoring of each of the subject drainage structures and bat boxes established in adjacent vegetation is recommended following exclusion of microbats from the subject drainage structures and to continue quarterly until the end of construction. At the completion of construction, monitoring would continue in line with the nest box management plans for Sections 1 and 2 (Biosis 2014, Ecosure 2014), with summer and winter surveys on a bi-annual basis for six years. Corrective actions would be required should the performance criteria not be achieved following two years of monitoring. Following the initial two years of monitoring, if results indicate early uptake consistently, monitoring can cease and is not required for the full six years.

4.4 Control Sites

Monitoring of microbat persistence and behaviour would also be undertaken at the frequency and duration nominated above, at the drainage structures classified as high or medium that would not be subject to direct impacts (ie. 40, 66 and 67) once adjacent construction begins. These drainage structures would provide control sites for monitoring to provide a measure of natural variability and indirect impacts.

4.5 Monitoring Methodology

The following monitoring methodology would be undertaken for both the bat boxes in adjacent vegetation as well as 'in culvert' design features and bat boxes within drainage structures.

An Ecologist would physically inspect the subject drainage structures and alternative habitat features and record the following:

- Identification code of nest box or habitat feature;
- Evidence of microbats (guano and/or staining);
- Number of microbats present;

- Identification of species;
- Indications of breeding activity;
- Occurrence of any pest species such as feral bees;
- Condition of the bat roost box (eg. any deterioration, structurally unstable) if applicable;
- Date and time of inspection;
- Drainage structure/ roost identification number;
- Roost features present; and
- Record of rainfall during monitoring period.

It should be noted that evidence of microbats in the form of guano can be influenced by wet weather. Less guano would be expected following significant periods of rainfall.

4.6 Reporting

Annual results of the information stated within Section 4.5 would be provided to RMS, Department of Planning and the Environment (DP&E) and EPA (consistent with the requirement under condition D8(l) of the approval) during construction with a final post construction monitoring report incorporating an analysis of the results provided to EPA and DP&E.

Post-construction monitoring would be consistent with condition D8(k) of the approval.

4.7 Performance Measures and Corrective Actions

Table 4.1 presents the main goals of microbat management and includes relevant management measures for microbats that would be employed prior to the commencement of construction, during construction and post construction. The table also describes how the identified mitigation measures would be monitored, the timing and frequency of monitoring, the parties responsible for implementing the measures, the performance thresholds that each goal is measured against and the corrective actions if deviation from the performance criteria occurs.

4.8 Summary of Monitoring Program

A summary of the monitoring program is provided in Table 4.1.

Table 4.1 Summary of Monitoring Program

Monitoring Component	*Goal*	*Timing/ Frequency*	*Responsibility*	*Performance Threshold*	*Corrective Actions if Deviation from Performance Criteria*
Exclusion devices	▪ Ensure exclusion devices remain effective.	▪ Day after installation. ▪ Following significant rainfall events (>50 mm in 24 hours). ▪ Quarterly if no significant rainfall events.	Project Ecologist/ Contractor	▪ Any breach of exclusion devices.	▪ Re-instate damaged exclusion devices (eg. apply additional gap filler or replace plywood with liquid nails).
Bat boxes	▪ Successfully provide alternate roost habitat in suitable locations in proximity to the subject drainage structures. ▪ Observe uptake, breeding and persistent use of replacement roosting habitat.	▪ Day after exclusion from subject drainage structures. ▪ Quarterly during construction. ▪ Bi-annual summer and winter for six years following completion of construction (as per the nest box management plans for Sections 1 and 2).	Project Ecologist	▪ No evidence of usage within two years of installation.	▪ Re-locate within adjacent vegetation (changing aspect, move closer to water etc). ▪ If not inhabited by microbats following completion of construction on the subject drainage structures, bat boxes would be re-located within the new RCBCs.

Monitoring Component	*Goal*	*Timing/ Frequency*	*Responsibility*	*Performance Threshold*	*Corrective Actions if Deviation from Performance Criteria*
Pre-work checks	▪ Low number of injuries/ mortality to microbats from construction activities.	▪ One day prior to starting work on the subject drainage structure and on the day of work.	▪ Construction team/ Project Ecologist	▪ Low number of injuries/ mortality to microbats from construction activities.	▪ Notification to DoE, EPA if a microbat mortality is recorded on the Project. ▪ Adaptive management response plan to be provided by Project Ecologist if mortality recorded. ▪ Stop construction and review the Microbat Management Plan procedures for exclusion and removal of microbats. ▪ Preparation of an EWMS for all construction activities and where necessary, include measures to minimise risk to microbats. ▪ Induction of all personnel involved with construction activities would be undertaken to communicate microbat management requirements.
Habitat design features within drainage structures	▪ Observe uptake, breeding and persistent use of replacement roosting habitat.	▪ Commence six months following installation. ▪ Quarterly during construction. ▪ Bi-annual summer and winter for six years following completion of construction (as per the nest box management plans for Sections 1 and 2).	Project Ecologist	▪ Evidence of usage is confirmed consistently (numbers not decreasing over two years).	▪ Modify the design of existing roost features. ▪ Consider provision of additional roost features.

Monitoring Component	*Goal*	*Timing/ Frequency*	*Responsibility*	*Performance Threshold*	*Corrective Actions if Deviation from Performance Criteria*
Control sites (drainage structures 40, 66, 67).	▪ Identify natural variability of microbats within the Project footprint.	▪ Quarterly from pre-exclusion. ▪ Quarterly during construction. ▪ Bi-annual summer and winter for six years following completion of construction (as per the nest box management plans for Sections 1 and 2).	Project Ecologist	N/A	N/A

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Definitions and Acronymys

APBJV	Arup Parsons Brinckerhoff Joint Venture
CEMP	Construction Environmental Management Plan
CPC	Concrete Pipe Culvert
DoE	Australian Government Department of Environment
DP&E	NSW Department of Planning and the Environment
EIS	Environmental Impact Statement
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
EPA	NSW Environmental Protection Authority
EWMS	Environmental Work Method Statement
FFMP	Flora and Fauna Management Plan
NSW	New South Wales
OEH	Office of Environment and Heritage
Project Ecologist	A suitably qualified Ecologist engaged to advise on/ undertake ecological management throughout the project.
Project footprint	All areas to be cleared as part of the Project inclusive of permanent and temporary works.
RCBC	Reinforced Concrete Box Culvert
TSC Act	NSW *Threatened Species Conservation Act 1995*
S2W	Sapphire to Woolgoolga Pacific Highway Upgrade Project
W2G	Woolgoolga to Gleungie Pacific Highway Upgrade Project (referred to throughout the document as 'the Project'.

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Appendix A

Subject Drainage Features

Table A.1 Subject Drainage Features

Section	*Drainage Structure Ref. No.*	*Drainage Structure ID*	*Northing*	*Easting*	*Chainage (m)*	*Location*	*No. of Cells*	*Width (RCBC only) (mm)*	*Height or Dia. (mm)*	*Feature Type*	*Proposal Action*	*Date/s Inspected*	*Broad Habitat Type*	*Presence of Water/ Moisture (NOV 2013-FEB 2014)*	*Presence of Water/ Moisture (JULY 2014)*	*Potential Microbat Roost Features within Drainage Structure*	*Evidence of Microbat Usage (NOV 2013-FEB 2014)*	*Evidence of Microbat Usage (JULY 2014)*	*Cons/ Habitat Value*	*Proposed Management*
1	c46s1	46	6686141	512446	13,310	Pacific Highway, north of McPhillips Road	2	3000	3000	RCBC	Replace	06/11/2013; 11/02/2014; 22/07/14	Wet sclerophyll forest	Boney's Creek. Contains permanent pools suitable for Large-footed Myotis foraging.	Boney's Creek - pool at inlet ~3 m wide, outlet narrows to 1.5 m wide creek. Water to 1 cm in culvert and dripping through jointing gaps.	Yes - 12 culvert cell joins with gaps to 35 mm wide x 280 mm deep. Rough concrete patches on ceiling of culvert. Mud nests.	Yes - Medium to large guano accumulations below patches of rough concrete and culvert cell joins. Staining present on these features.	North cell 4th joint from outlet 136 x *M.australis*, north cell joint 7 from outlet 1 x *M.australis*, north cell joint 10 from outlet 111 x *M.australis*, Southern cell joint 10 from outlet 3 x *M.australis*, southern cell joint 4 from outlet 227 x *M.australis*. Total: 478 *M.australis* observed.	High	▪ Exclusion. ▪ Nine bat boxes in adjacent vegetation. ▪ Maximum jointing gaps (as per manufacturer's specifications). Note: The alterative roosting habitat provided would require a minimum carrying capacity of the existing structure. Existing culvert has 12 cell joints. ▪ Roughened concrete obvert. ▪ At least nine bat boxes (combination of lattice, concrete blocks and hanging bat-boxes) positioned within the culvert. ▪ Monitoring.
1	c49s1	49	6686377	511986	13,850	Pacific Highway	1	2400	2100	RCBC	Replace	06/11/2013; 11/02/2014; 22/07/2014	Wet sclerophyll forest	Ephemeral drainage line. Likely to support surface water during wet periods.	Moist sediment in base of culvert. Ephemeral drainage line dry.	Yes - Culvert cell joins with gaps up to 30 mm wide x 120 mm deep. Rough concrete on culvert ceiling and at cell joins. Mud nest.	Yes - Medium guano accumulations below culvert cell joins and patches of rough concrete. 1 x male Little Bentwing-bat (*Miniopterus australis*) roosting in culvert cell join (30 mm wide x 120 mm deep) during the 11/02/2014 survey.	Lots of staining, large amounts of guano on walls and ground.	Medium	▪ Monitoring. ▪ Restrict pedestrian access to the drainage structure; ▪ Project Ecologist to have input into the EWMS for this specific site; ▪ If bats are taking flight during daylight hours, cease works within 50 m of the subject drainage structure and contact the Project Ecologist. The Project Ecologist would advise if bat boxes, exclusion devices or alternative measures are required.
1	c66s1	66	6687502	510216	15,950	Pacific Highway, north of Grays Road	3	3300	2400	RCBC	Retain	06/11/2013; 11/02/2014; 22/07/2014	Swamp sclerophyll forest	Drainage line with permanent pools suitable for Large-footed Myotis foraging.	Water in centre cell approximately 5 cm deep. Northern and southern cells dry. Trickle of water at outlet.	Yes - Gaps between culvert cells at joins to 30 mm wide and 200 mm deep. Mud nests	Yes - Medium guano accumulations bellow cell joins. 1 x bat (unable to be identified) in 450 mm pipe which intersects the southern cell during 11/02/2014 survey.	Staining, medium-large amounts of guano beneath jointing gaps. Southern cell 1 x *M. australis* in middle of culvert in joint gap. Southern cell 3 x *M.australis* in 4th jointing gap from inlet. Northern cell 8 x *M.australis* in joint 1 from outlet, 14 x *M.australis* in joint 3 from outlet, 70 x *M.australis* in joint 6 from outlet. Middle cell 15 x *M.australis* in 4th jointing gap from outlet (which was 15 mm wide with water beneath it). Total: 111 *M.australis*	High	▪ Restrict pedestrian access to the drainage structure; ▪ Project Ecologist to have input into the EWMS for this specific site; ▪ If bats are taking flight during daylight hours, cease works within 50 m of the subject drainage structure and contact the Project Ecologist. The Project Ecologist would advise if bat boxes, exclusion devices or alternative measures are required.
1	c67s1	67	6687539	510154	16,000	Pacific Highway, south of shell service station, north of Grays Road	1	-	1200	RCP	Retain	06/11/2013; 11/02/2014; 22/07/2014	Swamp sclerophyll forest	Ephemeral drainage line. Limited Large-footed Myotis foraging value.	Small pool at outlet culvert dry.	Yes - Culvert cell join gaps to 40 mm wide x 100 mm deep. Culvert lift holes to 50 mm deep. Rough concrete.	Yes - 2 x Gould's Wattled Bat (*Chalinolobus gouldii*) roosting from cell joins. Small guano accumulations throughout culvert below cell joins and lift holes.	Staining. Medium to large guano deposits throughout, under lifting points and jointing gaps. 1 x *Rhinolophus megaphyllus* observed.	Medium	▪ Monitoring.

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2	c25s2	25	6690435	506619	20,665	Pacific Highway Southern abutment of Halfway Creek Bridge	4	3000	2400	RCBC	Replace	05/11/2013; 11/2/2014; 11/07/2014	Swamp sclerophyll forest east; mostly cleared west	Drainage line with permanent water (approximately 200 mm deep) and large pool at the outlet.	400 mm of water, deeper pools either side.	Yes - Culvert lift holes (eight in total) approximately 150 mm wide x 150 mm long, with 4 (east) to 200 mm deep (non-earth) and 4 (west) with earth cavities between 300 and 1000 mm deep.	Yes - 05/11/2013 survey: Approximately 40-50 Large-footed Myotis *Myotis macropus* (counted 30 adults and 12 young) recorded in four of the culvert lift holes, numbering approximately 20 adults and 10 young (western side cell 2 from north - approximately 400 mm deep earth cavity); 3 adults (western side cell 3 from north - approximately 300 mm deep earth cavity); one adult (eastern side cell 4 from north - approximately 200 mm deep non-earth cavity) and 6 adults and 2 young (western side cell 4 from north - approximately 400 mm deep earth cavity). One male collected (weight - 10 grams; forearm 39mm, feet 9 mm long; distinct calcar; long-pointed tragus). 11/02/2014 survey: >22 Large-footed Myotis observable (possibly more unobservable) including young from the first seasonal breeding event. Recorded roosting in three of the culvert lift holes, numbering approximately 20 (western side cell 2 from north); 4 adults (western side in northern cell) and three (eastern side cell 4 from north). Staining and/or guano also detected in other lift holes.	Cell 1 - 75 x *M.australis*,Cell 2 - 14 x *M.australis*, Cell 3 - 7 x *M.australis*, Cell 4 - 3 x *M.schreibersii.*	High	▪ Exclusion. ▪ Four bat boxes in adjacent vegetation and blind culvert. ▪ Maximum jointing gaps (as per manufacturer's specifications). ▪ Roughened concrete obvert. ▪ At least four bat boxes (combination of lattice, concrete blocks and hanging bat-boxes) positioned within the culvert. ▪ Monitoring.
2	Halfway Creek Bridge	Halfway Creek Bridge	6690525	506616	21,000	Pacific Highway	-	-	-	Bridge	Replace	05/11/2013; 11/02/2014; 22/07/14	Wet sclerophyll forest along Halfway Creek; dry sclerophyll forest in broader area	Halfway Creek; provides good potential Large-footed Myotis foraging habitat.	Dry	Yes - Gaps between decking; blocked scuppers; cavities in piers; rough concrete below decking.	Yes - Large accumulations of guano and staining in three locations showing roosting from patches of rough concrete on the below the southern span. 1 x *M.australis* on rough concrete recorded during 11/02/2014 survey.	2 x *M.australis* in the new precast section (southbound). Medium to large guano deposits under southbound cell 2.	Medium	▪ Install temporary lattice style bat box under the southern span of existing bridge. ▪ Exclusion. ▪ Two bat boxes in adjacent vegetation. ▪ Maximise cavities between concrete planks/ segments and around piers/ headstocks. ▪ Replicate areas of rough concrete, concrete ledges and concrete angles. ▪ Relocate lattice style bat box under new Halfway Creek Bridge. ▪ Install bat boxes (combination of lattice, concrete blocks and hanging bat-boxes) under new Halfway Creek Bridge. ▪ Monitoring.

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2	c32s2	32	6698664	504414	29,360	Pacific Highway - southbound lane	1	9000	3000	ARCH	Extend	04/11/2013; 11/02/2014; 11/07/2014	Swamp sclerophyll forest along the drainage line; dry sclerophyll forest in broader area	Glenugie Creek. Support pools potentially suitable for Large-footed Myotis foraging.	Approximately 6 x 8 m x 100 mm deep pond in the middle of the culvert.	Yes - 17 Arch segment gaps up to 30 mm wide and approximately 150 mm deep.	Yes - Guano present throughout arch, including medium accumulations below segment joins. 5 x Eastern Bentwing-bat (*Miniopterus schreibersii*) roosting individually in segment joins during 11/02/2014. Known to be occupied in early 2013 (late January to early February) and May to October 2013, with >100 bats (probable bentwings) recorded at times (David Rohweder, pers.com.).	8 of 17 joins were occupied with approximately 80-100 *M.australis* per joint. Total: (estimate) 600-800 *M.australis*.	High	▪ Nine bat boxes in adjacent vegetation. ▪ Maximum jointing gaps (as per manufacturer's specifications). ▪ Restrict pedestrian access to the existing arch (limited to essential entry only); ▪ No vehicular access beneath the existing arch; ▪ Sandbag water within the existing arch to trap water (which is an essential requirement for microbats) for the duration of construction; ▪ Install a temporary barrier in the form of a series of geofabric/ plastic sheets on the end of the arch between the works area and the microbats which is to be extended to be lowered during daily works and raised prior to dusk daily; ▪ Ensure the fly-way beneath the arch is not obstructed at night; ▪ Ensure water flow is re-instated following completion of works; and ▪ Works directly adjoining the Arch would be avoided during the Large-footed Myotis breeding season (ie. no works between early October and mid-April), if Large-footed Myotis are present. Further consultation would take place with EPA if works are proposed during this period. ▪ Monitoring.
2	c40s2	40	6699472	504252	30,160	Pacific Highway - northbound lane	1	1500	1500	RCBC	Retain	05/11/2013; 11/02/2014; 10/7/14	Swamp sclerophyll forest along the drainage line; dry sclerophyll forest in broader area	Drainage line with permanent pools suitable for Large-footed Myotis foraging. Water in cells between 100 and 400 mm deep during the 05/11/2013 survey.	400 mm at the outlet to 30 mm at the inlet.	Yes - Culvert cell joins to 20-40 mm wide and stepping in places, 150 mm deep.	Yes - Staining on the ceiling of the culvert around areas of rough concrete and cell joins.	Staining around rough patches. 180-200 *M.australis* in a single joint crack 8 m from outlet (west side).	High	▪ Monitoring.