



Construction Ecological Monitoring

Annual Report - Revision 1

March 2017

CMC Group



ecology / vegetation / wildlife / aquatic ecology / GIS

Executive summary

New South Wales Roads and Maritime Services is upgrading the Pacific Highway between Woolgoolga and Ballina in northern New South Wales. This upgrade will increase the carriage way from two lanes to a divided four lane carriageway.

CMC Group was engaged to construct Section 2 of the Woolgoolga to Ballina Pacific Highway upgrade, from Halfway Creek to Glenugie. Ecosure Pty Ltd have been assisting CMC since April 2015 to meet and where possible, exceed, their environmental management responsibilities for this upgrade. As part of these works, Ecosure monitored nest boxes and other artificial structures for fauna. This report provides the results of this monitoring program from February 2016 to December 2016.

Microbat structure monitoring for microbats occurred quarterly as per the approved management plan. Ecosure monitored five times during the year, with an additional monitoring period in November. This was part of Ecosure internal quality assurance audit. Monitoring encompassed boxes installed in 2014 as well as a number of culverts, including control sites away from the clearing for the road (at Bebo Arch).

Boxes attached to the Halfway Creek bridge were occupied by the threatened large-footed myotis (*Myotis macropus*) during all periods of monitoring, this species is listed as vulnerable under the New South Wales *Threatened Species Conservation Act 1995*. Bent-wing bats (*Miniopterus* sp.) were also observed at control sites. Apart from these areas, uptake of built microbat structures was low. It is recommended that a review of the location/orientation of boxes is undertaken prior to the next scheduled monitoring event (Summer 2017).

Nest box monitoring is required during summer and winter months throughout construction activities. The first round of nest box monitoring occurred in February and March 2016 (summer) with the second round in August 2016 (winter). Both monitoring events were of 70% of installed nest boxes (159).

Eighteen individuals comprising of three species were recorded across the two monitoring events in eleven nest boxes; with one box found to contain a pair of squirrel gliders. Forty-eight nest boxes out of 159 (30%) showed evidence of occupancy (excluding evidence of pest or spider species).

The remaining 30% of nest boxes (90) were installed in September 2016 and will be monitored from 2017. Nest boxes will be well-established and should provide optimal occupancy results. Maintenance of boxes was minimal with only minor occurrences of damage, while occurrence of pest species (wasps, honeybees and termites) occurred in only four (2.5%) of the nest boxes over both monitoring events

Glossary, acronyms and abbreviations

CEMP	Construction Environmental Management Plan
FFMP	Appendix B2 of the Construction Environmental Management Plan: Construction Flora and Fauna Management Plan – Halfway Creek to Glenugie Pacific Highway Upgrade (CMC 2015)
GIS	Geographic Information System
HC2G	Section 2 of the Pacific Highway Upgrade from Halfway Creek to Glenugie
MCoA	Minister of the Environment’s Conditions of Approval
MMP	Woolgoolga to Glenugie Pacific Highway Upgrade: Microbat Management Plan Section 1 and 2 (Geolink 2014)
NBMP	W2B Pacific Highway Upgrade Habitat Tree Assessment and Nest box management plan for Section 2 – Halfway Creek to Glenugie – Final (Ecosure 2014).
NSW	New South Wales
PMP	Project Management Plan
Roads and Maritime	Roads and Maritime Services
TSC Act	NSW <i>Threatened Species Conservation Act 1995</i>
W2B	Woolgoolga to Ballina

Contents

Executive summary.....	i
Glossary, acronyms and abbreviations	ii
List of figures	iv
List of plates	iv
List of tables	v
1 Introduction	1
1.1 Background	1
1.2 Objectives and scope.....	1
2 Methods	2
2.1 Literature review	2
2.2 Ecological monitoring program	2
2.2.1 Microbat box installation	2
2.2.2 Microbat structure monitoring	2
2.2.3 Nest box monitoring	3
2.3 Timeframes and status.....	4
3 Results.....	7
3.1 Microbat structure monitoring	7
3.2 Nest box monitoring	16
4 Discussion.....	18
4.1 Microbat monitoring.....	18
4.2 Nest box monitoring	18
5 Recommendations.....	20
References.....	21
Appendix 1 Microbat monitoring results	22
Appendix 2 Nest box monitoring results	23
Appendix 3 Weather conditions	44

List of figures

Figure 1 Microbat structure locations	5
Figure 2 Locations of installed nest boxes and occupancy	9

List of plates

Plate 1 Nest box inspection using Jameson poles	4
Plate 2 Nest box inspection through tree climbing	4
Plate 3 Large-footed myotis in lattice nest box	8
Plate 4 Two sugar gliders (winter 2016)	17
Plate 5 Evidence of occupancy example.....	17
Plate 6 Feather-tail glider (summer 2016).....	17
Plate 7 Common brushtail possum (summer 2016).....	17

List of tables

Table 1 Drainage structures within Section 2 (taken from Geolink 2014)	3
Table 3 Monitoring and maintenance schedule for nest box and microbat structure monitoring (adapted from Ecosure 2014 and Geolink 2014)	4
Table 4 Microbat monitoring results – nest boxes.....	7
Table 5 Microbat monitoring results – culverts.....	8
Table 6 Summary of nest box monitoring results	16
Table 7 Construction ecological monitoring timing	20
Table 8 Summary of nest box monitoring results	24
Table 9 Summary of weather conditions for monitoring periods	44

1 Introduction

1.1 Background

New South Wales Roads and Maritime Services (Roads and Maritime) are upgrading the Pacific Highway between Woolgoolga and Ballina in northern New South Wales. This upgrade will increase the carriage way from two lanes to a divided four lane carriageway.

The CMC Group was engaged by Roads and Maritime to construct Section 2 of the Woolgoolga to Ballina Pacific Highway upgrade, from Halfway Creek to Glenugie (HC2G). Ecosure Pty Ltd (Ecosure) have been assisting CMC since April 2015 to meet and where possible, exceed, their environmental management responsibilities for this upgrade. Ecosure was engaged by CMC to interpret various threatened species management plans and to undertake ecological monitoring during construction, from February 2016 to December 2016.

1.2 Objectives and scope

The project objective was to undertake monitoring of threatened microbat artificial habitat (including bat boxes and culverts) and installed nest boxes, as per the approved management plans developed as part of the planning and construction of Section 2 of the W2B upgrade.

The key components of the scope for this project were to:

- a) Review construction monitoring requirements of both the Threatened Microbat Management Plan (MMP) and Nest Box Management Plan (NBMP) for Section 2 of the W2B Pacific Highway upgrade (Halfway Creek to Glenugie).
- b) Implement the approved monitoring program required during the construction phase until December 2016. Specifically, monitoring was undertaken as follows:
 - quarterly microbat monitoring
 - biannual monitoring of bat boxes (occurring twelve months after installation followed by summer and winter census)
 - monitoring of nest boxes and maintenance in accordance with the NBMP and the Construction Environment Management Plan (CEMP).
- c) Provide a report that summarises the results of the above monitoring.

2 Methods

2.1 Literature review

Key background information and databases were reviewed including but not limited to:

- previous reports relating to species management including the MMP and NBMP
- CEMP, especially Appendix B2: Construction Flora and Fauna Management Plan – Halfway Creek to Glenugie Pacific Highway Upgrade (FFMP)
- refereed journals on nest box occupation/uptake.

Following the literature review, field maps were produced with key background information and requirements.

2.2 Ecological monitoring program

2.2.1 Microbat box installation

Prior to Ecosure's project involvement, 19 microbat boxes were installed within the project area, including 12 boxes near Bebo Arch (MMP 17-28), two boxes under Halfway Creek Bridge and five in trees surrounding Halfway Creek (MMP1 - MMP5) (Geolink 2014).

In accordance with the Microbat Management Plan (GeoLink 2014), a range of microbat box designs were used to increase chances of uptake, account for differing species preferences, address seasonality and thermoregulatory considerations and the fact that bats are known to regularly change roost locations. Designs included:

- two-chambered tree mounted
- three-chambered tree mounted
- four-chambered hanging
- four-chambered tree mounted
- lattice-style under Halfway Creek bridge.

2.2.2 Microbat structure monitoring

Nineteen nest boxes and four drainage structures (culverts) were inspected quarterly during the 2016 monitoring program as well as an additional inspection carried out as part of Ecosure's internal quality assurance audit. The drainage structures were included in the monitoring due to being medium to high conservation/habitat values for microbats (GeoLINK 2014) (Table 1). Three control sites (Structures 40, 66 and 67) were also monitored at Bebo Arch, to the north of the project.

Table 1 Drainage structures within Section 2 (taken from Geolink 2014)

Chainage	Reference No. (Identification)	Feature Type	Conservation/Habitat Value
20,665	25 (Halfway Creek Culvert)	RCBC	High
21,000	Halfway Creek Bridge	Bridge (plus two bat boxes)	Medium
29,360	32 (Bebo Arch)	ARCH	High
30,160	40	RCBC	High

2.2.3 Nest box monitoring

Nest box monitoring occurred in summer and winter months throughout construction activities, as per the NBMP. The first round of nest box monitoring occurred in February and March 2016 (summer) and included monitoring of 70% of installed boxes. The second round of monitoring occurred in August 2016 (winter) and also included monitoring of 70% of installed nest boxes (Table 1) (Figure 1).

Nest boxes were monitored by a team of three, consisting of a qualified ecologist and two wildlife field officers. Monitoring was conducted through the use of extendable poles (Jameson poles), fitted with an inspection camera as well as through tree climbing (by trained and experienced tree climber and spotter) when required (Plates 1 and 2).

Each nest box was visited and evidence of use recorded. This could include:

- occurrence of a native animal or pest species within the nest box
- occurrence of nesting material, scats, feathers etc.

During each monitoring event, any minor maintenance issues were recorded and where possible addressed on site. Any pest animals were also removed and the box cleaned when required.

As an additional aid to determine occurrence, double sided tape was attached to the entrance of 28 nest boxes of various sizes during the summer (March 2016) monitoring event. Tape was then collected during the winter monitoring event and checked for hair. Any hair found was identified. This method assisted in identifying mammals moving in or out of the nest box entrance, even if not currently present (Lindenmayer et al. 2009).



Plate 1 Nest box inspection using Jamieson poles



Plate 2 Nest box inspection through tree climbing

2.3 Timeframes and status

Monitoring and maintenance of drainage structures and nest boxes were completed as per the following table (Table 3).

Table 2 Monitoring and maintenance schedule for nest box and microbat structure monitoring (adapted from Ecosure 2014 and Geolink 2014)

Management action	Year 1 2015	Year 2 2016	Responsibility	Monitoring frequency	Status of completion
Pre-construction					
Microbat monitoring	✓		Contractor	N/A	Completed
Implement nest box management plan	✓		RMS	N/A	Completed
Construction					
Microbat monitoring – four drainage structures and bat boxes		✓	Contractor (Ecosure)	Quarterly	Completed
Commission construction of nest boxes	✓		RMS	N/A	Completed
Installation of 70% nest boxes – pre-clearing	✓		Contractor (Ecosure)	N/A	Completed in June 2015
Installation of the remaining 30% of nest boxes - post clearing		✓	Contractor (Ecosure)	N/A	Completed in September 2016
Nestbox monitoring		✓	Contractor (Ecosure)	Summer and winter	Summer monitoring completed in March 2016 Winter monitoring completed in August 2016



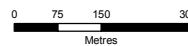
Figure 1: Bat box locations for section 2
Map 1 of 2

CMC Pty Ltd

Ecological monitoring



Job number: PR1491
 Revision: 0
 Author: DJB
 Date: 19/12/2016



GDA 1994 MGA Zone 56
 Projection: Transverse Mercator
 Datum: GDA 1994
 Units: Meter



Figure 1: Bat box locations for section 2
Map 2 of 2

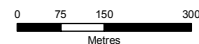
CMC Pty Ltd

Ecological monitoring

- Chainages
- Bat box locations
- PlanExtent
- Lot
- ▭ Project boundary



Job number: PR1491
 Revision: 0
 Author: DJB
 Date: 19/12/2016



GDA 1994 MGA Zone 56
 Projection: Transverse Mercator
 Datum: GDA 1994
 Units: Meter

3 Results

3.1 Microbat structure monitoring

Nineteen nest boxes (Table 4) and four drainage structures (Table 5) were inspected during the monitoring program. Detailed results are shown in Appendix 1.

Table 3 Microbat monitoring results – nest boxes

Monitoring event	Number of nest boxes containing microbats	Location of nest boxes containing microbats	Scientific name	Common name	Number of individuals
March 2016	2	2 boxes under Halfway Creek Bridge	<i>Myotis macropus</i>	Large-footed myotis	>10 in each box
August 2016	2	2 boxes under Halfway Creek Bridge	<i>Myotis macropus</i>	Large-footed myotis	>10 in each box
October 2016*	2	2 boxes under Halfway Creek Bridge (new*)	<i>Myotis macropus</i>	Large-footed myotis	2 17 in large box
November 2016	2	2 boxes under Halfway Creek Bridge (new*)	<i>Myotis macropus</i>	Large-footed myotis	Nothing in originally installed boxes, only in new boxes under Halfway Creek Bridge
December 2016	2	2 boxes under Halfway Creek Bridge (new*)	<i>Myotis macropus</i>	Large-footed myotis	Nothing in originally installed boxes, only in new boxes under Halfway Creek Bridge

*two lattice-style microbat boxes were moved from the old Halfway Creek Bridge to the new Halfway Creek Bridge.

One nest box (MM19) has fallen down (possibly damage by termites). Culverts were also monitored as per the MMP (Table 4).

Table 4 Microbat monitoring results – culverts

Monitoring event	Number of structures containing microbats	Location of structures containing microbats	Scientific name	Common name	Number of individuals
March 2016	2	Between the culvert joins under Halfway Creek Bridge	<i>Myotis macropus</i>	Large-footed myotis	4
		Between the culvert joins under Bebo Arch bridge	<i>Myotis macropus</i>	Large-footed myotis	5
			<i>Miniopterus spp</i>	Bent-wing bat	2
August 2016	1	Between the culvert joins under Bebo Arch bridge	<i>Myotis macropus</i> (probable)	Unidentified (probably large-footed myotis)	>5
October 2016	0	Evidence only (guano – Bebo Arch bridge)	n/a	n/a	n/a
November 2016	0	N/A			
December 2016	0	N/A			

Plate 3 shows large-footed myotis found in the lattice nest box under the Halfway Creek Bridge.



Plate 3 Large-footed myotis in lattice nest box at existing Halfway Creek bridge

The large-footed myotis (*Myotis macropus*) and both possible bent-wing bat species (either *Miniopterus australis* or *Miniopterus schreibersii oceansis*) are listed as vulnerable under the *Threatened Species Conservation Act 1995*.

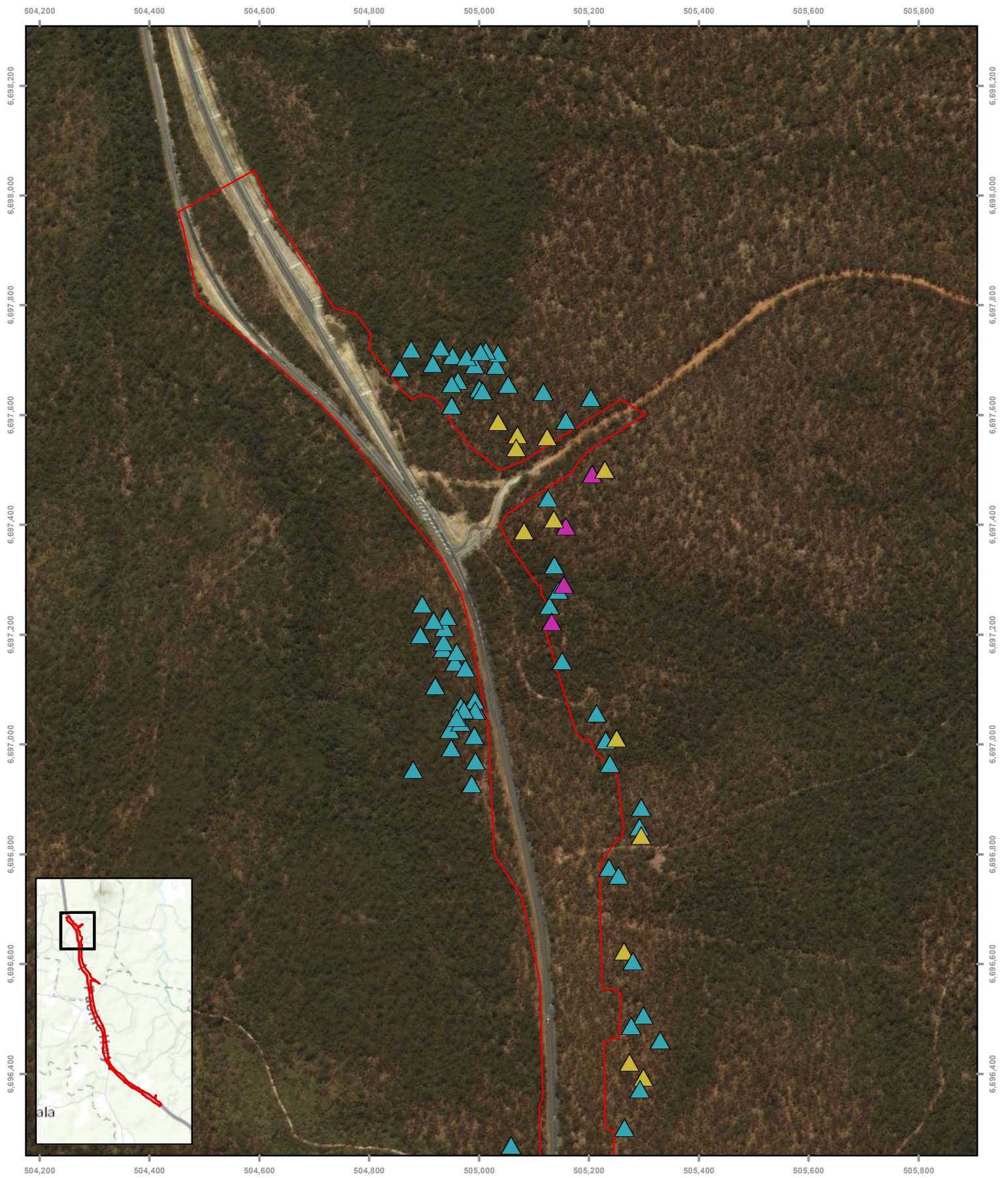


Figure 2: Locations of installed nest boxes and occupancy

Page 1 of 7

CMC Group
Ecological monitoring

Proposed clearing area

Nestboxes

- ▲ Wood; not occupied
- ▲ Wood, occupied
- ▲ Wood, evidence of occupancy



Job number: PR1491
 Revision: 0
 Author: DB
 Date: 20/12/2016



GDA 1994 MGA Zone 56
 Projection: Transverse Mercator
 Datum: GDA 1994
 Units: Meter

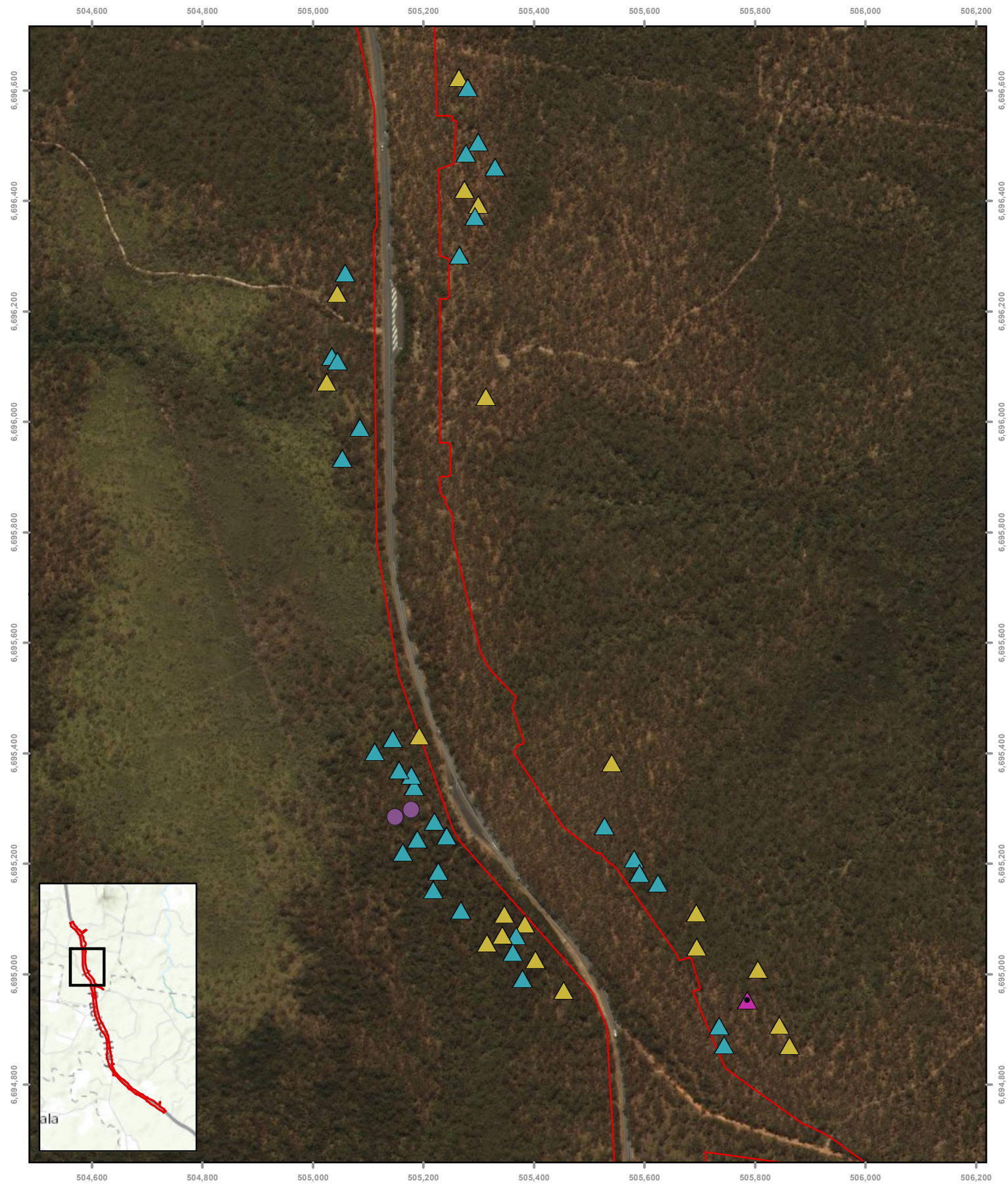


Figure 2: Locations of installed nest boxes and occupancy

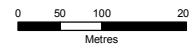
Page 2 of 7

CMC Group
Ecological monitoring

- Proposed clearing area
 - Threatened species occupancy (summer)
- Nestboxes**
- Aluminium, not occupied
 - Wood; not occupied
 - Wood, occupied
 - Wood, evidence of occupancy



Job number: PR1491
Revision: 0
Author: DB
Date: 20/12/2016



GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

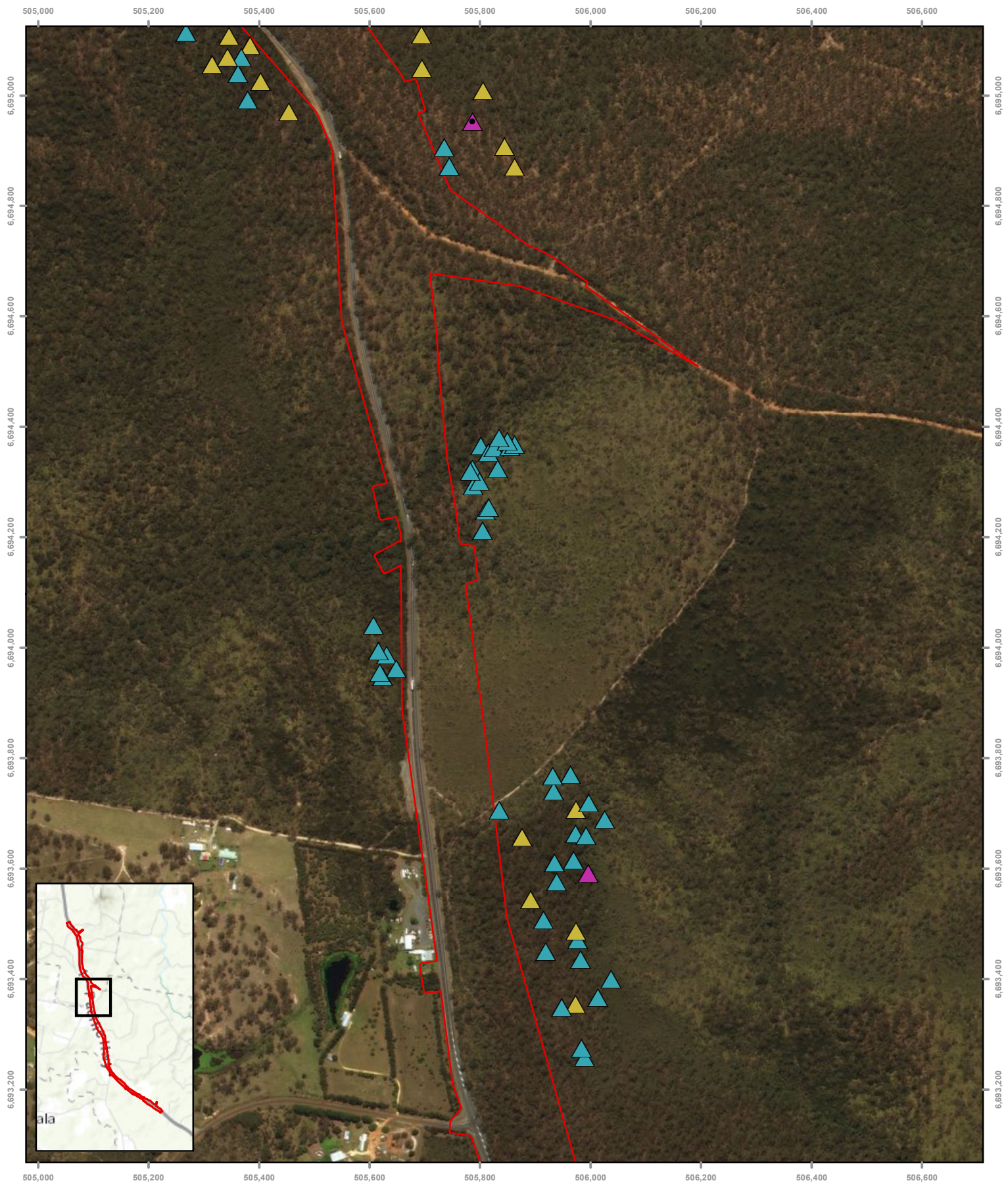


Figure 2: Locations of installed nest boxes and occupancy

Page 3 of 7

CMC Group
Ecological monitoring

Proposed clearing area
Threatened species occupancy (summer)

Nestboxes
 Wood; not occupied
 Wood, occupied
 Wood, evidence of occupancy



Job number: PR1491
 Revision: 0
 Author: DB
 Date: 20/12/2016



0 50 100 200
 Metres

GDA 1994 MGA Zone 56
 Projection: Transverse Mercator
 Datum: GDA 1994
 Units: Meter

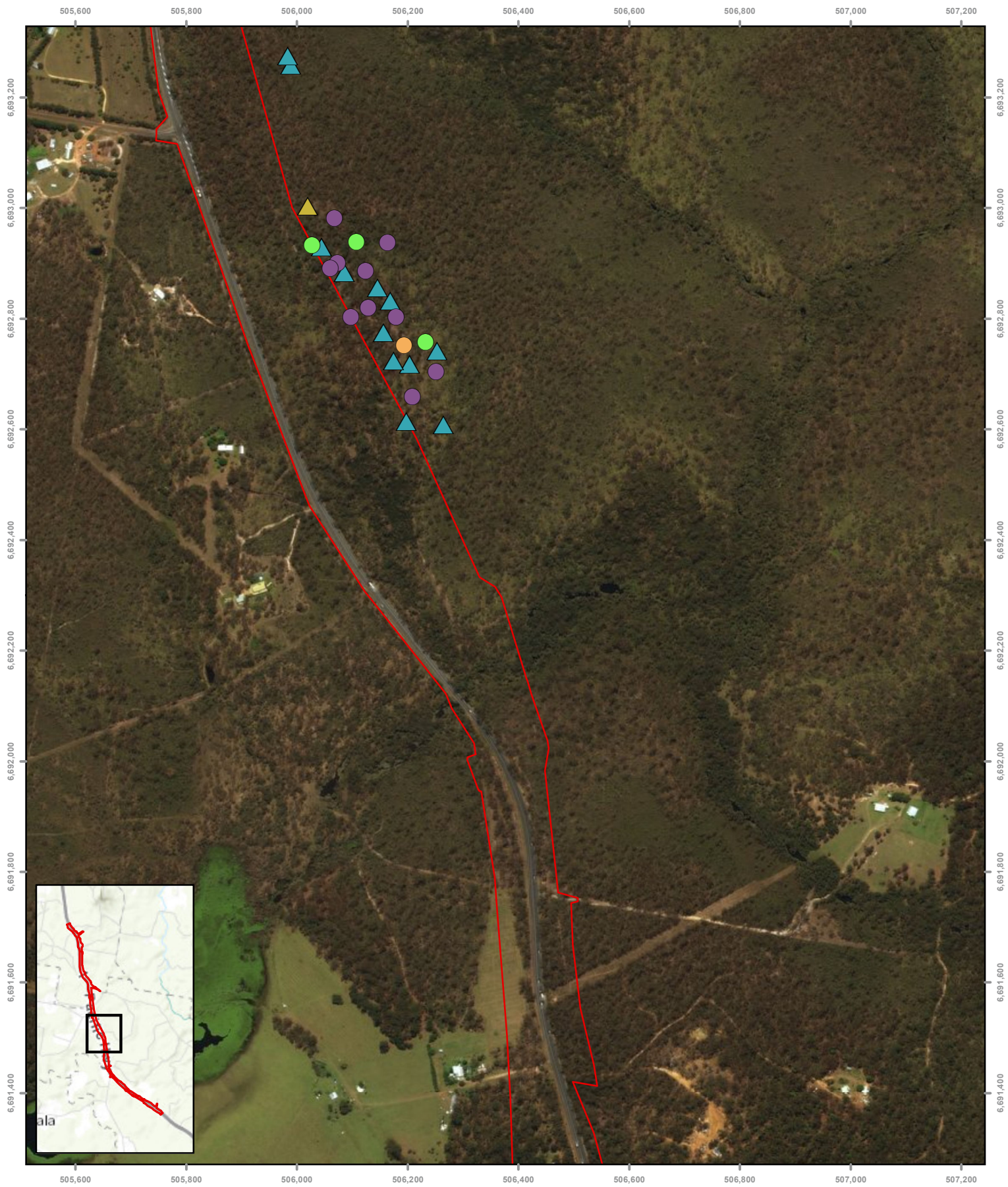


Figure 2: Locations of installed nest boxes and occupancy

Page 4 of 7

CMC Group
Ecological monitoring

Proposed clearing area

Nestboxes

- Aluminium, not occupied
- Aluminium, occupied
- Aluminium, evidence of occupancy
- ▲ Wood; not occupied
- ▲ Wood, evidence of occupancy



Job number: PR1491
 Revision: 0
 Author: DB
 Date: 20/12/2016

GDA 1994 MGA Zone 56
 Projection: Transverse Mercator
 Datum: GDA 1994
 Units: Meter

Data Sources: © Ecosure Pty Ltd, 2016; RMS, 2015. Image Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MagnyIndia, © OpenStreetMap contributors, and the GIS User Community
 Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
 ECOSURE does not warrant the accuracy or completeness of information displayed in this map and any person using it does so at their own risk. ECOSURE shall bear no responsibility or liability for any errors, faults, defects, or omissions in the information.

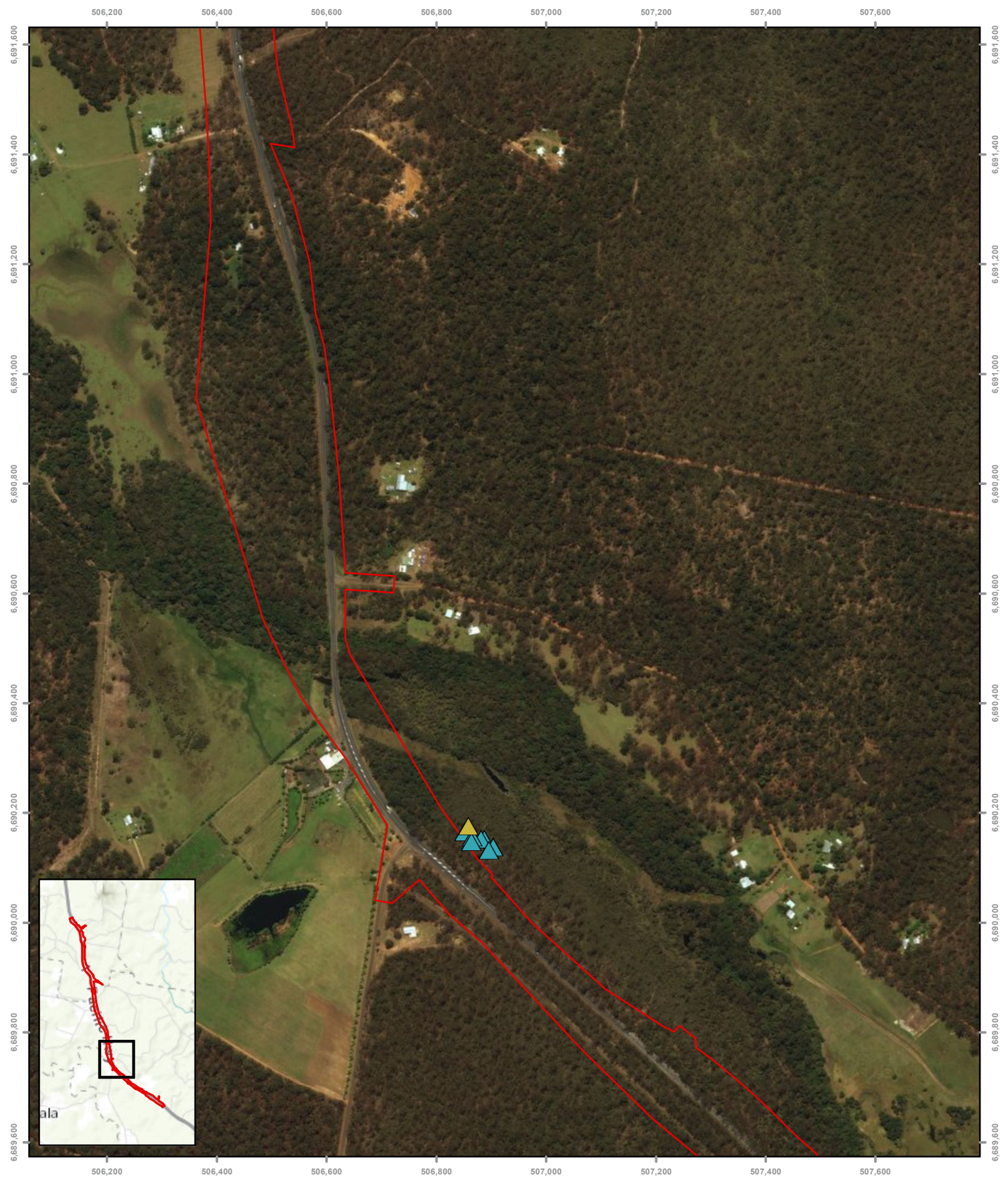


Figure 2: Locations of installed nest boxes and occupancy

Page 5 of 7

CMC Group
Ecological monitoring

Proposed clearing area

Nestboxes
▲ Wood; not occupied
▲ Wood, evidence of occupancy



Job number: PR1491
 Revision: 0
 Author: DB
 Date: 20/12/2016

GDA 1994 MGA Zone 56
 Projection: Transverse Mercator
 Datum: GDA 1994
 Units: Meter

Data Sources: © Ecosure Pty Ltd, 2016; RMS, 2015, Image Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MagnyIndia, © OpenStreetMap contributors, and the GIS User Community
 Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
 ECOSURE does not warrant the accuracy or completeness of information displayed in this map and any person using it does so at their own risk. ECOSURE shall bear no responsibility or liability for any errors, faults, defects, or omissions in the information.

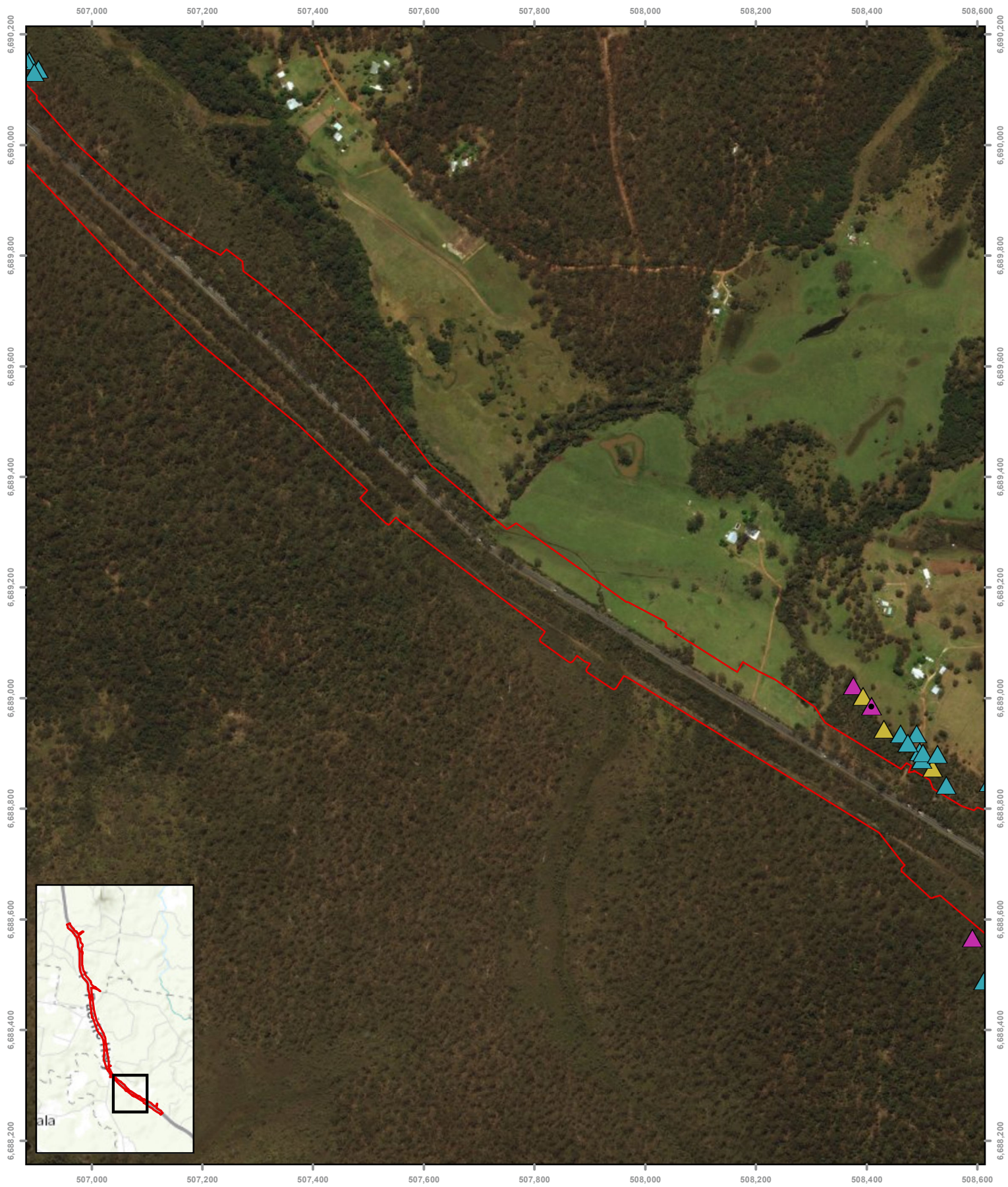


Figure 2: Locations of installed nest boxes and occupancy

Page 6 of 7

CMC Group
Ecological monitoring

- Proposed clearing area
 - Threatened species occupancy (summer)
- Nestboxes**
- ▲ Wood; not occupied
 - ▲ Wood, occupied
 - ▲ Wood, evidence of occupancy



Job number: PR1491
Revision: 0
Author: DB
Date: 20/12/2016

0 50 100 200
Metres

GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

Data Sources: © Ecosure Pty Ltd, 2016; RMS, 2015. Image Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, Magyria, © OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
PR1491_MP1_NestboxLocations_Jan2017
A4
ECOSURE does not warrant the accuracy or completeness of information displayed in this map and any person using it does so at their own risk. ECOSURE shall bear no responsibility or liability for any errors, faults, defects, or omissions in the information.

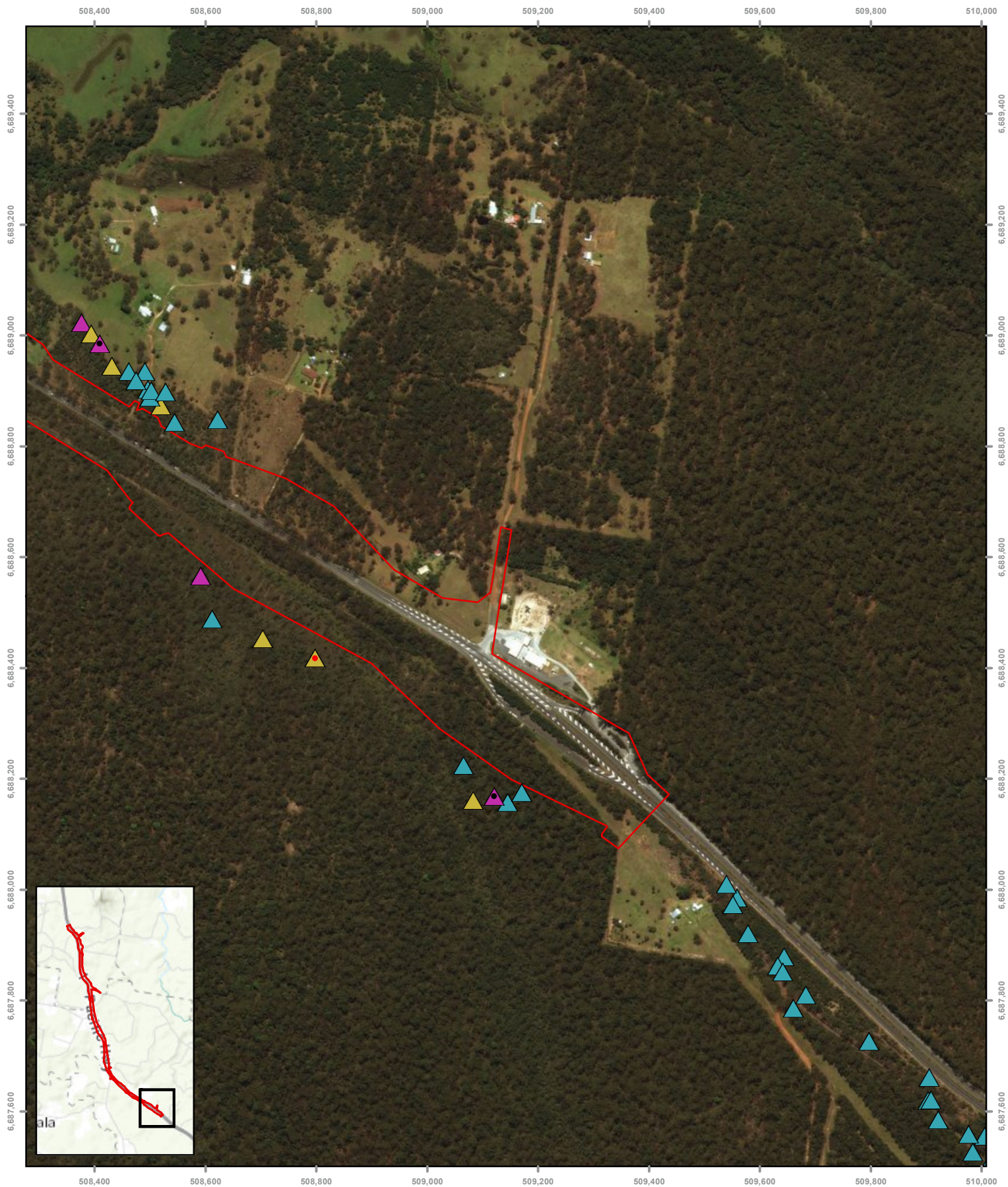


Figure 2: Locations of installed nest boxes and occupancy

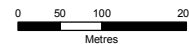
Page 7 of 7

CMC Group
Ecological monitoring

- Proposed clearing area
 - Threatened species occupancy (winter)
 - Threatened species occupancy (summer)
- Nestboxes**
- ▲ Wood; not occupied
 - ▲ Wood, occupied
 - ▲ Wood, evidence of occupancy



Job number: PR1491
Revision: 0
Author: DB
Date: 20/12/2016



GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

3.2 Nest box monitoring

The first round of nest box monitoring occurred in February and March 2016 (summer) and the second round of monitoring occurred in August 2016 (winter). Both monitoring events were of the 70% of installed nest boxes (Table 5; Figure 2) (Detailed results for every box are shown in Appendix 2).

Table 5 Summary of nest box monitoring results

Monitoring event	Number of nest boxes surveyed	Number of nest boxes containing native species	Number of nest boxes showing evidence of occupancy (excluding pests)	Percentage showing signs of use by non-pest species	Species present within nest boxes		
					Scientific name	Common name	Number of individuals
Summer 2016	156*	10	12	14%	<i>Trichosurus vulpecula</i>	common brush tail possum	6
					<i>Acrobates pygmaeus</i>	feathertail glider	4
					<i>Petaurus norfolcensis</i>	squirrel glider	4
Winter 2016	159	2	40	26%	<i>Petaurus norfolcensis</i>	squirrel glider	4

*four nest boxes were not monitored during summer monitoring but were inspected during winter monitoring event.

Eighteen individuals consisting of three species were recorded in 11 nest boxes, with one box containing two squirrel gliders during both monitoring events (Tree tag #120, could be the same individuals). Forty eight nest boxes (30%) were occupied or showed evidence of occupancy in at least one of the two monitoring events (excluding evidence of pests). Evidence of occupancy was determined through presence of nests, leaf litter, bark, scats etc inside the box, as well as scratches or bite marks in and around the boxes (Plate 5). Eucalypt leaves are usually associated with glider nests (e.g Law 2014). Double-sided tape revealed the presence of two squirrel gliders in apparently empty boxes (Appendix 2).

Pests or evidence of pests were found in four boxes over the two monitoring events (three in summer and one in winter) (one termite nest, two mud wasp nests and evidence of honeybees in one box). All pest species or evidence was removed. Spiders or webs occurred in five boxes, which may be a deterrent for some birds or mammals, but is not considered a pest species as such.



Plate 4 Two sugar gliders (Box#120, winter 2016)



Plate 5 Evidence of occupancy example (Box #3, winter 2016)



Plate 6 Feather-tail glider (summer 2016, in Aluminium/Polystyrene composite) (Box #94)



Plate 7 Common brushtail possum (Box#7, summer 2016).

Squirrel gliders were the most commonly encountered species (eight individuals were recorded, although it is possible that one box contained the same individuals in both monitoring events), and evidence of their presence was also most common. Evidence of occupancy was also usually consistent with glider use for the majority of boxes (Plate 5).

This species is listed under the TSC Act as vulnerable. Feather-tail gliders and common brushtail possums are protected under the *National Parks and Wildlife Act 1974*, but are not considered to be of conservation significance.

Pest species were found in four nest boxes (mud wasps, honeycomb and termites), with spiders found in a further five nest boxes over both monitoring periods.

Weather conditions for all monitoring periods are shown in Appendix 3.

4 Discussion

4.1 Microbat monitoring

Uptake of microbat boxes was generally low, with animals primarily confined to lattice-style boxes underneath both the old and new Halfway Creek bridges (see Ecosure 2017 [in prep] for more details on the new boxes installed within the new bridge). Microbat boxes have been installed since 2014, and so are well-established, however, microbats are notoriously slow to take up nest boxes, with some species taking up to three years to utilise a box (e.g. Tweed Valley Wildlife Carers n.d).

There are many variables associated with roost box uptake, such as varying microclimate requirements (between species and seasonally within species). In other studies, large-footed myotis have been shown to use both hanging roost boxes and lattice-style boxes. For example, myotis were reported to regularly use both styles in and around the study area (Silver and Lloyd 2014).

Hanging boxes were initially installed as temporary habitat in the interim between demolishing an old culvert (Myotis habitat) and constructing the replacement culvert. After the new culvert was constructed and lattice-style boxes installed, Myotis continued to use both types of boxes (December 2012 – April 2014). However, during the four most recent monitoring events in 2016, hanging boxes have not been occupied, which suggests some preference in this instance for either the lattice-style box or the location of these lattice boxes. As such, it is recommended that lattice-style boxes are provided for this species in future projects. A variety of boxes of different designs should continue to be provided when targeting a range of microbat species, and also account for seasonal variation of roosting requirements within species (including large-footed myotis).

Large-footed myotis and bent-wing bats were recorded in the cracks within the culverts at Bebo Arch during March and August surveys, with evidence of occupancy recorded in October. It is possible that these cracks are less attractive to bats during warmer months.

4.2 Nest box monitoring

Over both summer and winter monitoring events, 30% of boxes showed signs of use or had an individual within the box. During summer monitoring, occupancy was higher than winter (10 vs 2 boxes), but overall evidence of use was lower (14% vs 26%), possibly just because winter monitoring occurred later, giving longer for boxes to be used and for nesting material to accumulate. The low number of individuals present during winter may be due to a local flowering event approximately 1-2 km to the south, where there was an abundance of banksia flowering. Animals may have temporarily moved to take advantage of this event and so there was evidence of recent use but no animals. It is also possible that animals retreated to more thermally favourable locations during the cold winter months. Eleven out of 12 occupied nest boxes were wood, with one feathertail glider utilising a composite box (Appendix 2; Plate 6). This is a low rate of occupancy compared with the number of composite boxes (28 of 159, or 18%). If occupancy was similar to the wooden boxes, approximately eight composite boxes

should be occupied or show signs of occupancy.

Comparing these results to a recent study on the effect of entrance size, tree size and landscape context on nest box uptake by Le Roux et al. (2016) shows some interesting preliminary comparisons. More powerful conclusions should be possible after two or more years data are collected.

Le Roux et al. (2016) monitored their nest boxes up to ten times over two years from 2013 and found uptake of 69%, significantly greater than the current results. However, Le Roux et al. (2016) note that they had no rare or threatened fauna occupying nest boxes, in contrast to the current study, where the most commonly encountered species was the squirrel glider, listed as vulnerable under the TSC Act.

Le Roux et al. (2016) also found a greater occurrence of pest species than the current study. Honey bees occupied 14% of nest boxes in reserves, with exotic birds present in 17% of boxes (Le Roux et al. 2016). The current study had just one box with termites, two with mud wasp nests and one with evidence of honeybees. No pest birds were detected. It is possible that over time, and with a greater number of nest boxes to monitor next year, pest species occupancy may increase.

5 Recommendations

Further monitoring of both microbat and nest boxes are recommended to occur in 2017, as per the schedule from the MMP (Geolink 2014) and NBMP (Ecosure 2014) (summarised in Table 6). The green indicates the completion of monitoring and maintenance component. Post-construction monitoring will occur in summer and winter months for six years (until the end of 2023).

It is recommended that the layout and direction of microbat boxes are reviewed to see if more uptake is possible prior to beginning monitoring in 2017, however it is noted that there is some evidence that uptake by microbats is slower than by other fauna and may not be expected until 2017. Given the minimal update of boxes by microbats, this may need to be reviewed after 2017.

Unless further monitoring contradicts recent results, future projects involving large-footed myotis should include provision of lattice-style boxes (which, based on recent results, appears to be their preference at this location). However a variety of boxes of different design should continue to be installed when targeting a range of species, and also account for seasonal variation within species (Silver and Lloyd 2014).

Table 6 Construction ecological monitoring timing

Timing	2016				2017			
	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring
Target group								
Microbat structure monitoring	✓	✓	✓	✓	✓	✓	✓	✓
Nestbox monitoring and maintenance	✓		✓		✓		✓	

References

- BOM 2016, *Bureau of Meteorology – Climate Data Online- Grafton (Station 058161)*, Australian Government, viewed 13 December 2016, <http://www.bom.gov.au/climate/dwo/IDCJDW2050.latest.shtml>.
- Silver, V and Lloyd, A 2014, *Consulting Ecology Newsletter of the Ecological Consultants Association of NSW*, Volume 33 August 2014.
- Ecosure 2014, *Habitat Tree Assessment and Nest Box Management Plan for Section 2: Halfway Creek to Glenugie, Woolgoolga to Ballina Pacific Highway Upgrade*. Report prepared for Roads and Maritime Services, October 2014, West Burleigh.
- Geolink 2014, *Woolgoolga to Glenugie Pacific Highway Upgrade: Microbat Management Plan. Section 1 and 2*. Report prepared for NSW Roads and Maritime Services, Lennox Head, NSW.
- Law, B (2014) A Survey for Eastern Pygmy Possums *Cercartetus nanus* in selected Reserves of Pittwater. Unpublished report prepared for Pittwater Council (now Northern Beaches Council) by Dr Brad Law, Narrabeen, NSW.
- Le Roux, DS, Ikin, K, Lindenmayer, DB, Bistricher, G, Manning, AD and Gibbons, P, 2016, Effects of Entrance Size, Tree Size and Landscape Context on Nest Box Occupancy. Considerations for management and biodiversity offsets. *Forest Ecology and Management*. 366 (2016) 135-142.
- Lindenmayer, DB, Welsh, A, Donnelly, C, Crane, M, Michael, D, Macgregor, C, McBurney, L, Montague-Drake, R & Gibbons P 2009, Are nest boxes a viable alternative source of cavities for hollow-dependent animals? Long-term monitoring of nest box occupancy, pest use and attrition. *Biological Conservation*, vol. 142, pp. 33-42.
- RTA 2011, *Biodiversity Guidelines: protecting and managing biodiversity on RTA projects*. Revision 0/September 2011, Roads and Transport Authority, North Sydney, NSW.
- Silver, V and Lloyd, A (2014) Creating Roosting Habitat Alternatives for Breeding Myotis. *Consulting Ecology*. Vol.33, pp 15-18.
- Tweed Valley Wildlife Carers, n.d *Building a Nestbox for Microbats*. Tweed Valley Wildlife Carers Inc, Murwillumbah.


Appendix 1


Microbat monitoring results


Appendix 2


Nest box monitoring results

Table 7 Summary of nest box monitoring results


Tree tag number	Nest box size and type	Summer		Winter		Notes	Photo (if available)
		Species occupying box (# in brackets)	Evidence of occupancy	Species occupying box (# in brackets)	Evidence of occupancy		
1	Small mammal box	None	None	None	None		
2	Small mammal box	None	None	None	None		
3	Small glider box	None	None	None	None		
4	Small parrot box	None	Yes (leaf litter)	None	None	Potential glider nest	
5	Large parrot box	None	None	None	None		


Tree tag number	Nest box size and type	Summer		Winter		Notes	Photo (if available)
		Species occupying box (# in brackets)	Evidence of occupancy	Species occupying box (# in brackets)	Evidence of occupancy		
6	Small mammal box	None	None	None	None		
7	Large owl box	Common brushtail possum (1)		None	None		
8	Small glider box	None	None	None	Yes (leaf litter)		
9	Possum box	None	None	None	None		


Tree tag number	Nest box size and type	Summer		Winter		Notes	Photo (if available)
		Species occupying box (# in brackets)	Evidence of occupancy	Species occupying box (# in brackets)	Evidence of occupancy		
10	small glider box	Feathertail glider (3)		None	Yes (leaf litter)	Female and two joeys (summer)	
11	Small mammal box	None	Yes (termites)	None	None		
12	Small parrot box	None	Yes (Bite marks at entrance)	None	None		
13	small glider box	None	None	None	None		
14	Large glider box	None	None	None	None		

Tree tag number	Nest box size and type	Summer		Winter		Notes	Photo (if available)
		Species occupying box (# in brackets)	Evidence of occupancy	Species occupying box (# in brackets)	Evidence of occupancy		
15	Possum box	Common brushtail possum (1)		None	None		
16	Small mammal box	None	None	None	None		
17	Small parrot box	Common brushtail possum (1)		None	None		
18	Large owl box	None	None	None	Mud wasp nest		
19	Possum box	None	None	None	None		
20	Small mammal box	None	None	None	None		
21	Small glider box	None	Yes (leaf litter)	None	Yes (lots of fresh and old leaf litter)		

Tree tag number	Nest box size and type	Summer		Winter		Notes	Photo (if available)
		Species occupying box (# in brackets)	Evidence of occupancy	Species occupying box (# in brackets)	Evidence of occupancy		
22	Large parrot box	None	None	None	None		
23	Small glider box	None	None	None	None		
24	Possum Box	None	None	None	None		
25	Small mammal box	None	None	None	Yes Ringtail? (leaf litter, mostly bark and sticks, scats)	Potential ringtail nest	
26	Large glider box	None	None	None	None		
27	Small parrot box	None	None	None	None		
28	Small mammal box	None	None	None	Yes (fresh leaf litter)	Potential squirrel glider	
29	Small parrot box	None	None	None	None		
30	Possum box	None	None	None	None		
31	Possum box	None	None	None	None		
32	Large glider box	None	None	None	None		

Tree tag number	Nest box size and type	Summer		Winter		Notes	Photo (if available)
		Species occupying box (# in brackets)	Evidence of occupancy	Species occupying box (# in brackets)	Evidence of occupancy		
33	Small mammal box	None	None	None	Yes (old leaf litter)	Potential squirrel glider, however not occupied for long	
34	Small glider box	None	None	None	Yes (old leaf litter)	Potential squirrel glider, however not occupied for long	
35	Large glider box	None	None	None	None		
36	Possum box	None	None	None	None		
37	Small mammal box	None	None	None	Yes (leaf litter)	Potential squirrel glider	
38	Large parrot box	None	None	None	None		
39	Small mammal box	None	None	None	Yes (lots of leaf litter)	Potential squirrel glider	

Tree tag number	Nest box size and type	Summer		Winter		Notes	Photo (if available)
		Species occupying box (# in brackets)	Evidence of occupancy	Species occupying box (# in brackets)	Evidence of occupancy		
40	Large owl box	None	None	None	None		
41	Small mammal box	None	None	None	None		
42	Small parrot box	None	None	None	None		
43	Small mammal box	None	None	None	None		
44	Small mammal box	None	Yes (gliders; nesting material)	None	Yes (nesting material, lots of leaf litter)	Probable squirrel glider	
45	Small parrot box	None	Yes (relatively new glider nest; unoccupied- few days old)	None	Yes (lots of old leaf litter)	Probable squirrel glider	


Tree tag number	Nest box size and type	Summer		Winter		Notes	Photo (if available)
		Species occupying box (# in brackets)	Evidence of occupancy	Species occupying box (# in brackets)	Evidence of occupancy		
46	Small mammal box	Squirrel glider		None	Yes (full of new and old leaf litter, recently used)		
47	small mammal box	None	Yes (glider nest; unoccupied)	None	Yes (lots of old leaf litter)	Probable squirrel glider	
48	Small mammal box	No data	No data	None	None		
49	small mammal box	None	None	None	None		
50	Small mammal box	None		None	Yes (recently used lots of old and new leaf litter)	Potential squirrel glider	

Tree tag number	Nest box size and type	Summer		Winter		Notes	Photo (if available)
		Species occupying box (# in brackets)	Evidence of occupancy	Species occupying box (# in brackets)	Evidence of occupancy		
51	Large glider box	None	None	None	Yes (lots of leaf litter and scats)	Potential squirrel glider	
53	Large owl box	None		None	None		
54	large glider box	None	None	None	None		
55	large glider box	None	None	None	None		
56	Small mammal box	None	None	None	None (scratches on tree)	Tree has been used, but not necessarily the nest box	
57	Large parrot box	None	None	None	None		
58	Possum box	None	None	None	None		
59	Possum box	None	None	None	Yes (small scat)		
60	Small mammal box	None	None	None	None		
61	Possum box	None		None	None		
62	Possum box	None		None	None		
63	Small mammal box	None	None	None	None		


Tree tag number	Nest box size and type	Summer		Winter		Notes	Photo (if available)
		Species occupying box (# in brackets)	Evidence of occupancy	Species occupying box (# in brackets)	Evidence of occupancy		
64	Large parrot box	Common brushtail possum (1)		None	Yes (some leaf litter)		
65	Small mammal box	None	None	None	None		
66	Large parrot box	None		None	Yes (scattered leaves)		
67	Possum box	No data	No data	None	None		
68	Small mammal box	None	None	None	None		
69	Possum box	None	None	None	Yes (smell of urine)	Possible brushtail possum	
70	Small mammal box	None	None	None	None		
71	Large parrot box	None	None	None	None		
72	Small mammal box	None	None	None	None		
73	Small mammal box	None	Yes (beetle shells possibly from feeding)	None	Yes (lots of leaf litter)	Possible squirrel glider	
74	Small mammal box	No data	No data	None	None		

Tree tag number	Nest box size and type	Summer		Winter		Notes	Photo (if available)
		Species occupying box (# in brackets)	Evidence of occupancy	Species occupying box (# in brackets)	Evidence of occupancy		
75	Large owl box	None	None	None	Yes (mud wasp nest)	Pest	
76	Possum box	None	None	None	None		
77	Possum box	None	None	None	None		
78	Possum box (aluminium)	None	None	None	None		
79	Small mammal box (aluminium)	None	None	None	Yes (spider)	Spiders	
80	Small mammal box	None	None	None	Yes (cobwebs)	Spiders	
81	Large owl box (aluminium)	None	None	None	None		
82	Small mammal box (aluminium)	None	None	None	Yes (spider)	Spiders	
83	Small glider box	None	None	None	None		
84	Large parrot box (aluminium)	None	None	None	None		

Tree tag number	Nest box size and type	Summer		Winter		Notes	Photo (if available)
		Species occupying box (# in brackets)	Evidence of occupancy	Species occupying box (# in brackets)	Evidence of occupancy		
85	Large glider box (aluminium)	None	None	None	None		
86	Small mammal box (aluminium)	None	None	None	None		
87	Small parrot box (aluminium)	None	None	None	None		
88	Possum box (aluminium)	None	None	None	None		
89	Possum box (aluminium)	None	None	None	None		
90	Small mammal box (aluminium)	None	None	None	None		
91	Large parrot box (aluminium)	None	None	None	None		
92	Possum box (aluminium)	None	None	None	None		
93	small mammal box (aluminium)	None	None	None	None		

Tree tag number	Nest box size and type	Summer		Winter		Notes	Photo (if available)
		Species occupying box (# in brackets)	Evidence of occupancy	Species occupying box (# in brackets)	Evidence of occupancy		
94	small mammal box (aluminium)	Feathertail glider (1)		None	Yes (leaf litter, previously used)		
95	Small mammal box	None	None	None	None		
96	Possum box (aluminium)	None	None	None	None		
97	Large parrot box (aluminium)	None	Yes (few leaves in box-does not look like nesting)	None	None		
98	Possum box (aluminium)	None	None	None	None		
99	Small parrot box (aluminium)	None	None	None	None		

Tree tag number	Nest box size and type	Summer		Winter		Notes	Photo (if available)
		Species occupying box (# in brackets)	Evidence of occupancy	Species occupying box (# in brackets)	Evidence of occupancy		
100	Small mammal box (aluminium)	None	None	None	None		
101	Possum box (aluminium)	None	None	None	None		
102	Large Owl box	None	None	None	None		
103	Small glider box	None	None	None	None		
104	Small glider box	None	None	None	None		
105	Large parrot box	None	None	None	None		
106	Possum box	None	None	None	None		
107	Possum box	None	None	None	None		
108	Small glider box	None	None	None	None		
109	Large parrot box	None	None	None	None		
110	Small mammal box	None	None	None	Yes (half full of leaves)	Possible squirrel glider	

Tree tag number	Nest box size and type	Summer		Winter		Notes	Photo (if available)
		Species occupying box (# in brackets)	Evidence of occupancy	Species occupying box (# in brackets)	Evidence of occupancy		
118	Small mammal box	None	None	None	None		
119	Small mammal box	None	None	None	None		
120	Small mammal box	Squirrel glider (2)		Squirrel glider (2)	Full of leaves		
121	Small mammal box	None	Yes (glider nest very fresh)	None	None	Probable squirrel glider	
122	Large glider box	None	None	None	None		
123	Large parrot box	None	Yes (leaf nest, mud wasp nest)	None	None		

Tree tag number	Nest box size and type	Summer		Winter		Notes	Photo (if available)
		Species occupying box (# in brackets)	Evidence of occupancy	Species occupying box (# in brackets)	Evidence of occupancy		
124	Small mammal box	None	None	None	Yes (lots of leaf litter)		
125	Small mammal box	None	None	None	None		
126	Large owl box	Common brushtail possum (1)		None	None		
127	Large parrot box	Common brushtail possum (1)		None	None		
128	Possum box	None	None	None	Yes (some bark)		
129	Small mammal box	None	Yes (glider, leaf nest recently used)	Squirrel glider			
130	Small mammal box	None	Yes (glider nest)	None	Yes (lots of leaf litter, euc leaves)		
131	Large glider box	None	Yes (evidence of some use, bits of bark, maybe some hair or insect legs)	None	None		
132	Possum box	None	None	None	None		
133	Small glider box	None	None	None	None		

Tree tag number	Nest box size and type	Summer		Winter		Notes	Photo (if available)
		Species occupying box (# in brackets)	Evidence of occupancy	Species occupying box (# in brackets)	Evidence of occupancy		
134	Large owl box	None	None	None	None		
135	Small glider box	None	None	None	None (spider shavings)		
136	Small mammal box	None	None	None	Yes (fresh green leaf litter)		
137	Small mammal box	None	None	None	None	Water in box	
138	Small mammal box	None	None	None	Yes (glider leaf nest-old and new leaves)		
139	Small glider box	None	None	None	None		
140	Small glider box	None	None	None	Yes (some leaf litter, sticks)		
141	Small mammal box	None	None	None	Yes (some loose leaves)		
142	Small mammal box	None	None	None	None		
143	Small mammal box	None	None	None	Yes (lots of leaf litter, some chewed <i>E.fibrosa</i> , recently used)		

Tree tag number	Nest box size and type	Summer		Winter		Notes	Photo (if available)
		Species occupying box (# in brackets)	Evidence of occupancy	Species occupying box (# in brackets)	Evidence of occupancy		
144	Small mammal box	None	Yes (honeycomb in sawdust, not occupied)	None	None		
145	Small parrot box	None	None	None	None		
146	Large parrot box	None	None	None	None		
147	Possum box (aluminium)	None	None	None	None		
148	Possum box (aluminium)	None	None	None	None		
149	Small parrot box (aluminium)	None	None	None	None		
150	Small mammal box (aluminium)	None	None	None	None		
151	Possum box (aluminium)	None	None	None	None		
152	Small mammal box	None	None	None	None		
153	Large glider box	None	None	None	None		

Tree tag number	Nest box size and type	Summer		Winter		Notes	Photo (if available)
		Species occupying box (# in brackets)	Evidence of occupancy	Species occupying box (# in brackets)	Evidence of occupancy		
154	Large parrot box	None	None	None	None		
155	Small mammal box	None	None	None	None		
156	Small glider box	None	None	None	Yes (spider web)		
157	Small mammal box	None	None	None	Yes (scattered leaves-4)	Probably not a complete nest	
158	Small mammal box	None	None	None	None		
159	Small mammal box	None	None	None	None		
160	Small mammal box	None	None	None	None		
161	Small mammal box	None	None	None	Yes (shavings some sticks)		
162	Large owl box	None	None	None	None		
163	Small mammal box	None	None	None	None		

Tree tag number	Nest box size and type	Summer		Winter		Notes	Photo (if available)
		Species occupying box (# in brackets)	Evidence of occupancy	Species occupying box (# in brackets)	Evidence of occupancy		
No tag (300)	Small mammal box		Yes				
No tag (301)	Small mammal box		None				
No tag (302)	Small mammal box		Yes				
No tag (303)	Small mammal box		None				

Appendix 3 Weather conditions

Weather conditions during monitoring (BOM 2016)

Table 8 Summary of weather conditions for monitoring periods

Date	Min (°C)	Max (°C)	Rain (mm)	Survey type
29 February 2016	17.9	31.9	0	Nest box monitoring
1 March 2016	20.3	27.9	0	Nest box monitoring
2 March 2016	20.3	29.8	0	Nest box monitoring
3 March 2016	20.6	27.8	0	Nest box monitoring
16 March 2016	20.3	27.7	0.8	Microbat monitoring
15 August 2016	9.4	21.1	4.8	Nest box monitoring
16 August 2016	5.7	22.1	0	Nest box monitoring
17 August 2016	3.0	22.5	0	Nest box monitoring
18 August 2016	5.0	23.0	0	Nest box monitoring
25 August 2016	9.6	21.1	10.4	Microbat monitoring
20 October 2016	11.2	26.2	0	Microbat monitoring
10 November 2016	17.5	28.9	7.4	Microbat monitoring
12 December 2016	13.8	29.2	0	Microbat monitoring

Revision History

Revision No.	Revision date	Details	Prepared by	Reviewed by	Approved by
00	20/12/2016	Ecological Monitoring 2016 – Section 2 W2B Pacific Highway Upgrade - DRAFT	Dr Elvira Lanham, Principal Ecologist	Dr Carissa Free, Senior Ecologist	Beth Kramer, Senior Environmental Scientist and Regional Manager
01	09/01/2017	Ecological Monitoring 2016 – Section 2 W2B Pacific Highway Upgrade – DRAFT – Revision 1	Dr Elvira Lanham, Principal Ecologist	Gillian McLeay Senior Environmental Scientist	Dr Elvira Lanham, Principal Ecologist
02	6/03/2017	Ecological Monitoring 2016 – Section 2 W2B Pacific Highway Upgrade	Dr Elvira Lanham, Principal Ecologist	Beth Kramer, Senior Environmental Scientist and Regional Manager	

Distribution List

Copy #	Date	Type	Issued to	Name
1	6/03/2017	Electronic	CMC Group	Martin Mulhearn
2	6/03/2017	Electronic	Ecosure	Administration

Citation: Ecosure (2017), Construction Ecological Monitoring Annual Report Final, CMC Group, Burleigh Heads

Report compiled by Ecosure Pty Ltd

ABN: 63 106 067 976

admin@ecosure.com.au

www.ecosure.com.au

PR1491 Ecological Monitoring Section 2 of W2B Pacific Highway Upgrade 2016R1



Adelaide

PO Box 145
Pooraka SA 5095
P 1300 112 021
M 0407 295 766

Brisbane

PO Box 675
Fortitude Valley QLD 4006
P 07 3606 1030

Coffs Harbour

PO Box 4370
Coffs Harbour Jetty NSW 2450
P 02 562 8103

Gold Coast

PO Box 404
West Burleigh QLD 4219
P 07 5508 2046
F 07 5508 2544

Rockhampton

PO Box 235
Rockhampton QLD 4700
P 07 4994 1000
F 07 4994 1012

Sydney

PO Box 880
Surry Hills NSW 2010
P 1300 112 021

© Ecosure Proprietary Limited 2017

Commercial in confidence. The information contained in this document produced by Ecosure Pty Ltd is solely for the use of the Client identified on the cover sheet for the purpose for which it has been prepared and Ecosure Pty Ltd undertakes no duty to or accepts any responsibility to any third party who may rely upon this document. All rights reserved. No section or element of this document may be removed from this documents, reproduced, electronically stored or transmitted in any form without the written permission of Ecosure Pty Ltd.