

# Oxley Highway to Kempsey

2018-19 Annual Ecological Monitoring Report

Roads and Maritime Services | September 2019





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# Introduction

## Purpose

This report provides an update on the ecological issues associated with the Oxley Highway to Kempsey Pacific Highway upgrade. This report covers the period from 22 July 2017 to 21 July 2018. This report has been prepared in accordance with the Oxley Highway to Kempsey Ecological Monitoring Program (Roads and Maritime 2016), for submission to the Department of Planning and Environment and Environment Protection Authority (EPA). This report includes koala, giant barred frog, brush-tailed phascogale, yellow-bellied glider, aerial crossing (glider poles and rope bridges), widened median, fauna underpasses, fauna fencing/road kill and landscaping/revegetation undertaken in 2018/19.

In some instances, monitoring of a particular species or mitigation measure requires several monitoring events throughout the year. In these instances it is considered more informative to wait until all monitoring events have been conducted for that year, before reporting on the results. This allows, for example, analysis between seasons and further statistical analysis to be conducted than if individual monitoring events are reported on. Table 1 details those species/ mitigation measures monitored during the period.

**Table 1** Ecological monitoring requirements during the last reporting period

Species / mitigation monitored	Timing	Done/ yet to be done	Reporting
Koala	Spring/Summer	Year 3 monitoring (2017) completed. Year 4 monitoring (2018) completed. Year 5 monitoring scheduled for spring 2019 and summer 2019/20.	Year 4 monitoring included in this report
Spotted-tail Quoll	Autumn/winter	Year 4 monitoring (2018) completed. Year 6 monitoring scheduled for autumn/winter 2020.	Year 4 monitoring (2018) included in previous report
Giant Barred Frog	Spring, Summer and Autumn	Year 3 monitoring (2017/18) completed. Year 4 monitoring (2018/19) completed. Year 5 monitoring scheduled for spring 2019, summer 2019/20 and autumn 2020.	Year 4 monitoring included in this report
Brush-tailed phascogale	Winter and summer year 4, 6 and 8.	Year 4 monitoring (2018) completed. Year 6 monitoring scheduled for winter/summer 2020.	Year 4 monitoring included in this report
Yellow-bellied	Winter and spring year	Year 4 monitoring (2018)	Year 4 monitoring

Species / mitigation monitored	Timing	Done/ yet to be done	Reporting
glider	4, 6 and 8.	completed. Year 6 monitoring scheduled for winter/spring 2020	included in this report
Squirrel Glider	Autumn and winter year 4, 6 and 8.	Year 4 monitoring (2018) completed. Year 6 monitoring scheduled for autumn/spring 2020.	Year 4 monitoring included in previous report.
Aerial Crossings	Autumn and spring year 4, 6 and 8.	Year 4 monitoring (2018) completed. Year 6 monitoring scheduled for autumn/spring 2020.	Year 4 monitoring included in this report
Widened Median	Winter and spring year 4, 6 and 8.	Year 4 monitoring (2018) completed. Year 6 monitoring scheduled for winter/spring 2020	Year 4 monitoring included in this report
Green-thighed Frog	Summer (although ultimately rainfall dependent)	2018 monitoring completed. 2019 monitoring not undertaken due to lack of rain as per EMP. Recent approved updates to the EMP permits flexibility for future monitoring to permit alternative rainfall events deemed suitable by the project ecologist.	Year 4 monitoring included in last report.
Nest Box	Winter and summer year 4, 6 and 8.	Winter 2017, Summer 2017/18 and Winter 2018 complete. Year 6 monitoring scheduled for winter/summer 2020.	Year 4 monitoring (2018) included in previous report
Bat box	Winter and summer year 4, 6 and 8.	Winter 2017, Summer 2017/18 and Winter 2018 complete. Year 6 monitoring scheduled for winter/summer 2020.	Year 4 monitoring (2018) included in previous report
Fauna underpasses & fauna fencing	Autumn/spring/summer	Year 4 monitoring (2018/19) completed. Year 6 monitoring scheduled for late autumn 2020, late spring /early summer 2020	One report for Year 4 (first year of operation) to be included in 2018/19 annual report.
Road kill	Weekly during October (spring), January (summer) and April	Construction / post opening – July 2017 – June 2018 completed. Year 4 Year 4 monitoring (2018/19)	Year 4 monitoring included in this report

Species / mitigation monitored	Timing	Done/ yet to be done	Reporting
	(autumn)	completed. Year 5 monitoring scheduled for October 2019, January 2020 and April 2020.	
Revegetation and landscaping	Monthly for three years after operation	Year 4 monitoring (2018/19) completed.	Year 4 monitoring included in this report

## Statutory and planning framework

Approval for the Oxley Highway to Kempsey Pacific Highway upgrade was granted by the then Department of Planning & Infrastructure on 8 February 2012. Roads and Maritime has constructed and opened the project in stages. The three main stages of the project are:

- Stage 1 - The Sancrox Traffic Arrangement works located about two kilometres north of the Oxley Highway / Pacific Highway intersection. This section of the project opened to traffic on 30 November 2015
- Stage 2 - Kundabung to Kempsey Stage consisting of about 14 kilometres of dual carriageway, commencing north of Barrys Creek near Kundabung (chainage 24,000) and connecting to the Kempsey Bypass at Stumpy Creek (Chainage 37,800). This stage of the project opened to traffic on 31 October 2017.
- Stage 3 - Oxley Highway to Kundabung Stage consisting of about 24 kilometres of dual carriageway, commencing just north of the Oxley Highway / Pacific Highway intersection (chainage 700) and connecting with the Kundabung to Kempsey stage just north of Barrys Creek (chainage 24,000). This stage of the project opened to traffic in two parts initially on 17 November 2017 and finally in its entirety on 29 March 2018.

The Oxley Highway to Kempsey Pacific Highway upgrade approval included the requirement to develop an ecological monitoring program:

*The Proponent shall develop an Ecological Monitoring Program to monitor the effectiveness of the biodiversity mitigation measures implemented as part of the project. The program shall be developed by a suitably qualified and experienced ecologist in consultation with the OEH and DPI (Fishing and Aquaculture) and shall include but not necessarily be limited to:*

- a) an adaptive monitoring program to assess the effectiveness of the mitigation measures identified in conditions B1, B4, B7 and B31(b) and allow amendment to the measures if necessary. The monitoring program shall nominate performance parameters and criteria against which effectiveness will be measured and include operational road kill surveys to assess the effectiveness of fauna crossings and exclusion fencing implemented as part of the project;*
- b) mechanisms for developing additional monitoring protocols to assess the effectiveness of any additional mitigation measures implemented to address additional impacts in the case of design amendments or unexpected threatened species finds during construction (where these additional impacts are generally consistent with the biodiversity impacts identified for the project in the documents listed under condition A1);*
- c) monitoring shall be undertaken during construction (for construction-related impacts) and from opening of the project to traffic (for operation/ ongoing impacts) until such time as the effectiveness*

*of mitigation measures can be demonstrated to have been achieved over a minimum of three successive monitoring periods (i.e 6 years) after opening of the project to traffic, unless otherwise agreed by the Director General. The monitoring period may be reduced with the agreement of the Director General in consultation with the OEH and DPI (Fishing and Aquaculture), depending on the outcomes of the monitoring;*

- d) provision for the assessment of the data to identify changes to habitat usage and whether this can be directly attributed to the project;*
- e) details of contingency measures that would be implemented in the event of changes to habitat usage patterns directly attributable to the construction or operation of the project; and*
- f) provision for annual reporting of monitoring results to the Director General and the OEH and DPI (Fishing and Aquaculture), or as otherwise agreed by those agencies.*

*The Program shall be submitted to the Director General for approval no later than 6 weeks prior to the commencement of construction that would result in the disturbance of native vegetation (unless otherwise agreed by the Director General).*

The initial Oxley Highway to Kempsey Ecological Monitoring Program was approved by the Department of Planning & Environment on 25 January 2014. This was updated in 2016 and approved by the Department on 6 December 2016. The EMP was subsequently updated in 2019 and approved by the Department on 20 August 2019. The species and mitigation monitoring reports included in the appendices to this annual report have been assessed against the 2016 EMP version as it was the relevant document during the reporting period.

# Appendix A Koala





# Koala Monitoring 2018

**Year 4 Surveys – Oxley Highway to Kempsey, Pacific Highway Upgrade**

Prepared for Roads and Maritime Services

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*Cover photograph:* Koala scats in Maria River National Park (left) and Koala photographed using underpass in Cairncross State Forest (right).

## Executive Summary

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### Context

This report documents findings from the spring-summer 2018 monitoring period for the Koala, as required for the Oxley Highway to Kempsey (OH2K) Pacific Highway upgrade project (the Project).

### Aims

The aim of the Koala monitoring program is to determine whether the Project is having an impact on Koala populations within the study area.

### Methods

Each monitoring location was surveyed in accordance with the monitoring method and design specified in the Oxley Highway to Kempsey Pacific Highway Upgrade Ecological Monitoring Program (EMP, RMS 2016). Surveys were undertaken in November and December 2018.

### Key Results

- A total of 93 plots across 31 clusters were surveyed in spring-summer 2018. Koalas were found to be present within 16 of the 31 clusters (52%).
- The mean SAT activity level for all plots, measured as the percentage of trees at each plot with scats present, was 2.5% (with a standard deviation of 5.4) and ranged from 0 to 36.7%. This is higher than the mean activity recorded for plots during 2015, 2016 and 2017 surveys (2.0%, 0.7% and 1.8% respectively), but lower than the mean activity recorded during baseline surveys (4.9%).
- Koalas were recorded more frequently at impact sites (67%) than at control sites (38%), which is consistent with results observed in the previous monitoring events.
- Koalas have been recorded using three of the fourteen culverts (located within the vicinity of the monitoring sites) being monitored as part of the Fauna Underpass Monitoring for the Project.
- There was no significant change in the difference between Koala presence at control and impact clusters between 2018 and baseline surveys.
- There was no significant change in the difference between Koala presence at clusters with and without mitigation between 2018 and baseline surveys.
- Average plot activity levels for each treatment type have not decreased from the baseline surveys beyond the recommended 10% tolerance level.

### Conclusions

- Performance measures relating to survey requirements have been met.
- Fauna fence has been installed as required by Schedule 3 of the EPBC approval.
- The performance measure relating to changes in distribution and habitat use has not been met as Koala presence and activity levels appear to have decreased between the baseline, and all following monitoring events. However this apparent decrease has occurred at both control and impact sites. In each of the monitoring surveys undertaken to date, impact sites recorded higher percentages of Koala presence than control sites. In addition, presence and activity levels increased in 2018 compared to previous monitoring years and, in accordance with Lewis (2014), have not decreased from the baseline surveys beyond the recommended 10% tolerance level. As such, results of monitoring undertaken to date indicate that the observed changes in Koala activity/presence across the Project area cannot be directly attributed to the Project and are within the 10% tolerance level.

### ***Management Implications***

As no significant changes in Koala presence and activity levels from baseline surveys have been detected to date, and as Koalas have been detected using three dedicated fauna underpasses within the Project area, no additional mitigation recommendations have been made at this time.

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# 1. Introduction

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## 1.1 Context

The Oxley Highway to Kempsey (OH2K) section of the Pacific Highway Upgrade Project (the Project) was approved in 2012 subject to various Ministers Conditions of Approval (MCoA) and a Statement of Commitments (SoC). A subsequent approval with additional conditions of consent (CoA) was granted in 2014 by the Commonwealth Department of Environment (DoE) for Matters of National Environmental Significance (MNES) listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1995* (EPBC Act). The Ecological Monitoring Program (hereafter referred to as the EMP) (RMS 2016) combines these approval conditions and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project. The Koala was identified as requiring mitigation and monitoring during the Project's construction and operational periods.

### 1.1.1 Legal status

The Koala (*Phascolarctos cinereus*) is listed as vulnerable under both the NSW *Biodiversity Conservation Act* (BC Act 2016) and the Commonwealth EPBC Act. Monitoring of the species is required under the Project's approval.

### 1.1.2 Monitoring framework

The design, methods and performance indicators that define the Koala monitoring program are specified in the EMP. The monitoring program specifies that monitoring of all sites would occur in Years 1, 2 and 3 (construction phase) once substantial construction had commenced. Following the completion of the Project, monitoring was to continue in Years 4, 5, 6 and 8 (operation phase) or until the mitigation measures can be demonstrated to have been effective for the Koala.

To date, these monitoring events have been conducted and reported on as follows:

- Spring-summer 2015: *Koala Monitoring. Year 1 surveys - Oxley Highway to Kempsey Pacific Highway Upgrade* (Niche 2016)
- Spring- summer 2016: *Koala Monitoring 2016. Year 2 surveys - Oxley Highway to Kempsey Pacific Highway Upgrade* (Niche 2017)
- Spring-summer 2017: *Koala Monitoring 2017. Year 3 surveys - Oxley Highway to Kempsey Pacific Highway Upgrade* (Niche 2018a)
- Spring-summer 2018: Current report.

This report represents the first of the four required operational monitoring reports. Construction monitoring was completed in spring-summer 2017.

### 1.1.3 Baseline data

In accordance with the EMP, baseline surveys for the Koala were undertaken in 2014 to provide baseline data that could be used to identify changes in habitat use before and after construction of the Project, and determine whether any changes can be reasonably attributed to the Project. Baseline monitoring was conducted by Lewis Ecological prior to the commencement of construction (Lewis 2014). Remote cameras were also opportunistically deployed (targeting other threatened species) in August 2013, while spotlighting and Spot Assessment Technique (SAT) plot surveys were undertaken in spring 2013.

#### 1.1.4 Purpose of this report

This report details the findings obtained from the 2018 monitoring period. As mentioned previously, it represents the first monitoring report for the operational phase of the Project.

The aim of this report is to summarise the methods and results of the spring-summer 2018 monitoring, and to compare the results with the baseline surveys to determine whether performance measures are being met and comment on whether additional measures should be considered.

### 1.2 Performance Measures

The EMP specifies the following performance measures for the Koala:

- *Monitoring is undertaken during baseline surveys from Year 1 – Year 6 & Year 8, or until mitigation measures are demonstrated to be effective.*
- *Monitoring during Year 1 – Year 6 & Year 8 is undertaken at the Impact and Control sites where monitoring was undertaken during baseline surveys, subject to ongoing landowner agreement. Where landowner agreement cannot be obtained and the process in Section 3.1.2 of the EMP has been followed, this performance indicator will also be considered to have been met.*
- *Mitigation measures are demonstrated to be effective as defined in the EPBC approval when all monitoring events are considered at Year 8.*
- *Fauna fence is installed at a minimum in areas identified in Schedule 3 of the EPBC approval at Year 4.*
- *No changes to densities, distribution, habitat use and movement patterns compared to baseline data during monitoring in Year 1 – 6 & Year 8, and then when all monitoring events are considered at Year 8.*

### 1.3 Monitoring Timing

Monitoring is to occur during spring-summer.

### 1.4 Reporting

Annual reporting of monitoring results will include:

- A detailed description of the monitoring methodology
- Results of the monitoring surveys
- Discussion of the results, including how the results compare against performance measures, if any modifications to timing or frequency of monitoring periods or monitoring methodology are required, and any other recommendations
- If contingency measures should be implemented.

All reports prepared under the EMP will be submitted to the Director General of the NSW Department of Planning and Environment and the NSW Environment Protection Authority.



## 2. Survey Methodology

### 2.1 Monitoring Design

In accordance with the baseline monitoring surveys, eight broad areas within a 20 kilometre radius of the Project were surveyed. These eight areas include South Sancrox, North Sancrox, Cairncross State Forest (South), Cairncross State Forest (North), Cooperabung Hill, Mingaletta Road to Smiths Creek, Kundabung Road to North of Pipers Creek and Maria River State Forest. Within each of these areas, three types of monitoring treatments were established:

- **Type A:** Impact with mitigation. Mitigation plots are located within 500 metres of sufficiently large culverts (>1.8 metres, to allow Koalas to pass under the Highway) that are paired with floppy top fencing.
- **Type B:** Impact without mitigation. Plots where mitigation has not been proposed or only partial mitigation is proposed. Partial mitigation plots are where only floppy top fencing is present but with obvious openings at interchanges or entry/exit points.
- **Type C:** Control or reference. These are located in areas at least three kilometres, and often 5-10 kilometres from the Project.

Each treatment type (A, B or C) is represented by a cluster of three SAT plots within each of the eight areas, resulting in nine SAT plots per area giving a total of 72 baseline SAT plots, established by Lewis (2014) (with the exception of Cairncross State Forest (South) that had an additional type B cluster during baseline and Mingaletta to Smiths Creek where no type B cluster was established during baseline). Of these 72 plots, 24 were mitigation (type A), three part mitigation and 21 no mitigation (type B), and 24 were control sites (type C). To ensure a balanced monitoring design between impact plots (mitigated and not mitigated) and control plots, an additional 24 control plots (type C) were established during the first monitoring event in 2015 (Niche 2016). In accordance with the baseline monitoring design these additional 24 control plots were established at least three kilometres from the Project and were grouped in clusters of three plots, one cluster for each of the eight broad areas.

In 2015, eight of the baseline plots had to be relocated to nearby locations because they had been established in the construction site itself or because they were located on private property and access was not possible. Three of the baseline monitoring plots that could not be accessed could not be relocated because there weren't any suitable sites nearby. These three plots were all part of the same cluster (impact, no mitigation) located in the North Sancrox area.

Details of the 96 monitoring plots are presented in Table 1 and the location of the 93 accessible monitoring plots are shown in Figure 1.

**Table 1: SAT monitoring plots**

Area	Type	Sub category	Data source	Plot name	Easting	Northing
South Sancrox	Impact	No Mitigation	Baseline	1 Sancrox East - Cassegrains	483348	6521736
	Impact	No Mitigation	Baseline	2 Sancrox East - Cassegrains	483455	6521789
	Impact	No Mitigation	Baseline	3 Sancrox East - Cassegrains	483412	6521882
	Impact	Mitigation	Baseline_Niche relocation	1 Sancrox South	483299	6520671
	Impact	Mitigation	Baseline_Niche relocation	2 Sancrox South	483254	6520383
	Impact	Mitigation	Baseline_Niche relocation	3 Sancrox South	483196	6520217
	Control	Control	Baseline	1 Cowarra State Forest	480608	6519056

Area	Type	Sub category	Data source	Plot name	Easting	Northing
	Control	Control	Baseline	2 Cowarra State Forest	480658	6519496
	Control	Control	Baseline	3 Cowarra State Forest	481305	6519136
	Control	New Control	Niche	COWARRA NC1	479706	6518522
	Control	New Control	Niche	COWARRA NC2	479788	6517922
	Control	New Control	Niche	SAT COWARRA NC3	479795	6518227
North Sancrox	Impact*	No Mitigation	Baseline	1 Sancrox North - Expressway Spares	483042	6521731
	Impact*	No Mitigation	Baseline	2 Sancrox North - Expressway Spares	482869	6521683
	Impact*	No Mitigation	Baseline	3 Sancrox North - Expressway Spares	482999	6521818
	Impact	Mitigation	Baseline	1 Fernbank Creek	483101	6523362
	Impact	Mitigation	Baseline	2 Fernbank Creek	483032	6523223
	Impact	Mitigation	Baseline	3 Fernbank Creek	483056	6523123
	Control	Control	Baseline	1 Lake Innes	488124	6518469
	Control	Control	Baseline	2 Lake Innes	488047	6518398
	Control	Control	Baseline	3 Lake Innes	488228	6518390
	Control	New Control	Niche	COWARRA NC3 -SAT COW4	479674	6516436
	Control	New Control	Niche	SAT COW5	479704	6516174
	Control	New Control	Niche	SAT COW6	479667	6515913
Cairncross State Forest (South)	Impact	No Mitigation	Baseline	1 Cairncross State Forest (South)	482428	6526536
	Impact	No Mitigation	Baseline	2 Cairncross State Forest (South)	482385	6526644
	Impact	No Mitigation	Baseline	3 Cairncross State Forest (South)	482393	6526416
	Impact	No Mitigation	Baseline	16 Cairncross State Forest (south)	481655	6527256
	Impact	No Mitigation	Baseline	17 Cairncross State Forest (south)	481590	6527316
	Impact	No Mitigation	Baseline	18 Cairncross State Forest (south)	481637	6527175
	Impact	Mitigation	Baseline	4 Cairncross State Forest (South)	482249	6525930
	Impact	Mitigation	Baseline	5 Cairncross State Forest (South)	482125	6526077
	Impact	Mitigation	Baseline	6 Cairncross State Forest (South)	482488	6526226
	Control	Control	Baseline	1 Limeburners Creek ""The Hatch""	487011	6529909
	Control	Control	Baseline	2 Limeburners Creek ""The Hatch""	487014	6529455
	Control	Control	Baseline	3 Limeburners Creek ""The Hatch""	487035	6528694
	Control	New Control	Niche	SAT PEVI1	476817	6528422
	Control	New Control	Niche	SAT PEVI2	476730	6528225
	Control	New Control	Niche	Cairncross NC1	475996	6528211
	Cairncross State Forest (north)	Impact	No Mitigation	Baseline_Niche relocation	7 Cairncross State Forest (North)	481346
Impact		No Mitigation	Baseline	8 Cairncross State Forest (North)	481695	6530786
Impact		No Mitigation	Baseline	9 Cairncross State Forest (North)	481184	6530864
Impact		Mitigation	Baseline	10 Cairncross State Forest (north)	481238	6530264
Impact		Mitigation	Baseline	11 Cairncross State Forest (north)	481173	6530319
Impact		Mitigation	Baseline	12Cairncross State Forest (north)	481438	6530335
Control		Control	Baseline	13 Cairncross State Forest (Pembroke)	473751	6528881
Control		Control	Baseline	14 Cairncross State Forest (Pembroke)	473464	6528969

Area	Type	Sub category	Data source	Plot name	Easting	Northing
	Control	Control	Baseline	15 Cairncross State Forest (Pembroke)	473424	6529115
	Control	New Control	Niche	SAT RR1	475284	6532709
	Control	New Control	Niche	SAT RR2	475113	6532603
	Control	New Control	Niche	SAT RR3	474816	6532732
Cooperabung Hill	Impact	No Mitigation	Baseline	1 Cooperabung	482793	6537012
	Impact	No Mitigation	Baseline	2 Cooperabung	482755	6537093
	Impact	No Mitigation	Baseline	3 Cooperabung	482876	6537115
	Impact	Mitigation	Baseline_Niche relocation	4 Cooperabung	482481	6539327
	Impact	Mitigation	Baseline_Niche relocation	5 Cooperabung	482364	6539761
	Impact	Mitigation	Baseline	6 Cooperabung	482364	6538610
	Control	Control	Baseline	1 Cooperabung Hill (Gum Scrub)	475489	6541854
	Control	Control	Baseline	2 Cooperabung Hill (Gum Scrub)	475570	6541903
	Control	Control	Baseline	3 Cooperabung Hill (Gum Scrub)	475838	6541962
	Control	New Control	Niche	SAT FL1	473693	6542127
	Control	New Control	Niche	SAT ST1	473346	6543256
	Control	New Control	Niche	SAT ST2	473682	6542890
Mingaletta to Smiths Creek	Impact	Mitigation	Baseline	1 Mingaletta-Smiths Creek	483304	6543632
	Impact	Mitigation	Baseline	2 Mingaletta-Smiths Creek	483444	6543585
	Impact	Mitigation	Baseline	3 Mingaletta-Smiths Creek	483100	6543670
	Control	Control	Baseline	1 Ballengara State Forest (Gregs Road)	477750	6543274
	Control	Control	Baseline	2 Ballengara State Forest (Gregs Road)	477644	6543623
	Control	Control	Baseline	3 Ballengara State Forest (Gregs Road)	477551	6543709
	Control	New Control	Niche	SAT BR1	477010	6544693
	Control	New Control	Niche	SAT BR2	476890	6544832
	Control	New Control	Niche	SAT BR3	476777	6544973
Kundabung Road to North of Pipers Creek	Impact	No Mitigation	Baseline	1 Kundabung	483095	6549036
	Impact	No Mitigation	Baseline	2 Kundabung	482873	6549112
	Impact	No Mitigation	Baseline	3 Kundabung	483285	6549374
	Impact	Mitigation	Baseline	4 Kundabung	483369	6550655
	Impact	Mitigation	Baseline	5 Kundabung	483331	6550938
	Impact	Mitigation	Baseline	6 Kundabung	483083	6550608
	Control	Control	Baseline	1 Kumbatine National Park	476044	6549609
	Control	Control	Baseline	2 Kumbatine National Park	476165	6549738
	Control	Control	Baseline	3 Kumbatine National Park	475889	6549468
	Control	New Control	Niche	SAT MAC1	476538	6552784
	Control	New Control	Niche	SAT MAC2	476558	6552361
	Control	New Control	Niche	SAT MAC3	476481	6552612
	Maria River State Forest	Impact	Part Mitigation	Baseline_Niche relocation	1 Maria River	483074
Impact		Part Mitigation	Baseline	2 Maria River	482836	6554330
Impact		Part Mitigation	Baseline_Niche relocation	3 Maria River	482993	6554024

Area	Type	Sub category	Data source	Plot name	Easting	Northing
	Impact	Mitigation	Baseline	4 Maria River	482886	6552623
	Impact	Mitigation	Baseline	5 Maria River	482754	6552462
	Impact	Mitigation	Baseline	6 Maria River	483135	6552449
	Control	Control	Baseline	1 Maria River National Park	486965	6554366
	Control	Control	Baseline	2 Maria River National Park	486971	6554479
	Control	Control	Baseline	3 Maria River National Park	487004	6554203
	Control	New Control	Niche	SAT CO1	486292	6552230
	Control	New Control	Niche	SAT CO3	486811	6552227
	Control	New Control	Niche	SAT MAR 1	486811	6552454

\* could not be surveyed due to private landowner access restrictions.

## 2.2 Koala Spot Assessment Technique (SAT)

Surveys were undertaken following the SAT methodology (Phillips and Callaghan 2011) in accordance with the EMP monitoring procedure for Koala population monitoring. The SAT method involves a radial assessment of Koala activity within the immediate area surrounding a tree that is known to have been used by the species or is considered to be of importance to the species. The following describes the application of this technique:

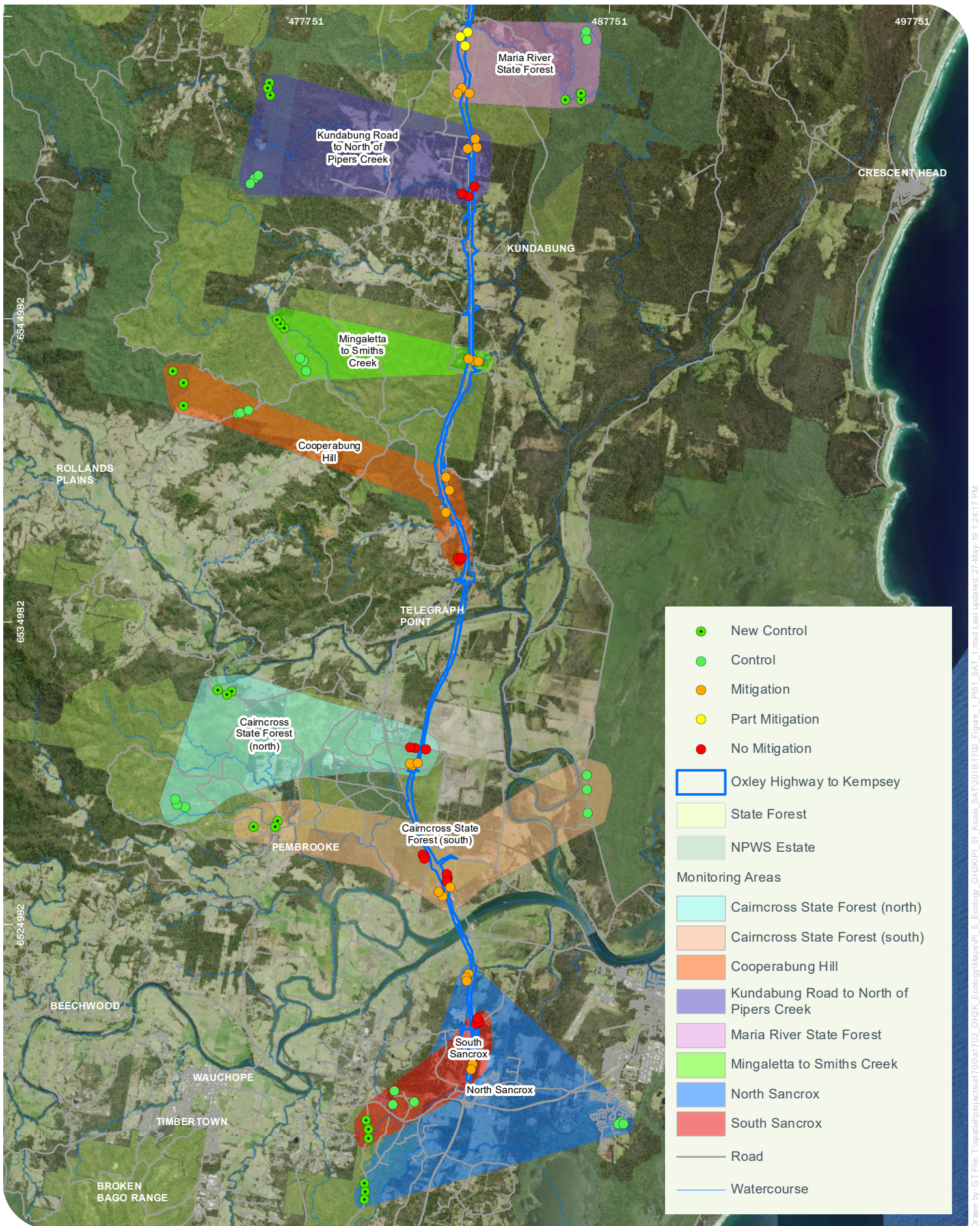
1. Locate and mark a tree that is:
  - a) A tree of any species beneath which one or more Koala faecal pellets have been observed; and/or
  - b) A tree in which a Koala has been observed; and/or
  - c) Any other tree known or considered to be important for Koalas or of interest for other assessment purposes.
2. Identify and mark the 29 nearest trees to the tree marked initially.
3. Undertake a search for Koala faecal pellets beneath each of the 30 marked trees. Visually inspect the ground surface beneath trees to a distance of one metre from the trunk. If no pellets are observed, rake the leaf litter within the prescribed search area. Two person minutes per tree should be dedicated to the search for faecal pellets. The search should be ended once a single pellet is found or the search time has expired (whichever happens first). Faecal pellets should not be removed from the site unless verification is necessary.
4. Calculate the activity level of a site as the percentage of surveyed trees within the site (of 30 trees) that have a Koala faecal pellet recorded within its search area. The result is used to assess whether the site supports “Low”, “Medium (normal)” or “High” Koala activity.
5. Record the presence (or absence) of scats, along with a number of other attributes including the species of the tree under which the scat was located.

The selection criteria trees (SCTs) of each plot were marked (tagged) and have been used as the centre tree for the radial searches during each survey event.

## 2.3 Analysis

General SAT plot presence and activity results are presented for plot, cluster and area. More detailed analyses of impact vs. control sites and mitigation vs. no mitigation sites were undertaken using cluster presence/absence results. Plots within the same cluster are not independent from each other and therefore cannot be used for most statistical analyses. Between year activity levels were compared using mean plot activity results.

Based on the methods used to collect the data and the location of the plots, it was determined that a Chi-square test was the most suitable statistical test to assess differences in Koala presence between areas, treatments and years. This test compares the proportion of plots with and without Koala scats and so is suitable for presence/absence data. The Chi-square test also allows for analysis of data where sample sizes between categories may differ, as is the case here where there are an unequal number of impact and control sites.



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**SAT plot locations**  
**Koala Monitoring: Pacific Highway Upgrade - Oxley Highway to Kempsey**

Niche PM: Radika Michniewicz  
 Niche Proj. #: 1702 PI5.1  
 Client: Roads and Maritime Services

**Figure 1**

### 3. Results

#### 3.1 SAT Plots

Surveys were undertaken between 6 November 2018 and 17 December 2018. Field data for each SAT plot is presented in Annex 1. The DBH (diameter at breast height) is provided for the marked tree. This tree was used as the SCT for the current monitoring event and will be used as the SCT for all future monitoring events. All of the 93 accessible SAT plots were surveyed across the eight monitoring areas (Figure 1).

##### 3.1.1 Presence/absence

###### *SAT plots*

Table 2 provides a summary of presence/absence results for plots and clusters. Graph 1 shows the percentage of plots and clusters with scats present for each monitoring period to date and Graph 2 shows the percentage of clusters within each area with scats present, for each monitoring period to date. Table 3 provides a detailed comparison of the activity level for each plot and presence/absence results of each cluster for each monitoring period to date and Figure 2 shows the SAT cluster presence/absence results for the 2018 monitoring (map reference ID for each cluster is listed in Table 3).

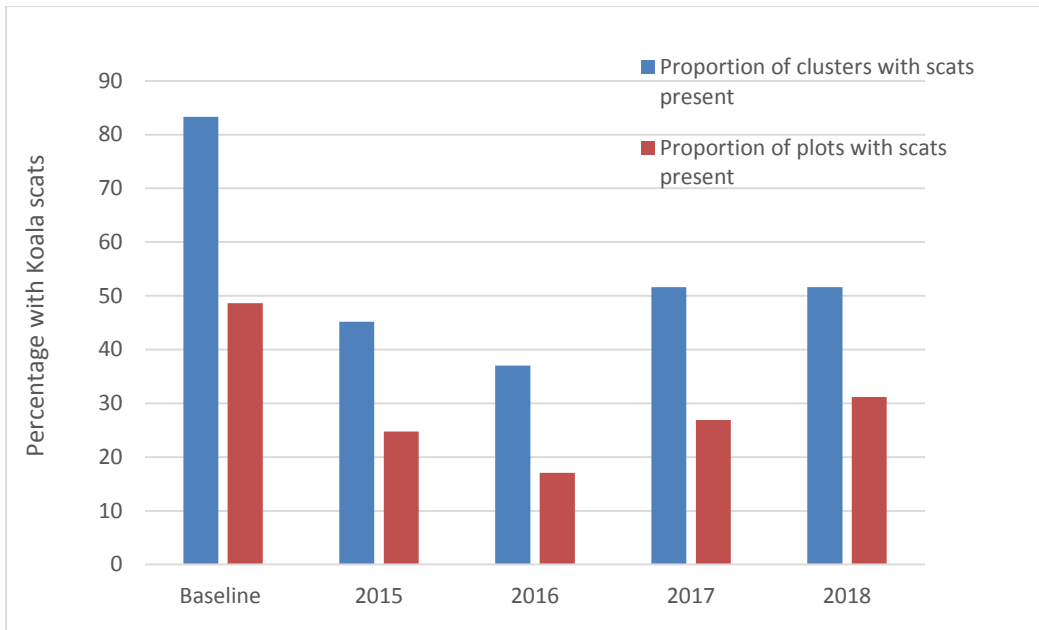
Of the 93 surveyed plots, Koala scats were recorded from 31% (29 of 93) of the individual plots. This is higher than 2015, 2016 and 2017 surveys (25%, 17%, and 27% respectively), but lower than the 49% recorded during baseline surveys. When grouped according to cluster, Koala scats were recorded at 52% of clusters (16 of 31). This is the same as recorded in 2017, higher than recorded in 2015 and 2016 (45% and 37% respectively), but lower than the 83% recorded during baseline surveys. It should be noted that baseline surveys included only 24 (of 31) clusters; if we consider only those clusters in common between baseline and 2018 surveys, scats were recorded at 57% (13 of 23) of these clusters during the 2018 monitoring.

Of note is the ongoing presence of scats at the 11 plots (located within clusters KUND2, MR1, MR2 and MR4) that were not surveyed in 2016 due to wildfires that resulted in the complete loss of canopy in many areas. Prior to the wildfires, baseline surveys recorded presence at four of these plots (note only eight were surveyed during baseline as three of the 11 are new controls and were not monitored during baseline surveys) and 2015 surveys recorded presence at one of these plots. Since the 2016 wildfires, 2017 and 2018 surveys recorded presence at six and eight of the plots respectively. The substantial canopy regrowth and prevalence of young leaves on the trees in these areas may have encouraged the rapid re-use of these areas by Koalas after the fires and provides ongoing abundant foraging resources.

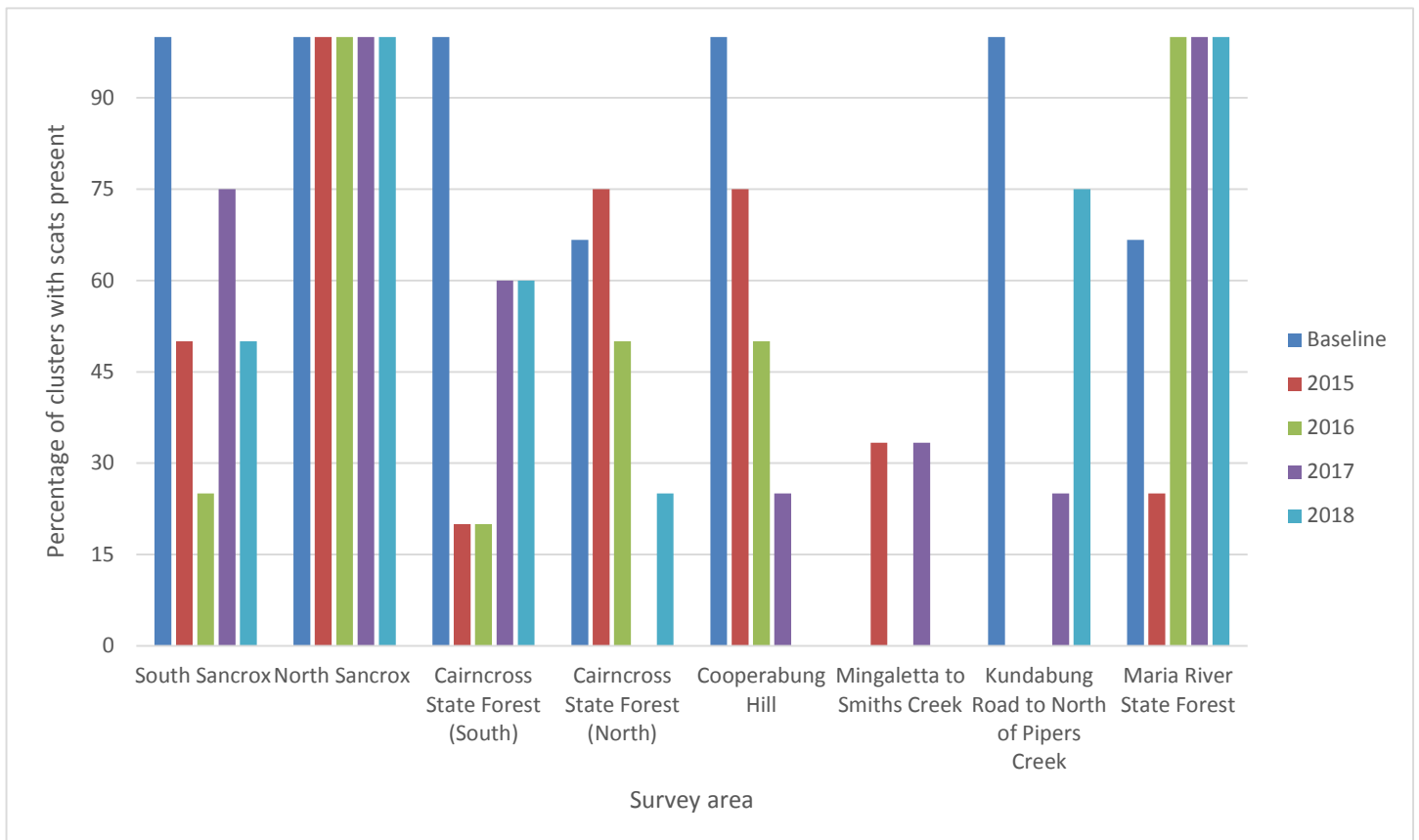
Koala presence was mainly recorded in the northern and southern areas, with activity in the northern area possibly being influenced by regenerating vegetation after the wildfire.

**Table 2: Presence/absence results**

	Baseline	2015	2016	2017	2018
Number of plots with scats present (n = plots surveyed)	35 (49%, n= 72)	23 (25%, n = 93)	14 (17%, n= 82)	25 (27%, n = 93)	29 (31%, n = 93)
Number of clusters with scats present (n = clusters surveyed)	20 (83%, n= 24)	14 (45%, n = 31)	10 (37%, n= 27)	16 (52%, n = 31)	16 (52%, n = 31)



**Graph 1: Percentage of plots and clusters with scats present for each monitoring event to date**



**Graph 2: Koala presence in areas across all monitoring events**

***Additional Koala records***

There are a number of culverts and bridges along the length of the Project that may provide passage for Koalas (Figure 2). Fourteen of these are being monitored as part of the Fauna Underpass Monitoring component of the Project. Koalas have been detected using three of the dedicated fauna underpasses to date and these are shown on Figure 2. In addition, a Koala was observed during spotlighting surveys undertaken as part of the Yellow-bellied Glider monitoring component of the Project (Figure 2). These records all occur in areas where Koalas were detected during SAT surveys.



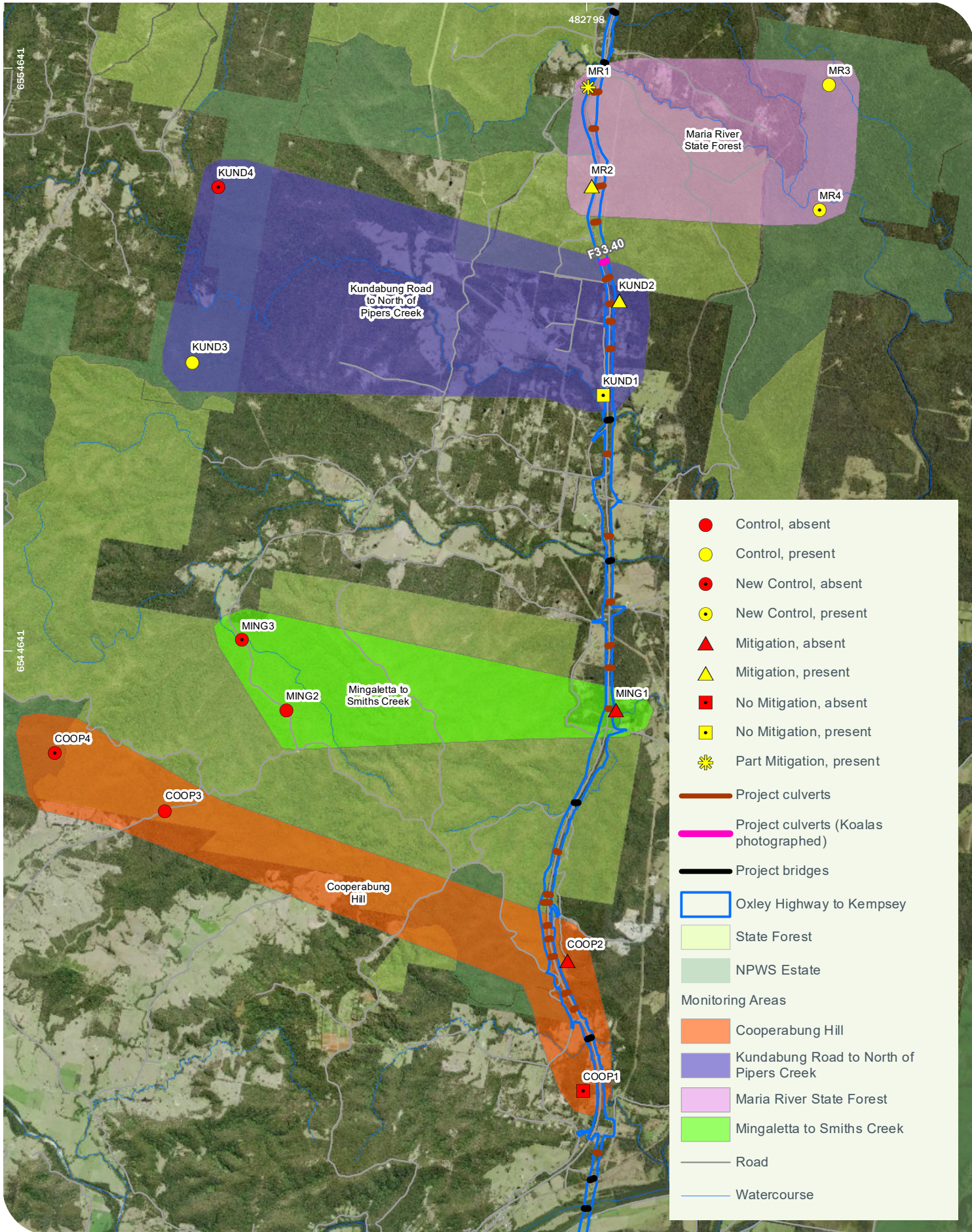
**Table 3: SAT plot results baseline – 2018**

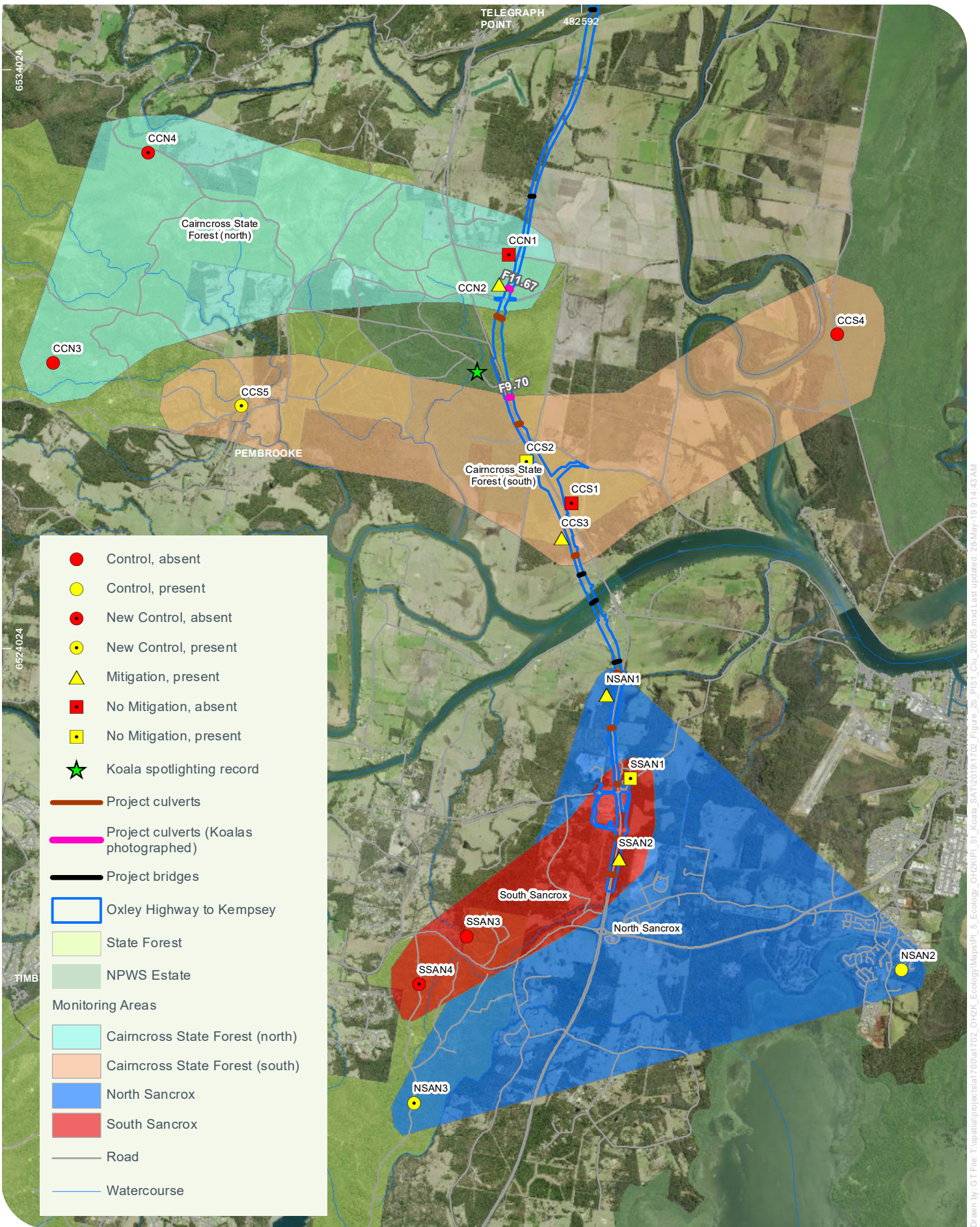
Area	Type	Data source	Site ID	MapRef	Plot activity (%)				Scat presence (per cluster)				
					Baseline	2015	2016	2017	Baseline	2015	2016	2017	2018
South Sancrox	No Mitigation	Baseline	SANCROX E1	SSAN1	10.0	3.3	0.0	23.3	present	present	absent	present	present
			SANCROX E2		0.0	0.0	0.0	0.0					
			SANCROX E3		0.0	0.0	0.0	0.0					
	Mitigation	Baseline_Niche relocation	SANCROX S1	SSAN2	13.3	0.0	0.0	3.3	present	absent	absent	present	present
			SANCROX S2		3.3	0.0	0.0	0.0					
			SANCROX S3		10.0	0.0	0.0	0.0					
	Control	Baseline	COWARRA SF1	SSAN3	0.0	0.0	0.0	0.0	present	absent	present	absent	absent
			COWARRA SF2		3.3	0.0	0.0	0.0					
			COWARRA SF3		10.0	0.0	6.7	0.0					
	New Control	Niche	SAT COWARRA NC1	SSAN4	-	0.0	0.0	0.0	Not monitored	present	absent	present	absent
SAT COWARRA NC2			-		3.3	0.0	6.7						
SAT COWARRA NC3			-		0.0	0.0	3.3						
North Sancrox	No Mitigation	Baseline	SANCROX N1	-	3.3	-	-	-	present	No access	No access	No access	No access
			SANCROX N2		0.0	-	-	-					
			SANCROX N3		0.0	-	-	-					
	Mitigation	Baseline	FERNBANK CK1	NSAN1	33.3	0.0	3.3	16.7	present	present	present	present	present
			FERNBANK CK2		30.0	0.0	6.7	6.7					
			FERNBANK CK3		23.3	6.7	3.3	13.3					
	Control	Baseline	LAKE INNES1	NSAN2	26.7	13.3	0.0	3.3	present	present	present	present	present
			LAKE INNES2		13.3	6.7	3.3	6.7					
			LAKE INNES3		3.3	6.7	0.0	0.0					
	New Control	Niche	SAT COW4	NSAN3	-	10.0	0.0	3.3	Not monitored	present	present	present	present
SAT COW5			-		0.0	0.0	0.0						
SAT COW6			-		0.0	3.3	0.0						

Area	Type	Data source	Site ID	MapRef	Plot activity (%)				Scat presence (per cluster)				
					Baseline	2015	2016	2017	Baseline	2015	2016	2017	2018
Cairncross State Forest (South)	No Mitigation	Baseline	CAINCROSS SF1	CCS1	0.0	0.0	0.0	0.0	present	present	absent	absent	absent
			CAINCROSS SF2		3.3	6.7	0.0	0.0					
			CAINCROSS SF3		0.0	3.3	0.0	0.0					
	No Mitigation	Baseline	CAINCROSS SF16	CCS2	0.0	0.0	3.3	3.3	present	absent	present	present	present
			CAINCROSS SF17		0.0	0.0	3.3	0.0					
			CAINCROSS SF18		13.3	0.0	0.0	6.7					
	Mitigation	Baseline	CAINCROSS SF4	CCS3	3.3	0.0	0.0	3.3	present	absent	absent	present	present
			CAINCROSS SF5		3.3	0.0	0.0	0.0					
			CAINCROSS SF6		0.0	0.0	0.0	0.0					
	Control	Baseline	LIMEBURNERS CK1	CCS4	0.0	0.0	0.0	3.3	present	absent	absent	present	absent
			LIMEBURNERS CK2		3.3	0.0	0.0	0.0					
			LIMEBURNERS CK3		0.0	0.0	0.0	3.3					
New Control	Niche	SAT PEV11	CCS5	-	0.0	0.0	0.0	Not monitored	absent	absent	absent	present	
		SAT PEV12		-	0.0	0.0	0.0						
		SAT PEV13		-	0.0	0.0	0.0						
Cairncross State Forest (north)	No Mitigation	Baseline_Niche relocation	CAINCROSS SF7	CCN1	0.0	3.3	0.0	0.0	absent	present	absent	absent	absent
		Baseline	CAINCROSS SF8		0.0	20.0	0.0	0.0					
		Baseline	CAINCROSS SF9		0.0	10.0	0.0	0.0					
	Mitigation	Baseline	CAINCROSS SF10	CCN2	3.3	0.0	0.0	0.0	present	present	present	absent	present
			CAINCROSS SF11		3.3	0.0	3.3	0.0					
			CAINCROSS SF12		6.7	3.3	0.0	0.0					
	Control	Baseline	CAINCROSS SF13	CCN3	6.7	3.3	3.3	0.0	present	present	present	absent	absent
			CAINCROSS SF14		0.0	0.0	0.0	0.0					
			CAINCROSS SF15		0.0	3.3	0.0	0.0					

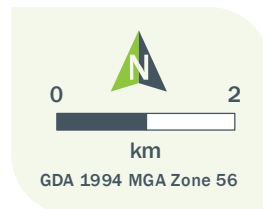
Area	Type	Data source	Site ID	MapRef	Plot activity (%)				Scat presence (per cluster)				
					Baseline	2015	2016	2017	Baseline	2015	2016	2017	2018
	New Control	Niche	SAT RR1	CCN4	-	0.0	0.0	0.0	Not monitored	absent	absent	absent	absent
			SAT RR2		-	0.0	0.0	0.0					
			SAT RR3		-	0.0	0.0	0.0					
Cooperabung Hill	No Mitigation	Baseline	COOPERABUNG1	COOP1	3.3	3.3	0.0	0.0	present	present	present	absent	absent
			COOPERABUNG2		0.0	23.3	3.3	0.0					
			COOPERABUNG3		10.0	0.0	0.0	0.0					
	Mitigation	Baseline_Niche relocation	COOPERABUNG4	COOP2	0.0	3.3	6.7	0.0	present	present	present	present	absent
			COOPERABUNG5		3.3	3.3	0.0	10.0					
			COOPERABUNG6		0.0	0.0	0.0	0.0					
	Control	Baseline	COOP HILL1	COOP3	6.7	0.0	0.0	0.0	present	absent	absent	absent	absent
			COOP HILL2		0.0	0.0	0.0	0.0					
			COOP HILL3		0.0	0.0	0.0	0.0					
New Control	Niche	SAT FL1	COOP4	-	16.7	0.0	0.0	Not monitored	present	absent	absent	absent	
		SAT ST1		-	0.0	0.0	0.0						
		SAT ST2		-	20.0	0.0	0.0						
Mingaletta to Smiths Creek	Mitigation	Baseline	MIN-SMITHS CK1	MING1	0.0	0.0	0.0	0.0	absent	absent	absent	absent	absent
			MIN-SMITHS CK2		0.0	0.0	0.0	0.0					
			MIN-SMITHS CK3		0.0	0.0	0.0	0.0					
	Control	Baseline	BALLENGARA SF1	MING2	0.0	0.0	0.0	0.0	absent	absent	absent	absent	absent
			BALLENGARA SF2		0.0	0.0	0.0	0.0					
			BALLENGARA SF3		0.0	0.0	0.0	0.0					
New Control	Niche	SAT BR1	MING3	-	6.7	0.0	0.0	Not monitored	present	absent	present	absent	
		SAT BR2		-	0.0	0.0	3.3						
		SAT BR3		-	0.0	0.0	0.0						

Area	Type	Data source	Site ID	MapRef	Plot activity (%)				Scat presence (per cluster)				
					Baseline	2015	2016	2017	Baseline	2015	2016	2017	2018
Kundabung Road to North of Pipers Creek	No Mitigation	Baseline	KUNDABUNG 1	KUND1	0.0	0.0	0.0	0.0	present	absent	absent	absent	present
			KUNDABUNG 2		10.0	0.0	0.0	0.0					
			KUNDABUNG 3		0.0	0.0	0.0	0.0					
	Mitigation	Baseline	KUNDABUNG 4	KUND2	33.3	0.0	fire	0.0	present	absent	fire	present	present
			KUNDABUNG 5		13.3	0.0	fire	3.3			fire		
			KUNDABUNG 6		10.0	0.0	0.0	0.0			absent		
	Control	Baseline	KUMBATINE NP1	KUND3	3.3	0.0	0.0	0.0	present	absent	absent	absent	present
			KUMBATINE NP2		0.0	0.0	0.0	0.0					
			KUMBATINE NP3		0.0	0.0	0.0	0.0					
New Control	Niche	SAT MAC1	KUND4	-	0.0	0.0	0.0	Not monitored	absent	absent	absent	absent	
		SAT MAC2		-	0.0	0.0	0.0						
		SAT MAC3		-	0.0	0.0	0.0						
Maria River State Forest	Part Mitigation	Baseline_Niche relocation	MARIA RIVER 1	MR1	0.0	0.0	fire	0.0	present	absent	no access - fire	present	present
		Baseline	MARIA RIVER 2		3.3	0.0	fire	0.0					
		Baseline_Niche relocation	MARIA RIVER 3		6.7	0.0	fire	16.7					
	Mitigation	Baseline	MARIA RIVER 4	MR2	0.0	0.0	fire	6.7	absent	present	no access - fire	present	present
			MARIA RIVER 5		0.0	0.0	fire	0.0					
			MARIA RIVER 6		0.0	3.3	fire	0.0					
	Control	Baseline	MARIA NP1	MR3	0.0	0.0	0.0	3.3	present	absent	present	present	present
			MARIA NP2		10.0	0.0	3.3	0.0					
			MARIA NP3		10.0	0.0	3.3	3.3					
New Control	Niche	SAT CO1	MR4	-	0.0	fire	6.7	Not monitored	absent	no access - fire	present	present	
		SAT CO3		-	0.0	fire	3.3						
		SAT MAR 1		-	0.0	fire	6.7						





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### SAT cluster results 2018 - South

## Koala Monitoring: Pacific Highway Upgrade - Oxley Highway to Kempsey

Niche PM: Radika Michniewicz  
Niche Proj. #: 1702 P15.1  
Client: Roads and Maritime Services

**Figure 2b**

public\_NSW\_imagery:

### 3.1.2 Activity levels

Individual plot activity levels are provided above in Table 3. A summary of the SAT activity level for plots, clusters and areas in all monitoring events is provided in Table 4 and Table 5.

#### **Plot and cluster activity**

The mean SAT activity level for all plots, measured as the percentage of trees at each plot with scats present, was 2.5% (standard deviation (SD) of 5.4) and ranged from 0 to 36.7%. This is higher than the mean activity recorded for plots during 2015, 2016 and 2017 surveys (2.0%, 0.7% and 1.8% respectively), but lower than the mean activity during baseline surveys (4.9%).

Considering the activity level within active plots only, i.e. plots where scats were found to be present, the average activity level was 8.0% (SD7.0), which is higher than or equal to the mean activity recorded for active plots during 2015, 2016 and 2017 surveys (8.0%, 4.0%, and 6.8% respectively), but lower than the mean activity recorded for active plots during baseline surveys (10.1%).

The EMP requires interpretation of site activity levels to assess areas as supporting low, medium or high Koala activity. Phillips and Callaghan (2011) used Atlas data to calculate activity levels of sites where Koala scats were recorded. These data were then used to define categories of habitat use in populations of varying densities. The Port Macquarie-Hastings and Kempsey LGAs support a significant Koala population, including a concentrated population in the coastal areas, east of the Pacific Highway and south of Hastings River, as well as pockets of higher density/activity in surrounding areas, including Maria River National Park (BioLink 2013, PMHC 2017). While Phillips and Callaghan (2011) use an arbitrary definition of population densities (low =  $\leq 0.1$  Koala/hectare), the study area naturally consists of areas of varying densities. Discussions with Port Macquarie-Hastings Council confirmed that population density varies throughout the region and therefore one general population density cannot be attributed to all sites. In addition, as site specific density data is not available for all sites, it is not possible to designate the sites as being low or high density populations according to Phillips and Callaghan. However, in compliance with the EMP, if we consider the habitat use category of Phillips and Callaghan (2011) for low density populations on the east coast, as per the baseline studies (Lewis 2014), using activity levels of SAT plots where scats were recorded, average SAT plot activity has consistency fallen into to the “medium (normal)” use category (3.3% - 12.6%) for populations in an east coast, low density area.

**Table 4: Summary of SAT activity results**

	Baseline	2015	2016	2017	2018
Average activity per plot (n = plots surveyed)	4.9% (SD8.0, n = 72)	2.0% (SD4.6, n = 93)	0.7% (SD1.6, n = 82)	1.8% (SD4.1, n = 93)	2.5% (SD5.4, n = 93)
Average activity per active plot (n = plots with activity)	10.1% (SD9.0, n = 35)	8.0% (SD6.3 n = 23)	4.0% (SD1.4, n = 14)	6.8% (SD5.3, n = 25)	8.0% (SD7.0, n = 29)
Average activity per cluster (n = plots surveyed)	4.9% (SD6.9, n = 24)	2.0% (SD3.5, n = 31)	0.7% (SD1.1, n = 27)	1.8% (SD2.8, n = 31)	2.5% (SD4.5, n = 31)
Average activity per active cluster (n = active clusters)	5.9% (SD7.1, n = 20)	4.4% (SD4.0, n = 14)	1.9% (SD1.1, n = 10)	3.5% (SD3.0, n = 16)	4.9% (SD5.5, n = 16)
Average activity per area (n = 8)	4.8% (SD4.7)	2.1% (SD2.3)	0.9% (SD0.9)	1.9% (SD2.0)	2.6% (SD3.1)

### Area activity

Table 5 and Graph 3 show Koala activity at each of the eight monitoring areas. Area activity is the mean activity of all surveyed plots with the area. As for the 2016 and 2017 monitoring, SAT plot activity was highest at the following locations:

- North Sancrox (4.1%): scats were recorded at all three clusters and at seven of the nine SAT plots.
- Maria River State Forest (9.2%): scats were recorded at all four clusters and at nine of the 12 SAT plots. Three of the four clusters were regenerating after the 2016 wildfires.

To date, activity levels appear to fluctuate across the years within each monitoring area and a definitive increasing or decreasing activity trend is not apparent.

While North Sancrox has previously consistently recorded the highest activity, Maria River State Forest recorded higher activity during 2018 monitoring due to high plot activity in regenerating areas.

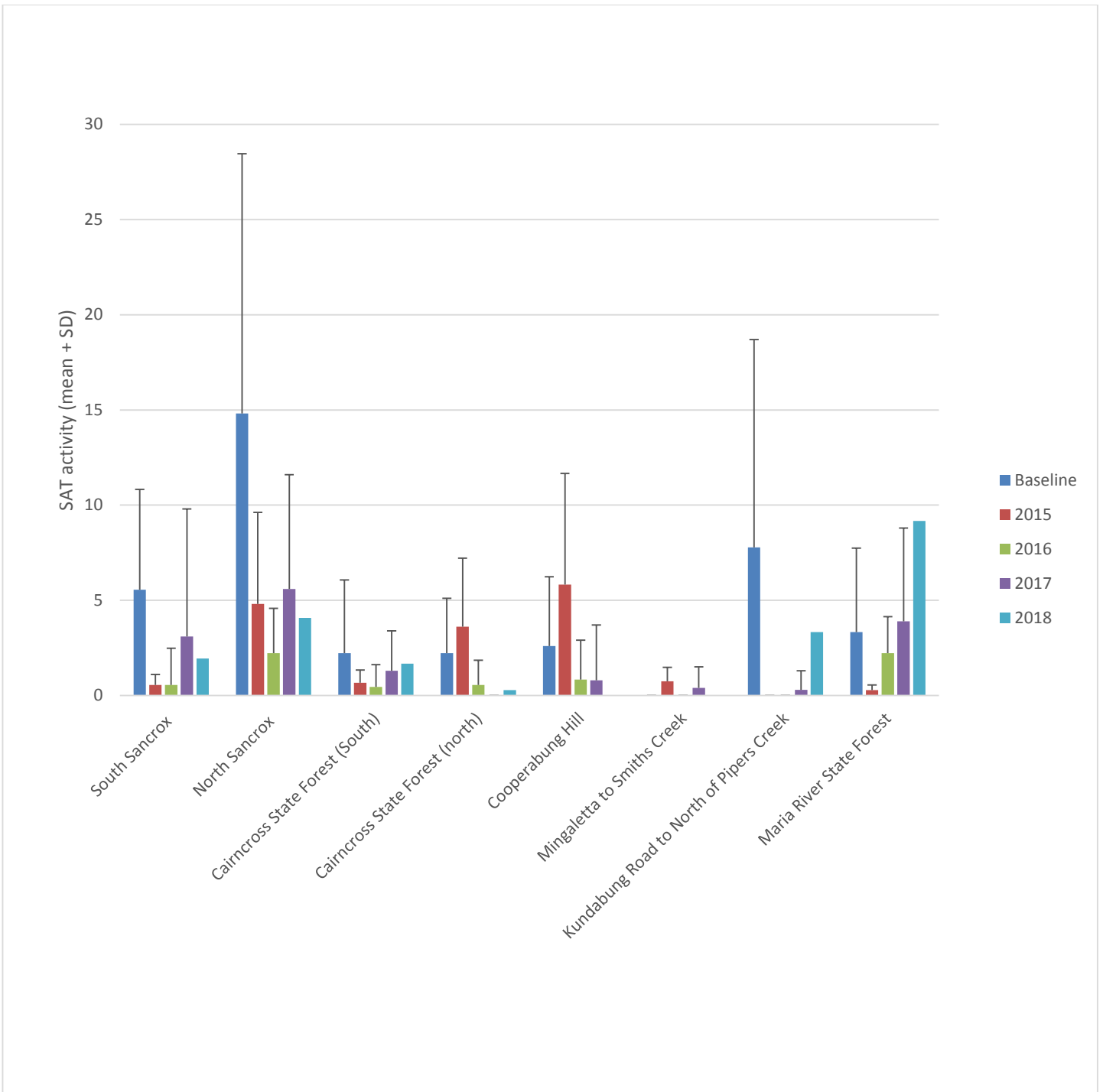
Mingaletta to Smiths Creek has generally recorded low activity levels during each monitoring year.

A notable reduction in apparent activity was within the Cooperabung Hill area; no scats were recorded in 2018 but scats have been recorded during each previous monitoring event. 2017 monitoring revealed a similar pattern within the Cairncross State Forest (north) area, whereby no scats were recorded in 2017 after having been recorded during each previous monitoring event. 2018 monitoring again recorded presence in this area.

**Table 5: Area activity levels**

Monitoring Area	Baseline	2015	2016	2017	2018
South Sancrox	5.6% (SD5.3)	0.6% (SD1.3)	0.6% (SD1.9)	3.1% (SD6.7)	1.9% (SD3.0)
North Sancrox	14.8 (SD13.7)	4.8% (SD5.0)	2.2% (SD2.4)	5.6% (SD6.0)	4.1% (SD3.2)
Cairncross State Forest (South)	2.2% (SD3.8)	0.7% (SD1.9)	0.4% (SD1.2)	1.3% (SD2.1)	1.7% (SD2.7)
Cairncross State Forest (North)	2.2% (SD2.9)	3.6% (SD5.9)	0.6% (SD1.3)	0	0.3% (SD1.0)
Cooperabung Hill	2.6% (SD3.6)	5.8% (SD8.8)	0.8% (SD2.1)	0.8% (SD2.9)	0
Mingaletta to Smiths Creek	0	0.7% (SD2.2)	0	0.4% (SD1.1)	0
Kundabung Road to North of Pipers Creek	7.8% (SD10.9)	0	0	0.3% (SD1.0)	3.3% (SD5.9)
Maria River State Forest	3.3% (SD4.4)	0.3% (SD1.0)	2.2% (SD1.9)	3.9% (SD4.9)	9.2% (SD10.6)

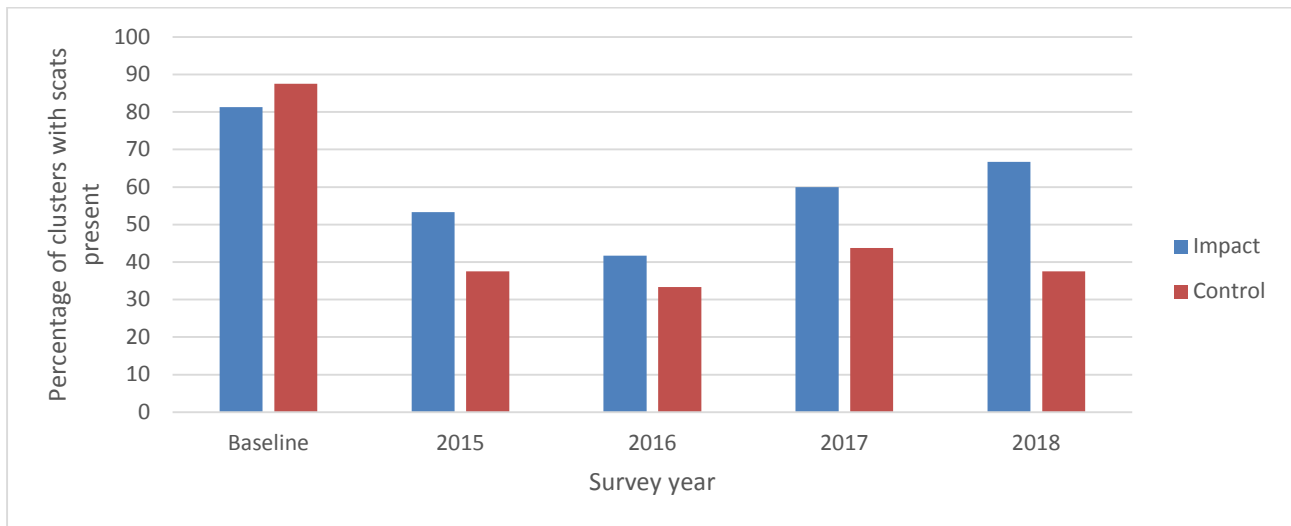




Graph 3: Koala activity across the eight monitoring areas

### 3.2 Impact v Control Cluster Presence/Absence Analysis

A higher percentage of impact clusters had scats present than did control clusters during the 2018 monitoring (67% cf 38%) period. This result is the same as that of the previous monitoring years (Graph 4). If we compare the Koala presence/absence results between control and impact clusters there is no significant difference in Koala presence at impact and control clusters between the 2018 surveys and baseline, 2015, 2016 or 2017 surveys ( $X^2 = 0.012$ ,  $df = 1$ ,  $p > 0.05$ ;  $X^2 = 0.425$ ,  $df = 1$ ,  $p > 0.05$ ;  $X^2 = 0.291$ ,  $df = 1$ ,  $p > 0.05$ ; and  $X^2 = 0.365$ ,  $df = 1$ ,  $p > 0.05$  respectively).



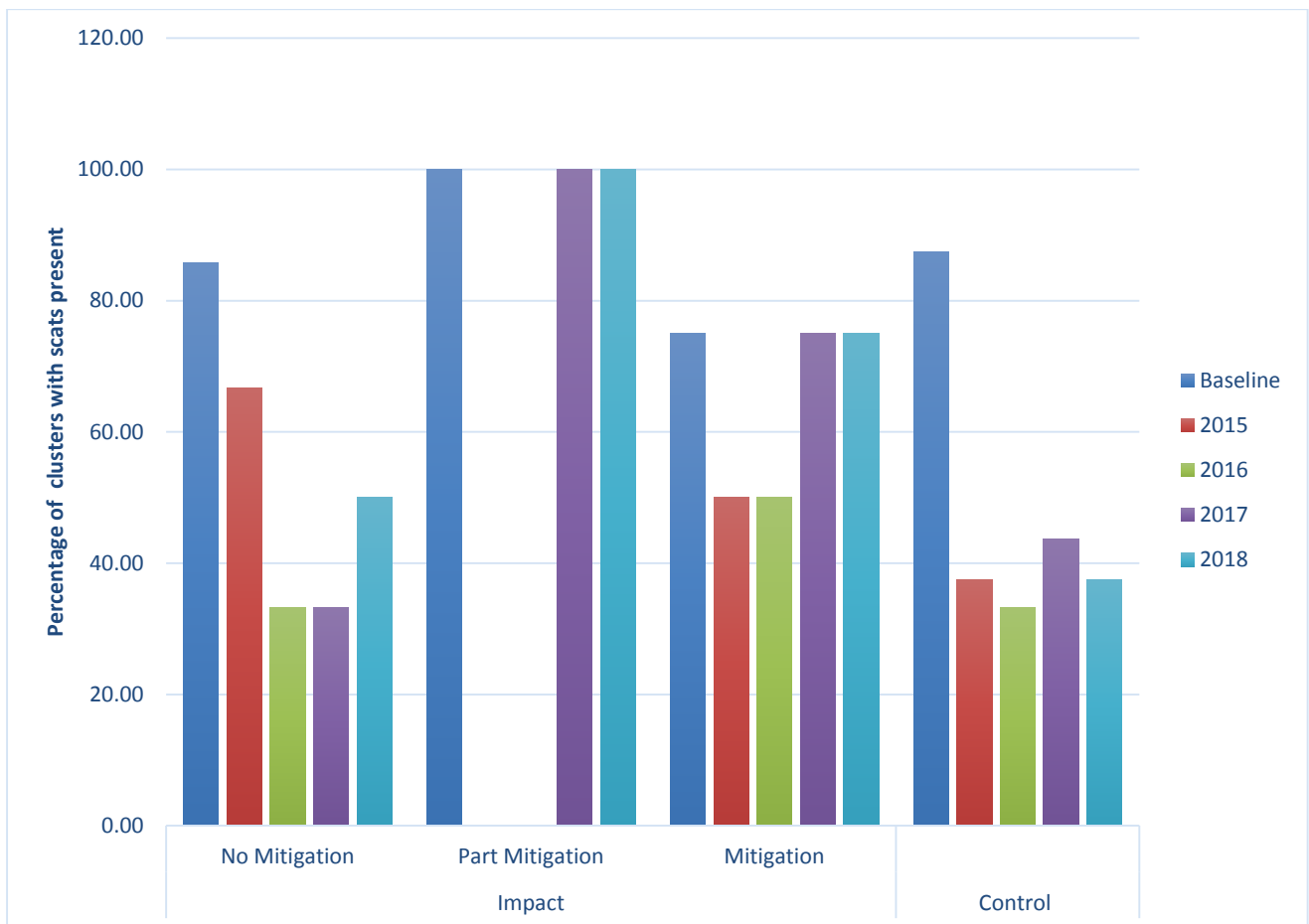
Graph 4: Koala presence at control and impact clusters

### 3.3 Mitigation v No Mitigation Analysis

#### 3.3.1 Presence/absence analysis

Comparing Koala presence between mitigation and no-mitigation clusters shows no significant difference between the 2018 surveys and baseline, 2015, 2016, or 2017 surveys ( $X^2 = 0.024$ ,  $df = 1$ ,  $p > 0.05$ ;  $X^2 = 0.007$ ,  $df = 1$ ,  $p > 0.05$ ;  $X^2 = 0.972$ ,  $df = 1$ ,  $p > 0.05$ ; and  $X^2 = 0.133$ ,  $df = 1$ ,  $p > 0.05$ , respectively). Graph 5 shows the percentage of clusters with scats present within different cluster types. There is no overall apparent trend between impact clusters with mitigation or without mitigation. While mitigation clusters appear to have a higher presence percentage in 2016, 2017 and 2018 than clusters with no mitigation, the presence percentage at clusters with no mitigation is similar to the presence percentage at control clusters during these years. This suggests that any difference is likely site specific and not related to construction activities.

The apparent increase in percentage presence in 2017 and 2018 at mitigation (and part mitigation) clusters is likely due, in part, to the 11 plots that were not surveyed in 2016. Five of these plots are mitigation plots, four of which recorded scats in 2018. In addition, North Sancrox has consistently been recorded as a high activity area and has only a mitigation cluster, without a balancing no-mitigation cluster.



Graph 5: Koala presence and cluster type

### 3.3.2 Treatment activity analysis

Koala activity (mean activity of plots) for the treatment types is provided in Table 6 and is shown for each area in Graph 6 (mean activity of all plots within each cluster type for each area). When considering all plots, average activity levels have decreased from baseline levels for all treatments, including control plots. When considering only active plots (with scats present), activity levels at control and no-mitigation plots were slightly higher than baseline levels, and activity levels at mitigation plots were slightly lower than baseline levels. The 2018 monitoring plot activity levels were similar among treatments. Lewis 2014 recommends that analyses should:

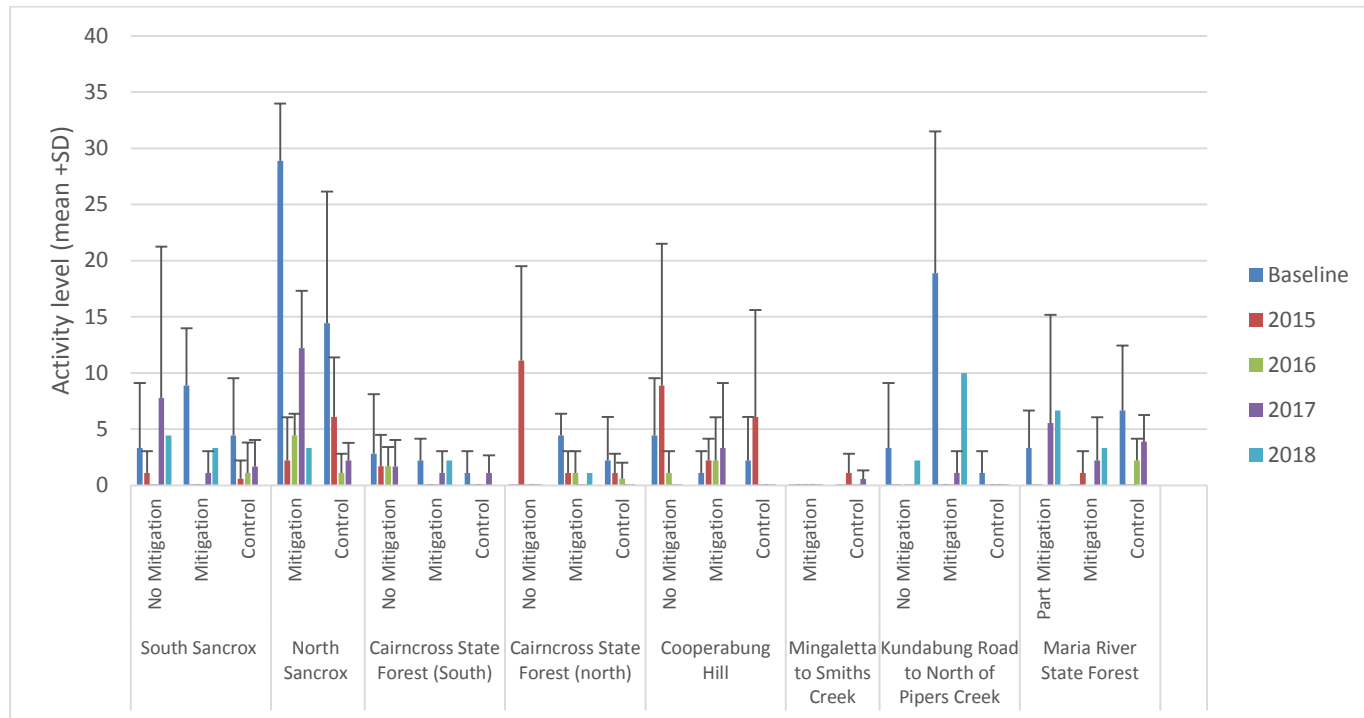
*“Ensure any future comparison of Koala activity levels take into account the following baseline data and with a 10% tolerance level to account for variability:*

- *Broader study area set at 5% activity;*
- *The three treatment classes of Mitigation set at 8.05%, control reference set at 4.03% and no mitigation set at 2.64%.”*

When considering all plots or active plots only, activity levels for each treatment type have not decreased from the baseline surveys beyond the recommended 10% tolerance level. Nor is there a greater than 10% difference between treatment types.

**Table 6: Control, mitigation and no mitigation plot activity levels**

	Control					Mitigation					No Mitigation				
	Baseline	2015	2016	2017	2018	Baseline	2015	2016	2017	2018	Baseline	2015	2016	2017	2018
Activity levels of all plots (n = plots surveyed)	4.0 (24) (SD6.4)	1.9 (38) (SD4.5)	0.5 (45) (SD1.4)	1.2 (48) (SD2.1)	2.5 (48) (SD6.4)	8.1 (24) (SD11.0)	0.8 (24) (SD1.8)	1.2 (19) (SD2.3)	2.6 (24) (SD4.7)	2.9 (24) (SD4.5)	2.6 (24) (SD4.2)	3.5 (21) (SD6.6)	0.6 (18) (SD1.3)	2.4 (21) (SD6.2)	2.1 (21) (SD3.7)
Activity levels of active plots (n = active plots)	8.8 (11) (SD6.9)	9.0 (10) (SD5.9)	3.9 (6) (SD1.4)	4.4 (13) (SD1.6)	9.2 (13) (SD9.5)	12.9 (15) (SD11.5)	4.0 (5) (SD1.5)	4.7 (5) (SD1.8)	7.9 (8) (SD5.0)	7.0 (10) (SD4.6)	7.0 (9) (SD3.9)	9.2 (8) (SD8.1)	3.3 (3) (SD0.0)	12.5 (4) (SD9.2)	7.2 (6) (SD3.3)



**Graph 6. Mean Koala activity for cluster type within areas (mean ± SD)**

### 3.4 Tree Species Use

A total of 2,790 trees were assessed across the 93 plots (30 at each plot). Koala scats were recorded at 70 (2.5%) of the trees surveyed. Surveyed trees included 31 different tree species. The most commonly surveyed tree species were Tallowwood (*Eucalyptus microcorys*, 20.8%), Coastal Blackbutt (*E. pilularis*, 9.9%), and Pink Bloodwood (*Corymbia intermedia*, 9.1%), together representing 39.8% of all trees surveyed. Koala scats were recorded at 12 (38.7%) different species (Table 7). Considering the percentage of individual tree species where scats were recorded, Koala scats were most commonly recorded beneath Swamp Mahogany (*E. robusta*, 10.7%), Scribbly Gum (*E. signata*, 9.5%), Tallowwood (5.3%), and Thin-leaved Stringybark (*E. eugenioides*, 4.4%). Diameter at breast height for SCTs are provided in Annex 1.

The baseline study (Lewis 2014) suggests comparing activity levels at Tallowwood trees given that they are widespread, are frequently surveyed and yielded relatively high activity scores during baseline surveys (i.e. 9.5%). Use of Tallowwoods (percent of surveyed Tallowwoods with scats) was 2.68%, 0.75%, 4.7% and 5.3% in 2015, 2016, 2017 and 2018, respectively. As such, compared to the baseline surveys, activity at Tallowwood trees has been consistently lower, but has increased during each subsequent monitoring event. This reflects the overall lower activity levels observed since the baseline studies were undertaken.

**Table 7: Tree species where scats were recorded – 2018 monitoring**

Common name	Species name	Total surveyed	No. with scats	Percent use (%)
Swamp Mahogany	<i>Eucalyptus robusta</i>	28	3	10.7
Small-fruited Grey Gum	<i>Eucalyptus propinqua</i>	249	4	1.6
Coastal Blackbutt	<i>Eucalyptus pilularis</i>	276	8	2.9
Pink Bloodwood	<i>Corymbia intermedia</i>	255	4	1.6
Tallowwood	<i>Eucalyptus microcorys</i>	581	31	5.3
Forest Oak	<i>Allocasuarina torulosa</i>	53	1	1.9
Turpentine	<i>Syncarpia glomulifera</i>	195	1	0.5
White Stringy bark	<i>Eucalyptus globoidea</i>	145	5	3.5
White Mahogany	<i>Eucalyptus acmenoides</i>	49	1	2.0
Thin-leaved Stringybark	<i>Eucalyptus eugenioides</i>	68	3	4.4
Red Bloodwood	<i>Corymbia gummifera</i>	187	2	1.1
Scribbly Gum	<i>Eucalyptus signata</i>	74	7	9.5

### 3.5 Weather Conditions

Weather conditions during the field surveys were generally warm to hot (maximum temperatures between 22 and 31 degrees) with a few light to moderate rainfall events (Kempsey weather station 059007, Table 8).

**Table 8: Weather conditions - 2018 monitoring**

Date	Rainfall (mm)	Temp (°C) (max)	Temp (°C) (min)	Wind speed at 9am (km/h)
6/11/2018	0	29.3	18.4	7
9/11/2018	0	22.5	8.9	11
15/11/2018	0.2	30.2	17.7	6
28/11/2018	0.6	29.3	19.0	9
29/11/2018	3.0	27.6	17.8	30
30/11/2018	0	26.9	14.7	6
4/12/2018	0	28.9	12.5	6
5/11/2018	0.6	24.8	16.7	4
6/11/2018	1.8	24.9	16.1	9
7/11/2018	0	26.1	*	11
11/12/2018	0	26.9	16.0	17
12/12/2018	1.4	25.6	18.8	9
13/12/2018	0	29.5	16.1	0
14/12/2018	7.4	31.6	17.6	4
17/12/2018	26.4	29.3	16.8	9

\* no data available

## 4. Discussion

### 4.1 Performance Measures

A discussion of the 2018 survey results in relation to the performance measures are provided in Table 9.

**Table 9: Performance measures**

Performance measure	Response
Monitoring is undertaken during baseline surveys and from Year 1 – Year 6 & 8, or until mitigation measures are demonstrated to be effective.	<b>This performance measure has been met.</b> To date, SAT plot monitoring has been undertaken during baseline, Year 1 (2015), Year 2 (2016), Year 3 (2017) and Year 4 (2018) of the Project.
Monitoring during Year 1 – Year 6 & 8 is undertaken at the Impact and Control sites where monitoring was undertaken during baseline surveys, subject to ongoing landowner agreement. Where landowner agreement cannot be obtained and the process in Section 3.1.2 of the EMP has been followed, this performance indicator will also be considered to have been met.	<b>This performance measure has been met.</b> Monitoring was undertaken at the same sites as surveyed in 2015. In 2015, eight of the baseline plots had to be relocated to nearby locations because they had been established in the construction site itself or because they were located on private property and access was not possible. Also, three of the baseline monitoring plots that could not be accessed could not be relocated because there weren't any suitable sites nearby. These three plots were all part of the same cluster (impact, no mitigation) located in the North Sancrox area. Details of all 96 monitoring plots are presented in Table 1 and the location of the 93 accessible monitoring plots are shown in Figure 1.
Mitigation measures are demonstrated to be effective as defined in the EPBC approval when all monitoring events are considered at Year 8.	Not applicable for Year 4. However, a summary of the efficacy of the mitigation measures to date in relation to treatment Type A: impact with mitigation (sufficiently large culverts and floppy top fencing), indicates: <ul style="list-style-type: none"> <li>• Three of the fourteen monitored culverts have recorded use by the Koala (Figure 2)</li> <li>• Since commencement of construction (year 1), six Koalas have been recorded as road kill, five during construction and one during operation. The last construction Koala road kill occurred in October 2016, year 2 of the Project (Niche 2018b). The Project became operational in year 4, March 2018 and in September 2018 a Koala road kill occurred at Barry's Creek, between clusters MING1 and COOP2. It was considered most likely that the Koala accessed the road corridor via a flood damaged section of the fauna fence, which has since been repaired.</li> </ul>
Fauna fence is installed at a minimum in areas identified in Schedule 3 of the EPBC approval at Year 4.	<b>This performance measure has been met.</b> Roads and Maritime have advised that fauna fencing is complete in all areas in accordance with Condition 3c and Schedule 3 of EPBC Approval 2012/6518.
No changes to densities, distribution, habitat use and movement patterns compared to baseline data during monitoring in Year 1 – 6 & 8, and then when all monitoring events are considered at Year 8.	<b>This performance measure has not been met.</b> <i>Distribution and habitat use</i> As for previous monitoring years, while the 2018 monitoring results indicate a reduction in the presence and activity of Koalas across the Project area from the baseline surveys, this result is consistent across both the impact and control sites with no significant difference in the proportion of impact and control sites with scats between years. Any observed decrease in Koala presence/activity cannot therefore be directly attributed to disturbance due to the Project. In addition, presence and activity levels increased in 2018 compared to previous monitoring years and, in accordance with Lewis 2014, have not decreased from the baseline surveys beyond the recommended 10% tolerance level. As such, while changes have



Performance measure	Response
	<p>occurred (as specified in the performance measure), these changes cannot be directly attributed to the Project and are within the 10% tolerance level.</p> <p><i>Movement patterns and density</i></p> <p>SAT plots do not provide any data on individual movement patterns. They also do not provide any data on Koala density, as it is not possible to determine the number of Koalas from scat records.</p>

## 5. Recommendations

### 5.1 Contingency Measures and Recommendations

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those that are considered to be relevant to the Koala monitoring program are listed and discussed in Table 10. No additional mitigation recommendations have been made at this stage based on the following:

- No significant changes from baseline surveys have been detected to date
- Koalas have been detected using three of the dedicated fauna underpasses within the Project area
- Damage to fauna fences has been repaired.

**Table 10: Contingency measures**

Potential problem	Contingency measure proposed in EMP	Discussion of proposed measure
Decline in presence of target species recorded at Impact sites after the upgrade has been completed, when compared to change in Control sites.	<ul style="list-style-type: none"> <li>• Investigate cause of decline in consultation with EPA and DoTE within two weeks of results reported by ecologist.</li> <li>• If the cause of the decline is considered most likely attributable to the upgrade of the highway, mitigation measures will be reviewed within two months of the above consultation.</li> </ul>	<p><b>This contingency measure is not considered relevant.</b></p> <p>To date, no significant change has been detected in the difference in Koala presence at control and impact sites between baseline and subsequent monitoring events.</p>

## References

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Niche (2018b). Contractor Ecological Monitoring Report 2017/2018. Annual Ecological Monitoring Report 2017. Oxley Highway to Kempsey Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

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PMHC (2017). Draft Koala Recovery Strategy 2017. Port Macquarie-Hastings Council.

RMS (2016). Oxley Highway to Kempsey Pacific Highway Upgrade Ecological Monitoring Program. Roads and Maritime Update to report prepared by SMEC Hyder Joint Venture, August 2016.

## Annex 1. Koala SAT results – 2018 monitoring

On a number of occasions the marked tree did not correspond with the baseline and 2015 monitoring SCT (selection criteria tree) species. As such, for clarity of results and to facilitate future monitoring, the DBH is provided for the marked tree, and this tree is considered as the “New SCT” for the current and future monitoring events. DBH = diameter at breast height in centimetres (cm), Radial = radial distance of search area from New SCT in metres (m).

Area N	Monitoring area	Treatment	Sub-category	Site_ID	Map ref	Activity	New SCT	DBH (cm)	Radial (m)	Notes
1	South Sancrox	Impact	No Mitigation	SANCROX E1	SSAN1	6.7	Tallowwood	47	20	
1	South Sancrox	Impact	No Mitigation	SANCROX E2		0.0	Thin-leaved Stringybark	34	25	
1	South Sancrox	Impact	No Mitigation	SANCROX E3		6.7	Tallowwood	27	25	
1	South Sancrox	Impact	Mitigation	SANCROX S1	SSAN2	0.0	Blackbutt	46	35	
1	South Sancrox	Impact	Mitigation	SANCROX S2		6.7	Thin-leaved Stringybark	55	40	
1	South Sancrox	Impact	Mitigation	SANCROX S3		3.3	Flooded Gum	58	35	Not tagged
1	South Sancrox	Control	Control	COWARRA SF1	SSAN3	0.0	Small-fruited Grey Gum	55	35	Tag hacked off
1	South Sancrox	Control	Control	COWARRA SF2		0.0	Blackbutt	98	40	
1	South Sancrox	Control	Control	COWARRA SF3		0.0	Small-fruited Grey Gum	33	15	
1	South Sancrox	Control	New Control	SAT COWARRA NC1	SSAN4	0.0	Blackbutt	75	35	
1	South Sancrox	Control	New Control	SAT COWARRA NC2		0.0	Mahogany	53	25	
1	South Sancrox	Control	New Control	SAT COWARRA NC3		0.0	Blackbutt	62	25	
2	North Sancrox	Impact	No Mitigation	SANCROX N1						No access
2	North Sancrox	Impact	No Mitigation	SANCROX N2						No access
2	North Sancrox	Impact	No Mitigation	SANCROX N3						No access
2	North Sancrox	Impact	Mitigation	FERNBANK CK1	NSAN1	3.3	Tallowwood	63	25	
2	North Sancrox	Impact	Mitigation	FERNBANK CK2		0.0	Tallowwood	38	30	
2	North Sancrox	Impact	Mitigation	FERNBANK CK3		6.7	Tallowwood	46	35	
2	North Sancrox	Control	Control	LAKE INNES1	NSAN2	6.7	Tallowwood	72	15	Not tagged
2	North Sancrox	Control	Control	LAKE INNES2		3.3	Swamp Mahogany	117	30	
2	North Sancrox	Control	Control	LAKE INNES3		3.3	Swamp Mahogany	76	20	

Area N	Monitoring area	Treatment	Sub-category	Site_ID	Map ref	Activity	New SCT	DBH (cm)	Radial (m)	Notes
2	North Sancrox	Control	New Control	SAT COW4	NSAN3	3.3	Blackbutt	72	25	
2	North Sancrox	Control	New Control	SAT COW5		0.0	Small-fruited Grey Gum	28	20	
2	North Sancrox	Control	New Control	SAT COW6		10.0	Tallowwood	56	15	
3	Cairncross State Forest (South)	Impact	No Mitigation	CAINCROSS SF1	CCS1	0.0	Tallowwood	33	25	
3	Cairncross State Forest (South)	Impact	No Mitigation	CAINCROSS SF2		0.0	Tallowwood	42	30	
3	Cairncross State Forest (South)	Impact	No Mitigation	CAINCROSS SF3		0.0	Tallowwood	22	30	
3	Cairncross State Forest (south)	Impact	No Mitigation	CAINCROSS SF16	CCS2	0.0	Tallowwood	38	25	
3	Cairncross State Forest (south)	Impact	No Mitigation	CAINCROSS SF17		0.0	Tallowwood	47	25	
3	Cairncross State Forest (south)	Impact	No Mitigation	CAINCROSS SF18		3.3	Tallowwood	53	35	Not tagged
3	Cairncross State Forest (South)	Impact	Mitigation	CAINCROSS SF4	CCS3	6.7	Tallowwood	59	45	
3	Cairncross State Forest (South)	Impact	Mitigation	CAINCROSS SF5		0.0	Tallowwood	64	45	
3	Cairncross State Forest (South)	Impact	Mitigation	CAINCROSS SF6		0.0	Blackbutt	76	25	
3	Cairncross State Forest (South)	Control	Control	LIMEBURNERS CK1	CCS4	0.0	Scribbly Gum	94	45	Not tagged
3	Cairncross State Forest (South)	Control	Control	LIMEBURNERS CK2		0.0	Scribbly Gum	76	40	Not tagged
3	Cairncross State Forest (South)	Control	Control	LIMEBURNERS CK3		0.0	Scribbly Gum	44	50	Not tagged
3	Cairncross State Forest (South)	Control	New Control	SAT PEVI1	CCS5	6.7	Sydney Blue Gum	61	40	
3	Cairncross State Forest (South)	Control	New Control	SAT PEVI2		3.3	Sydney Blue Gum	41	20	
3	Cairncross State Forest (South)	Control	New Control	SAT PEVI3		0.0	Sydney Blue Gum	56	30	
4	Cairncross State Forest (north)	Impact	No Mitigation	CAINCROSS SF7	CCN1	0.0	Blackbutt	67	40	
4	Cairncross State Forest (north)	Impact	No Mitigation	CAINCROSS SF8		0.0	Forest Red Gum	45	30	
4	Cairncross State Forest (north)	Impact	No Mitigation	CAINCROSS SF9		0.0	Blackbutt	65	45	
4	Cairncross State Forest (north)	Impact	Mitigation	CAINCROSS SF10	CCN2	3.3	Swamp Mahogany	33	45	
4	Cairncross State Forest (north)	Impact	Mitigation	CAINCROSS SF11		0.0	Tallowwood	53	45	
4	Cairncross State Forest (north)	Impact	Mitigation	CAINCROSS SF12		0.0	Tallowwood	70	25	
4	Cairncross State Forest (north)	Control	Control	CAINCROSS SF13	CCN3	0.0	Small-fruited Grey Gum	45	25	
4	Cairncross State Forest (north)	Control	Control	CAINCROSS SF14		0.0	Sydney Blue Gum	36	30	

Area N	Monitoring area	Treatment	Sub-category	Site_ID	Map ref	Activity	New SCT	DBH (cm)	Radial (m)	Notes
4	Cairncross State Forest (north)	Control	Control	CAINCROSS SF15		0.0	Sydney Blue Gum	83	30	Not tagged
4	Cairncross State Forest (north)	Control	New Control	SAT RR1	CCN4	0.0	Tallowwood	77	40	
4	Cairncross State Forest (north)	Control	New Control	SAT RR2		0.0	Small-fruited Grey Gum	56	40	
4	Cairncross State Forest (north)	Control	New Control	SAT RR3		0.0	Tallowwood	62	40	
5	Cooperabung Hill	Impact	No Mitigation	COOPERABUNG1	COOP1	0.0	Tallowwood	67	40	
5	Cooperabung Hill	Impact	No Mitigation	COOPERABUNG2		0.0	Small-fruited Grey Gum	49	50	
5	Cooperabung Hill	Impact	No Mitigation	COOPERABUNG3		0.0	Tallowwood	51	35	
5	Cooperabung Hill	Impact	Mitigation	COOPERABUNG4	COOP2	0.0	Tallowwood	34	35	
5	Cooperabung Hill	Impact	Mitigation	COOPERABUNG5		0.0	Tallowwood	25	40	
5	Cooperabung Hill	Impact	Mitigation	COOPERABUNG6		0.0	Tallowwood	69	30	
5	Cooperabung Hill	Control	Control	COOP HILL1	COOP3	0.0	Tallowwood	46	35	
5	Cooperabung Hill	Control	Control	COOP HILL2		0.0	Small Fruited Grey Gum	36	35	
5	Cooperabung Hill	Control	Control	COOP HILL3		0.0	Tallowwood	34	35	
5	Cooperabung Hill	Control	New Control	SAT FL1	COOP4	0.0	Resinifera	39	45	
5	Cooperabung Hill	Control	New Control	SAT ST1		0.0	Mahogany	33	20	
5	Cooperabung Hill	Control	New Control	SAT ST2		0.0	Tallowwood	32	25	
6	Mingaletta to Smiths Creek	Impact	Mitigation	MIN-SMITHS CK1	MING1	0.0	Blackbutt	53	35	
6	Mingaletta to Smiths Creek	Impact	Mitigation	MIN-SMITHS CK2		0.0	Tallowwood	42	20	
6	Mingaletta to Smiths Creek	Impact	Mitigation	MIN-SMITHS CK3		0.0	Small-fruited Grey Gum	57	30	
6	Mingaletta to Smiths Creek	Control	Control	BALLENGARA SF1	MING2	0.0	Tallowwood	37	30	
6	Mingaletta to Smiths Creek	Control	Control	BALLENGARA SF2		0.0	Tallowwood	31	50	
6	Mingaletta to Smiths Creek	Control	Control	BALLENGARA SF3		0.0	Tallowwood	37	45	
6	Mingaletta to Smiths Creek	Control	New Control	SAT BR1	MING3	0.0	Sydney Blue Gum	32	25	
6	Mingaletta to Smiths Creek	Control	New Control	SAT BR2		0.0	Sydney Blue Gum	48	25	
6	Mingaletta to Smiths Creek	Control	New Control	SAT BR3		0.0	Flooded Gum	50	40	
7	Kundabung Road to North of Pipers Creek	Impact	No Mitigation	KUNDABUNG 1	KUND1	0.0	Flooded Gum	47	30	

Area N	Monitoring area	Treatment	Sub-category	Site_ID	Map ref	Activity	New SCT	DBH (cm)	Radial (m)	Notes
7	Kundabung Road to North of Pipers Creek	Impact	No Mitigation	KUNDABUNG 2		6.7	Tallowwood	82	30	
7	Kundabung Road to North of Pipers Creek	Impact	No Mitigation	KUNDABUNG 3		0.0	Pink Bloodwood	38	45	
7	Kundabung Road to North of Pipers Creek	Impact	Mitigation	KUNDABUNG 4	KUND2	13.3	Blackbutt	72	45	
7	Kundabung Road to North of Pipers Creek	Impact	Mitigation	KUNDABUNG 5		16.7	Blackbutt	40	30	
7	Kundabung Road to North of Pipers Creek	Impact	Mitigation	KUNDABUNG 6		0.0	Grey Ironbark	56	25	
7	Kundabung Road to North of Pipers Creek	Control	Control	KUMBATINE NP1	KUND3	0.0	Tallowwood	32	25	
7	Kundabung Road to North of Pipers Creek	Control	Control	KUMBATINE NP2		0.0	Tallowwood	38	25	
7	Kundabung Road to North of Pipers Creek	Control	Control	KUMBATINE NP3		3.3	Tallowwood	44	25	
7	Kundabung Road to North of Pipers Creek	Control	New Control	SAT MAC1	KUND4	0.0	Red Mahogany	82	30	
7	Kundabung Road to North of Pipers Creek	Control	New Control	SAT MAC2		0.0	Spotted Gum	41	35	
7	Kundabung Road to North of Pipers Creek	Control	New Control	SAT MAC3		0.0	Spotted Gum	54	30	
8	Maria River State Forest	Impact	Part Mitigation	MARIA RIVER 1	MR1	6.7	Pink Bloodwood	32	45	
8	Maria River State Forest	Impact	Part Mitigation	MARIA RIVER 2		0.0	Tallowwood	49	25	
8	Maria River State Forest	Impact	Part Mitigation	MARIA RIVER 3		13.3	Tallowwood	26	35	
8	Maria River State Forest	Impact	Mitigation	MARIA RIVER 4	MR2	6.7	Thin-leaved Stringybark	40	20	
8	Maria River State Forest	Impact	Mitigation	MARIA RIVER 5		0.0	Tallowwood	66	25	
8	Maria River State Forest	Impact	Mitigation	MARIA RIVER 6		3.3	Tallowwood	39	40	
8	Maria River State Forest	Control	Control	MARIA NP1	MR3	20.0	Pink Bloodwood	29	40	
8	Maria River State Forest	Control	Control	MARIA NP2		10.0	Tallowwood	58	25	
8	Maria River State Forest	Control	Control	MARIA NP3		36.7	Tallowwood	31	25	
8	Maria River State Forest	Control	New Control	SAT CO1	MR4	10.0	White Stringybark	62	35	
8	Maria River State Forest	Control	New Control	SAT CO3		0.0	Blackbutt	67	40	
8	Maria River State Forest	Control	New Control	SAT MAR 1		3.3	Tallowwood	76	35	

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# Appendix B Giant Barred Frog



# Giant Barred Frog Monitoring 2018/2019

**Oxley Highway to Kempsey, Pacific Highway Upgrade**

Prepared for Roads and Maritime Services

September 2019

## Document control

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*Cover photograph: Giant Barred Frog (Photo: Matthew Stanton)*

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## Executive summary

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### **Context**

This report documents findings of the second (spring 2018) and third (autumn 2019) operational monitoring surveys for the Giant Barred Frog (*Mixophyes iteratus*), as required for the Oxley Highway to Kempsey (OH2K) Pacific Highway Upgrade Project (the Project), and specified in the Oxley Highway to Kempsey (OH2K) Ecological Monitoring Program (EMP, RMS 2019a). Summer 2019 surveys were not undertaken due to insufficient rainfall. The NSW Roads and Maritime Services (Roads and Maritime) is required to manage and monitor the effectiveness of biodiversity mitigation measures implemented as part of the Project. The Giant Barred Frog is one of the threatened species identified as requiring mitigation and monitoring throughout the course of the construction and operational periods of the Project.

### **Aims**

The aim of the Giant Barred Frog monitoring program is to determine, through evaluation of the performance indicators outlined in the EMP, if the Project is having an impact on the species and whether corrective actions are required.

### **Methods**

Six sites (two reference and four impact) were monitored. Each site consists of a one kilometre transect along the creek line, divided into 10 x 100 metre zones. Each monitoring location was surveyed in accordance with the monitoring method and design specified in the EMP. Surveys were undertaken after a sufficient rainfall trigger event (> 10 millimetres within a 24 hour period) and involved passive listening, call playback (upon arrival and at intervals during searches), active searching (within 20 metres of each creek bank) and habitat surveys within each of the 100 metre zones.

### **Key results**

Surveys were undertaken on the 15 – 17 October 2018 (spring), and 11 – 13 March 2019 (autumn) after suitable rainfall. Summer 2019 surveys were not undertaken due to insufficient rainfall. A total of 72 Giant Barred Frogs were recorded during the 2018/2019 monitoring period and 28.6% (n = 20) of those captured were recaptures. Frogs were recorded at all sites during all seasons with the exception of Cooperabung Creek reference site where no frogs were recorded during the spring surveys.

All sites showed evidence of breeding via presence of juveniles or sub-adults, gravid females or reproductive males during at least one survey event.

Chytrid fungus was detected at Cooperabung Creek reference site during the 2018/2019 monitoring period, however is considered to be present at all monitoring sites, where it has been detected previously.

All sites had at least one water quality parameter for one or more monthly results for which the median downstream value exceeded the 80<sup>th</sup> percentile of the upstream value.

## **Conclusions**

Performance measures relating to undertaking monitoring have to date been met.

The performance measure relating to continued presence of Giant Barred Frogs during each survey event where it was identified during baseline surveys was met for five of the six sites. Giant Barred Frogs were not recorded at Cooperabung reference site during the spring survey, where it was recorded during spring baseline surveys. Giant Barred Frogs were however recorded at this site during autumn 2019 surveys.

The performance measure relating to changes in density was met for all impact sites except Pipers Creek impact site and Cooperabung Creek impact site. Cooperabung Creek impact, Pipers Creek impact and Cooperabung Creek reference sites all show a decreasing trend in mean records and densities. However, as this decreasing trend is evident at both impact and reference sites, it is not possible to attribute these changes to the Project at this stage.

The water quality performance measure was met for all parameters. Values above the 80<sup>th</sup> percentile trigger value were not considered to be attributable to construction activities.

## **Management implications**

Given the variable nature of annual mean records among sites, the absence of summer survey records from the current monitoring period, the evidence of a decreasing trend at a reference site and the lack of a distinct difference between impact and reference sites, it is not possible to attribute observed changes to the Project. As such, it is recommended that monitoring continue as per the EMP.

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# 1. Introduction

---

## 1.1 Context

The Oxley Highway to Kempsey (OH2K) section of the Pacific Highway Upgrade Project (the Project) was approved in 2012 subject to various Ministers Conditions of Approval (MCoA) and a Statement of Commitments (SoC). A subsequent approval with additional conditions of consent (CoA) was granted in 2014 by the Commonwealth Department of Environment (DoE) for Matters of National Environmental Significance (MNES) listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1995* (EPBC Act). The Ecological Monitoring Program (hereafter referred to as the EMP) (RMS 2019a) combines these approval conditions and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project. The Giant Barred Frog (*Mixophyes iteratus*) was one threatened species identified as requiring mitigation and monitoring through the course of the Project's construction and operational period.

### 1.1.1 Legal status

The Giant Barred Frog is listed as endangered under the New South Wales *Biodiversity Conservation Act 2016* (BC Act) and Commonwealth EPBC Act. Monitoring of the species is required under the Project's approval.

### 1.1.2 Monitoring framework

The design, methods and performance indicators that define the Giant Barred Frog monitoring program are specified in the EMP and Giant Barred Frog Management Strategy (GBFMS, Lewis 2013). Where there are discrepancies between the EMP and the GBFMS, the EMP takes precedence (Section 1.2 RMS 2019a).

The EMP required monitoring of the Giant Barred Frog three times a year (spring, summer and autumn) in years 1, 2 and 3 once substantial construction commenced. Following completion of the Project, surveys are to be undertaken for five consecutive years, in spring, summer and autumn of Year 4, 5, 6, 7 and 8 (operational phase) or until mitigation measures can be demonstrated to have been effective. To date, these monitoring events have been undertaken and reported as follows:

- Construction phase monitoring:
  - *Autumn 2015*: Niche 2015a
  - *Spring 2015, summer and autumn 2016*: Niche 2016
  - *Spring 2016, summer and autumn 2017*: Niche 2017
  - *Spring 2017, summer 2018*: Niche 2018.
- Operational phase monitoring:
  - *Autumn 2018*: Niche 2018
  - *Spring 2018, (summer 2019 insufficient rainfall) and autumn 2019*: current report.

This report addresses the second (spring 2018), third (summer 2019) and fourth (autumn 2019) survey events of operational phase monitoring of the Project. Summer 2019 surveys were not undertaken due to insufficient rainfall. This report therefore represents the fifth of nine monitoring reports for the Giant Barred Frog. The next round of operational monitoring will commence in spring 2019.

Water quality monitoring is also being conducted within Giant-Barred Frog habitat and potential habitat. Water quality monitoring commenced prior to construction, continued during construction and will continue for three years during the operational phase. Water monitoring results for the Giant Barred Frog impact sites are included in this report.

### 1.1.3 Baseline data

The EMP specifies the following regarding the Giant Barred Frog:

*“The Giant Barred Frog was recorded at Maria River and suitable habitat was identified at Smiths Creek, Pipers Creek and Cooperabung Creek during surveys undertaken to inform the Environmental Assessment (GHD 2010). Targeted surveys undertaken over eight nights between late November 2012 and late January 2013, involving spotlighting, call-playback and tadpole searches, identified the Giant Barred Frog at Cooperabung Creek (south), Cooperabung Creek downstream at Haydons Wharf Road, Smiths Creek, Pipers Creek and Maria River. Areas of suitable habitat for the Giant Barred Frog were also identified at both Stumpy Creek and Barrys Creek”*

The EMP lists six sites to be monitored:

- Four impact sites: Cooperabung Creek, Smiths Creek, Pipers Creek, and Maria River.
- Two reference sites: Sun Valley Road (where it crosses Cooperabung Creek), and Old Coast Road (where it crosses Pipers Creek).

Baseline surveys (Niche 2015b) recorded a total of 152 Giant Barred Frogs, at all six monitoring sites in spring and summer and at four sites in autumn. Frogs were absent from the Maria River impact site and Pipers Creek reference site during the autumn 2014 baseline survey.

### 1.1.4 Purpose of this report

The purpose of this report is to summarise the methods and results of the 2018/2019 monitoring and determine if performance measures are being met, as per the EMP.

## 1.2 Performance Measures

The EMP specifies the following performance measures for the Giant Barred Frog:

- *Monitoring is undertaken during baseline surveys and Years 1 – 8 or until monitoring can demonstrate that mitigation measures are effective.*
- *Monitoring during Years 1 – 8 is undertaken at the Impact and Control sites where baseline monitoring was undertaken, subject to landowner agreement.*
- *Continued presence of Giant Barred Frogs during each survey event in Years 1 – 8 at sites where it was identified during baseline surveys, subject to access due to landowner agreement.*
- *Mitigation measures are effective as defined in the EPBC approval when all monitoring events are considered at Year 8.*
- *Median values of all downstream water quality monitoring at GBF habitat or potential habitat locations during construction and operation (Year 1 – 6) is less than the 80th percentile value of the upstream site (where 80th percentile is the value at which median values at the downstream site are above 80% of the recorded background water quality records), where this change is found to be attributable to construction or operation.*
- *No change to densities, distribution, habitat use and movement patterns compared to baseline data during monitoring in Years 1 – 8, and then when all monitoring events are considered at Year 8.*

## 1.3 Monitoring Timing

Monitoring is to occur three times a year: spring, summer and autumn. Monitoring is to occur in the middle of the season, within one week of rainfall of 10 millimetres within a 24 hour period.

## 1.4 Reporting

As per the EMP, annual reporting of monitoring results will include:

- Detailed description of monitoring methodology
- Results of the monitoring period
- Discussion of results, including how the results compare against performance measures, if any modifications to timing or frequency of monitoring periods or monitoring methodology are required and any other recommendations
- If contingency measures should be implemented.

All reports prepared under the EMP will be submitted to NSW Department of Planning, Industry and Environment (DPIE; previously the NSW Department of Planning and Environment) and the NSW Environment Protection Authority (EPA).

## 1.5 Limitations

The following limitations to the monitoring procedure were encountered:

- As reported in Niche 2017, increasing density of Lantana (*Lantana camera*) at a number of sites, notably Maria River impact site and Pipers Creek impact site, is hampering survey efforts. Safe navigation of the creek lines has become difficult due to low visibility and steep creek banks. Giant Barred Frogs have become difficult to detect and impossible to access in areas due to this Lantana growth.
- Summer 2019 surveys were not undertaken due to insufficient rainfall.

## 2. Methodology

---

### 2.1 Monitoring Sites

Monitoring was undertaken at the four impact and two reference sites. Each site consists of a one kilometre transect along the creek line.

Where possible, impact site transects extend 450 metres upstream and 450 metres downstream of the Project footprint (assumes Project boundary width of 100 metres) and are divided into 10 x 100 metre zones, resulting in four to five zones downstream of the Project footprint, one within the Project footprint, and four to five upstream of the Project footprint. As for previous monitoring events, the Cooperabung Creek impact site was not surveyed for the full kilometre as access agreements with landowners could not be obtained for the final downstream zone, and for the first two upstream zones.

The two reference sites are located several kilometres upstream of the Project footprint within Cooperabung Creek and Pipers Creek.

The location of all monitoring sites is shown in Figure 1, with detailed locations for each site transect provided in Figure 2 to Figure 7.

### 2.2 Giant Barred Frog Survey Method

Surveys were undertaken in accordance with the EMP after sufficient rainfall events.

A two hour minimum search time, using two ecologists, at each site was employed, however access and movement difficulties due to dense vegetation often resulted in increased survey time. Surveys involved passive listening, call playback (upon arrival and at intervals during searches), active searching (within 20 metres of creek bank) and habitat surveys. In accordance with the EMP, the following habitat data was collected within each of the 100 metre zones:

- Overstorey vegetation cover (OS, expressed as a cover percentage out of 100%)
- Shrub cover (expressed as a cover percentage out of 100%)
- Ground cover (expressed as a cover percentage out of 100%)
- Leaf litter cover (expressed as a cover percentage out of 100%)
- Bare soil/earth (expressed as a cover percentage out of 100%)
- Presence of cattle (based on hoof marks, manure and whether it is recent or aged evidence)
- Number of pools and riffles within the zone
- Approximate depth of the deepest pool within the zone
- Number of breaches in frog fencing, if applicable.

The position of all observed Giant Barred Frogs was recorded and, where possible, individuals were captured. Captured individuals were checked for recapture status and fitted with a Passive Integrated Transponder (PIT) tag if the individual was previously unknown. In accordance with the EMP, the following data were collected for captured individuals:

- Location according to demarcated survey zone
- Distance from stream edge
- Sex (male, female, unknown)
- Breeding condition with:
  - Males assessed on the colouration of their nuptial pads (i.e. no colour, light, moderate, dark)

- Females based on whether they are gravid or not gravid (egg bearing).
- Snout-vent length (millimetres)
- Weight (grams).

A swab sample to test for the presence of Chytrid fungus was also undertaken during the 2018/2019 surveys, however this is no longer a requirement of the EMP, as Chytrid fungus has been detected at all sites, and will not be undertaken in future surveys.

Temperature and humidity (either by windwatch or hygrometer), % cloud cover and broad wind level (scale of 0-3 where 0 = no wind) were recorded for each survey. Rainfall (millimetres) within the previous 24 hours was recorded from the Port Macquarie Airport (BOM Station No. 060183), Maria River (BOM Station No. 560003) and Kundabung AWS (Roads and Maritime Station No. RMSN3AWS).

## 2.3 Water Quality

Water quality monitoring was undertaken by Roads and Maritime between 30 March 2018 and 29 March 2019 (RMS 2019b). RMS (2019) presents results from the first operational water quality monitoring period and this report summarises water quality data from both upstream and downstream sites for Cooperabung Creek, Smiths Creek, Pipers Creek, and Maria River.

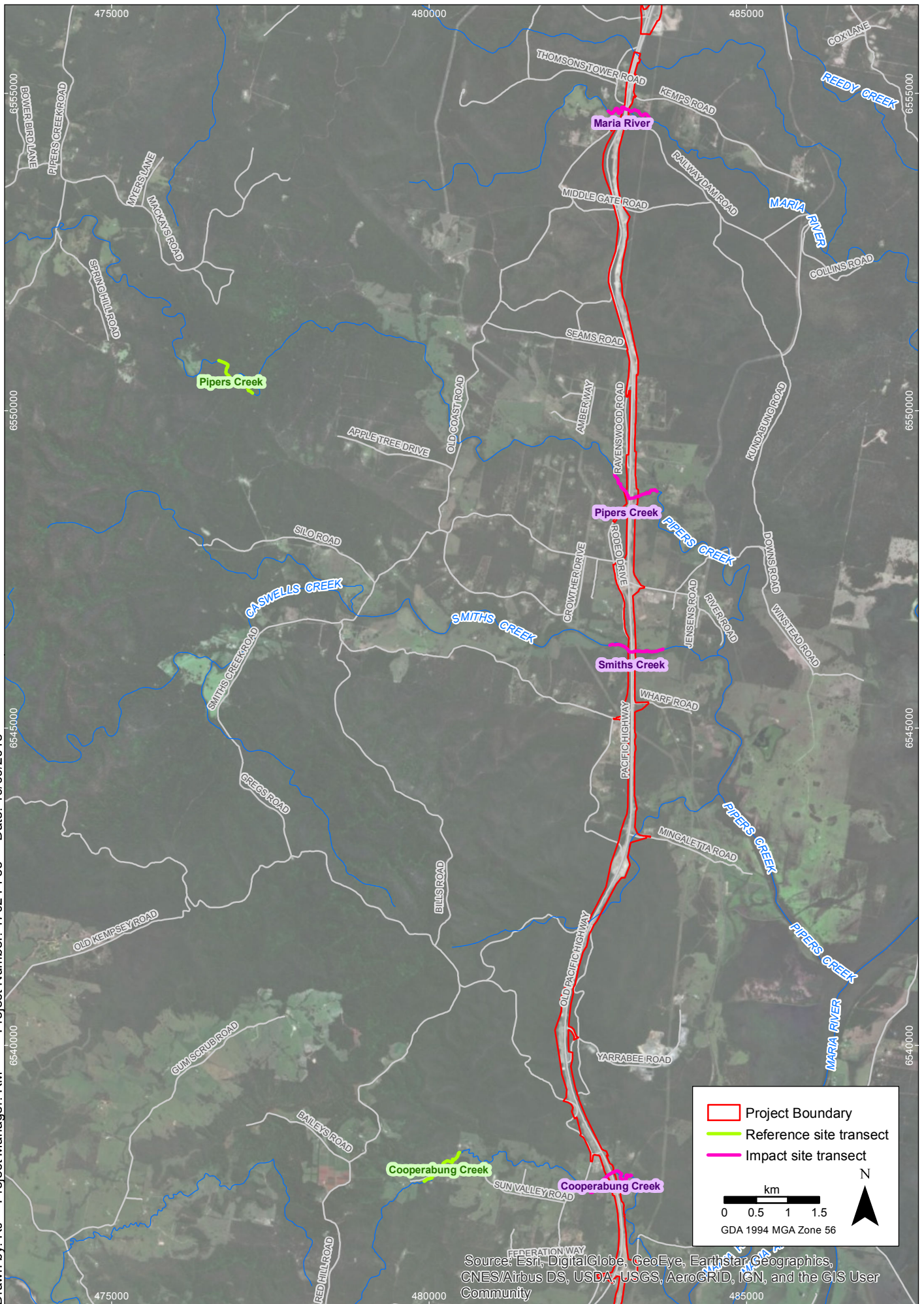
The median water quality value for downstream sites was compared with the site specific trigger values developed for the upstream site based on: the 80<sup>th</sup> percentile and, where relevant, the 20<sup>th</sup> percentile (where parameters have a lower acceptable limit e.g. EC, DO, pH, NTU), as well as the ANZECC default trigger values for physical and chemical stressors for south-east Australian slightly disturbed, freshwater ecosystems. Trigger values were derived from 24 sampling events up to and including the month indicated, where data was available.

## 2.4 Analysis

The Minimum Number Known Alive (MNA) (see Sutherland 2006) was calculated for each of the sites. The MNA is based on the number of new individuals encountered over multiple visits, where any new animals are summed, providing an aggregate total. As this method does not account for any migration out of the population or any death, it may over-estimate the total population size if counts are completed over a long period of time. As baseline studies commenced in 2013 it is possible that considering cumulative records over these last five years may overestimate the actual population. Data is provided for the annual new captures and a cumulative MNA over the years is also provided, however this data should be approached with caution, as the lifespan of the Giant Barred Frog may not extend beyond four or five years (Michael Mahony unpublished data).

Changes in Giant Barred Frog density within the zones and distribution along transects across the years were investigated by considering mean annual records within each specific zone. In addition, movement of individuals between zones was examined for recaptured frogs.

Drawn by: RJ Project Manager: RM Project Number: 1702 PI 53 Date: 19/09/2018



Source: Esri, DigitalGlobe, GeoEye, EarthStar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Giant Barred Frog Monitoring Sites: overview  
Pacific Highway Upgrade - Oxley Highway to Kempsey



Giant Barred Frog monitoring: Cooperabung Creek impact site  
 Pacific Highway Upgrade - Oxley Highway to Kempsey

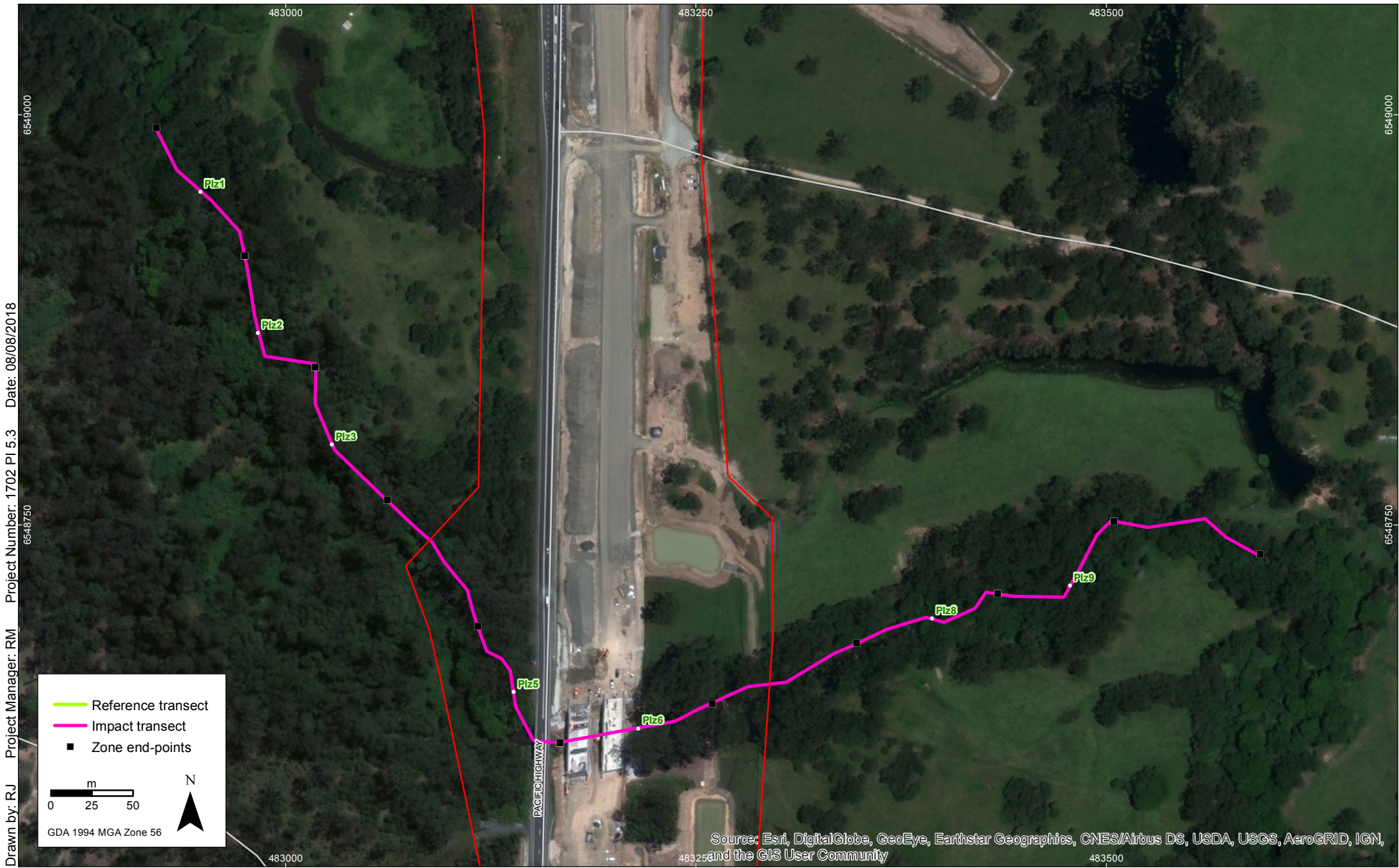




Giant Barred Frog monitoring: Smiths Creek impact site  
Pacific Highway Upgrade - Oxley Highway to Kempsey

**FIGURE 3**

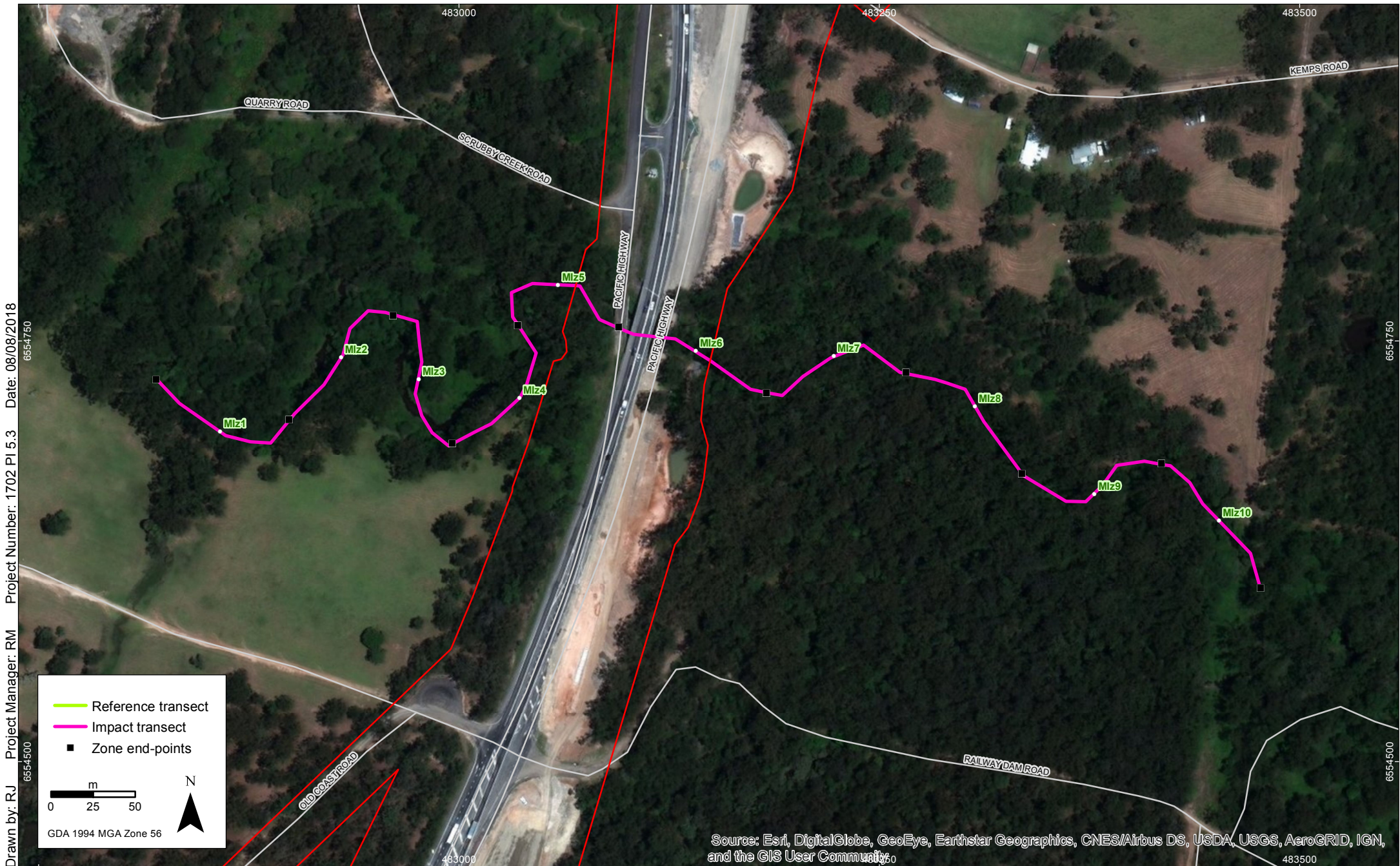
Imagery: (c) DigitalGlobe



Giant Barred Frog monitoring: Pipers Creek impact site  
 Pacific Highway Upgrade - Oxley Highway to Kempsey

**FIGURE 4**

Imagery: (c) DigitalGlobe



Giant Barred Frog monitoring: Maria River impact site  
 Pacific Highway Upgrade - Oxley Highway to Kempsey



Drawn by: RJ Project Manager: RM Project Number: 1702.PI 5.3 Date: 08/08/2018

Giant Barred Frog monitoring: Cooperabung Creek reference site  
 Pacific Highway Upgrade - Oxley Highway to Kempsey



Giant Barred Frog monitoring: Pipers Creek reference site  
Pacific Highway Upgrade - Oxley Highway to Kempsey

### 3. Results

#### 3.1 2018/2019 Giant Barred Frog Monitoring Results

Field data are presented in Annex 1 and Annex 2. Survey dates and trigger rainfall events measured at Port Macquarie Airport (060183) weather station were as follows:

- 15 - 17 October 2018 (spring): 33.6 millimetres recorded on the 11<sup>th</sup> October 2019 prior to surveys
- 11 – 13 March 2019 (autumn): 32 millimetres recorded on the 10<sup>th</sup> March 2019 prior to surveys.

There was insufficient rainfall during December 2018, January and February 2019 to trigger summer surveys.

##### 3.1.1 Survey results

A total of 72 Giant Barred Frogs were recorded in spring and autumn during the 2018/2019 monitoring surveys. Frogs were recorded at all sites during autumn surveys and at five of the six sites during spring surveys (Table 1). Of the 72 frogs recorded, 70 were captured, of which 20 were recaptures (28.6%). Frogs were recorded at all sites during all seasons with the exception of Cooperabung Creek reference site where no frogs were recorded during the spring surveys. Pipers Creek reference site recorded the greatest mean number of frogs.

The cumulative MNA is highest at the Pipers Creek reference site (MNA = 165) and Smiths Creek reference site (MNA = 112). As mentioned in Section 2.4, this estimate of MNA is likely an overestimate of the population as calculation of the MNA does not take dispersal or deaths into account.

**Table 1: Giant Barred Frogs recorded at each site during 2018/2019 surveys**

	Cooperabung Creek impact	Smiths Creek impact	Pipers Creek impact	Maria River impact	Cooperabung Creek reference	Pipers Creek reference
Spring (2018)	3	13	2	2	0	9
Autumn (2019)	1	3	3	3	3	30
Mean number of frogs per visit	2.0	8.0	2.5	2.5	1.5	19.5
Standard Error (SE)	1.4	7.1	1.0	1.0	2.1	14.8
New captures	2	10	5	4	1	28
Cumulative MNA	53	112	45	92	73	165

### 3.1.2 Evidence of breeding

Table 2 presents records of breeding evidence. All sites showed evidence of breeding via the presence of juveniles or sub-adults, gravid females or reproductive males during at least one survey event during 2018/2019.

**Table 2: Breeding evidence records 2018/2019**

		Juveniles	Sub-adults	Gravid females	Nuptial pads
Cooperabung Creek impact	Spring	1			2
	Autumn	1			
Maria River impact	Spring			1	
	Autumn	1			2
Pipers Creeks impact	Spring			1	
	Autumn			1	
Smiths Creek impact	Spring	2	1	2	2
	Autumn			3	
Cooperabung Creek reference	Spring				
	Autumn		1	1	
Pipers Creek reference	Spring				7
	Autumn	4	2	2	9

### 3.1.3 Weather conditions

The prevailing weather conditions encountered during the field surveys are summarised in Table 3 (Port Macquarie Airport (BOM Station No. 060183)). Additional details of the prevailing micrometeorological conditions at the six sites during the field surveys are presented in Annex 1.

**Table 3: Weather conditions: spring 2018 and autumn 2019**

Date	Min temp (°C)	Max temp (°C)	Humidity (%)	Rainfall 24 hours (mm)	Rainfall 7 days (mm)	Rainfall 30 days (mm)
15/10/2018	15.1	21.1	90	7.8	52.8	91.2
16/10/2018	17.7	23.6	76	5.6	58.2	96.8
17/10/2018	18.5	24.0	89	15.4	73.6	112.2
11/03/2019	21.7	31.2	65	0	34.4	89.2
12/03/2019	17.7	31.5	97	0	34.4	87.4
13/03/2019	17.6	27.8	77	0	34.4	87.4

### 3.1.4 Chytrid fungus

Chytrid fungus sampling was carried out during all monitoring events. Table 4 presents current and previous monitoring event results. During the current monitoring period Chytrid fungus was detected during autumn at Cooperabung Creek reference site only. Chytrid fungus was not detected during the spring monitoring surveys at any of the sites. Chytrid fungus was not detected at the remaining five sites during the 2018/2019 monitoring period, however it has been previously detected at these sites during either baseline surveys or previous monitoring events. It is presumed that once present, this pathogen will remain at a location on a permanent basis. Chytrid fungus is therefore considered to be present at all monitoring sites.

**Table 4: Chytrid fungus detection/presence at each site for all surveys conducted to date**

	Cooperabung Creek impact	Smiths Creek impact	Pipers Creek impact	Maria River impact	Cooperabung Creek reference	Pipers Creek reference
<b>Baseline</b>	not detected	<b>detected</b>	not detected	not detected	<b>detected</b>	not detected
<b>2015/2016</b>	not detected	not detected	<b>detected</b>	<b>detected</b>	not detected	<b>detected</b>
<b>2016/2017</b>	<b>detected</b>	not detected	not detected	not detected	<b>detected</b>	<b>detected</b>
<b>2017/2018</b>	not detected	<b>detected</b>	not detected	not detected	not detected	not detected
<b>2018/2019</b>	not detected	not detected	not detected	not detected	<b>detected</b>	not detected

### 3.1.5 Habitat use

Habitat information collected for each site is presented in Annex 1. Microhabitat use was highly variable. Frogs were recorded on and buried within leaf litter, using flood debris as shelter, within the creeks, on rocks and under logs and vegetation.

No frogs were found to have breached the frog fences at any sites (i.e. observed on the wrong side of the fence).



### 3.2 Comparison with Previous Surveys

As previously mentioned, the summer survey was not undertaken due to insufficient rainfall.

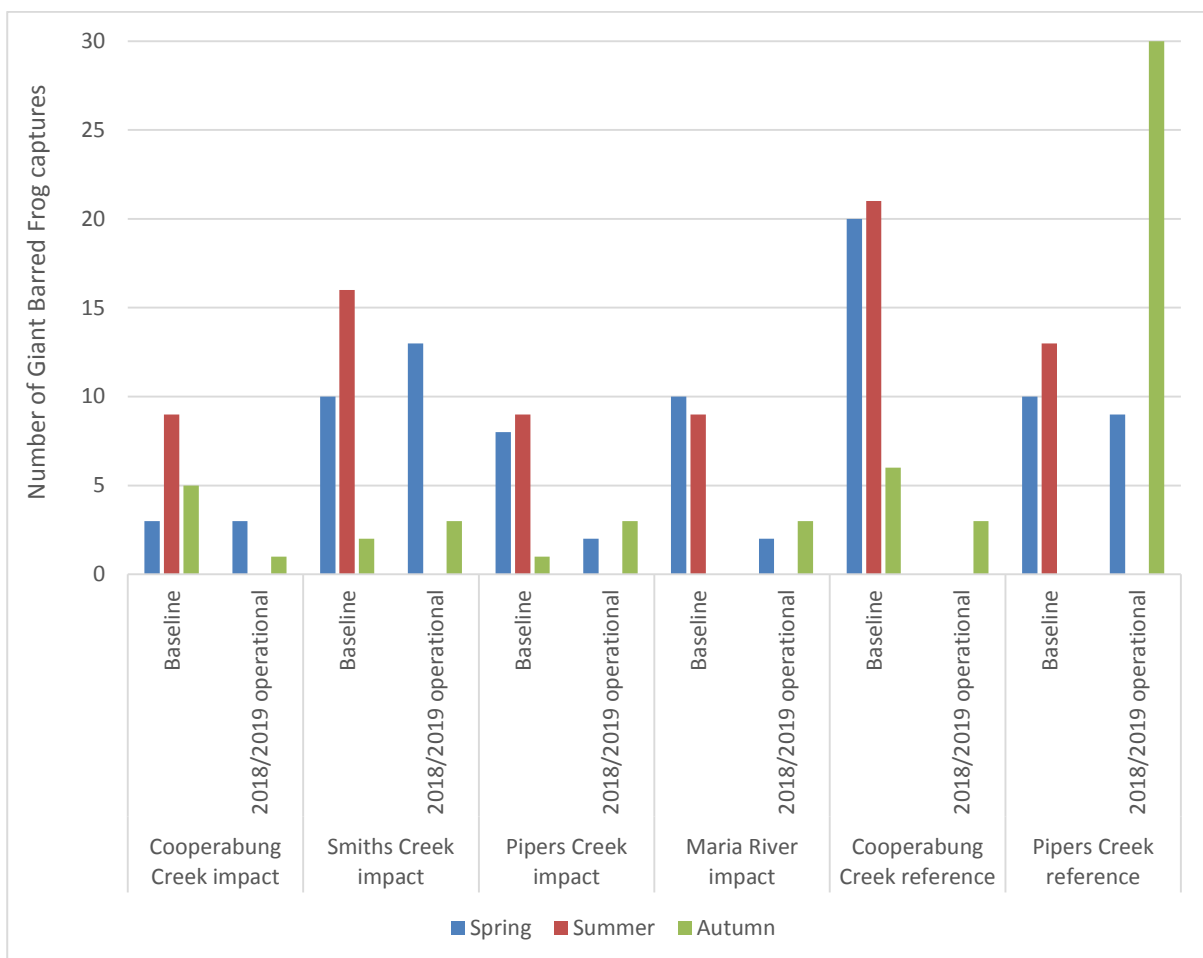
#### 3.2.1 Baseline and 2018/2019 surveys

Graph 1 presents the Giant Barred Frog records for baseline and the 2018/2019 operational monitoring surveys.

Baseline surveys recorded the Giant Barred Frog at all six monitoring sites in spring and summer and at four sites in autumn. Giant Barred Frogs were not recorded at the Maria River impact site and Pipers Creek reference site during the autumn 2014 baseline survey.

The 2018/2019 monitoring recorded Giant Barred Frogs at five monitoring sites in spring and at all six sites in autumn. Giant Barred Frogs were not recorded at Cooperabung Creek reference site during the spring 2018 surveys, where it was recorded during the spring baseline surveys.

Giant Barred Frogs were therefore recorded during all 2018/2019 surveys at the two sites (one impact site) where they were not recorded during the autumn baseline surveys (Pipers Creek reference site and Maria River impact site), however they were not recorded at the Cooperabung Creek reference site in the spring survey, where they were recorded during baseline surveys.



**Graph 1: Giant Barred Frog records: baseline and 2018/2019 monitoring**

### 3.2.2 Annual mean records

The mean number of records each year for each site is shown in Graph 2.

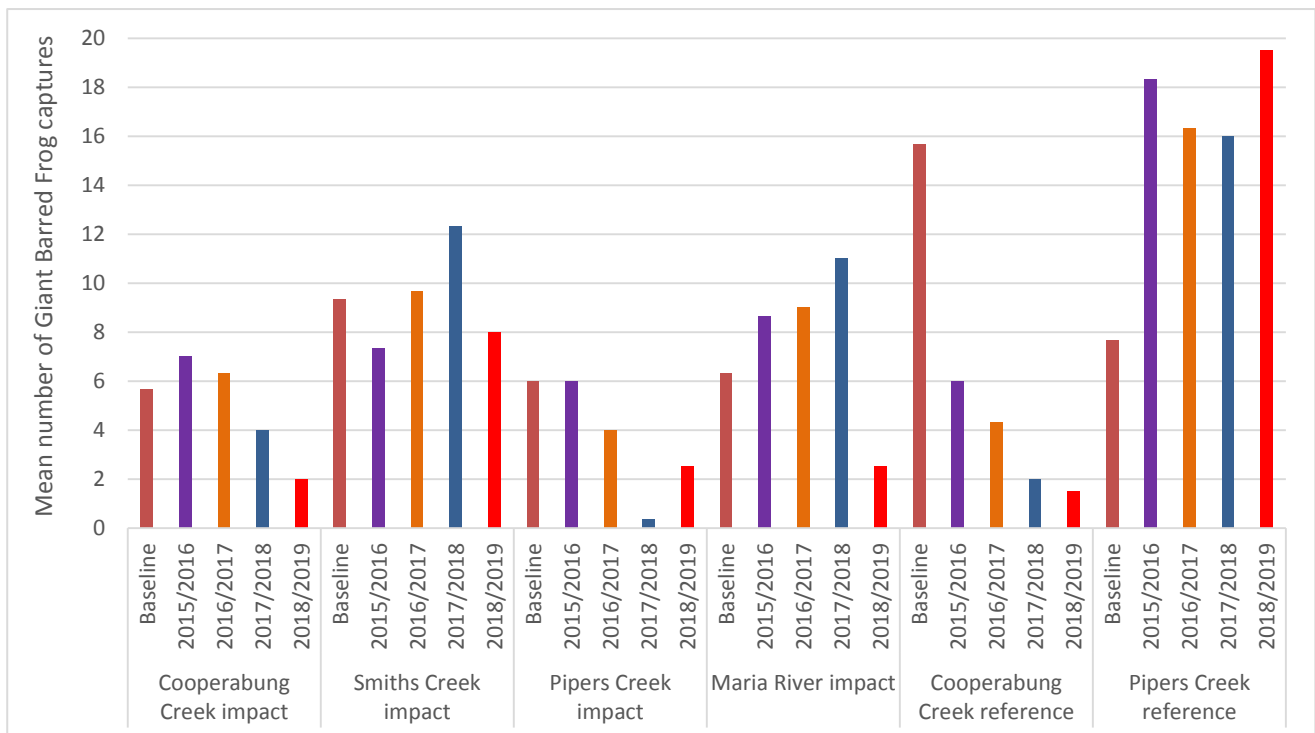
The mean number of Giant Barred Frogs recorded at Cooperabung Creek impact site and Cooperabung Creek reference site has decreased annually since 2015/2016 and baseline, respectively. Pipers creek impact site showed a similar annual decrease, however the mean number of Giant Barred Frogs recorded increased at this site in the current monitoring period.

The mean number of Giant Barred Frogs recorded at Smiths Creek impact site and Maria River impact site has increased annually since 2015/2016 and baseline respectively, however the mean number of Giant Barred Frogs recorded decreased substantially at both these sites in the current monitoring period.

The mean number of Giant Barred Frogs recorded at Pipers Creek reference site decreased in the current monitoring period, however there is no apparent annual trend at this site.

The mean number of Giant Barred Frogs recorded during the current monitoring period decreased from the previous monitoring event at all sites excluding Pipers Creek impact site. It should be noted that the greatest number of Giant Barred Frogs are generally recorded in the summer surveys of each monitoring cycle. The absence of the summer survey period is likely to have resulted in lower mean records for the current monitoring period.

Given the variable nature of annual mean records among sites, the absence of summer survey records from the current monitoring period, the evidence of a decreasing trend at a reference site and the lack of a distinct difference between impact and reference sites, it is not possible to attribute observed changes to the Project.



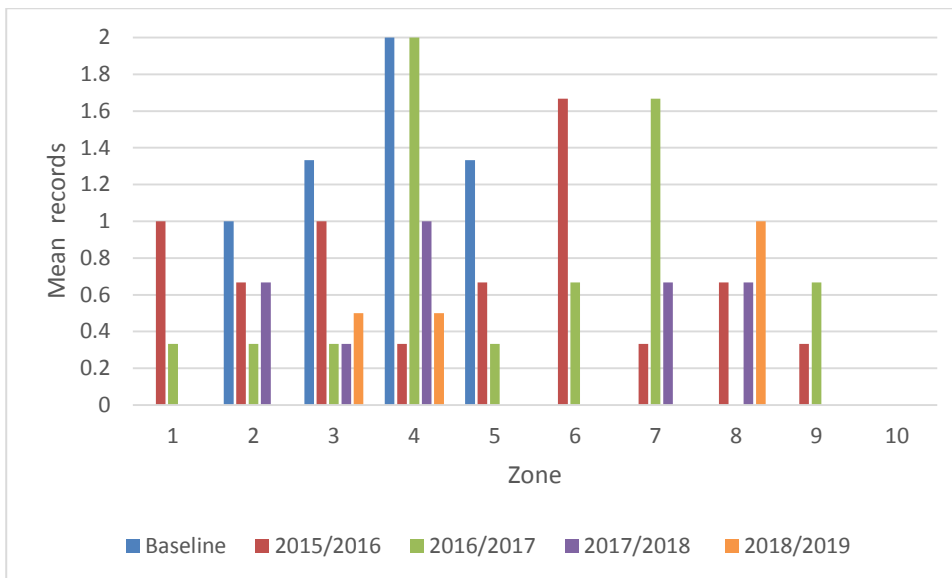
**Graph 2: Mean annual Giant Barred Frog records by site**

### 3.3 Density and Distribution

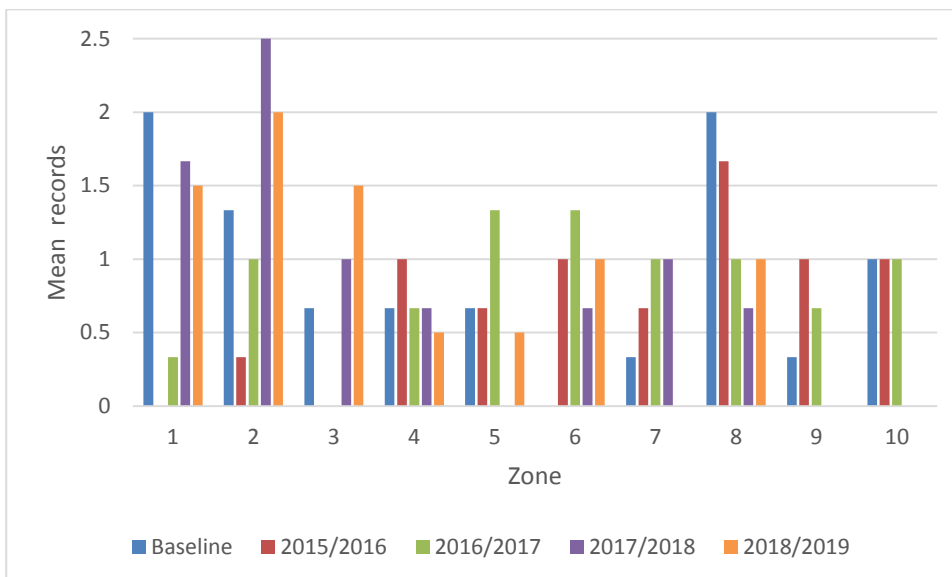
Graph 3 - Graph 8 present the density (*annual mean number of Giant Barred Frog records per zone*) and distribution of Giant Barred Frog records along the survey transect for each site and each monitoring period. Figure 8 - Figure 13 show the total number of captures within each zone over all monitoring periods.

The density of Giant Barred Frogs has been considered as the *mean number of records per year per zone* (Graph 3 to Graph 8). While the zones may vary in size slightly due to the nature of the creek's bank formation and the non-linear nature of the creek line, the zones themselves are consistent between years. As such comparisons can be made within the same zone between years to help identify trends in changing frog numbers. There is no consistent trend evident at any site for frogs to be found in any particular zone. Density appears to be highly variable across the years and along the transect and there is no evidence of lower frog densities within zones 5 and 6, i.e. under the carriageway and immediately adjacent.

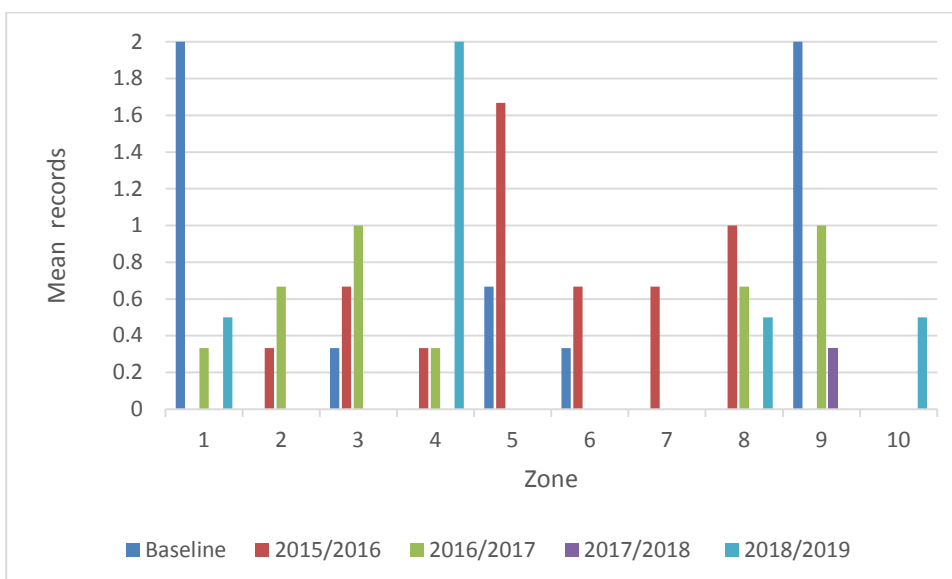
Figure 8 - Figure 13 show all capture records (i.e. cumulative records), whereby capture records (including recaptures) are shown as count ranges, where larger circles indicate larger frog counts. While density data indicates that frog distribution along the transects varies from year to year, when considering all years, frogs mostly appear to be using the entire length of the transect and there is no evidence of frogs being recorded only in one particular zone. In addition, there is no evidence of frogs being absent from zones 5 and 6. While capture frequencies within zones directly under the carriageway consistently fall into the lower range category (1-7 frogs), the low capture frequency range occurs regularly along the transects and at all sites.



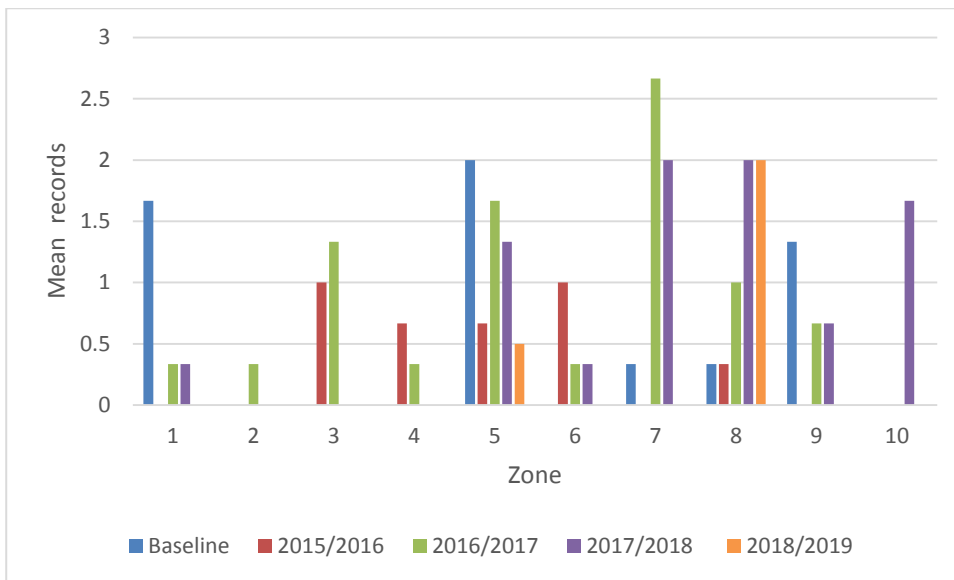
**Graph 3: Cooperabung Creek impact site: mean number of Giant Barred Frogs per zone**



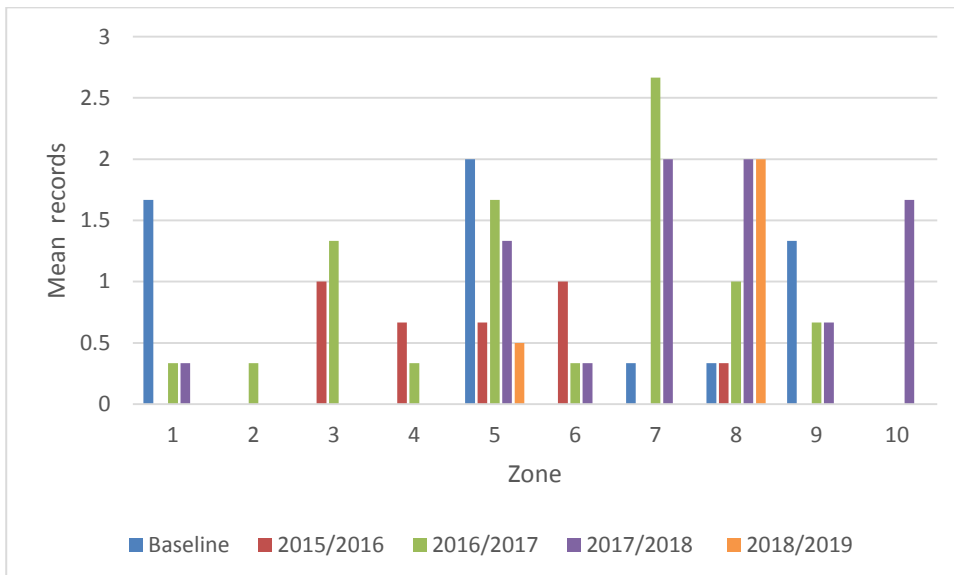
**Graph 4: Smiths Creek impact site: mean number of Giant Barred Frogs per zone**



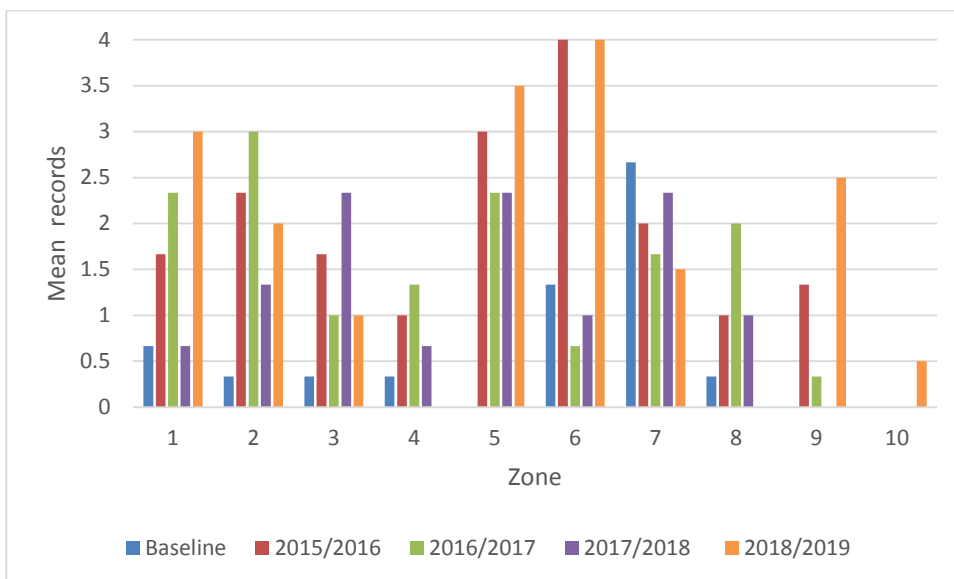
**Graph 5: Pipers Creek impact site: mean number of Giant Barred Frogs per zone**



**Graph 6: Maria River impact site: mean number of Giant Barred Frogs per zone**



**Graph 7: Cooperabung Creek reference site: mean number of Giant Barred Frogs per zone**



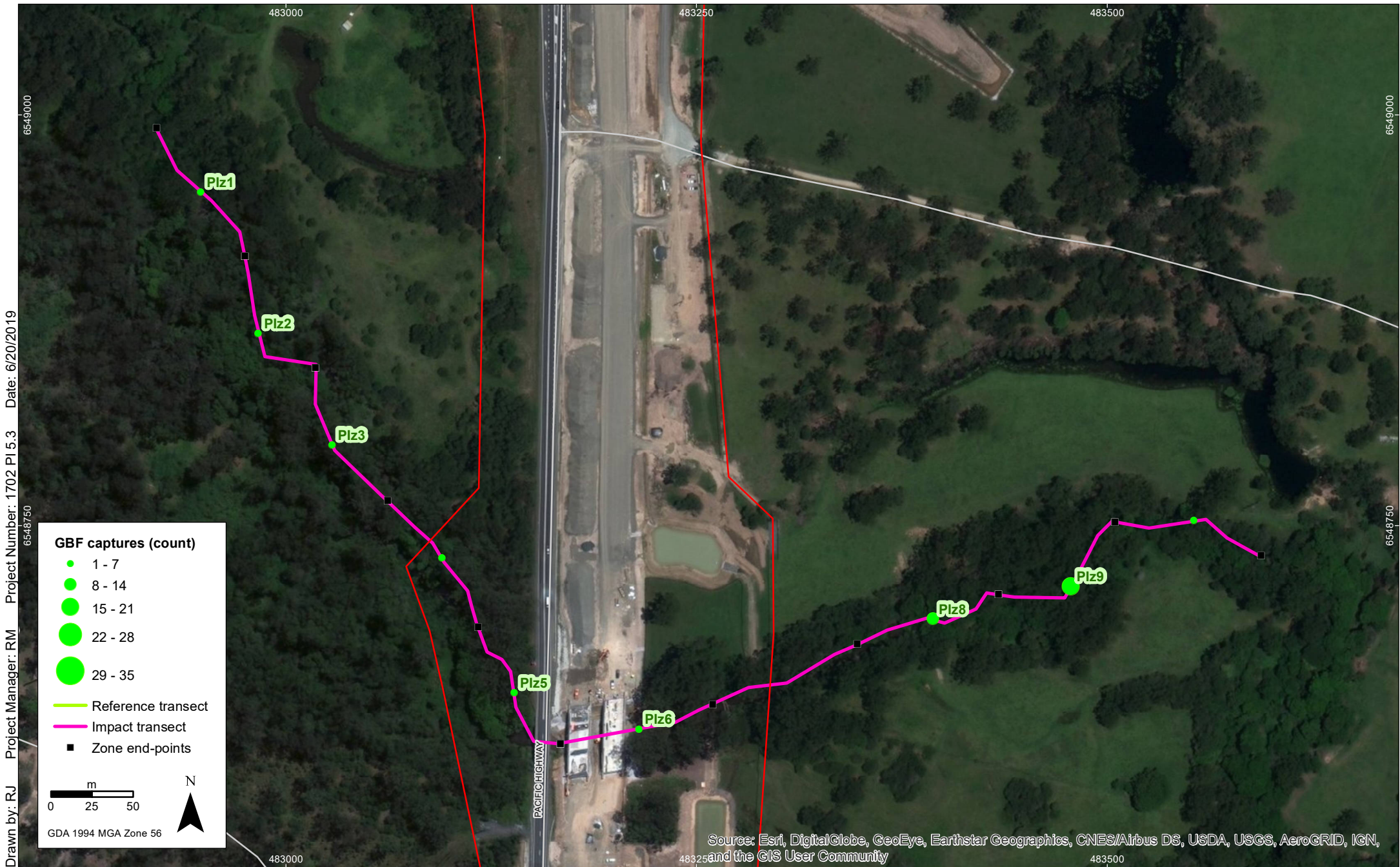
**Graph 8: Pipers Creek reference site operational: mean number of Giant Barred Frogs per zone**



Giant Barred Frog capture distribution: Cooperabung Creek impact site  
Pacific Highway Upgrade - Oxley Highway to Kempsey

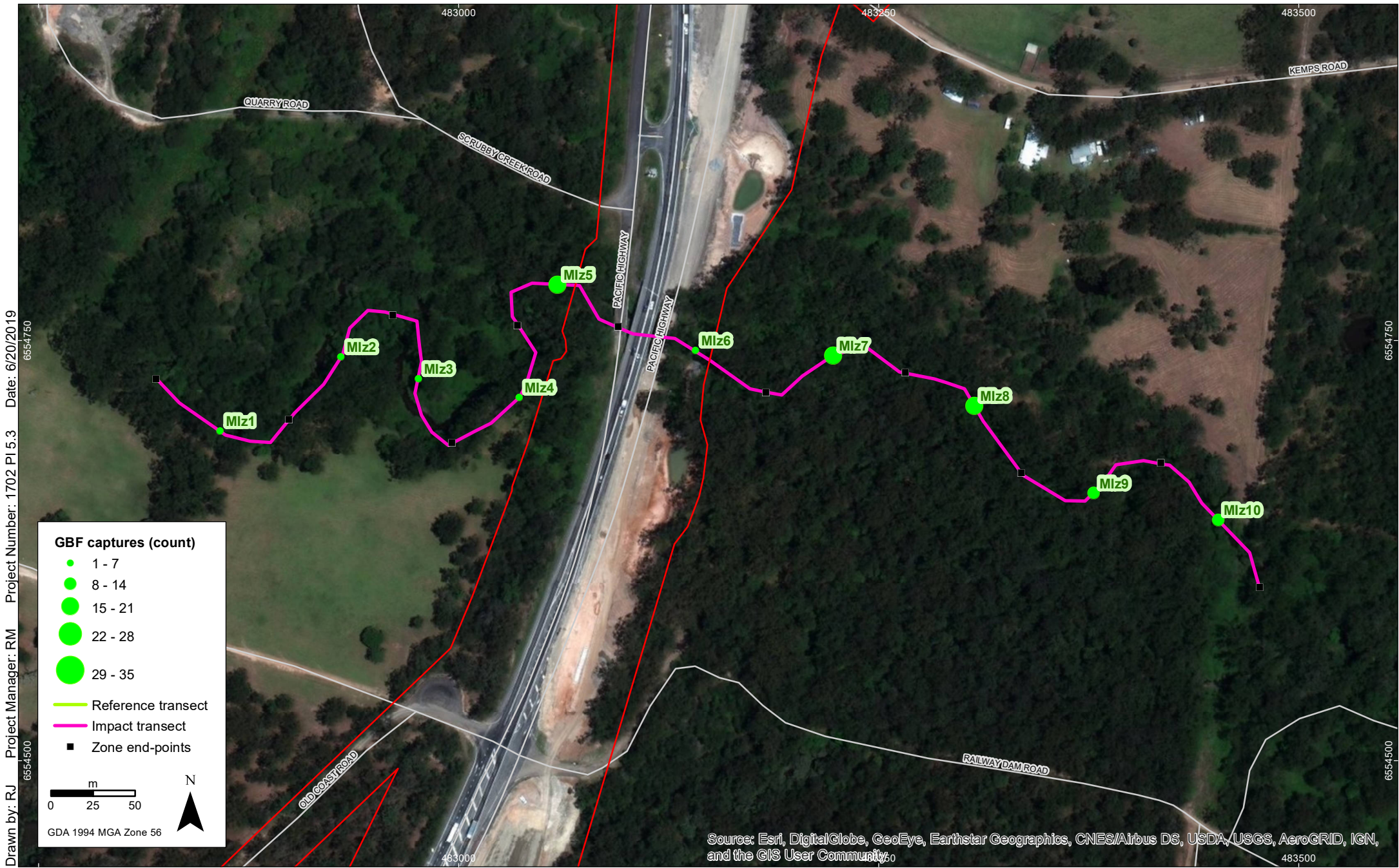


Giant Barred Frog capture distribution: Smiths Creek impact site  
Pacific Highway Upgrade - Oxley Highway to Kempsey



Giant Barred Frog capture distribution: Pipers Creek impact site  
 Pacific Highway Upgrade - Oxley Highway to Kempsey





Giant Barred Frog capture distribution: Maria River impact site  
Pacific Highway Upgrade - Oxley Highway to Kempsey

**FIGURE 11**  
Imagery: (c) DigitalGlobe



Giant Barred Frog capture distribution: Cooperabung Creek reference site  
Pacific Highway Upgrade - Oxley Highway to Kempsey



Giant Barred Frog capture distribution: Pipers Creek reference site  
Pacific Highway Upgrade - Oxley Highway to Kempsey

### 3.4 Movement

Recapture data of PIT-tagged individuals was used to determine movements along the transects, and notably, past the midpoint of the transect i.e. from one side of the carriageway to the other at the impact sites. It should be noted that this analysis does not imply that individuals that have not been found on opposite sides of the carriageway have not traversed at some time. Graph 9 - Graph 14 show the movement patterns of individual recaptured Giant Barred Frogs at each site and the data is summarised for each site below. As reference sites by their nature do not traverse the carriageway, a transect midpoint has been included to provide an indication of movements along the transects and permit comparison between reference and impact sites. The reference midpoint was chosen as the arbitrary midpoint location to provide similar recapture circumstances to the impact sites (i.e. equal zones on either side). It should however be noted that comparisons made between impact and reference sites do not take into account other potentially confounding factors such as site specific population ecology. Capture order is indicated by the numbers beside each capture point and a single capture point indicates recaptures within the same zone (order not indicated).

A total of 81 individuals have been recaptured on at least one occasion over all monitoring events. Of these, 48 recaptures have occurred at the impact sites. Fifteen (31%) of these individuals from impact sites have been captured on both sides of the carriageway over successive monitoring events. Of the 33 recaptures at the reference sites, 12 (36%) have been captured on both sides of the midpoint over successive monitoring events.

*Cooperabung Creek impact site:* Ten Giant Barred Frogs have been recaptured over all monitoring periods. Of these individuals, four (40%) have been captured on both sides of the carriageway, including one individual (ID#7) that traversed on at least two occasions.

*Smiths Creek impact site:* Eighteen frogs have been recaptured over all monitoring periods. Of these individuals, four (22%) have been captured on both sides of the carriageway.

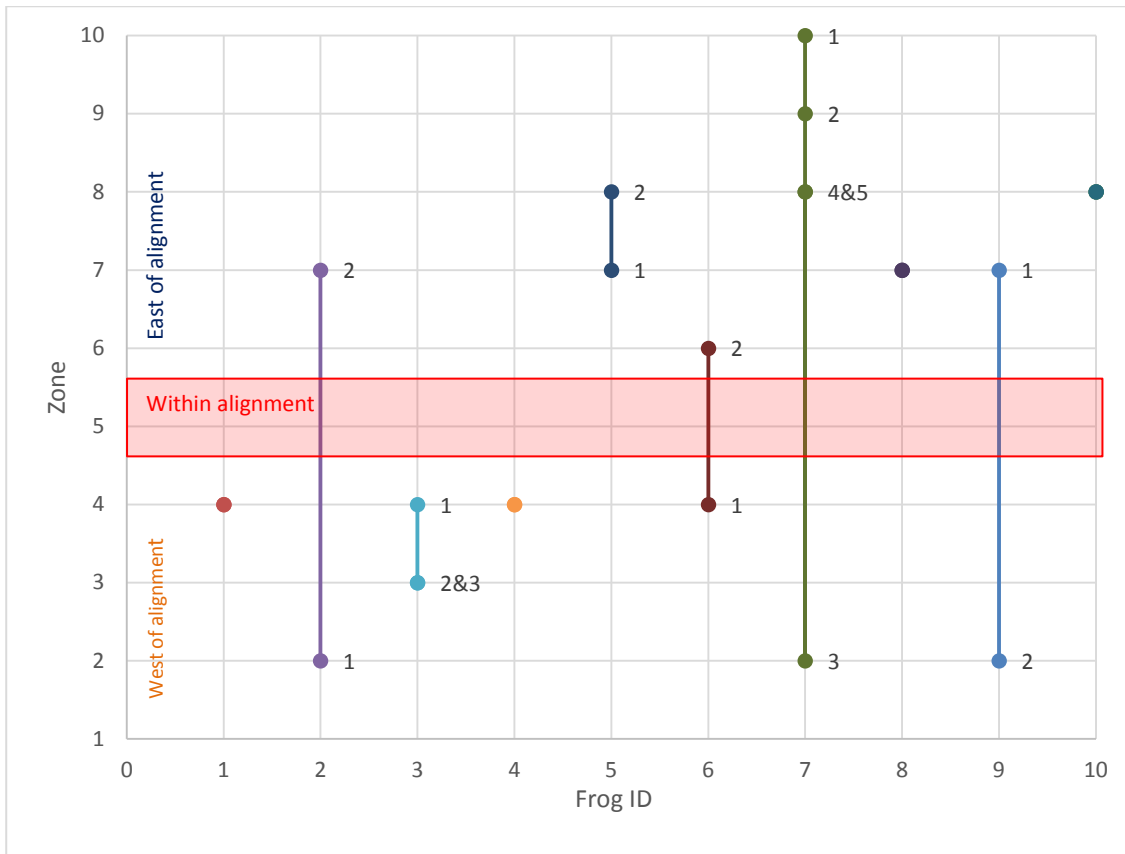
*Pipers Creek impact site:* Eleven Giant Barred Frogs have been recaptured over all monitoring periods. Of these individuals, three (27%) have been captured on both sides of the carriageway.

*Maria River impact site:* Nine Giant Barred Frogs have been recaptured over all monitoring periods. Of these individuals, four (44%) have been captured on both sides of the carriageway.

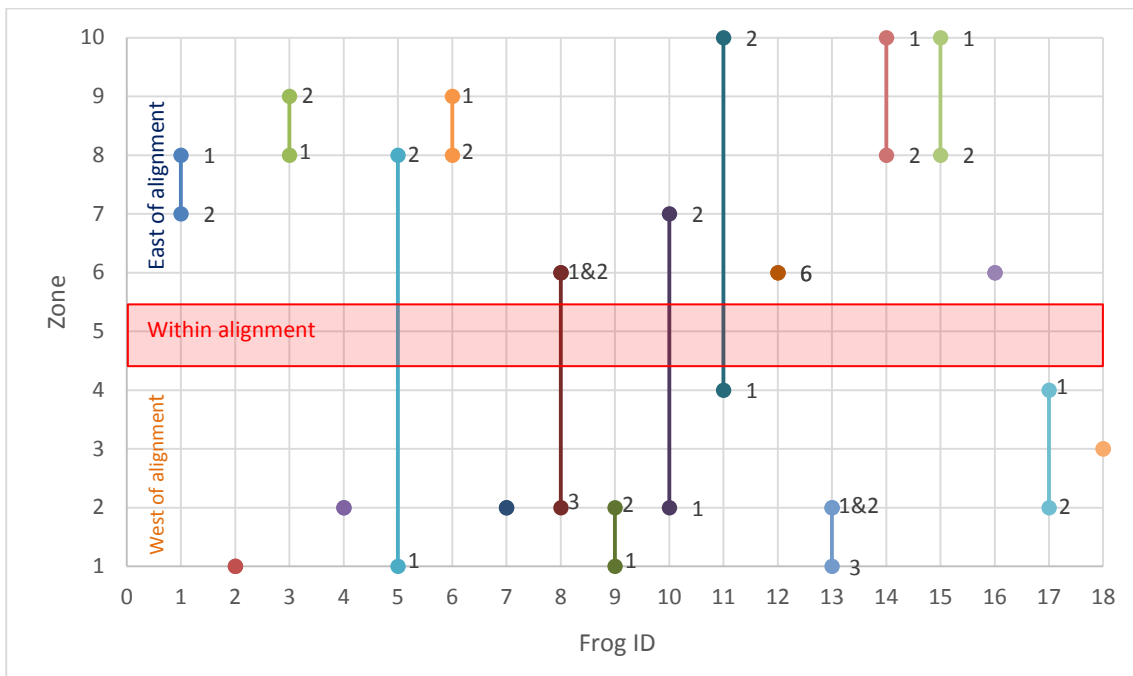
*Cooperabung Creek reference site:* Nine Giant Barred Frogs have been recaptured over all monitoring periods. Of these individuals, two (22%) have been captured on both sides of the transect midpoint.

*Pipers Creek reference site:* Twenty-four Giant Barred Frogs have been recaptured over all monitoring periods. Of these individuals, ten (42%) have been captured on both sides of the transect midpoint.

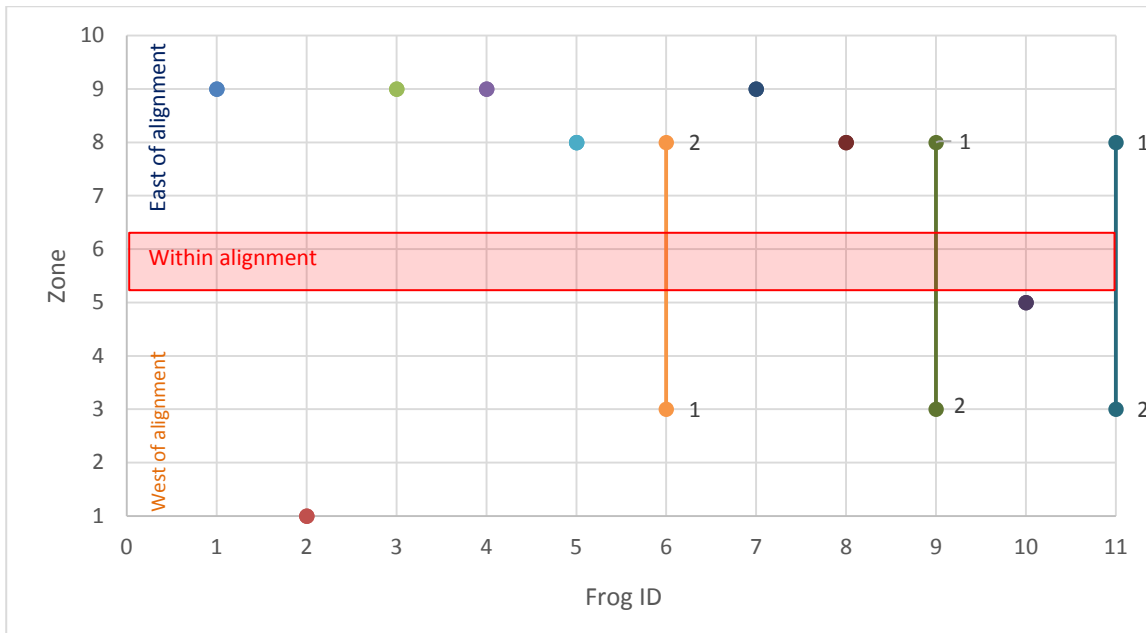
At the impact sites, while the monitored waterways continue uninterrupted under the carriageway, there is a distinct change in streamside vegetation within the area immediately under the carriageway. Under the carriageway at all impact sites, streamside vegetation ranges from completely absent to very limited, represented by small clumps of shrubs and/or *Lomandra* spp. The streamside habitat in these areas is limited to the large rocks and boulders deposited during construction of the Project. Despite this abrupt change in streamside habitat immediately under the carriageway, a number of Giant Barred Frogs have been recorded traversing the carriageway. The percentage of Giant Barred Frogs found to have traversed the impact site midpoints do not appear to differ substantially from the percentage of Giant Barred Frogs found to have traversed the reference site midpoints.



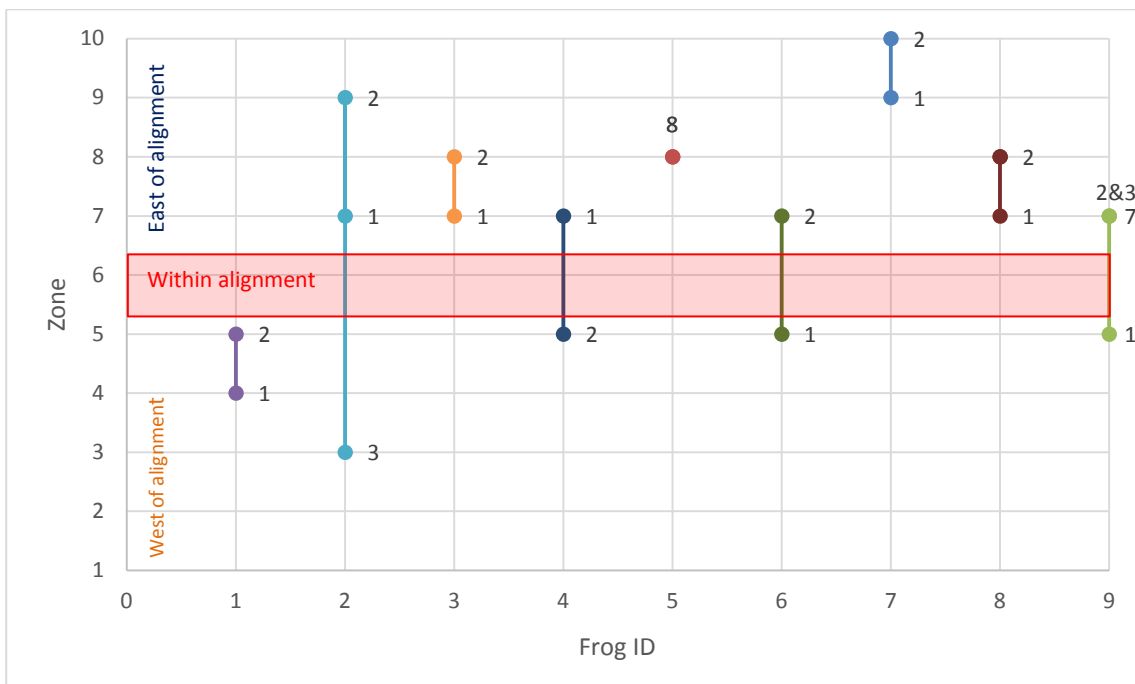
Graph 9: Cooperabung Creek impact site: recapture movement patterns



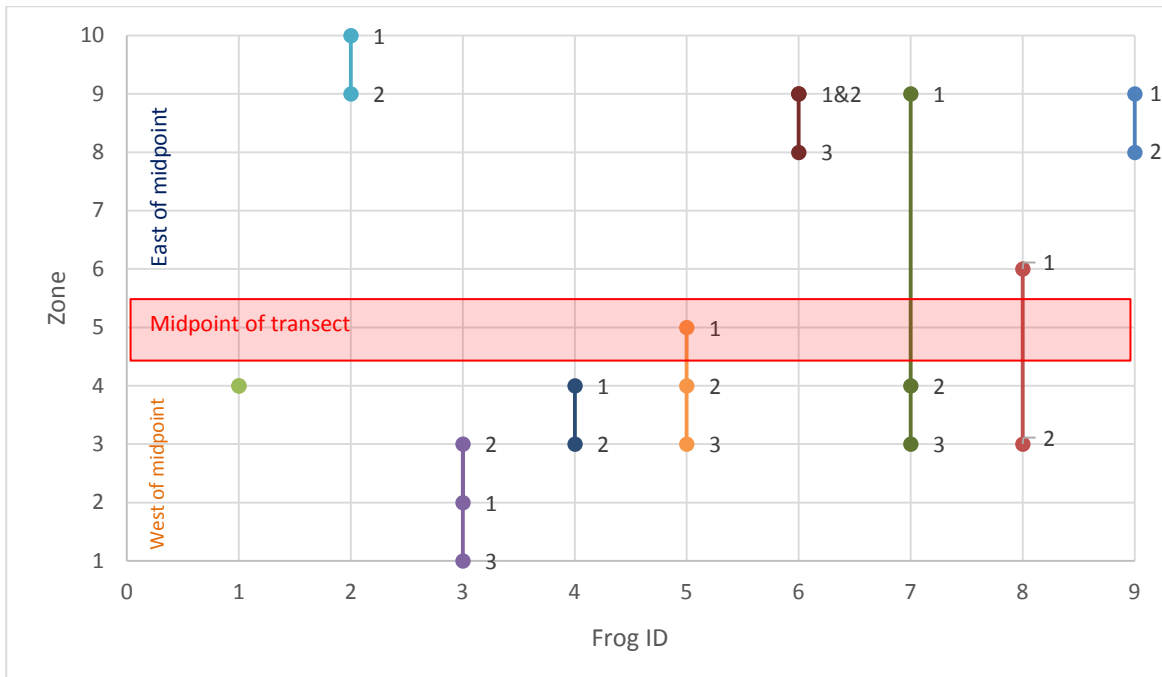
Graph 10: Smiths Creek impact site: recapture movement patterns



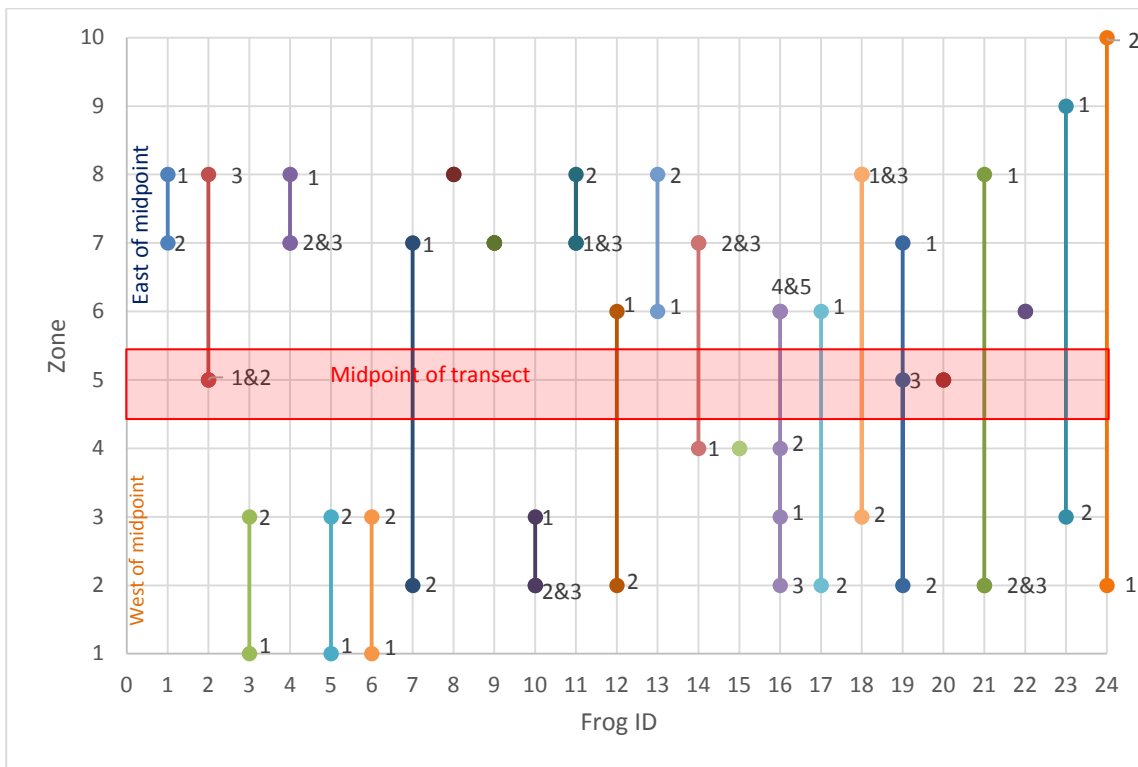
**Graph 11: Pipers Creek impact site: recapture movement patterns**



**Graph 12: Maria River impact site: recapture movement patterns**



**Graph 13: Cooperabung Creek reference site: recapture movement patterns**



**Graph 14: Pipers Creek reference site: recapture movement patterns**

### 3.5 Water Quality

Water quality monitoring was undertaken by Roads and Maritime. Data included in this report represents the first operational monitoring period, from 30 March 2018 to 29 March 2019 (RMS 2019b). Presented here is a summary of the data collected for Cooperabung Creek, Smiths Creek, Pipers Creek and Maria River, for the purpose of assessing the water quality in relation to desired parameters and the water quality performance measures specified in the EMP. Annex 3 presents data extracted from the water quality reports. It shows only those sampling results where the calculated median downstream value exceeded (was above the 80<sup>th</sup> percentile) or was below (below the 20<sup>th</sup> percentile) desired threshold values of the upstream site.

#### 3.5.1 Parameters

Table 5 presents the number of occasions downstream median values were greater than the 80<sup>th</sup> percentile, and of these, the number that exceeded the ANZECC trigger value. All sites had at least one parameter for one or more monthly results, for which the median downstream value exceeded the 80<sup>th</sup> percentile of the upstream value. These are discussed below.

*Electrical conductivity:* Downstream median values were higher than the upstream trigger values throughout the 12 months at all sites except Maria River. These values, while slightly elevated, were well within ANZECC guideline trigger values. According to RMS 2019b, the greater differences between upstream and downstream values occurred when there was no visible flow, sample points persisting as isolated ponds, or in some cases dry upstream conditions at the time of sampling. At Smiths Creek elevated nutrients/sediments is likely associated with agricultural activities and Project construction works. Continued vegetation growth and landscaping will likely reduce sediments entering the waterway.

*Dissolved oxygen:* Downstream median values were regularly below or above the calculated upstream 80<sup>th</sup> and 20<sup>th</sup> percentile trigger value. At Cooperabung Creek and Smiths Creek the variability coincided with algae outbreaks and both these sites were noted as having little to no flow or existing as isolated ponds. The water quality monitoring report considered impacts attributable to construction to be negligible.

*pH:* Downstream median values were generally within, or close to, the calculated upstream 80<sup>th</sup> and 20<sup>th</sup> percentile trigger values. pH levels were within the default ANZECC trigger value range for all but one instance at Smiths Creek. The water quality monitoring report considered impacts to be unrelated to construction.

*Turbidity:* Downstream turbidity was variable throughout the year and for sites. With 80<sup>th</sup> percentile values being exceeded on one occasion at Cooperabung Creek and Maria River and on five occasions at Smiths Creek. The ANZECC upper limit default trigger value was exceeded at Smith Creek on one occasion. At Smiths Creek, differences between upstream and downstream values coincided with shallow isolated ponds and algae growth. The water quality monitoring report considered impacts attributable to the Project to be negligible or minor.

*Nitrogen and Phosphorus:* Downstream nitrogen and phosphorus values were variable throughout the year and for sites. Levels were generally consistent within upstream and downstream ranges. However, elevated levels were recorded at Smiths Creek, Pipers Creek and Maria River with samples above the ANZECC trigger value. Differences between upstream and downstream was generally when the sampling points persisted as isolated ponds. The water quality monitoring report considered impacts attributable to construction to be negligible.



*Metals:* There was limited variation in the level of metals with the exception of aluminium, chromium, iron, manganese and zinc. Levels were generally consistent with upstream values. Differences between upstream and downstream values was generally when the sampling points persisted as isolated ponds. The water quality monitoring report considered elevated metal parameters unlikely to be attributable to construction related activities.

The water quality monitoring report suggested that results were not inconsistent with the variability and levels experienced during the pre-construction monitoring.

**Table 5: Triggered water quality parameters per site**

Parameter	Number of samples where downstream median value > 80th % (# downstream value exceeds ANZECC trigger/range)			
	Cooperabung Creek	Smiths Creek	Pipers Creek	Maria River
Temperature °C	2	2	2	3
Electrical Conductivity uS/cm	5	3 (1)	3	0
Dissolved oxygen %	2	3	4	0
pH	2	2	2	1
Turbidity (NTU)	1	5 (1)	0	1 (1)
Total suspended solids mg/L	3	4	0	1
Aluminium mg/L	1 (2)	2 (3)	1 (1)	1 (5)
Arsenic mg/L	0	0	0	0
Cadmium mg/L	0	0	0	0
Chromium mg/L	0	0	0	1 (1)
Copper mg/L	0	0	0	0
Iron mg/L	1	1	2	0
Lead mg/L	0	0	0	0
Manganese mg/L	2	2	0	0
Mercury mg/L	0	0	0	0
Nickel mg/L	0	0	0	0
Silver mg/L	0	0	0	0
Zinc mg/L	2 (2)	0 (3)	2 (2)	3 (4)
Total nitrogen mg/L	0	2 (2)	3 (2)	1 (5)
Total phosphorus mg/L	0	4 (3)	3	4 (1)

## 4. Discussion

### 4.1 Performance Measures

A summary of Year 1 (2015/2016), Year 2 (2016/2017), Year 3 (2017/2018) and Year 4 (2018/2019) survey results in relation to the performance measures is provided in Table 6.

**Table 6: Performance measures and discussion of results.**

Performance measure	Discussion
Monitoring is undertaken during baseline surveys and Years 1 – 8 or until monitoring can demonstrate that mitigation measures are effective.	<b>This performance measure has been met for Baseline, Year 1 (2015/2016), Year 2 (2016/2017), Year 3 (2017/2018) and Year 4 (2018/2019).</b> Giant Barred Frog monitoring has been undertaken at all six sites according to the EMP to date. Summer 2018/2019 surveys were not undertaken due to insufficient rainfall.
Monitoring during Year 1 – 8 is undertaken at the Impact and Control sites where baseline monitoring was undertaken, subject to landowner agreement.	<b>This performance measure has been met for Baseline, Year 1 (2015/2016), Year 2 (2016/2017), Year 3 (2017/2018) and Year 4 (2018/2019).</b> Giant Barred Frog monitoring has been undertaken at all six baseline sites, where landowner agreement permitted.
Continued presence of Giant Barred Frogs during each survey event in Year 1 – 8 at sites where it was identified during baseline surveys, subject to access due to landowner agreement.	<b>This performance measure has been met for all sites in Year 1 (2015/2016), 5 of 6 sites in Year 2 (2016/2017), Year 3 (2017/2018) and Year 4 (2018/2019).</b> Baseline: Giant Barred Frogs were recorded at all six monitoring sites in spring and summer and at four sites in autumn. Giant Barred Frogs were not recorded at the Maria River impact site and Pipers Creek reference site during the autumn 2014 baseline survey. Year 1 (2015/2016): Giant Barred Frogs were detected at all six sites during all surveys. Year 2 (2016/2017): Giant Barred Frogs were detected at all six sites in spring and summer and five sites in autumn. Not recorded at Pipers Creek impact site during the autumn 2017 survey where it was detected during baseline surveys. Year 3 (2017/2018): Giant Barred Frogs were detected at all six sites in spring and five sites in summer and autumn. Not recorded at Pipers Creek impact site during summer and autumn 2018 where it was detected during baseline surveys. Year 4 (2018/2019): Giant Barred Frogs were detected at five sites in spring and all six sites in autumn. Not recorded at Cooperabung Creek reference site during spring 2018 where it was detected during baseline surveys. Giant Barred Frogs have been recorded at all six sites on at least one occasion during each monitoring period.
Mitigation measures are effective as defined in the EPBC approval when all monitoring events are considered at Year 8.	This performance measure is not yet applicable. Initial results (review of movement patterns of re-captured individuals showing records along the creek on either side of the carriageway) indicate that Giant Barred Frogs are moving underneath the road. It is unknown if they used the underpasses, however, no breaches of the frog fencing were observed during surveys.
Median values of all downstream water quality monitoring at GBF habitat or potential habitat locations during construction and operation (Year 1 – 6) is less than the 80th percentile value of the upstream site (where 80th percentile is the value at which median values at the downstream site are above 80% of the recorded background water quality records), where this change is found to be attributable to construction or operation.	<b>This performance measure has been met for all parameters at all sites.</b> Whilst values at all sites have exceeded the 80 <sup>th</sup> percentile on one or more occasion, impacts potentially attributable to construction were considered negligible or minor. Variability at some sites was a result of extensive algae outbreaks and low water flows. RMS (2019b) in referring to relevant waterways states “while exceedances have occurred they have tended to be smaller and less frequent. ...As noted previously, these changes are considered to be unrelated to the project activities / changes, but rather other land use activities within the catchment. At other locations e.g. SW7, SW9 and SW11 extensive algae outbreaks and very low flows have resulted in variability, particularly with respect to dissolved oxygen and electrical conductivity”.

Performance measure	Discussion
<p>No change to densities, distribution, habitat use and movement patterns compared to baseline data during monitoring in Year 1 – 8, and then when all monitoring events are considered at Year 8.</p>	<p><b>This performance measure has been met for all sites except Pipers Creek impact site and Cooperabung Creek impact site.</b></p> <p>The number and location of Giant Barred Frogs recorded varied between season and year at all sites. Cooperabung Creek impact, Pipers Creek impact and Cooperabung Creek reference sites all show a decreasing trend in mean records and densities. However, as this decreasing trend is evident at both impact and reference sites, it is not possible to attribute these changes to the Project at this stage.</p> <p>Within-year movement patterns that would permit comparison between baseline and subsequent monitoring events is not possible due to lack of data (surveys and captures are too infrequent), however, assessment of movement patterns of recaptured individuals over all surveys show that 31% of recaptured frogs have been found to traverse from one side of the carriageway to the other.</p>

## 5. Recommendations

### 5.1 Contingency Measures

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those that are considered relevant to the Giant Barred Frog monitoring program are listed and discussed in Table 7.

**Table 7: Contingency measures**

Potential problem	Contingency measure proposed in EMP	Discussion of proposed measure
Decline in presence of target species recorded at Impact sites after the upgrade has been completed, when compared to change in Control sites.	<p>The cause of the decline in populations at impacts sites will be investigated in consultation with EPA and DoTE within two weeks of results reported by ecologist.</p> <p>If the cause of decline is considered most likely attributed to the upgrade of the highway (and not another event such as bushfire), mitigation measures, such as the location and types of fauna crossings and fauna fencing will be reviewed within two months of the above consultation being completed.</p>	<p>The mean number of Giant Barred Frogs recorded during the current monitoring period was lower compared to the previous monitoring event at all sites excluding Pipers Creek impact site. It should be noted that the greatest number of Giant Barred Frogs are generally recorded in summer each monitoring cycle. The absence of the summer survey period is likely to have resulted in lower mean records for the current monitoring period.</p> <p>It is not possible to attribute observed changes in Giant Barred Frog presence/abundance at the sites to the Project for the following reasons:</p> <ul style="list-style-type: none"> <li>• The variable nature of annual mean records among sites</li> <li>• The absence of summer survey records from the current monitoring period</li> <li>• The evidence of a decreasing trend at a reference site</li> <li>• The lack of a distinct difference between impact and reference sites.</li> </ul> <p>The apparent reduction in Giant Barred Frog numbers, however, is noted and will be considered in future monitoring events. <b>This contingency measure is not yet considered relevant.</b></p>

### 5.2 Recommendations

A summary of those performance indicators that were not met in the 2018/2019 monitoring period, recommended corrective actions and general recommendations are provided in Table 8.

**Table 8: Recommendations**

Performance measure	Action
Continued presence of Giant Barred Frogs during each survey event in Year 1 – 8 at sites where it was identified during baseline surveys, subject to access due to landowner agreement.	<p><b>This performance measure has been met for 5 of 6 sites in Year 4 (2018/2019).</b></p> <p>Giant Barred Frogs were not recorded at Cooperabung Creek reference site during spring 2018 survey, where it was detected during baseline surveys. However it was recorded during the autumn 2019 surveys at this site.</p> <p>As this is a reference site it is recommended that monitoring continue as per the EMP.</p>
No change to densities, distribution, habitat use and movement patterns compared to baseline data during monitoring in Year 1 – 8, and then when all monitoring events are considered at Year 8.	<p><b>This performance measure has been met for all sites except Pipers Creek impact site and Cooperabung Creek impact site.</b></p> <p>As discussed in Table 6, Cooperabung Creek impact, Pipers Creek impact and Cooperabung Creek reference sites all show a decreasing trend in mean records and densities. However, as this decreasing trend is evident at both impact and reference sites, it is not possible to attribute these changes to the Project at this stage.</p> <p>It is recommended that monitoring continue as per the EMP.</p>



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## Annex 1 – 2018/2019 data summary for each monitoring site

### Cooperabung Creek impact site

**Table 9: Summary of surveys and prevailing abiotic variables: Cooperabung Creek impact site**

Date	Time		Air temp. °C	Water temp. °C	Humidity %	Stream depth (cm)	Wind (0-3, 0= no wind)	Cloud cover %	Rain (0-3, 0= no rain)
15/10/2018	Start	12:35am	17	17	80	40	0	100	0
	Finish	2:45am	19	17	95	20	0	100	2
12/03/2019	Start	1:15am	22.2	23	64	40	0	0	0
	Finish	3:20am	22.3	23	71	0	0	0	0

**Table 10: Habitat details: Cooperabung Creek impact site**

Zone	OS %	Sh %	G %	LL %	BE %	Cattle	Pools	Riffles	DoP (cm)	FB	EF	Frogs detected
5	60	10	40	15	40	N	1	0	35			0
4	70	10	40	25	30	Y	1	0	60			1
3	80	15	60	10	5	Y	1	1	20			1
2	30	20	45	5	40	Y	2	1	80			0
6	65	40	70	10	20	N	1	0	40			0
7	60	50	35	5	30	Y	1	0	50			0
8	80	30	50	10	10	Y	1	0	20			2
9	70	20	70	10	10	Y	1	0	40			0
1												
10												

OS = overstorey cover, Sh = Shrub cover, G = Ground cover, LL = leaf litter cover, BE = bare earth, DoP = depth of deepest pool, FB = fence breach, EF = exotic fish

**Table 11: Summary of captures: Cooperabung Creek impact site**

	Spring 2018	Autumn 2019
Number of frogs recorded	3	1
Number of adult males	2	0
Number of adult females	0	0
Number of sub-adults	0	0
Number of juveniles	1	1
Number of recaptures	2	0
Number of frogs with Chytrid/ swabbed	0/3	0/0

**Habitat:** Microhabitat within these zones included flood debris as overhang shelter, grass and leaf litter. Frogs were located on litter, in Lomandra and at the base of a tree.

### Smiths Creek impact site

**Table 12: Summary of surveys and prevailing abiotic variables: Smiths Creek impact site**

Date	Time		Air temp. °C	Water temp. °C	Humidity %	Stream depth (cm)	Wind (0-3, 0= no wind)	Cloud cover %	Rain (0-3, 0= no rain)
17/10/2018	Start	9:30pm	20	19	99	50	1	100	1
	Finish	1:30am	20	19	99	50	1	100	3
11/03/2019	Start	10:20pm	23	23	68	20	0	10	0
	Finish	12:30am	22	23	75	10	0	0	0

**Table 13: Habitat details: Smiths Creek impact site**

Zone	OS %	Sh %	G %	LL %	BE %	Cattle	Pools	Riffles	DoP (cm)	FB	EF	Frogs detected
1	70	5	80	85	15	Y	2	2	50			3
2	90	60	85	85	15	Y	2	2	80			4
3	80	10	40	40	50	Y	1	0	100			3
4	45	50	80	85	10	Y	1	0	50			1
5	30	40	70	30	20	N	1	0	50			1
6	70	10	80	85	15	N	1	1	200			2
7	45	50	100	80	0	N	1	0	200			
8	40	10	90	95	0	N	1	0	200			2
9	90	15	80	80	0	N	1	1	200			
10	75	15	10	10	90	N	1	0	200			

OS = overstorey cover, Sh = Shrub cover, G = Ground cover, LL = leaf litter cover, BE = bare earth, DoP = depth of deepest pool, FB = fence breach, EF = exotic fish

**Table 14: Summary of captures: Smiths Creek impact site**

	Spring 2018	Autumn 2019
Number of frogs recorded	13	3
Number of adult males	3	0
Number of adult females	3	3
Number of sub-adults	1	0
Number of juveniles	2	0
Number of recaptures	5	1
Number of frogs with Chytrid/ swabbed	0/13	0/3

**Habitat:** Microhabitat within these zones included bare ground, shrubs, grass and leaf litter.



### Pipers Creek impact site

**Table 15: Summary of surveys and prevailing abiotic variables: Pipers Creek impact site**

Date	Time		Air temp. °C	Water temp. °C	Humidity %	Stream depth (cm)	Wind (0-3, 0= no wind)	Cloud cover %	Rain (0-3, 0= no rain)
16/10/2018	Start	11:00pm	19	17	90	100	0	100	3
	Finish	1:48am	19	17	87	100	0	100	1
13/03/2019	Start	11:35pm	22.8	23	99	50	0	100	1
	Finish	2:21am	24.4	23	95	40	0	80	1

**Table 16: Habitat details: Pipers Creek impact site**

Zone	OS %	Sh %	G %	LL %	BE %	Cattle	Pools	Riffles	DoP (cm)	FB	EF	Frogs detected
1	35	55	70	40	20	N	1	0	100+			1
2	70	50	80	80	10	N	1	0	100+			
3	80	60	80	70	10	N	1	0	100+			1
4	85	20	70	60	10	N	1	0	100+			1
5	55	20	60	50	5	N	1	0	100+			
6	20	100	100	80	0	N	1	0	100+			
7	50	15	40	5	25	Y	2	2	100+			
8	50	20	30	15	55	Y	2	2	100+			1
9	85	10	25	10	60	Y	2	1	100+			
10	20	50	75	50	25	Y	1	0	100+			1

OS = overstorey cover, Sh = Shrub cover, G = Ground cover, LL = leaf litter cover, BE = bare earth, DoP = depth of deepest pool, FB = fence breach, EF = exotic fish

**Table 17: Summary of captures: Pipers Creek impact site**

	Spring 2018	Autumn 2019
Number of frogs recorded	2	3
Number of adult males	1	2
Number of adult females	1	1
Number of sub-adults	0	0
Number of juveniles	0	0
Number of recaptures	0	0
Number of frogs with Chytrid/ swabbed	0/2	0/3

**Habitat:** Microhabitat use included leaf litter, grass and on bare ground at tree base.

### Maria River impact site

**Table 18: Summary of surveys and prevailing abiotic variables: Maria River impact site**

Date	Time		Air temp. °C	Water temp. °C	Humidity %	Stream depth (cm)	Wind (0-3, 0= no wind)	Cloud cover %	Rain (0-3, 0= no rain)
16/10/2018	Start	7:30pm	21	17	95	50	1	100	2
	Finish	10:30pm	19	17	95	50	0	100	3
13/03/2019	Start	7:30pm	24.9	23	72	40	0	100	1
	Finish	11:09pm	23.8	23	98	40	1	100	2

**Table 19: Habitat details: Maria River impact site**

Zone	OS %	Sh %	G %	LL %	BE %	Cattle	Pools	Riffles	DoP (cm)	FB	EF	Frogs detected
1	80	50	5	80	20	N	unk	unk	unk			
2	50	5	10	50	50	N	unk	unk	unk			
3	20	100	100	80	0	N	unk	unk	unk			
4	30	100	90	90	5	N	unk	unk	unk			
5	40	60	50	100	0	N	unk	unk	unk			1
6	90	80	15	100	5	N	unk	unk	unk			
7	70	75	80	40	15	N	unk	unk	unk			
8	80	65	90	60	5	N	unk	unk	unk			5
9	40	80	25	90	0	Y	unk	unk	unk			
10		100										

OS = overstorey cover, Sh = Shrub cover, G = Ground cover, LL = leaf litter cover, BE = bare earth, DoP = depth of deepest pool, FB = fence breach, EF = exotic fish

**Table 20: Summary of captures: Maria River impact site**

	Spring 2018	Autumn 2019
Number of frogs recorded	2	3
Number of adult males	1	2
Number of adult females	1	0
Number of sub-adults	0	0
Number of juveniles	0	1
Number of recaptures	0	0
Number of frogs with Chytrid/ swabbed	0/1	0/3

**Habitat:** Microhabitat within these zones included under logs and leaf litter. Lantana is very abundant along both side of the river banks and is the dominant vegetation from MIz1 to MIz5.

### Cooperabung Creek reference site

**Table 21: Summary of surveys and prevailing abiotic variables: Cooperabung Creek reference site**

Date	Time		Air temp. °C	Water temp. °C	Humidity %	Stream depth (cm)	Wind (0-3, 0= no wind)	Cloud cover %	Rain (0-3, 0= no rain)
17/10/2018	Start	7:30pm	21	19	99	15	0	100	1
	Finish	9:00pm	20	19	99	30	0	100	2
11/03/2019	Start	7:45pm	26	24	63	0	0	5	0
	Finish	9:53pm	25	24	63	0	0	10	0

**Table 22: Habitat details: Cooperabung Creek reference site**

Zone	OS %	Sh %	G %	LL %	BE %	Cattle	Pools	Riffles	DoP (cm)	FB	EF	Frogs detected
1	1	70	20	40	60	10	Y	3	4			
2	2	50	15	20	30	20	Y	4	4			
3	3	80	30	30	60	5	Y	3	4			
4	4	15	20	10	40	5	Y	4	5			
5	5	95	50	20	80	15	Y	2	3			
6	6	95	10	50	90	10	Y	3	3			
7	7	50	15	10	5	80	Y	4	6			
8	8	20	5	70	20	5	Y	3	3			2
9	9	90	5	40	80	10	Y	3	4			1
10	10	85	15	20	50	40	Y	3	3			

OS = overstorey cover, Sh = Shrub cover, G = Ground cover, LL = leaf litter cover, BE = bare earth, DoP = depth of deepest pool, FB = fence breach, EF = exotic fish

**Table 23: Summary of captures: Cooperabung Creek reference site**

	Spring 2018	Autumn 2019
Number of frogs recorded	0	3
Number of adult males		0
Number of adult females		2
Number of sub-adults		0
Number of juveniles		1
Number of recaptures		2
Number of frogs with Chytrid/ swabbed	0/0	1/3

**Habitat:** Microhabitat found being used included grass and leaf litter.

### Pipers Creek reference site

**Table 24: Summary of surveys and prevailing abiotic variables: Pipers Creek reference site**

Date	Time		Air temp. °C	Water temp. °C	Humidity %	Stream depth (cm)	Wind (0-3, 0= no wind)	Cloud cover %	Rain (0-3, 0= no rain)
15/10/2018	Start	7:31pm	18	17	99	10	1	100	2
	Finish	12:00pm	17	17	95	40	1	100	3
12/03/2019	Start	7:50pm	28	24	53	30	0	80	0
	Finish	12:30pm	22.8	24	67	10	0	75	0

**Table 25: Habitat details: Pipers Creek reference site**

Zone	OS %	Sh %	G %	LL %	BE %	Cattle	Pools	Riffles	DoP (cm)	FB	EF	Frogs detected
1	80	5	20	50	30	N	1	1	80			6
2	60	60	5	40	70	N	2	2	40			4
3	95	70	80	60	5	N	3	2	60			2
4	60	30	95	50	10	N	2	2	20			
5	40	20	60	40	20	N	2	2	40			6
6	95	30	75	30	15	N	1	1	40			8
7	90	65	80	25	25	N	2	1	25			3
8	80	10	90	50	10	N	2	1	50			
9	95	60	60	10	20	N	2	2	40			5
10	80	20	70	20	20	N	2	1	40			1

OS = overstorey cover, Sh = Shrub cover, G = Ground cover, LL = leaf litter cover, BE = bare earth, DoP = depth of deepest pool, FB = fence breach, EF = exotic fish

**Table 26: Summary of captures: Pipers Creek reference site**

	Spring 2018	Autumn 2019
Number of frogs recorded	9	30
Number of adult males	8	18
Number of adult females	1	6
Number of sub-adults	0	0
Number of juveniles	0	6
Number of recaptures	5	5
Number of frogs with Chytrid/ swabbed	0/8	0/14

**Habitat:** Microhabitat within these zones included within leaf litter, sheltering under Lomandra, and on the creek bed.

## Annex 2 - Giant Barred Frog individual capture data

L = length (mm); W = weight (g); DW = distance to water (m); S = swabbed for Chytrid fungus; Z = Zone; U = unknown; M = male; F = female; J = juvenile

Site type	Location	Season	Sex	Age	Reproductive status	L	W	DW	Pit_Tag_Co	Capture status	S	Z	Activity	Microhabitat
impact	Cooperabung Ck	spring	Unk	Juv	juvenile	42	12	1	not tagged	first time	Y	3	sitting	base of tree
impact	Cooperabung Ck	spring	M	adult	light nuptials	73	70	1.5	00079205FF	recapture	Y	8	calling	leaf litter
impact	Cooperabung Ck	spring	M	adult	light nuptials	80	65	1	000791EBBD	recapture	Y	8	calling	Lomandra
impact	Cooperabung Ck	autumn1	Unk	Juv	unk	unk	20	10	not tagged	first time	N	4	sitting	on stick in veg
impact	Maria River	spring	F	adult	possibly gravid	139	163	2	0007A3DE53	first time	Y	5	sitting	leaf litter
impact	Maria River	spring	M	adult	calling			unk	not tagged	uncaptured	N	8	calling	unk
impact	Maria River	autumn1	M	adult	light nuptials	68	47	10	0007A38CA4	first time	Y	8	calling	leaf litter
impact	Maria River	autumn1	M	adult	light nuptials	67	44	5	0007A3AB40	first time	Y	8	calling	leaf litter
impact	Maria River	autumn1	Unk	Juv	unk	47	15	15	not tagged	first time	Y	8	sitting	under log
impact	Pipers Ck	spring	F	adult	gravid	94	135		0007A2E861	first time	Y	1	sitting	base of tree
impact	Pipers Ck	spring	M	adult	no nuptials	79	78		0007A0D205	first time	Y	4	sitting	base of tree
impact	Pipers Ck	autumn1	F	adult	lightly gravid	104	144	25	0007A2E987	first time	Y	3	sitting	grass
impact	Pipers Ck	autumn1	M	adult	no nuptials	80	62	2.5	0007A3ED0F	first time	Y	8	sitting	creek bed rock
impact	Pipers Ck	autumn1	M	adult	no nuptials	81	60	3	0007A3F2B3	first time	Y	10	sitting	leaf litter
impact	Smiths Ck	spring	Unk	Juv	juvenile	48	16	5.0	not tagged	first time	Y	1	sitting	leaf litter
impact	Smiths Ck	spring	Unk	Juv	juvenile	49.0	20.0	8.0	not tagged	first time	Y	1	sitting	leaf litter
impact	Smiths Ck	spring	Unk	Sub-adult	sub-adult	68.0	42	10.0	0007A0EFB8	first time	Y	1	sitting	bare ground
impact	Smiths Ck	spring	F	adult	gravid	101.0	174.0	12.0	00077E6A5F	recapture	Y	2	sitting	under shrubs
impact	Smiths Ck	spring	M	adult	light nuptials	85	80	15	00079FED7C	first time	Y	3	sitting	lantana and litter
impact	Smiths Ck	spring	M	adult	moderately dark nuptials	80	67	25	0007A0CE0B	recapture	Y	3	sitting	bare ground

Site type	Location	Season	Sex	Age	Reproductive status	L	W	DW	Pit_Tag_Co	Capture status	S	Z	Activity	Microhabitat
impact	Smiths Ck	spring	F	adult	possibly gravid	63	123.0	4.0	0007A3B459	first time	Y	3	sitting	leaf litter
impact	Smiths Ck	spring		adult		86.0	108		00079F8F77	first time	Y	4	sitting	
impact	Smiths Ck	spring	Unk	adult	unk	90	109	25	0007A0E973	first time	Y	5	sitting	raised tier of underpass in revegetation area
impact	Smiths Ck	spring	M	adult	no nuptials	69	63	3	0007A01C1A	recapture	Y	6	sitting	leaf litter near fallen timber
impact	Smiths Ck	spring	F	adult	unk	94	126	30	00079EA3F1	first time	Y	6	sitting	
impact	Smiths Ck	spring	Unk	adult	unk	150	96	2	0007D1E298	recapture	Y	8	sitting	
impact	Smiths Ck	spring	Unk	adult	unk	87	146	2	00079EA483	recapture	Y	8	sitting	grass
impact	Smiths Ck	autumn1	F	adult	lightly gravid	89	132	15	0007A39284	first time	Y	2	sitting	base of tree
impact	Smiths Ck	autumn1	F	adult	lightly gravid	91	143	20	0007A3BC0A	first time	Y	2	sitting	base of tree
impact	Smiths Ck	autumn1	F	adult	moderately gravid	94	125	5	0007A09A12	recapture	Y	2	buried	leaf litter
reference	Cooperabung Ck	autumn1	F	adult	lightly gravid	96	159	25	00076345D6	recapture	Y	8	sitting	grass
reference	Cooperabung Ck	autumn1	F	adult	non-gravid	89	127	15	00077E7E2D	recapture	Y	8	sitting	grass
reference	Cooperabung Ck	autumn1	Unk	Juv	sub-adult	45	16	2	not tagged	first time	Y	9	sitting	leaf litter
reference	Pipers Ck	spring	F	adult	non-gravid	90	135	15	000791EC0D	recapture	Y	5	sitting	leaf litter
reference	Pipers Ck	spring	M	adult	light nuptials	72	60	1.5	000791EA9A	recapture	Y	6	calling	leaf litter
reference	Pipers Ck	spring	M	adult	light nuptials	71	65	3	000791EC31	recapture	Y	6	calling	leaf litter
reference	Pipers Ck	spring	M	adult	dark nuptials	75	72	5	0007D261CD	first time	Y	9	calling	leaf litter
reference	Pipers Ck	spring	M	adult	light nuptials	70	50	2	0007A3DF2B	first time	Y	9	calling	leaf litter
reference	Pipers Ck	spring	M	adult	light nuptials	77	50	1	0007A3C6FA	first time	Y	9	calling	leaf litter
reference	Pipers Ck	spring	M	adult	light nuptials	75	75	4	0007920736	recapture	Y	9	sitting	leaf litter
reference	Pipers Ck	spring	M	adult	light nuptials	unk	unk	2	not tagged	uncaptured	N	9	sitting	leaf litter
reference	Pipers Ck	spring	M	adult	unk	77	61	12	900118001374700	recapture	Y	10	sitting	leaf litter

Site type	Location	Season	Sex	Age	Reproductive status	L	W	DW	Pit_Tag_Co	Capture status	S	Z	Activity	Microhabitat
reference	Pipers Ck	autumn1	M	adult	dark nuptials	72	53	2	0007A3DCBF	first time	Y	1	sitting	ck bed rocks
reference	Pipers Ck	autumn1	M	adult	light nuptials	68	50	5	0007A38B2A	first time	Y	1	sitting	Lomandra
reference	Pipers Ck	autumn1	M	adult	light nuptials	68	60	5	0007A3B0B2	first time	Y	1	calling	under log
reference	Pipers Ck	autumn1	M	adult	no nuptials	70	52	10	0007A3AB67	first time	Y	1	sitting	leaf litter
reference	Pipers Ck	autumn1	M	adult	no nuptials	79	70	10	0007A3F00E	first time	Y	1	sitting	leaf litter
reference	Pipers Ck	autumn1	F	adult	non-gravid	92	116	5	0007A3AB34	first time	Y	1	sitting	log
reference	Pipers Ck	autumn1	M	adult	dark nuptials	71	49	2	0007A3E1C0	first time	Y	2	sitting	Lomandra
reference	Pipers Ck	autumn1	F	adult	lightly gravid	90	130	10	0007A3D9D0	first time	Y	2	sitting	Lomandra
reference	Pipers Ck	autumn1	M	adult	no nuptials	80	59	5	00077E7D76	recapture	N	2	sitting	leaf litter
reference	Pipers Ck	autumn1	Unk	Juv		48	20	15	000791EB93	first time	N	2	sitting	leaf litter
reference	Pipers Ck	autumn1	M	adult	lightly gravid	74	60	5	0007A3DF2B	recapture	Y	3	sitting	Lomandra
reference	Pipers Ck	autumn1	F	adult	no nuptials	90	133	0.5	0007923BFA	recapture	Y	3	sitting	ck bed
reference	Pipers Ck	autumn1	M	adult	no nuptials	79	57	2	0007A394CB	first time	Y	5	sitting	ck bed
reference	Pipers Ck	autumn1	M	adult	no nuptials	72	52	1	0007A391A3	first time	Y	5	sitting	ck bed
reference	Pipers Ck	autumn1	F	adult	no nuptials	97	154	20	0007A005DF	first time	Y	5	sitting	base of tree
reference	Pipers Ck	autumn1	Unk	Juv	unk	36	8	1.5	not tagged	first time	N	5	sitting	ground
reference	Pipers Ck	autumn1	Unk	Juv	unk	46	16	1	not tagged	first time	N	5	sitting	ck bed
reference	Pipers Ck	autumn1	Unk	Juv	unk	40	10	1	not tagged	first time	Y	5	sitting	rocks
reference	Pipers Ck	autumn1	M	adult	dark nuptials	78	61	8	000791EBA3	recapture	N	6	sitting	ck bed
reference	Pipers Ck	autumn1	M	adult	light nuptials	71	46	1	0007A3D0EF	first time	N	6	sitting	Lomandra
reference	Pipers Ck	autumn1	M	adult	light nuptials	63	44	10	0007A2EC07	first time	N	6	calling	leaf litter
reference	Pipers Ck	autumn1	M	adult	light nuptials	69	42	5	0007A38893	first time	N	6	sitting	ck bed
reference	Pipers Ck	autumn1	M	adult	light nuptials	76	58	10	0007A3F17D	first time	N	6	calling	leaf litter
reference	Pipers Ck	autumn1	M	adult	no nuptials	62	34	10	0007A3E2CE	first time	N	6	sitting	Lomandra
reference	Pipers Ck	autumn1	M	adult	no nuptials	78	64	2	000791EC31	recapture	N	6	sitting	leaf litter

Site type	Location	Season	Sex	Age	Reproductive status	L	W	DW	Pit_Tag_Co	Capture status	S	Z	Activity	Microhabitat
reference	Pipers Ck	autumn1	F	adult	non-gravid	96	129	5	0007A3F040	first time	N	6	sitting	ck bed rocks
reference	Pipers Ck	autumn1	F	adult	non-gravid	95	146	12	0007A384E5	first time	N	6	sitting	bare ground
reference	Pipers Ck	autumn1	M	adult	no nuptials	75	60	4	0007A39819	first time	N	7	sitting	under leaf
reference	Pipers Ck	autumn1	Unk	Juv	sub-adult	50	12	6	not tagged	first time	N	7	sitting	tree base
reference	Pipers Ck	autumn1	Unk	Juv	sub-adult	40	8	5	not tagged	first time	N	7	sitting	leaf litter



## Annex 3 - Water Quality data (extracted from RMS 2019b)

**Table 27: Triggered water quality parameters: Cooperabung Creek**

Parameter	ANZECC trigger value	Median downstream site value (Upstream 20 <sup>th</sup> % - 80 <sup>th</sup> % trigger range) Values in black = < 20 <sup>th</sup> % Values in red = > 80 <sup>th</sup> % Shaded cells = outside/above ANZECC trigger											
		April 2018	May 2018	June 2018	July 2018	August 2018	September 2018	October 2018	November 2018	December 2018	January 2019	February 2019	March 2019
Temperature °C	NA		18.4 (19.0-23.7)	13.6 (19.0-23.7)	12.4 (19.0-23.7)	12.0 (17.1-23.7)	16.0 (16.3-23.3)			24.3 (16.3-23.6)	25.6 (16.3-23.6)		
Electrical Conductivity uS/cm	125 – 2200		396.0 (216-348)	191.5 (216.6-348.0)		378.0 (223.8-348.0)	461.0 (223.8-348.0)			305.0 (206.6-301.4)	504.0 (206.6-309.8)		
Dissolved oxygen %	85 – 110	72.0 (36.4-82.4)	75.0 (36.4-82.4)	83.3 (36.4-82.0)	84.1 (36.4-83.5)	63.3 (36.4-80.0)	71.7 (36.4-83.5)	76.9 (36.4-85.3)	47.1 (35.1-85.3)	55.5 (35.0-83.5)	62.7 (35.0-83.5)		
pH	6.5 – 8		7.4 (6.7-7.3)		7.3 (6.7-7.2)		6.6 (6.7-7.2)		6.6 (6.7-7.2)				
Turbidity (NTU)	6 – 50		7.6 (9.2-21.7)			3.3 (8.0-28.8)	5.5 (8.0-28.8)	31.1 (8.0-28.8)					
Total suspended solids mg/L	-			8 (5-7)				10 (5-7)	9 (5-7)				
Aluminium mg/L	0.055		0.03 (0.02-0.10)	0.38 (0.02-0.12)			0.01			0.08 (0.01-0.10)			
Arsenic mg/L	0.024												
Cadmium mg/L	0.0002												
Chromium mg/L	0.001												
Copper mg/L	0.0014												
Iron mg/L	ID		0.33 (0.36-0.94)				0.20 (0.35-0.83)			1.13 (0.35-1.06)			
Lead mg/L	0.0034												
Manganese mg/L	1.9						0.488 (0.034-0.266)			0.601 (0.034-0.363)			
Mercury mg/L	0.0006												
Nickel mg/L	0.011												

Parameter	ANZECC trigger value	Median downstream site value (Upstream 20 <sup>th</sup> % - 80 <sup>th</sup> % trigger range) Values in black = < 20 <sup>th</sup> % Values in red = > 80 <sup>th</sup> % Shaded cells = outside/above ANZECC trigger											
Silver mg/L													
Zinc mg/L	0.008		0.039 (0.005-0.013)				0.052 (0.005-0.009)						
Total nitrogen mg/L	0.5					0.1 (0.2-0.4)	0.1 (0.2-0.4)				0.1 (0.2-0.5)	0.1 (0.2-0.5)	
Total phosphorus mg/L	0.05												

ID = insufficient representative data (ANZECC)

**Table 28: Triggered water quality parameters: Smiths Creek**

Parameter	ANZECC trigger value	Median downstream site value (Upstream 20 <sup>th</sup> % - 80 <sup>th</sup> % trigger range)											
		April 2018	May 2018	June 2018	July 2018	August 2018	September 2018	October 2018	November 2018	December 2018	January 2019	February 2019	March 2019
Temperature °C	NA		16.5 (17.1-23.7)	13.3 (17.1-23.7)	10.5 (17.1-23.7)	11.5 (15.6-23.7)					24.0 (13.6-23.6)		24.6 (13.6-23.5)
Electrical Conductivity uS/cm	125 – 2200	179.0 (202.2-300.4)	202.0 (202.2-300.4)	174.5 (197.2-300.4)				188.0 (195.2-290.2)	174.0 (176.4-262.2)		306.0 (192.4-262.0)	573.0 (192.4-271.4)	2580.0 (192.4-323.6)
Dissolved oxygen %	85 – 110	68.7 (31.7-73.5)	59.3 (31.7-66.2)	86.1 (37.1-66.2)	86.0 (31.7-67.3)	86.1 (31.7-74.4)	61.2 (31.7-74.4)	67.8 (31.7-75.2)	36.8 (31.7-75.2)	30.4 (26.0-75.2)	6.1 (26.0-75.2)	36.1 (23.1-75.2)	63.0 (23.1-75.2)
pH	6.5 – 8					7.7 (6.9-7.4)				6.8 (7.0-7.4)		7.6 (7.0-7.4)	
Turbidity (NTU)	6 – 50		7.8 (11.0-20.2)	22.0 (11.3-20.8)	5.5 (10.2-20.8)	6.1 (11.0-20.8)	4.9 (10.6-20.8)	46.4 (10.6-20.8)		25.1 (10.9-20.8)		62.9 (10.9-20.5)	49.5 (10.9-22.8)
Total suspended solids mg/L	-									10 (5-9)	16 (5-7)	14 (5-7)	33 (5-6)
Aluminium mg/L	0.055		0.08 (0.02-0.12)	0.23 (0.02-0.12)						0.09 (0.02-0.08)			
Arsenic mg/L	0.024												
Cadmium mg/L	0.0002												
Chromium mg/L	0.001												
Copper mg/L	0.0014												
Iron mg/L	ID									1.41 (0.44-1.19)			
Lead mg/L	0.0034												
Manganese mg/L	1.9			0.007 (0.012-0.391)						0.984 (0.017-0.499)			1.569 (0.037-0.578)
Mercury mg/L	0.0006												
Nickel mg/L	0.011												
Silver mg/L													

Parameter	ANZECC trigger value	Median downstream site value (Upstream 20 <sup>th</sup> % - 80 <sup>th</sup> % trigger range)													
		Values in black = < 20 <sup>th</sup> %    Values in red = > 80 <sup>th</sup> %    Shaded cells = outside/above ANZECC trigger													
Zinc mg/L	0.008							0.010 (0.005-0.011)				0.009 (0.005-0.011)			0.012 (0.005-0.012)
Total nitrogen mg/L	0.5		0.1 (0.2-0.6)		0.2 (0.3-0.6)	0.1 (0.2-0.6)								0.6 (0.2-0.5)	1.7 (0.2-0.5)
Total phosphorus mg/L	0.05				0.01 (0.02-0.05)							0.04 (0.01-0.03)	0.08 (0.01-0.04)	0.07 (0.01-0.03)	0.38 (0.01-0.03)

ID = insufficient representative data (ANZECC)

**Table 29: Triggered water quality parameters: Pipers Creek**

Parameter	ANZECC trigger value	Median downstream site value (Upstream 20 <sup>th</sup> % - 80 <sup>th</sup> % trigger range)											
		April 2018	May 2018	June 2018	July 2018	August 2018	September 2018	October 2018	November 2018	December 2018	January 2019	February 2019	March 2019
Temperature °C	NA		16.7 (17.1-23.8)	12.9 (17.1-23.8)	10.6 (17.1-23.8)	10.4 (15.8-23.8)					24.6 (13.9-24.1)		24.0 (13.9-23.9)
Electrical Conductivity uS/cm	125 – 2200	216.0 (252.8-430.2)		197.0 (211.2-430.2)			405.5 (211.2-383.2)					500.0 (210.8-361.6)	519.5 (210.8-413.2)
Dissolved oxygen %	85 – 110	51.0 (37.9-71.5)	43.5 (37.5-68.0)	73.2 (37.5-64.5)	74.0 (37.5-65.5)	79.0 (37.5-68.0)	80.0 (37.5-75.7)	66.7 (37.9-75.7)	23.1 (37.9-73.0)	25.5 (36.1-73.0)	39.6 (34.4-73.0)	24.4 (33.1-73.0)	75.8 (34.4-76.7)
pH	6.5 – 8					7.7 (6.9-7.5)			6.9 (7.0-7.5)				7.6 (7.1-7.5)
Turbidity (NTU)	6 – 50					8.8 (11.8-57.5)	7.7 (12.3-57.5)						
Total suspended solids mg/L	-												
Aluminium mg/L	0.055			0.27 (0.03-0.24)						0.06 (0.03-0.19)			
Arsenic mg/L	0.024												
Cadmium mg/L	0.0002												
Chromium mg/L	0.001												
Copper mg/L	0.0014												
Iron mg/L	ID		0.95 (0.43-0.69)				0.19 (0.41-0.69)			1.94 (0.41-0.69)			0.31 (0.35-0.69)
Lead mg/L	0.0034												
Manganese mg/L	1.9			0.014 (0.036-0.188)						0.663 (0.037-0.263)			
Mercury mg/L	0.0006												
Nickel mg/L	0.011												
Silver mg/L													

Parameter	ANZECC trigger value	Median downstream site value (Upstream 20 <sup>th</sup> % - 80 <sup>th</sup> % trigger range)											
		Values in black = < 20 <sup>th</sup> % Values in red = > 80 <sup>th</sup> % Shaded cells = outside/above ANZECC trigger											
Zinc mg/L	0.008							0.009 (0.005-0.008)					0.030 (0.005-0.009)
Total nitrogen mg/L	0.5			0.6 (0.2-0.5)		0.1 (0.3-0.5)		0.5 (0.2-0.4)			0.6 (0.2-0.4)		
Total phosphorus mg/L	0.05									0.03 (0.01-0.02)	0.04 (0.01-0.03)	0.03 (0.01-0.02)	

ID = insufficient representative data (ANZECC)

**Table 30: Triggered water quality parameters: Maria River**

Parameter	ANZECC trigger value	Median downstream site value (Upstream 20 <sup>th</sup> % - 80 <sup>th</sup> % trigger range)												
		April 2018	May 2018	June 2018	July 2018	August 2018	September 2018	October 2018	November 2018	December 2018	January 2019	February 2019	March 2019	
Temperature °C	NA			13.4 (17.4-23.6)	10.9 (17.4-23.6)	11.3 (16.3-23.6)					23.0 (13.0-22.8)	24.8 (13.0-22.5)		24.5 (13.0-22.5)
Electrical Conductivity uS/cm	125 – 2200	184.0 (204.8-470.0)	194.0 (202.6-470.0)					166.5 (184.4-342.2)		146.5 (184.4-298.4)	183.0 (184.4-322.2)			106.0 (179.8-322.2)
Dissolved oxygen %	85 – 110	19.2 (23.8-67.0)	8.1 (22.3-67.0)	41.8 (22.3-67.0)	43.2 (22.3-67.0)	58.4 (22.3-67.0)	43.2 (22.3-67.4)	46.2 (22.3-56.5)	13.2 (22.3-52.5)	12.5 (22.3-52.5)	3.4 (22.3-52.9)			45.1 (22.3-53.3)
pH	6.5 – 8	6.4 (6.7-7.3)			6.7 (6.8-7.3)	7.4 (6.8-7.3)	6.7 (6.8-7.3)	6.6 (6.8-7.3)	6.6 (6.8-7.2)					
Turbidity (NTU)	6 – 50					11.3 (16.1-51.2)	8.5 (14.6-51.2)	12.9 (13.3-47.4)			61.4 (13.2-38.8)			
Total suspended solids mg/L	-										32 (5-11)			
Aluminium mg/L	0.055		0.11 (0.05-0.32)	0.25 (0.05-0.26)			0.06 (0.05-0.21)			0.12 (0.05-0.20)				0.20 (0.05-0.15)
Arsenic mg/L	0.024													
Cadmium mg/L	0.0002													
Chromium mg/L	0.001													0.002 (0.001)
Copper mg/L	0.0014													
Iron mg/L	ID													
Lead mg/L	0.0034													
Manganese mg/L	1.9			0.070 (0.083-0.208)										
Mercury mg/L	0.0006													
Nickel mg/L	0.011													
Silver mg/L														

Parameter	ANZECC trigger value	Median downstream site value (Upstream 20 <sup>th</sup> % - 80 <sup>th</sup> % trigger range)											
		Values in black = < 20 <sup>th</sup> %    Values in red = > 80 <sup>th</sup> %    Shaded cells = outside/above ANZECC trigger											
Zinc mg/L	0.008			0.010 (0.005-0.009)			0.013 (0.005-0.012)			0.011 (0.005-0.012)			0.020 (0.005-0.016)
Total nitrogen mg/L	0.5	0.6 (0.5-0.8)	0.4 (0.5-0.8)	0.6 (0.5-0.8)	0.4 (0.5-0.8)	0.3 (0.5-0.8)	0.4 (0.5-0.8)	0.6 (0.5-0.8)	0.7 (0.5-0.8)		2.2 (0.5-0.8)		
Total phosphorus mg/L	0.05					0.01 (0.02-0.04)			0.05 (0.02-0.04)	0.04 (0.02-0.03)	0.20 (0.02-0.03)		0.05 (0.02-0.03)

ID = insufficient representative data (ANZECC), DNS = Did not sample



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# Appendix C Brush-tailed phascogale



# Brush-tailed Phascogale Monitoring 2018/2019

**Oxley Highway to Kempsey, Pacific Highway Upgrade**

Prepared for Roads and Maritime Services

May 2019

## Document control

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Project Director:	Rhidian Harrington
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*Cover photograph:* Brush-tailed Phascogale captured at Site 3 impact site during 2018/2019 summer surveys.

## Executive summary

---

### **Context**

This report documents findings for the 2018/2019 monitoring period, the first of three operational monitoring periods for the Brush-tailed Phascogale (*Phascogale tapoatafa*), as required for the Oxley Highway to Kempsey (OH2K) Pacific Highway Upgrade Project (the Project), and specified in the Oxley Highway to Kempsey (OH2K) Ecological Monitoring Program (EMP, RMS 2016).

### **Aims**

The aim of the Brush-tailed Phascogale monitoring program is to determine if mitigation measures are being used by the species and whether the Project is having a local negative impact on the species. The aims of this report are to summarise the methods and results of the 2018/2019 monitoring period and determine if performance measures are being met, as per the EMP.

### **Methods**

Four paired impact and control sites were monitored in winter (July) 2018 and summer (February) 2019. Each monitoring location was surveyed in accordance with the monitoring method and design specified in the EMP. Arboreal trapping was undertaken for four nights over approximately two hectares of habitat using 20 Elliot B traps baited with oats, honey and peanut butter. Hair tubes were also attached to trees in a grid formation baited with honey, peanut butter and oats and left for 14 consecutive nights.

### **Key results**

One individual Brush-tailed Phascogale was recorded at Site 3 impact site during the summer 2018/2019 monitoring period. Other species captured during trapping included the Black Rat (*Rattus rattus*), Bush Rat (*Rattus fuscipes*) and Brown Antechinus (*Antechinus stuartii*). Hair tube samples detected two genera: the Brushtail Possum (*Trichosurus* sp.) and *Rattus* sp. No Brush-tailed Phascogales have been identified occupying nest boxes within the vicinity of the survey sites, established as part of associated ecological monitoring for the Project.

### **Conclusion**

Performance measures for the 2018/2019 monitoring period were partially met. Surveys were undertaken before and after the Project's construction and at impact and reference sites during the 2018/2019 monitoring period, successfully meeting two of the three performance measures. Presence of adults and/or lactating Brush-tailed Phascogales was established at one (Site 3 impact) of the four monitored impact sites.

### **Management implications**

It is not possible to establish a decline in presence of Brush-tailed Phascogales at the survey sites due to the absence of records from baseline data. Despite the positive outcome of the detection of an individual at Site 3 impact site, the following recommendations have been made:

- Continued use of nest box data is recommended to augment the confirmed records of the species in the relevant areas.
- Inclusion of incidental records from other ecological monitoring components of the Project such as fauna underpass monitoring and Spotted-tailed Quoll monitoring is recommended.
- Consideration should be given to the use of infrared motion-detecting cameras to replace the use of hair tubes.

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# 1. Introduction

---

## 1.1 Context

The Oxley Highway to Kempsey (OH2K) section of the Pacific Highway Upgrade Project (the Project) was approved in 2012 subject to various Ministers Conditions of Approval (MCoA) and a Statement of Commitments (SoC). A subsequent approval with additional conditions of consent (CoA) was granted in 2014 by the Commonwealth Department of Environment (DoE) for Matters of National Environmental Significance (MNES) listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Ecological Monitoring Program (hereafter referred to as the EMP) (RMS 2016) combines these approval conditions and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project. The Brush-tailed Phascogale (*Phascogale tapoatafa*) was one threatened species identified as requiring monitoring following the completion of the Projects' construction, during the operational phase of the Project.

### 1.1.1 Legal status

The Brush-tailed Phascogale is listed as vulnerable under the New South Wales *Biodiversity Conservation Act 2016* (BC Act). Monitoring of the species is required under the Project's approval conditions.

### 1.1.2 Monitoring framework

The design, methods and performance indicators that define the Brush-tailed Phascogale monitoring program are specified in the EMP.

The EMP requires monitoring to occur in summer prior to the commencement of construction and in winter and summer in Year 4, 6 and 8 of the Project (operational phase). To date, these monitoring events have been reported as follows:

- *Summer 2014*: Baseline report (Lewis 2014)
- *Winter and Summer 2018/2019*: Current Report.

This report therefore represents the first of three reports required for the operational phase monitoring.

### 1.1.3 Baseline data

Baseline surveys were undertaken in summer prior to the commencement of construction by Lewis Ecological (Lewis 2014). No Brush-tailed Phascogale's were recorded during baseline surveys.

### 1.1.4 Purpose of this report

This report details the findings of the first of three operational monitoring periods for the Brush-tailed Phascogale. The aims of this report are to summarise the methods and results of the 2018/2019 monitoring period and determine if performance measures are being met, as per the EMP.

## 1.2 Performance Measures

The EMP specifies the following performance measures for the Brush-tailed Phascogale:

- *Monitoring is undertaken before and after the construction of the upgrade.*
- *Monitoring is undertaken at impact and control sites.*
- *Presence of adults and/or lactating Brush-tailed Phascogales during Brush-tail Phascogale monitoring and/or nest box monitoring.*



### **1.3 Monitoring Timing**

Monitoring is to be undertaken in winter and summer in Year 4, 6 and 8, during high movement periods for the species, between May and July and in mid-summer.

### **1.4 Reporting**

Annual reporting of monitoring results will include:

- Detailed description of monitoring methodology
- Results of the monitoring period
- Discussion of results, including how the results compare against performance measures, if any modifications to timing or frequency of monitoring periods or monitoring methodology are required and any other recommendations
- If contingency measures should be implemented.

All reports prepared under the EMP will be submitted to the Director General of the Department of Planning and Environment and the Environment Protection Authority.

## 2. Survey Methods

---

### 2.1 Monitoring Sites

Monitoring areas were identified during baseline surveys within four broad areas containing Moist Slopes Forest and Dry Ridgetop Forest habitat, where the species was considered likely to occur (GHD 2010, GHD 2011). They include:

- Site 1: Cairncross State Forest
- Site 2: Ballengarra State Forest South
- Site 3: Ballengarra State Forest North
- Site 4: Maria River State Forest.

Each site consists of an impact site and a paired control site. Impact sites were established during baseline surveys, however control sites were not. Control sites were therefore selected prior to the 2018/2019 monitoring period and located a minimum distance of 500 metres to one kilometre, where access permitted, from the paired impact site within contiguous vegetation. Monitoring site locations are shown in Figure 1 – and trap locations at each site are shown in Figure 2- Figure 5.

### 2.2 Methods

#### 2.2.1 Arboreal trapping

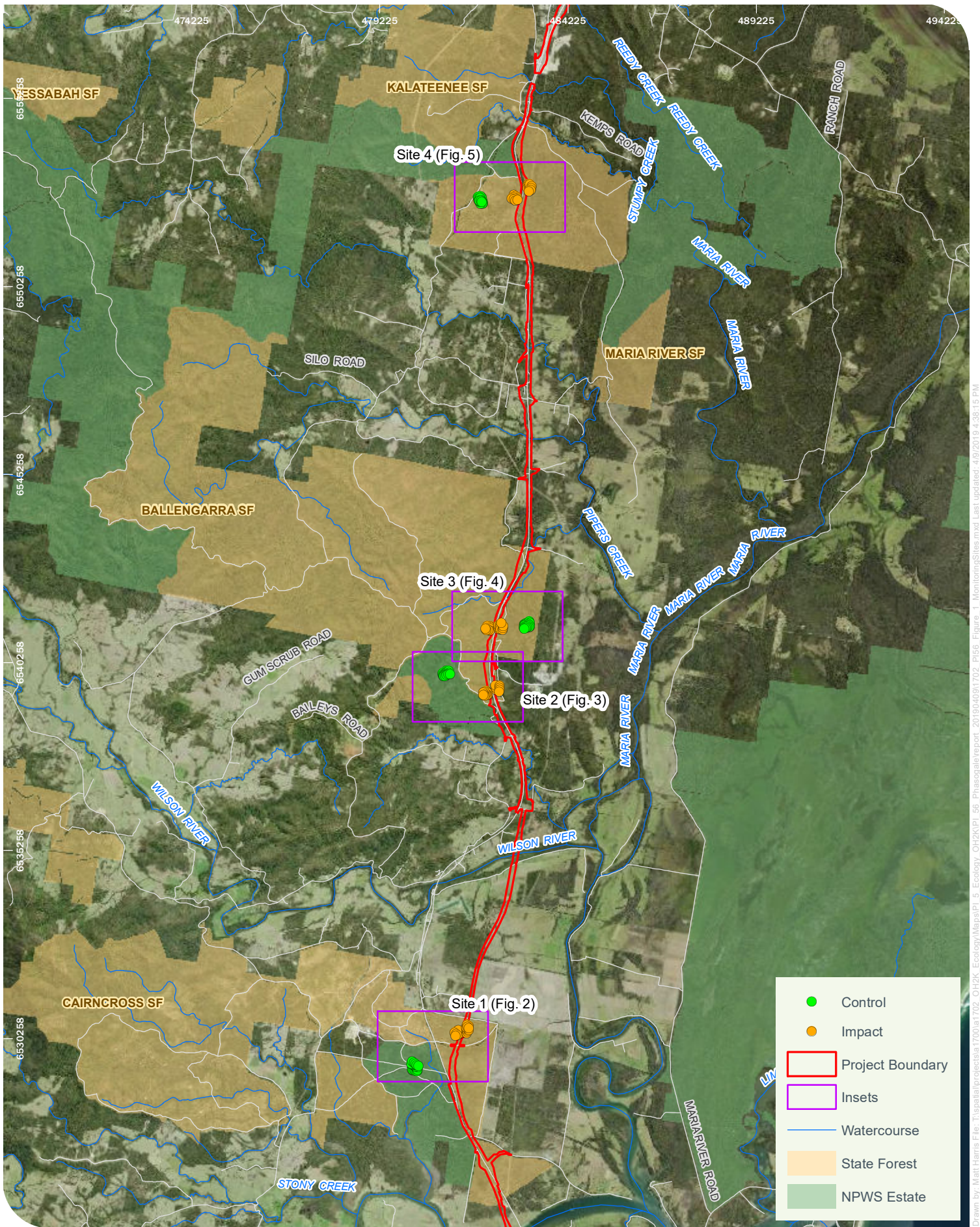
In accordance with the EMP, arboreal trapping was undertaken using a grid configuration of 20 tree-mounted Elliot B traps distributed over approximately two hectares of habitat for four consecutive nights at each control and impact site. At impact sites, 10 traps were deployed on either side of the carriageway. Traps were positioned on brackets and installed approximately two metres above the ground on a range of mature canopy tree species and baited with a mixture of oats, peanut butter and honey. The host tree was sprayed with a mixture of honey water above the trap as an additional attractant. Traps were checked each morning and bait was replaced as necessary.

The following details were recorded for any captured fauna, where this could be determined with minimal animal handling:

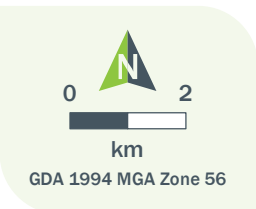
- Trap location
- Sex
- Age class
- Mass
- Breeding condition.

#### 2.2.2 Hair tubes

Hair tubes were attached to the same host trees used for arboreal trapping, therefore following the same grid configuration with 20 hair tubes over approximately two hectares of habitat. Hair tubes were baited with a mixture of oats, peanut butter and honey and left for 14 consecutive nights. Hair samples were sent to Barbara Triggs ('Dead Finish') for analysis, and were identified to species level where possible.



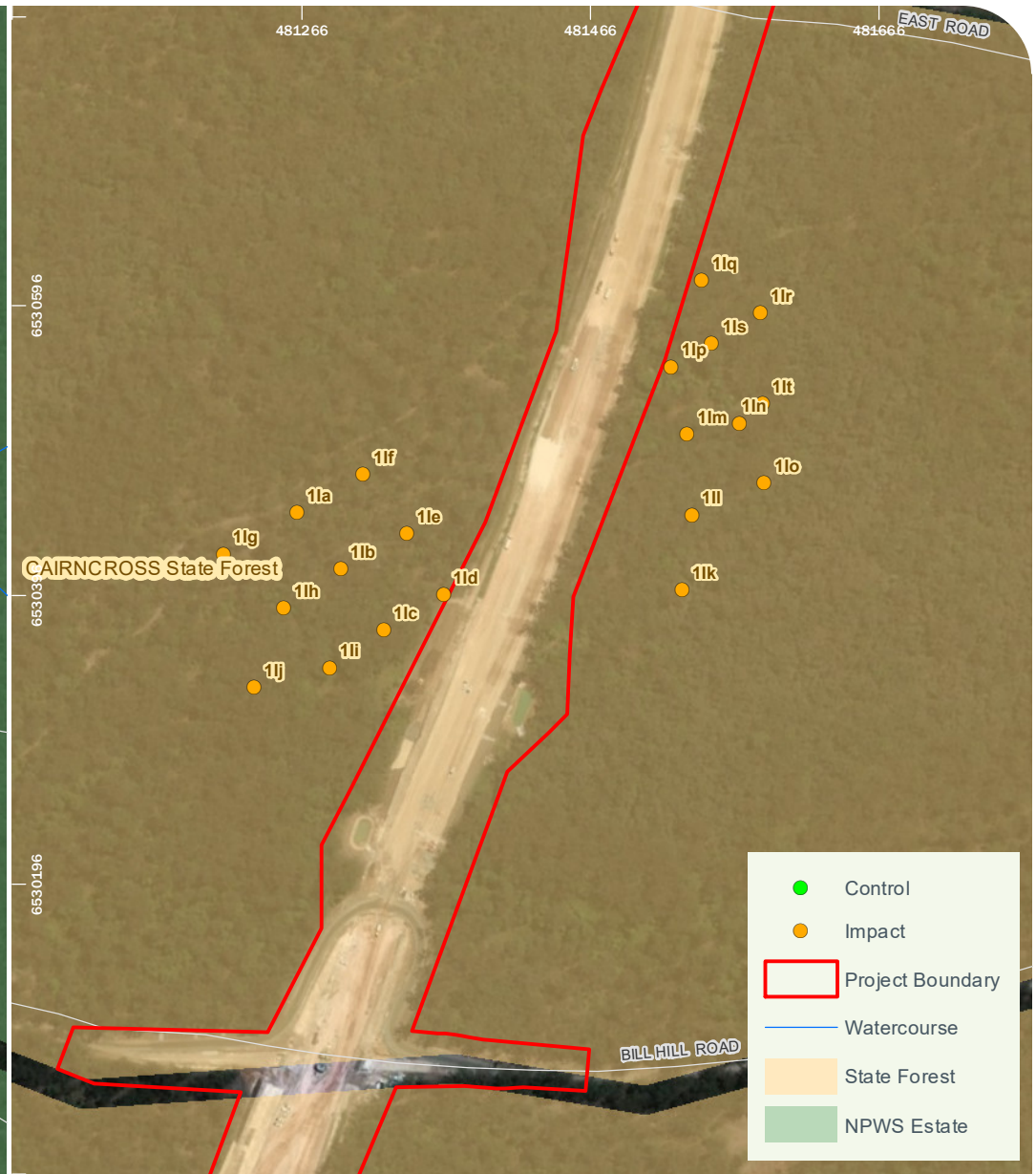
Drawn by: Matt Harris File: \\spatial\projects\1700\1702\_OH2K\_Ecology\Maps\P1\_5\_Ecology\_OH2K\P1\_56\_Phascogale\report\_2019\0409\1702\_P156\_Figure\_1\_MonitoringSites.mxd Last updated: 4/9/2019 4:38:15 PM

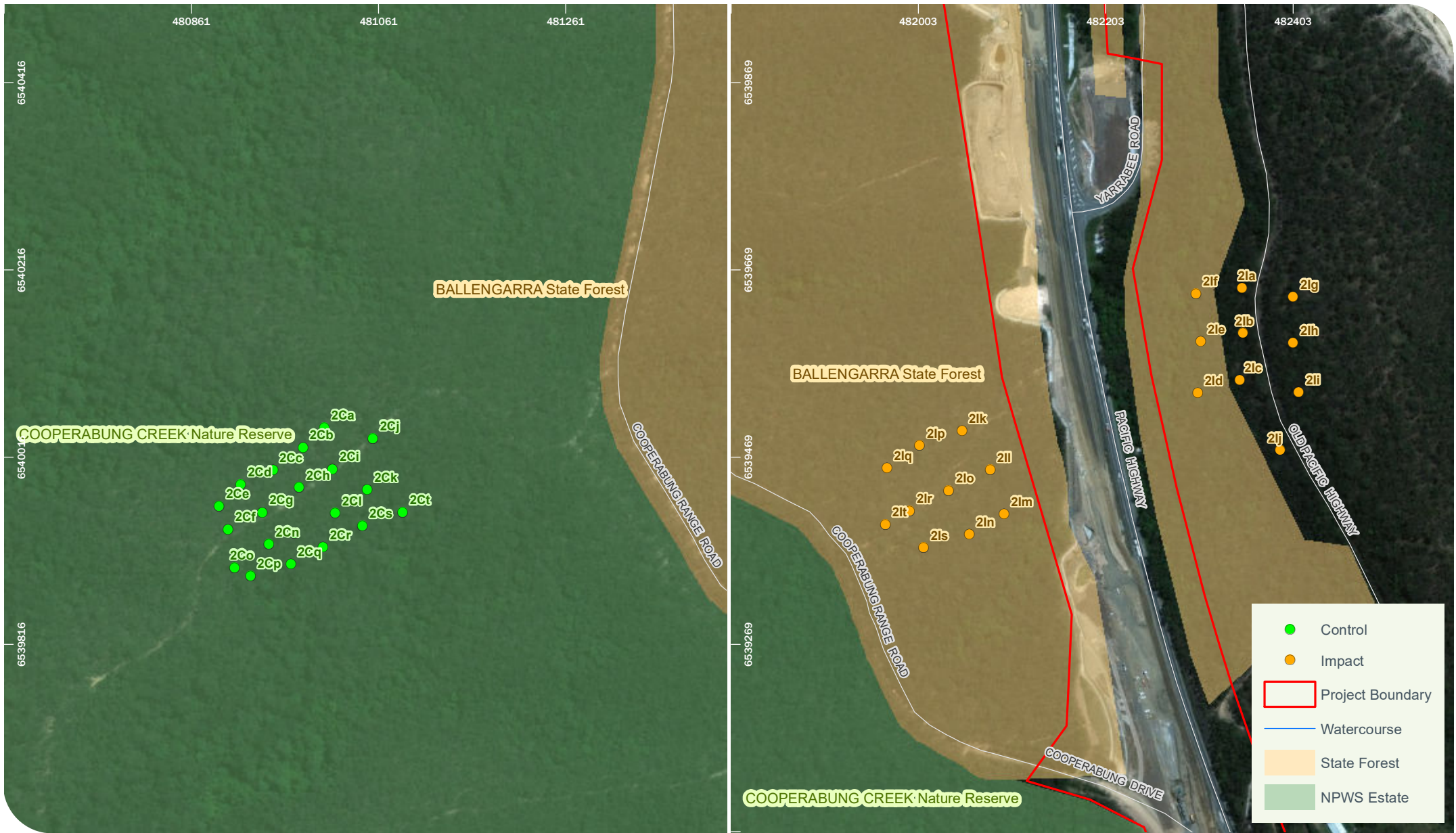


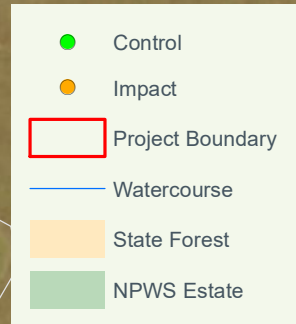
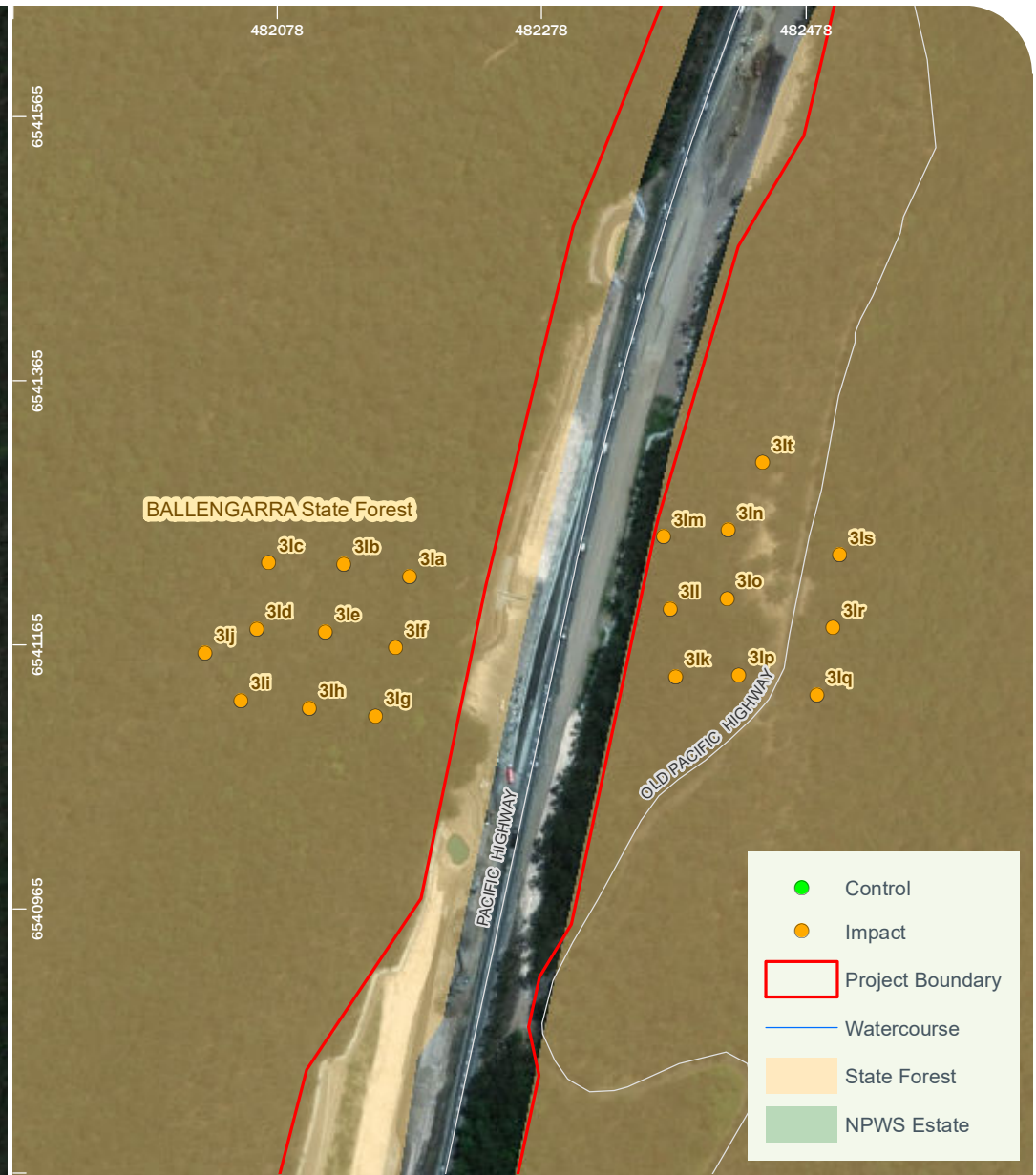
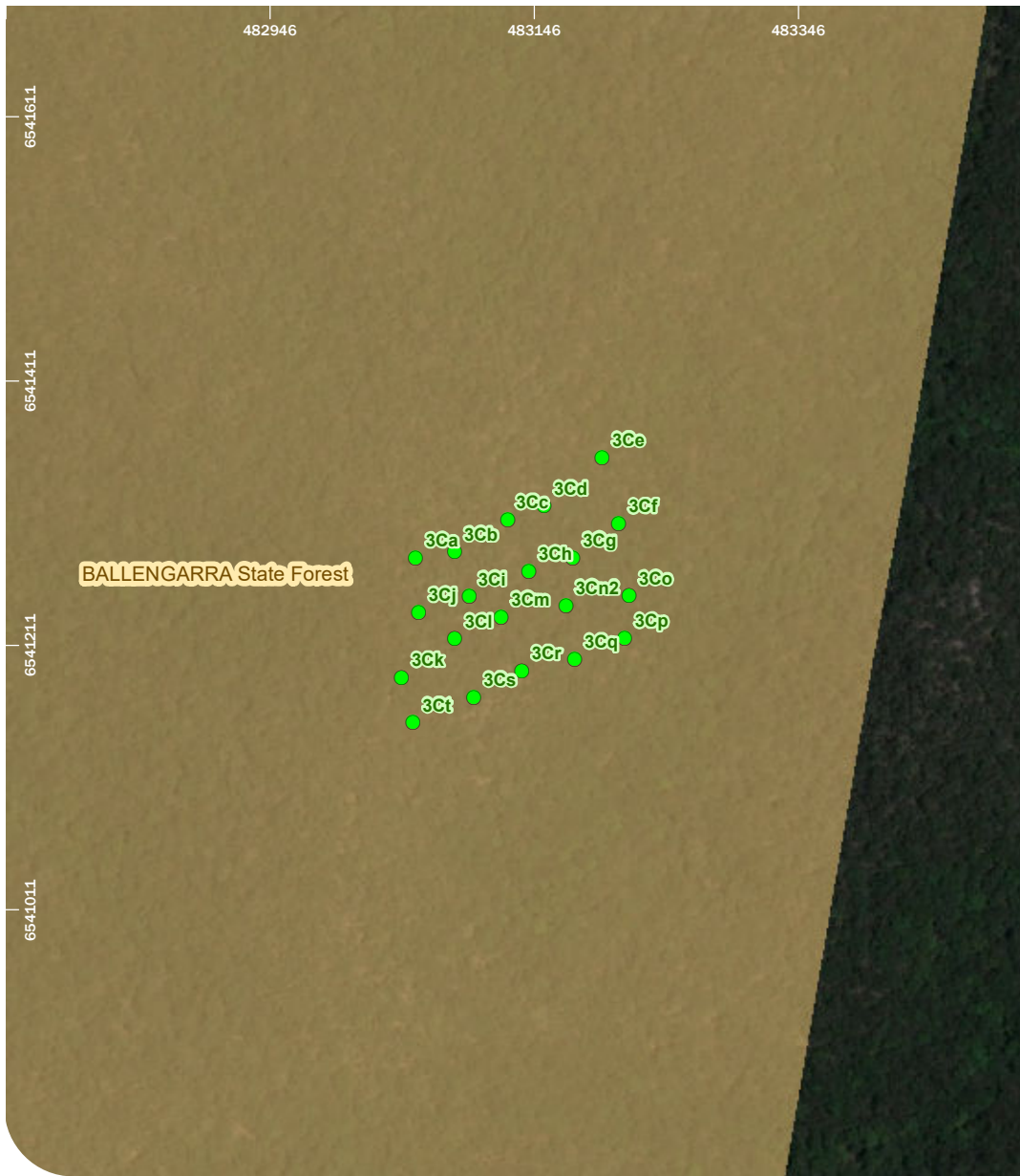
Niche PM: Radika Michniewicz  
 Niche Proj. #: 1702 P15.6  
 Client: Roads and Maritime Services

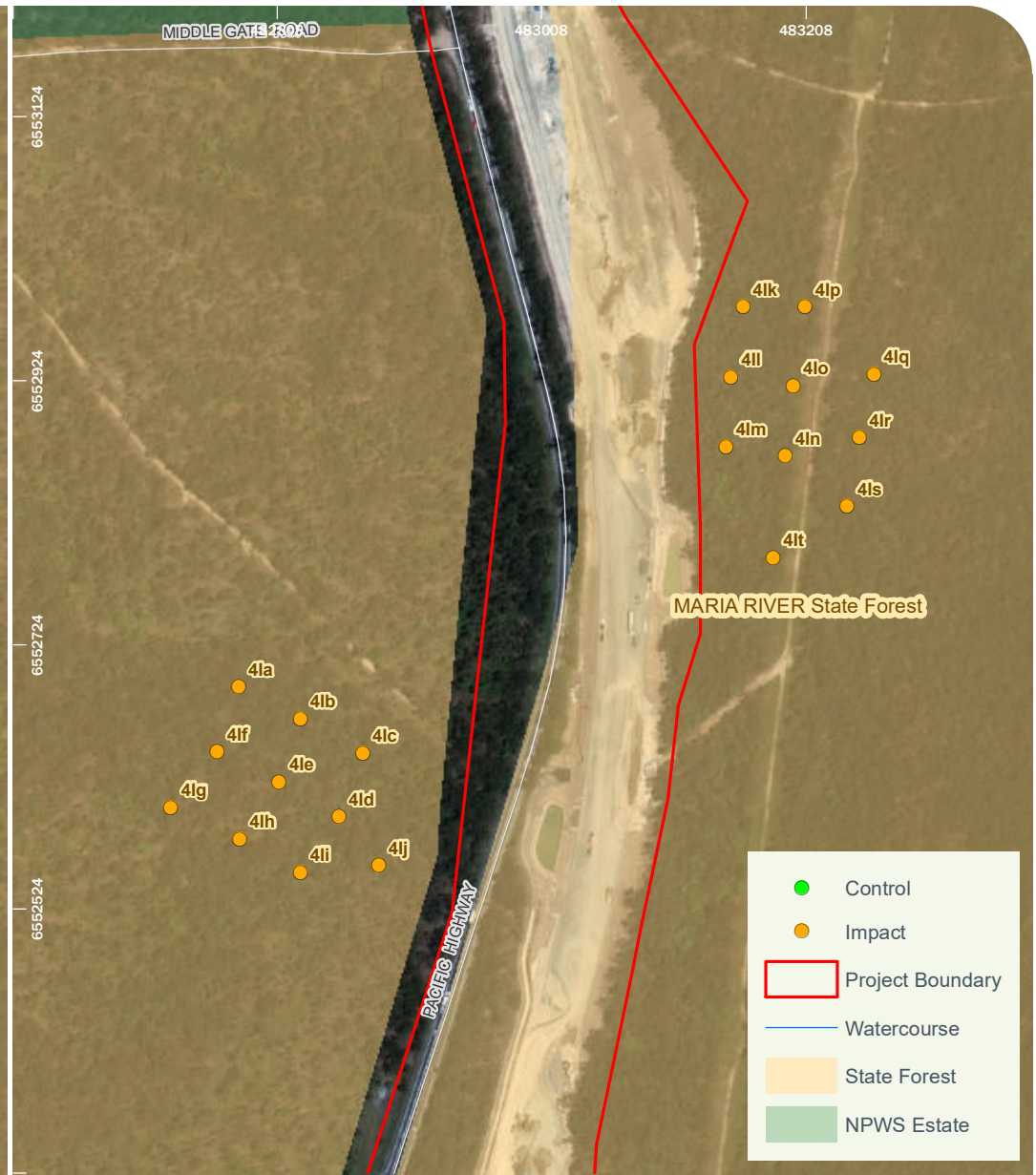
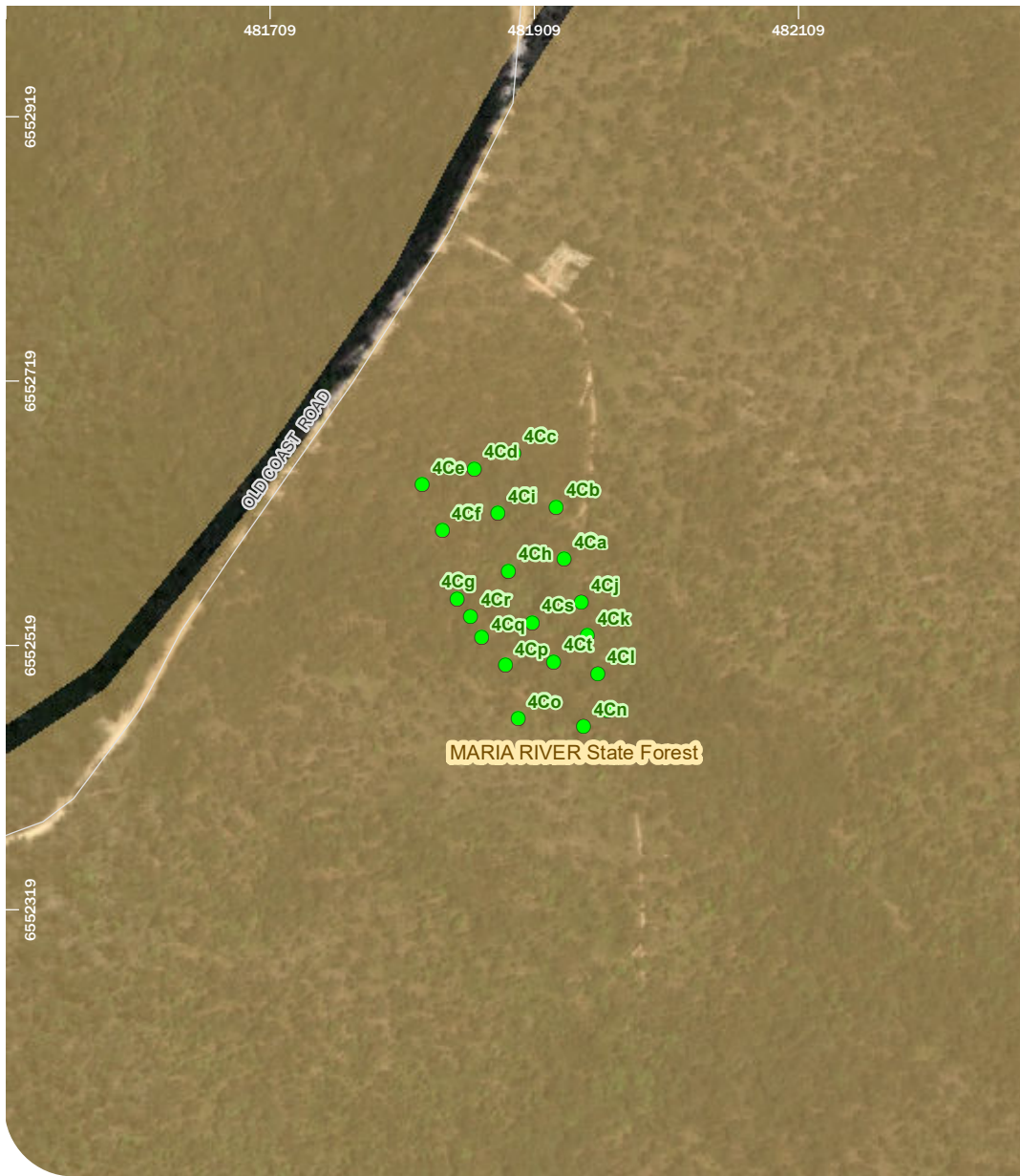
### Overview of monitoring sites Brush-tailed Phascogale Monitoring: Pacific Highway Upgrade – Oxley Highway to Kempsey

**Figure 1**









### 3. Results

#### 3.1 Timing and Conditions

Weather conditions (Port Macquarie Airport, station ID 060139) experienced during the arboreal trapping surveys are provided in Table 1.

Arboreal trapping surveys were undertaken as follows:

- Winter: Sites 1 and 4 from 2-7 July 2018; Sites 2 and 3 from 9-13 July 2018. Due to time and weather constraints during winter surveys, the Site 1 control site was deployed and retrieved a day later than the impact site. This is not considered to have impacted the results.
- Summer: Sites 1 and 4 from 11-15 February 2019; Sites 2 and 3 from 4-8 February 2019.

Hair tube surveys were undertaken as follows:

- Winter: Hair tubes were deployed on 4, 5 and 10 July 2018 and retrieved from 24-26 July 2018.
- Summer: Hair tubes were deployed on 5 and 12 February 2019 and retrieved on 26 and 27 February 2019.

**Table 1: Arboreal trapping survey weather conditions 2018/2019**

Date range	Min temperature (°C)	Max temperature (°C)	24 hour rainfall (mm)
2/7/18 – 7/7/18	8.4	24.7	76
9/7/18 – 13/7/2018	5.3	19.7	0
4/2/19 – 8/2/19	16.5	31.8	0.2
11/2/19 – 15/2/19	13.6	39.7	14.2

#### 3.2 2018/2019 Monitoring Results

Field results for the 2018/2019 monitoring period are provided in Annex 1. The outcomes of the arboreal trapping and hair tube surveys are summarised below.

##### 3.2.1 Arboreal trapping

A summary of the species captured at each site is provided in Table 2. Arboreal trapping yielded low capture rates with a total of four different species detected. One Brush-tailed Phascogale (a young adult) was captured at Site 3 impact site during the summer surveys. The Brown Antechinus (*Antechinus stuartii*) was the most commonly captured species, with 16 and 15 individuals captured during winter and summer respectively, with recorded presence at all except one site (Site 4). Other species captured included the introduced Black Rat (*Rattus rattus*) and native Bush Rat (*Rattus fuscipes*).



**Table 2: Summary of species captured during 2018/2019 surveys**

Monitoring area	Site	Impact		Control	
		Winter	Summer	Winter	Summer
Cairncross State Forest	1	Black Rat (5) Brown Antechinus (9)	Brown Antechinus (7)	Brown Antechinus (1)	Brown Antechinus (3)
Ballengarra State Forest South	2	Brown Antechinus (2)	Brown Antechinus (3)	No captures	Brown Antechinus (1)
Ballengarra State Forest North	3	Bush Rat (1)	<b>Brush-tailed Phascogale (1)</b> Brown Antechinus (1)	Brown Antechinus (4)	Bush Rat (1)
Maria River State Forest	4	No captures	No captures	Black Rat (1)	No captures

(#) = number of individuals captured

### 3.2.2 Hair tubes

A complete list of hair tube results for the 2018/2019 monitoring period is provided in Annex 1 and a summary of the species detected is provided in Table 3. No Brush-tailed Phascogales were detected using hair tube sampling. From a total of 160 hair tubes deployed, 49 hair tubes (31%) contained hair samples in winter and 39 (24%) in summer. The Brushtail Possum (*Trichosurus sp.*) was the most commonly detected species identified from hairs samples from all sites, accounting for 41 (84%) of the winter samples and 34 (87%) of the summer samples.

**Table 3: Hair tube analysis results 2018/2019**

Species	Site 1		Site 2		Site 3		Site 4	
	impact	control	impact	control	impact	control	impact	control
<i>Trichosurus sp.</i>	✓	✓	✓	✓	✓	✓	✓	✓
<i>Rattus rattus</i>	✓				✓			
<i>Rattus sp.</i>	✓				✓			
Rodent	✓							

### 3.3 Nest Box Monitoring Data

No Brush-tailed Phascogales have been recorded occupying nest boxes during the nest box monitoring program that forms part of the Project's ecological monitoring requirements. Nest boxes have to date been monitored on five occasions; in winter 2016 and summer and winter of 2017 and 2018. Monitoring of the nest boxes will continue in summer and winter of 2020 and 2022.

## 4. Discussion

### 4.1 Performance Measures

A summary of 2018/2019 survey results in relation to the performance measures is provided in Table 4.

**Table 4: Summary of performance measures for the 2018/2019 monitoring period**

Performance measure	Discussion
Monitoring is undertaken before and after construction of the upgrade.	<p><b>This performance measure has been met.</b></p> <p>Baseline monitoring was undertaken prior to construction (Lewis 2014) and after completion of the upgrade (during operational phase) in winter and summer 2018/2019 (current report). Monitoring will continue as per the EMP in Year 6 and 8.</p>
Monitoring is undertaken at Impact and Control sites.	<p><b>This performance measure has been met for the 2018/2019 monitoring period.</b></p> <p>Control sites were not established/monitored during baseline surveys. Baseline impact sites were monitored and control sites were established and monitored during the 2018/2019 monitoring period.</p>
Presence of adults and/or lactating Brush-tailed phascogales during Brush-tail Phascogale monitoring and/or nest box monitoring.	<p><b>This performance measure has been met for one of four impact sites.</b></p> <p>Brush-tailed Phascogales were not recorded during baseline surveys or during the winter 2018 surveys.</p> <p>One individual was recorded at Site 3 impact site during the summer 2019 trapping surveys.</p> <p>Brush-tailed Phascogales have not been recorded at the remaining three impact sites or at any of the control sites.</p>

## 5. Recommendations

### 5.2 Contingency Measures and Recommendations

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those that are considered relevant to the Brush-tailed Phascogale monitoring are listed and discussed in Table 5. While it is not possible to establish a decline in presence of Brush-tailed Phascogales at the survey sites due to the absence of records from baseline data, and despite the subsequent positive outcome of the detection of an individual at Site 3 impact site, the following recommendations have been made:

- Continued use of nest box data is recommended to augment the confirmed records of the species in the relevant areas.
- Inclusion of incidental records from other ecological monitoring components of the Project such as fauna underpass monitoring, Spotted-tailed Quoll monitoring and aerial crossing monitoring is recommended.
- As discussed in the baseline report (Lewis 2014), the usefulness of hair tubes is questionable due to their lower rates of detection and potential analysis inaccuracies. Observations have also been made during these and other trapping surveys (R. Michniewicz *pers. obs.*) of evident trap and bait interference without a capture or hair record. For these reasons, it is recommended, as was recommended in the baseline report, that consideration be given to the use of infrared motion-detecting cameras to replace the use of hair tubes. Cameras could be attached to adjacent trees and set to face the baited traps and set to monitor during trapping surveys, and then to continue monitoring post trapping surveys, with baited traps being replaced by a protected bait for a minimum period of 14 consecutive nights.

**Table 5: Contingency measures**

Potential Problem	Contingency measure proposed in the EMP	Discussion of proposed measure
Decline in presence of target species recorded at Impact sites after the upgrade has been complete, compared to change in Control sites.	<p>The cause of decline in populations at impact sites will be investigated in consultation with EPA and DOTE within two weeks of results reported by ecologist.</p> <p>If the cause of decline is considered most likely attributed to the upgrade of the highway (and not another event such as bushfire), mitigation measures, such as the location and types of fauna crossings and fauna fencing will be reviewed within two months of the above consultation being completed.</p>	<p>Due to the absence of records from Brush-tailed Phascogale baseline data, it is not possible to determine a decline in presence of this species.</p> <p>One individual was recorded at Site 3 impact site during the 2018/2019 surveys.</p> <p><b>This contingency measure is not considered relevant.</b></p>

## References

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GHD (2010). Oxley Highway to Kempsey Upgrading the Pacific Highway Environmental Assessment. Report prepared by GHD on behalf of RTA, September 2010.

GHD (2011). Pacific Highway Upgrade - Oxley Highway to Kempsey. Supplementary Flora and Fauna Assessment. Report prepared by GHD on behalf of RTA, February 2011.

Lewis (2014). Oxley Highway to Kempsey. Pre-construction Baseline Monitoring: Winter-Summer. Prepared by Lewis Ecological.

RMS (2016). Oxley Highway to Kempsey Pacific Highway Upgrade Ecological Monitoring Program. Roads and Maritime Update to report prepared by SMEC Hyder Joint Venture, August 2016.

## Annex 1 – 2018/2019 field data

**Table 6: Arboreal trapping data**

Site	Season	Date	Site type	SOC	Trap ID	Species	Sex	Age
1	Winter	07/07/2018	Control	W	1Ck	<i>Antechinus stuartii</i>	M	adult
1	Winter	04/07/2018	Impact	E	1	<i>Rattus rattus</i>	F	adult
1	Winter	03/07/2018	Impact	W	1lc	<i>Rattus rattus</i>	F	adult
1	Winter	04/07/2018	Impact	W	1lj	<i>Rattus rattus</i>	M	adult
1	Winter	05/07/2018	Impact	W	1lj	<i>Rattus rattus</i>	unk	adult
1	Winter	04/07/2018	Impact	E	1lk	<i>Antechinus stuartii</i>	M	adult
1	Winter	05/07/2018	Impact	E	1lo	<i>Antechinus stuartii</i>	unk	adult
1	Winter	03/07/2018	Impact	E	1lp	<i>Antechinus stuartii</i>	M	adult
1	Winter	05/07/2018	Impact	E	1lp	<i>Antechinus stuartii</i>	unk	adult
1	Winter	04/07/2018	Impact	E	1lq	<i>Antechinus stuartii</i>	F	adult
1	Winter	06/07/2018	Impact	E	1lq	<i>Rattus rattus</i>	F	adult
1	Winter	06/07/2018	Impact	E	1lr	<i>Antechinus stuartii</i>	M&F	adult
1	Winter	04/07/2018	Impact	E	1ls	<i>Antechinus stuartii</i>	M	adult
1	Winter	06/07/2018	Impact	E	1lt	<i>Antechinus stuartii</i>	M	adult
2	Winter	12/07/2018	Impact	W	2lr	<i>Antechinus stuartii</i>	M&F	adult
3	Winter	13/07/2018	Control	E	3Cb	<i>Antechinus stuartii</i>	unk	adult
3	Winter	13/07/2018	Control	E	3Co	<i>Antechinus stuartii</i>	unk	adult
3	Winter	13/07/2018	Control	E	3Cp	<i>Antechinus stuartii</i>	M	adult
3	Winter	12/07/2018	Control	E	3Cq	<i>Antechinus stuartii</i>	unk	adult
3	Winter	12/07/2018	Impact	E	3le	<i>Rattus fuscipes</i>	unk	adult
4	Winter	04/07/2018	Control	W	4Co	<i>Rattus rattus</i>	M	YA
3	Summer	05/02/2019	Impact	E	3lp	<b><i>Phascogale tapoatafa</i></b>	YA	YA
2	Summer	06/02/2019	Impact	W	2ls	<i>Antechinus stuartii</i>	M	adult
2	Summer	07/02/2019	Impact	W	2ls	<i>Antechinus stuartii</i>	M	unk
2	Summer	08/02/2019	Impact	W	2lr	<i>Antechinus stuartii</i>	M	YA
2	Summer	08/02/2019	Control	W	2Cg	<i>Antechinus stuartii</i>	F	adult
3	Summer	08/02/2019	Impact	E	3lr	<i>Antechinus stuartii</i>	unk	adult
3	Summer	08/02/2019	Control	E	3Cl	<i>Rattus fuscipes</i>	M	YA
1	Summer	14/02/2019	Impact	E	1lp	<i>Antechinus stuartii</i>	M	adult
1	Summer	15/02/2019	Impact	W	1lg	<i>Antechinus stuartii</i> x2	M&F	YA & adult
1	Summer	15/02/2019	Impact	W	1lh	<i>Antechinus stuartii</i>	M	adult
1	Summer	15/02/2019	Impact	W	1ld	<i>Antechinus stuartii</i>	M	adult
1	Summer	15/02/2019	Impact	E	1lm	<i>Antechinus stuartii</i> x2	M&F	adult
1	Summer	15/02/2019	Impact	W	1Cl	<i>Antechinus stuartii</i> x3	unk	unk

SOC = side of carriageway; E = east; W = west; M = male; F = female; YA = young adult; unk = unknown

**Table 7: Hair tube field results**

Area	HT ID	Site	Site type	SOC	Winter deploy date	Winter retrieve date	Winter species ID	Summer deploy date	Summer retrieve date	Summer species ID
Cairncross State Forest	1Ca	1	Control	W	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1Cb	1	Control	W	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1Cc	1	Control	W	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1Cd	1	Control	W	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1Ce	1	Control	W	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1Cf	1	Control	W	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1Cg	1	Control	W	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1Ch	1	Control	W	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	probable <i>Trichosurus</i> sp.
Cairncross State Forest	1Ci	1	Control	W	04/07/2018	24/07/2018	probable <i>Trichosurus</i> sp.	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1Cj	1	Control	W	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1Ck	1	Control	W	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1Cl	1	Control	W	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1Cm	1	Control	W	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1Cn	1	Control	W	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1Co	1	Control	W	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1Cp	1	Control	W	04/07/2018	24/07/2018	no ID	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1Cq	1	Control	W	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1Cr	1	Control	W	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1Cs	1	Control	W	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1Ct	1	Control	W	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1Ia	1	Impact	W	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1Ib	1	Impact	W	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	probable <i>Trichosurus</i> sp.
Cairncross State Forest	1Ic	1	Impact	W	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	no hairs not sent

Area	HT ID	Site	Site type	SOC	Winter deploy date	Winter retrieve date	Winter species ID	Summer deploy date	Summer retrieve date	Summer species ID
Cairncross State Forest	1ld	1	Impact	W	04/07/2018	24/07/2018	<i>Trichosurus</i> sp.	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1le	1	Impact	W	04/07/2018	24/07/2018	<i>Rattus rattus</i>	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1lf	1	Impact	W	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1lg	1	Impact	W	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	probable <i>Trichosurus</i> sp.
Cairncross State Forest	1lh	1	Impact	W	04/07/2018	24/07/2018	<i>Trichosurus</i> sp.	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1li	1	Impact	W	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1lj	1	Impact	W	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1lk	1	Impact	E	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	no ID
Cairncross State Forest	1ll	1	Impact	E	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1lm	1	Impact	E	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	probable <i>Rattus</i> sp.
Cairncross State Forest	1ln	1	Impact	E	04/07/2018	24/07/2018	<i>Rattus</i> sp.	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1lo	1	Impact	E	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1lp	1	Impact	E	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1lq	1	Impact	E	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1lr	1	Impact	E	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1ls	1	Impact	E	04/07/2018	24/07/2018	probable rodent	12/02/2019	27/02/2019	no hairs not sent
Cairncross State Forest	1lt	1	Impact	E	04/07/2018	24/07/2018	no hairs not sent	12/02/2019	27/02/2019	no hairs not sent
Ballengarra State Forest South	2Ca	2	Control	W	10/07/2018	25/07/2018	<i>Trichosurus</i> sp.	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest South	2Cb	2	Control	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	<i>Trichosurus</i> sp.
Ballengarra State Forest South	2Cc	2	Control	W	10/07/2018	25/07/2018	<i>Trichosurus</i> sp.	05/02/2019	26/02/2019	<i>Trichosurus</i> sp.
Ballengarra State Forest South	2Cd	2	Control	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	<i>Trichosurus</i> sp.
Ballengarra State Forest South	2Ce	2	Control	W	10/07/2018	25/07/2018	<i>Trichosurus</i> sp.	05/02/2019	26/02/2019	<i>Trichosurus</i> sp.
Ballengarra State Forest South	2Cf	2	Control	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest South	2Cg	2	Control	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	<i>Trichosurus</i> sp.

Area	HT ID	Site	Site type	SOC	Winter deploy date	Winter retrieve date	Winter species ID	Summer deploy date	Summer retrieve date	Summer species ID
Ballengarra State Forest South	2Ch	2	Control	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	<i>Trichosurus</i> sp.
Ballengarra State Forest South	2Ci	2	Control	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	probable <i>Trichosurus</i> sp.
Ballengarra State Forest South	2Cj	2	Control	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest South	2Ck	2	Control	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest South	2Cl	2	Control	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest South	2Cm	2	Control	W	10/07/2018	25/07/2018	<i>Trichosurus</i> sp.	05/02/2019	26/02/2019	no ID
Ballengarra State Forest South	2Cn	2	Control	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest South	2Co	2	Control	W	10/07/2018	25/07/2018	<i>Trichosurus</i> sp.	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest South	2Cp	2	Control	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no ID
Ballengarra State Forest South	2Cq	2	Control	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	probable <i>Trichosurus</i> sp.
Ballengarra State Forest South	2Cr	2	Control	W	10/07/2018	25/07/2018	<i>Trichosurus</i> sp.	05/02/2019	26/02/2019	probable <i>Trichosurus</i> sp.
Ballengarra State Forest South	2Cs	2	Control	W	10/07/2018	25/07/2018	<i>Trichosurus</i> sp.	05/02/2019	26/02/2019	probable <i>Trichosurus</i> sp.
Ballengarra State Forest South	2Ct	2	Control	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	<i>Trichosurus</i> sp.
Ballengarra State Forest South	2Ia	2	Impact	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	<i>Trichosurus</i> sp.
Ballengarra State Forest South	2Ib	2	Impact	E	10/07/2018	25/07/2018	<i>Trichosurus</i> sp.	05/02/2019	26/02/2019	<i>Trichosurus</i> sp.
Ballengarra State Forest South	2Ic	2	Impact	E	10/07/2018	25/07/2018	<i>Trichosurus</i> sp.	05/02/2019	26/02/2019	<i>Trichosurus</i> sp.
Ballengarra State Forest South	2Id	2	Impact	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	<i>Trichosurus</i> sp.
Ballengarra State Forest South	2Ie	2	Impact	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	<i>Trichosurus</i> sp.
Ballengarra State Forest South	2If	2	Impact	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	<i>Trichosurus</i> sp.
Ballengarra State Forest South	2Ig	2	Impact	E	10/07/2018	25/07/2018	<i>Trichosurus</i> sp.	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest South	2Ih	2	Impact	E	10/07/2018	25/07/2018	<i>Trichosurus</i> sp.	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest South	2Ii	2	Impact	E	10/07/2018	25/07/2018	<i>Trichosurus</i> sp.	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest South	2Ij	2	Impact	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest South	2Ik	2	Impact	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent



Area	HT ID	Site	Site type	SOC	Winter deploy date	Winter retrieve date	Winter species ID	Summer deploy date	Summer retrieve date	Summer species ID
Ballengarra State Forest South	2Il	2	Impact	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest South	2Im	2	Impact	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest South	2In	2	Impact	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest South	2Io	2	Impact	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest South	2Ip	2	Impact	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest South	2Iq	2	Impact	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest South	2Ir	2	Impact	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest South	2Is	2	Impact	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest South	2It	2	Impact	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Ca	3	Control	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Cb	3	Control	E	10/07/2018	25/07/2018	<i>Trichosurus</i> sp.	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Cc	3	Control	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Cd	3	Control	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Ce	3	Control	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Cf	3	Control	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Cg	3	Control	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Ch	3	Control	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Ci	3	Control	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Cj	3	Control	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Ck	3	Control	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Cl	3	Control	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Cm	3	Control	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Cn	3	Control	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	<i>Rattus rattus</i>
Ballengarra State Forest North	3Co	3	Control	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent

Area	HT ID	Site	Site type	SOC	Winter deploy date	Winter retrieve date	Winter species ID	Summer deploy date	Summer retrieve date	Summer species ID
Ballengarra State Forest North	3Cp	3	Control	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Cq	3	Control	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Cr	3	Control	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Cs	3	Control	E	10/07/2018	25/07/2018	<i>Trichosurus</i> sp.	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Ct	3	Control	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Ia	3	Impact	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Ib	3	Impact	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Ic	3	Impact	W	10/07/2018	25/07/2018	<i>Trichosurus</i> sp.	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Id	3	Impact	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Ie	3	Impact	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3If	3	Impact	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Ig	3	Impact	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Ih	3	Impact	W	10/07/2018	25/07/2018	<i>Trichosurus</i> sp.	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Ii	3	Impact	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Ij	3	Impact	W	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Ik	3	Impact	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Il	3	Impact	E	10/07/2018	25/07/2018	<i>Rattus</i> sp.	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Im	3	Impact	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3In	3	Impact	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	probable <i>Trichosurus</i> sp.
Ballengarra State Forest North	3Io	3	Impact	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Ip	3	Impact	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Iq	3	Impact	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Ir	3	Impact	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Ballengarra State Forest North	3Is	3	Impact	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent

Area	HT ID	Site	Site type	SOC	Winter deploy date	Winter retrieve date	Winter species ID	Summer deploy date	Summer retrieve date	Summer species ID
Ballengarra State Forest North	3It	3	Impact	E	10/07/2018	25/07/2018	no hairs not sent	05/02/2019	26/02/2019	no hairs not sent
Maria River State Forest	4Ca	4	Control	W	05/07/2018	26/07/2018	<i>Trichosurus</i> sp.	12/02/2019	26/02/2019	<i>Trichosurus</i> sp.
Maria River State Forest	4Cb	4	Control	W	05/07/2018	26/07/2018	<i>Trichosurus</i> sp.	12/02/2019	26/02/2019	no hairs not sent
Maria River State Forest	4Cc	4	Control	W	05/07/2018	26/07/2018	<i>Trichosurus</i> sp.	12/02/2019	26/02/2019	no hairs not sent
Maria River State Forest	4Cd	4	Control	W	05/07/2018	26/07/2018	no ID	12/02/2019	26/02/2019	no hairs not sent
Maria River State Forest	4Ce	4	Control	W	05/07/2018	26/07/2018	<i>Trichosurus</i> sp.	12/02/2019	26/02/2019	probable <i>Trichosurus</i> sp.
Maria River State Forest	4Cf	4	Control	W	05/07/2018	26/07/2018	<i>Trichosurus</i> sp.	12/02/2019	26/02/2019	probable <i>Trichosurus</i> sp.
Maria River State Forest	4Cg	4	Control	W	05/07/2018	26/07/2018	<i>Trichosurus</i> sp.	12/02/2019	26/02/2019	<i>Trichosurus</i> sp.
Maria River State Forest	4Ch	4	Control	W	05/07/2018	26/07/2018	<i>Trichosurus</i> sp.	12/02/2019	26/02/2019	<i>Trichosurus</i> sp.
Maria River State Forest	4Ci	4	Control	W	05/07/2018	26/07/2018	<i>Trichosurus</i> sp.	12/02/2019	26/02/2019	<i>Trichosurus</i> sp.
Maria River State Forest	4Cj	4	Control	W	05/07/2018	26/07/2018	no hairs not sent	12/02/2019	26/02/2019	no hairs not sent
Maria River State Forest	4Ck	4	Control	W	05/07/2018	26/07/2018	no hairs not sent	12/02/2019	26/02/2019	no hairs not sent
Maria River State Forest	4Cl	4	Control	W	05/07/2018	26/07/2018	no hairs not sent	12/02/2019	26/02/2019	no hairs not sent
Maria River State Forest	4Cm	4	Control	W	05/07/2018	26/07/2018	<i>Trichosurus</i> sp.	12/02/2019	26/02/2019	no hairs not sent
Maria River State Forest	4Cn	4	Control	W	05/07/2018	26/07/2018	no hairs not sent	12/02/2019	26/02/2019	no hairs not sent
Maria River State Forest	4Co	4	Control	W	05/07/2018	26/07/2018	no ID	12/02/2019	26/02/2019	no hairs not sent
Maria River State Forest	4Cp	4	Control	W	05/07/2018	26/07/2018	<i>Trichosurus</i> sp.	12/02/2019	26/02/2019	<i>Trichosurus</i> sp.
Maria River State Forest	4Cq	4	Control	W	05/07/2018	26/07/2018	no hairs not sent	12/02/2019	26/02/2019	<i>Trichosurus</i> sp.
Maria River State Forest	4Cr	4	Control	W	05/07/2018	26/07/2018	<i>Trichosurus</i> sp.	12/02/2019	26/02/2019	no hairs not sent
Maria River State Forest	4Cs	4	Control	W	05/07/2018	26/07/2018	no ID	12/02/2019	26/02/2019	no hairs not sent
Maria River State Forest	4Ct	4	Control	W	05/07/2018	26/07/2018	<i>Trichosurus</i> sp.	12/02/2019	26/02/2019	no hairs not sent
Maria River State Forest	4Ia	4	Impact	W	05/07/2018	26/07/2018	<i>Trichosurus</i> sp.	12/02/2019	26/02/2019	no hairs not sent
Maria River State Forest	4Ib	4	Impact	W	05/07/2018	26/07/2018	<i>Trichosurus</i> sp.	12/02/2019	26/02/2019	<i>Trichosurus</i> sp.
Maria River State Forest	4Ic	4	Impact	W	05/07/2018	26/07/2018	<i>Trichosurus</i> sp.	12/02/2019	26/02/2019	<i>Trichosurus</i> sp.

Area	HT ID	Site	Site type	SOC	Winter deploy date	Winter retrieve date	Winter species ID	Summer deploy date	Summer retrieve date	Summer species ID
Maria River State Forest	4ld	4	Impact	W	05/07/2018	26/07/2018	<i>Trichosurus</i> sp.	12/02/2019	26/02/2019	<i>Trichosurus</i> sp.
Maria River State Forest	4le	4	Impact	W	05/07/2018	26/07/2018	<i>Trichosurus</i> sp.	12/02/2019	26/02/2019	<i>Trichosurus</i> sp.
Maria River State Forest	4lf	4	Impact	W	05/07/2018	26/07/2018	<i>Trichosurus</i> sp.	12/02/2019	26/02/2019	no hairs not sent
Maria River State Forest	4lg	4	Impact	W	05/07/2018	26/07/2018	<i>Trichosurus</i> sp.	12/02/2019	26/02/2019	<i>Trichosurus</i> sp.
Maria River State Forest	4lh	4	Impact	W	05/07/2018	26/07/2018	<i>Trichosurus</i> sp.	12/02/2019	26/02/2019	no hairs not sent
Maria River State Forest	4li	4	Impact	W	05/07/2018	26/07/2018	no hairs not sent	12/02/2019	26/02/2019	no hairs not sent
Maria River State Forest	4lj	4	Impact	W	05/07/2018	26/07/2018	no hairs not sent	12/02/2019	26/02/2019	no hairs not sent
Maria River State Forest	4lk	4	Impact	E	04/07/2018	26/07/2018	<i>Trichosurus</i> sp.	12/02/2019	26/02/2019	no hairs not sent
Maria River State Forest	4ll	4	Impact	E	04/07/2018	26/07/2018	no hairs not sent	12/02/2019	26/02/2019	no hairs not sent
Maria River State Forest	4lm	4	Impact	E	04/07/2018	26/07/2018	no hairs not sent	12/02/2019	26/02/2019	no hairs not sent
Maria River State Forest	4ln	4	Impact	E	04/07/2018	26/07/2018	no hairs not sent	12/02/2019	26/02/2019	no hairs not sent
Maria River State Forest	4lo	4	Impact	E	04/07/2018	26/07/2018	no hairs not sent	12/02/2019	26/02/2019	no hairs not sent
Maria River State Forest	4lp	4	Impact	E	04/07/2018	26/07/2018	<i>Trichosurus</i> sp.	12/02/2019	26/02/2019	no hairs not sent
Maria River State Forest	4lq	4	Impact	E	04/07/2018	26/07/2018	no hairs not sent	12/02/2019	26/02/2019	no hairs not sent
Maria River State Forest	4lr	4	Impact	E	04/07/2018	26/07/2018	no hairs not sent	12/02/2019	26/02/2019	no hairs not sent
Maria River State Forest	4ls	4	Impact	E	04/07/2018	26/07/2018	no hairs not sent	12/02/2019	26/02/2019	no hairs not sent
Maria River State Forest	4lt	4	Impact	E	04/07/2018	26/07/2018	no hairs not sent	12/02/2019	26/02/2019	no hairs not sent

SOC = side of carriageway; E = east; W = west

**Table 8: Hair tube analysis by Barbara Triggs of Dead Finish**

Season	Site	Tube ID	Mammal ID - definite	Mammal ID - probable
Winter	Site 1 Impact	1In	few rodent hairs	<i>Rattus</i> sp.
Winter	Site 1 Impact	1Id	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 1 Impact	1Ie	<i>Rattus rattus</i>	
Winter	Site 1 Impact	1Is	few fine hairs	rodent
Winter	Site 1 Impact	1Ih	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 1 Control	1Cp	one fine hair - no ID	
Winter	Site 1 Control	1Ci	one hair	<i>Trichosurus</i> sp.
Winter	Site 2 Impact	2Ii	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 2 Impact	2Ia	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 2 Impact	2Ib	few hairs	<i>Trichosurus</i> sp.
Winter	Site 2 Impact	2Ig	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 2 Impact	2In	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 2 Control	2Cc	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 2 Control	2Ca	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 2 Control	2Ce	few hairs	<i>Trichosurus</i> sp.
Winter	Site 2 Control	2Cr	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 2 Control	2Cs	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 2 Control	2Co	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 2 Control	2Cm	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 3 Impact	3Il	<i>Rattus</i> sp.	<i>R. rattus</i>
Winter	Site 3 Impact	3Ic	few hairs	<i>Trichosurus</i> sp.
Winter	Site 3 Impact	3Ih	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 3 Control	3Cs	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 3 Control	3Cb	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 4 Impact	4Ib	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 4 Impact	4Ia	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 4 Impact	4Ip	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 4 Impact	4Ik	few fine hairs	<i>Trichosurus</i> sp.
Winter	Site 4 Impact	4If	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 4 Impact	4Ig	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 4 Impact	4Ih	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 4 Impact	4Id	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 4 Impact	4Ie	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 4 Impact	4Ic	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 4 Control	4Ct	few fine hairs	<i>Trichosurus</i> sp.
Winter	Site 4 Control	4Co	one fine hair - no ID	
Winter	Site 4 Control	4Cs	few very fine hairs - no ID	
Winter	Site 4 Control	4Cm	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 4 Control	4Cg	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>

Season	Site	Tube ID	Mammal ID - definite	Mammal ID - probable
Winter	Site 4 Control	4Cr	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 4 Control	4Cp	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 4 Control	4Ca	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 4 Control	4Cb	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 4 Control	4Cc	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 4 Control	4Cd	one fine hair - no ID	
Winter	Site 4 Control	4Ce	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 4 Control	4Cf	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Winter	Site 4 Control	4Ci	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Summer	Site 4 Control	4Ch	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
Summer	Site 1 Impact	1Il	no hairs	
Summer	Site 1 Impact	1Ik	one fine hair - no ID	
Summer	Site 1 Impact	1Im	two rodent hairs	<i>Rattus</i> sp.
Summer	Site 1 Impact	1Ig	one hair	<i>Trichosurus</i> sp.
Summer	Site 1 Impact	1Ib	few fine hairs	<i>Trichosurus</i> sp.
Summer	Site 1 Impact	1If	no hairs	
Summer	Site 1 Impact	1Ip	no hairs	
Summer	Site 1 Control	1Ch	one hair	<i>Trichosurus</i> sp.
Summer	Site 1 Control	1Ck	no hairs	
Summer	Site 2 Impact	2Ia	<i>Trichosurus</i> sp.	
Summer	Site 2 Impact	2Ib	<i>Trichosurus</i> sp.	
Summer	Site 2 Impact	2Ic	<i>Trichosurus</i> sp.	
Summer	Site 2 Impact	2If	<i>Trichosurus</i> sp.	
Summer	Site 2 Impact	2Ie	<i>Trichosurus</i> sp.	
Summer	Site 2 Impact	2Id	<i>Trichosurus</i> sp.	
Summer	Site 2 Control	2Cb	<i>Trichosurus</i> sp.	
Summer	Site 2 Control	2Cc	<i>Trichosurus</i> sp.	
Summer	Site 2 Control	2Cd	<i>Trichosurus</i> sp.	
Summer	Site 2 Control	2Ce	<i>Trichosurus</i> sp.	
Summer	Site 2 Control	2Cg	<i>Trichosurus</i> sp.	
Summer	Site 2 Control	2Ch	<i>Trichosurus</i> sp.	
Summer	Site 2 Control	2Ct	<i>Trichosurus</i> sp.	
Summer	Site 2 Control	2Cm	one fine hair - no ID	
Summer	Site 2 Control	2Cs	few fine hairs	<i>Trichosurus</i> sp.
Summer	Site 2 Control	2Ci	few fine hairs	<i>Trichosurus</i> sp.
Summer	Site 2 Control	2Cp	one fine hair - no ID	
Summer	Site 2 Control	2Cq	<i>Trichosurus</i> sp.	
Summer	Site 2 Control	2Cr	<i>Trichosurus</i> sp.	
Summer	Site 3 Impact	3In	<i>Trichosurus</i> sp.	
Summer	Site 3 Control	3Cn	<i>Rattus</i> sp.	<i>R. rattus</i>

Season	Site	Tube ID	Mammal ID - definite	Mammal ID - probable
Summer	Site 4 Impact	4Ib	<i>Trichosurus sp.</i>	
Summer	Site 4 Impact	4Ic	<i>Trichosurus sp.</i>	
Summer	Site 4 Impact	4ID	<i>Trichosurus sp.</i>	
Summer	Site 4 Impact	4Ie	<i>Trichosurus sp.</i>	
Summer	Site 4 Impact	4Ig	<i>Trichosurus sp.</i>	
Summer	Site 4 Impact	4Ie	<i>Trichosurus sp.</i>	
Summer	Site 4 Control	4Ce	few fine hairs	<i>Trichosurus sp.</i>
Summer	Site 4 Control	4Cf	few fine hairs	<i>Trichosurus sp.</i>
Summer	Site 4 Control	4Cg	<i>Trichosurus sp.</i>	
Summer	Site 4 Control	4Ch	<i>Trichosurus sp.</i>	
Summer	Site 4 Control	4Ci	<i>Trichosurus sp.</i>	
Summer	Site 4 Control	4Ca	<i>Trichosurus sp.</i>	
Summer	Site 4 Control	4Cp	<i>Trichosurus sp.</i>	
Summer	Site 4 Control	4Cq	<i>Trichosurus sp.</i>	

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# Appendix D Yellow-bellied glider



# Yellow-bellied Glider Monitoring 2018

**Oxley Highway to Kempsey, Pacific Highway Upgrade**

Prepared for Roads and Maritime Services

April 2019

## Document control

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Project Director:	Rhidian Harrington
Project Manager:	Radika Michniewicz
Authors:	Jodie Danvers
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Local Government Area:	Kempsey and Port Macquarie Hastings

## Document revision status

Author	Revision number	Internal review	Date issued
Jodie Danvers	D0	Radika Michniewicz	20/2/2019
Jodie Danvers	D1	Radika Michniewicz	11/3/2019
Jodie Danvers and Radika Michniewicz	D2	Amanda Griffith	08/04/2019
Radika Michniewicz	R0		8/04/2019

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*Cover photograph:* Yellow-bellied Gliders (*Petaurus australis*) in a nest box north of the Project, immediately east of Tamban State Forest.

## Executive summary

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### **Context**

This report documents findings for the 2018 monitoring period, the first of three operational monitoring periods for the Yellow-bellied Glider (*Petaurus australis*), as required for the Oxley Highway to Kempsey (OH2K) Pacific Highway Upgrade Project (the Project) and specified in the Oxley Highway to Kempsey (OH2K) Ecological Monitoring Program (EMP, RMS 2016).

### **Aims**

The aim of the Yellow-bellied Glider monitoring program is to determine whether the Project is impacting the species. The aims of this report are to summarise the methods and results of the 2018 monitoring period and determine if performance measures are being met, as per the EMP

### **Methods**

Call playback and spotlighting surveys were carried out over three non-consecutive nights at three paired impact and reference sites. Call playback involved 10 minutes of active listening for vocalisations, intermittent call playback for 15 minutes followed by 10 minutes of active listening. Spotlighting was carried out along established 500 metre transects, with the observer walking at a rate of 30 minutes/500 metres.

### **Key Results**

During the 2018 monitoring period one Yellow-bellied Glider was detected during surveys at the Ballengarra impact site, where it had not been confirmed during baseline surveys. No Yellow-bellied Gliders were detected at either of the other two impact sites or any of the three reference sites during the surveys. However, additional monitoring data and incidental observations (from other ecological monitoring programs associated with the Project) confirmed presence of the species in the vicinity of the Maria River and Ballengarra impact sites.

### **Conclusions**

Performance measures for the 2018 monitoring period were partially met. Surveys were undertaken before and after the Project's construction at impact and reference sites, successfully meeting two of the three performance measures. The continued presence of Yellow-bellied Gliders at sites where it was identified during baseline surveys was met at the Maria River impact site only (through presence as detected via the other ecological monitoring associated with the Project). However the species was detected at the Ballengarra impact site for which there were no confirmed records during the baseline surveys. Ongoing presence at the remaining three sites where presence was confirmed during baseline surveys (Cairncross impact site, Ballengarra and Maria River reference sites) will continue to be assessed through future monitoring.

### **Management implications**

The following recommendations should be considered:

- It is recommended that monitoring continue as per the EMP to determine any trends in decline of the species.
- Continued use of additional data and incidental records is recommended to augment the confirmed records of the species in the relevant areas.

- It should be noted that continued presence of the Yellow-bellied Glider at the Maria River impact site was determined using additional data (from other ecological monitoring programs associated with the Project). Given that this species has predominantly been recorded on the eastern side of the carriageway, and that the transect is on the western side of the carriageway and runs behind residential properties with household pets and substantial backyard lighting, consideration should be given to moving the transect the east of the carriageway, where the baseline observation was made, if future surveys and additional data fail to detect an ongoing presence.

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# 1. Introduction

## 1.1 Context

The Oxley Highway to Kempsey (OH2K) section of the Pacific Highway Upgrade Project (the Project) was approved in 2012 subject to various Ministers Conditions of Approval (MCoA) and a Statement of Commitments (SoC). A subsequent approval with additional conditions of consent (CoA) was granted in 2014 by the Commonwealth Department of Environment (DoE) for Matters of National Environmental Significance (MNES) listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1995* (EPBC Act). The Ecological Monitoring Program (hereafter referred to as the EMP) (RMS 2016) combines these approval conditions and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project. The Yellow-bellied Glider (*Petaurus australis*) was one threatened species identified as requiring monitoring following the completion of the Projects' construction, during the operational phase.

### 1.1.1 Legal status

The Yellow-bellied Glider is listed as vulnerable under the New South Wales *Biodiversity Conservation Act 2016* (BC Act). Monitoring of the species is required under the Project's approval.

### 1.1.2 Monitoring framework

The design, methods and performance indicators that define the Yellow-bellied Glider monitoring program are specified in the EMP.

The EMP requires monitoring to occur in spring prior to commencement of construction and in August-December in Year 4, 6 and 8 (operational phase). To date, these monitoring events have been reported as follows:

- *Spring 2013*: Baseline report (Lewis 2014)
- *Spring 2018*: Current report.

This report therefore represents the first of three reports required for the operational phase monitoring.

### 1.1.3 Baseline data

Baseline surveys were conducted in spring prior to the commencement of construction by Lewis Ecological in 2013 (Lewis 2014). Surveys confirmed presence of Yellow-bellied Gliders at four of the six monitoring sites on at least one occasion. Individuals were primarily detected by calling, with only one site recording an observation.

**Table 1: Baseline survey results**

Site	Baseline
Cairncross impact	Recorded during two surveys. Detected during spotlighting. Responded to call playback.
Cairncross reference	No Yellow-bellied Gliders confirmed (unconfirmed calls recorded).
Ballengarra impact	No Yellow-bellied Gliders confirmed (unconfirmed calls recorded).
Ballengarra reference	Recorded during a single survey. Responded to call playback.
Maria River impact	Recorded during a single survey. Responded to call playback.
Maria River reference	Recorded during all three surveys. Responded to call playback.



#### **1.1.4 Purpose of this report**

This report details the findings of the first of three operational monitoring events for the Yellow-bellied Glider. The aims of this report are to summarise the methods and results of the 2018 monitoring and determine if performance measures are being met, as per the EMP.

### **1.2 Performance Measures**

The EMP specifies the following performance measures for the Yellow-bellied Glider:

- *Monitoring is undertaken before and after construction of the upgrade*
- *Monitoring is undertaken at impact and control sites*
- *Continued presence of Yellow-bellied Gliders at sites where it was identified during baseline surveys.*

### **1.3 Monitoring Timing**

Monitoring is to be undertaken between August and December in Year 4, 6 and 8 of the Project's operational phase. Surveys are to be undertaken in spring to coincide with high movement periods for the species which breeds between July and September and disperses between spring and summer.

### **1.4 Reporting**

As per the EMP, the annual reporting of monitoring results will include:

- Detailed description of monitoring methodology
- Results of the monitoring period
- Discussion of results, including how the results compare against performance measures, if any modifications to timing or frequency of monitoring periods or monitoring methodology are required and any other recommendations
- If contingency measures should be implemented.

All reports prepared under the EMP will be submitted to the Director General of the NSW Department of Planning and Environment (DP&E) and the NSW Environment Protection Authority (EPA).

### **1.5 Limitations**

Road noise at impact sites may negatively impact the ability to hear Yellow-bellied Gliders calling at a distance, particularly at the Maria River impact site, where the transect lies adjacent to the highway and passes behind residential properties.

## 2. Surveys Methods

### 2.1 Monitoring Sites

Monitoring was undertaken at impact and reference sites previously selected during baseline surveys (Lewis 2014) as shown in Figure 1. Impact sites were established within known Yellow-bellied Glider habitat and paired with reference sites of similar vegetation and habitat type.

**Table 2: Yellow-bellied Glider paired monitoring sites (adapted from Table 5-1 of Lewis 2014)**

Monitoring area	Treatment	Impact site	Paired reference site
Cairncross	Impact with mitigation (widened median)	Rawdon Creek Nature Reserve, west of carriageway	Cairncross State Forest approximately 10 kilometres west of impact site
Ballengarra	Impact with mitigation (aerial crossing structure)	Ballengarra State Forest, west of carriageway at Barry's Creek	Ballengarra State Forest approximately 5 kilometres west of impact site
Maria River	Impact with mitigation (reduced clearing limits)	Kalateenee State Forest, west of carriageway at Maria River	Maria River National Park approximately 5 kilometres east impact site

### 2.2 Survey Method

Surveys were undertaken in accordance with the EMP. At each monitoring site, call playback and spotlighting surveys were carried out over three non-consecutive nights in spring with a minimum of seven days between consecutive surveys.

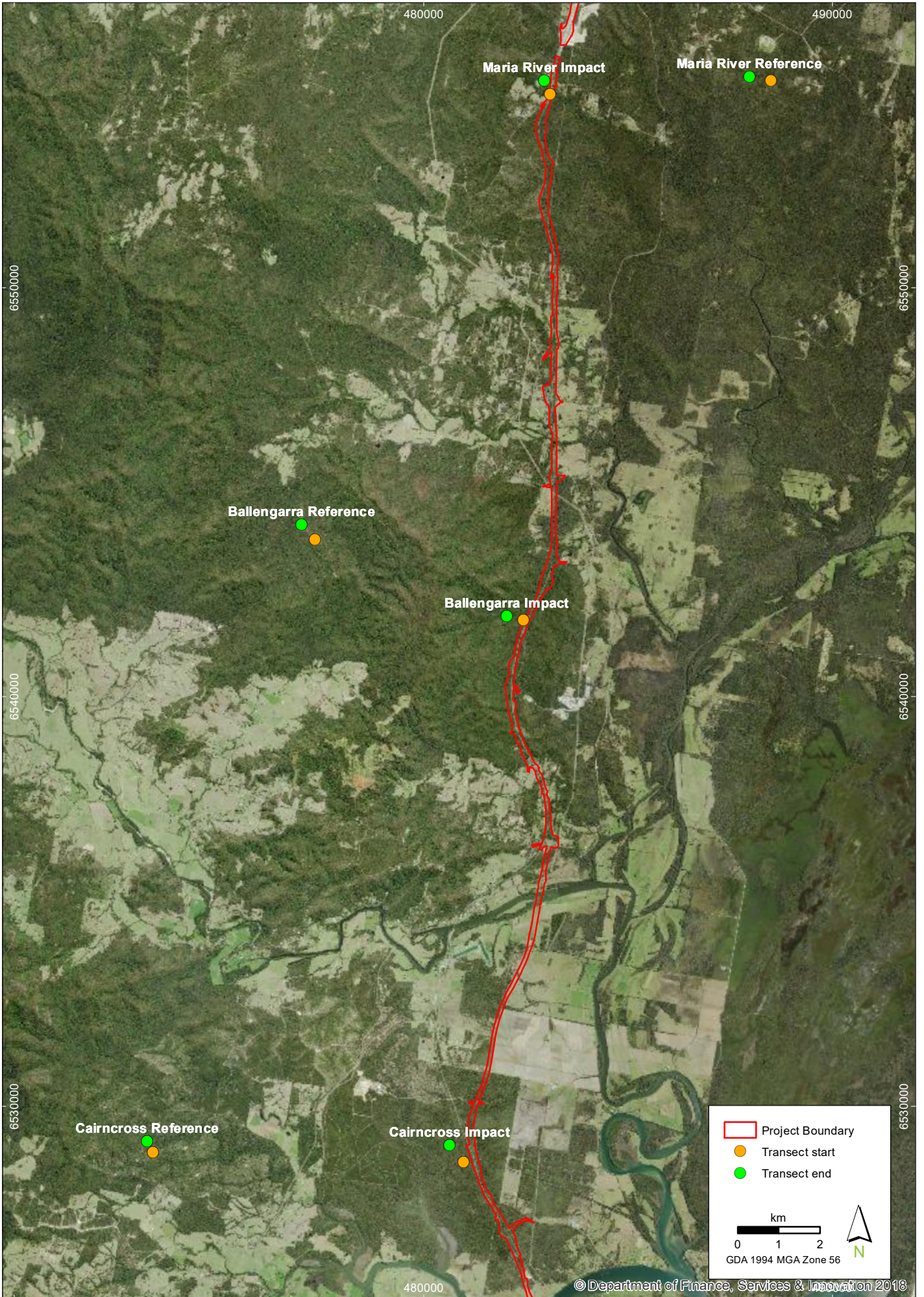
#### 2.2.1 Call playback

Upon arrival at site, 10 minutes of active listening for vocalisations was carried out followed by call playback. As per baseline surveys, Yellow-bellied Glider calls were played intermittently for 15 minutes to provoke a response. Calls of the Powerful Owl, Masked Owl and Sooty Owl were then used when the Yellow-bellied Glider calls failed to elicit a response. Call playback was followed by another 10 minute period of active listening. Vocalisations of this species can be heard up to 400 metres away.

#### 2.2.2 Spotlighting

Spotlighting was conducted along 500 metre transects, with the observer walking at a rate of 30 minutes/500 metres and continually listening for vocalisations. Transects were located along forest trails indicated by start and end points established during baseline surveys. Although this species is considered spotlight-shy, it may be detected by its frequent movements during foraging activities.

Drawn by: GT Project Manager: RM Project Number: 1702 PI 5.5 Date: 1/7/2019 T:\spatial\projects\1700\1702\_OH2K\_Ecology\Maps\PI\_5\_YBG\_Monitoring\1702\_PI\_55\_Figure\_1\_sites.mxd



### Yellow-bellied Glider Monitoring Sites

Pacific Highway Upgrade - Oxley Highway to Kempsey: Yellow-bellied Glider Monitoring

### 3. Results

Figure 2 shows the Yellow-bellied Glider 2018 monitoring records, and includes additional incidental Yellow-bellied Glider observations.

#### 3.1 2018 Monitoring Results

Results of call playback and spotlighting surveys are provided in Annex 1. A summary of the species detected at each site is provided below in Table 3.

Survey dates and weather conditions are provided in Annex 1. All surveys were undertaken during calm evenings without notable rainfall.

A single Yellow-bellied Glider was detected during spotlighting surveys at the Ballengarra impact site. A number of species such as the Feathertail Glider (*Acrobates pygmaeus*), Common Brushtail Possum (*Trichosurus vulpecula*), Common Ringtail Possum (*Pseudocheirus peregrinus*), Koala (*Phascolarctos cinereus*) and a Sooty Owl (*Tyto tenebricosa*) were also observed during spotlighting surveys. Sugar Gliders (*Petaurus breviceps*) were heard calling at Cairncross reference site and Ballengarra impact site.

Call playback surveys did not elicit responses by Yellow-bellied Gliders during the 2018 monitoring surveys, contrary to baseline surveys where all but one record were responses to call playback. A Sooty Owl responded to Yellow-bellied Glider call playback at the Cairncross reference site. No other responses to call playback were detected.

**Table 3: Summary of species detected during 2018 surveys**

Monitoring area	Impact site	Reference site
Cairncross	Feathertail Glider Common Ringtail Possum Koala	Sooty Owl Boobook ( <i>Ninox novaeseelandiae</i> ) Sugar Glider White-throated Nightjar ( <i>Eurostopodus mystacalis</i> ) Eastern Grey Kangaroo ( <i>Macropus giganteus</i> )
Ballengarra	Yellow-bellied Glider Sugar Glider Tawny Frogmouth ( <i>Podargus strigoides</i> )	Macropod species
Maria River	Common Brushtail Possum Echidna ( <i>Tachyglossus aculeatus</i> )	Common Ringtail Possum Common Brushtail Possum

#### 3.2 Additional Data

##### **Nest boxes**

Yellow-bellied Gliders have been recorded on four occasions occupying nest boxes during the nest box monitoring program that forms part of the Project’s ecological monitoring requirements. The nest boxes, listed in Table 4, occur within close proximity (within 100 metres) to two of the Yellow-bellied Glider impact sites; Maria River impact site and Ballengarra impact site (Figure 2).

##### **Incidental records**

During 2018 Giant Barred Frog surveys that form part of the Project’s ecological monitoring requirements, the Yellow-bellied Glider was heard calling from the Giant Barred Frog Maria River impact site (located approximately 105 metres to the east of the Yellow-bellied Glider Maria River impact site) and observed at

the Giant Barred Frog Piper’s Creek reference site (approximately 6.2 kilometres south of the Yellow-bellied Glider Ballengarra reference site).

**Table 4: Yellow-bellied Glider nest box records**

Nest box type	No. Individuals	Survey period	Area
Large glider	2	Summer 2017	Maria River
Possum	2	Winter 2017	Maria River
Small Owl	1	Summer 2018	Maria River
Large Glider	1	Summer 2018	Ballengarra

### 3.3 Comparison to Baseline Surveys

Table 5 provides a comparison of baseline survey results with the 2018 monitoring and additional records. The additional records have been included in the determination of ongoing presence of the species in monitoring areas. An additional record was considered as representing presence in a monitoring area when that record occurred within 500 metres of the transect location. This is based on a conservative estimate of Yellow-bellied Glider home ranges of 20 hectares and their call range (OEH 2017).

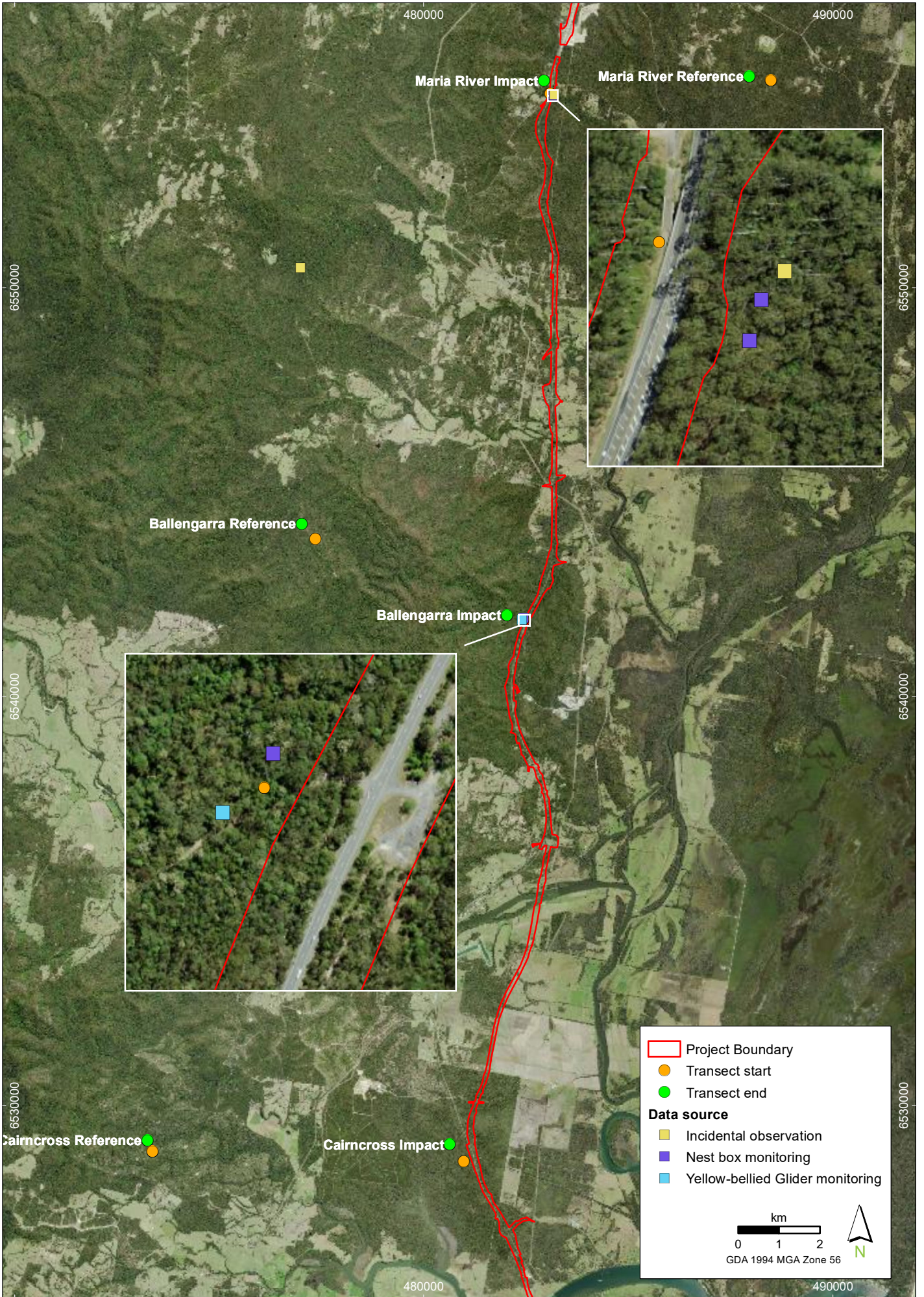
The continued presence of the Yellow-bellied Glider and the Maria River impact site has been confirmed using additional data. While not confirmed during the baseline surveys, it has also been found to be present at the Ballengarra impact site. Presence/ongoing presence at the remaining four sites will continue to be assessed through future monitoring.

**Table 5: Yellow-bellied Glider records**

Site	Baseline	2018 monitoring	Additional data	2018 ongoing presence analysis
Cairncross impact	Present (2)	0	0	Not detected
Cairncross reference	0	0	0	Not previously confirmed
Ballengarra impact	0	Present (1)	Present (1)	Present (new record)
Ballengarra reference	Present (1)	0	0	Not detected
Maria River impact	Present (1)	0	Present (4)	Ongoing presence
Maria River reference	Present (3)	0	0	Not detected

(#) = Number of surveys recording/incidental records of Yellow-bellied Gliders.

Drawn by: GT Project Manager: RM Project Number: 1702 PI 5.5 Date: 4/8/2019 T:\spatial\projects\1702\_OH2K\_Ecology\Maps\PI\_5\_Ecology\Maps\PI\_5\_Ecology\_OH2KPI\_5\_YBG\_Monitoring\1702\_PI\_55\_Figure\_2\_sites.mxd



### Yellow-bellied Glider Monitoring Results and Additional Data

Pacific Highway Upgrade - Oxley Highway to Kempsey: Yellow-bellied Glider Monitoring

**FIGURE 2**

Imagery: (c) LPI 2014

## 4. Discussion

### 4.1 Performance Measures

A summary of the 2018 survey results in relation to the performance measures is provided in Table 6.

**Table 6: Summary of performance measures for the 2018 monitoring period.**

Performance measure	Discussion
Monitoring is undertaken before and after construction of the upgrade.	<p><b>This performance measure has been met.</b></p> <p>Baseline monitoring was undertaken prior to construction in 2013 (Lewis 2014) and after completion of the upgrade (operational) in spring 2018 (current report). Monitoring will continue as per the EMP in Year 6 and 8.</p>
Monitoring is undertaken at Impact and Control sites.	<p><b>This performance measure has been met.</b></p> <p>Monitoring was undertaken at the paired impact-control (reference) sites established during baseline surveys.</p>
Continued presence of Yellow-bellied Gliders at sites where it was identified during baseline surveys.	<p><b>This performance measure has been met for one of the four relevant sites.</b></p> <p>Yellow-bellied Gliders were confirmed at four of the six sites during the baseline surveys; Maria River impact and reference site, Cairncross impact site and Ballengarra reference site.</p> <p>Ballengarra impact and Cairncross reference sites did not record confirmed presence during baseline surveys.</p> <p>2018 monitoring (including additional data) recorded Yellow-bellied Gliders at the Ballengarra (not confirmed during baseline surveys) and Maria River impact sites.</p> <p>Presence was not detected during the 2018 monitoring period at the remaining three sites where it was identified during baseline surveys. Therefore, this performance measure has not been met for two reference sites (Ballengarra and Maria River) and one impact site (Cairncross).</p>

## 5. Recommendations

### 5.1 Contingency Measures and Recommendations

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those that are considered relevant to the Yellow-bellied Glider monitoring are listed and discussed in Table 7. The following recommendations should be considered:

- It is recommended that monitoring continue as per the EMP to determine any trends in species decline.
- Continued use of additional data and incidental records is recommended to augment the confirmed records of the species in the relevant areas.
- It should be noted that continued presence of the Yellow-bellied Glider at the Maria River impact site was determined using additional data. Given that this species has predominantly been recorded on the eastern side of the carriageway, and that the transect is on the western side of the carriageway and runs behind residential properties with household pets and substantial backyard lighting, consideration should be given to moving the transect to the east of the carriageway, where the baseline observation was made, if future surveys and additional data fail to detect an ongoing presence.

**Table 7: Contingency measures**

Potential Problem	Contingency Measure	Discussion of proposed measure
Decline in presence of target species recorded at impact sites after the upgrade has been complete, compared to change in control sites.	<p>The cause of decline in populations at impact sites will be investigated in consultation with EPA and DOTE within two weeks of results reported by ecologist.</p> <p>If the cause of decline is considered most likely attributed to the upgrade of the highway (and not another event such as bushfire), mitigation measures, such as the location and types of fauna crossings and fauna fencing will be reviewed within two months of the above consultation being completed.</p>	<p>Detection of the Yellow-bellied Glider at impact sites during 2018 surveys was lower than baseline surveys. However, this was consistent with reference sites and therefore cannot be attributed to the Project.</p> <p>2018 monitoring confirmed presence at two of the three impact sites. Maria River had confirmed presence in both survey periods, while Cairncross was confirmed during baseline surveys and absent during 2018 surveys, and Ballengarra impact sites recorded presence for 2018 but not during baseline surveys.</p> <p><b>This contingency measure is not considered relevant at this stage.</b></p>



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Lewis (2014). Oxley Highway to Kempsey. Pre-construction Baseline Monitoring: Winter-Summer. Prepared by Lewis Ecological.

OEH (2017). *Yellow-bellied Glider - Profile*. Available online: <https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10601> accessed 5 March 2019.

RMS (2016). Oxley Highway to Kempsey Pacific Highway Upgrade Ecological Monitoring Program. Roads and Maritime Update to report prepared by SMEC Hyder Joint Venture, August 2016.

## Annex 1 – Monitoring Results

**Table 8: 2018 Yellow-bellied Glider monitoring results**

Date	Site	Site type (reference/ impact)	ID type (seen/heard)	Fauna type	Species
31/10/2018	Cairncross SF reference	reference	heard	Bird	Sooty Owl* ( <i>Tyto tenebricosa</i> )
31/10/2018	Cairncross SF reference	reference	heard	Bird	Southern Boobook ( <i>Ninox novaeseelandiae</i> )
31/10/2018	Cairncross SF reference	reference	heard	Mammal	Sugar Glider ( <i>Petaurus breviceps</i> )
31/10/2018	Cairncross SF impact	impact	seen	Mammal	Feathertail Glider ( <i>Acrobates pygmaeus</i> )
06/11/2018	Maria River SF impact	impact	seen	Mammal	Common Brushtail Possum ( <i>Trichosurus vulpecula</i> )
08/11/2018	Ballengarra SF reference	reference	heard	Mammal	Macropod species
08/11/2018	Ballengarra SF impact	impact	seen	Mammal	Yellow-bellied Glider ( <i>Petaurus australis</i> )
14/11/2018	Cairncross Ref	reference	heard	Mammal	Sugar Glider
20/11/2018	Maria River SF reference	reference	seen	Mammal	Common Ringtail Possum ( <i>Pseudocheirus peregrinus</i> )
20/11/2018	Maria River SF reference	reference	seen	Mammal	Common Brushtail Possum
20/11/2018	Maria River SF impact	impact	seen	Mammal	Echidna ( <i>Tachyglossus aculeatus</i> )
22/11/2018	Ballengarra SF impact	impact	heard	Mammal	Sugar Glider
22/11/2018	Ballengarra SF impact	impact	seen	Bird	Tawny Frogmouth ( <i>Podargus strigoides</i> )
27/11/2018	Cairncross SF impact	impact	seen	Mammal	Koala ( <i>Phascolarctos cinereus</i> )
27/11/2018	Cairncross SF impact	impact	seen	Mammal	Feathertail Glider
27/11/2018	Cairncross SF impact	impact	seen	Mammal	Common Ringtail Possum
04/12/2018	Cairncross SF reference	reference	heard	Bird	White-throated Nightjar ( <i>Eurostopodus mystacalis</i> )
04/12/2018	Cairncross SF reference	reference	seen	Mammal	Eastern Grey Kangaroo ( <i>Macropus giganteus</i> )

\* responded to Yellow-bellied Glider call playback

**Table 9: 2018 Yellow-bellied Glider survey data**

Site	Replicate	Date	Temp (°C)	Rain (mm)	Wind (rating 1 = lowest, 3 = highest)
Cairncross SF impact	1	31/10/2018	20	0	0
Cairncross SF reference	1	31/10/2018	24	0	0
Ballengarra SF impact	1	30/10/2018	20	0	1
Ballengarra SF reference	1	30/10/2018	17.5	0	1
Maria River SF impact	1	29/10/2018	17.5	0	0
Maria River SF reference	1	29/10/2018	18.6	0	0
Cairncross SF impact	2	14/11/2018	21	0	0
Cairncross SF reference	2	14/11/2018	22	1	0
Ballengarra SF impact	2	08/11/2018	12	0	1
Ballengarra SF reference	2	08/11/2018	16.1	0	1
Maria River SF impact	2	06/11/2018	23	0	0
Maria River SF reference	2	06/11/2018	24.6	0	0
Cairncross SF impact	3	27/11/2018	22	0	0
Cairncross SF reference	3	04/12/2018	21.3	0	0
Ballengarra SF impact	3	22/11/2018	21.4	0	1
Ballengarra SF reference	3	22/11/2018	23.4	0	1
Maria River SF impact	3	20/11/2018	20.3	0	1
Maria River SF reference	3	20/11/2018	20.9	0	1

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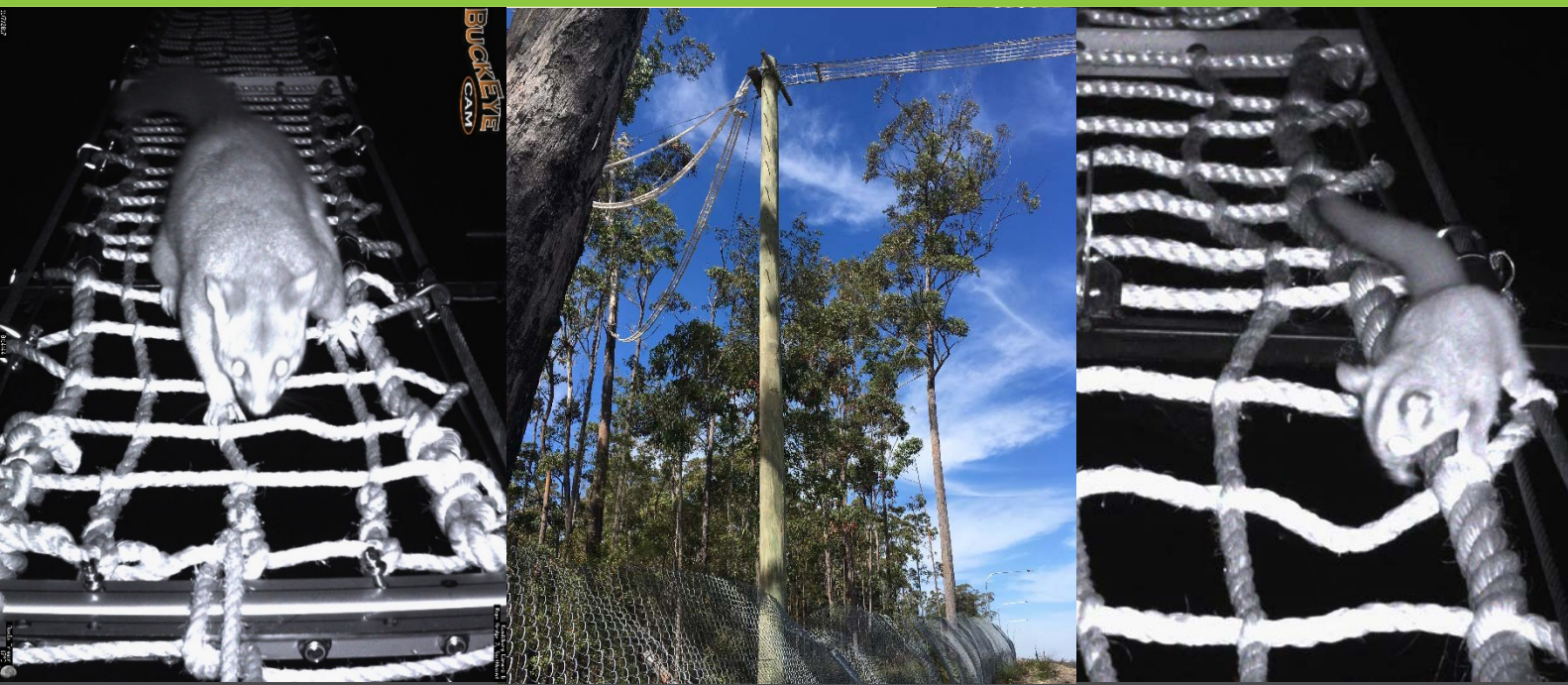
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## Appendix E Aerial Crossing (Glider poles and rope bridges)



# Aerial Crossing Monitoring 2018

**Oxley Highway to Kempsey, Pacific Highway Upgrade**

**Prepared for Roads and Maritime Services**

**May 2019**

## Document control

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Project Director:	Rhidian Harrington
Project Manager:	Radika Michniewicz
Authors:	Jodie Danvers
Internal review:	Radika Michniewicz, Amanda Griffith
Document status:	Rev 0
Local Government Area:	Kempsey and Port Macquarie Hastings

## Document revision status

Author	Revision number	Internal review	Date issued
Jodie Danvers	D1	Radika Michniewicz	10/04/2019
Jodie Danvers	D2	Radika Michniewicz	13/05/2019
Radika Michniewicz	D3	Amanda Griffith	14/05/2019
Radika Michniewicz	R0		

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*Cover photograph: Brushtail Possum on Rope Bridge 2 (left), Rope Bridge 2 (middle), Sugar Glider foraging on Rope Bridge 1 (right).*

## Executive Summary

---

### **Context**

This report documents findings for the 2018 monitoring period, the first of three monitoring periods for the aerial crossings, as required for the Oxley Highway to Kempsey (OH2K) Pacific Highway Upgrade Project (the Project) and specified in the Oxley Highway to Kempsey (OH2K) Ecological Monitoring Program (EMP, RMS 2016).

### **Aims**

The aim of the aerial crossing monitoring program is to determine whether the aerial crossings, rope bridges and gliders poles, are being used by the target arboreal fauna species. The aims of this report are to summarise the methods and results of the 2018 monitoring period and determine if performance measures are being met, as per the EMP.

### **Methods**

In accordance with the EMP, three rope bridges (RB1, RB2 and RB3) and three glider pole (GP1, GP2 and GP3) crossings in the northern Kundabung to Kempsey (Ku2K) section of the Project were monitored in autumn 2018 and late spring/early summer of 2018. Monitoring involved the use of automated cameras for a period of 60 consecutive days, hair tube deployment on rope bridge poles and 50 metre radius searches around crossing poles for dead animals or road kill.

### **Key Results**

A successful crossing was considered to have occurred if an individual animal was detected using the median glider pole or was detected in rapid succession at both the western and eastern ends of the rope bridge. In summary:

- The eastern rope bridge poles at RB1 and RB2 have shown use by indicator species including the Feathertail Glider, Sugar Glider and Brushtail Possum. However, there were no fauna records on the western poles to indicate a successful crossing.
- Arboreal fauna were not recorded using RB3.
- Glider crossings GP2 and GP3 have been successfully used by indicator glider species including the Feathertail Glider and Sugar Glider. No fauna were detected using GP1.
- No targeted threatened species were detected during the 2018 monitoring.
- No dead or injured fauna were recorded within 50 metres of the aerial crossings during road kill surveys or 50 metre perimeter searches.

### **Conclusions**

Performance measures were partially met following the 2018 monitoring period. One of the three rope bridges (RB2) showed possible evidence of a complete crossing by native fauna, however none of the rope bridges showed use by the targeted threatened species. Two of the three glider pole crossings showed evidence of use by native gliders known to the Project area, but have not shown use by the target threatened species. No native fauna were identified as road kill within 50 metres of the aerial crossings during the 2018 monitoring program.



### ***Management Implications***

A number of recommendations have been made to address proposed contingency measures and include:

- Maintenance and/or replacement of non-functioning cameras as soon as possible.
- Increasing monitoring period from current two 60-day monitoring periods over one year, to continuous monitoring/downloading during monitoring and non-monitoring years.
- Continuous downloading of camera images following completion of the required maintenance to establish correct functioning of all cameras. If fauna records remain minimal or absent, a review of the connectivity of the crossing structures, including surrounding vegetation and installation of leader ropes or ladders, is recommended.

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# 1. Introduction

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## 1.1 Context

The Oxley Highway to Kempsey (OH2K) section of the Pacific Highway Upgrade Project (the Project) was approved in 2012 subject to various Ministers Conditions of Approval (MCoA) and a Statement of Commitments (SoC). A subsequent approval with additional conditions of consent (CoA) was granted in 2014 by the Commonwealth Department of Environment (DoE) for Matters of National Environmental Significance (MNES) listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1995* (EPBC Act). The Ecological Monitoring Program (hereafter referred to as the EMP) (RMS 2016) combines these approval conditions and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project.

Aerial crossings have been installed to reduce the impacts on fauna, facilitate movement and maintain habitat connectivity for existing glider/arboreal mammal populations. These structures are to be monitored to assess their effectiveness in maintaining habitat connectivity, as required by the EMP.

### 1.1.1 Monitoring framework

The design, methods and performance indicators that define the aerial crossing monitoring program are specified in the EMP.

The EMP requires monitoring to occur in autumn and late spring/early summer in Years 4, 6 and 8 (operational phase) of the Project. The EMP specifies that additional monitoring may be required if the aerial crossings are found to be ineffective and require modification.

This report represents the first of three reports required for the aerial crossing monitoring – Year 4 autumn and spring/summer 2018.

### 1.1.2 Background data

The installation of aerial crossings was employed as a means of mitigating the barrier effects of roads on gliders and arboreal mammals. Section 2.2.4 of the EMP states:

*“The effectiveness of wildlife crossings will be based on their use by fauna groups previously recorded in proximity to the Project (<one kilometre). It is assumed that the Project bisects the habitat of at least some individuals from each of the nominated fauna groups (Table 4). Fauna species known to occur within the Project area that may be potentially adversely affected by the upgrade are listed in Table 5. These species will indicate the successful usage of crossing structures.”*

Gliding and arboreal fauna potentially impacted by habitat fragmentation and the barrier effect of the Project are provided in Table 1. The EMP states that *“some of these species will be used as indicator species to measure the success of fauna crossings”*. Table 2 lists the target gliders and arboreal mammals and the indicator species to be used to assess crossing use. The use of aerial crossings by indicator and target species from Table 2 will be discussed.

**Table 1: Species that are known or likely to occur in the Project area potentially impacted by habitat fragmentation (from Table 4 of the EMP)**

Fauna group	Species	Occurrence in Project Area
Gliders	Feathertail Glider ( <i>Acrobates pygmaeus</i> )	Known
	Yellow-bellied Glider ( <i>Petaurus australis</i> )	Known
	Sugar Glider ( <i>Petaurus breviceps</i> )	Known
	Squirrel Glider ( <i>Petaurus norfolcensis</i> )	Moderate likelihood
Arboreal mammals	Koala ( <i>Phascolarctos cinereus</i> )	Known
	Common Brushtail Possum ( <i>Trichosurus vulpecula</i> )	Known
	Common Ringtail Possum ( <i>Pseudocheirus peregrinus</i> )	Known
	Brush-tailed Phascogale ( <i>Phascogale tapoatafa</i> )	High likelihood

**Table 2: Indicator and target species to assess usage of crossings (from Table 5 of the EMP)**

Fauna group	Indicator species (known from Project area)	Target (threatened) species
Arboreal mammals	Brushtail Possum, Ringtail Possum	Brush-tailed Phascogale
Koala	Koala	Koala
Gliders	Sugar Glider, Feathertail Glider	Squirrel Glider, Yellow-bellied Glider

### 1.1.3 Purpose of this report

This report details the findings of the first of three monitoring periods for the aerial crossings. The aims of this report are to summarise the methods and results of the 2018 monitoring and determine if performance measures are being met, as per the EMP.

## 1.2 Performance Measures

The EMP specifies the following performance measures for rope bridges:

- Complete crossing of the rope bridge, (through camera monitoring or other evidence of completed crossings (i.e. ear tags, notches)), by a diversity of native arboreal fauna species known to occur in the Project area, such as Brushtail possum or Sugar glider.
- Complete crossing of the rope bridge, (through camera monitoring or other evidence of completed crossings (i.e. ear tags, notches)), by arboreal target species (Brush-tailed Phascogale, Squirrel Glider, or Yellow-bellied Glider).
- Lower rates of road kill arboreal species in proximity to rope bridges than in sections of the upgrade away from crossing studies.

The EMP specifies the following performance measures for glider poles:

- Evidence of use of glider poles by native gliders known to occur in the Project area, such as the Sugar Glider.
- Evidence of use of glider poles by arboreal target species (Squirrel Glider, or Yellow-bellied Glider).
- Lower rates of road kill gliders in proximity to glider poles than in sections of the upgrade away from crossing structures.

### 1.3 Monitoring Timing

Monitoring is to be undertaken in Years 4, 6 and 8 of the Project's operational phase. Monitoring is to occur in late autumn and late spring/early summer each year for a minimum of 60 days. The timing of monitoring coincides with breeding seasons and dispersal periods for target and other gliding or arboreal species known from the Project area. Arboreal species' movements increase in autumn as individuals seek flowering resources and in spring as individuals disperse post-breeding.

### 1.4 Reporting

Annual reporting of monitoring results will outline:

- Detailed description of monitoring methodology
- Results of the monitoring period
- Discussion of results, including how the results compare against performance measures, if any modifications to timing or frequency of monitoring periods or monitoring methodology are required and any other recommendations
- If contingency measures should be implemented.

All reports prepared under the EMP will be submitted to the Director General of the Department of Planning and Environment and the Environment Protection Authority.

### 1.5 Limitations

The following limitations to the monitoring procedure were encountered:

- The camera detection system is designed to maximise the likelihood that any animal using the structures is photographed, i.e. the cameras are fitted with motion detectors triggered to take photographs as animals pass by and the glider poles also have collars to force the animals through a single gap where the camera is trained. However, the highly mobile nature of gliders may result in their arrival on the structures at a variety of locations, all of which cannot be captured by the cameras. As a result complete passage across the structure/road may not always be captured. This limitation applies to both glider poles and rope bridges.
- Trapping is not required as a part of the monitoring program. Therefore, evidence of a complete crossing cannot be assessed using additional methods, as described in the rope bridge performance measures (i.e. ear tags, notches).

## 2. Surveys Methods

### 2.1 Monitoring Sites

The Project involved the installation of eleven rope bridge and seven glider pole crossings. Of these, three rope bridge crossings and three glider pole crossings in the northern Kundabung to Kempsey (Ku2K) section of the Project are to be monitored. Details of the monitored crossings, including nominated target and indicator species, are provided in Table 3 and their location is provided in Figure 1.

Rope bridge crossings consist of a single rope crossing between two poles on either side of the carriageway. Glider crossings consist of three poles, one on the eastern and western sides of the carriageway and one in the median, allowing gliders to traverse the highway.

**Table 3: Monitored aerial crossings (adopted from Tables 4, 5, 14, 15 and 16 of the EMP)**

Crossing name	Crossing type	Target species	Indicator species
RB1	rope bridge 1	Yellow-bellied Glider, Squirrel Glider, Brush-tailed Phascogale*	Brushtail Possum, Ringtail Possum, Sugar Glider, Feathertail Glider
RB2	rope bridge 2	Yellow-bellied Glider, Squirrel Glider, Brush-tailed Phascogale*	Brushtail Possum, Ringtail Possum, Sugar Glider, Feathertail Glider
RB3	rope bridge 3	Yellow-bellied Glider, Squirrel Glider, Brush-tailed Phascogale*	Brushtail Possum, Ringtail Possum, Sugar Glider, Feathertail Glider
GP1	glider pole 1	Yellow-bellied Glider, Squirrel Glider	Sugar Glider, Feathertail Glider
GP2	glider pole 2	Yellow-bellied Glider, Squirrel Glider	Sugar Glider, Feathertail Glider
GP3	glider pole 3	Yellow-bellied Glider, Squirrel Glider	Sugar Glider, Feathertail Glider

\*The Brush-tailed Phascogale was excluded from the target species in Table 14 of the EMP but included as a target species in Table 15, and has therefore been considered a target species for all rope bridge crossings.

### 2.2 Survey Methods

#### 2.2.1 Remote cameras

Automated cameras were installed at each crossing structure. A single camera was installed on each median glider pole and at each end of the rope bridge crossing. Customised surveillance systems were installed at rope bridge and glider crossings using BuckEye Cam X7D Covert IR wireless surveillance cameras (minimum response time 200 milliseconds) and standard antennae. Cameras were mounted on a customised adjustable camera mount or strut. Power was provided via a solar panel and extension power cable connected to a battery housing near ground level, which is mounted on each pole. Each median glider pole was fitted with a collar to direct animals toward the camera in order to capture their image. Rope bridge poles were fitted with an external dual active infra-red sensor to trigger cameras. All cameras were calibrated for short focus and reduced infrared output to maximise species identification. These devices were specifically designed by Faunatech Pty Ltd for these crossing structures. Images were downloaded wirelessly to ground level via X-Manager software installed on a laptop. Images were downloaded from two 60-day periods; one in late autumn and one in late spring/early summer. However, where possible, downloaded images that occurred outside of the specified monitoring periods were retained and used as value adding data.

### **2.2.2 Hair tubes**

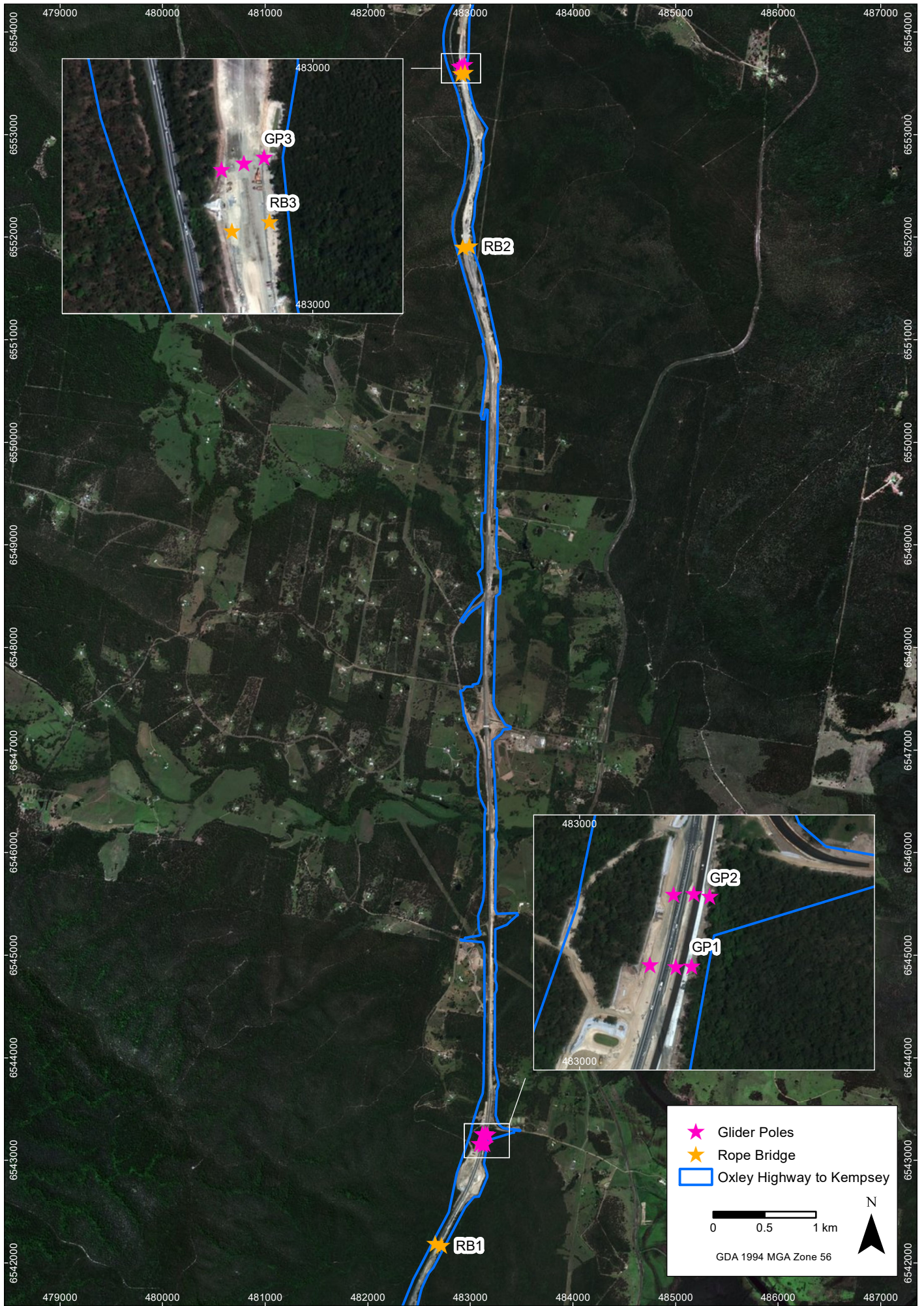
Hair tubes were installed on the pole at each end of the rope bridge structures only and left in place for 14 consecutive nights during both monitoring periods. Each hair tube was baited with a mixture of oats and peanut butter. Hair samples were sent to Barbara Triggs ('Dead Finish') for analysis, and were identified to species level where possible.

### **2.2.3 Perimeter search**

At each download, the ground within a 50 metre radius of both rope bridge poles and glider poles was inspected for any dead animals or road kill. Data collected during the road kill surveys as part of the ecological monitoring for the Project were also assessed for road kill within 50 metres of the crossing poles.



Drawn by: MH Project Manager: RM Project Number: 1702 5.10 Date: 4/11/2019



Location of monitored aerial crossings

Aerial Crossing Monitoring: Pacific Highway Upgrade – Oxley Highway to Kempsey

**FIGURE 1**

Imagery: (c) LPI 2009-04-17

## 3. Results

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Raw data and camera details for the autumn and spring/summer 2018 monitoring periods are presented in Annex 1.

### 3.1 Remote Cameras

Combined results from autumn and spring/summer 2018 monitoring for the rope bridge and glider pole crossings are presented in Table 4 and Table 5 respectively.

The sixty day monitoring periods were 7 March - 7 May 2018 (autumn) and 26 October - 24 December 2018 (late spring/early summer). However, data downloading was undertaken by Roads and Maritime prior to the first monitoring period in February 2018, and all images present on the cameras at the time of downloading were retained by Niche. Fauna records obtained outside the nominated 60-day monitoring period were included in the results as they are considered to provide potentially valuable data.

#### 3.1.1 Rope bridge crossings

All six cameras provided a signal for the autumn 2018 monitoring period, however spring/summer data was not available for the western pole at RB2 (camera 5) as this camera was not able to be accessed by the downloading computer. At the time of writing this report Roads and Maritime were in the process of investigating maintenance/replacement options for the malfunctioning camera.

Photographic data was analysed for the detection of the same species in rapid succession at both the western and eastern ends of the rope bridge crossings as an indication of a successful crossing. No rapid succession records were obtained.

The eastern poles at RB1 and RB2 were used by nominated indicator species including the Feathertail Glider, Sugar Glider and Brushtail Possum, however no fauna species has been detected on the western poles. A possible successful crossing of RB2 occurred in November 2017 prior to the first autumn 2018 monitoring event, whereby a Brushtail Possum was recorded heading west from the eastern RB2 pole, a second Brushtail Possum was then recorded by the same camera approximately 14 minutes later heading east back towards the eastern RB2 pole. It is considered likely that this is the same individual. The lack of image at the western pole of RB2 (camera 5) may indicate an incomplete crossing, or failure of camera 5 to capture the image. Camera 5, while providing a signal until no later than October 2018, had not recorded an image since October 2017. RB3 has not recorded use by arboreal species to date. No target threatened species have been recorded using the rope bridges.

Rapid visual assessment of rope bridge pole positioning identified the apparent isolation of the eastern and western poles of RB3 from the adjacent vegetation. Contrary to RB1 and RB2 poles that are within the canopy trees of the surrounding habitat, RB3 poles are approximately 10–15 metres from the adjacent vegetation, to which they are connected by leader ropes.

It should be noted that 19 of the 31 arboreal fauna records (61%) on rope bridge crossings occurred outside of the specified monitoring periods. This data revealed one species, the Brushtail Possum, that would otherwise not have been detected using rope bridge crossings to date.

**Table 4: Fauna use of rope bridge crossings autumn and spring/summer\* 2018**

Species	RB1		RB2		RB3	
	Eastern (camera 2)	Western (camera 1)	Eastern (camera 6)	Western* (camera 5)	Eastern (camera 8)	Western (camera 7)
Feathertail Glider	Y (14)		Y (9)			
Brushtail Possum			Y (1)			
Sugar Glider	Y (4)					

(n) = number of separate occasion the species was detected. \* spring/summer data not available for RB2 western pole

### 3.1.2 Glider crossings

All three cameras provided a signal during the autumn 2018 monitoring period, however spring/summer data is not available for GP1 and GP3 as cameras were not able to be accessed by the downloading computer. At the time of writing this report Roads and Maritime were in the process of investigating maintenance/replacement options for the malfunctioning cameras.

A successful crossing is considered to have occurred if an individual animal is detected using the median pole. Feathertail Gliders and Sugar Gliders were detected using both GP2 and GP3 on at least one occasion, events that are therefore considered as successful crossings. GP2 and GP3 have therefore been successfully used by indicator glider species whilst GP1 has not detected a single crossing by indicator or target species. Target threatened species have not been detected using any of the glider crossings. The absence of records from GP1 may require further examination, given the close proximity of this pole to GP2.

It should be noted that six of the seven glider pole records (86%) occurred prior to the first autumn 2018 monitoring and revealed one species, the Sugar Glider, which would otherwise not have been detected using glider poles to date.

**Table 5: Fauna use of glider crossings during autumn and spring/summer\* 2018**

Species	GP1 (camera 3)	GP2 (camera 4)	GP3 (camera 9)
Feathertail Glider		Y (1)	Y (4)
Sugar Glider		Y (1)	Y (1)

(n) = number of separate occasions the species was detected. \* spring/summer data not available for GP1 and GP3.

### 3.1.3 Camera maintenance

Camera operating status as of the last download event on 7 January 2019 is provided in Table 6. Note that the last photo recorded represents any photograph, which indicates functional operation.

**Table 6: Camera operating status**

Camera	Crossing	Location	Status January 2019
1	RB1	W	Last photo 7/1/2019
2	RB1	E	Last photo 16/11/2018
3	GP1	M	Last photo 9/05/2018. Computer/antennae not detecting January 2019 download.
4	GP2	M	Last photo 26/10/2018
5	RB2	W	Last photo 31/10/2017. Computer/antennae not detecting January 2019 download.
6	RB2	E	Last photo 20/12/2018
7	RB3	W	Last photo 4/10/2017
8	RB3	E	Last photo 4/10/2017
9	GP3	M	Last photo 18/2/2018. Computer/antennae not detecting January 2019 download.

### **3.2 Hair Tubes**

Hairs were recorded only at the western and eastern poles of RB3 during the autumn monitoring period. One fine hair was observed in both tubes but could not be identified.

No hairs were recorded during the spring/summer monitoring period.

### **3.3 Road Kill and 50 metre Perimeter Search**

No dead animals were recorded during the 50 metre perimeter searches around each pole. Road kill surveys undertaken as part of the ecological monitoring for the Project recorded no fauna within 50 metres of the arboreal crossing structures during the spring 2018 surveys.

## 4. Discussion

### 4.1 Performance Measures

A summary of the 2018 survey results in relation to the performance measures is provided in Table 7 and Table 8.

**Table 7: Indicators of success for rope bridge crossings**

Performance measure	Discussion
Complete crossing of the rope bridge, (through camera monitoring or other evidence (i.e. ear tags, notches)), by a diversity of native arboreal fauna species known to the project area, such as Brush tail possum or Sugar glider.	<p><b>This performance measure has not been met.</b></p> <p>No individual has been recorded using both sides of a crossing in rapid succession. One record from RB2 shows a Brushtail Possum heading west and then the same species heading east approximately 14 minutes later. This may be the same individual and may represent a complete crossing however this cannot be confirmed due to the absence of a record from the western pole. It is possible that the western camera had already malfunctioned at this point or that the animal turned back prior to reaching the western end.</p> <p>Arboreal fauna have been detected on the eastern poles of RB1 and RB2, however, the majority of fauna detected using the rope bridges are glider species. As gliders may arrive and depart from the rope bridge at an undefined point, they may do so without triggering the second camera.</p> <p>The absence of scansorial fauna and few records of non-gliding arboreal mammals is noted.</p>
Complete crossing of the rope bridge, (through camera monitoring or other evidence (i.e. ear tags, notches)), by arboreal target species (Brush-tailed Phascogale, Squirrel Glider, or Yellow-bellied Glider).	<p><b>This performance measure has not been met.</b></p> <p>Arboreal target species were not recorded using the rope bridge crossings.</p>
Lower rates of road kill arboreal species in proximity to rope bridge than in sections of the upgrade away from crossing structures.	<p><b>This performance measure has been met.</b></p> <p>No road kill was observed within 50 metres of the aerial crossings.</p>

**Table 8: Indicators of success for glider poles**

Performance measure	Discussion
Evidence of use of glider poles by native gliders known to occur in the Project area, such as Sugar Glider.	<p><b>This performance measure has been met by two of the three crossings.</b></p> <p>Feathertail Gliders and Sugar Gliders were recorded using median glider poles GP2 and GP3, indicating a successful crossing. No gliders were recorded at GP1.</p> <p>It should however be noted that spring/summer data is not available for GP1 or GP3.</p>
Evidence of use of glider poles by arboreal target species (Squirrel Glider, or Yellow-bellied Glider).	<p><b>This performance measure has not been met.</b></p> <p>Arboreal target species were not recorded using the glider poles.</p>
Lower rates of road kill gliders in proximity to glider poles than in sections of the upgrade away from crossing structures.	<p><b>This performance measure has been met.</b></p> <p>No road kill was observed within 50 metres of the aerial crossings.</p>

## 5. Recommendations

### 5.1 Contingency Measures

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those that are considered to be relevant to the aerial crossing monitoring program are listed and discussed in Table 9.

**Table 9: Contingency measures**

Potential problems	Contingency measure proposed in EMP	Discussion of proposed measure
<ul style="list-style-type: none"> <li>Low usage rates of rope bridge by arboreal fauna.</li> <li>Low usage rates of glider poles of gliding species.</li> <li>High rate of arboreal vehicle strike in proximity to rope bridges.</li> </ul>	<ul style="list-style-type: none"> <li>Review/modify frequency and/or timing of monitoring periods.</li> <li>Review/modify habitat (i.e. canopy species adjoining rope bridge and connectivity to rope bridge).</li> </ul>	<p>Only one non-gliding arboreal species (the Brushtail Possum) was detected using the rope bridges on a single occasion, prior to the autumn 2018 monitoring.</p> <p>GP1 and RB3 have no recorded use to date.</p> <p>Target species have not been recorded using any aerial crossing structure.</p> <p><b>These contingency measures are considered relevant and recommendations to address them are provided below.</b></p>

### 5.2 Recommendations

The recommendations provided in Table 10 aim to address proposed contingency measures and to meet performance criteria. In addition to the recommendations provided in Table 9, we recommend that maintenance and/or replacement of non-functioning cameras be undertaken as soon as possible. Currently three cameras are not communicating with the download computer. At the time of writing this report Roads and Maritime were in the process of investigating maintenance/replacement options for the malfunctioning cameras.

**Table 10: Recommendations**

Relevant contingency measure proposed in EMP	Recommendation
Review/modify frequency and/or timing of monitoring periods.	We have to date observed that the number of species detected increases by increasing the observation period. It is therefore recommended that camera monitoring should be increased from the current two 60-day monitoring events to continual monitoring/downloading. Increased data will provide more information regarding their use and increase the likelihood of detecting indicator and/or target species (and meeting performance criteria). This would increase the number of monitoring events from two to four in order to cover the entire year, whereby downloading occurs every three months. We would also suggest this for project years when monitoring is not currently scheduled (2019, 2021).
Review/modify habitat (i.e. canopy species adjoining rope bridge and connectivity to rope bridge).	Consideration should be given to reviewing pole connectivity, particularly for poles that appear isolated from vegetation, notably RB3. It is recommended that continual downloading of camera records be undertaken following completion of the required maintenance to establish correct functioning of all cameras. If fauna records remain minimal or absent, a review of the connectivity of the crossing structures, including surrounding vegetation and installation of leader ropes or ladders, is recommended.

## References

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RMS (2016). Oxley Highway to Kempsey Pacific Highway Upgrade Ecological Monitoring Program. Roads and Maritime Update to report prepared by SMEC Hyder Joint Venture, August 2016.

## Annex 1 – Field Data

**Table 11: 2018 aerial crossing camera results**

Camera	Season	Site	Crossing type	Pole	Date	Time	Species	Arboreal (Y/N)	In/Out of 60 days	Certainty (Definite/Probable)	Direction of travel	Evidence of complete crossing
2	spring/summer	RB1	Rope	E	16/12/2017	6:55:16	<i>Corvus</i> sp.	N	Out	Definite	NA	NA
2	spring/summer	RB1	Rope	E	23/12/2017	7:30:57	Small Bird	N	Out	Definite	NA	NA
2	spring/summer	RB1	Rope	E	11/02/2018	4:28:09	unknown	Y	Out	Probable	NA	NA
2	spring/summer	RB1	Rope	E	15/02/2018	3:16:45	Feathertail Glider	Y	Out	Probable	Unk	Unknown
2	autumn	RB1	Rope	E	07/04/2018	23:54:30	Feathertail Glider	Y	In	Probable	Both	Unknown
2	autumn	RB1	Rope	E	16/04/2018	0:51:02	Feathertail Glider	Y	In	Probable	Both	Unknown
2	autumn	RB1	Rope	E	16/04/2018	2:09:55	Feathertail Glider	Y	In	Definite	Both	Unknown
2	autumn	RB1	Rope	E	17/04/2018	0:11:49	Feathertail Glider	Y	In	Definite	W	Unknown
2	autumn	RB1	Rope	E	20/04/2018	22:54:50	Feathertail Glider	Y	In	Definite	E	Unknown
2	autumn	RB1	Rope	E	11/05/2018	0:22:50	Feathertail Glider	Y	Out	Definite	W	Unknown
2	autumn	RB1	Rope	E	11/05/2018	0:28:26	Feathertail Glider	Y	Out	Definite	E	Unknown
2	spring/summer	RB1	Rope	E	30/08/2018	9:59:30	Small Bird	N	Out	Definite	NA	NA
2	spring/summer	RB1	Rope	E	01/09/2018	9:22:43	Small Bird	N	Out	Definite	NA	NA
2	spring/summer	RB1	Rope	E	06/09/2018	20:55:06	Sugar Glider	Y	Out	Probable	Unk	Unknown
2	spring/summer	RB1	Rope	E	09/09/2018	3:31:32	Sugar Glider	Y	Out	Probable	W	Unknown
2	spring/summer	RB1	Rope	E	13/09/2018	1:33:53	Feathertail Glider	Y	Out	Probable	W	Unknown
2	spring/summer	RB1	Rope	E	13/09/2018	7:47:25	Small Bird	N	Out	Definite	NA	NA
2	spring/summer	RB1	Rope	E	21/09/2018	2:55:26	Feathertail Glider	Y	Out	Probable	Unk	Unknown
2	spring/summer	RB1	Rope	E	29/09/2018	19:58:00	Feathertail Glider	Y	Out	Probable	W	Unknown
2	spring/summer	RB1	Rope	E	30/09/2018	21:34:43	Feathertail Glider	Y	Out	Definite	E	Unknown
2	spring/summer	RB1	Rope	E	02/10/2018	21:40:47	Feathertail Glider	Y	Out	Probable	Unk	Unknown
2	spring/summer	RB1	Rope	E	12/10/2018	1:26:28	Feathertail Glider	Y	Out	Probable	W	Unknown



Camera	Season	Site	Crossing type	Pole	Date	Time	Species	Arboreal (Y/N)	In/Out of 60 days	Certainty (Definite/ Probable)	Direction of travel	Evidence of complete crossing
2	spring/summer	RB1	Rope	E	24/10/2018	6:56:39	Bird	N	Out	Definite	NA	NA
2	spring/summer	RB1	Rope	E	02/11/2018	1:15:31	Sugar Glider	Y	In	Probable	Unk	Unknown
2	spring/summer	RB1	Rope	E	03/11/2018	8:36:15	Small Bird	Y	In	Definite	NA	NA
2	spring/summer	RB1	Rope	E	07/11/2018	11:55:13	Small Bird	Y	In	Definite	NA	NA
2	spring/summer	RB1	Rope	E	16/11/2018	2:57:59	Sugar Glider	Y	In	Probable	W	Unknown
4	spring/summer	GP2	Glider	M	30/09/2017	23:31:38	Sugar Glider	Y	Out	Probable	Unk	Yes
4	autumn	GP2	Glider	M	16/03/2018	21:33:27	Feathertail Glider	Y	In	Probable	Unk	Yes
5	spring/summer	RB2	Rope	W	28/09/2017	9:44:36	Australian Magpie	N	Out	Definite	Unk	NA
5	spring/summer	RB2	Rope	W	21/10/2017	18:01:15	Australian Magpie	N	Out	Definite	Unk	NA
5	spring/summer	RB2	Rope	W	21/10/2017	18:25:10	Australian Magpie	Y	Out	Definite	Unk	NA
5	spring/summer	RB2	Rope	W	24/10/2017	17:27:44	Australian Magpie	N	Out	Definite	Unk	NA
5	spring/summer	RB2	Rope	W	31/10/2017	5:49:44	Australian Magpie	N	Out	Definite	Unk	NA
6	spring/summer	RB2	Rope	E	07/11/2017	0:00:20	Brush-tail possum	Y	Out	Definite	W	Possible
6	spring/summer	RB2	Rope	E	07/11/2017	0:14:14	Brush-tail possum	Y	Out	Definite	E	Possible
6	spring/summer	RB2	Rope	E	12/11/2017	3:42:13	Feathertail Glider	Y	Out	Definite	Unk	Unknown
6	spring/summer	RB2	Rope	E	12/11/2017	23:19:41	Feathertail Glider	Y	Out	Definite	Unk	Unknown
6	spring/summer	RB2	Rope	E	13/12/2017	0:36:08	Feathertail Glider	Y	Out	Definite	Unk	Unknown
6	spring/summer	RB2	Rope	E	20/10/2018	2:56:19	Feathertail Glider	Y	Out	Definite	Unk	Unknown
6	spring/summer	RB2	Rope	E	26/11/2018	22:00:50	Feathertail Glider	Y	In	Definite	Unk	Unknown
6	spring/summer	RB2	Rope	E	02/12/2018	3:45:55	Feathertail Glider	Y	In	Definite	Unk	Unknown
6	spring/summer	RB2	Rope	E	04/12/2018	1:20:41	Feathertail Glider	Y	In	Definite	Unk	Unknown
6	spring/summer	RB2	Rope	E	04/12/2018	21:46:46	Feathertail Glider	Y	In	Definite	Unk	Unknown
6	spring/summer	RB2	Rope	E	08/12/2018	2:53:55	Feathertail Glider	Y	In	Definite	Unk	Unknown
7	spring/summer	RB3	Rope	W	25/09/2017	10:25:00	Pied Butcherbird	N	Out	Definite	Unk	NA
8	spring/summer	RB2	Rope	E	17/09/2017	7:00:51	Australian Magpie	N	Out	Definite	Unk	NA
8	spring/summer	RB2	Rope	E	25/09/2017	8:01:31	Australian Magpie	N	Out	Definite	Unk	NA

Camera	Season	Site	Crossing type	Pole	Date	Time	Species	Arboreal (Y/N)	In/Out of 60 days	Certainty (Definite/Probable)	Direction of travel	Evidence of complete crossing
9	spring/summer	GP3	Glider	M	16/11/2017	3:38:33	Feathertail Glider	Y	Out	Definite	Unk	Yes
9	spring/summer	GP3	Glider	M	23/11/2017	3:48:46	Feathertail Glider	Y	Out	Definite	Unk	Yes
9	spring/summer	GP3	Glider	M	26/11/2017	2:04:43	Feathertail Glider	Y	Out	Definite	Unk	Yes
9	spring/summer	GP3	Glider	M	02/12/2017	21:12:29	Feathertail Glider	Y	Out	Definite	Unk	Yes
9	spring/summer	GP3	Glider	M	11/12/2017	2:20:46	Sugar glider	Y	Out	Definite	Unk	Yes

E = east; W = west; M = median; NA = not applicable; N = No; Y = Yes; Unk = unknown

**Table 12: Camera details**

Camera	Crossing	Loc	Season	Data source	start 60 days	end 60 days	TOTAL photos	TOTAL fauna	TOTAL arboreal	60 day photos	60 day fauna	60 day arboreal	Notes
1	RB1	W	spring/summer 2017	Roads and Maritime	NA	NA	8	0	0	NA	NA	NA	
2	RB1	E	spring/summer 2017	Roads and Maritime	NA	NA	66	4	2	NA	NA	NA	
3	GP1	M	spring/summer 2017	Roads and Maritime	NA	NA	181	0	0	NA	NA	NA	False triggers
4	GP2	M	spring/summer 2017	Roads and Maritime	NA	NA	214	1	1	NA	NA	NA	False triggers
5	RB2	W	spring/summer 2017	Roads and Maritime	NA	NA	17	5	0	NA	NA	NA	Magpies
6	RB2	E	spring/summer 2017	Roads and Maritime	NA	NA	80	5	5	NA	NA	NA	26 photos were 1 possum
7	RB3	W	spring/summer 2017	Roads and Maritime	NA	NA	6	1	0	NA	NA	NA	
8	RB3	E	spring/summer 2017	Roads and Maritime	NA	NA	4	2	0	NA	NA	NA	Magpies
9	GP3	M	spring/summer 2017	Roads and Maritime	NA	NA	48	5	5	NA	NA	NA	
1	RB1	W	Autumn 2018	Niche	01/03/2018	01/05/2018	0	0	0	0	0	0	
2	RB1	E	Autumn 2018	Niche	01/03/2018	01/05/2018	16	7	7	14	5	5	
3	GP1	M	Autumn 2018	Niche	01/03/2018	01/05/2018	38	0	0	35	0	0	False triggers
4	GP2	M	Autumn 2018	Niche	01/03/2018	01/05/2018	61	1	1	56	1	1	False triggers
5	RB2	W	Autumn 2018	Niche	01/03/2018	01/05/2018	0	0	0	0	0	0	
6	RB2	E	Autumn 2018	Niche	01/03/2018	01/05/2018	0	0	0	0	0	0	
7	RB3	W	Autumn 2018	Niche	01/03/2018	01/05/2018	0	0	0	0	0	0	
8	RB3	E	Autumn 2018	Niche	01/03/2018	01/05/2018	0	0	0	0	0	0	
9	GP3	M	Autumn 2018	Niche	01/03/2018	01/05/2018	0	0	0	0	0	0	
1	RB1	W	spring/summer 2018	Niche	26/10/2018	26/12/2018	3	0	0	0	0	0	Last photo 7/1/2019
2	RB1	E	spring/summer 2018	Niche	26/10/2018	26/12/2018	79	16	10	36	4	2	Last photo 16/11/2018
3	GP1	M	spring/summer 2018	Niche	26/10/2018	26/12/2018	0	0	0	0	0	0	Computer/antennae not detecting
4	GP2	M	spring/summer 2018	Niche	26/10/2018	26/12/2018	3	0	0	3	0	0	False triggers
5	RB2	W	spring/summer 2018	Niche	26/10/2018	26/12/2018	0	0	0	0	0	0	Computer/antennae not detecting
6	RB2	E	spring/summer 2018	Niche	26/10/2018	26/12/2018	13	6	6	10	5	5	Last photo 20/12/2018
7	RB3	W	spring/summer 2018	Niche	26/10/2018	26/12/2018	0	0	0	0	0	0	Last photo 4/10/2017
8	RB3	E	spring/summer 2018	Niche	26/10/2018	26/12/2018	0	0	0	0	0	0	Last photo 4/10/2017
9	GP3	M	spring/summer 2018	Niche	26/10/2018	26/12/2018	0	0	0	0	0	0	Computer/antennae not detecting

Loc = location; E = east; W = west; M = median; NA = not applicable

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# Appendix F Widened median



# Widened Median Monitoring 2018

**Oxley Highway to Kempsey, Pacific Highway Upgrade**

Prepared for Roads and Maritime Services

January 2019

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*Cover photograph: Widened median and aerial crossings photographed from Bill Hill Rd.*

## Executive Summary

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### **Context**

This report documents findings for the 2018 monitoring period, the first of three monitoring periods for the widened median, as required for the Oxley Highway to Kempsey (OH2K) Pacific Highway Upgrade Project (the Project) and specified in the Oxley Highway to Kempsey (OH2K) Ecological Monitoring Program (EMP, RMS 2016). The NSW Roads and Maritime Services (Roads and Maritime) is required to manage and monitor the effectiveness of biodiversity mitigation measures implemented as part of the Project.

### **Aims**

The aim of the widened median monitoring program is to determine whether the widened median is being used by glider species. The aims of this report are to summarise the methods and results of the 2018 monitoring period and determine if performance measures are being met, as per the EMP.

### **Methods**

Monitoring was undertaken in accordance with the EMP, within the widened median and retained habitat either side of the highway corridor using the following techniques:

- Hair tube sampling: conducted over the three 14-night periods. Hair tube transects were established in the widened median and within adjacent retained forest habitat either side of the road corridor (three transects in total). Each transect contained 20 hair tubes spaced 25 to 30 metres apart baited with a mixture of honey, oats and peanut butter.
- Spotlighting transects: undertaken on a weekly basis for a period of 16 weeks, commencing on 6 June 2018. Transects (a minimum of 500 metres) were located within the widened median and retained forest habitat either side of the upgrade corridor (three transects in total).
- Nest box monitoring: nest boxes within the median and adjacent habitat each side of the carriageway were monitored as part of the Nest Box Monitoring Program for the Project.

### **Key Results**

Combined surveys revealed potentially high numbers of Black Rats within the median and use of the median by Feathertail Gliders, Sugar Gliders and probable Squirrel Gliders, with Sugar Gliders roosting in a nest box within the median. Yellow-bellied Gliders were not detected during any surveys.

### **Conclusions**

The performance indicator requiring evidence of use of median vegetation by the target glider species (Yellow-bellied Glider and Squirrel Glider) has not been met. A number of possible/likely Squirrel Glider observations were made during spotlighting surveys, including one observation of an individual within the median considered likely to be a Squirrel Glider due to its larger body size and tail. The Yellow-bellied Glider was not recorded within the median.

The performance indicator requiring evidence of use by dispersing individuals and different age cohorts cannot be assessed using the prescribed survey methods.

The performance indicator requiring use by glider species other than threatened species e.g. sugar glider has been met. Both the Sugar Glider and Feathertail Glider have been recorded using the median during spotlighting surveys and nest box inspections.



### ***Management Implications***

Given that this is the first of three monitoring periods for the widened median contingency measures are considered not relevant at this time. However, to ensure the success of the widened median for target fauna and other native fauna, and that this success can be determined, the following points should be considered:

- Monitoring of the aerial crossings linking the median with adjacent habitat may prove useful in providing additional fauna observations if currently proposed surveys provide inadequate records due to species' behavioural use of the median (i.e. transitory *cf.* resource use).
- The possibility of high numbers of Black Rats within the median may pose a risk to native species through predation and competition for resources within the isolated median. Roads and Maritime should consider discussing this issue with the NSW EPA.

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# 1. Introduction

## 1.1 Context

The Oxley Highway to Kempsey (OH2K) section of the Pacific Highway Upgrade Project (the Project) was approved in 2012 subject to various Ministers Conditions of Approval (MCoA) and a Statement of Commitments (SoC). A subsequent approval with additional conditions of consent (CoA) was granted in 2014 by the Commonwealth Department of Environment (DoE) for Matters of National Environmental Significance (MNES) listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1995* (EPBC Act). The Ecological Monitoring Program (hereafter referred to as the EMP) (RMS 2016) combines these approval conditions and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project.

### 1.1.1 Monitoring framework

The design, methods and performance indicators that define the widened median monitoring program are specified in the EMP. Monitoring of the widened median was to commence during the first optimal season, that is, during breeding and dispersal periods (June – September) for target species, following the completion of the Project. As the final stage of the Project was opened in March 2018, monitoring commenced in June 2018, year 4 of the Project. Monitoring is to be undertaken for a minimum of three years: in years 4, 6 and 8 of the Project. Additional years may be required if the widened median is found to be ineffective and requires modification or supplementation with alternative crossing structures.

This report presents the results of the first of the three monitoring periods – year 4, winter/spring 2018.

### 1.1.2 Background data

The retention of trees within a median that separates the north and south carriageway has been employed as a means of mitigating the barrier effect of roads on gliders by providing safe crossing opportunities. The median is approximately 50 metres at its widest. Vegetation communities in the widened median and either side of the carriageway include Moist Gully Forest, Paperbark Swamp Forest, Swamp Mahogany/Forest Red Gum Swamp Forest, Moist Floodplain Forest and Dry Ridgetop Forest (RMS 2016) (see Figure 1). The target species and their breeding and dispersal periods are provided in Table 1.

**Table 1: Target species (from Table 18 of the EMP)**

Target species	Breeding season	Likely dispersal
Yellow-bellied Glider ( <i>Petaurus australis</i> )	Between July and September (variable depending on habitat characteristics)	Winter to spring (when young 12-24 months of age)
Squirrel Glider ( <i>Petaurus norfolcensis</i> )	Between April and November (peak during winter)	Autumn to spring

### 1.1.3 Purpose of this report

This report details the findings obtained from the first monitoring period for the widened median. The aims of this report are to summarise the methods and results of the 2018 monitoring and determine if performance measures are being met, as per the EMP.

## 1.2 Performance Measures

The EMP specifies the following performance measures for the widened median:

- *Evidence of use of median vegetation by the target glider species*
- *Evidence of use by dispersing individuals and different age cohorts*
- *Use by glider species other than threatened species e.g. sugar glider*

Target glider species identified in the EMP include the Yellow-bellied Glider (*Petaurus australis*) and Squirrel Glider (*Petaurus norfolcensis*).

## 1.3 Monitoring Timing

Monitoring is to be undertaken over 16 weeks from June to September in years 4, 6 and 8 of the Project.

## 1.4 Reporting

As per the EMP, the annual reporting of monitoring results will include:

- Detailed description of monitoring methodology employed
- Results of the monitoring period
- Discussion of results, including how the results compare against performance measures, if any modifications to timing or frequency of monitoring periods or monitoring methodology are required and any other recommendations
- If contingency measures should be implemented.

All reports prepared under the EMP will be submitted to the Director General of the Department of Planning and Environment and the Environment Protection Authority.

## 1.5 Limitations

The EMP performance indicator specifies “*Evidence of use by dispersing individuals and different age cohorts*”. Spotlighting surveys do not permit the determination of dispersal (observations provide information on presence/absence and behaviour only) and offer limited opportunity to determine age of individuals.

Where possible, individuals were identified to species, however accurate identification of Squirrel Gliders during spotlighting surveys was not always possible due to distinguishing features being hidden from view, distance from which observations were made and rapid movement of individuals.

## 2. Methods

---

### 2.1 Monitoring Sites

Monitoring was undertaken in accordance with the EMP, within the widened median and retained habitat either side of the highway corridor (Figure 1).

### 2.2 Survey Methods

Surveys were undertaken in accordance with the EMP using the following techniques:

- Hair tube sampling
- Spotlighting transects
- Nest box monitoring.

#### 2.2.1 Hair tube sampling

Hair tube sampling was conducted over the three 14-night periods specified in the EMP, as follows:

- Period 1: 12 – 28 June
- Period 2: 24 July - 9 August
- Period 3: 11 September – 3 October.

Hair tube transects were established in the widened median and within adjacent retained forest habitat either side of the road corridor (three transects in total). Each transect contained 20 hair tubes spaced 25 to 30 metres apart. Each hair tube was attached to the trunk of a tree at approximately three metres above the ground, and baited with a mixture of honey, oats and peanut butter. The trunk of the trees were sprayed with honey water as an additional attractant. Hair samples were sent to Barbara Triggs (Dead Finish) for analysis.

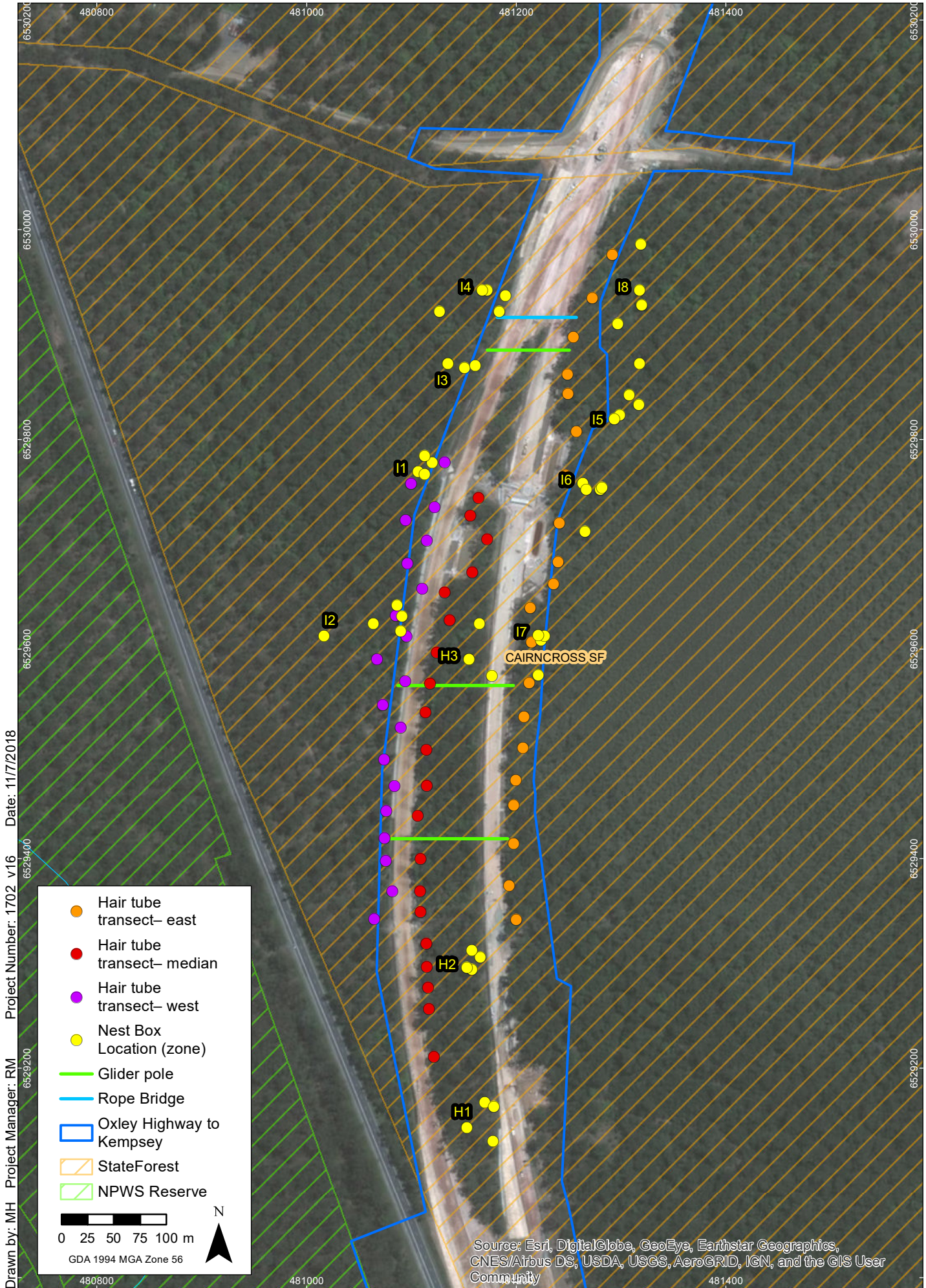
#### 2.2.2 Spotlighting surveys

Spotlighting surveys were undertaken on a weekly basis for a period of 16 weeks, commencing on 6 June 2018. Three random 500 metre transects were surveyed each week and involved two observers walking at a speed of approximately one kilometre per hour. Transects were located within the widened median and retained forest habitat either side of the upgrade corridor (three transects in total).

#### 2.2.3 Nest box monitoring

Nest boxes within the median and adjacent habitat each side of the carriageway were monitored as part of the Nest Box Monitoring Program for the Project. There are 11 nest boxes located within the median and a further 18 boxes on the eastern side and 18 boxes on the western side of the carriageway immediately adjacent to the median.

Each nest box was visually inspected using a wireless camera attached to the end of an extendable pole, or by a tree climber when inspection from the ground was not possible. Details recorded for each box included: occupation by fauna, species if present, signs of use by fauna, box condition, maintenance required, changes to surrounding landscape and daily weather conditions.



Widened median monitoring area

Pacific Highway Upgrade - Oxley Highway to Kempsey

**FIGURE 1**

Imagery: (c) LPI NSW 2014-10-06



### 3. Results

Figure 2 shows the spotlighting and relevant nest box monitoring results.

#### 3.1 Hair Tube Sampling

Results of the hair tube sampling are provided in Annex 1. A summary of the hair tube results is provided in Table 2. *Rattus* species were the only species detected by hair tubes within the median. The Brushtail Possum (*Trichosurus* sp.) was detected on the eastern and western side of the carriageway.

A higher proportion of tubes collected hair samples within the median (70%, cf 25% on the east and 10% on the west), however these were all *Rattus* species and predominantly the invasive Black Rat (*Rattus rattus*). There was a relatively high number of Black Rat records for the median (35, cf 11 on the east and two on the west). As Black Rats are known to compete with and predate upon native fauna (Stokes *et al.* 2009, Banks and Hughes 2012), and their presence on Australian offshore islands was determined to be a key threatening process at both the NSW and Commonwealth level due to their ability to rapidly colonise, compete with and predate upon native species (NSW TSSC 2000, TSSC 2006), the possibility of this species existing in high numbers within the widened median, and any necessary actions, should be considered. The isolation of the median may have a detrimental impact on any native fauna using this habitat.

**Table 2: Summary of hair tube results**

Transect	East				Median				West			
Period	1	2	3	TOTAL	1	2	3	TOTAL	1	2	3	TOTAL
<i>Rattus</i> sp.	1	1	0	2	3	4	0	7	0	0	1	1
<i>Rattus rattus</i>	9	2	0	11	10	12	13	35	0	1	1	2
Rodent	1	0	0	1	0	0	0	0	0	2	0	2
<i>Trichosurus</i> sp.	1	0	0	1	0	0	0	0	0	0	1	1
Tubes with hairs	12 (60%)	3 (15%)	0 (0%)	15 (25%)	13 (65%)	16 (80%)	13 (65%)	42 (70%)	0 (0%)	3 (15%)	3 (15%)	6 (10%)
Tubes without hairs	8 (40%)	17 (85%)	20 (100%)	45 (75%)	7 (35%)	4 (20%)	7 (35%)	18 (30%)	20 (100%)	17 (75%)	17 (75%)	54 (90%)



### 3.2 Spotlighting Surveys

Spotlighting transects were undertaken for 16 weeks from the 6 June to the 19 September 2018. Results of the spotlighting surveys are provided in Annex 2. A summary of the spotlighting results is provided in Table 3. Sugar Gliders and Feathertail Gliders were observed using the widened median, with the Feathertail Glider only being observed within the median and not within adjacent habitat. Observations included a record of an individual foraging in *Melaleuca quinquenervia* trees within the median.

A number of records were considered to represent possible records of Squirrel Gliders, including one from within the median. As mentioned, identifying the threatened Squirrel Glider with certainty was not possible due to distinguishing features being hidden from view, distance from which observations were made and rapid movement of individuals. As expected, due to fauna fencing located along the outer edge of the carriageway and extending into the culvert that traverses the median, Brushtail Possums were only observed within forest habitat either side of the upgrade corridor. There were no observations of Yellow-bellied Gliders. At the time of surveys, a proportion of Tallowwoods (*Eucalyptus microcorys*) and Stringybarks were observed to be flowering in the vicinity of the widened median. Potential sap feed trees for the Yellow-bellied Glider within the median are mostly limited to Blackbutts (*E. pilularis*).

**Table 3: Summary of spotlighting results**

Species	Transect		
	East	Median	West
Feathertail Glider ( <i>Acrobates pygmaeus</i> )		✓ (2)	
Sugar / Squirrel Glider ( <i>Petaurus breviceps</i> / <i>Petaurus norfolcensis</i> )	✓ (6)	✓ (1)	✓ (1)
Sugar Glider ( <i>Petaurus breviceps</i> )	✓ (2)	✓ (2)	✓ (1)
Common Brushtail Possum ( <i>Trichosurus vulpecula</i> )	✓ (3)		✓ (2)
Cat ( <i>Felis catus</i> )	✓ (1)		
Bat (Microbat and Flying Fox)	✓ (1)	✓ (1)	
Bird		✓ (1)	
<i>Rattus</i> sp.			✓ (1)

### 3.3 Nest Box Monitoring

Eighteen nest boxes were installed on either side of the carriageway and 12 nest boxes within the widened median as part of the *Nest Box Plan of Management* (NBPoM, Lewis 2013). The results of inspections to date are provided in Annex 3 and have been extracted from the 2017/2018 Nest Box Monitoring report (Niche 2018). Table 4 summarises the species recorded using these nest boxes during the 2017/2018 survey period as well as all inspections to date.

Considering all nest box monitoring events, 27% of the boxes (three boxes) within the median have been found to be occupied on at least one occasion and 73% (eight boxes) have been found to be occupied or have shown signs of use on at least one occasion. The rate of occupancy/use of boxes with the median is similar to the rate of occupancy/use of nest boxes in adjacent forested habitat.

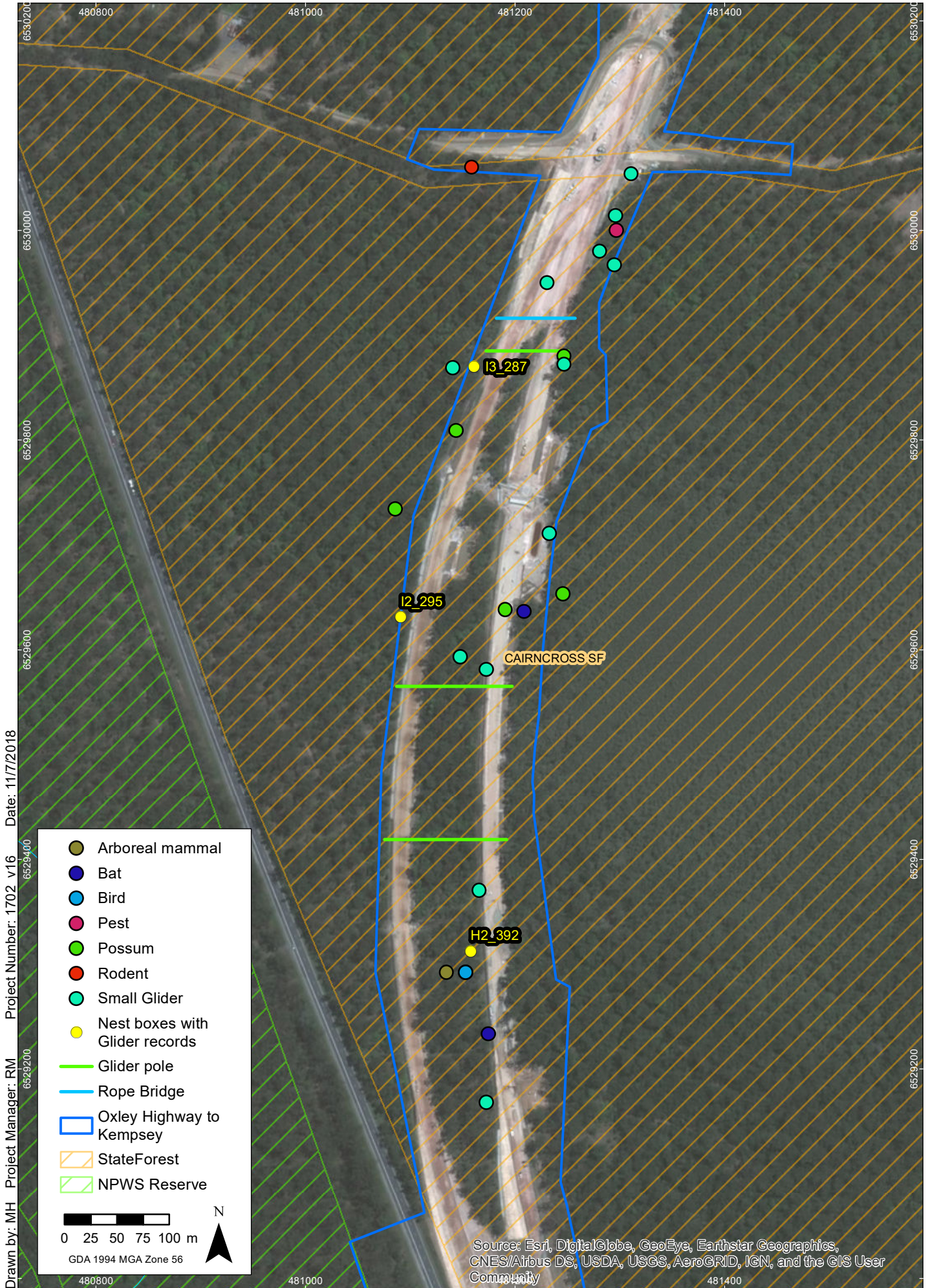
Sugar Gliders have been recorded occupying nest boxes within the median on three occasions. The three records of Sugar Gliders from the median occurred within the same nest box (H2-392). Other species identified using nest boxes within the median include *Antechinus* sp. on one occasion and a Lace Monitor on one occasion. Overall there have been five records of occupation, using three nest boxes within the median. Comparably, there have been six records of occupation from four nest boxes on the eastern side of the carriageway (species included Brushtail Possums and the Lace Monitor) and three records of occupation from two nest boxes on the western side of the carriageway (Sugar Glider in I2-295 and I3-287).

The Yellow-bellied Glider has been recorded on four occasions using nest boxes along the alignment (Niche 2018) in locations 10-15 kilometres north of the widened median. Similarly, the Squirrel Glider has been recorded on three occasions in nest boxes from 1.5 to 10 kilometres from the median.

**Table 4: Nest box occupancy and species recorded in nest boxes within and adjacent to the median**

Species	Summer/winter 2017/2018			All inspections		
	East	Median	West	East	Median	West
Number of boxes occupied at least once (%)	2 (11%)	2 (18%)	2 (11%)	4 (22%)	3 (27%)	2 (11%)
Number of boxes occupied or showing signs of use at least once (%)	11 (61%)	8 (73%)	13 (72%)	12 (67%)	8 (73%)	13 (72%)
Sugar Glider		✓ (1)	✓ (2)		✓ (3)	✓ (3)
Brushtail Possums ( <i>Trichosurus</i> spp.)	✓ (2)			✓ (5)		
<i>Antechinus</i> sp.		✓ (1)			✓ (1)	
Lace monitor ( <i>Varanus varius</i> )				✓ (1)	✓ (1)	

(#) number of occasions found occupying nest boxes



Widened median monitoring results

Pacific Highway Upgrade - Oxley Highway to Kempsey

**FIGURE 2**

Imagery: (c) LPI NSW 2014-10-06

## 4. Discussion

### 4.1 Performance Measures

A summary of the 2018 survey results in relation to the performance measures is provided in Table 5.

**Table 5: Summary of performance measures**

Performance measure	Discussion
Evidence of use of median vegetation by the target glider species (Yellow-bellied Glider and Squirrel Glider).	<p><b>This performance measure has not been met.</b></p> <p>A number of possible/likely Squirrel Glider observations were made during spotlighting surveys, including one observation of an individual within the median considered likely to be a Squirrel Glider due to its larger body size and tail.</p> <p>The Yellow-bellied Glider was not recorded within the median.</p>
Evidence of use by dispersing individuals and different age cohorts.	<p><b>This performance measure cannot be assessed.</b></p> <p>Spotlighting surveys do not permit the determination of dispersal (they provide information on presence/absence and behaviour only in this instance) and offer limited opportunity to determine age of individuals.</p>
Use by glider species other than threatened species e.g. sugar glider	<p><b>This performance measure has been met.</b></p> <p>Both the Sugar Glider and Feathertail Glider have been recorded using the median during spotlighting surveys and nest box inspections.</p>

## 5. Recommendations

### 5.1 Contingency Measures

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those that are considered relevant to the widened median monitoring are listed and discussed in Table 6.

**Table 6: Contingency measures**

Potential problem	Contingency measure	Discussion of proposed measure
No evidence of use of the median vegetation by the target glider species.	Investigate alternative crossing structures (e.g. glider poles and/or rope bridges) in consultation with EPA.	<p>Sugar Gliders were recorded actively foraging within the median vegetation, as well as occupying and using a number of the installed nest boxes. These species are listed in the EMP as indicator species for the target species, to be used to assess the success of road crossing structures (glider poles and rope bridges). However the use of indicator species to assess the success of the widened median as a mitigation measure is not provided for within the EMP.</p> <p>Yellow-bellied Gliders have not been recorded within the median. Squirrel Gliders have also not been definitively recorded, however several observations were considered likely to have been Squirrel Gliders (rather than Sugar Gliders).</p> <p>Yellow-bellied Glider records from nest box monitoring and other incidental records (Niche 2019) occur from approximately 10 kilometres north of the median. Baseline surveys undertaken in 2013 identified Yellow-bellied Gliders within Cairncross State Forest directly to the south west of the median (Lewis 2014), however current surveys of the same area did not record this species.</p> <p>It is considered that the median is providing roosting and foraging habitat for small gliders. As the aerial crossings are not being monitored it is not possible to confirm traverses, however the presence of these gliders within the median and occupation of the installed nest boxes would indicate traverses of the highway on at least a number of occasions. Yellow-bellied Gliders were not detected within the median or in adjacent habitat during current surveys. Foraging and roosting habitat is present within the median, however it is not abundant. It is possible that the median may provide transitory habitat only for this species, in which case detection may be less likely.</p> <p>Further monitoring results will provide information that can be used to better understand use of this habitat by the target species.</p> <p><b>This contingency measure is not considered relevant at this stage.</b></p>

### 5.2 Recommendations

Given that this is the first of three monitoring periods for the widened median, contingency measures are considered not relevant at this time. Continued monitoring as per the EMP will likely add to the number of fauna records and allow for a better understanding of fauna presence and use of the widened median. However, to ensure the success of the widened median for target fauna and other native fauna, and that this success can be determined, the following points should be considered:

- Monitoring of the aerial crossings linking the median with adjacent habitat may prove useful in providing additional fauna observations if currently proposed surveys provide inadequate records due to species' behavioural use of the median habitat (i.e. transitory *cf* resource use).
- The possibility of high numbers of Black Rats within the median may pose a risk to native species through predation and competition for resources within the isolated median. Roads and Maritime should consider discussing this issue with the NSW EPA.

## References

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## Annex 1 – Hair tube results

**Table 7: Hair tube results**

Transect	HT#	Map ref	Easting	Northing	Tree type	Deploy date 1	Retrieve date 1	ID 1	Deploy date 2	Retrieve date 2	ID 2	Deploy date 3	Retrieve date 3	ID 3
E	1	E1	481292	6529976	Turpentine	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
E	2	E2	481273	6529935	Turpentine	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
E	3	E3	481255	6529897	Stringybark	12/06/2018	28/06/2018	rodent	24/07/2018	09/08/2018	<i>Rattus</i> sp.	11/09/2018	03/10/2018	no hairs
E	4	E4	481249	6529862	Stringybark	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	<i>Rattus rattus</i>	11/09/2018	03/10/2018	no hairs
E	5	E5	481250	6529843	Melaleuca	12/06/2018	28/06/2018	<i>Rattus rattus</i>	24/07/2018	09/08/2018	<i>Rattus rattus</i>	11/09/2018	03/10/2018	no hairs
E	6	E6	481257	6529807	Melaleuca	12/06/2018	28/06/2018	<i>Rattus rattus</i>	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
E	7	E7	481248	6529765	Allocasuarina/Casuarina	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
E	8	E8	481241	6529720	Stag	12/06/2018	28/06/2018	<i>Rattus rattus</i>	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
E	9	E9	481240	6529683	Melaleuca	12/06/2018	28/06/2018	<i>Rattus rattus</i>	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
E	10	E10	481236	6529662	Bloodwood	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
E	11	E11	481214	6529639	Blackbutt	12/06/2018	28/06/2018	<i>Rattus rattus</i>	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
E	12	E12	481215	6529606	Allocasuarina/Casuarina	12/06/2018	28/06/2018	<i>Trichosurus</i> sp. Likely <i>T. vulpecula</i>	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
E	13	E13	481213	6529567	Blackbutt	12/06/2018	28/06/2018	<i>Rattus rattus</i>	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
E	14	E14	481208	6529535	Bloodwood	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
E	15	E15	481206	6529505	Melaleuca	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
E	16	E16	481200	6529475	Melaleuca	12/06/2018	28/06/2018	<i>Rattus rattus</i>	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
E	17	E17	481198	6529451	Allocasuarina/Casuarina	12/06/2018	28/06/2018	<i>Rattus</i> sp.	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
E	18	E18	481198	6529414	Bloodwood	12/06/2018	28/06/2018	<i>Rattus rattus</i>	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
E	19	E19	481193	6529374	Allocasuarina/Casuarina	12/06/2018	28/06/2018	<i>Rattus rattus</i>	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
E	20	E20	481200	6529341	Blackbutt	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
Med	1	M1	481164	6529744	Bloodwood	12/06/2018	28/06/2018	<i>Rattus</i> sp.	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
Med	2	M2	481156	6529727	Bloodwood	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	<i>Rattus rattus</i>	11/09/2018	03/10/2018	<i>Rattus rattus</i>
Med	3	M3	481173	6529705	Stringybark	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	<i>Rattus rattus</i>	11/09/2018	03/10/2018	<i>Rattus rattus</i>

Transect	HT#	Map ref	Easting	Northing	Tree type	Deploy date 1	Retrieve date 1	ID 1	Deploy date 2	Retrieve date 2	ID 2	Deploy date 3	Retrieve date 3	ID 3
Med	4	M4	481158	6529673	Turpentine	12/06/2018	28/06/2018	<i>Rattus rattus</i>	24/07/2018	09/08/2018	<i>Rattus sp.</i>	11/09/2018	03/10/2018	<i>Rattus rattus</i>
Med	5	M5	481132	6529654	Stringybark	12/06/2018	28/06/2018	<i>Rattus rattus</i>	24/07/2018	09/08/2018	<i>Rattus rattus</i>	11/09/2018	03/10/2018	<i>Rattus rattus</i>
Med	6	M6	481137	6529627	Turpentine	12/06/2018	28/06/2018	<i>Rattus rattus</i>	24/07/2018	09/08/2018	<i>Rattus rattus</i>	11/09/2018	03/10/2018	no hairs
Med	7	M7	481124	6529596	Blackbutt	12/06/2018	28/06/2018	<i>Rattus rattus</i>	24/07/2018	09/08/2018	<i>Rattus rattus</i>	11/09/2018	03/10/2018	<i>Rattus rattus</i>
Med	8	M8	481118	6529566	Stringybark	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	<i>Rattus rattus</i>	11/09/2018	03/10/2018	<i>Rattus rattus</i>
Med	9	M9	481114	6529539	Allocasuarina/Casuarina	12/06/2018	28/06/2018	<i>Rattus rattus</i>	24/07/2018	09/08/2018	<i>Rattus rattus</i>	11/09/2018	03/10/2018	no hairs
Med	10	M10	481114	6529503	Allocasuarina/Casuarina	12/06/2018	28/06/2018	<i>Rattus sp.</i>	24/07/2018	09/08/2018	<i>Rattus rattus</i>	11/09/2018	03/10/2018	<i>Rattus rattus</i>
Med	11	M11	481115	6529469	Melaleuca	12/06/2018	28/06/2018	<i>Rattus rattus</i>	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	<i>Rattus rattus</i>
Med	12	M12	481106	6529441	Ironbark	12/06/2018	28/06/2018	<i>Rattus rattus</i>	24/07/2018	09/08/2018	<i>Rattus rattus</i>	11/09/2018	03/10/2018	no hairs
Med	13	M13	481109	6529400	Turpentine	12/06/2018	28/06/2018	<i>Rattus sp.</i>	24/07/2018	09/08/2018	<i>Rattus sp.</i>	11/09/2018	03/10/2018	<i>Rattus rattus</i>
Med	14	M14	481109	6529369	Allocasuarina/Casuarina	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	<i>Rattus sp.</i>	11/09/2018	03/10/2018	<i>Rattus rattus</i>
Med	15	M15	481109	6529349	Bloodwood	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
Med	16	M16	481114	6529318	Allocasuarina/Casuarina	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	<i>Rattus sp.</i>	11/09/2018	03/10/2018	<i>Rattus rattus</i>
Med	17	M17	481115	6529296	Melaleuca	12/06/2018	28/06/2018	<i>Rattus rattus</i>	24/07/2018	09/08/2018	<i>Rattus rattus</i>	11/09/2018	03/10/2018	<i>Rattus rattus</i>
Med	18	M18	481116	6529276	Allocasuarina/Casuarina	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	<i>Rattus rattus</i>	11/09/2018	03/10/2018	no hairs
Med	19	M19	481117	6529256	Blackbutt	12/06/2018	28/06/2018	<i>Rattus rattus</i>	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	<i>Rattus rattus</i>
Med	20	M20	481122	6529211	Bloodwood	12/06/2018	28/06/2018	<i>Rattus rattus</i>	24/07/2018	09/08/2018	<i>Rattus rattus</i>	11/09/2018	03/10/2018	no hairs
W	1	W1	481132	6529778	Melaleuca	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	<i>Trichosurus sp.</i> Likely <i>T. vulpecula</i>
W	2	W2	481100	6529758	Turpentine	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
W	3	W3	481122	6529735	Stringybark	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
W	4	W4	481095	6529723	Blackbutt	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	<i>Rattus sp.</i>
W	5	W5	481115	6529704	Turpentine	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
W	6	W6	481096	6529681	Stringybark	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
W	7	W7	481110	6529657	Blackbutt	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
W	8	W8	481085	6529632	Tallowwood	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
W	9	W9	481096	6529612	Turpentine	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs



Transect	HT#	Map ref	Easting	Northing	Tree type	Deploy date 1	Retrieve date 1	ID 1	Deploy date 2	Retrieve date 2	ID 2	Deploy date 3	Retrieve date 3	ID 3
W	10	W10	481067	6529590	Turpentine	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
W	11	W11	481094	6529569	Bloodwood	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
W	12	W12	481073	6529546	Tallowwood	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	rodent	11/09/2018	03/10/2018	no hairs
W	13	W13	481090	6529525	Blackbutt	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
W	14	W14	481074	6529494	Blackbutt	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
W	15	W15	481084	6529469	Tallowwood	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
W	16	W16	481076	6529445	Melaleuca	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
W	17	W17	481075	6529419	Blackbutt	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	<i>Rattus rattus</i>	11/09/2018	03/10/2018	no hairs
W	18	W18	481076	6529398	Tallowwood	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	no hairs
W	19	W19	481082	6529369	Tallowwood	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	no hairs	11/09/2018	03/10/2018	<i>Rattus rattus</i>
W	20	W20	481065	6529342	Blackbutt	12/06/2018	28/06/2018	no hairs	24/07/2018	09/08/2018	rodent	11/09/2018	03/10/2018	no hairs

## Annex 2 – Spotlighting field data

**Table 8: Spotlighting weather conditions.**

Date	Temperature °C	Rain	Wind (scale 0-3)
06/06/2018	17.6	N	0
13/06/2018	8.6	N	1
20/06/2018	11.2	N	0
27/06/2018	6.7	N	0
04/07/2018	12.1	Y	1
11/07/2018	11	N	0
18/07/2018	11	N	1
25/07/2018	7	N	1
01/08/2018	8	N	0
08/08/2018	7	N	1
15/08/2018	7	N	1
22/08/2018	7	N	2
29/08/2018	10	N	0
05/09/2018	15	N	0
12/09/2018	15.5	N	1
19/09/2018	15.2	N	0

**Table 9: Spotlighting results**

Date	Transect (East, Median, West)	Easting	Northing	ID type (seen/heard)	Species type	Species	Notes (direction of travel if seen)
06/06/2018	M	481135	6529292	seen	Arboreal mammal	No ID	Previous 24hr rainfall high. Long range observation. Hidden in foliage. Two small close together eyes with orange/pink shine
06/06/2018	W	481159	6530060	seen	Rodent	<i>Rattus</i> sp.	Previous 24hr rainfall high
13/06/2018	M	481153	6529292	seen	Small Glider	Feathertail Glider	Eye shine and observed gliding
20/06/2018	E	481246	6529653	seen	Possum	Brushtail Possum	Eye shine and identified in tree
20/06/2018	W	481086	6529734	seen	Possum	Brushtail Possum	Eye shine and identified in tree
27/06/2018	E	481247	6529880	seen	Possum	Brushtail Possum	
04/07/2018	E	481233	6529711	heard	Small Glider	Sugar Glider	Heard call from approximately 80 metres away
04/07/2018	E	481311	6530054	seen	Small Glider	Sugar Glider	
04/07/2018	E	481254	652869	seen	Small Glider	2 x Sugar or Squirrel Glider	Possible Squirrel Gliders
04/07/2018	M	481148	6529593	seen	Small Glider	Feathertail Glider	Observed landing on tree and climbing up
11/07/2018	E	481297	6530000	seen	Introduced predator	Cat	Very brief observation. Likely cat due to behaviour on ground walking fence line.
11/07/2018	M	481166	6529370	seen	Small Glider	Sugar Glider	Foraging in <i>Melaleuca quinquenervia</i>
11/07/2018	M	481173	6529581	seen	Small Glider	Sugar Glider	Active, possibly same individual already seen as glided in from that direction.
18/07/2018	W	481144	6529809	seen	Possum	Brushtail Possum	
25/07/2018	E	481191	6529638	seen	Possum	Brushtail Possum	
25/07/2018	W	481141	6529869	seen	Small Glider	Sugar or Squirrel Glider	Active
01/08/2018							No observations
08/08/2018							No observations
15/08/2018	M	481175	6529233	seen	Bat	Microbat	Active foraging
15/08/2018	E	481209	6529636	seen	Bat	Flying Fox	In tree, flew away

Date	Transect (East, Median, West)	Easting	Northing	ID type (seen/heard)	Species type	Species	Notes (direction of travel if seen)
15/08/2018	E	481281	6529980	seen	Small Glider	Sugar or Squirrel Glider	Active
22/08/2018							No observations
29/08/2018							No observations
05/09/2018	E	481296	6530014	seen	Small Glider	Sugar or Squirrel Glider	Foraging, likely Sugar Glider
05/09/2018	M	481173	6529168	seen	Small Glider	Sugar or Squirrel Glider	Gliding. Possible Squirrel Glider due to larger body and tail.
12/09/2018	E	481295	6529967	seen	Small Glider	Sugar or Squirrel Glider	Foraging in flowering Stringybark.
12/09/2018	E	481247	6529872	seen	Small Glider	Sugar or Squirrel Glider	Foraging
12/09/2018	M	481153	6529292	seen	Bird	Unknown	Roosting
19/09/2018	W	481231	6529950	seen	Small Glider	Likely Sugar Glider	Foraging in flowering Stringybark.

## Annex 3 – Nest box results

**Table 10: Nest box monitoring results (extracted from Niche 2018)**

Zone	Location	Box #	Box type	Height (m)	Tree species	Winter 2016 species	Winter 2016 signs of use	Summer 2016/2017 species	Summer 2016/2017 signs of use	Winter 2017 species	Winter 2017 signs of use	Summer 2017/2018 species	Summer 2017/2018 signs of use	Winter 2018 species	Winter 2018 signs of use
H1	Median	385	LG	10	Blackbutt		Nil		Nil		Nil		bark shredded		shredded bark
H1	Median	386	SG	7	Blackbutt		Messy leaf nest, some messy scat, prob rodent		Old leaf nest, prob SuG/SqG		Old scrappy leaf nest, prob ante.	Antechinus sp.	leaf litter-occupied ran out on inspection		euc leaf nest
H1	Median	387	Parr	8	Blackbutt		Old scattered leaf nest		Nil		Nil		Nil		woody debris
H1	Median	388	Poss.	8	Blackbutt		Nil		Few scattered leaves, ants		Ext leaf nest, prob SuG/SqG.		leaf litter		euc leaf nest
H2	Median	389	MB	7	Tallowwood		Nil		Nil		Nil		Nil		Nil
H2	Median	390	SG	6	Tallowwood		Old petaurid nest		Old leaf nest, SuG/SqG		Old leaf nest, SuG//SqG.		leaf nest		euc leaf nest.
H2	Median	391	LG	10	Blackbutt		Nil		Nil		Nil		Nil		Nil
H2	Median	392	SG	6	Blackbutt	Sugar Glider x 1	occupied		Old leaf nest, SuG/SqG	SuG x 3	Leaf nest.		leaf litter	Sugar Glider	occupied
H3	Median	393	Cock	12	Blackbutt		Nil		Some leaf litter	Lace Monitor x 1 (young)	Few leaves.		Leaf nest		euc leaves and bark
H3	Median	394	Poss.	6	Blackbutt		Nil		Nil		Nil		Nil		Nil
H3	Median	395	SG	6	Turpentine		Nil		Nil		Nil		Nil		Nil
H3	Median	396	LG	10	Blackbutt		Nil		Nil		Nil		bark		shredded bark

Zone	Location	Box #	Box type	Height (m)	Tree species	Winter 2016 species	Winter 2016 signs of use	Summer 2016/2017 species	Summer 2016/2017 signs of use	Winter 2017 species	Winter 2017 signs of use	Summer 2017/2018 species	Summer 2017/2018 signs of use	Winter 2018 species	Winter 2018 signs of use
11	West	290	Scan	6	Sw. Mahog		nil		Old leaf nest, prob SuG/SqG		Nil	Ants	Nil		Nil
11	West	292	SG	8	P. Bloodwood		Messy leaf nest, scats, poss BTphas		Nil		Nil		Nil		Nil
11	West	293	SG	8	Sw. Mahog		Nil		Ante nest, latrine cnr, messy.		Old ante nest, latrine cnr.		old leaf		leaves and latrine
11	West	294	Poss.	7	Sw. Mahog		CBTP evidence		CBTP marks		CBTP use.		bark		leaf and bark debris
12	West	288	LG	10	Wh. Stringybark		Nil		Nil		Nil		Nil		Nil
12	West	289	Parr	8	Blackbutt		Nil		Old SuG/SqG leaf nest		Nil		leaf nest		conical leaf nest
12	West	291	MB	7	Wh. Stringybark		Nil		Nil		Nil		Nil		Nil
12	West	295	SG	8	Blackbutt	Petaurid sp x 1	Leaf nest		Bowled SuG/SqG leaf nest		Extensive bowled leaf nest, SuG/SqG.		old conical leaf nest	Sugar Glider	occupied
12	West	296	Scan	6	Wh. Stringybark		Nil		Partial SuG/SqG leaf nest		Few leaves, prob ante.		leaf litter		euc leaves
13	West	283	SO	10	Tallowwood		nil		CBTP marks, old Euro beehive		CBTP use and old Euro beehive.		bark		leaves and bark
13	West	284	Poss.	7	Tallowwood		Nil		Nil		Nil		bark		leaves and bark
13	West	285	LG	10	Blackbutt		Flat scattered leaves,		Old Leaf nest, prob CBTP		Scattered leaves, prob CBTP.		leaf litter		leaves and bark
13	West	286	SG	8	White Stringybark		Few scattered leaves, fresh		Old leaf nest, prob SuG/SqG		Old leaf nest, SuG/SqG.		lots of leaf litter		conical euc leaf nest

Zone	Location	Box #	Box type	Height (m)	Tree species	Winter 2016 species	Winter 2016 signs of use	Summer 2016/2017 species	Summer 2016/2017 signs of use	Winter 2017 species	Winter 2017 signs of use	Summer 2017/2018 species	Summer 2017/2018 signs of use	Winter 2018 species	Winter 2018 signs of use
13	West	287	Scan	8	Mahog sp		Old petaurid leaf nest		Old leaf nest, prob SuG/SqG		Old bowled leaf nest, SuG/SqG.		conical leaf nest	Sugar Gliders	occupied
14	West	279	LG	10	Mahog sp.		CBTP evidence, old bark		Strips of bark, poss scat, BTPhas?		Bark strips, leaves, prob CRtP. Old Euro beehive.		leaf litter		leaves and bark
14	West	280	MB	8	Blackbutt		nil		Nil		Nil		Nil		Nil
14	West	281	Parr	8	Mahog sp.		Few fresh leaves		Few leaves, old Euro beehive		Few scattered leaves, prob ante.		leaf litter, old wasp nest		leaves and bark
14	West	282	Poss.	8	Turp		CBTP evidence		Few leaves, CBtP marks		CBtP use.		leaf litter		leaves and bark
15	East	297	SG	6	Wh. Mahog		Nil		Nil		Nil		pest debris, old honeycomb		Nil
15	East	298	Poss.	8	Tallowwood		CBTP evidence		CBTP marks		Heavy CBtP use, wear.		Nil		Nil
15	East	299	Add. Poss.	8	Tallowwood		Nil	SEBtP x 1	SEBtP marks		CBtP use.		Nil		bark, old wasp nest
15	East	300	SO	10	Mahog. sp.		Fresh leaves, branchlets		CBtP marks		Old leaf nest, prob SuG.		euc leaves and honeycomb		euc leaf
15	East	301	LG	10	Tallowwood		Nil		CBtP marks		Heavy CBtP use, wear.		few scattered leaves		old euc leaf
16	East	307	Poss.	6	Mahog sp	CBTP x 1	Fresh leaf, extensive		Nil	CBTP x 1	occupied		euc leaf nest		euc leaf and bark
16	East	308	SG	7	Bloodwood sp.		nil		Nil		Very old leaf nest, prob ante. Old Euro beehive.		leaf nest and honeycomb		Allocasuarina leaf nest

Zone	Location	Box #	Box type	Height (m)	Tree species	Winter 2016 species	Winter 2016 signs of use	Summer 2016/2017 species	Summer 2016/2017 signs of use	Winter 2017 species	Winter 2017 signs of use	Summer 2017/2018 species	Summer 2017/2018 signs of use	Winter 2018 species	Winter 2018 signs of use
16	East	309	Parr	9	Mahog sp		Nil		Nil	Lace Monitor x 1	Nil	Common Brushtail Possum	occupied		bark and saw dust
16	East	310	Scan	5	Mahog sp		Nil		Nil		Partial leaf nest, prob ante.		euc leaf nest		euc leaf
16	East	311	LG	9	Mahog sp		Nil		Nil		Nil		pest activity, woody debris		bark and insect debris
17	East	312	Parr	7	Mahog sp		Messy leaf nest. Prob Ante		Nil		Old partial leaf nest, SuG/SqG.		leaf litter		conical euc leaf nest
17	East	313	LG	9	Mahog sp		Nil		Nil		Nil		woody debris		shredded bark
17	East	314	LG	10	Sw. Mahog		Nil		Nil		Nil		pest activity and old honeycomb		shredded bark
17	East	315	MB	6	White Stringybark		Nil		Nil		Nil		Nil		Nil
18	East	316	LG	10	White Stringybark		Nil		Nil		Nil	Ants	leaf, debris, ants nest		Nil
18	East	317	Poss.	7	Turp		Nil		Possible latrine cnr, Ante? no leaf		CBtP use.		euc leaves		euc leaf
18	East	318	Parr	8	Blackbutt		nil		Nil		Nil		woody debris		Nil
18	East	319	Cockatoo	10	Blackbutt		Nil		Some old leaf, poss Owlet nightjar		Old leaf, possible CBTP wear.	Common Brushtail Possum	occupied		Euc leaves



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# Appendix G Fauna underpasses



# Fauna Underpass Monitoring 2018/2019

**Oxley Highway to Kempsey, Pacific Highway Upgrade**

Prepared for Roads and Maritime Services

June 2019

## Document control

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*Cover photograph: Koala recorded in F11.67 (left) and Common Brushtail Possum using fauna furniture in F34.72 (right) during late spring/summer surveys.*

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## Executive summary

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### **Context**

This report documents findings of the 2018/2019 monitoring period, the first of three monitoring periods for the fauna underpasses, as required for the Oxley Highway to Kempsey (OH2K) Pacific Highway Upgrade Project (the Project), and specified in the Oxley Highway to Kempsey (OH2K) Ecological Monitoring Program (EMP, RMS 2016).

### **Aims**

The aim of the fauna underpass monitoring program is to determine whether fauna are using the underpass structures to complete crossings under the Pacific Highway. The aim of this report is to determine if the Project is meeting the performance indicators of success for the mitigation measure, and provide corrective actions where required.

### **Methods**

Fourteen underpasses were surveyed in accordance with the monitoring method specified in the EMP, specifically:

- Two remote cameras were placed within each underpass and left to record for 60 consecutive days
- 10 hair tube traps were placed in and around the entrance to each underpass for 14 consecutive nights
- Sand plots were established in combined fauna underpasses and monitored for eight consecutive nights
- Scat searches were conducted within underpasses and adjoining habitat during sand plot surveys and camera deployment and retrieval.

### **Key Results**

The key results of the 2018/2019 fauna underpass monitoring were as follows:

- All but one of the required fauna groups (frogs), were recorded using eleven of the fourteen underpasses; frogs were the only absent group at all underpasses. The remaining three underpasses (F1.62, C4.46 and F21.24) had records of all but two of the required fauna groups, with frogs and either arboreal mammals, macropods or reptiles, respectively, the absent groups.
- Two of the three EPBC listed target threatened species, the Koala and Spotted-tailed Quoll were recorded. The Giant Barred Frog was not recorded using the underpasses.
- Non-EPBC target species, the Green-thighed Frog and Brush-tailed Phascogale were not recorded using any underpasses. Indicator species for the Brush-tailed Phascogale were recorded at all underpasses. However, no frogs were recorded at any underpass to date.
- Two of the three cover-dependent/low mobility species fauna groups, reptiles and small ground-dwelling mammals, were recorded at the majority of underpasses. Frogs were not recorded.
- Non-native predators including cats, dogs and foxes, were detected at all of the fourteen monitored underpasses. Seven of the 14 monitored underpasses showed high use by non-native predators, F1.04, F1.62, F26.40, C32.35, F33.40, F34.72 and C36.40.
- The 2018/2019 average weekly road kill decreased slightly from that recorded during baseline monitoring: 10.4 to 9.0. Three road kill records were within 200 metres of monitored underpasses.

## **Conclusions**

Performance measures were partially met for the 2018/2019 underpass monitoring event. Two of the three EPBC listed target species (Koala and Spotted-tailed Quoll) were recorded completing crossings however it was considered that the Giant Barred Frog is unlikely to be detected at the nominated underpass. An assessment regarding sufficient crossing frequency of EPBC target species could not be undertaken to the detail specified in the EMP, however the use of the underpasses by fauna, as measured and monitored according to the EMP, can indicate whether the underpasses allow for the opportunity for movement within home ranges, dispersal and/or re-colonisation. This has been met at three underpasses for Koalas and one underpass for the Spotted-tailed Quoll. The performance indicators for non-EPBC target species were also partially met: indicator species for the Brush-tailed Phascogale were recorded at all underpasses; indicator species for the Green-thighed Frog were not recorded; and cover-dependent and low mobility fauna were recorded at the majority of underpasses for two of the three relevant fauna groups, with frogs not recorded at any underpass. The performance indicator requiring a reduced incidence of road kill from baseline monitoring was met.

## **Management Implications**

This report presents the results of the first of three monitoring events, as such continued monitoring as per the EMP is recommended. While specific recommendations have not been made, the following considerations may assist the program in meeting its performance measures:

- Consideration could be given to extending the camera monitoring period to increase the opportunity for detecting EPBC species.
- The likelihood of detecting the Green-thighed Frog and other amphibians using current survey methods is low. Consider undertaking targeted frog surveys during/following suitable weather conditions to determine the use of underpasses by amphibians.
- Consider consulting with Local Land Services concerning control methods for foxes and dogs in the area, focusing on those underpasses where they have been recorded, notably, F1.04, F1.62, F26.40, F33.40, F34.72 and C36.40.

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## 1. Introduction

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### 1.1 Context

The Oxley Highway to Kempsey (OH2K) section of the Pacific Highway Upgrade Project (the Project) was approved by the NSW Department of Environment and Planning in 2012 subject to various Ministers Conditions of Approval (MCoA) and a Statement of Commitments (SoC). A subsequent approval with additional conditions of consent (CoA) was granted in 2014 by the Commonwealth Department of Environment (DoE) for Matters of National Environmental Significance (MNES) listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1995* (EPBC Act). The Ecological Monitoring Program (hereafter referred to as the EMP) (RMS 2016) combines these approval conditions and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project.

Fauna underpasses were installed to reduce the impacts on fauna, facilitate movement and maintain habitat connectivity for native fauna. These structures are to be monitored to assess their effectiveness in facilitating fauna movement, as required by the EMP.

#### 1.1.1 Monitoring framework

The design, methods and performance indicators that define the fauna underpass monitoring program are specified in the EMP. The EMP specifies that monitoring be undertaken at 14 underpasses, including 10 dedicated fauna underpasses and four combined drainage/fauna culverts.

The EMP requires monitoring to occur in autumn and late spring/early summer in Years 4, 6 and 8 (operational phase) of the Project. The EMP specifies that additional monitoring may be required if underpasses are determined to be ineffective.

This report represents the first of three reports required for the underpass monitoring – Year 4 autumn 2018 and spring/summer 2018/2019.

#### 1.1.2 Background data

##### ***Underpass selection***

The Project includes over 50 underpasses that may facilitate the passage of fauna, including bridges, dedicated fauna underpasses and combined drainage/fauna culverts. The EMP specifies that 14 underpasses be monitored based on the following criteria:

- All dedicated fauna underpasses will be monitored.
- Combined underpasses that are 50 metres or more in length, and located in proximity to intact native vegetation (fauna habitat) will be monitored.
- No combined culverts that are located in cleared, disturbed or modified areas will be monitored.
- No combined culverts that are located within 600 metres of another monitored underpass will be monitored.
- No incidental underpasses will be monitored (small culverts that are not intended to allow for the passage of fauna but may be used incidentally by small fauna).

### Indicator species

The EMP provides a list of indicator and target (threatened) species to determine the successful use of fauna crossing structures. These species are those that have been previously recorded in proximity to the Project or are known to occur in the Project area and were considered as being potentially adversely affected by the Project. Section 2.2.4 of the EMP states:

*“The effectiveness of wildlife crossings will be based on their use by fauna groups previously recorded in proximity to the Project (<one kilometre). It is assumed that the Project bisects the habitat of at least some individuals from each of the nominated fauna groups (Table 4). Fauna species known to occur within the Project area that may be potentially adversely affected by the upgrade are listed in Table 5. These species will indicate the successful usage of crossing structures.”*

Table 1 lists the five fauna groups that are to be used to assess the effectiveness of the underpasses, as well as the indicator and target species for each of the five groups.

**Table 1: Indicator species for fauna crossings (from Table 5 of the EMP)**

Fauna group	Indicator species (known from area)	Target (threatened) species
Frogs	<i>Litoria</i> sp., <i>Limnodynastes</i> sp., <i>Crinia</i> sp., Giant Barred Frog	Green-thighed Frog, Giant Barred Frog
Small ground-dwelling mammals	Antechinus, rodents and bandicoots, Echidna, Spotted-tailed Quoll	Spotted-tailed Quoll, Brush-tailed Phascogale
Arboreal mammals	Brushtail Possum, Ringtail Possum	Brush-tailed Phascogale
Koala	Koala	Koala
Macropods	Swamp Wallaby, Red-necked Wallaby, Eastern Grey Kangaroo	N/A

### 1.1.3 Purpose of this report

This report details the findings obtained from the first operational monitoring event for the fauna underpasses. The aims of this report are to summarise the methods and results of the 2018/2019 monitoring and determine if performance measures are being met, as per the EMP.

## 1.2 Performance Measures

The EMP specifies the following performance measures for fauna underpasses:

- *Complete safe crossing of the crossing by the targeted EPBC species at sufficient frequency to ensure that habitat connectivity is maintained or improves from baseline conditions, and ongoing population viability by providing opportunity for species dispersal and re-colonisation when all monitoring events are considered at Year 8*
- *For non-EPBC species, recorded presence of indicator species from nominated classes during underpass monitoring*
- *For non-EPBC species, recorded presence of cover dependent species or fauna species with low mobility during underpass monitoring*
- *Reduced incidence of road kill from baseline conditions.*

### 1.3 Monitoring Timing

Monitoring is to be undertaken in Years 4, 6 and 8 of the Project’s operational phase. Monitoring is to occur in late autumn and late spring/early summer each monitoring year for a minimum of 60 days. The timing of monitoring coincides with breeding seasons and dispersal periods for target species, shown in Table 2.

**Table 2: Breeding seasons and likely dispersal periods of threatened target species (from Table 13 of the EMP)**

Scientific name	Common name	Breeding season	Likely dispersal period
<i>Dasyurus maculatus</i>	Spotted-tail Quoll	April to July	Spring and summer
<i>Litoria brevipalmata</i>	Green-thighed Frog	Late spring and summer	In association with rainfall events
<i>Mixophyes iteratus</i>	Giant Barred Frog	Late spring to early summer	In association with rainfall events
<i>Phascogale tapoatafa</i>	Brush-tailed Phascogale	May to July	Mid-summer
<i>Phascolarctos cinereus</i>	Koala	Spring and summer	Spring and summer

### 1.4 Reporting

Annual reporting of monitoring results will include:

- Detailed description of monitoring methodology
- Results of the monitoring period
- Discussion of results, including how the results compare against performance measures, if any modifications to timing or frequency of monitoring periods or monitoring methodology are required and any other recommendations
- If contingency measures should be implemented.

All reports prepared under the EMP will be submitted to the Secretary of the Department of Planning and Environment and the Environment Protection Authority.

### 1.5 Limitations

- Due to their small size and cryptic nature, frogs and smaller reptiles are difficult to detect within the underpasses using the current survey methods and thus if present, may have gone undetected.
- The EMP requires installation of sand plots at combined underpasses, which serve as combined drainage/fauna culverts. It was considered that sand plots established across the active drainage channel of the culvert would likely wash away. In consultation with Roads and Maritime it was therefore determined that sand plots would be established across the entire width of the underpass only if the drainage channel was not inundated with water.
- The EMP requires an assessment of the effectiveness of the underpasses for species listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (hereafter referred to as EPBC species) based on “*Complete safe crossing of the crossing by the targeted EPBC species at sufficient frequency to ensure that habitat connectivity is maintained or improves from baseline conditions, and ongoing population viability by providing opportunity for species dispersal and re-colonisation*”. The EMP does not define what “*sufficient frequency*” would be and baseline crossing frequencies are unknown and therefore cannot be used to assess the success of the underpasses. In addition, this monitoring program does not provide a means of measuring dispersal and re-colonisation of species or population viability. The limitations of the EMP with regards to this performance measure is discussed in detail in Table 11.

## 2. Methods

### 2.1 Monitoring Sites

Monitoring was undertaken at 14 underpasses, including 10 dedicated fauna underpasses and four combined drainage/fauna culverts. Table 3 lists the fauna groups nominated in Table 12 of the EMP and shows the relevance of each of these groups at each of the underpasses (as specified in Table 12 of EMP). Target species (non-EPBC and EPBC listed species) have also been considered separately to their related fauna group as Table 12 of the EMP specifically nominates individual target species at certain underpasses. While the Brush-tailed Phascogale was not specifically nominated within Table 12 of the EMP, it is listed in Table 13 of the EMP as a species targeted by underpasses and has therefore been included separately as a non-EPBC target species. Underpass F34.72 was erroneously omitted from Table 12 in the EMP; the text states all dedicated underpasses are to be monitored, therefore, after consultation with Roads and Maritime, F34.72 was included in the monitoring. Fauna groups were therefore not nominated for F34.72 within the EMP. For the purpose of assessment, fauna groups/species nominated for the two closest underpasses (F33.40 and C36.4) have been included here as a guide for F34.72. The location of each monitored underpass is shown in Figure 1 and Figure 2.

**Table 3: Monitored fauna underpasses and target species (adapted from Table 12 of the EMP).**

	Indicator Species	F1.04	F1.62	C4.46	C7.26	F9.70	F11.67	F20.54	F21.24	F22.32	F26.40	C32.35	F33.40	F34.72*	C36.40
<b>Fauna group/species (target threatened species)</b>															
Frogs (Green-thighed Frog)	<i>Litoria</i> sp., <i>Limnodynastes</i> sp., <i>Crinia</i> sp., Giant Barred Frog	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Small ground-dwelling mammals (Brush-tailed Phascogale)	<i>Antechinus</i> spp, rodents and bandicoots, Echidna, Spotted-tail Quoll	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Arboreal mammals (Brush-tailed Phascogale)	Brushtail Possum, Ringtail Possum		✓	✓	✓	✓	✓			✓			✓	✓	✓
Macropods	Swamp Wallaby, Red-necked Wallaby, Eastern Grey Kangaroo	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Reptiles		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<b>Non-EPBC target species</b>															
Green-thighed Frog	<i>Litoria</i> sp., <i>Limnodynastes</i> sp., <i>Crinia</i> sp., Giant Barred Frog												✓		✓
Brush-tailed Phascogale <sup>+</sup>	<i>Antechinus</i> spp, rodents and bandicoots, Echidna, Spotted-tail Quoll, Brushtail Possum, Ringtail Possum														
<b>EPBC target species</b>															
Giant Barred Frog	Giant Barred Frog														✓
Koala	Koala	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Spotted-tail Quoll	Spotted-tail Quoll				✓	✓	✓	✓	✓	✓	✓		✓	✓	✓

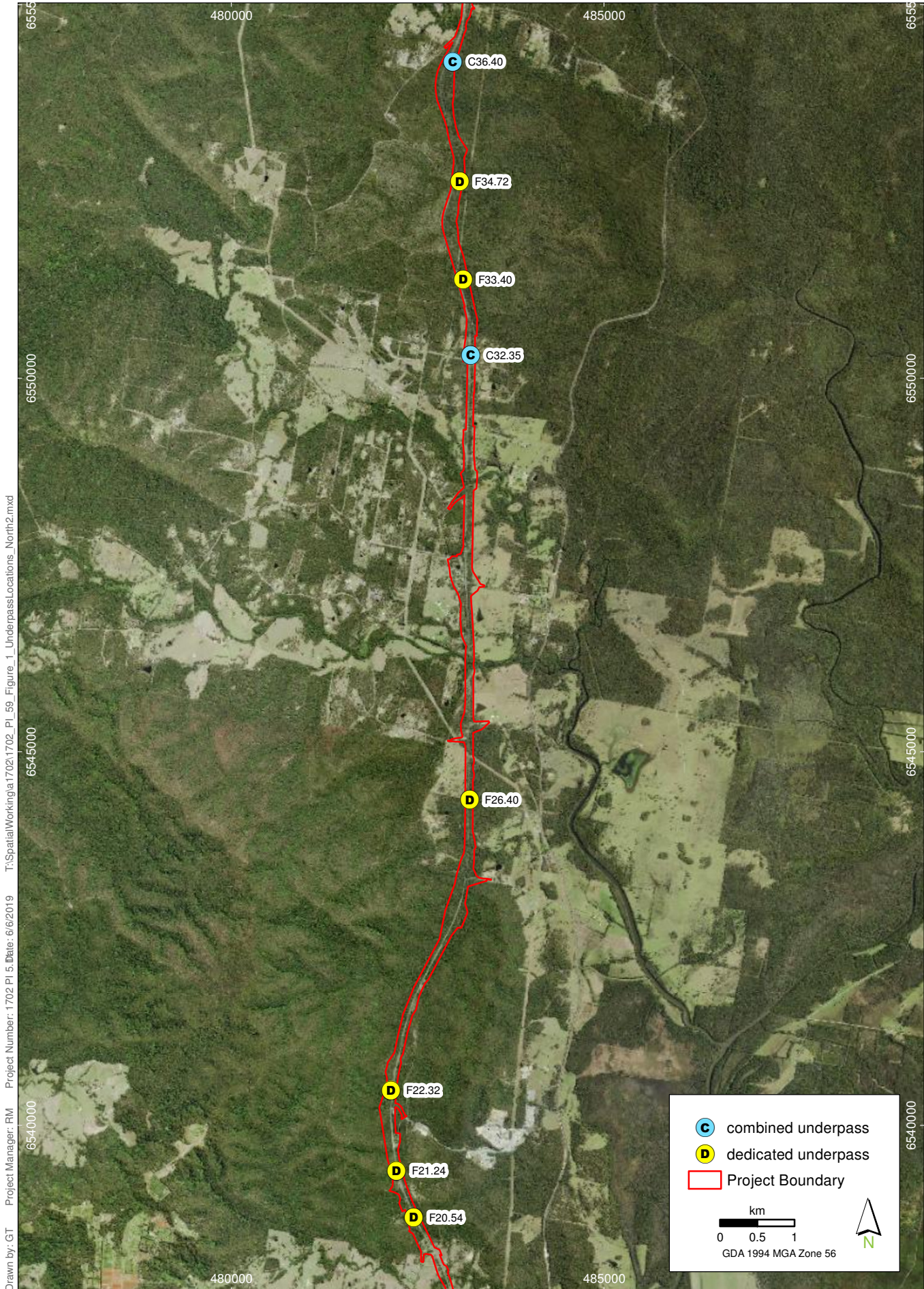
+ The Brush-tailed Phascogale was not specifically nominated at any underpass in Table 12 of the EMP.

\*Nominated fauna groups/species are based on the two closest underpasses and proximity of recorded Green-thighed Frog habitat.

## 2.2 Survey Method

Surveys were undertaken in accordance with the EMP. At each underpass the following survey techniques were used:

- Two motion-detecting cameras were installed in the middle of each underpass, one facing along the fauna furniture and one facing along the ground, where possible. Cameras were left operating for 60 days in autumn and late spring/early summer.
- Sand plots at least one metre wide were established across the entire width of the raised cement footpath at each end of combined underpasses as drainage channels were inundated at the time of monitoring. Sand plots were monitored for eight nights in each monitoring period. Each morning plots were checked, any tracks recorded and plots raked clean.
- Ten hair-tubes were attached to fauna furniture (where possible) or placed along the ground within each underpass and in adjoining habitat. Hair tubes were baited with a mixture of peanut butter, honey and oats and left for a minimum of 14 consecutive nights in each monitoring period. Hair samples were sent to Barbara Triggs ('Dead Finish') for analysis, and were identified to species level where possible.
- Scat searches were undertaken within underpasses and adjoining habitat during sand plot surveys and camera deployment and retrieval.



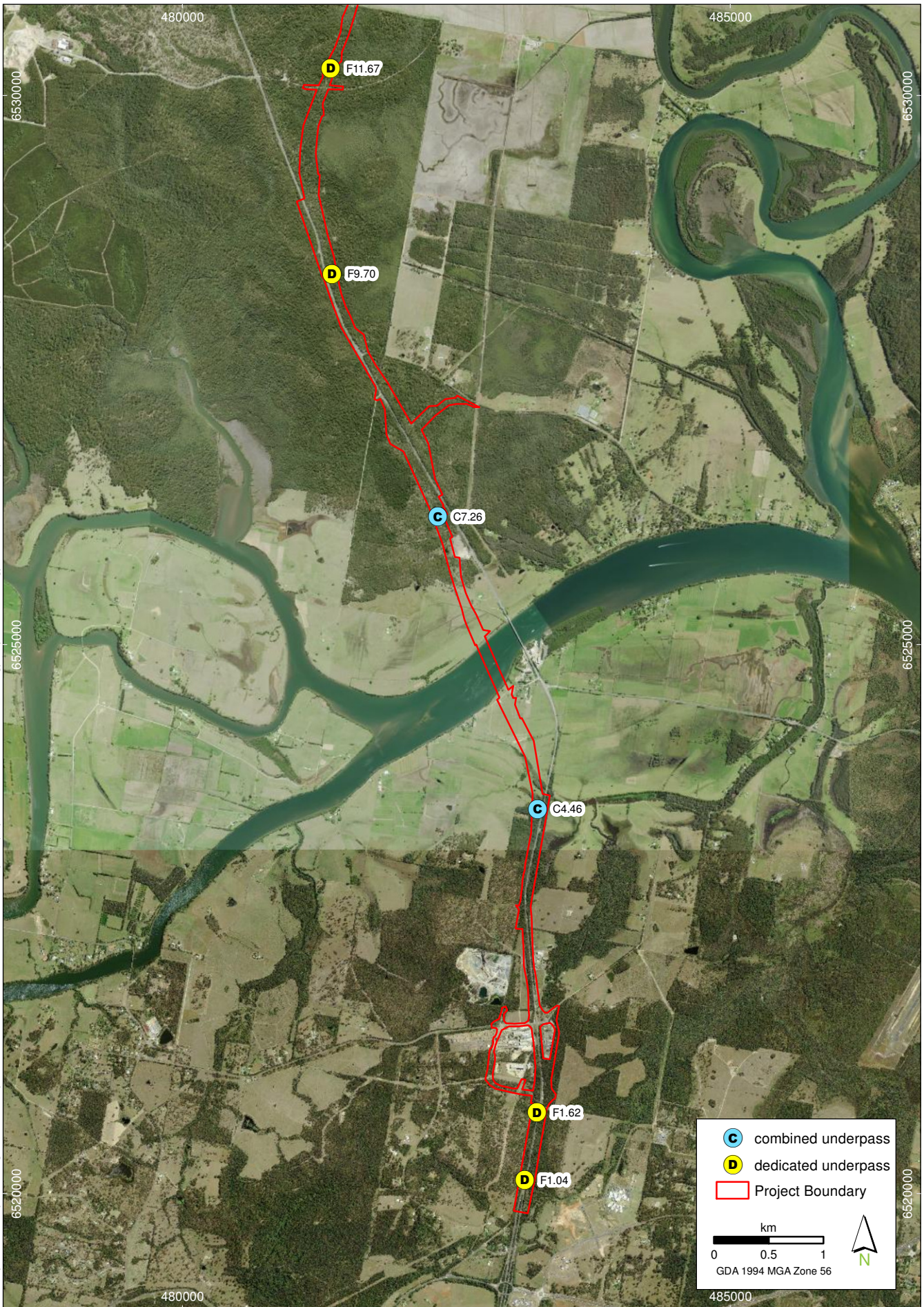
Fauna Underpass Locations - North

Oxley Highway to Kempsey - PI 5.9 Fauna Underpass Monitoring

**FIGURE 1**

Imagery: (c) LPI 2013

Drawn by: GT Project Manager: RM Project Number: 1702 PI 5 Date: 6/6/2019 T:\spatial\projects\at1700\at1702\_OH2K\_Ecology\Maps\PI\_5\_Ecology\_OH2K\PI\_59\_Figure\_2\_UnderpassLocations\_South.mxd



### Fauna Underpass Locations - South

Oxley Highway to Kempsey - PI 5.9 Fauna Underpass Monitoring

**FIGURE 2**

Imagery: (c) LPI 2013

### 3. Results

#### 3.1 2018/2019 Monitoring Summary

Detailed field data are provided in Annex 1 and Annex 2. Results of the different survey methods were combined to provide an overall assessment of the use of the monitored underpasses.

##### 3.1.1 Monitoring periods

The 2018/2019 monitoring periods were as follows:

- Autumn 2018: 27 March 2018 – 29 May 2018
- Late spring/early summer 2018/2019: 21 November 2018 – 24 January 2019.

Hair tube surveys were undertaken in the first two weeks of the monitoring period. Sand plots were monitored for eight nights in autumn (7 – 15 May 2018) and late spring (21 – 29 November 2018). As the deployment periods were longer than the minimum 60 days, different species that had not been recorded within the 60 day monitoring period were considered as value adding data and included in the assessment of underpass use by fauna groups.

A number of issues including camera malfunctions, battery depletion and camera tampering and theft were encountered during the monitoring periods. Camera details, including monitoring dates and durations, for autumn and spring/summer surveys are provided in Annex 1.

##### 3.1.2 Remote cameras

Table 4 provides a summary of the fauna records for the monitored underpasses. Cameras captured a total of 975 fauna records over the two monitoring periods. A proportion (8.6%) of records were unidentified, which were mostly partial and/or unclear images. Of those records that were identified, 54.1% were identified as native fauna.

**Table 4: 2018/2019 camera fauna record summary**

Underpass	# fauna records	# natives	# non native	# unidentified	# introduced predator	% native	% introduced predator
F1.04	98	26	64	8	52	26.5	53.1
F1.62	60	9	37	14	26	15.0	43.3
C4.46	76	57	14	5	11	75.0	14.5
C7.26	55	42	13	0	7	76.4	12.7
F9.70	100	16	53	31	21	16.0	21.0
F11.67	56	44	8	4	1	78.6	1.8
F20.54	77	54	21	2	16	70.1	20.8
F21.24	35	26	8	1	7	74.3	20.0
F22.32	112	87	22	3	9	77.7	8.0
F26.40	93	51	41	1	34	54.8	36.6
C32.35	20	14	6	0	6	70.0	30.0
F33.40	54	18	26	10	19	33.3	35.2
F34.72	121	71	46	4	42	58.7	34.7
C36.40	18	12	5	1	5	66.7	27.8
<b>TOTALS</b>	<b>975</b>	<b>527</b>	<b>364</b>	<b>84</b>	<b>256</b>	<b>54.1</b>	<b>26.3</b>



### 3.2 Native Fauna Use of Underpasses

Results of the different survey methods were combined to provide an overall assessment of the use of monitored underpasses. While a specific means of determining a “complete safe crossing” by targeted EPBC species is not specified in the EMP, it is considered that animals captured on remote cameras within the underpass are using the underpass to complete successful crossings. Table 5 shows the use of underpasses by fauna groups and target species. Shaded squares indicate the underpasses where fauna groups/target species were nominated (Table 3). All but one of the required fauna groups (frogs), were recorded using eleven of the fourteen underpasses; frogs were the only absent group at all underpasses. The remaining three underpasses (F1.62, C4.46 and F21.24) had records of all but two of the required fauna groups, with frogs and either arboreal mammals, macropods or reptiles, respectively, the absent groups. A summary of the use of underpasses by the respective fauna groups is as follows:

- Frogs: not recorded at any underpass.
- Small ground-dwelling mammals: recorded at all nominated underpasses; represented by rodents, antechinus, bandicoots, the Echidna and the Spotted-tailed Quoll.
- Arboreal mammals: recorded at seven of the nine nominated underpasses, and at two additional underpasses; represented by the Brushtail Possum and the Koala.
- Macropods: recorded at 13 of the 14 nominated underpasses (excluding C4.46); represented by the Eastern Grey Kangaroo and Swamp Wallaby.
- Reptiles: recorded at 13 of the 14 nominated underpasses (excluding F21.24); represented predominantly by the Eastern Water Dragon and Lace Monitor.

**Table 5: Native fauna use of underpasses – autumn 2018 and spring/summer 2018/2019**

	Indicator Species	F1.04	F1.62	C4.46	C7.26	F9.70	F11.67	F20.54	F21.24	F22.32	F26.40	C32.35	F33.40	F34.72*	C36.40
<b>Fauna group/species (target threatened species)</b>															
Frogs (Green-thighed Frog)	<i>Litoria</i> sp., <i>Limnodynastes</i> sp., <i>Crinia</i> sp., Giant Barred Frog														
Small ground-dwelling mammals (Brush-tailed Phascogale)	<i>Antechinus</i> spp, rodents and bandicoots, Echidna, Spotted-tail Quoll	Y (3)	Y (3)	Y (3)	Y (2)	Y (2)	Y (3)	Y (4)	Y (3)	Y (5)	Y (3)	Y (1)	Y (3)	Y (3)	Y (2)
Arboreal mammals (Brush-tailed Phascogale)	Brushtail Possum, Ringtail Possum	Y (1)		Y (1)	Y (1)	Y (1)	Y (1)			Y (1)		Y (1)		Y (1)	Y (1)
Macropods	Swamp Wallaby, Red-necked Wallaby, Eastern Grey Kangaroo	Y (1)	Y (1)		Y (1)	Y (1)	Y (2)	Y (2)	Y (1)	Y (2)	Y (2)	Y (1)	Y (1)	Y (1)	Y (1)
Reptiles		Y (2)	Y (1)	Y (1)	Y (2)	Y (3)	Y (1)	Y (2)		Y (1)	Y (1)	Y (1)	Y (3)	Y (2)	Y (2)
<b>Non-EPBC target species</b>															
Green-thighed Frog	<i>Litoria</i> spp., <i>Limnodynastes</i> spp., <i>Crinia</i> spp., Giant Barred Frog														
Brush-tailed Phascogale*	<i>Antechinus</i> spp, rodents and bandicoots, Echidna, Spotted-tail Quoll, Brushtail Possum, Ringtail Possum														
<b>EPBC target species</b>															
Giant Barred Frog	Giant Barred Frog														
Koala (Koala)	Koala					Y	Y						Y		
Spotted-tail Quoll	Spotted-tail Quoll														Y

\* The Brush-tailed Phascogale was not specifically nominated at any underpass in Table 12 of the EMP. \*Nominated fauna groups/species are based on the two closest underpasses. (#) = number of different species detected.

### 3.3 EPBC Target Species

Three of the five target threatened species (Table 1) are listed under the EPBC Act, including the Koala (*Phascolarctos cinereus*), Giant Barred Frog (*Mixophyes iteratus*) and Spotted-tailed Quoll (*Dasyurus maculatus*). These species were specifically nominated as target species at all, one and 10 of the underpasses respectively. Two of these species were recorded using four underpasses during the 2018/2019 monitoring period; the Koala was detected using F9.70, F11.67 and F33.40, and the Spotted-tailed Quoll was detected using C36.40. Details of these records are provided in Table 6 and discussed below. The Giant Bared Frog was not detected using any underpass.

The Koala was detected on a single occasion at three of the 14 nominated underpasses during the spring/summer monitoring period, with all individuals heading in an easterly direction. All three underpasses are dedicated fauna underpasses with installed fauna furniture (rails and refuge poles) targeted specifically at Koalas. However all three individuals were recorded on the ground. Underpasses used were all similar in width (3 metres), height (2.4-3 metres) and length (38-49 metres) and all three connect State Forest habitat on either side of the road.

The Spotted-tailed Quoll was detected using a nominated combined drainage/fauna culvert heading in a westerly direction on the raised fauna footpath. The underpass provides connectivity of habitat from Maria River State Forest in the east linked indirectly to the northern tip of Kumbatine National Park in the west. The western side of the underpass opens to a lightly re-vegetated median area that is separated from the open woodland of Kumbatine National Park by a local two-lane road.

The Giant Barred Frog was specifically nominated as a species that may ‘possibly’ (RMS 2016) use C36.40. Given the constructed state of C36.40, the intermittent water flow within the underpass and in the drainage line connecting to the underpass, and the absence of habitat within the underpass to facilitate movement (including shelter such as leaf litter, vegetation, rocks and logs), it is considered unlikely that this species would use this underpass. The nearest baseline record is from Maria River, approximately 500 metres to the north (Lewis 2014).

As mentioned, it is considered that animals captured on remote cameras within the underpass are using the underpass to complete successful crossings. Koalas have therefore been recorded completing safe crossings at three of the 14 underpasses at which it is a target species, and the Spotted-tail Quoll has been recorded completing a safe crossing at one of 10 underpasses at which it is a target species.

**Table 6: Recorded EPBC species in underpasses**

Season	Underpass	Date	Time	Species	Position	Direction
Autumn	C36.40	28/05/2018	2:43:37	Spotted-tailed Quoll	Ground	West
Spring/summer	F33.40	23/11/2018	5:41:47	Koala	Ground	East
Spring/summer	F11.67	24/11/2018	23:16:54	Koala	Ground	East
Spring/summer	F9.70	16/12/2018	11:06:19	Koala	Ground	East

### 3.4 Non-EPBC Target Species

Non-EPBC target threatened species include the Green-thighed Frog (*Litoria brevipalmata*) and Brush-tailed Phascogale (*Phascogale tapoatafa*).

#### 3.4.1 Presence of indicator species

The Green-thighed Frog was specifically nominated as a species that may ‘possibly’ (RMS 2016) use F33.40 and C36.40. Indicator species for this target species include those species listed within the frog fauna group, however no amphibians were detected at any of the underpasses during the 2018/2019 monitoring periods. F33.40 is located approximately 150 metres (western side of carriageway) and 250 metres (eastern side of carriageway) south of Green-thighed Frog ponds constructed as part of the Project’s mitigation requirements for this species, in proximity to a site where the species was recorded during targeted surveys (Site 16, Lewis 2013). However, no Green-thighed Frogs have been recorded at these ponds during the two monitoring events undertaken by Niche as part of the Project’s Green-thighed Frog pond monitoring in 2016/2017 and 2018/2019 (Niche 2017a; Niche 2018a). It should be noted that it is unlikely that, if present, individuals from the identified Site 16 population would travel the required distance to F33.40 (Lemckert and Slatyer 2002). C36.40 is within 400 metres of a targeted survey site (Site 17, exact location not provided; Lewis 2013) identified as a likely location for the species and visited during targeted surveys. However, no Green-thighed Frogs were recorded at this site during the targeted surveys. It is therefore considered unlikely that Green-thighed Frogs use C36.40 or F33.40.

Indicator species for the Brush-tailed Phascogale include those species included in the small ground-dwelling mammal fauna group and the arboreal mammal fauna group. While the Brush-tailed Phascogale was not specifically nominated at individual underpasses, for the purpose of assessment, it is assumed that this species is a general target at all underpasses where the small ground-dwelling mammals and/or arboreal mammal fauna groups have been nominated, i.e. at all underpasses. Representatives of the small ground-dwelling fauna group were detected at all underpasses with at least one indicator species at any underpass and representatives of the arboreal mammal group were recorded at seven of the nine nominated underpasses. It is therefore considered that indicator species for the Brush-tailed phascogale have recorded use at all relevant underpasses.

#### 3.4.2 Presence of cover-dependant/low mobility species

Cover dependent fauna, or fauna with low mobility, was not defined within the EMP. As such it has been assumed to include animals whose size is likely to limit dispersal ability and increase predation/exposure risk, i.e. smaller terrestrial fauna species, which have a reduced ability to disperse and greater vulnerability to exposure and predation compared to larger, more mobile species. Cover-dependent and low mobility fauna has been interpreted as including individuals from three fauna groups: frogs, reptiles and small ground-dwelling mammals.

As discussed, at least one indicator species from the small ground-dwelling mammal fauna group were recorded at all nominated underpasses, represented by rodents, antechinus, bandicoots, the Echidna and the Spotted-tailed Quoll; and reptiles were recorded at 13 of the 14 nominated underpasses (excluding F21.24), represented predominantly by the Eastern Water Dragon and Lace Monitor.

Frogs were not recorded using the underpasses. This lack of detection could be attributed to the survey methods and weather conditions at the time of surveys. Hair tubes, remote cameras and limited opportunistic surveys are generally not very effective at detecting small, and often cryptic, amphibian species.

### 3.5 Use of underpasses by non-native predators

Non-native predators including cats, dogs and foxes, were detected at all of the fourteen monitored underpasses. Table 7 shows the non-native predators recorded using each underpass and the percentage of all identified fauna records that were non-native predators.

Based on previous underpass monitoring outcomes (Sandpiper Ecological 2015, Sandpiper Ecological 2017) and in consultation with North Coast Local Land Services (Biosecurity Manager, *pers. comm.* 2017), it was considered that visitation by non-native predators equating to greater than 25% of visitations to the underpass or visitations by non-native predators on more than 25% of the days monitored, constitutes high use by non-native predators.

Seven of the 14 monitored underpasses showed high use by non-native predators. The highest use was recorded at F1.04, F1.62 and F26.40, with visitation by non-native predators accounting for 53.1%, 43.3% and 36.6% of visitations respectively; the majority of which were Foxes. The exotic predators recorded within C32.35, F33.40 were predominantly Cats, while F34.72 had high visitation by Dogs.

**Table 7: Exotic predator use of underpasses**

	F1.04	F1.62	C4.46	C7.26	F9.70	F11.67	F20.54	F21.24	F22.32	F26.40	C32.35	F33.40	F34.72	C36.40
Fox ( <i>Vulpes vulpes</i> )	47	22	8	1	13	0	2	0	4	22	0	2	0	0
Cat ( <i>Felis catus</i> )	5	4	3	6	8	1	6	5	4	5	6	15	16	3
Dog ( <i>Canis familiaris/dingo</i> )	0	0	0	0	0	0	8	2	1	7	0	2	26	2
% of visitations	<b>53.1</b>	<b>43.3</b>	14.5	12.7	21.0	1.8	20.8	20.0	8.0	<b>36.6</b>	<b>30.0</b>	<b>35.2</b>	<b>34.7</b>	<b>27.8</b>

**Bold** indicates visitation rate by exotic predators > 25% of all visitations.

### 3.6 Road Kill

#### 3.6.1 Weekly road kill rate

As part of the road kill monitoring component of the Project, road kill surveys were undertaken in October 2018 (spring) and January 2019 (summer), involving weekly surveys of the entire length of the Project for four weeks in each season. Detailed reporting of these surveys is presented in Niche 2019a. There were a total of 72 road kill records for the spring and summer road kill monitoring events, including 45 in spring and 27 in summer. Baseline surveys recorded 83 animals as road kill during the spring (36 records) and summer (47 records) monitoring events. Table 8 shows a comparison between the average weekly road kill for baseline and the 2018/2019 monitoring events. While spring weekly road kill rates were higher in the 2018/2019 monitoring period (11.3) than during baseline (9.5), summer weekly road kill rates were lower in the 2018/2019 monitoring period (6.8) compared to baseline (11.8) and the overall average weekly road kill rate has decreased from baseline.

#### 3.6.2 Within 200 metres of monitored fauna underpasses

Table 9 shows the road kill records within 200 metres of monitored underpasses during 2018/2019 and baseline monitoring events. There were a total of three road kill records within 200 metres of monitored underpasses during spring and summer 2018/2019 road kill surveys. Two of these records were within 200 metres of C32.35. Baseline road kill surveys recorded five road kill within 200 metres of monitored underpasses including F1.04, F34.72, F22.32 and C7.26.

### 3.6.3 Threatened species road kill

Table 10 lists the threatened species identified as road kill throughout the Project to date. One Koala was identified as road kill in September 2018 (outside of the monitoring period), within a fenced area of the highway on the northbound left lane near Barry’s Creek. The individual likely entered through a flood damaged section of the fauna fencing, which was immediately addressed with temporary repairs by RMS and permanent works completed on the 19 -21 September 2018. No other target species were identified as road kill during the 2018/2019 monitoring period. However it should be noted that road kill surveys are undertaken from a vehicle travelling at 80 kilometres per hour, without an opportunity to stop due to safety restrictions. The ability to positively identify small fauna (including frogs and small ground-dwelling mammals) is therefore highly limited.

The baseline monitoring report (Lewis 2014) states that, based on baseline Koala road kill records, “*the baseline count for road kill should be set at 1 individual per 8 weeks*”. Koala road kill has therefore not increased from the baseline count.

**Table 8: Average weekly road kill rate comparison**

Monitoring period		Spring (n)	Summer (n)	2018/2019 (n)
Baseline	2013/2014	9.0 (4)	11.8 (4)	10.4 (8)
Operational	2018/2019	11.3 (4)	6.8 (4)	9.0 (8)

n = number of surveys

**Table 9: Road kill within 200 metres of monitored fauna underpasses**

Event	Season	Species	Native/Introduced	Fauna category	Underpass	Distance (metres)
2018/2019	Spring	Medium Mammal	unknown	Medium ground dwelling mammal	C32.35	136.8
2018/2019	Summer	Medium Mammal	unknown	Medium ground dwelling mammal	F21.24	31.9
2018/2019	Summer	Kangaroo	native	Large ground dwelling mammal	C32.35	54.3
Baseline	Autumn	Brush-tail Possum	native	Arboreal Mammal	F1.04	67.0
Baseline	Spring	Lace Monitor	native	Reptile	F34.72	77.8
Baseline	Spring	Koala	native	Arboreal Mammal	F22.32	117.3
Baseline	Summer	Eastern Grey Kangaroo	native	Large ground dwelling mammal	C7.26	150.4
Baseline	Summer	Red-necked Wallaby	native	Large ground dwelling mammal	F22.32	150.5

**Table 10: Threatened species road kill to date**

Monitoring type (report)	Monitoring period	Threatened species identified as road kill (number recorded)
Baseline (Lewis 2014)	2013-2014	<ul style="list-style-type: none"> <li>• Koala (1*)</li> <li>• Grey-headed Flying Fox (2)</li> </ul>
Clearing (Niche 2015)	2014-2015	<ul style="list-style-type: none"> <li>• Koala (4)</li> <li>• Grey-headed Flying Fox (1)</li> <li>• Masked Owl (2)</li> <li>• Spotted-tail Quoll (1)</li> </ul>
Construction (Niche 2016)	2015-2016	<ul style="list-style-type: none"> <li>• Koala (3)</li> </ul>
Construction (Niche 2017b)	2016-2017	<ul style="list-style-type: none"> <li>• Koala (2)</li> </ul>
Construction (current)	2017-2018	Nil
Operational	2018-2019	<ul style="list-style-type: none"> <li>• Koala (1)</li> </ul>

\* = An additional three Koala road kill were recorded between August 2013 and February 2014, outside of the monitoring period.

## 4. Discussion

### 4.1 Performance Measures

A summary and discussion of the 2018/2019 fauna underpass monitoring results in relation to the performance measures is provided in Table 11.

**Table 11: Performance measures**

Performance measure	Discussion
Complete safe crossing of the crossing by the targeted EPBC species at sufficient frequency to ensure that habitat connectivity is maintained or improves from baseline conditions, and ongoing population viability by providing opportunity for species dispersal and re-colonisation when all monitoring events are considered at Year 8.	<p><b>This performance measure cannot be assessed to the level specified in the EMP due to lack of data.</b> The crossing frequency required to determine effective habitat connectivity each EPBC species and baseline crossing frequencies are unknown. As such, it is not possible to determine if fauna are crossing with ‘sufficient frequency’ and therefore it is not possible to use this metric to assess the success of the underpasses. In addition, the monitoring program does not provide a means of measuring dispersal and re-colonisation of species.</p> <p>The role of habitat connectivity in species genetic diversity and population viability is broad, complex, population and species-specific, and beyond the scope of this monitoring program. For example, a larger wider-ranging species may require habitat connectivity over a much broader area to ensure population viability due to the broader distribution of resources when compared to a smaller species with smaller home range areas. The use of the underpasses by fauna, as measured and monitored according to the EMP, can only indicate that the underpasses allow for the opportunity for movement within home ranges, dispersal and/or re-colonisation. This has been met at three underpasses for Koalas and one underpass for the Spotted-tailed Quoll.</p> <p>Monitoring in years 4, 6 and 8 permits the reporting of the frequency of use of underpasses by EPBC target species within specific monitoring periods. These frequencies may be used within the framework of the monitoring program to identify changes in use, for example as species become more familiar with the crossings or seasonal differences. In addition, direction of travel may be used to identify any directional trends over the three prescribed monitoring years. Beyond this, large-scale conclusions cannot be drawn based on the monitoring results.</p> <p>To date, two target EPBC species (Koala and Spotted-tailed Quoll) have been recorded during the 2018/2019 monitoring.</p> <p>The Koala was recorded using three underpasses, each on a single occasion. These events all occurred within the second (spring/summer) monitoring event, which may reflect a developed familiarity with the crossings or the movement seasonality of this species. The Spotted-tailed Quoll was detected using one underpass on a single occasion.</p> <p>The Giant Barred Frog was not detected at the nominated C36.40 and is considered unlikely to be detected at this underpass given the lack of suitable aquatic habitat. Giant Barred Frog monitoring for the Project has however shown that this species is traversing the Pacific Highway within the monitored waterways under bridges (Niche 2018b).</p>
For non-EPBC species, recorded presence of indicator species from nominated classes during underpass monitoring.	<p><b>This performance measure has been met for one of the two non-EPBC target threatened species.</b></p> <p>Indicator species (small ground-dwelling mammals and/or arboreal mammals) for the Brush-tailed Phascogale were recorded using all underpasses.</p> <p>Indicator species for the Green-thighed Frog were not recorded using the two underpasses where this species was nominated. It is noted that the EMP states that this species may ‘possibly’ use these underpasses. However it is considered unlikely that the Green-thighed Frog uses the nominated underpasses (F33.40 and C36.40) due to the distance of the identified population from F33.40 and the absence of baseline records in proximity to C36.40.</p>
For non-EPBC species, recorded presence of cover-dependent species or fauna species with low mobility during underpass monitoring.	<p><b>This performance measure has been met at the majority of underpasses for two of the three relevant fauna groups.</b></p> <p>Cover-dependent and low mobility fauna has been interpreted as including individuals from three fauna groups: frogs, reptiles and small ground-dwelling mammals.</p> <ul style="list-style-type: none"> <li>• Frogs were not recorded at any underpass.</li> <li>• Reptiles were recorded at 13 of the 14 nominated underpasses (excluding F21.24).</li> <li>• Small ground-dwelling mammals were recorded at all nominated underpasses.</li> </ul>
Reduced incidence of road kill from baseline conditions.	<p><b>This performance measure has been met.</b></p> <p>The annual average weekly road kill rate has decreased slightly from baseline to 2018/2019 operational monitoring (10.4 in baseline <i>cf.</i> 9.0 in 2018/2019).</p>

## 5. Recommendations

### 5.1 Contingency Measures

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those that are related to the underpass monitoring program are listed and discussed in Table 12.

**Table 12: Contingency measures**

Potential problem	EMP contingency measure	Discussion of proposed measure
No recorded presence of indicator species from the nominated classes in underpasses.	Commence review/modification of fauna furniture associated with underpasses within two weeks of results reported by ecologist.	<p>Four of the five fauna groups have been detected at the majority of monitored underpasses.</p> <p>Frogs have not been detected using any underpass, however monitoring methods do not favour their detection.</p> <p>Continued monitoring, as per the EMP, will add to the number of records at each underpass.</p> <p><b>This contingency measure is not considered relevant at this stage</b></p>
No recorded presence of cover- dependent species or fauna species with low mobility in underpasses.	Commence review/modification of habitat (i.e. vegetation composition and structure; type and abundance of natural habitat features) adjoining the underpass within two weeks of results reported by ecologist.	<p>Two of the three relevant fauna groups have been detected using the majority of underpasses.</p> <p>Frogs have not been detected using any underpass, however monitoring methods do not favour their detection.</p> <p>Continued monitoring, as per the EMP, will add to the number of records at each underpass.</p> <p><b>This contingency measure is not considered relevant at this stage</b></p>
Increased incidence of road kill from baseline conditions, in proximity to underpasses, particularly target species.	Commence review/modification of frequency and/or timing of monitoring periods within two weeks of results reported by ecologist.	<p>Overall annual weekly road kill rates have decreased slightly in 2018/2019 compared to baseline monitoring.</p> <p>2018/2019 monitoring recorded three road kill within 200 metres of monitored underpasses (F21.24 and C32.35) and baseline monitoring recorded five road kill within 200 metres of four different underpasses (F1.04, F34.72, F22.32 and C7.26). There has not been an increase in road kill in proximity to monitored underpasses.</p> <p>One target species (the Koala) was recorded as road kill during the 2018/2019 monitoring period, which does not represent an increase from previous target species road kill records. The baseline monitoring report (Lewis 2014) states that, based on baseline Koala road kill records, “<i>the baseline count for road kill should be set at 1 individual per 8 weeks</i>”. Koala road kill has therefore not increased from the baseline count.</p> <p><b>This contingency measure is not considered relevant.</b></p>
Inferior results compared to baseline surveys for the EPBC species, relevant to reference site monitoring.	If it is not reasonable or feasible to redesign/modify the underpass, discussions with EPA, DP&I and DoTE will be undertaken to determine if additional biodiversity offsets are required within 1 month of above reviews being completed.	<p>Comparison of underpass records with EPBC species reference site monitoring may be undertaken only at a superficial level due to the different means of data collection of the different monitoring components.</p> <p>Koalas were recorded along the entire length of the Project during baseline surveys (Lewis 2014). The Koala was recorded using three underpasses in areas where the Koala had recorded presence during baseline surveys (Niche 2019b). Ongoing monitoring of the underpasses may provide additional data regarding use of underpasses by the Koala along the length of the Project.</p> <p>The Spotted-tailed Quoll was not recorded during baseline surveys (Niche 2018c) but was recorded using one nominated underpass during the 2018/2019 fauna underpass monitoring.</p> <p>The Giant Barred Frog has been recorded traversing the Project under constructed bridges at locations where it was recorded during baseline surveys (Niche 2018b), but not using the nominated underpass, which is considered unlikely to provide suitable habitat for this species.</p> <p><b>This contingency measure is not considered relevant.</b></p>



## 5.2 Recommendations

This report presents the results of the first of three monitoring events, as such continued monitoring as per the EMP is recommended and is likely to increase the number of species detected. While specific recommendations have not been made, the considerations provided in Table 13 may assist the program in meeting its performance measures.

**Table 13: Recommendations**

Problem identified	Discussion/Recommendations and actions
Absence of use of the fauna underpasses by key target EBPC species	<ul style="list-style-type: none"> <li>• Consideration could be given to extending the camera monitoring period to increase the opportunity for detecting EPBC species.</li> <li>• The likelihood of detecting the Green-thighed Frog and other amphibians using current survey methods is low. Consider undertaking targeted frog surveys during/following suitable weather conditions to determine the use of underpasses by amphibians.</li> </ul>
Absence of some fauna groups from select underpasses.	
Lack of evidence of use by frog species.	
High visitation/usage rates by exotic predators	<p>Non-native predators including cats, dogs and foxes, were detected at all of the fourteen monitored underpasses. Seven of the 14 monitored underpasses showed high use by non-native predators, F1.04, F1.62, F26.40, C32.35, F33.40, F34.72 and C36.40.</p> <ul style="list-style-type: none"> <li>• Consider consulting with Local Land Services concerning control methods for foxes and dogs in the area, focusing on those underpasses where these fauna have been recorded, notably, F1.04, F1.62, F26.40, F33.40, F34.72 and C36.40.</li> </ul>

## References

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## Annex 1 – Camera Results

**Table 14: 2018/2019 remote camera records – F1.04, F1.62, C4.46, C7.26, F9.70, F11.67 and F20.54**

Underpass	F1.04		F1.62		C4.46		C7.26		F9.70		F11.67		F20.54	
Fauna group / Species	autumn	spring/ summer	autumn	spring/ summer	autumn	spring/ summer	autumn	spring/ summer	autumn	spring/ summer	autumn	spring/ summer	autumn	spring/ summer
<b>Small ground-dwelling mammals</b>														
<i>Antechinus</i> sp.				Y (1)		Y (6)								Y (1)
Bandicoot	Y (1)	Y (1)				Y (2)						Y (9)		Y (17)
Northern Brown Bandicoot ( <i>Isoodon macrourus</i> )														Y (4)
Long-nosed Bandicoot ( <i>Perameles nasuta</i> )												Y (4)		Y (3)
Echidna ( <i>Tachyglossus aculeatus</i> )								Y (2)			Y (1)	Y (2)		
Spotted-tailed Quoll ( <i>Dasyurus maculatus</i> )*														
<i>Rattus fuscipes</i>											Y (1)			
<i>Rattus</i> spp.	Y (8)		Y (12)		Y (4)				Y (6)	Y (24)				Y (2)
Rodent/Marsupial	Y (2)	Y (2)	Y (4)		Y (1)				Y (1)					
<b>Arboreal mammals</b>														
Brush-tail Possum		Y (2)			Y (5)	Y (35)			Y (1)			Y (11)		
Common Brush-tail Possum ( <i>Trichosurus vulpecula</i> )						Y (1)			Y (1)					
<b>Koala</b>														
Koala ( <i>Phascolarctos cinereus</i> )*										Y (1)		Y (1)		
<b>Macropods</b>														
Eastern Grey Kangaroo ( <i>Macropus giganteus</i> )	Y (1)	Y (3)	Y (3)					Y (1)	Y (2)		Y (7)	Y (1)		Y (11)
Macropod sp.								Y (1)						

Underpass	F1.04		F1.62		C4.46		C7.26		F9.70		F11.67		F20.54	
Fauna group / Species	autumn	spring/ summer	autumn	spring/ summer	autumn	spring/ summer	autumn	spring/ summer	autumn	spring/ summer	autumn	spring/ summer	autumn	spring/ summer
Swamp Wallaby ( <i>Wallabia bicolor</i> )														Y (1)
Wallaby											Y (1)			Y (5)
<b>Reptiles</b>														
Blue-tongue Lizard ( <i>Tiliqua scincoides</i> )														
Eastern Water Dragon ( <i>Intellagama lesueurii</i> )		Y (4)		Y (3)		Y (7)		Y (31)		Y (2)				Y (4)
Lace Monitor ( <i>Varanus varius</i> )		Y (9)						Y (5)		Y (1)		Y (14)		Y (5)
Snake										Y (1)				
<b>Other</b>														
Microbat														Y (3)
Unk Mammal	Y (1)									Y (1)				
<i>Rattus rattus</i>			Y (11)		Y (2)	Y (1)	Y (2)	Y (4)	Y (10)	Y (22)			Y (3)	Y (2)
Raven ( <i>Corvus</i> sp.)					Y (1)									
Wood Duck ( <i>Chenonetta jubata</i> )														
Fox ( <i>Vulpes vulpes</i> )	Y (36)	Y (11)	Y (22)		Y (8)			Y (1)	Y (9)	Y (4)			Y (2)	
Hare ( <i>Lepus europeus</i> ) / Rabbit ( <i>Oryctolagus cuniculus</i> )		Y (5)										Y (1)		
Cat ( <i>Felis catus</i> )	Y (5)		Y (4)		Y (3)		Y (4)	Y (2)	Y (8)		Y (1)		Y (1)	Y (5)
Wild Dog ( <i>Canis lupus</i> )													Y (7)	Y (1)

Y = detected; (n) = number of records; \* = EPBC target species

**Table 15: 2018/2019 remote camera records – F21.24, F22.32, F26.40, C32.35, F33.40, F34.72 and C36.40**

Underpass	F21.24		F22.32		F26.40		C32.35		F33.40		F34.72		C36.40	
	autumn	spring/ summer	autumn	spring/ summer	autumn	spring/ summer	autumn	spring/ summer	autumn	spring/ summer	autumn	spring/ summer	autumn	spring/ summer
<b>Small ground-dwelling mammals</b>														
<i>Antechinus</i> sp.				Y (1)		Y (2)					Y (2)			
Bandicoot		Y (16)		Y (32)	Y (1)	Y (2)		Y (1)		Y (1)			Y (1)	Y (1)
Northern Brown Bandicoot ( <i>Isoodon macrourus</i> )		Y (2)		Y (2)						Y (3)				
Long-nosed Bandicoot ( <i>Perameles nasuta</i> )		Y (3)												
Echidna ( <i>Tachyglossus aculeatus</i> )														
Spotted-tailed Quoll ( <i>Dasyurus maculatus</i> )*													Y (1)	
<i>Rattus</i> sp.		Y (1)	Y (2)	Y (1)						Y (8)				
Rodent/Marsupial				Y (1)	Y (1)				Y (1)	Y (1)	Y (4)			
<b>Arboreal mammals</b>														
Brush-tail Possum				Y (9)				Y (1)				Y (14)		
Common Brush-tail Possum ( <i>Trichosurus vulpecula</i> )				Y (1)								Y (2)		
<b>Koala</b>														
Koala ( <i>Phascolarctos cinereus</i> )*										Y (1)				
<b>Macropods</b>														
Grey Kangaroo ( <i>Macropus giganteus</i> )				Y (4)	Y (1)	Y (1)				Y (1)		Y (17)		Y (4)
Macropod sp.					Y (6)	Y (2)								
Swamp Wallaby ( <i>Wallabia bicolor</i> )				Y (2)	Y (1)	Y (4)								
Wallaby	Y (1)	Y (4)		Y (4)	Y (18)		Y (2)							
<b>Reptiles</b>														
Blue-tongue Lizard ( <i>Tiliqua scincoides</i> )										Y (1)				

Underpass	F21.24		F22.32		F26.40		C32.35		F33.40		F34.72		C36.40	
Fauna group / Species	autumn	spring/ summer	autumn	spring/ summer	autumn	spring/ summer	autumn	spring/ summer	autumn	spring/ summer	autumn	spring/ summer	autumn	spring/ summer
Eastern Water Dragon ( <i>Intellagama lesueurii</i> )								Y (7)	Y (7)			Y (6)	Y (1)	Y (1)
Lace Monitor ( <i>Varanus varius</i> )				Y (28)		Y (12)				Y (4)	Y (6)	Y (24)	Y (1)	Y (2)
<b>Other</b>														
Microbat				Y (2)			Y (1)							
<i>Rattus rattus</i>		Y (1)	Y (12)	Y (1)	Y (5)				Y (6)	Y (1)	Y (4)			
Unk Mammal			Y (1)											
Raven ( <i>Corvus</i> sp.)														
Wood Duck ( <i>Chenonetta jubata</i> )								Y (2)						
Fox ( <i>Vulpes vulpes</i> )			Y (4)		Y (19)	Y (3)			Y (2)					
Hare ( <i>Lepus europeus</i> ) / Rabbit ( <i>Oryctolagus cuniculus</i> )						Y (2)								
Cat ( <i>Felis catus</i> )	Y (4)	Y (1)		Y (4)	Y (2)	Y (3)	Y (5)	Y (1)	Y (7)	Y (8)	Y (10)	Y (6)	Y (3)	
Wild Dog ( <i>Canis lupus</i> )	Y (1)	Y (1)		Y (4)	Y (7)					Y (2)	Y (22)	Y (4)	Y (2)	

Y = detected; (n) = number of records; \* = EPBC target species

**Table 16: Autumn 2018 camera details**

Underpass	Camera	Operating for entire period (Y/N)	Install date	Retrieve date	Operational days	Location	Direction facing (E/W)	Number of fauna records	Note
F1.04	423	No	27/03/2018	29/05/2018	58	top	W	0	Last photo triggered 25/05/2018
F1.04	449	Yes	27/03/2018	29/05/2018	60+	bottom	W	61	
F1.62	445	Yes	27/03/2018	29/05/2018	60+	top	E	27	
F1.62	432	Yes	27/03/2018	29/05/2018	60+	bottom	W	29	
C4.46	428	Yes	27/03/2018	29/05/2018	60+	both	E/W	14	
C4.46	415	No	08/05/2018	29/05/2018	unk	bottom	W	10	Deployed late due to unfinished underpass
C4.46	435	No	27/03/2018	07/05/2018	unk	top	W	0	Malfunction collected 7/5 and replaced 8/5.
C7.26	447	No	27/03/2018	29/05/2018	48	top	W	3	Last photo false trigger on the 15/5/19
C7.26	443	Yes	27/03/2018	29/05/2018	60+	bottom	E	5	
F9.7	430	Yes	27/03/2018	31/05/2018	60+	top	E	19	
F9.7	425	Yes	27/03/2018	31/05/2018	60+	bottom	E	17	
F11.67	431	Yes	27/03/2018	31/05/2018	60+	bottom	E	4	
F11.67	174	No	27/03/2018	31/05/2018	56	top	E	0	Last photo triggered 23/05/2018
F20.54	426	Yes	27/03/2018	31/05/2018	60+	top	W	4	
F20.54	433	Yes	27/03/2018	31/05/2018	60+	bottom	E	10	
F21.24	399	Yes	27/03/2018	31/05/2018	60+	bottom	E	6	
F21.24	398	Yes	27/03/2018	31/05/2018	60+	top	E	0	
F22.32	424	Yes	27/03/2018	31/05/2018	60+	bottom	W	7	
F22.32	440	No	27/03/2018	31/05/2018	52	top	E	12	Last photo triggered 19/05/2018
F26.4	400	Yes	28/03/2018	31/05/2018	60+	bottom	E	55	
F26.4	436	No	28/03/2018	31/05/2018	30	top	E	5	Camera malfunction
C32.35	444	Yes	28/03/2018	31/05/2018	60+	bottom	W	5	
C32.35	438	Yes	28/03/2018	31/05/2018	60+	bottom	E	3	
F33.4	60	No	28/03/2018	31/05/2018	unk	bottom	W	9	Camera malfunction



Underpass	Camera	Operating for entire period (Y/N)	Install date	Retrieve date	Operational days	Location	Direction facing (E/W)	Number of fauna records	Note
F33.4	397	Yes	28/03/2018	31/05/2018	60+	top	E	14	
F34.72	65	Yes	28/03/2018	31/05/2018	60+	bottom	E	42	
F34.72	401	Yes	28/03/2018	31/05/2018	60+	top	E	6	
C36.4	67	No	28/03/2018	31/05/2018	30	bottom	E	2	Camera malfunction
C36.4	175	Yes	28/03/2018	31/05/2018	60+	bottom	W	6	

**Table 17: Spring/summer 2018/2019 camera details**

Underpass	Camera #	Operating for entire period (Y/N)	Install date	Retrieve date	Operational days	Location	Direction facing (E/W)	Number of fauna records	Notes
F1.04	174	Y	31/10/2018	23/11/2018	60+	top	W	1	Malfunction. Replaced batteries 23/11/18
F1.04	400	Y	31/10/2018	23/01/2019	60+	bottom	W	36	
F1.62	448	Y	31/10/2018	23/01/2019	60+	top	W	4	
F1.62	379	N	31/10/2018	stolen	Stolen	bottom	W	0	
C4.46	446	Y	31/10/2018	23/01/2019	60+	top	W	48	Middle culvert
C4.46	166	Y	31/10/2018	23/01/2019	60+	bottom	W	4	Middle culvert
C7.26	370	Y	31/10/2018	23/01/2019	60+	top	W	34	23/11/18 batteries replaced
C7.26	436	Y	31/10/2018	23/01/2019	60+	bottom	W	13	
F9.7	386	Y	30/10/2018	24/01/2019	60+	top	E	51	Camera was moved (11/11/18) to face wall. Repositioned 23/11/18.
F9.7	175	Y	30/10/2018	24/01/2019	60+	bottom	E	13	Camera was moved (11/11/18) to face wall. Repositioned 23/11/18.
F11.67	179	N	30/10/2018	24/01/2019	unk	top	E	0	23/11/18 battery change and lowered camera sensitivity due to excessive false triggers. Camera malfunction taking constant photos.
F11.67	383	Y	30/10/2018	24/01/2019	60+	bottom	E	52	
F20.54	374	Y	30/10/2018	24/01/2019	60+	top	E	10	
F20.54	428	Y	30/10/2018	24/01/2019	60+	bottom	E	53	
F21.24	415	Y	31/10/2018	22/01/2019	60+	top	W	1	
F21.24	431	Y	31/10/2018	22/01/2019	60+	bottom	W	28	
F22.32	423	Y	30/10/2018	22/01/2019	60+	top	W	13	
F22.32	369	Y	30/10/2018	22/01/2019	60+	bottom	W	80	
F26.4	173	Y	30/10/2018	24/01/2019	60+	top	E	3	
F26.4	440	Y	30/10/2018	24/01/2019	60+	bottom	E	30	

Underpass	Camera #	Operating for entire period (Y/N)	Install date	Retrieve date	Operational days	Location	Direction facing (E/W)	Number of fauna records	Notes
C32.35	445	Y	30/10/2018	23/01/2019	60+	bottom	E	2	
C32.35	176	Y	30/10/2018	23/01/2019	60+	bottom	W	10	
F33.4	376	Y	30/10/2018	23/01/2019	60+	top	E	5	
F33.4	411	Y	30/10/2018	23/01/2019	60+	bottom	E	26	
F34.72	441	Y	30/10/2018	23/01/2019	60+	top	E	15	
F34.72	398	Y	30/10/2018	23/01/2019	60+	bottom	E	58	
C36.4	416	Y	31/10/2018	16/01/2019	60+	bottom	E	8	Possibly not functioning prior to 22/11
C36.4	372	Y	31/10/2018	16/01/2019	60+	bottom	W	1	Possibly not functioning prior to 22/11

## Annex 2 – Field Data

**Table 18: Sand plot survey results - autumn 2018 and spring 2018/2019**

Species	C7.26	C4.46	C32.35	C36.40
Fox	Y	Y	Y	
Rodent	Y	Y	Y	Y
Bird		Y		
Cat		Y	Y	Y
Brush-tail Possum	Y	Y		Y
Bandicoot			Y	
Lace Monitor				Y
Water Dragon	Y	Y	Y	Y
Skink/Small Lizard				Y
Macropod				Y
Reptile	Y	Y		Y
Mammal				Y
Unknown		Y		Y

Y = detected

**Table 19: Tracks and scats results - autumn 2018 and spring 2018/2019**

Underpass	F1.04		F1.62		C4.46		C7.26		F9.70		F11.67		F20.54		C32.35		C36.40		
	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	
Bandicoot					T														
Macropod		T						T			T	T			T				T
Microbat						C, I	C								C			C	
Rodent					C, T		C		C										
Reptile						I		T							C			C	C
Dog	T											T		T					
Deer	T	T	T																
Cat															T				

S = spring/summer, A = autumn, I = observed, C = scat, T = track

**Table 20: Species detected by hair tube surveys**

Underpass	F1.04		F1.62		C4.46		C7.26		F11.67		F20.54		F21.54		F26.40		C32.35		F33.40		F34.72	
	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S
<i>Rattus</i> sp.							Y										Y					
Rodent	Y								Y		Y		Y		Y		Y		Y			
Macropod			Y																			
<i>Trichosurus</i> sp.						Y											Y					Y

S = spring/summer, A = autumn, Y = detected

**Table 21: Hair tube results - autumn 2018 and spring 2018/2019**

Season	Underpass	Location	# of tubes	Deploy date	Retrieve date	Tubes with hair (samples sent for ID)	Species ID definite	Species ID probable	
autumn	1.04	underpass	6	27/03/2018	12/04/2018	2	One hair	Rodent	
autumn	1.04	adjacent	4	27/03/2018	12/04/2018	1	One hair-no ID		
autumn	1.62	underpass	6	27/03/2018	12/04/2018	0			
autumn	1.62	adjacent	4	27/03/2018	12/04/2018	2	One hair	Macropod	
autumn	4.46	underpass	6	Fauna furniture incomplete - hair tubes not deployed					
autumn	4.46	adjacent	4	Fauna furniture incomplete - hair tubes not deployed					
autumn	7.26	underpass	6	27/03/2018	12/04/2018	1	One hair-no ID		
autumn	7.26	adjacent	4	27/03/2018	12/04/2018	1	Two rodent hairs	<i>Rattus sp.</i>	
autumn	9.7	underpass	6	27/03/2018	12/04/2018	1	One hair-no ID		
autumn	9.7	adjacent	4	27/03/2018	12/04/2018	0			
autumn	11.67	underpass	6	27/03/2018	12/04/2018	1	One hair	Rodent	
autumn	11.67	adjacent	4	27/03/2018	12/04/2018	1	One hair-no ID		
autumn	20.54	underpass	6	27/03/2018	12/04/2018	1	One hair	Rodent	
autumn	20.54	adjacent	4	27/03/2018	12/04/2018	0			
autumn	21.24	underpass	6	27/03/2018	12/04/2018	1	One hair	Rodent	
autumn	21.24	adjacent	4	27/03/2018	12/04/2018	0			
autumn	22.32	underpass	6	27/03/2018	12/04/2018	1	One hair-no ID		
autumn	22.32	adjacent	4	27/03/2018	12/04/2018	0			
autumn	26.4	underpass	6	28/03/2018	12/04/2018	1	One hair	Rodent	
autumn	26.4	adjacent	4	28/03/2018	12/04/2018	1	One hair	Rodent	
autumn	32.35	underpass	6	28/03/2018	12/04/2018	1	Two fine hairs	Rodent	
autumn	32.35	adjacent	4	28/03/2018	12/04/2018	1	Two rodent hairs	<i>Rattus sp.</i>	
autumn	33.4	underpass	6	28/03/2018	12/04/2018	1	One hair	Rodent	
autumn	33.4	adjacent	4	28/03/2018	12/04/2018	1	One hair-no ID		
autumn	34.72	underpass	6	28/03/2018	12/04/2018	0			
autumn	34.72	adjacent	4	28/03/2018	12/04/2018	1	One hair-no ID		
autumn	36.4	underpass	6	28/03/2018	12/04/2018	1	One hair-no ID		
autumn	36.4	adjacent	4	28/03/2018	12/04/2018	0			
spring/summer	1.04	underpass	6	31/10/2018	19/11/2018	0			
spring/summer	1.04	adjacent	4	31/10/2018	19/11/2018	0			
spring/summer	1.62	underpass	6	31/10/2018	19/11/2018	0			
spring/summer	1.62	adjacent	4	31/10/2018	19/11/2018	0			
spring/summer	4.46	underpass	6	31/10/2018	19/11/2018	1	<i>Trichosurus sp.</i>	<i>T. vulpecula</i>	
spring/summer	4.46	adjacent	4	31/10/2018	19/11/2018	4	<i>Trichosurus sp.</i>	<i>T. vulpecula</i>	
spring/summer	7.26	underpass	6	31/10/2018	19/11/2018	0			
spring/summer	7.26	adjacent	4	31/10/2018	19/11/2018	0			
spring/summer	9.7	underpass	6	30/10/2018	19/11/2018	0			
spring/summer	9.7	adjacent	4	30/10/2018	19/11/2018	0			
spring/summer	11.67	underpass	6	30/10/2018	19/11/2018	0			

Season	Underpass	Location	# of tubes	Deploy date	Retrieve date	Tubes with hair (samples sent for ID)	Species ID definite	Species ID probable
spring/summer	11.67	adjacent	4	30/10/2018	19/11/2018	0		
spring/summer	20.54	underpass	6	30/10/2018	19/11/2018	0		
spring/summer	20.54	adjacent	4	30/10/2018	19/11/2018	0		
spring/summer	21.24	underpass	6	31/10/2018	19/11/2018	0		
spring/summer	21.24	adjacent	4	31/10/2018	19/11/2018	0		
spring/summer	22.32	underpass	6	30/10/2018	19/11/2018	0		
spring/summer	22.32	adjacent	4	30/10/2018	19/11/2018	0		
spring/summer	26.4	underpass	6	30/10/2018	19/11/2018	0		
spring/summer	26.4	adjacent	4	30/10/2018	19/11/2018	0		
spring/summer	32.35	underpass	6	30/10/2018	19/11/2018	0		
spring/summer	32.35	adjacent	4	30/10/2018	19/11/2018	1	Few hairs	<i>Trichosurus</i> sp.
spring/summer	33.4	underpass	6	30/10/2018	19/11/2018	0		
spring/summer	33.4	adjacent	4	30/10/2018	19/11/2018	0		
spring/summer	34.72	underpass	6	31/10/2018	19/11/2018	5	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
spring/summer	34.72	adjacent	4	31/10/2018	19/11/2018	3	<i>Trichosurus</i> sp.	<i>T. vulpecula</i>
spring/summer	36.4	underpass	6	31/10/2018	19/11/2018	0		
spring/summer	36.4	adjacent	4	31/10/2018	19/11/2018	0		

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# Appendix H Fauna fencing and road kill





# Fauna Fence and Road Kill Monitoring 2018/2019

**Oxley Highway to Kempsey, Pacific Highway Upgrade**

**Prepared for Roads and Maritime Services**

**August 2019**

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*Cover photograph: Standard fauna fence with Lace monitor (left), frog fence with Green Tree Snake (right).*

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## Executive summary

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### **Context**

This report documents findings of the 2018/2019 monitoring period, which includes the first of three monitoring periods for the fauna fence and the first of four operational monitoring periods for road kill, as required by the Oxley Highway to Kempsey (OH2K) Ecological Monitoring Program (EMP, RMS 2016).

### **Aims**

The aim of the fauna fence and road kill monitoring program is to determine if purpose built fauna fences are stopping fauna from crossing the road, thereby reducing road kill. The aims of this report are to summarise the methods and results of the 2018/2019 monitoring period and determine if performance measures are being met and provide corrective actions where required, as per the EMP.

### **Methods**

Monitoring of the fauna fences involved surveying the fence lines on foot identifying breaches, damage and maintenance issues. The following sections of fencing were surveyed:

- 200 metres north and south of the underpass on both sides of the carriageway where it adjoins a fauna underpass monitored as part of the fauna underpass monitoring component of the Project
- The entire length of frog and phascogale fencing
- Searches for threatened frogs on both sides of the entire length of frog fencing.

Road kill monitoring was undertaken along the entire length of the Project. Surveys involved observations made from a vehicle travelling at approximately 80 km/h. Road kill fauna observed on the road and within three metres of the road verge were recorded using a GPS.

### **Key Results**

The key results of the 2018/2019 fauna fence and road kill monitoring were:

- A number of maintenance issues were identified including vegetation encroachments, fallen trees, gaps underneath the fence caused by environmental factors i.e. water or erosion, platting or netting lifting and detached Phascogale panels.
- No fence breaches (evident passage by fauna) were recorded during the fauna fence monitoring, however a Koala was recorded as road kill in September 2018.
- No threatened frog species were identified during targeted surveys, fence monitoring or road kill surveys.
- There were a total of 45 road kill records in spring, 27 in summer and 20 in autumn. Birds, medium ground dwelling mammals and large ground dwelling mammals were the most commonly recorded fauna groups.
- Of the 59 road kill records (excluding birds) from the 2018/2019 monitoring period, 26 (44%) records were within and 33 (56%) records were outside fenced areas. The rate of road kill in unfenced areas (6.4 kilometres; 5.16 records/kilometre) was higher than the rate in fenced areas (30.6 kilometres; 0.85 records/kilometre).
- Of the 59 road kill records (excluding birds) there were four road kill records within 200 metres of any aerial crossing during the 2018/2019 road kill surveys. The rate of road kill within 200 metres of aerial crossings (5.2 kilometres; 0.77 records/kilometre) was substantially lower than outside this boundary (31.8 kilometres; 1.73 records/kilometre).

- Of the 59 road kill records (excluding birds) 24 occurred within 200 metres of underpasses. The rate of road kill within 200 metres of fauna underpasses/bridges (19.2 kilometres; 1.25 records/kilometre) was slightly lower than the rate outside this boundary (17.8 kilometres; 1.96 records/kilometre).
- The overall average weekly road kill rate has decreased from baseline (8.0) to 2018/2019 (7.7) for the same three seasons.

### ***Conclusions***

All performance measures for both the fauna fence and road kill monitoring were met for the 2018/2019 monitoring period:

- There were no records of Giant Barred Frog or Green-thighed Frog road kill
- Rates of road kill were lower within fenced areas compared to unfenced areas
- Incidence of road kill has reduced from baseline
- Roads and Maritime have advised that fauna fencing is complete
- Rates of road kill were lower in proximity to underpasses and aerial crossings.

### ***Management Implications***

Given that all performance measures were met and that contingency measures were addressed as required, there are no recommendations based on the outcomes of the 2018/2019 monitoring period.

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# 1. Introduction

## 1.1 Context

The Oxley Highway to Kempsey (OH2K) section of the Pacific Highway Upgrade Project (the Project) was approved in 2012 subject to various Ministers Conditions of Approval (MCoA) and a Statement of Commitments (SoC). A subsequent approval with additional conditions of consent (CoA) was granted in 2014 by the then Commonwealth Department of Environment (DoE) for Matters of National Environmental Significance (MNES) listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1995* (EPBC Act). The Ecological Monitoring Program (hereafter referred to as the EMP) (RMS 2016) combines these approval conditions and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project.

Fauna fences were installed to prevent fauna crossing the road surface, thereby reducing road kill and guiding animals towards safe wildlife crossing structures (underpasses and aerial crossing structures). The fauna fence and road kill are to be monitored to assess their effectiveness in reducing fauna road kill, as required by the EMP.

### 1.1.1 Monitoring framework

The design, methods and performance indicators that define the fauna fence and road kill monitoring program are specified in the EMP.

#### ***Fauna fence***

The EMP requires fauna fence monitoring to occur in Years 4, 6 and 8 (operational phase). This report represents the first of three reports required for the fauna fence monitoring – Year 4 autumn 2018 and spring/summer 2018/2019.

#### ***Road kill***

Road kill monitoring was required for baseline, during clearing, during construction and upon completion of the Project (operational) in Years 4, 5, 6 and 8. The road kill monitoring framework provided within the EMP and the reporting status to date is shown in Table 1. The 2018/2019 monitoring period represents the first operational monitoring period and includes spring (October 2018), summer (January 2019) and autumn (April 2019). This report represents the first of four reports required for the operational phase monitoring.

**Table 1: Road kill monitoring**

Project Phase	Monitoring event: report	Timing of survey	Location
Baseline	<i>spring 2013, summer 2014, autumn 2014:</i> Niche 2015	Weekly during October (spring), January (summer) and April (autumn) prior to commencement of construction (12 weeks).	Entire length of existing highway in Project area
During clearing operations	<i>November 2014- July 2015:</i> Niche 2015	Daily	Portion of existing highway adjacent to clearing operations
One month following clearing operations			
For the duration of construction	<i>8 August 2015 – 22 July 2016:</i> Niche 2016a <i>27 July 2016 – 28 July 2017:</i> Niche 2017a <i>4 August 2017 – March 29 2018:</i> Niche 2018	Weekly (Note: as the opening of the Project occurred in three stages, weekly monitoring of the Project continued in the unopened sections of the Project to satisfy construction monitoring requirements.)	Entire length of existing highway in Project area

Project Phase	Monitoring event: report	Timing of survey	Location
Within one month of opening of the Project	Twelve week post-opening periods were as follows: <ul style="list-style-type: none"> <li>• Ku2K: from 3 November 2017</li> <li>• OH2Ku Stage 1: from 17 November 2017</li> <li>• OH2Ku Stage 2: from 30 March 2018</li> </ul> All in Niche 2018.	Weekly for 12 weeks. If this period does not coincide with the season (i.e. October (spring), January (summer) and April (autumn) in which baseline surveys were undertaken, also undertake weekly surveys during the first survey period (April, October or January) to occur after the opening of the Project (to allow for comparison to baseline results).	Entire length of completed Project
Upon completion of the Project (operation phase)	Year 4: <ul style="list-style-type: none"> <li>• Spring (October 2018)</li> <li>• Summer (January 2019)</li> <li>• Autumn (April 2019)</li> </ul> Current report.	Weekly during October (spring), January (summer) and April (autumn (12 weeks) in Year 4, 5, 6 and 8, or until mitigation measures can be demonstrated to have been effective as defined in the EPBC approval.	Entire length of completed Project

### 1.1.2 Background data

The fauna fence aims to prevent animals crossing the road surface and to guide animals towards safe fauna crossing structures. Three types of fauna fencing has been installed as per the EMP as follows:

- Standard floppy-top fencing: *Permanent floppy top fencing will comprise of a heavily galvanised, floppy-top mesh fauna fence. Mesh one metre wide will be attached to the base of the fauna fencing and laid over the ground away from the carriageway to provide an effective barrier to burrowing animals. The mesh must be pinned to the ground with metal pins every metre without any gaps between the mesh and the ground. Fauna exclusion fencing at underpass entrances will have wide angled openings to encourage usage by fauna and must have a minimum length of 200 metres of fauna fencing on each side of the underpass and on each side of the carriageway or road.*
- Frog fencing:
  - *Giant Barred Frog fencing is to be at least 900 millimetres in height and will comprise of gauze size 30-40 millimetres to prevent frogs from moving through the fence, yet allow for the flow of overland water. The gauze will include a small return of not less than 150 millimetres on the ground.*
  - *Green-thighed Frog fencing is to comprise of 500 millimetres high neoprene rubber sheeting (>4 millimetre thickness) including a small rubber return of not less than 100 millimetres on the ground. The fence must consist of a hot dip galvanized pressed sheet metal or powder coated aluminium pressed sheet mounted on a galvanized star picket. This fencing was unsuccessful and has since been replaced. Roads and Maritime removed the neoprene sheeting and replaced it with vermin-proof mesh, as approved on the Pacific Highway Upgrade between Woolgoolga and Ballina. These frog fencing replacement works were completed in November 2018.*
  - *Where both frog species occur in association the frog fencing must account for both morphologies.*
- Phascogale fencing: *Phascogale fencing is attached to floppy top fauna fencing. At the base of floppy top fauna fences, a second layer of mesh is installed to 200 millimetres above ground level height, offset from the first layer of mesh to create maximum opening size of 25 millimetres. Above 200 millimetres, 600 millimetre hot dip galvanised pressed steel sheet or powder coated aluminium pressed sheet are affixed to the floppy top fauna fencing.*

Standard fauna fencing was installed within State Forests, where the Project traverses regional corridors, between dual carriageway bridges and culverts and on the outside of all spill containment / water quality treatment basins. Targeted threatened species fauna fencing was installed in areas of known or high potential habitat with high risk of fauna accessing the carriageway.



### 1.1.3 Purpose of this report

This report documents findings of the 2018/2019 monitoring period, which includes the first of three monitoring periods for the fauna fence and the first of four operational monitoring periods for road kill. The aims of this report are to summarise the methods and results of the 2018/2019 monitoring and determine if performance measures are being met, as per the EMP.

## 1.2 Performance Measures

The EMP specifies the following performance measures for fauna fence monitoring:

- *No records of Giant Barred Frog or Green-thighed Frog road kill on the main carriageways directly adjacent to installed frog fencing in any monitoring event during Years 4, 6 & 8*
- *Lower rates of road kill in proximity to fauna fencing than in sections of the upgrade not near fauna fencing during all monitoring events (Year 4, 6 & 8)*
- *Reduced incidence of road kill from baseline conditions*
- *Fauna exclusion fencing is installed at a minimum in the locations identified in Schedule 3 of the EPBC approval at Year 4.*

The EMP specifies the following performance measures for road kill monitoring:

- *Lower rates of road kill in proximity (i.e. areas of the main carriageways within areas adjacent to installed fauna fencing, and within 100 metres of rope bridges and fauna underpasses) to fauna fencing, rope bridges and fauna underpasses than in sections of the upgrade not near wildlife crossing structures or fauna fences in Year 1 – 6 & 8 monitoring events*
- *Reduced incidence of road kill from baseline conditions during monitoring events in Years 1-6 & 8 and when all monitoring events are considered at Year 8*
- *Fauna exclusion fencing is installed at a minimum in the locations identified in Schedule 3 of the EPBC approval at Year 4.*

## 1.3 Monitoring Timing

Fauna Fence monitoring is to be undertaken in Years 4, 6 and 8 of the Project's operational phase. Fauna fence monitoring is to occur in late autumn and late spring/early summer and searches for threatened frogs is to be undertaken in spring and summer.

Operational road kill monitoring is required weekly for four weeks during October (spring), January (summer) and April (autumn) in Years 4, 5, 6 and 8.

## 1.4 Reporting

Annual reporting of monitoring results will outline:

- Detailed description of monitoring methodology employed
- Results of the monitoring period
- Discussion of results, including how the results compare against performance measures, if any modifications to timing or frequency of monitoring periods or monitoring methodology are required and any other recommendations
- If contingency measures should be implemented.

All reports prepared under the EMP will be submitted to the Secretary of the Department of Planning and Environment and the Environment Protection Authority.

## 1.5 Limitations

- As rainfall determines the movement of threatened frogs, searches for threatened frogs were undertaken following rainfall in spring. However, the lack of rainfall during summer 2018/2019 resulted in searches being undertaken during a dry period, when it is considered unlikely that frogs would have been mobile and hence exposed to road crossing risks, which may have impacted results.
- Identification and detection of road kill was limited to what can be observed whilst travelling at 80km/hr as it was not considered safe to stop on the operational highway. As such:
  - Some road kill fauna were identified to the vertebrate group level only.
  - Some records were classified as 'unknown' as road kill fauna could not be identified as a result of extensive collision damage.
  - It is possible that small fauna such as frogs, snakes, small mammals and birds have been undercounted as small-sized road kill fauna have the potential to be partially or wholly removed by scavenger animals, resulting in impossible identification from the vehicle.
- Due to their small size and cryptic nature, frogs and smaller reptiles are difficult to detect within the underpasses using the current survey methods and thus if present, may have gone undetected.
- Safety issues prevent the removal of road kill following each survey and therefore, despite efforts, road kill may have been recorded multiple times over the four weekly surveys resulting in double-counting and 'unknown' records as the condition of the animal deteriorated.

## 2. Methodology

### 2.1 Monitoring Sites

Monitoring of the fauna fence involved surveys of the following sections of fencing:

- 200 metres north and south of the underpass and on both sides of the carriageway where it adjoins one of the 14 fauna underpasses monitored as part of the fauna underpass monitoring component of the Project
- The entire length of frog and phascogale fencing
- Searches for threatened frogs on both sides of the entire length of frog fencing.

Road kill monitoring was undertaken along the entire length of the Project.

### 2.2 Survey Methods

Surveys were undertaken in accordance with the EMP and are outlined below.

#### 2.2.1 Fauna fence inspections

The first monitoring of the fauna fence was undertaken in autumn 2018 in its entirety and the second monitoring event was undertaken in late spring 2018 in conjunction with fauna underpass monitoring and in summer 2019 for the remainder of the fencing. Surveys involved inspection of the fauna fence on foot for 200 metres north and south of the monitored underpasses and on both sides of the carriageway. The entire length of phascogale and frog fence was surveyed as well as the edge of the highway in proximity to fencing where possible and safe to do so. Possible breaches, damage and maintenance issues, such as impinging vegetation growth, were noted and their location recorded.

#### 2.2.2 Frog searches

Searches for threatened frogs were undertaken on both sides of the frog fence in spring 2018 and summer 2018/2019 to identify the presence of any frogs that may have breached the frog fence. Surveys were timed to follow rainfall in order to coincide with frog movement where possible. Table 2 shows the rainfall recorded by Bureau of Meteorology (BOM) weather stations prior to surveys. It should be noted that summer surveys for threatened frogs were undertaken during a particularly dry period.

**Table 2: Threatened frog survey dates and 24 hour rainfall**

Date	Season	Previous 24hr rainfall Kempsey Airport (mm)	Previous 24hr rainfall Port Macquarie Airport (mm)	Previous 24hr rainfall Telegraph Point (mm)
08/11/2018	spring	25	28	7.2
26/02/2018	summer	1.4	4	4.6

#### 2.2.3 Road kill surveys

Road kill surveys of the entire Project were undertaken once a week for four weeks during October 2018 (spring), January 2019 (summer) and April 2019 (autumn). These surveys involved observations made from a vehicle travelling at approximately 80 km/hr. Road kill fauna observed on the road and within three metres of the road verge were recorded by the passenger. Due to the safety issues associated with the operational highway, it was not possible to stop the vehicle to closer inspect or remove road kill. Road kill records were grouped into general fauna groups for analysis.

## 2.3 Analysis

Weekly road kill rates were calculated to compare changes in rates of road kill between years. An analysis of the number of road kill events (excluding bird records) that occurred within or outside of fenced sections of the Project was undertaken by calculating a *road kill per kilometre* rate. A similar analysis was undertaken to compare road kill rates within 200 metres of fauna crossings. Fauna crossing zones were created by grouping fauna crossings that occurred within 400 metres of each other (i.e. their 200 metre boundary overlapped) and included 200 metres north and south of the crossing/s. The road kill records that occurred within the zones were compared to road kill records outside of the zones. Aerial crossings and underpasses (including bridges and culverts) were analysed separately.

## 3. Results

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Detailed survey results for the 2018/2019 monitoring are presented in Annex 1 and Annex 2.

### 3.1 Fence Inspections

Fauna fence inspection results are provided in Annex 1.

#### 3.1.1 Maintenance

A number of maintenance issues were identified during the 2018/2019 monitoring. Maintenance is required in relation to vegetation encroachments, fallen trees, gaps underneath the fence caused by environmental factors i.e. water or erosion, platting or netting lifting and detached phascogale panels.

Of particular note, problems with the neoprene frog fence were identified in autumn 2018 and reported to Roads and Maritime. These issues have since been rectified by Roads and Maritime. Roads and Maritime removed the neoprene sheeting and replaced it with vermin-proof mesh, as approved on the Pacific Highway Upgrade between Woolgoolga and Ballina. These frog fencing replacement works were completed in November 2018.

#### 3.1.2 Possible breaches

No signs of possible fence breaches by fauna were recorded during the 2018/2019 fence monitoring, however a Koala (*Phascolarctos cinereus*) was recorded as road kill in September 2018. This record is discussed further in Section 3.3.4. While no fauna was recorded on the highway-side of the fauna fence during fence inspections, undertaking maintenance to address identified gaps and ensure secure fastening of the base netting should prevent breaches from occurring.

### 3.2 Threatened Frog Searches

Diurnal searches for threatened frogs were undertaken on the 8 November 2018 (spring) and 26 February 2019 (summer). No threatened frog species were identified during targeted surveys, fence monitoring or road kill surveys. A single dead frog was found during the spring surveys which could not be identified due to its deteriorated condition, however it was determined from colouration and size as unlikely to be either the threatened Giant Barred Frog (*Mixophyes iteratus*) or Green-thighed Frog (*Litoria brevipalmata*).

It should be noted that summer surveys for threatened frogs were undertaken during a particularly dry period. It was intended that surveys would be done following periods of substantial rainfall, where frogs were likely to have been more mobile. However the EMP specifies surveys be undertaken in summer. As such, surveys were undertaken as late as possible in summer (while waiting for optimal conditions), however substantial rain had not fallen by this time. It is therefore considered that conditions were not optimal to determine the effectiveness of the frog fence by searching for road kill at this time as the frogs were unlikely to have been very active.

### 3.3 Road Kill Surveys

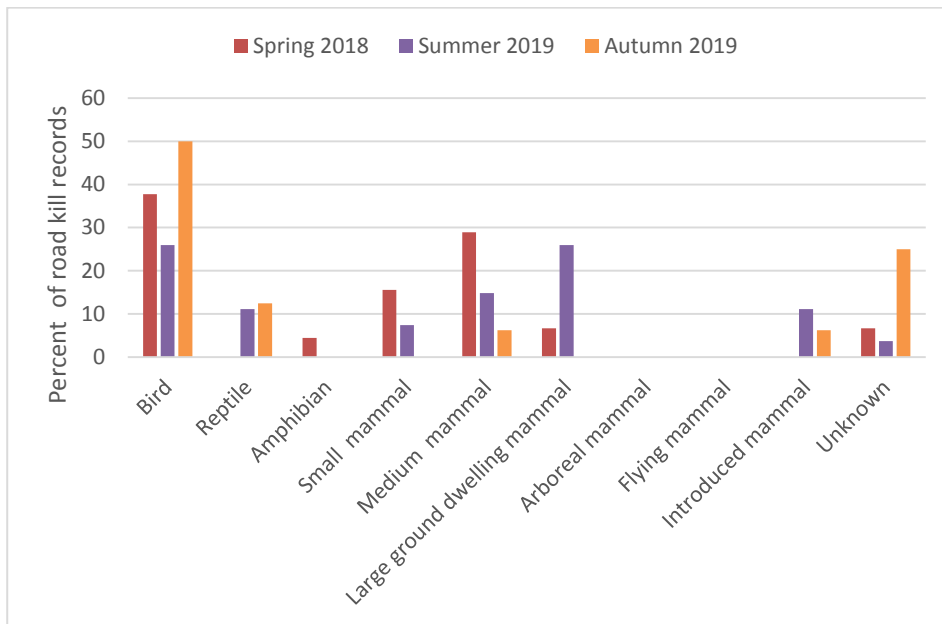
Road kill results are provided in Annex 2. The distribution of road kill records is shown in Figure 1 and Figure 2.

#### 3.3.3 Total alignment

Fauna categories for analysis were defined as follows:

- Arboreal mammals
- Flying mammals (i.e. bats)
- Introduced mammals
- Small mammals
- Medium mammals
- Large ground dwelling mammals
- Amphibians
- Reptiles
- Birds
- Unknown

There were a total of 45 road kill records in spring, 27 in summer and 20 in autumn. The percentage of road kill records for each category for the current monitoring period is presented in Graph 1. Combining spring, summer and autumn results, birds (35.9% of road kill, n =33), medium ground dwelling mammals (20.7% of road kill, n = 19), and large ground dwelling mammals (12.0%, n = 11), were the most commonly recorded fauna groups.



Graph 1: 2018/2019 road kill records

#### 3.3.4 Threatened fauna

There was one record of threatened fauna identified as road kill that occurred outside of the 2018/2019 road kill and fauna fence surveys. A road kill Koala was observed on the 16 September 2018 by Roads and Maritime within a fenced area of the highway on the northbound left lane near Barry’s Creek (Figure 2, map section 3). The individual likely entered the carriageway through a flood damaged section of the fauna fence which was immediately addressed with temporary repairs by Roads and Maritime and permanent works completed on the 19 -21 September 2018. Table 3 lists the threatened species identified as road kill throughout the Project to date. The baseline monitoring report (Lewis 2014) states that, based on baseline Koala road kill records, “the baseline count for road kill should be set at 1 individual per 8 weeks”. Koala road kill has therefore not increased from the baseline count.

**Table 3: Threatened species road kill**

Monitoring type (report)	Monitoring period	Threatened species identified as road kill (number recorded)
Baseline (Lewis 2014)	2013-2014	Koala (1*) Grey-headed Flying Fox (2)
Clearing (Niche 2015)	2014-2015	Koala (4) Grey-headed Flying Fox (1) Masked Owl (2) Spotted-tail Quoll (1)
Construction (Niche 2016b)	2015-2016	Koala (3)
Construction (Niche 2017b)	2016-2017	Koala (2)
Construction (Niche 2018)	2017-2018	Nil
Operational (current)	2018-2019	Koala (1)

\* = An additional three Koala road kill were recorded between August 2013 and February 2014, outside of the monitoring period.

### 3.3.5 Fauna fence

A total of approximately 30,600 metres (82.7%) of the 37,000 metres of the Project is fenced with a minimum of standard fauna fence (data provided by Roads and Maritime).

An analysis of the number of road kill events (excluding the bird records) that occurred either within or outside of fenced sections of the Project (considering those road kill observations made at the edge of a fenced area, or in an area where fencing was present on one side of the carriageway only, to be outside) was undertaken. Of the 59 road kill records (excluding birds) from the 2018/2019 monitoring period, 26 (44%) records were within and 33 (56%) records were outside fenced areas. Considering the data with regard to fencing along the highway, calculation of a *road kill per kilometre* rate (excluding birds) showed the rate of road kill in unfenced areas (6.4 kilometres; 5.16 records/kilometre) to be substantially higher than the rate in fenced areas (30.6 kilometres; 0.85 records/kilometre).

### 3.3.6 Fauna crossings

The performance indicator for road kill refers to lower rates of road kill “*within 100 metres of rope bridges and fauna underpasses*”. However the EMP identifies “*high rates of fauna road strike mortality within 200 metres of fauna underpasses*” as a potential problem for fauna fences for which contingency measures have been provided. An analysis of road kill within 200 metres of fauna crossings has therefore been undertaken in order to address the trigger for contingency measures. It is considered that this analysis is sufficient to address the performance indicator, as it extends the range within which road kill rates should be lower. As discussed in Section 2.3 fauna crossing zones were created by grouping fauna crossings that occurred within 400 metres of each other (i.e. their 200 metre boundary overlapped). The road kill records that occurred within these zones were compared to road kill records outside of the zones. Aerial crossings and underpasses (including bridges and culverts) were analysed separately.

### ***Aerial crossings***

There are 18 aerial crossings along the entire length of the Project that fall into nine separate zones. Both rope bridges and glider pole crossings were considered in this analysis. The Project consists of 5,176 metres that fall within 200 metres of an aerial crossing, and therefore 31,824 metres outside of these zones. Of the 59 road kill records (excluding birds) from the 2018/2019 monitoring period there were four road kill records within 200 metres of any aerial crossing during the 2018/2019 road kill surveys. Calculation of a *road kill per kilometre* rate (excluding birds) showed the rate of road kill within 200 metres of aerial crossings (5.2 kilometres; 0.77 records/kilometre) to be substantially lower than outside this boundary (31.8 kilometres; 1.73 records/kilometre).

### ***Underpasses***

There are 42 culverts and 12 bridge areas throughout the Project that are considered to provide fauna passage under the carriageway, which fall into 39 separate zones. The Project consists of 19,175 metres that fall within 200 metres of an underpass/bridge, and therefore 17,825 metres outside of these zones. Of the 59 road kill records (excluding birds) from the 2018/2019 monitoring period 24 occurred within 200 metres of underpasses, while the remaining 35 occurred outside this boundary. Calculation of a *road kill per kilometre* rate (excluding birds) found the rate of road kill within 200 metres of fauna underpasses/bridges (19.2 kilometres; 1.25 records/kilometre) to be slightly lower than the rate outside this boundary (17.8 kilometres; 1.96 records/kilometre).

### **3.3.7 Comparison with baseline and previous monitoring**

Baseline surveys were undertaken prior to the commencement of construction for 12 weeks in spring 2013, summer 2014 and autumn 2014. Monitoring took place weekly for four weeks in each of the seasons as required by the EMP. Baseline surveys recorded 96 animals as road kill during the three monitoring events, representing 33 species and an average weekly road kill for spring, summer and autumn of 9.5, 11.8 and 3.3 respectively.

The average weekly road kill for all monitoring periods is presented in Table 4.

In order to compare the results of the baseline surveys with that of subsequent monitoring periods, the average weekly road kill for the four survey weeks undertaken in each season of the baseline surveys (spring (October), summer (January), autumn (May)), was compared to the same four weeks of each subsequent monitoring event. While spring and autumn weekly road kill rates were higher in the 2018/2019 monitoring period (11.3 in spring, 5.0 in autumn) than during baseline (9.5 in spring, 3.3 in autumn), summer weekly road kill rates were lower in the 2018/2019 monitoring period (6.8) compared to baseline (11.8). The overall average weekly road kill rate decreased from baseline of 8.0 to 7.7 for the same three seasons.

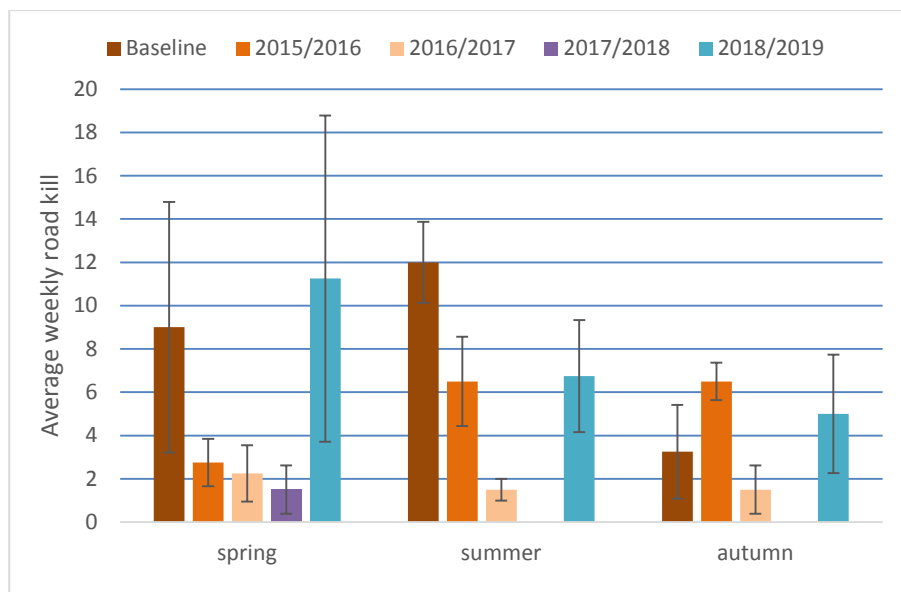
Graph 2 shows the seasonal average weekly road kill for each of the same four week periods for all monitoring events. Winter has been excluded from the graph as winter surveys were not undertaken during baseline surveys and do not form part of the operational road kill monitoring.



**Table 4: Weekly road kill rates for monitoring undertaken along the entire Project alignment**

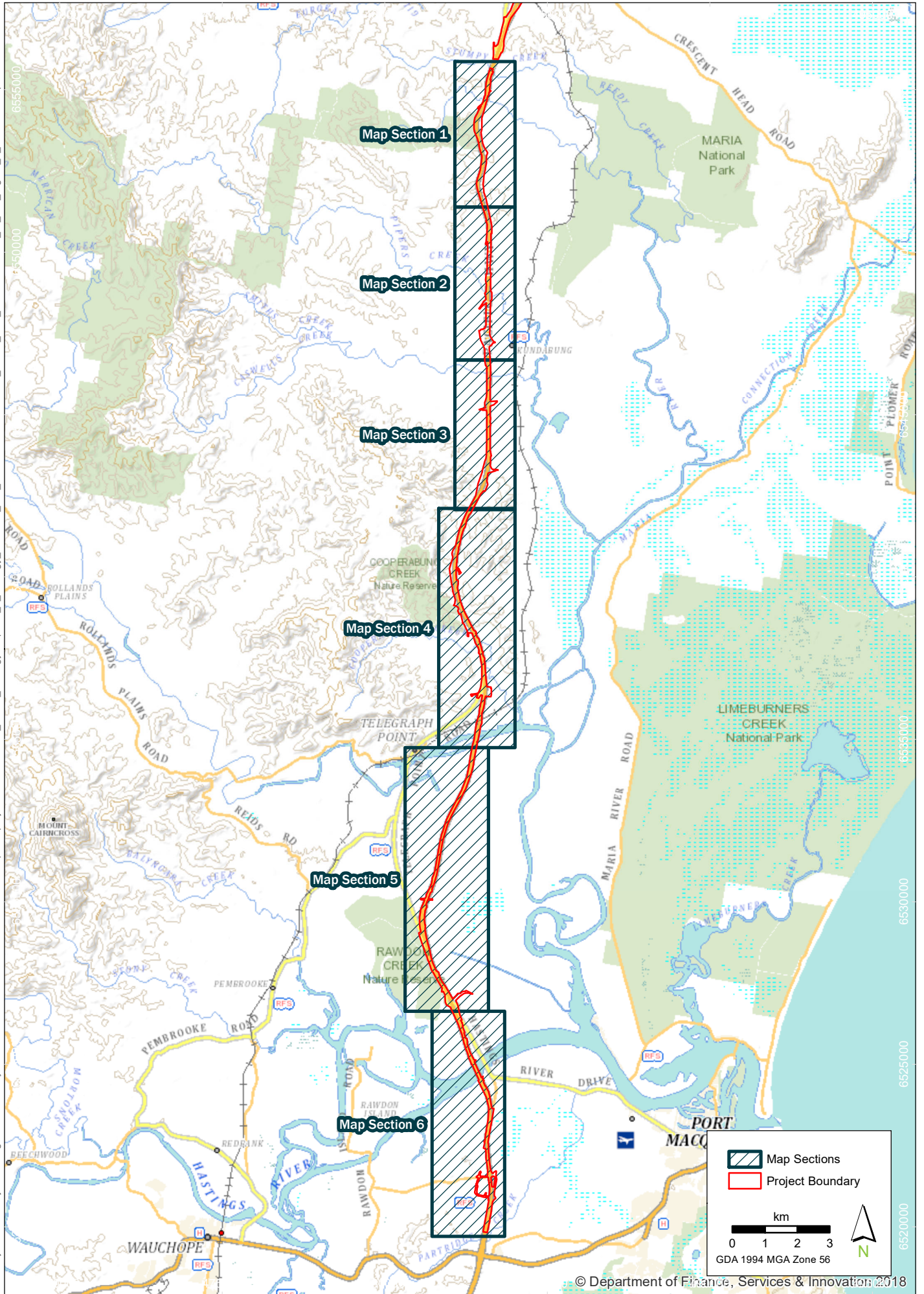
Monitoring period		Spring (n)	Summer (n)	Autumn (n)	Winter (n)	Annual (n)
Baseline	2013/2014	9.5 (4)	11.8 (4)	3.3 (4)	No surveys	8.0 (12)
Construction phase	2015/2016 (all surveys)	4.2 (13)	5.8 (14)	6.7 (13)	4.1 (12)	5.0 (52)
	2015/2016 (4 weeks)	2.75 (4)	6.5 (4)	6.5 (4)	3.0 (4)	
	2016/2017 (all surveys)	3.3 (13)	2.6 (13)	2.0 (12)	2.2 (14)	2.3 (52)
	2016/2017 (4 weeks)	4.0 (4)	1.5 (4)	1.5 (4)	2.5 (4)	
	2017/2018 (all surveys)	2.9 (9)	No surveys*	No surveys*	3.3 (4)	3.0 (13)
	2017/2018 (4 weeks)	1.5 (4)	No surveys*	No surveys*	3.3 (4)	
12-week post-opening	2017/2018 (all sections combined)					4.5 (12)
Operational	2018/2019	11.3 (4)	6.8 (4)	5.0 (4)	No surveys	7.7 (12)

n = number of survey weeks; \* = construction partially complete



**Graph 2: Average ( $\pm$ SD, n = 4) weekly road kill in spring, summer and autumn**

Drawn by: GT Project Manager: RM Project Number: 1702 PI 5 Date: 7/3/2019 T:\spatial\projects\1700\1702\_OH2K\_Ecology\Maps\PI\_5\_Ecology\Maps\PI\_5\_Ecology\_OH2K\PI\_511\_FaunaFence\1702\_PL\_511\_Figure\_1\_OverviewMap.mxd

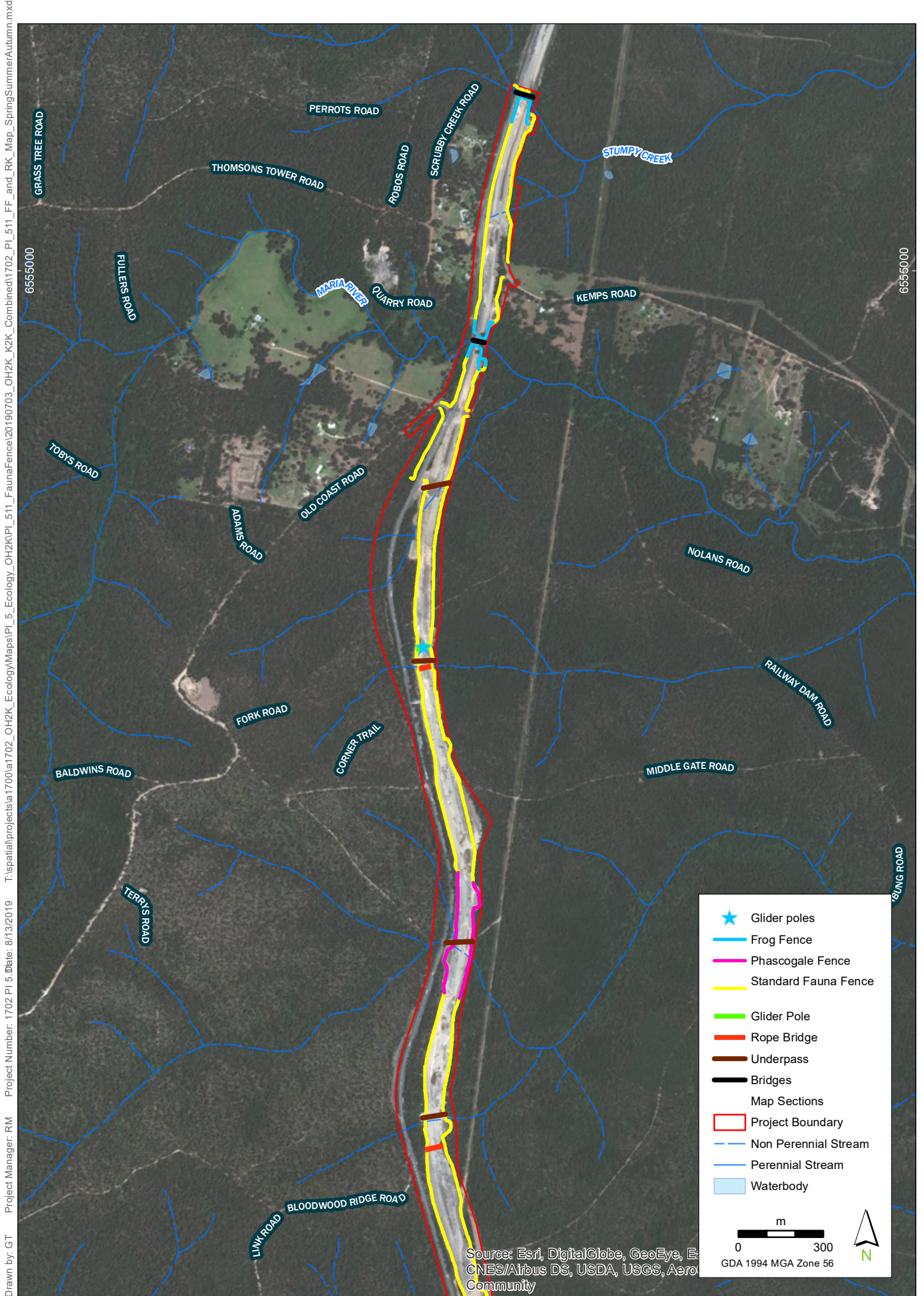


### Fauna Fence and Road Kill Monitoring – Overview

Oxley Highway to Kempsey Pacific Highway Upgrade - PI 5.11 Fauna Fencing



**FIGURE 1**  
Imagery: (c) DigitalGlobe 25/11/2015

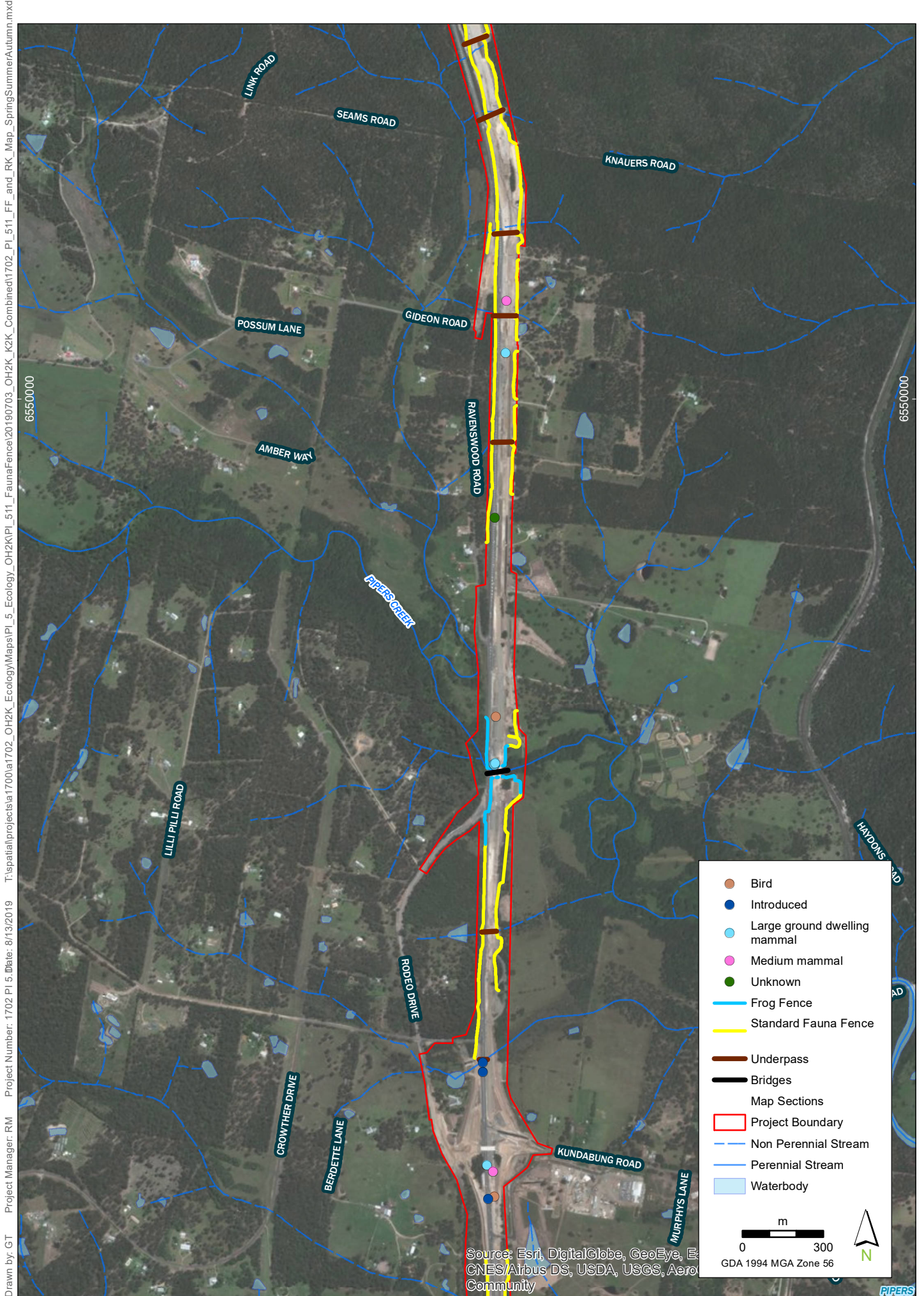


### Fauna Fence and Road Kill Monitoring - Map Section 1

Oxley Highway to Kempsey Pacific Highway Upgrade - PI 5.11 Fauna Fencing

**FIGURE 2.1**

Imagery: (c) DigitalGlobe 25/11/2015



Drawn by: GT Project Manager: RM Project Number: 1702 PI 5. Date: 8/13/2019 T:\spatial\projects\1700\1702\_OH2K\_Ecology\Maps\PI\_5\_Ecology\_OH2K\PI\_511\_FaunaFence\1702\_PL\_511\_FF\_and\_RK\_Map\_SpringSummerAutumn.mxd

Source: Esri, DigitalGlobe, GeoEye, Earthstar (CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, SIA, User 410913) 25/11/2015

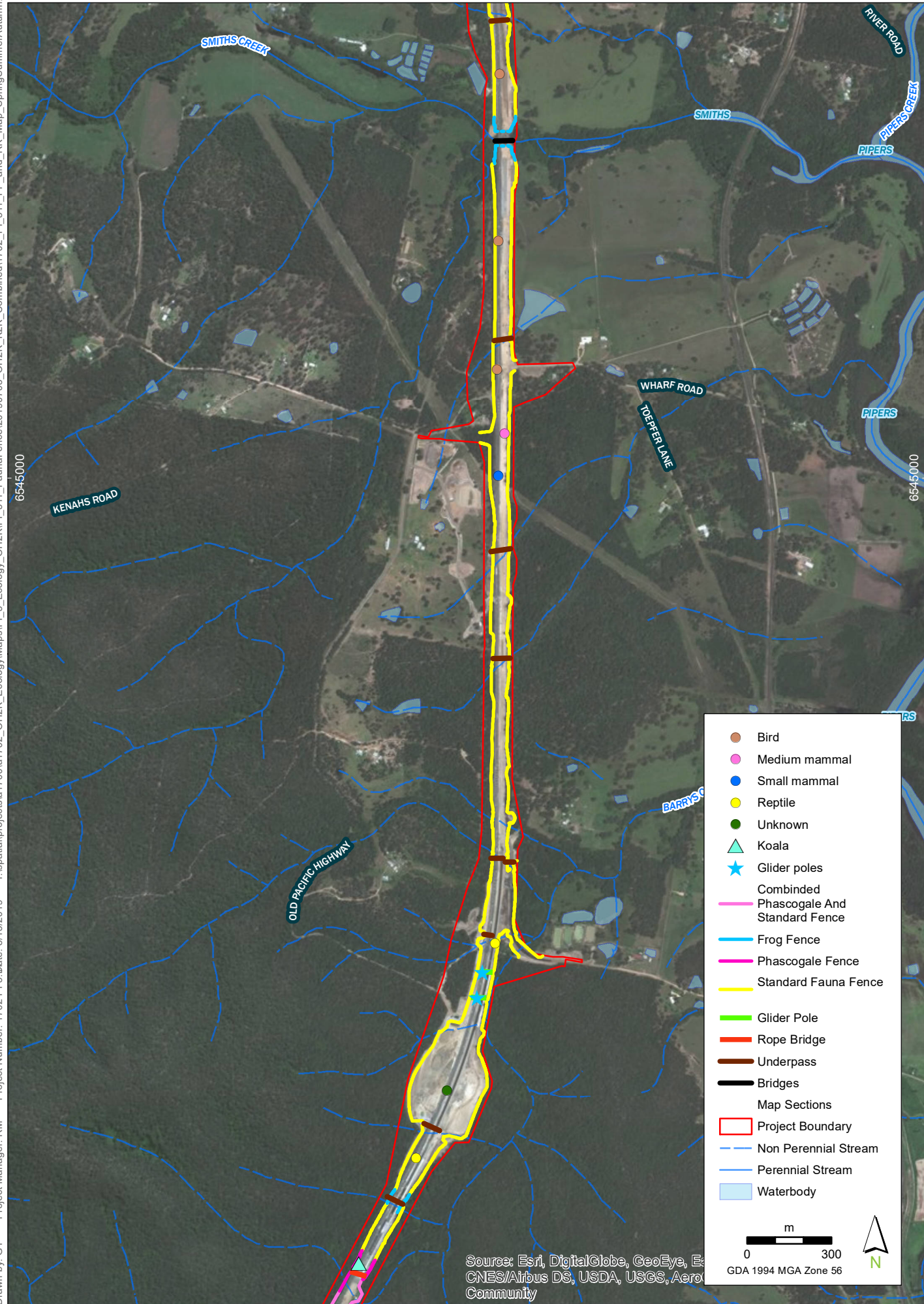
### Fauna Fence and Road Kill Monitoring - Map Section 2

Oxley Highway to Kempsey Pacific Highway Upgrade - PI 5.11 Fauna Fencing

**FIGURE 2.2**

Imagery: (c) DigitalGlobe 25/11/2015

Drawn by: GT Project Manager: RM Project Number: 1702 PI 5. Date: 8/13/2019 T:\spatial\projects\1700\1702\_OH2K\_Ecology\Maps\PI\_5\_Ecology\_OH2K\PI\_511\_FaunaFence\1702\_OH2K\_Combined\1702\_PL\_511\_FF\_and\_RK\_Map\_SpringSummerAutumn.mxd



Source: Esri, DigitalGlobe, GeoEye, Earthstar (United States), CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

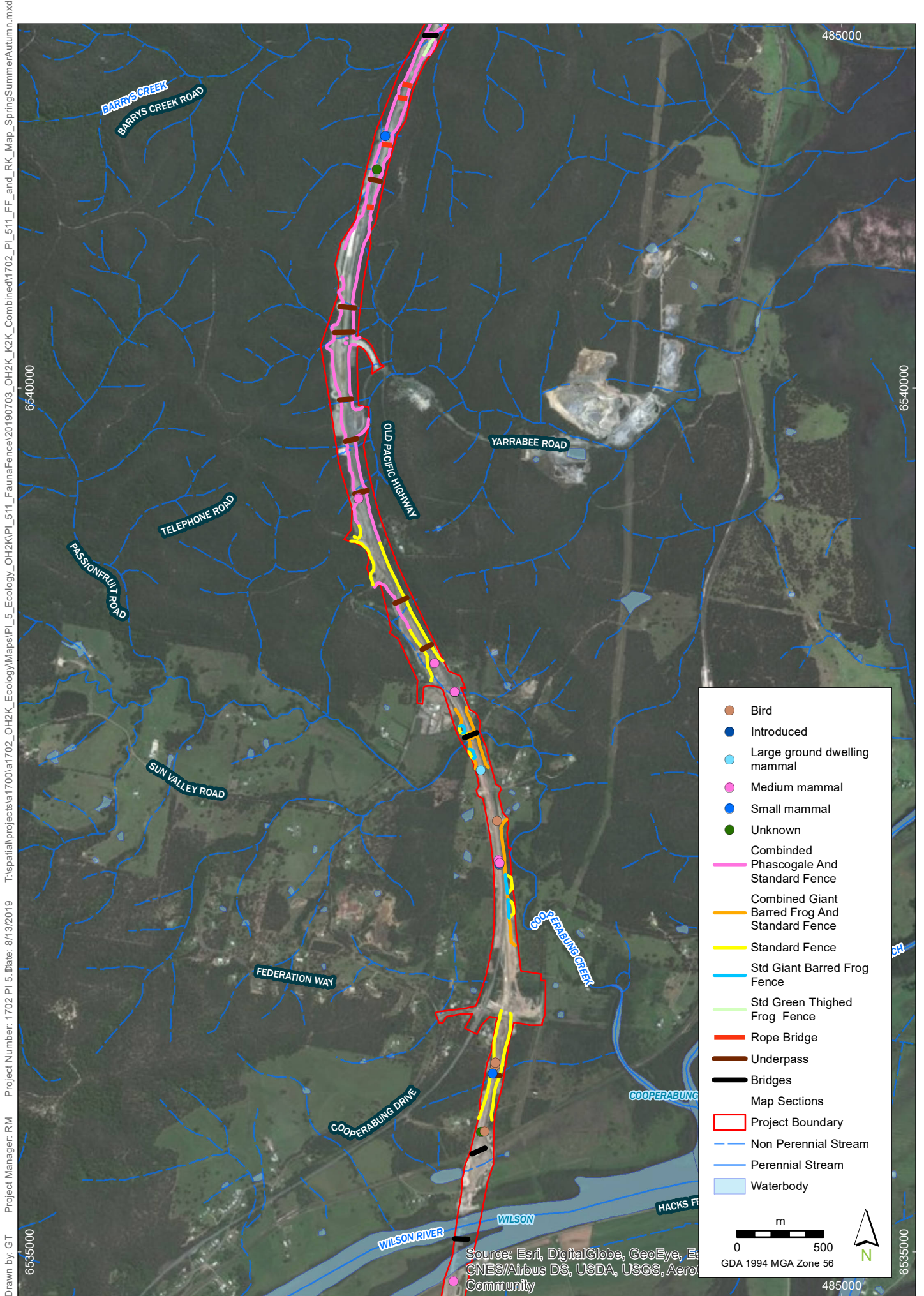
### Fauna Fence and Road Kill Monitoring - Map Section 3

Oxley Highway to Kempsey Pacific Highway Upgrade - PI 5.11 Fauna Fencing

**FIGURE 2.3**

Imagery: (c) DigitalGlobe 25/11/2015



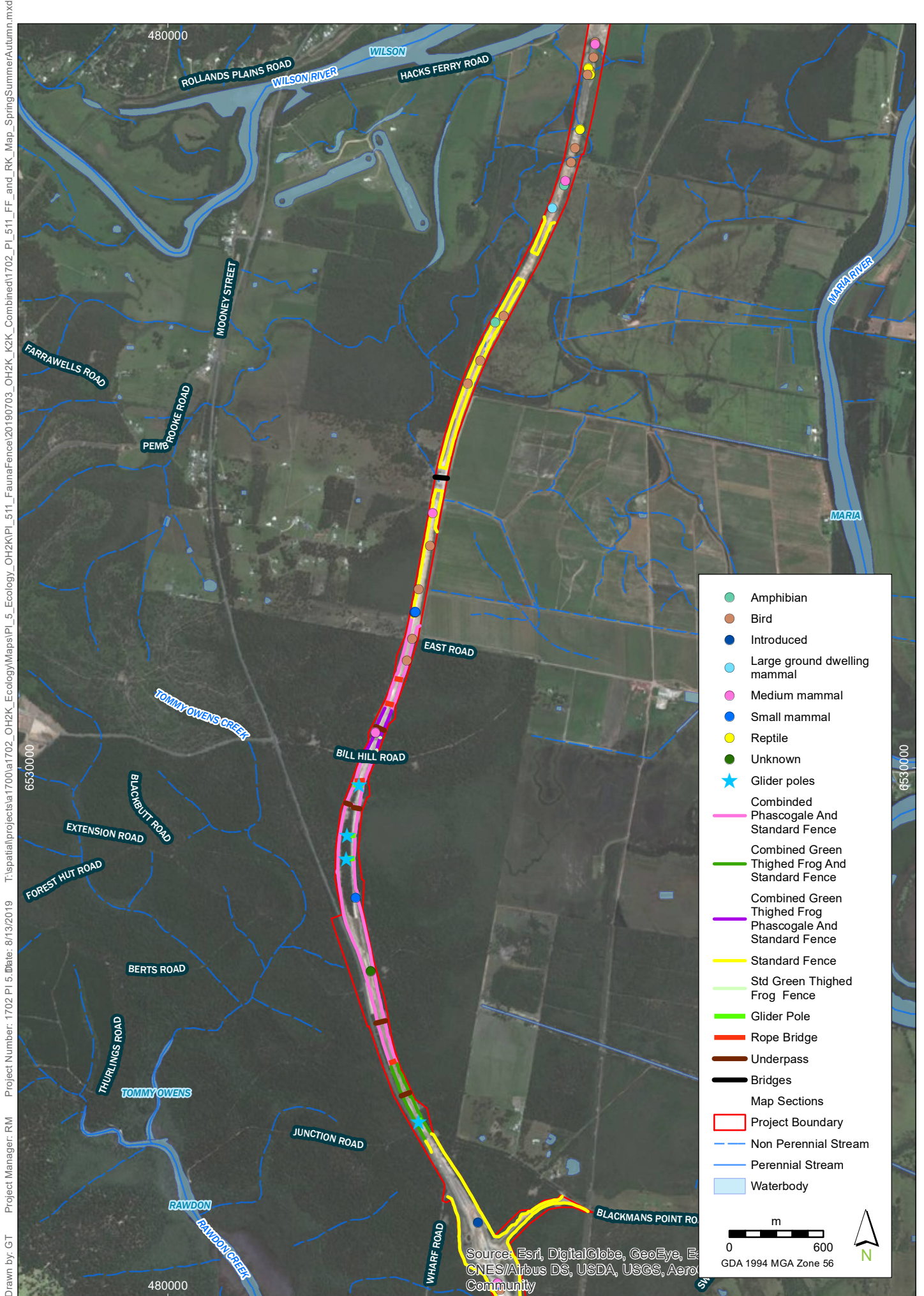


### Fauna Fence and Road Kill Monitoring - Map Section 4

Oxley Highway to Kempsey Pacific Highway Upgrade - PI 5.11 Fauna Fencing

**FIGURE 2.4**

Imagery: (c) DigitalGlobe 25/11/2015



Project Number: 1702 PI 5. Date: 8/13/2019  
 Project Manager: RM  
 Drawn by: GT  
 T:\spatial\projects\1700\1702\_0H2K\_Ecology\Maps\PI\_5\_Ecology\_0H2K\PI\_511\_FaunaFence\1702\_PL\_511\_FF\_and\_RK\_Map\_SpringsSummerAutumn.mxd

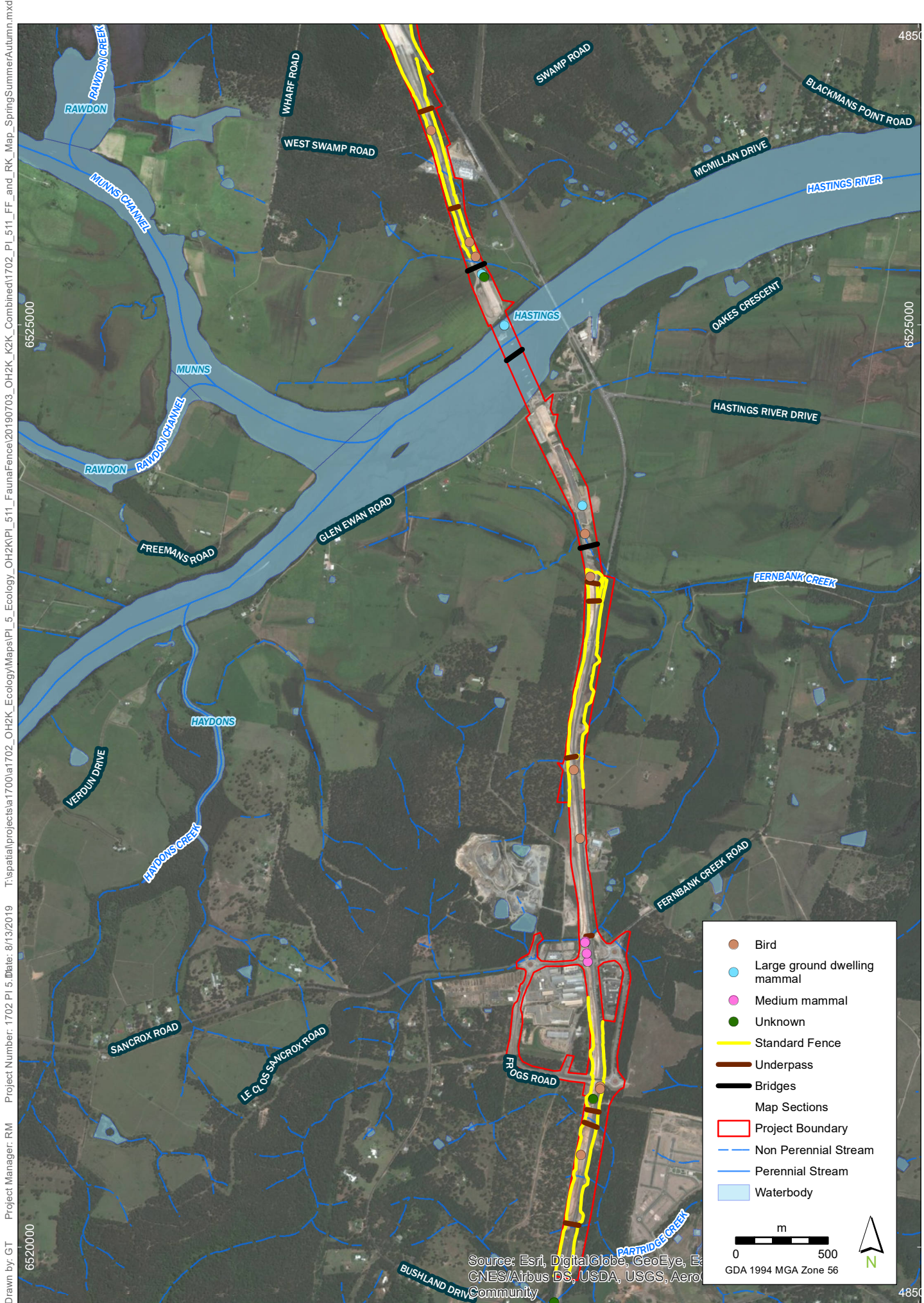
Source: Esri, DigitalGlobe, GeoEye, Earthstar, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, SIA, User, Google Earth, Community

### Fauna Fence and Road Kill Monitoring - Map Section 5

Oxley Highway to Kempsey Pacific Highway Upgrade - PI 5.11 Fauna Fencing

**FIGURE 2.5**

Imagery: (c) DigitalGlobe 25/11/2015



Fauna Fence and Road Kill Monitoring - Map Section 6

Oxley Highway to Kempsey Pacific Highway Upgrade - PI 5.11 Fauna Fencing

FIGURE 2.6

Imagery: (c) DigitalGlobe 25/11/2015



## 4. Discussion

### 4.1 Performance Measures

#### 4.1.1 Fauna fence

A summary of 2018/2019 survey results in relation to the fauna fence performance measures are provided in Table 5.

**Table 5: Indicators of success for fauna fencing**

Performance measure	Discussion
No records of Giant Barred Frog or Green-thighed Frog road kill on the main carriageways directly adjacent to installed frog fencing in any monitoring event during Years 4, 6 & 8.	<b>This performance measure has been met.</b> No Giant Barred Frog or Green-thighed Frog road kill were recorded.
Lower rates of road kill in proximity to fauna fencing than in sections of the upgrade not near fauna fencing during all monitoring events (Year 4, 6 & 8).	<b>This performance measure has been met.</b> Of the 59 road kill records (excluding birds) from the 2018/2019 monitoring period, 26 (44%) records were within and 33 (56%) records were outside fenced areas. The rate of road kill in unfenced areas (5.16 records/kilometre) was higher than the rate in fenced areas (0.85 records/kilometre).
Reduced incidence of road kill from baseline conditions.	<b>This performance measure has been met.</b> The overall average weekly road kill rate has decreased slightly from baseline (8.0) to 2018/2019 (7.7) for the same three seasons.
Fauna fence is installed at a minimum in areas identified in Schedule 3 of the EPBC approval at Year 4.	<b>This performance measure has been met.</b> Roads and Maritime have advised that all fauna fencing as identified in Schedule 3 of the EPBC approval has been installed.

#### 4.1.2 Road kill

A summary of 2018/2019 survey results in relation to the road kill performance measures are provided in Table 6.

**Table 6: Performance measures for road kill monitoring**

Performance measure	Discussion
Lower rates of road kill in proximity (i.e. areas of the main carriageways within areas adjacent to installed fauna fencing, and within 100m of rope bridges and fauna underpasses) to fauna fencing, rope bridges and fauna underpasses than in sections of the upgrade not near wildlife crossing structures or fauna fences in Year 1 – 6 & 8 monitoring events.	<b>This performance measure has been met.</b> As discussed in 3.3.6, road kill within 200 metres of fauna crossings was analysed. <i>Fauna fence:</i> Of the 59 road kill records (excluding birds) 26 (44%) records were within and 33 (56%) records were outside fenced areas. The rate of road kill in unfenced areas (5.16 records/kilometre) was higher than the rate in fenced areas (0.85 records/kilometre). <i>Aerial crossing 200 metre boundary:</i> Of the 59 road kill records (excluding birds) there were four road kill records within 200 metres of any aerial crossing during the 2018/2019 road kill surveys. The rate of road kill within 200 metres of aerials crossings (0.77 records/kilometre) was substantially lower than outside this boundary (1.73 records/kilometre). <i>Underpass 200 metre boundary:</i> Of the 59 road kill records (excluding birds) 24 occurred within 200 metres of underpasses, while the remaining 35 occurred outside. The rate of road kill within 200 metres of fauna underpasses/bridges (1.25 records/kilometre) was lower than the rate outside this boundary (1.96 records/kilometre).

Performance measure	Discussion
<p>Reduced incidence of road kill from baseline conditions during monitoring events in Years 1- 6 &amp; 8 and when all monitoring events are considered at Year 8.</p>	<p><b>This performance measure has been met.</b>            The overall average weekly road kill rate has decreased slightly from baseline (8.0) to 2018/2019 (7.7) for the same three seasons.</p>
<p>Fauna exclusion fencing is installed at a minimum in the locations identified in Schedule 3 of the EPBC approval at Year 4.</p>	<p><b>This performance measure has been met.</b>            Roads and Maritime have advised that all fauna fencing as identified in Schedule 3 of the EPBC approval has been installed.</p>

## 5. Recommendations

### 5.1 Contingency Measures and Recommendations

The EMP lists potential problems and contingency measures for the Project's mitigation measures. Those that are related to the fauna fence monitoring program are listed and discussed in Table 7.

Given that all performance measures were met and that contingency measures were addressed as required, there are no recommendations based on the outcomes of the 2018/2019 monitoring period.

**Table 7: Contingency measures for fauna fencing**

Potential problems	Contingency measure	Discussion of proposed measure
Breach in fauna fencing.  High rates of fauna road strike mortality within 200 metres of fauna underpasses.	Commence review/modification of fauna exclusion fencing design, location or extent depending on species struck by vehicles within two weeks of results reported by ecologist.	Road kill rates were lower in proximity to underpasses. There were no recorded possible breaches during 2018/2019 fauna fence surveys.  One Koala road kill was recorded within a fenced area by Roads and Maritime in September 2018. The breached fauna fence was identified and temporary repairs were immediately undertaken within two days of the road kill being found and permanent works completed on the 19 -21 September 2018.  <b>This contingency measure is not considered relevant.</b>
	Inspect fence for breaches and inform maintenance as necessary within two weeks of results reported by ecologist.  Any damage to fauna fencing will be temporarily repaired within one week of a breach being identified.	<b>These contingency measures were relevant during the 2018/2109 monitoring period and implemented as required.</b>
	Permanent repair to occur as soon as possible and within two months of the breach being identified.	<b>This contingency measure was relevant during the 2018/2109 monitoring period and implemented as required.</b>  Permanent repairs to the fauna fence were completed within five days of the identified breach.

## References

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Niche (2015). OH2K Pacific Highway Upgrade. Annual Ecological Monitoring Report 2015. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

Niche (2016a). Road kill report 2015/2016- Oxley Highway to Kempsey, Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

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Niche (2017a). Road kill monitoring 2016/2017- Oxley Highway to Kempsey, Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

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Niche (2018). Contractor Ecological Monitoring Report 2017/2018. Oxley Highway to Kempsey, Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

RMS (2016). Oxley Highway to Kempsey Pacific Highway Upgrade Ecological Monitoring Program. Roads and Maritime Update to report prepared by SMEC Hyder Joint Venture, August 2016.

## Annex 1 – Fauna fence survey data

**Table 8: 2018/2019 fauna fence inspection results**

SOC = side of carriageway, E = East, W = West, STD FF = Standard Fauna Fence, m = metres

Season	Date	Section	SOC	Fence type	Easting	Northing	Observation / maintenance required
Autumn	12/04/2018	OH2Ku	E	STD FF	483236	6520739	South East of underpass 1.62. Vegetation clearing required at 200 m.
Autumn	07/05/2018	OH2Ku	E	STD FF	483241	6523502	South East of underpass 4.46. Requires vegetation clearing - inaccessible and pressing on fence in locations.
Autumn	07/05/2018	OH2Ku	E	STD FF	483241	6523502	North East of underpass 4.46. Inner fauna fence - requires vegetation removal from 100 m as inaccessible.
Autumn	12/04/2018	OH2Ku	E	STD FF	482336	6526166	South East of underpass 7.26. Some vegetation removal at 200 m.
Autumn	16/05/2018	OH2Ku	E	Frog	481609	6527827	Grass encroaching on frog fence.
Autumn	16/05/2018	OH2Ku	E	Phascogale	481431	6528298	Missing Phascogale mesh/wire and also section where mesh doesn't meet ground at rocky drainage line.
Autumn	16/05/2018	OH2Ku	E	Phascogale	481345	6528539	Large gap created due to opening angle of gate.
Autumn	16/05/2018	OH2Ku	E	Phascogale	481301	6528734	Gap at back of Phascogale panel due to undulations.
Autumn	16/05/2018	OH2Ku	E	Phascogale	481301	6528863	Top edge of Phascogale panel not attached.
Autumn	16/05/2018	OH2Ku	E	Phascogale	481207	6529190	Phascogale panel lifted and bent at corner of gate and overhang of gate opening not secured.
Autumn	16/05/2018	OH2Ku	E	STD FF (Phascogale)	481185	6529270	Vine growing over fence -clearing required.
Autumn	16/05/2018	OH2Ku	E	STD FF (Phascogale)	481298	6530041	Mesh lifting creating potential digging channel/gap.
Autumn	16/05/2018	OH2Ku	E	Frog + Phascogale	481298	6530070	Attachment issues and gaps created.
Autumn	16/05/2018	OH2Ku	E	Phascogale	481374	6530204	Height of Phascogale panel insufficient in places between underpass and Bill Hill Rd.
Autumn	16/05/2018	OH2Ku	E	Phascogale	481565	6530822	Gap under Phascogale wire.
Autumn	18/05/2018	OH2Ku	E	Frog+STD FF	483077	6537054	Fencing for Frog incomplete.
Autumn	16/05/2018	OH2Ku	E	Frog+STD FF	482887	6537988	Fence not completely finished at Cooperabung bridge.
Autumn	12/04/2018	OH2Ku	E	STD FF	482442	6538846	60 m of fence lying flat - ground securing has failed and fencing incomplete - base mesh missing.
Autumn	16/05/2018	OH2Ku	E	Phascogale	482199	6539727	Gap underneath Phascogale wire in rocky area near underpass.
Autumn	16/05/2018	OH2Ku	E	Phascogale	482170	6539800	Fauna escape under construction near Yarrabee Rd.
Autumn	16/05/2018	OH2Ku	E	Phascogale	482152	6540030	Gap under Phascogale wire.
Autumn	16/05/2018	OH2Ku	E	Phascogale	482150	6540231	Rocky drainage has created gap under Phascogale wire.
Autumn	16/05/2018	OH2Ku	E	Phascogale	482499	6541737	No Phascogale fence on gate.
Autumn	16/05/2018	OH2Ku	E	Phascogale	482648	6541995	No fine Phascogale mesh at sediment basin drain.
Autumn	16/05/2018	OH2Ku	E	Phascogale	482621	6542015	No Phascogale fence on gate and panel detached on adjacent fence.
Autumn	16/05/2018	OH2Ku	E	Frog	482621	6542015	Neoprene frog fence fallen down at end.
Autumn	16/05/2018	OH2Ku	E	Phascogale	482682	6542085	No Phascogale fence at sediment basin drain. Vegetation removal required locally.
Autumn	16/05/2018	Ku2K	E	Phascogale	482705	6542132	No Phascogale fence on gate.
Autumn	31/05/2018	Ku2K	E	Frog	482867	6542413	Gap at corner- mesh not joined. Mesh raised above ground over sealed drain pipe immediately to the north.

Season	Date	Section	SOC	Fence type	Easting	Northing	Observation / maintenance required
Autumn	31/05/2018	Ku2K	E	Frog	482867	6542425	Fine frog mesh does not continue to end of metal return – frog fencing incomplete?
Autumn	12/04/2018	Ku2K	E	STD FF	483144	6544340	Gap under the fence.
Autumn	31/05/2018	Ku2K	E	Frog	483249	6546156	Neoprene join detached.
Autumn	31/05/2018	Ku2K	E	Frog	483243	6546162	Neoprene join detached.
Autumn	31/05/2018	Ku2K	E	Frog	483243	6546162	Neoprene fencing fallen down at corner.
Autumn	31/05/2018	Ku2K	E	Frog + STD FF	483243	6546162	Vegetation clearing required south from this point.
Autumn	31/05/2018	Ku2K	E	Frog	483232	6546172	Neoprene fencing down.
Autumn	31/05/2018	Ku2K	E	Frog	483221	6546234	Gaps, tears and frog fence down north from Smiths Creek bridge.
Autumn	31/05/2018	Ku2K	E	STD FF	483246	6546262	Fauna fence falling over near gate.
Autumn	31/05/2018	Ku2K	E	Frog	483252	6546275	Tear at top of neoprene and gap underneath.
Autumn	31/05/2018	Ku2K	E	Frog	483251	6546276	Grass control required.
Autumn	31/05/2018	Ku2K	E	Frog	483213	6548651	Gap at corner - mesh needs screws and securing over rocks.
Autumn	12/04/2018	Ku2K	E	STD FF	483279	6550235	Gaps under fence at drainage line.
Autumn	12/04/2018	Ku2K	E	STD FF	483193	6551276	Gap under gate (no bottom mesh).
Autumn	12/04/2018	Ku2K	E	STD FF	483167	6551493	Vegetation encroaching on fence.
Autumn	31/05/2018	Ku2K	E	Phascogale	483105	6552634	Phascogale panels need to be attached to fauna fence at top and bottom to minimise gaps between the fauna fence and the panels. This applies to entire length of Phascogale fencing to the northern point and to the southern point on both sides of the highway.
Autumn	12/04/2018	Ku2K	E	STD FF	482971	6554238	South East of underpass 36.4. Vegetation removal from 100 metres onwards.
Autumn	12/04/2018	Ku2K	E	STD FF	482971	6554238	North East of underpass 36.4. Substantial vegetation removal required.
Autumn	31/05/2018	Ku2K	E	Frog	483137	6554744	Gap under neoprene.
Autumn	31/05/2018	Ku2K	E	Frog	483127	6554768	Neoprene coming away from screws.
Autumn	31/05/2018	Ku2K	E	Frog	483146	6554773	Tear in neoprene.
Autumn	31/05/2018	Ku2K	E	Frog	483302	6555584	Vegetation control required. Gap at fence between mesh and neoprene.
Autumn	31/05/2018	Ku2K	E	Frog	483300	6555605	Gap at corner.
Autumn	31/05/2018	Ku2K	MID (bridge)	Frog	483190	6546183	Mesh not attached to return.
Autumn	12/04/2018	OH2Ku	W	STD FF	483125	6520124	South West of underpass 1.04. Substantial vegetation removal required from 50 m onwards - fence not accessible.
Autumn	12/04/2018	OH2Ku	W	STD FF	483169	6520608	Gap under fence.
Autumn	12/04/2018	OH2Ku	W	STD FF	483181	6520666	Gap under fence.
Autumn	12/04/2018	OH2Ku	W	STD FF	483202	6520765	Gap under fence in drainage line.
Autumn	16/05/2018	OH2Ku	W	Frog	481506	6527889	Fence lifting creating gap underneath, pegs lifted.
Autumn	16/05/2018	OH2Ku	W	Frog	482831	6528112	Vegetation removal required along entire section, fence inaccessible.
Autumn	16/05/2018	OH2Ku	W	Phascogale	481374	6528259	Gaps under Phascogale mesh/wire. Numerous gaps to underpass due to ground being uneven.
Autumn	16/05/2018	OH2Ku	W	Phascogale	481088	6529550	A number of Phascogale panels not properly secured creating gaps for approximately 50 m.
Autumn	16/05/2018	OH2Ku	W	Phascogale	481191	6529886	Phascogale panels detached heading north to Bill Hill Rd.
Autumn	16/05/2018	OH2Ku	W	Phascogale	481248	6530093	No Phascogale panel on gate on northern side Bill Hill Rd.
Autumn	16/05/2018	OH2Ku	W	Frog	481262	6530125	Gap in the return fold.

Season	Date	Section	SOC	Fence type	Easting	Northing	Observation / maintenance required
Autumn	16/05/2018	OH2Ku	W	Phascogale	481299	6530178	Phascogale panel detached.
Autumn	16/05/2018	OH2Ku	W	Phascogale	481305	6530195	Height of Phascogale panel above frog return insufficient from this point to the underpass in places.
Autumn	16/05/2018	OH2Ku	W	Phascogale	481324	6530261	Phascogale fencing does not continue to underpass.
Autumn	16/05/2018	OH2Ku	W	Frog	481356	6530319	Gap under frog mesh.
Autumn	16/05/2018	OH2Ku	W	Phascogale	481445	6530596	Gap under Phascogale wire due to rocky drainage.
Autumn	16/05/2018	OH2Ku	W	Phascogale	481509	6530822	Gap under Phascogale wire.
Autumn	16/05/2018	OH2Ku	W	Phascogale	481510	6530844	Gap under Phascogale wire.
Autumn	17/05/2018	OH2Ku	W	Frog+STD FF	482866	6537849	Vegetation removal required north and south, fence inaccessible.
Autumn	16/05/2018	OH2Ku	W	Frog+STD FF	482849	6537912	Fence down, flood damage.
Autumn	17/05/2018	OH2Ku	W	Phascogale	482455	6538673	Grassy drainage channel creating gap under Phascogale wire.
Autumn	17/05/2018	OH2Ku	W	Phascogale	482422	6538722	Vegetation control required.
Autumn	17/05/2018	OH2Ku	W	Phascogale	482418	6538753	Gap under Phascogale wire.
Autumn	17/05/2018	OH2Ku	W	Phascogale	482418	6538762	Concrete drainage channel - no Phascogale mesh at bottom.
Autumn	17/05/2018	OH2Ku	W	Phascogale	482370	6538867	Gap under Phascogale and fauna fence at gate.
Autumn	16/05/2018	OH2Ku	W	Phascogale	482187	6539334	Vegetation removal required. Phascogale wire doesn't meet ground in adjacent concrete drainage channels.
Autumn	16/05/2018	OH2Ku	W	Phascogale	482092	6539925	Gap under Phascogale wire.
Autumn	16/05/2018	OH2Ku	W	Phascogale	482085	6539973	No Phascogale wire on gate.
Autumn	16/05/2018	OH2Ku	W	Phascogale	482047	6540286	Gap under Phascogale wire in drainage channel.
Autumn	16/05/2018	OH2Ku	W	Phascogale	482092	6540567	Fine mesh at base of panel missing.
Autumn	16/05/2018	OH2Ku	W	STD FF (Phascogale)	482101	6540580	Mesh overhang of gate opening insufficient resulting in a gap.
Autumn	16/05/2018	OH2Ku	W	Phascogale	482209	6540680	Gaps behind panels due to undulations. Two sections within 10 m.
Autumn	16/05/2018	OH2Ku	W	Phascogale	482136	6540860	Vegetation removal required within 100 m north.
Autumn	16/05/2018	OH2Ku	W	Phascogale	482266	6541222	Fencing incomplete.
Autumn	16/05/2018	OH2Ku	W	Phascogale	482319	6541414	Gap in Phascogale fence, incomplete?
Autumn	16/05/2018	OH2Ku	W	STD FF (Phascogale)	482383	6541578	Bottom mesh appears torn away. Possibly due to tractor movement.
Autumn	16/05/2018	OH2Ku	W	STD FF (Phascogale)	482394	6541613	Missing bottom mesh leaving gap. Approximately 20 m north.
Autumn	16/05/2018	OH2Ku	W	STD FF + Phascogale	482437	6541749	Fencing incomplete or damaged.
Autumn	16/05/2018	Ku2K	W	STD FF	482639	6542130	Damage to base mesh to 50 m north. Possible flooding debris.
Autumn	31/05/2018	Ku2K	W	Frog	482786	6542438	Join in neoprene not holding.
Autumn	31/05/2018	Ku2K	W	Frog	482808	6542454	Neoprene does not reach ground at the north and south side of underpass (frogs can pass directly through fence mesh).
Autumn	31/05/2018	Ku2K	W	Frog	482804	6542477	Neoprene has begun tearing at the connection point to metal return.
Autumn	12/04/2018	Ku2K	W	STD FF	483173	6544197	Encroaching saplings to be removed.
Autumn	12/04/2018	Ku2K	W	STD FF	483198	6544361	North West of underpass 26.4 there are no pegs in base mesh/wire.
Autumn	31/05/2018	Ku2K	W	Frog	483146	6548399	Grass clearing required north and south.
Autumn	31/05/2018	Ku2K	W	Frog	483155	6548699	Gap at corner - mesh not joined.
Autumn	12/04/2018	Ku2K	W	STD FF	483210	6550308	South West of underpass 32.35. Branches fallen over fence and vegetation to be cleared.
Autumn	12/04/2018	Ku2K	W	STD FF	483210	6550308	South West of underpass 32.35. Pegs lifting.

Season	Date	Section	SOC	Fence type	Easting	Northing	Observation / maintenance required
Autumn	12/04/2018	Ku2K	W	STD FF	483210	6550308	North West of underpass 32.35. Vegetation clearing required.
Autumn	12/04/2018	Ku2K	W	STD FF	483210	6550308	North West of underpass 32.35. Bottom mesh not pegged or pegs lifting.
Autumn	12/04/2018	Ku2K	W	STD FF	483110	6551323	South West of underpass 36.4. Corner not secured, directly south of underpass.
Autumn	12/04/2018	Ku2K	W	STD FF	483110	6551323	South West of underpass 36.4. Vegetation removal required in numerous locations.
Autumn	12/04/2018	Ku2K	W	STD FF	483110	6551323	North West of underpass 36.4. Vegetation removal required immediately north of underpass.
Autumn	12/04/2018	Ku2K	W	STD FF	483110	6551323	North West of underpass 36.4. Pegs lifting.
Autumn	31/05/2018	Ku2K	W	Phascogale	482989	6552491	Gap at corner - not joined.
Autumn	31/05/2018	Ku2K	W	STD FF (Phascogale)	483002	6552547	No bottom mesh on gate to pond.
Autumn	31/05/2018	Ku2K	W	Phascogale	483009	6552595	No panel or mesh on drainage rock channel.
Autumn	31/05/2018	Ku2K	W	Phascogale	483038	6552645	Phascogale panels need to be attached to fauna fence at top and bottom to minimise gaps between the fauna fence and the panels. This applies to entire length of Phascogale fencing to the northern point and to the southern point on both sides of the highway.
Autumn	31/05/2018	Ku2K	W	STD FF	483035	6552670	Fauna fence lifting at base due to steep bank eroding.
Autumn	16/05/2018	OH2Ku	W	Frog + Phascogale	481315	6530174	The installation Frog + Phascogale fence has resulted in a gap between the two parts that could act as a danger to small fauna getting trapped.
Spring/Summer	24/01/2019	OH2Ku	ALL	Frog	482874	6538007	Frog fence overgrown - extensive vegetation removal required north, south, east and west of bridge.
Spring/Summer	31/10/2018	OH2Ku	E	STD FF	483108	6519861	Vegetation removal required south from this point.
Spring/Summer	31/10/2018	OH2Ku	E	STD FF	483286	6523604	Vegetation removal required along both fence lines - adjacent to highway and on the western side of Winery Drive.
Spring/Summer	31/10/2018	OH2Ku	E	STD FF	482382	6526123	Base wire not attached to fence, leaving a gap.
Spring/Summer	31/10/2018	OH2Ku	E	STD FF	482306	6526354	Some shrub removal required.
Spring/Summer	24/01/2019	OH2Ku	E	Frog	481034	6527738	Frog fence low in locations - from 200 mm. Does not fulfil EMP and Green-thighed Frog Management Strategy specification (height of 500 mm for the neoprene rubber (replaced by vermin proof mesh) including a minimum return of 100 mm on the ground).
Spring/Summer	24/01/2019	OH2Ku	E	Frog	481632	6527829	Vegetation clearing required.
Spring/Summer	24/01/2019	OH2Ku	E	Phascogale	481534	6527940	Vegetation clearing required northward.
Spring/Summer	24/01/2019	OH2Ku	E	Phascogale	481506	6528002	End of combined Frog/Phascogale fence. There is no Phascogale fence north of this point where it is mapped.
Spring/Summer	24/01/2019	OH2Ku	E	Phascogale	481452	6528124	Start of Phascogale Fence. Determine if Phascogale fence required to continue south to meet Frog fence.
Spring/Summer	24/01/2019	OH2Ku	E	Phascogale	481307	6530047	Base of fauna fence lifting excessively.
Spring/Summer	24/01/2019	OH2Ku	E	Frog+Phascogale	481371	6530235	Vegetation removal required south.
Spring/Summer	24/01/2019	OH2Ku	E	Frog+Phascogale	481380	6530256	Vegetation removal required north and south.
Spring/Summer	24/01/2019	OH2Ku	E	Phascogale	481504	6530578	Vegetation removal required north and south.
Spring/Summer	24/01/2019	OH2Ku	E	Phascogale	481602	6530855	Vegetation removal required north and south.
Spring/Summer	24/01/2019	OH2Ku	E	Frog	483074	6537034	Vegetation clearing suggested to pre-empt overgrowth of fence.
Spring/Summer	30/10/2018	OH2Ku	E	STD FF	482474	6538793	Base netting does not come to the end of the fence at the underpass, creating a gap at the underpass.
Spring/Summer	22/01/2019	OH2Ku	E	Phascogale	482194	6539700	Vegetation removal required southward.



Season	Date	Section	SOC	Fence type	Easting	Northing	Observation / maintenance required
Spring/Summer	22/01/2019	OH2Ku	E	Phascogale	482264	6539796	Sheet metal panel missing.
Spring/Summer	22/01/2019	OH2Ku	E	Phascogale	482165	6539962	Vegetation clearing required both north and south of culvert.
Spring/Summer	22/01/2019	OH2Ku	E	Phascogale	482183	6540520	Dense weed - removal required.
Spring/Summer	22/01/2019	OH2Ku	E	Phascogale	482238	6540829	Vegetation removal required.
Spring/Summer	22/01/2019	OH2Ku	E	Phascogale	482291	6541020	Continued vegetation removal required.
Spring/Summer	22/01/2019	OH2Ku	E	Phascogale	482329	6541188	Extensive grass removal required southward.
Spring/Summer	22/01/2019	OH2Ku	E	Phascogale	482557	6541827	Sapling removal required.
Spring/Summer	22/01/2019	Ku2K	E	Phascogale	482701	6542091	Vegetation clearing required.
Spring/Summer	22/01/2019	Ku2K	E	Phascogale	482694	6542134	Vegetation and grass removal required in the area.
Spring/Summer	22/01/2019	Ku2K	E	STD FF	482817	6542348	Sapling removal required.
Spring/Summer	22/01/2019	Ku2K	E	Frog	483247	6546153	Grass covering frog fence - removal required.
Spring/Summer	22/01/2019	Ku2K	E	Frog	483227	6546196	Numerous gaps between rocks and fauna fence and between fauna fence and frog fence - frog fence needs to be attached or weighted down and gaps filled.
Spring/Summer	22/01/2019	Ku2K	E	Frog	483245	6546271	Grass covering frog fence - removal required.
Spring/Summer	23/01/2019	Ku2K	E	Frog	483267	6548592	Intermittent grass clearing required.
Spring/Summer	23/01/2019	Ku2K	E	Frog	483209	6548647	Frog fence overgrown - extensive clearing required.
Spring/Summer	30/10/2018	Ku2K	E	STD FF	483260	6550317	Base wire has come away from the main fence, leaving a gap between the two.
Spring/Summer	23/01/2019	Ku2K	E	Phascogale	483090	6552553	Vegetation encroaching of fence - clearing required.
Spring/Summer	31/10/2018	Ku2K	E	STD FF	483011	6554237	Top of fence is not curved/bent inwards - check integrity.
Spring/Summer	31/10/2018	Ku2K	E	STD FF	482971	6554238	North East underpass 36.4. North of underpass to 100 metres - vegetation clearing required on the highway side of the fauna fence.
Spring/Summer	22/01/2019	Ku2K	E	Frog	483308	6555588	Grass removal required in area.
Spring/Summer	31/10/2018	OH2Ku	W	STD FF	483042	6519948	Large branch fallen over fence.
Spring/Summer	24/01/2019	OH2Ku	W	Frog	481466	6527980	Clearing of vegetation from entire length frog fence required.
Spring/Summer	24/01/2019	OH2Ku	W	Frog+Phascogale	481448	6528023	Phascogale sheeting too narrow (0.15 m) over the top of the frog fence? Both east and west of culvert.
Spring/Summer	24/01/2019	OH2Ku	W	Phascogale	481373	6528255	Vegetation removal required south.
Spring/Summer	24/01/2019	OH2Ku	W	Phascogale	481300	6530191	Phascogale sheeting too narrow (0.15 m) over the top of the frog fence? Both east and west of culvert.
Spring/Summer	24/01/2019	OH2Ku	W	Frog+Phascogale	481347	6530326	Vegetation clearing required.
Spring/Summer	24/01/2019	OH2Ku	W	Frog+Phascogale	481395	6530435	Vegetation clearing required in area.
Spring/Summer	24/01/2019	OH2Ku	W	STD FF (Phascogale)	481495	6530720	Base wires of standard fauna fence deformed and pulled away from main fauna fence.
Spring/Summer	24/01/2019	OH2Ku	W	Phascogale	481517	6530866	Vegetation removal required northward.
Spring/Summer	24/01/2019	OH2Ku	W	Frog	482861	6537923	No frog fence around pipe culvert - check design and determine if required.
Spring/Summer	24/01/2019	OH2Ku	W	Frog	482845	6537961	Fence damaged from fallen tree - tree removed.
Spring/Summer	24/01/2019	OH2Ku	W	Phascogale	482421	6538734	Tree trimming and vegetation clearing required south to end of Phascogale fence.
Spring/Summer	24/01/2019	OH2Ku	W	Phascogale	482363	6538854	Trees fallen over fauna fence in multiple locations.
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482184	6539365	Tree growth into fence - removal required southward.
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482165	6539456	Grass removal required in area.

Season	Date	Section	SOC	Fence type	Easting	Northing	Observation / maintenance required
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482170	6539497	Tree growing into fence - removal required.
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482131	6539660	Vegetation on highway side of fence growing over and weighing down fauna fence – remove.
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482094	6539920	Vegetation growth through fauna fence - removal required.
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482040	6540259	Tree down over fence, fence damaged.
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482091	6540403	Vegetation encroaching on fence - removal required northward.
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482100	6540515	Grass encroaching on fence - removal required.
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482102	6540576	No overhanging wire cover at base of gate.
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482127	6540841	Sapling growth in and around fence panels northward - removal required.
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482195	6540987	Tree down over fence, fence damaged.
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482221	6541022	Vegetation removal required northward.
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482238	6541185	Vegetation and grass removal required in the area.
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482447	6541750	Grass removal required northward.
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482565	6541999	Vegetation and grass removal required northward.
Spring/Summer	22/01/2019	Ku2K	W	Phascogale	482599	6542076	Grass removal required.
Spring/Summer	22/01/2019	Ku2K	W	Frog	483180	6546183	Fence/gate maintenance appears to be incomplete - fencing not completely attached leaving a gap under the fauna fence and frog fence does not extend to end of fauna fence.
Spring/Summer	22/01/2019	Ku2K	W	Frog	483181	6546220	Frog fence mesh incompletely attached leaving a section of the fauna fence with no frog fence.
Spring/Summer	22/01/2019	Ku2K	W	Frog	483175	6546279	Grass covering frog fence - removal required.
Spring/Summer	23/01/2019	Ku2K	W	Frog	483149	6548416	Grass clearing required.
Spring/Summer	23/01/2019	Ku2K	W	Frog	483158	6548810	Branches and vegetation hanging over fence - clearing required.
Spring/Summer	30/10/2018	Ku2K	W	STD FF	483130	6551147	Gap at drainage line - base wire not properly covering to edges.
Spring/Summer	30/10/2018	Ku2K	W	STD FF	483097	6551238	Base wires has come away from the main fence, leaving a gap between the two.
Spring/Summer	30/10/2018	Ku2K	W	STD FF	483079	6551281	Gap between the fence and the drainage line.
Spring/Summer	23/01/2019	Ku2K	W	Phascogale	483005	6552612	Panel has detached and is hanging off.
Spring/Summer	23/01/2019	Ku2K	W	Phascogale	483038	6552693	Panel needs to be attached to fauna fence at top and bottom to prevent gaps - both east and west of culvert.
Spring/Summer	31/10/2018	Ku2K	W	STD FF	482919	6554226	The end of the fauna fence is not properly secured at the underpass, leaving a gap on both north and south sides.
Spring/Summer	31/10/2018	Ku2K	W	STD FF	482890	6554283	Tree fallen onto fence.
Spring/Summer	22/01/2019	Ku2K	W	Frog	483253	6555573	Vegetation removal required northward.

## Annex 2 – Road kill survey data

**Table 9: 2018/2019 road kill monitoring results**

Season	Date	Latitude	Longitude	Species	Native/Introduced	Assigned vertebrate group
Spring	03/10/2018	-31.439694	152.82315	Medium Mammal	Unknown	Medium mammal
Spring	03/10/2018	-31.399989	152.814449	Magpie	Native	Bird
Spring	03/10/2018	-31.394468	152.811939	Bird of prey	Native	Bird
Spring	03/10/2018	-31.394114	152.811776	Small Mammal	Unknown	Small mammal
Spring	03/10/2018	-31.355429	152.80628	Small Mammal	Unknown	Small mammal
Spring	03/10/2018	-31.354099	152.806569	Bird	Unknown	Bird
Spring	03/10/2018	-31.313033	152.820438	Unknown	Unknown	Unknown
Spring	03/10/2018	-31.309557	152.821279	Kookaburra	Native	Bird
Spring	03/10/2018	-31.294135	152.820458	Kangaroo	Native	Large ground dwelling mammal
Spring	03/10/2018	-31.248635	152.821532	Unknown	Unknown	Unknown
Spring	03/10/2018	-31.180668	152.823946	Medium Mammal	introduced	Medium mammal
Spring	03/10/2018	-31.227617	152.823727	Medium Mammal	Unknown	Medium mammal
Spring	03/10/2018	-31.290037	152.818886	Medium Mammal	Native	Medium mammal
Spring	03/10/2018	-31.322596	152.818473	Bird of prey	Native	Bird
Spring	03/10/2018	-31.324246	152.81815	Bird of prey	Native	Bird
Spring	03/10/2018	-31.328696	152.817107	Bird of prey	Native	Bird
Spring	03/10/2018	-31.330826	152.816361	Frog	Native	Amphibian
Spring	03/10/2018	-31.351604	152.807325	Bird of prey	Native	Bird
Spring	03/10/2018	-31.356945	152.806128	Owl	Native	Bird
Spring	03/10/2018	-31.376089	152.803312	Unknown	Unknown	Unknown
Spring	03/10/2018	-31.406148	152.816966	Bird	Native	Bird
Spring	03/10/2018	-31.418339	152.823037	Kangaroo	Native	Large ground dwelling mammal
Spring	03/10/2018	-31.434624	152.822861	Owl	Native	Bird
Spring	11/10/2018	-31.439719	152.823147	Medium Mammal	Unknown	Medium mammal
Spring	11/10/2018	-31.394209	152.81177	Small Mammal	Unknown	Small mammal
Spring	11/10/2018	-31.355398	152.80629	Rodent	Unknown	Small mammal
Spring	11/10/2018	-31.30939	152.821328	Bird	Native	Bird
Spring	11/10/2018	-31.228975	152.823479	Small Mammal	Unknown	Small mammal
Spring	11/10/2018	-31.290025	152.818872	Medium Mammal	Unknown	Medium mammal
Spring	11/10/2018	-31.296763	152.821443	Bird	Native	Bird
Spring	11/10/2018	-31.322703	152.818457	Medium Mammal	Unknown	Medium mammal
Spring	11/10/2018	-31.330579	152.816451	Medium Mammal	Unknown	Medium mammal
Spring	11/10/2018	-31.37187	152.802294	Small Mammal	Unknown	Small mammal
Spring	18/10/2018	-31.349704	152.807512	Bandicoot	Native	Medium mammal
Spring	18/10/2018	-31.338699	152.811732	Frog	Native	Amphibian
Spring	26/10/2018	-31.440664	152.823291	Medium Mammal	Introduced	Medium mammal

Season	Date	Latitude	Longitude	Species	Native/Introduced	Assigned vertebrate group
Spring	26/10/2018	-31.440267	152.823239	Medium Mammal	Introduced	Medium mammal
Spring	26/10/2018	-31.394103	152.811782	Medium Mammal	Unknown	Medium mammal
Spring	26/10/2018	-31.355391	152.806327	Rodent	Unknown	Small mammal
Spring	26/10/2018	-31.342243	152.809868	Bird	Native	Bird
Spring	26/10/2018	-31.209512	152.823127	Kangaroo	Native	Large ground dwelling mammal
Spring	26/10/2018	-31.209731	152.823373	Medium Mammal	Introduced	Medium mammal
Spring	26/10/2018	-31.32952	152.816852	Bird of prey - Owl	Native	Bird
Spring	26/10/2018	-31.340913	152.810736	Duck	Native	Bird
Spring	26/10/2018	-31.358196	152.805756	Bird of prey	Native	Bird
Summer	08/01/2019	-31.407016	152.817317	Macropod	Native	Large ground dwelling mammal
Summer	08/01/2019	-31.409504	152.818604	Wallaby	Native	Large ground dwelling mammal
Summer	08/01/2019	-31.431274	152.82253	Kookaburra	Native	Bird
Summer	08/01/2019	-31.324086	152.818008	Turtle	Native	Reptile
Summer	08/01/2019	-31.299061	152.821552	Fox	Introduced	Introduced
Summer	08/01/2019	-31.288528	152.81766	Medium Mammal	Unknown	Medium mammal
Summer	08/01/2019	-31.279915	152.813042	Medium Mammal	Unknown	Medium mammal
Summer	08/01/2019	-31.221445	152.823501	Raven	Native	Bird
Summer	08/01/2019	-31.206409	152.822982	Fox	Introduced	Introduced
Summer	08/01/2019	-31.196149	152.823451	Kangaroo	Native	Large ground dwelling mammal
Summer	08/01/2019	-31.338355	152.812289	Owl	Native	Bird
Summer	15/01/2019	-31.450106	152.822892	Magpie	Native	Bird
Summer	15/01/2019	-31.309979	152.821134	Echidna	Native	Small mammal
Summer	15/01/2019	-31.261002	152.814707	Small Mammal	Unknown	Small mammal
Summer	15/01/2019	-31.225569	152.823452	Bird	Unknown	Bird
Summer	15/01/2019	-31.196121	152.823423	Kangaroo	Native	Large ground dwelling mammal
Summer	15/01/2019	-31.407161	152.817465	Unknown	Unknown	Unknown
Summer	22/01/2019	-31.298814	152.821501	Medium Mammal	Unknown	Medium mammal
Summer	22/01/2019	-31.206084	152.822984	Fox	Introduced	Introduced
Summer	22/01/2019	-31.243936	152.823333	Turtle	Unknown	Reptile
Summer	22/01/2019	-31.327601	152.817446	Turtle	Unknown	Reptile
Summer	29/01/2019	-31.459087	152.820882	Wallaby	Native	Large ground dwelling mammal
Summer	29/01/2019	-31.419732	152.823177	Bird	Unknown	Bird
Summer	29/01/2019	-31.29898	152.821577	Medium Mammal	Unknown	Medium mammal
Summer	29/01/2019	-31.196102	152.823483	Kangaroo	Native	Large ground dwelling mammal
Summer	29/01/2019	-31.182392	152.823913	Kangaroo	Native	Large ground dwelling mammal
Summer	29/01/2019	-31.210555	152.823423	Black bird	Unknown	Bird
Autumn	05/04/2019	-31.324452	152.818144	Lizard	Native	Reptile
Autumn	05/04/2019	-31.262736	152.814192	Mammal	Unknown	Unknown
Autumn	05/04/2019	-31.187902	152.823474	Unknown	Unknown	Unknown
Autumn	12/04/2019	-31.324446	152.817935	Bird of prey	Native	Bird
Autumn	12/04/2019	-31.446777	152.823985	Magpie	Native	Bird

Season	Date	Latitude	Longitude	Species	Native/Introduced	Assigned vertebrate group
Autumn	12/04/2019	-31.210655	152.823178	Fox	Introduced	Introduced
Autumn	12/04/2019	-31.250807	152.820384	Lace Monitor	Native	Reptile
Autumn	18/04/2019	-31.421827	152.823479	Magpie	Native	Bird
Autumn	18/04/2019	-31.216111	152.823561	Bird	Unknown	Bird
Autumn	18/04/2019	-31.194548	152.823516	Bird	Unknown	Bird
Autumn	18/04/2019	-31.312986	152.820635	Bird	Unknown	Bird
Autumn	18/04/2019	-31.32346	152.818352	Bird of prey	Native	Bird
Autumn	18/04/2019	-31.446879	152.823987	Magpie	Native	Bird
Autumn	18/04/2019	-31.457338	152.821342	Small unknown	Unknown	Unknown
Autumn	18/04/2019	-31.447363	152.823579	Unknown	Unknown	Unknown
Autumn	28/04/2019	-31.362348	152.803642	Echidna	Native	Medium mammal

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# Appendix I Landscaping and Revegetation



# Contractor Ecological Monitoring Report 2018/2019

## Oxley Highway to Kempsey, Pacific Highway Upgrade

Prepared for Roads and Maritime Services

September 2019



## Document control

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Project Manager:	Radika Michniewicz
Authors:	Radika Michniewicz
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*Cover photograph:* OH2K dual carriageway and widened median.

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## Executive summary

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### **Context**

This report documents findings for the 2018/2019 contractor ecological monitoring associated with the Oxley Highway to Kempsey (OH2K) Pacific Highway Upgrade (the Project), as required by the Oxley Highway to Kempsey (OH2K) Ecological Monitoring Program (EMP, RMS 2019).

The EMP details the schedule of ecological monitoring requirements for the life of the Project. Those monitoring components that were undertaken during the 2018/2019 monitoring period by contractors and that are reported on in this document are listed below.

- **Landscaping and revegetation**

### **Key results and implications**

- Landscaping and revegetation
  - All sites have undergone a 12 month inspection.
  - Of the 188 native seeding sites, 163 (86.7%) have met the minimum 12 month criteria.
  - Of the 408 native planting sites, 398 (97.5%) have met the minimum 12 month criteria.
  - It is recommended that monitoring and reporting continue as per the requirements of the Landscape Maintenance Period, with all necessary management actions undertaken to ensure performance indicators are met and ongoing compliance at conforming sites.

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## 1. Introduction

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### 1.1 Context

The Oxley Highway to Kempsey (OH2K) section of the Pacific Highway Upgrade Project (the Project) was approved in 2012 subject to various Ministers Conditions of Approval (MCoA) and a Statement of Commitments (SoC). A subsequent approval with additional conditions of consent (CoA) was granted in 2014 by the Commonwealth Department of Environment (DoE) for Matters of National Environmental Significance (MNES) listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1995* (EPBC Act). The Ecological Monitoring Program (hereafter referred to as the EMP) (RMS 2019) combines these approval conditions and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project.

For a number of the monitoring components the Project has been divided into two sections:

- Oxley Highway to Kundabung (Ch. 0 - 24040), hereafter referred to as OH2Ku.
- Kundabung to Kempsey (Ch. 24040 - 37850), hereafter referred to as Ku2K.

### 1.2 Purpose of this Report

This report summarises the findings of the 2018/2019 construction contractor ecological monitoring surveys undertaken as part of the OH2K section of the Pacific Highway Upgrade Project. These were undertaken in accordance with the EMP from July 2018 to July 2019 (the current reporting period).

The EMP details the schedule of ecological monitoring requirements for the life of the Project. These are shown in Table 1. As the Project is now operational, all construction contractor monitoring requirements have been completed except landscaping and revegetation. This report therefore addresses landscaping and revegetation monitoring only. The landscaping and revegetation monitoring period that has been reported on in this report encompasses July 2018 – July 2019 inclusive.

**Table 1: Summary and schedule of monitoring requirements outlined in the EMP (RMS 2019)**

Mitigation Measure	Baseline Surveys						Construction Phase												Operation Phase																										
	Year 0 (2013-2014)						Year 1 (2015)				Year 2 (2016)				Year 3 (2017)				Year 4 (2018)				Year 5 (2019)				Year 6 (2020)				Year 7 (2021)				Year 8 (2022-2023)										
	S	Su	A	W	S	Su	Su	A	W	S	Su	Su	A	W	S	Su	Su	A	W	S	Su	Su	A	W	S	Su	Su	A	W	S	Su	Su	A	W	S	Su	Su	A	W	S	Su	A			
Koala	Completed									Completed	Completed					Completed	Completed					Completed	Completed					Completed	Completed					Completed	Completed					Completed	Completed				
Spotted-tail Quoll			Completed																					Completed	Completed					Completed	Completed														
Giant Barred Frog	Completed	Completed	Completed					Completed		Completed	Completed				Completed	Completed					Completed	Completed	NT	Completed			Completed	Completed					Completed	Completed					Completed	Completed					
Green-thighed Frog		Completed																																											
Yellow-bellied Glider	Completed																						Completed	Completed					Completed	Completed															
Brush-tailed Phascogale		Completed																					Completed	Completed					Completed	Completed															
Squirrel Glider																							Completed	Completed					Completed	Completed															
Road Kill	Completed	Completed	Completed				Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed			Completed	Completed					Completed	Completed					Completed	Completed					
Pre-clearing / clearing							Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed																															
Fauna underpasses																							Completed	Completed					Completed	Completed															
Rope Bridges																							Completed	Completed					Completed	Completed															
Glider Poles																							Completed	Completed					Completed	Completed															
Fauna Fencing																							Completed	Completed					Completed	Completed															
Widened Median																							Completed	Completed					Completed	Completed															
Nest boxes*																							Completed	Completed					Completed	Completed															
Bat Roost Boxes*				1	2		3	4	5	6	7	8	9		10	11							Completed	Completed					Completed	Completed															
Maundia Habitat Protection							Completed	Completed		Completed	Completed			Completed	Completed							Completed	Completed																						
Green-thighed frog ponds																						Completed	Completed					Completed	Completed																
Landscape monitoring							Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed																						

Su A W S = Summer, Autumn, Winter, Spring; NT = No rainfall trigger, surveys not done; 'n' = monitoring event numbers; # = timing is dependent on rainfall

- Completed
- Existing Niche Contract
- Additional monitoring completed as part of EPBC
- Lewis Ecological
- Construction Contractor

## 2. Landscape Monitoring

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The landscaping and revegetation data for the 2018/2019 monitoring period was provided by Roads and Maritime Services (Roads and Maritime). The data are provided in Annex 1. The results are summarised below.

### 2.1 Monitoring Framework and Timing

The EMP specifies the timing of the landscaping and revegetation monitoring as follows:

- *“Monitoring of landscaping would be conducted at 8 months and 12 months. The need for additional monitoring would be determined following analysis of the monitoring data.*
- *Maintenance of the landscaping and weeds would continue for the duration of the three year maintenance period or until such time as the revegetation is determined successful and is no longer requiring active management to maintain its survival.”*

All sites have now undergone a 12 month inspection. Ongoing monitoring of the sites is to be undertaken as part of the Landscape Maintenance Period. The Landscape Maintenance Period commenced in November 2018 for the Ku2K section of the Project and in July 2019 for the OH2Ku section of the Project. This period involves three years of ongoing monthly monitoring, reporting and maintenance of all native revegetation sites. Those sites that have reached compliance will continue to be monitored for ongoing compliance and maintenance.

To date, landscape and revegetation monitoring events have been reported on as follows:

- *2015/2016 monitoring: Niche 2016*
- *2016/2017 monitoring: Niche2017*
- *2017/2018 monitoring: Niche 2018*
- *2018/2019: current report.*

### 2.1 Performance Measures

The EMP specifies the following performance indicators for landscaping and revegetation:

***“Indicators of success of landscaping and revegetation include:***

- *Each area revegetated by native seeding must achieve the following minimum standards as assessed at 12 months following revegetation:*
  - *One native plant every 6 m<sup>2</sup>*
  - *Average minimum height of 15 cm, and*
  - *Native vegetation diversity to be assessed to the satisfaction of the Landscape Representative or the Project Ecologist.*
- *All areas required to be revegetated by native planting must achieve the following minimum standards as assessed at 12 months following revegetation:*
  - *Minimum plant growth of 30 cm following planting.*
  - *Minimum plant survival rate of 80%.*
- *Weed cover is less than 5% per restored area.”*

## **2.2 Monitoring Sites**

### **2.2.1 Native seeding**

A total of 188 native seeding revegetation monitoring sites exist within the Project for both the OH2Ku (101 sites) and Ku2K sections (87 sites). Of the 188 sites, all had undergone their 12 month inspection by 1 July 2019.

### **2.2.2 Native planting**

A total of 408 native planting monitoring sites exist within the Project for both the OH2Ku (268 sites) and Ku2K (140 sites) sections. Of the 408 sites, all had undergone their 12 month inspection by 1 July 2019.

## **2.3 Methods**

Monitoring of landscaping was conducted at 12 months for those sites that had not previously reached compliance or had not reached the 12 month monitoring date.

### **2.3.1 Data limitations and assumptions**

As discussed in Niche 2016, a number of limitations exist in relation to the landscape monitoring data. These include:

- Data collection was not standardised across the two monitoring contractors
- Parameters identified in the performance measures were not always specified in the data provided
- Species information was not provided
- Where information with respect to plant growth, density and distribution was provided, the data were generally descriptive, which does not allow for direct assessment against performance measures.

Roads and Maritime undertook a review of all the data, considering both recorded parameters as well as the descriptive records for each site to enable review and assessment against the required performance measures.

## 2.4 Native Seeding Results

Field data for monitoring surveys that were undertaken during the 2018/2019 monitoring period are provided in Annex 1. All 188 sites are listed and those sites that have met minimum criteria in the current or previous monitoring period are highlighted. A summary of the native seeding sites and results is provided in Table 2.

**Table 2: Native seeding site and result summary**

Section	Monitoring sites	Completed 12 month period	12 month criteria met
OH2Ku	101	101	91 (90.0%)
Ku2K	87	87	72 (82.8%)
<b>Total</b>	<b>188</b>	<b>188</b>	<b>163 (86.7%)</b>

### 2.4.1 Conforming sites

Of the 188 sites, 163 (86.7%) were determined to have met all minimum criteria. Minimum criteria are:

- One native plant every 6 m<sup>2</sup>
- Average minimum height of 15 centimetres (cm)
- Native vegetation diversity to be assessed to the satisfaction of the Landscape Representative or the Project Ecologist
- Weed cover is less than 5% per restored area.

### 2.4.2 Non-conforming sites

Of the 188 sites, 25 have not met minimum criteria (Table 3 and Table 4).

Within the OH2Ku section of the Project Non-conformance Reports (NCR) have been agreed upon for nine of the 10 sites for conversion of Vegetation Community Type from native grasses to pasture grass. NCRs are awaiting approval, pending successful pasture growth, which has now occurred. The tenth site (“Workshop site”) is on land destined for sale. The future land use of this area is not likely to be compatible with the revegetation goals and the site has been removed from the program.

Within the Ku2K section of the Project, all 15 non-conforming sites have shown an acceptable variety and quantity of native species but weak growth and very poor ground cover after several respray efforts. The ongoing requirements for these sites will be determined by the outcome of a current NSW Environment Protection Authority (EPA) inspection.

**Table 3: Non-conforming native seeding sites - OH2Ku**

Site	C'way	Vegetation Community Type	Date of Hydromulch	12 month inspection	As at August 2019 comments
Fill 13A		Native Grasses	Feb-17	Feb-18	Convert to a pasture grass mix. Outside influences (farming) will dominate outcomes. NCR raised to change to pasture grass. Would meet 12-month criteria for pasture grass.
Fill 13B		Native Grasses	Feb-17	Feb-18	Convert to a pasture grass mix. Outside influences (farming) will dominate outcomes. NCR raised to change to pasture grass. Would meet 12-month criteria for pasture grass.
Fill 11	NB	Native Grasses	Feb-17	Feb-18	Convert to a pasture grass mix. Outside influences (farming) will dominate outcomes. NCR raised to change to pasture grass. Would meet 12-month criteria for pasture grass.
Fill 11	median	Native Grasses	Feb-17	Feb-18	Convert to a pasture grass mix. Outside influences (farming) will dominate outcomes. NCR raised to change to pasture grass. Would meet 12-month criteria for pasture grass.



Site	C'way	Vegetation Community Type	Date of Hydromulch	12 month inspection	As at August 2019 comments
Fill 11	SB	Native Grasses	Feb-17	Feb-18	Convert to a pasture grass mix. Outside influences (farming) will dominate outcomes. NCR raised to change to pasture grass. Would meet 12-month criteria for pasture grass.
Fill 6	SB	Native Grasses	Aug-16	Aug-17	Convert to a pasture grass mix. Outside influences (farming) will dominate outcomes. NCR raised to change to pasture grass. Would meet 12-month criteria for pasture grass.
Cut 6	NB	Native Grasses	Nov-17	Nov-18	Convert to a pasture grass mix. Outside influences (farming) will dominate outcomes. NCR raised to change to pasture grass. Would meet 12-month criteria for pasture grass.
Cut 6	SB	Native Grasses	Nov-17	Nov-18	Convert to a pasture grass mix. Outside influences (farming) will dominate outcomes. NCR raised to change to pasture grass. Would meet 12-month criteria for pasture grass.
Fill 10	NB	Native Grasses	Nov-17	Nov-18	NCR pending for conversion of native grasses to Frangible Shrubs.
Workshop site	NB	Tall Shrubs	Nov-17	Nov-18	Surplus RMS land to be sold. Potential change of landuse and revegetation type.

C'way = carriageway, NB = northbound, SB = southbound.

**Table 4: Non-conforming native seeding sites – Ku2K**

Cut/Fill	C'way	Bench	Hydroseed / Hydromulch Date	12 month inspection	As at August 2019 comments
Cut 2	NB		Dec-16	Dec-17	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.
Cut 8	NB	sth Upper Smiths	Dec-16	Dec-17	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.
Cut 19	SB		Aug-16	Aug-17	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.
Cut 19	NB		Sep-16	Sep-17	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.
Cut 20	SB	Bottom	Aug-16	Aug-17	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.
Cut 20	NB		Sep-16	Sep-17	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.
Cut 22A	NB		Apr-17	Apr-18	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.
Cut 22B	NB		Mar-17	Mar-18	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.
Cut 23	NB		Mar-17	Mar-18	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.
Cut 18	SB		Sep-15	Sep-16	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.
Cut 18	NB		Sep-15	Sep-16	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.
Cut 21	NB		Dec-15	Dec-16	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.
Cut 8	NB		Aug-17	Aug-18	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.
Cut 15	NB		Sep-18	Sep-19	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.
Cut 16	NB		Sep-18	Sep-19	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.

C'way = carriageway, NB = northbound, SB = southbound.

## 2.5 Native Planting Results

Field data for monitoring surveys that were undertaken during the 2018/2019 monitoring period are provided in Annex 1. All 408 sites are listed and those sites that have met minimum criteria are highlighted. In addition to the 408 sites, 38 sites were deleted from the program for reasons provided in Annex 1. A summary of the native planting sites and results is provided in Table 5.

**Table 5: Native planting site and result summary**

Section (data source)	Monitoring sites	Completed 12 month period	12 month criteria met
OH2Ku (Lendlease)	268	268	263 (98.1%)
Ku2K (McConnell Dowell OHL JV)	140	140	135 (96.4%)
<b>Total</b>	<b>408</b>	<b>408</b>	<b>398 (97.5%)</b>

### 2.5.1 Conforming sites

Of the 408 sites, 398 (97.5%) were determined to have met all the 12 month minimum criteria. Minimum criteria are:

- Minimum plant growth of 30 cm following planting
- Minimum plant survival rate of 80%
- Weed cover is less than 5% per restored area.

### 2.5.2 Non-conforming sites

Of the 403 sites, 10 have not met minimum criteria (Table 6 and Table 7).

Within the OH2Ku section of the Project five sites have not met minimum criteria. Replacement planting is being investigated for these sites.

Within the Ku2K section of the Project five sites have not met minimum criteria. Replacement planting has been undertaken at these sites and additional planting has been proposed for spring 2019.

**Table 6: Non-conforming native planting sites - OH2Ku**

Bed ID	Planting date	12 month Review Due	Inspection Date	Observation & Action Required
31	30/04/2018	Apr-19	07/06/2019	Pocket plantings in scour rock have died. Investigate methodologies for replacing dead plants.
73	01/04/2018	Apr-19	07/06/2019	Plantings not present. Investigate 29 additional paperbark plantings.
215	14/03/2018	Mar-19	07/06/2019	Plantings appear to be absent. Investigate replacement planting.
302	01/05/2018	May-19	07/06/2019	Pocket plantings in scour rock have died. Investigate methodologies for replacing dead plants.
304	01/05/2018	May-19	07/06/2019	Pocket plantings in scour rock have died. Investigate methodologies for replacing dead plants.

**Table 7: Non-conforming native planting sites – Ku2K**

Identifier	C'way	Chainage	Description	Date Planted	12 month inspection	Comments
3	NB	24900	Rest area tubestock	Dec-17	Dec-18	Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018. Reassessment of suitability of some further failed species underway since January 2019.
4	NB	24900	Rest area feature trees	Nov-17	Nov-18	Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018. Further replacement of dead trees since January 2019 proposed in Spring 2019.
27	NB	29100	Kundabung Interchange feature trees	Apr-17	Apr-18	Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018. Further replacement of dead trees since January 2019 proposed in Spring 2019.
28	NB	29300	Kundabung Interchange feature trees	Oct-17	Oct-18	Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018. Further replacement of dead trees since January 2019 proposed in Spring 2019.
97	SB	29300	Kundabung Interchange feature trees	Oct-17	Oct-18	Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018. Further replacement of dead trees since January 2019 proposed in Spring 2019.

C'way = carriageway, NB = northbound, SB = southbound.

## 2.6 Discussion

A summary of the 2018/2019 monitoring results in relation to the performance measures for native seeding and native planting is provided in Table 8.

**Table 8: Landscaping and revegetation performance measures**

Performance indicators of success	Discussion
<p>Each area revegetated by native seeding must achieve the following minimum standards as assessed at 12 months following revegetation:</p> <ul style="list-style-type: none"> <li>One native plant every 6 m<sup>2</sup></li> <li>Average minimum height of 15 cm</li> <li>Native vegetation diversity to be assessed to the satisfaction of the Landscape Representative or the Project Ecologist</li> </ul> <p>Weed cover is less than 5% per restored area.</p>	<p><b>These performance indicators of success have been met to date by 163 (86.7%) of the 188 sites.</b></p> <p>The remaining 25 sites are summarised as follows:</p> <ul style="list-style-type: none"> <li>Nine subject to agreed Non-conformance Reports</li> <li>One deleted from the program</li> <li>15 awaiting EPA inspection outcome.</li> </ul>
<p>All areas required to be revegetated by native planting must achieve the following minimum standards as assessed at 12 months following revegetation:</p> <ul style="list-style-type: none"> <li>Minimum plant growth of 30 cm following planting</li> <li>Minimum plant survival rate of 80%</li> <li>Weed cover is less than 5% per restored area.</li> </ul>	<p><b>These performance indicators of success has been met to date by 398 (97.5%) of the 408 sites.</b></p> <p>Replanting is being investigated and planned for spring 2019 at non-conforming sites.</p>

## 2.7 Recommendations

The EMP lists potential problems and contingency measures for various components of the monitoring program, however specific contingency measures for landscaping and revegetation monitoring have not been provided within the EMP. However, the EMP states:

*“Maintenance of the landscaping and weeds would continue for the duration of the three year maintenance period as outlined in Section 6 or until such time as the revegetation is determined successful and is no longer requiring active management to maintain its survival.” And, “If these performance indicators are not achieved a non-conformance would be raised, to be closed out to the satisfaction of Roads and Maritime, and the Landscape Representative or the Project Ecologist.”*

### 2.7.1 Native seeding

All sites have undergone a 12 month assessment. Of the 188 sites, 25 have not met the performance indicators. NCRs have been agreed upon for nine of the 10 sites for conversion of Vegetation Community Type from native grasses to pasture grass. NCRs are awaiting approval, pending successful pasture growth, which has now occurred. The tenth site (“Workshop site”) is on land destined for sale. The future land use of this area is not likely to be compatible with the revegetation goals and the site has been removed from the program. The final 15 sites have undergone an EPA inspection. The outcome of this inspection will determine the ongoing treatment of these sites. It is recommended that monitoring and reporting continue as per the requirements of the Landscape Maintenance Period, with all necessary management actions undertaken to ensure performance indicators are met and ongoing compliance at conforming sites.

### 2.7.2 Native planting

All sites have undergone a 12 month assessment. Of the 408 sites, 10 have not met the performance indicators. Replanting at these sites is being investigated and is planned for spring 2019. It is recommended that monitoring and reporting continue as per the requirements of the Landscape Maintenance Period, with all necessary management actions undertaken to ensure performance indicators are met and ongoing compliance at conforming sites.

## References

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Niche (2016). OH2K Pacific Highway Upgrade. Annual Ecological Monitoring Report 2016. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

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Niche (2018). Contractor Ecological Monitoring Report 2017/2018. Oxley Highway to Kempsey, Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

RMS (2019). Oxley Highway to Kempsey Pacific Highway Upgrade Ecological Monitoring Program. Roads and Maritime Update to report prepared by SMEC Hyder Joint Venture, August 2019.

## Annex 1. Landscape and revegetation monitoring 2018/2019

### **Native seeding data OH2Ku.**

Refined data provided by Roads and Maritime. Sites that have reached minimum 12 month criteria in the current or previous monitoring periods are highlighted. C'way = carriageway, NB = northbound, SB = southbound.

Site	C'way	Vegetation Community Type	Date of hydromulch	12 month inspection	12 month criteria met to date	As at August 2019 comments
Fill 13A		Native Grasses	Feb-17	Feb-18	N	Convert to a pasture grass mix. Outside influences (farming) will dominate outcomes. NCR raised to change to pasture grass. Would meet 12-month criteria for pasture grass.
Fill 13B		Native Grasses	Feb-17	Feb-18	N	Convert to a pasture grass mix. Outside influences (farming) will dominate outcomes. NCR raised to change to pasture grass. Would meet 12-month criteria for pasture grass.
Fill 13C		Pasture Grasses	Jul-16	Jul-17	Y	Met in 2018/2019 monitoring. Weeds controlled to promote dominance of native species.
Cut 9	NB	Frangible Shrubs	Sep-15	Sep-16	Y	Met in 2018/2019 monitoring. Has improved and now meets requirements.
Fill 11	NB	Native Grasses	Feb-17	Feb-18	N	Convert to a pasture grass mix. Outside influences (farming) will dominate outcomes. NCR raised to change to pasture grass. Would meet 12-month criteria for pasture grass.
Fill 11	median	Native Grasses	Feb-17	Feb-18	N	Convert to a pasture grass mix. Outside influences (farming) will dominate outcomes. NCR raised to change to pasture grass. Would meet 12-month criteria for pasture grass.
Fill 11	SB	Native Grasses	Feb-17	Feb-18	N	Convert to a pasture grass mix. Outside influences (farming) will dominate outcomes. NCR raised to change to pasture grass. Would meet 12-month criteria for pasture grass.
Fill 6	SB	Native Grasses	Aug-16	Aug-17	N	Convert to a pasture grass mix. Outside influences (farming) will dominate outcomes. NCR raised to change to pasture grass. Would meet 12-month criteria for pasture grass.
Fill 1	NB	Frangible Shrubs	Mar-16	Mar-17	Y	Met in 2018/2019 monitoring. Weeds controlled to promote dominance of native species.
Blackmans Point Road	Blackmans Point Road	Frangible Shrubs/Native Grasses	Apr-16	Apr-17	Y	Met in 2016/2017 monitoring
Cut 11	NB	Frangible Shrubs	Nov-15	Nov-16	Y	Met in 2016/2017 monitoring
Cut 12	NB	Tall shrubs/Frangible Shrubs	Nov-15	Nov-16	Y	Met in 2016/2017 monitoring
Cut 24	SB	Tall shrubs/Frangible Shrubs	Sep-15	Sep-16	Y	Met in 2016/2017 monitoring
Cut 2A	NB	Tall Shrubs	Feb-16	Feb-17	Y	Met in 2016/2017 monitoring
Cut 2B	NB	Tall Shrubs	Feb-16	Feb-17	Y	Met in 2016/2017 monitoring

Site	C'way	Vegetation Community Type	Date of hydromulch	12 month inspection	12 month criteria met to date	As at August 2019 comments
Cut 5	NB	Tall shrubs/Frangible Shrubs	Sep-15	Sep-16	Y	Met in 2016/2017 monitoring
Cut 7	NB	Frangible Shrubs	Jul-15	Jul-16	Y	Met in 2016/2017 monitoring
Cut 7	SB	Frangible Shrubs	Jul-15	Jul-16	Y	Met in 2016/2017 monitoring
Cut 8	NB	Tall shrubs/Frangible Shrubs	Jul-15	Jul-16	Y	Met in 2016/2017 monitoring
Cut 8	SB	Tall shrubs/Frangible Shrubs	Jul-15	Jul-16	Y	Met in 2016/2017 monitoring
Cut 9	SB	Frangible Shrubs	Sep-15	Sep-16	Y	Met in 2016/2017 monitoring
Fill 12	NB	Frangible Shrubs	Nov-15	Nov-16	Y	Met in 2016/2017 monitoring
Fill 12	SB	Frangible Shrubs	Nov-15	Nov-16	Y	Met in 2016/2017 monitoring
Fill 23	SB	Frangible Shrubs	Jun-15	Jun-16	Y	Met in 2016/2017 monitoring
Fill 3	NB	Native Grasses	May-16	May-17	Y	Met in 2016/2017 monitoring
Fill 4	NB	Native Grasses	Jul-16	Jul-17	Y	Met in 2016/2017 monitoring
Fill 6	NB	Frangible Shrubs/Native Grasses	Jul-15	Jul-16	Y	Met in 2016/2017 monitoring
Fill 7	NB	Frangible Shrubs/Native Grasses	Jul-15	Jul-16	Y	Met in 2016/2017 monitoring
Fill 24	SB	Frangible Shrubs	Sep-15	Sep-16	Y	Met in 2016/2017 monitoring
Blackmans Point Interchange	East	Frangible Shrubs	Sep-15	Sep-16	Y	Met in 2017/2018 monitoring
Cut 1	NB	Tall Shrubs	Mar-16	Mar-17	Y	Met in 2017/2018 monitoring
Cut 10	NB	Native Grasses	Nov-15	Nov-16	Y	Met in 2017/2018 monitoring
Cut 11	SB	Tall shrubs/Frangible Shrubs	Sep-15	Sep-16	Y	Met in 2017/2018 monitoring
Cut 12	SB	Frangible Shrubs	Oct-16	Oct-17	Y	Met in 2017/2018 monitoring
Cut 13	NB	Frangible Shrubs	Sep-15	Sep-16	Y	Met in 2017/2018 monitoring
Cut 14	NB	Frangible Shrubs	Jan-17	Jan-18	Y	Met in 2017/2018 monitoring
Cut 14	SB	Frangible Shrubs	Jan-17	Jan-18	Y	Met in 2017/2018 monitoring
Cut 15	NB	Frangible Shrubs	Jan-17	Jan-18	Y	Met in 2017/2018 monitoring
Cut 15	SB	Frangible Shrubs	Jan-17	Jan-18	Y	Met in 2017/2018 monitoring
Cut 16	NB	Frangible Shrubs	Jan-17	Jan-18	Y	Met in 2017/2018 monitoring

Site	C'way	Vegetation Community Type	Date of hydromulch	12 month inspection	12 month criteria met to date	As at August 2019 comments
Cut 17	NB	Frangible Shrubs	Jan-17	Jan-18	Y	Met in 2017/2018 monitoring
Cut 20	NB	Tall Shrubs	Dec-15	Dec-16	Y	Met in 2017/2018 monitoring
Cut 21	NB	Tall Shrubs	Dec-15	Dec-16	Y	Met in 2017/2018 monitoring
Cut 22	NB	Tall Shrubs	Feb-17	Feb-18	Y	Met in 2017/2018 monitoring
Cut 23	NB	Tall Shrubs	Feb-17	Feb-18	Y	Met in 2017/2018 monitoring
Cut 23	SB	Frangible Shrubs	Feb-17	Feb-18	Y	Met in 2017/2018 monitoring
Cut 3	NB	Frangible Shrubs/Native Grasses	Jan-17	Jan-18	Y	Met in 2017/2018 monitoring
Cut 3	SB	Frangible Shrubs/Native Grasses	May-17	May-18	Y	Met in 2017/2018 monitoring
Cut19B	NB	Tall Shrubs	Oct-16	Oct-17	Y	Met in 2017/2018 monitoring
Fill 10	SB	Tall shrubs/Native Grasses	Dec-15	Dec-16	Y	Met in 2017/2018 monitoring
Fill 14	NB	Frangible Shrubs/Native Grasses	Apr-17	Apr-18	Y	Met in 2017/2018 monitoring
Fill 14	SB	Frangible Shrubs/Native Grasses	Apr-17	Apr-18	Y	Met in 2017/2018 monitoring
Fill 16	NB	Frangible Shrubs	Sep-15	Sep-16	Y	Met in 2017/2018 monitoring
Fill 19	NB	Tall Shrubs	Jan-17	Jan-18	Y	Met in 2017/2018 monitoring
Fill 2	NB	Tall Shrubs	Oct-16	Oct-17	Y	Met in 2017/2018 monitoring
Fill 20	NB	Tall Shrubs	Jan-17	Jan-18	Y	Met in 2017/2018 monitoring
Fill 22	NB	Tall Shrubs	Oct-16	Oct-17	Y	Met in 2017/2018 monitoring
Fill 23	NB	Frangible Shrubs	Jun-15	Jun-16	Y	Met in 2017/2018 monitoring
Fill 7	SB	Frangible Shrubs/Native Grasses	Jul-15	Jul-16	Y	Met in 2017/2018 monitoring
Haydons Wharf Interchange	East Inside	Frangible Shrubs	Jan-17	Jan-18	Y	Met in 2017/2018 monitoring
Cut 24	NB	Tall shrubs/Frangible Shrubs	Sep-15	Sep-16	Y	Met in 2017/2018 monitoring
Fill 5A	SB	Frangible Shrubs/Native Grasses	Jul-17	Jul-18	Y	Met in 2018/2019 monitoring. Weeds controlled to promote dominance of native species.
Cut 18	NB	Frangible Shrubs/Native Grasses	May-16	May-17	Y	Met in 2018/2019 monitoring. Weeds controlled to promote dominance of native species.
Cut 19A	NB	Frangible Shrubs	Dec-15	Dec-16	Y	Met in 2018/2019 monitoring. Weeds controlled to promote dominance of native species.
Fill 17	NB	Tall shrubs/Native Grasses	Jan-17	Jan-18	Y	Met in 2018/2019 monitoring. Weeds controlled to promote dominance of native species.



Site	C'way	Vegetation Community Type	Date of hydromulch	12 month inspection	12 month criteria met to date	As at August 2019 comments
Fill 18	NB	Tall Shrubs	Feb-17	Feb-18	Y	Met in 2018/2019 monitoring. Weeds controlled to promote dominance of native species.
Blackmans Point Interchange	West	Tall Shrubs	Dec-17	Dec-18	Y	Met in 2018/2019 monitoring
Cut 11	Centre	Tall shrubs/Frangible Shrubs	Sep-17	Sep-18	Y	Met in 2018/2019 monitoring
Cut 2	SB	Tall Shrubs	Nov-17	Nov-18	Y	Met in 2018/2019 monitoring. Weeds controlled to promote dominance of native species.
Cut 4	SB	Frangible shrubs	Oct-17	Oct-18	Y	Met in 2018/2019 monitoring. Weeds controlled to promote dominance of native species.
Cut 4	NB	Frangible Shrubs/Native Grasses	Oct-17	Oct-18	Y	Met in 2018/2019 monitoring. Weeds controlled to promote dominance of native species.
Cut 5	SB	Frangible Shrubs/Native Grasses	Oct-17	Oct-18	Y	Met in 2018/2019 monitoring
Cut 5	Service Road	Frangible Shrubs/Tall shrubs/Native Grasses	Oct-17	Oct-18	Y	Met in 2018/2019 monitoring. Weeds controlled to promote dominance of native species.
Cut 6	NB	Native Grasses	Nov-17	Nov-18	N	Convert to a pasture grass mix. Outside influences (farming) will dominate outcomes. NCR raised to change to pasture grass. Would meet 12-month criteria for pasture grass.
Cut 6	SB	Native Grasses	Nov-17	Nov-18	N	Convert to a pasture grass mix. Outside influences (farming) will dominate outcomes. NCR raised to change to pasture grass. Would meet 12-month criteria for pasture grass.
Fill 1	SB	Native Grasses/ frangible shrubs	Nov-17	Nov-18	Y	Met in 2018/2019 monitoring. Weeds controlled to promote dominance of native species.
Fill 10	NB	Native Grasses	Nov-17	Nov-18	N	NCR pending for conversion of native grasses to Frangible Shrubs.
Fill 13D		Pasture Grasses	Nov-17	Nov-18	Y	Met in 2018/2019 monitoring
Fill 13E	NB	Tall Shrubs	Sep-17	Sep-18	Y	Met in 2018/2019 monitoring
Fill 13E	SB	Tall Shrubs	Nov-17	Nov-18	Y	Met in 2018/2019 monitoring
Fill 13F		Tall shrubs/Frangible Shrubs	Nov-17	Nov-18	Y	Met in 2018/2019 monitoring
Fill 15	NB	Frangible Shrubs	Nov-17	Nov-18	Y	Met in 2018/2019 monitoring
Fill 15	SB	Frangible Shrubs	Nov-17	Nov-18	Y	Met in 2018/2019 monitoring
Fill 2	SB	Tall Shrubs	Nov-17	Nov-18	Y	Met in 2018/2019 monitoring. Weeds controlled to promote dominance of native species.
Fill 3	SB	Frangible shrubs/ tall shrubs	Oct-17	Oct-18	Y	Met in 2018/2019 monitoring
Fill 4	SB	Tall shrubs	Oct-17	Oct-18	Y	Met in 2018/2019 monitoring
Fill 5A	NB	Frangible Shrubs/Native Grasses	Oct-17	Oct-18	Y	Met in 2018/2019 monitoring
Fill 5A	Service Road	Frangible Shrubs/Native Grasses	Oct-17	Oct-18	Y	Met in 2018/2019 monitoring

Site	C'way	Vegetation Community Type	Date of hydromulch	12 month inspection	12 month criteria met to date	As at August 2019 comments
Fill 5B	NB	Frangible Shrubs/Native Grasses	Nov-17	Nov-18	Y	Met in 2018/2019 monitoring
Fill 5B	SB	Frangible Shrubs/Native Grasses	Oct-17	Oct-18	Y	Met in 2018/2019 monitoring
Fill 5B	Service Road	Frangible Shrubs/Native Grasses	Nov-17	Nov-18	Y	Met in 2018/2019 monitoring
Fill 5C	NB	Pasture Grasses	Nov-17	Nov-18	Y	Met in 2018/2019 monitoring
Fill 5C	SB	Pasture Grasses	Nov-17	Nov-18	Y	Met in 2018/2019 monitoring
Fill 5D	NB	Pasture Grasses	Nov-17	Nov-18	Y	Met in 2018/2019 monitoring
Fill 5D	SB	Pasture Grasses	Nov-17	Nov-18	Y	Met in 2018/2019 monitoring
Fill 5E	NB	Pasture Grasses	Sep-17	Sep-18	Y	Met in 2018/2019 monitoring
Fill 5E	SB	Pasture Grasses	Sep-17	Sep-18	Y	Met in 2018/2019 monitoring
Fill 9	NB	Tall Shrubs	Nov-17	Nov-18	Y	Met in 2018/2019 monitoring. Weeds controlled to promote dominance of native species.
Fill 9	SB	Tall Shrubs	Nov-17	Nov-18	Y	Met in 2018/2019 monitoring. Weeds controlled to promote dominance of native species.
Workshop site	NB	Tall Shrubs	Nov-17	Nov-18	N	Surplus RMS land to be sold. Potential change of landuse and revegetation type.
Yarrabee NB island	NB	Frangible Shrubs	Sep-17	Sep-18	Y	Met in 2018/2019 monitoring

### **Native seeding data Ku2K**

Refined data provided by Roads and Maritime (extracted by Roads and Maritime from data collected by Roads and Maritime). Sites that have met the minimum 12 month criteria in the current or in previous monitoring periods are highlighted. C'way = carriageway, NB = northbound, SB = southbound.

Cut/Fill	C'way	Bench	Hydroseed/ hydromulch Date	12 month inspection	12 month criteria met	As at August 2019 comments
Cut 2	NB		Dec-16	Dec-17	N	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.
Fill 4	NB		Jul-17	Jul-18	Y	Met in 2018/2019 monitoring period. Accepted as compliant at commencement of Landscape Maintenance Period November 2018.
Site 12	NB		May-17	May-18	Y	Met in 2018/2019 monitoring period. Accepted as compliant at commencement of Landscape Maintenance Period November 2018.
Fill 5	NB		Mar-17	Mar-18	Y	Met in 2018/2019 monitoring period. Accepted as compliant at commencement of Landscape Maintenance Period November 2018.
Fill 8	NB		Jan-17	Jan-18	Y	Met in 2018/2019 monitoring period. Accepted as compliant at commencement of Landscape Maintenance Period November 2018.
Cut 8	NB	sth Upper Smiths	Dec-16	Dec-17	N	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.
Site 26A+B	NB		Jul-17	Jul-18	Y	Met in 2018/2019 monitoring period. Accepted as compliant at commencement of Landscape Maintenance Period November 2018.
Fill 9	NB		Nov-16	Nov-17	Y	Met in 2018/2019 monitoring period. Accepted as compliant at commencement of Landscape Maintenance Period November 2018.
Fill 15	NB		May-17	May-18	Y	Met in 2018/2019 monitoring period. Accepted as compliant at commencement of Landscape Maintenance Period November 2018.
Fill 19	NB		Dec-16	Dec-17	Y	Met in 2018/2019 monitoring period. Accepted as compliant at commencement of Landscape Maintenance Period November 2018.
Cut 19	SB		Aug-16	Aug-17	N	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.
Cut 19	NB		Sep-16	Sep-17	N	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.
Cut 20	SB	Bottom	Aug-16	Aug-17	N	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.
Cut 20	NB		Sep-16	Sep-17	N	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.
Cut 22A	NB		Apr-17	Apr-18	N	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.
Cut 22B	NB		Mar-17	Mar-18	N	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.
Cut 23	NB		Mar-17	Mar-18	N	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.
Fill 7	NB		Mar-17	Mar-18	Y	Met in 2018/2019 monitoring period. Accepted as compliant at commencement of Landscape Maintenance Period November 2018.
Fill 16	NB		May-17	May-18	Y	Met in 2018/2019 monitoring period. Accepted as compliant at commencement of Landscape Maintenance Period November 2018.
Cut 10	NB		Feb-16	Feb-17	Y	Met in 2018/2019 monitoring period. Accepted as compliant at commencement of Landscape Maintenance Period November 2018.
Site 2	NB	Material Reuse Site No 2	Feb-16	Feb-17	Y	Met in 2018/2019 monitoring period. Accepted as compliant at commencement of Landscape Maintenance Period November 2018.
Fill 11	SB		Nov-15	Nov-16	Y	Met in 2018/2019 monitoring period. Accepted as compliant at commencement of Landscape Maintenance Period November 2018.

Cut/Fill	C'way	Bench	Hydroseed/ hydromulch Date	12 month inspection	12 month criteria met	As at August 2019 comments
Fill 11	NB		Nov-15	Nov-16	Y	Met in 2018/2019 monitoring period. Accepted as compliant at commencement of Landscape Maintenance Period November 2018.
Fill 16	SB		Apr-16	Apr-17	Y	Met in 2018/2019 monitoring period. Accepted as compliant at commencement of Landscape Maintenance Period November 2018.
Fill 17	NB		May-16	May-17	Y	Met in 2018/2019 monitoring period. Accepted as compliant at commencement of Landscape Maintenance Period November 2018.
Fill 18	NB		Nov-15	Nov-16	Y	Met in 2018/2019 monitoring period. Accepted as compliant at commencement of Landscape Maintenance Period November 2018.
Cut 18	SB		Sep-15	Sep-16	N	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.
Cut 18	NB		Sep-15	Sep-16	N	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.
Cut 21	NB		Dec-15	Dec-16	N	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.
Fill 1	NB		Aug-17	Aug-18	Y	Met in 2018/2019 monitoring period. Accepted as compliant at commencement of Landscape Maintenance Period November 2018.
Cut 3	NB	Bottom	Sep-15	Sep-16	Y	Met in 2016/2017 monitoring
Cut 3	NB	Top	Sep-15	Sep-16	Y	Met in 2017/2018 monitoring
Cut 3	SB	rest area median	Jun-16	Jun-17	Y	Met in 2016/2017 monitoring
Fill 4	SB		Jul-15	Jul-16	Y	Met in 2017/2018 monitoring
Fill 4	SB	Nth Mingaletta	Sep-15	Sep-16	Y	Met in 2016/2017 monitoring
Fill 5	SB	Drainage	Sep-15	Sep-16	Y	Met in 2016/2017 monitoring
Fill 5	SB		Sep-15	Sep-16	Y	Met in 2017/2018 monitoring
Cut 5	SB		Jul-15	Jul-16	Y	Met in 2016/2017 monitoring
Fill 6	SB		Sep-15	Sep-16	Y	Met in 2017/2018 monitoring
Cut 6	SB		Jul-15	Jul-16	Y	Met in 2016/2017 monitoring
Fill 7	SB		Oct-15	Oct-16	Y	Met in 2017/2018 monitoring
Cut 7	SB		Sep-15	Sep-16	Y	Met in 2017/2018 monitoring
Fill 8	SB		Oct-15	Oct-16	Y	Met in 2017/2018 monitoring
Cut 8	SB		Oct-15	Oct-16	Y	Met in 2016/2017 monitoring
Fill 9	SB	drainage	Aug-15	Aug-16	Y	Met in 2017/2018 monitoring
Fill 9	SB		Jan-16	Jan-17	Y	Met in 2017/2018 monitoring
Fill 10	SB		Apr-16	Apr-17	Y	Met in 2017/2018 monitoring

Cut/Fill	C'way	Bench	Hydroseed/ hydromulch Date	12 month inspection	12 month criteria met	As at August 2019 comments
Fill 10	NB	Smiths Creek to C28.68	Jan-16	Jan-17	Y	Met in 2017/2018 monitoring
Cut 10	SB		Feb-16	Feb-17	Y	Met in 2017/2018 monitoring
Site 16	SB	Material Reuse Site No 16	Apr-16	Apr-17	Y	Met in 2016/2017 monitoring
Cut 11	SB		Sep-15	Sep-16	Y	Met in 2016/2017 monitoring
Fill 12	SB		Oct-15	Oct-16	Y	Met in 2016/2017 monitoring
Cut 12	SB		Oct-15	Oct-16	Y	Met in 2017/2018 monitoring
Fill 13	SB		Sep-15	Sep-16	Y	Met in 2017/2018 monitoring
Cut 13	SB		Oct-15	Oct-16	Y	Met in 2017/2018 monitoring
Fill 14	SB		Mar-16	Mar-17	Y	Met in 2016/2017 monitoring
Cut 14	SB		Mar-16	Mar-17	Y	Met in 2016/2017 monitoring
Fill 15	SB		Mar-16	Mar-17	Y	Met in 2016/2017 monitoring
Cut 15	SB		Jan-16	Jan-17	Y	Met in 2016/2017 monitoring
Cut 16	SB		Mar-16	Mar-17	Y	Met in 2017/2018 monitoring
Cut 17	SB		Dec-15	Dec-16	Y	Met in 2017/2018 monitoring
Fill 18	SB		Jun-16	Jun-17	Y	Met in 2017/2018 monitoring
Fill 20	SB		Sep-15	Sep-16	Y	Met in 2017/2018 monitoring
Fill 20	NB		Sep-15	Sep-16	Y	Met in 2016/2017 monitoring
Cut 20	SB	Top	Sep-15	Sep-16	Y	Met in 2017/2018 monitoring
Cut 20	SB	Middle	Dec-15	Dec-16	Y	Met in 2017/2018 monitoring
Fill 21	SB		Mar-16	Mar-17	Y	Met in 2017/2018 monitoring
Fill 21	NB		Apr-16	Apr-17	Y	Met in 2017/2018 monitoring
Cut 21	SB		Dec-15	Dec-16	Y	Met in 2016/2017 monitoring
Fill 22	SB		Apr-16	Apr-17	Y	Met in 2017/2018 monitoring
Fill 22	NB		Nov-15	Nov-16	Y	Met in 2017/2018 monitoring
Fill 23	SB		Apr-16	Apr-17	Y	Met in 2017/2018 monitoring

Cut/Fill	C'way	Bench	Hydroseed/ hydromulch Date	12 month inspection	12 month criteria met	As at August 2019 comments
Fill 23	NB		Aug-17	Aug-18	Y	Met in 2016/2017 monitoring
Cut 3	SB		Sep-16	Sep-17	Y	Met in 2017/2018 monitoring
Site 10	SB		Oct-16	Oct-17	Y	Met in 2017/2018 monitoring
Site 5B	SB		Oct-16	Oct-17	Y	Met in 2017/2018 monitoring
Fill 19	SB		Dec-16	Dec-17	Y	Met in 2017/2018 monitoring
Fill 1	SB		Aug-15	Aug-16	Y	Met in 2017/2018 monitoring
Fill 2	SB		Aug-15	Aug-16	Y	Met in 2017/2018 monitoring
Fill 6	NB		Mar-17	Mar-18	Y	Met in 2017/2018 monitoring
Cut 10	NB	Off ramp drain	Aug-16	Aug-17	Y	Met in 2017/2018 monitoring
Fill 14	NB		May-17	May-18	Y	Met in 2017/2018 monitoring
Fill 10	NB	C28.68 to off ramp drain	Apr-17	Apr-18	Y	Met in 2017/2018 monitoring
Cut 8	NB		Aug-17	Aug-18	N	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.
Fill 12	NB		Aug-17	Aug-18	Y	Met in 2018/2019 monitoring period. Accepted as compliant at commencement of Landscape Maintenance Period November 2018.
Cut 15	NB		Sep-18	Sep-19	N	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.
Cut 16	NB		Sep-18	Sep-19	N	Acceptable variety and quantity of native species but weak growth in poor conditions and very poor ground cover after several respray efforts.

### **Native planting data OH2Ku**

Refined data provided by Roads and Maritime (extracted by Roads and Maritime from data collected by Lendlease).

Sites that have met the minimum 12 month criteria are highlighted.

<b>Bed ID</b>	<b>Planting date</b>	<b>12 month review due</b>	<b>Compliance (Y/N)</b>	<b>Inspection date</b>	<b>Observation &amp; action required</b>	<b>Action undertaken</b>	<b>Action date</b>
1a	24/10/2017	Oct-18	Y	Oct-18		N/A	
1b	24/10/2017	Oct-18	Y	Oct-18		N/A	
2	21/09/2016	Sep-17	Y	13/10/2017	Replace dead trees	Dead trees replaced	Nov-17
3	21/09/2016	Sep-17	Y	13/10/2017	Ok	N/A	
4	25/10/2017	Oct-18	Y	Oct-18	Ok	N/A	
5	25/10/2017	Oct-18	Y	Oct-18	Ok	N/A	
6	21/09/2016	Sep-17	Y	13/10/2017	Ok	N/A	
7	21/09/2016	Sep-17	Y	13/10/2017	Ok	N/A	
8	25/10/2016	Oct-17	Y	06/11/2017	Trees moved	N/A	
9	21/09/2016	Sep-17	Y	13/10/2017	Ok	N/A	
10	21/09/2016	Sep-17	Y	13/10/2017	Ok	N/A	
11	20/09/2016	Sep-17	Y	13/10/2017	Treat diseased tree species	Trees sprayed	Nov-17
12	20/09/2016	Sep-17	Y	13/10/2017	Treat diseased tree species	Trees sprayed	Nov-17
13	25/10/2017	Oct-18	Y	Oct-18		N/A	
14	25/10/2017	Oct-18	Y	Oct-18	Ok	N/A	
15	25/10/2017	Oct-18	Y	Oct-18	Ok	N/A	
16	21/09/2016	Sep-17	Y	13/10/2017	Replace dead trees	Dead trees replaced	Nov-17
17	21/09/2016	Sep-17	Y	13/10/2017	Ok	N/A	
18	25/10/2017	Oct-18	Y	Oct-18	Ok	N/A	
19	21/09/2016	Sep-17	Y	13/10/2017	Ok	N/A	
20	21/09/2016	Sep-17	Y	13/10/2017	Ok	N/A	
21	21/09/2016	Sep-17	Y	13/10/2017	Ok	N/A	
22	20/10/2016	Oct-17	Y	13/10/2017	Ok	N/A	
23	25/10/2017	Oct-18	Y	Oct-18	Ok	N/A	
24	25/10/2017	Oct-18	Y	Oct-18	Ok	N/A	
25	20/10/2016	Oct-17	Y	13/10/2017	Replace dead trees	Dead trees replaced	Nov-17
26	20/10/2016	Oct-17	Y	13/10/2017	Ok	N/A	
27	20/10/2016	Oct-17	Y	13/10/2017	Ok	N/A	
28	20/10/2016	Oct-17	Y	13/10/2017		N/A	
29	20/10/2016	Oct-17	Y	13/10/2017	Replace dead trees	Dead trees replaced	Nov-17
30	20/10/2016	Oct-17	Y	13/10/2017	Ok	N/A	
31	30/04/2018	Apr-19	N	07/06/2019	Pocket plantings in scour rock have died. Investigate methodologies for replacing dead plants.		
32	30/04/2018	Apr-19	Deleted	07/06/2019	Deleted due to proximity of fauna fence and power lines. No action required.	N/A	
33	30/04/2018	Apr-19	Y	07/06/2019		N/A	
34	21/10/2016	Oct-17	Y	13/10/2017	Ok	N/A	
35	21/10/2016	Oct-17	Y	13/10/2017	Ok	N/A	
36	21/10/2016	Oct-17	Y	13/10/2017	Ok	N/A	

Bed ID	Planting date	12 month review due	Compliance (Y/N)	Inspection date	Observation & action required	Action undertaken	Action date
37A	01/10/2017	Oct-18	Y	Oct-18	Ok	N/A	
37B	01/10/2017	Oct-18	Y	Oct-18	Ok	N/A	
38	01/10/2017	Oct-18	Y	Oct-18	Ok	N/A	
39	21/10/2016	Oct-17	Y	13/10/2017	Ok	N/A	
42	21/11/2017	Nov-18	Y	Nov-18	Ok	N/A	
43	21/11/2017	Nov-18	Y	Nov-18	Ok	N/A	
44			Deleted	06/11/2017	Moved to LM02	N/A	
45			Deleted	06/11/2017	Moved to LM02	N/A	
46	21/10/2016	Oct-17	Y	13/10/2017	Ok	N/A	
47	21/10/2016	Oct-17	Y	13/10/2017	Ok	N/A	
50			Deleted	06/11/2017	Trees banked	N/A	
51			Deleted	06/11/2017	Moved to LM02	N/A	
52	21/11/2017	Nov-18	Y	Nov-18	Ok	N/A	
53	21/11/2017	Nov-18	Y	Nov-18	Ok	N/A	
54	21/11/2017	Nov-18	Y	Nov-18	Ok	N/A	
56	21/11/2017	Nov-18	Y	Nov-18		N/A	
57A	01/10/2017	Oct-18	Y	Oct-18		N/A	
57B	01/10/2017	Oct-18	Y	Oct-18	Ok	N/A	
58	01/10/2017	Oct-18	Y	Oct-18	Not planted due to natural regrowth	N/A	
59	01/10/2017	Oct-18	Y	Oct-18	Ok	N/A	
60	01/10/2017	Oct-18	Y	Oct-18	Ok	N/A	
61			Deleted	06/11/2017	Deleted due to adequate natural revegetation.	N/A	
62			Deleted	06/11/2017	Trees banked	N/A	
63	21/10/2016	Oct-17	Y	13/10/2017	Ok	N/A	
65	21/10/2016	Oct-17	Y	13/10/2017	Ok	N/A	
68			Deleted	06/11/2017	Trees banked	N/A	
69			Deleted		Trees banked	N/A	
70			Deleted		Trees banked	N/A	
71			Deleted		Trees banked	N/A	
72			Deleted		Trees banked	N/A	
73	01/04/2018	Apr-19	N	07/06/2019	Plantings not present. Investigate 29 additional paperbark plantings.		
74	01/04/2018	Apr-19	Y	07/06/2019		N/A	
75			Deleted		Trees banked	N/A	
76			Deleted		Moved to Bed 27A, 69A, 181A	N/A	
77			Deleted		Moved to Bed 27A, 69A, 181A	N/A	
78			Deleted		Not planted	N/A	
79			Deleted		Moved to Bed 27A, 69A, 181A	N/A	
80			Deleted		Not planted	N/A	
81			Deleted		Moved to Bed 27A, 69A, 181A	N/A	
82			Deleted		Moved to Bed 27A, 69A, 181A	N/A	



Bed ID	Planting date	12 month review due	Compliance (Y/N)	Inspection date	Observation & action required	Action undertaken	Action date
83			Deleted		Moved to Bed 27A, 69A, 181A	N/A	
84			Deleted		Moved to Bed 27A, 69A, 181A	N/A	
85			Deleted		Deleted due to drainage redesign	N/A	
86			Deleted		Deleted due to drainage redesign	N/A	
87	01/11/2017	Nov-18	Y	Nov-18		N/A	
88	01/11/2017	Nov-18	Y	Nov-18		N/A	
89	03/11/2017	Nov-18	Y	Nov-18		N/A	
90	01/11/2017	Nov-18	Y	Nov-18		N/A	
91	01/11/2017	Nov-18	Y	Nov-18		N/A	
92	01/11/2017	Nov-18	Y	Nov-18		N/A	
93	01/11/2017	Nov-18	Y	Nov-18		N/A	
94	22/09/2017	Sep-18	Y	Sep-18		N/A	
95	22/09/2017	Sep-18	Y	Sep-18		N/A	
95A	01/05/2018	May-19	Y	07/06/2019	Area agreed to be compliant.	N/A	
96	22/09/2017	Sep-18	Y	Sep-18		N/A	
97	22/09/2017	Sep-18	Y	Sep-18		N/A	
98	22/09/2017	Sep-18	Y	Sep-18		N/A	
99	22/09/2017	Sep-18	Y	Sep-18		N/A	
100	22/09/2017	Sep-18	Y	Sep-18		N/A	
101	22/09/2017	Sep-18	Y	Sep-18		N/A	
102	22/09/2017	Sep-18	Y	Sep-18		N/A	
103	22/09/2017	Sep-18	Y	Sep-18		N/A	
104	22/09/2017	Sep-18	Y	Sep-18		N/A	
105	22/09/2017	Sep-18	Y	Sep-18		N/A	
106	22/09/2017	Sep-18	Y	Sep-18		N/A	
107	01/11/2017	Nov-18	Y	Nov-18		N/A	
108	22/09/2017	Sep-18	Y	Sep-18		N/A	
109	22/09/2017	Sep-18	Y	Sep-18		N/A	
110	22/09/2017	Sep-18	Y	Sep-18		N/A	
111	22/09/2017	Sep-18	Y	Sep-18		N/A	
112	22/09/2017	Sep-18	Y	Sep-18		N/A	
113	22/09/2017	Sep-18	Y	Sep-18		N/A	
114	22/09/2017	Sep-18	Y	Sep-18	Replace dead trees	Dead trees replaced	Nov-17
115	22/09/2017	Sep-18	Y	Sep-18		N/A	
116	22/09/2017	Sep-18	Y	Sep-18		N/A	
117	01/11/2017	Nov-18	Y	Nov-18		N/A	
118	01/11/2017	Nov-18	Y	Nov-18		N/A	
119	22/09/2017	Sep-18	Y	Sep-18		N/A	
120	15/09/2016	Sep-17	Y	13/10/2017	Replace dead trees	Dead trees replaced	Nov-17
120B	15/09/2016	Sep-17	Y	13/10/2017		N/A	
121	15/09/2016	Sep-17	Y	13/10/2017	Ok	N/A	

Bed ID	Planting date	12 month review due	Compliance (Y/N)	Inspection date	Observation & action required	Action undertaken	Action date
122	15/09/2016	Sep-17	Y	13/10/2017	Ok	N/A	
123	15/09/2016	Sep-17	Y	13/10/2017	Replace dead trees	Dead trees replaced	Nov-17
125	01/05/2018	May-19	Y	07/06/2019	Area agreed to be compliant.	N/A	
126	01/11/2017	Nov-18	Y	Nov-18		N/A	
127	21/09/2016	Sep-17	Y	Sep-17		N/A	
128	01/11/2017	Nov-18	Y	Nov-18		N/A	
129	01/11/2017	Nov-18	Y	Nov-18		N/A	
130	01/11/2017	Nov-18	Y	Nov-18		N/A	
131	15/09/2016	Sep-17	Y	13/10/2017	Ok	N/A	
132	21/09/2016	Sep-17	Y	13/10/2017	Ok	N/A	
133	15/09/2016	Sep-17	Y	13/10/2017	Replace dead trees	Dead trees replaced	Nov-17
134	15/09/2017	Sep-18	Y	Sep-18	Ok	N/A	
134B	15/09/2017	Sep-18	Y	Sep-18	Ok	N/A	
135	22/09/2017	Sep-18	Y	Sep-18	Ok	N/A	
136	20/09/2016	Sep-17	Y	13/10/2017	Ok	N/A	
137	01/05/2018	May-19	Y	07/06/2019	N/A	N/A	
138	01/05/2018	May-19	Y	07/06/2019	N/A	N/A	
139	01/05/2018	May-19	Y	07/06/2019	Native regrowth of similar species. Accept as is.	N/A	
140	01/05/2018	May-19	Y	07/06/2019	N/A	N/A	
141	01/11/2017	Nov-18	Y	Nov-18		N/A	
142	01/11/2017	Nov-18	Y	Nov-18		N/A	
143	01/11/2017	Nov-18	Y	Nov-18		N/A	
144	01/11/2017	Nov-18	Y	Nov-18		N/A	
145	14/06/2017	Jun-18	Y	Jun-18	Ok	N/A	
146	01/11/2017	Nov-18	Y	Nov-18		N/A	
147	22/09/2017	Sep-18	Y	Sep-18		N/A	
148	14/06/2017	Jun-18	Y	Jun-18	Ok	N/A	
149	22/09/2017	Sep-18	Y	Sep-18		N/A	
150	14/06/2017	Jun-18	Y	Jun-18	Ok	N/A	
151	14/06/2017	Jun-18	Y	Jun-18	Ok	N/A	
152	14/06/2017	Jun-18	Y	30/08/2018			
153	14/06/2017	Jun-18	Y	Jun-18	Trees planted	Trees replaced	Nov-17
154	01/10/2017	Oct-18	Y	Oct-18		N/A	
155	01/10/2017	Oct-18	Y	Oct-18		N/A	
156			Deleted	23/10/2017	Trees to be banked	N/A	
157			Deleted	23/10/2017	Trees to be banked	N/A	
158	14/06/2017	Jun-18	Y	Jun-18	Ok	N/A	
159	14/06/2017	Jun-18	Y	Jun-18	Ok	N/A	
160	14/06/2017	Jun-18	Y	Jun-18	Ok	N/A	
161	14/06/2017	Jun-18	Y	Jun-18	Ok	N/A	
162	14/06/2017	Jun-18	Y	Jun-18	6 trees to be planted	N/A	

Bed ID	Planting date	12 month review due	Compliance (Y/N)	Inspection date	Observation & action required	Action undertaken	Action date
163	14/06/2017	Jun-18	Y	Jun-18		N/A	
164	14/06/2017	Jun-18	Y	Jun-18	Trees moved to B1098	N/A	
165	14/06/2017	Jun-18	Y	Jun-18		N/A	
166A	14/06/2017	Jun-18	Y	Jun-18	Ok	N/A	
166B	14/06/2017	Jun-18	Y	Jun-18	Ok	N/A	
167	14/06/2017	Jun-18	Y	Jun-18	Ok	N/A	
168	16/06/2017	Jun-18	Y	Jun-18	Ok	N/A	
169	14/06/2017	Jun-18	Y	Jun-18	Ok	N/A	
170	14/06/2017	Jun-18	Y	Jun-18	Ok	N/A	
171	25/09/2017	Sep-18	Y	Sep-18		N/A	
172	25/09/2017	Sep-18	Y	Sep-18		N/A	
173	16/09/2017	Sep-18	Y	Sep-18	Ok	N/A	
174	25/09/2017	Sep-18	Y	Sep-18	Ok	N/A	
175	16/06/2017	Jun-18	Y	Jun-18	More planting undertaken	N/A	
176	16/06/2017	Jun-18	Y	Jun-18	Ok	N/A	
177	25/09/2017	Sep-18	Y	Sep-18	Ok	N/A	
178	16/06/2017	Jun-18	Y	Jun-18	Ok	N/A	
179	16/06/2017	Jun-18	Y	Jun-18	Ok	N/A	
180	25/09/2017	Sep-18	Y	Sep-18	Ok	N/A	
181A	25/09/2017	Sep-18	Y	Sep-18	Plants moved to drainage channel	N/A	
182	25/09/2017	Sep-18	Y	Sep-18	Plants moved to drainage channel	N/A	
183	05/07/2017	Jul-18	Y	Jul-18	Ok	N/A	
184	05/07/2017	Jul-18	Y	Jul-18		N/A	
185	05/07/2017	Jul-18	Y	Jul-18	Moved to Bed 27A, 69A, 181A	N/A	
186	25/09/2017	Sep-18	Y	Sep-18	Ok	N/A	
187	25/09/2017	Sep-18	Y	Sep-18		N/A	
188			Deleted		Moved to Bed 27A, 69A, 181A	N/A	
189			Deleted	23/10/2017	Moved to Bed 27A, 69A, 181A	N/A	
190			Deleted		Moved to Bed 27A, 69A, 181A	N/A	
191			Deleted	23/10/2017	Moved to Bed 27A, 69A, 181A	N/A	
192			Deleted	23/10/2017	Moved	N/A	
193			Deleted	23/10/2017	Moved to Bed 27A, 69A, 181A	N/A	
194	01/11/2017	Nov-18	Y	Nov-18		N/A	
195	25/09/2017	Sep-18	Y	Sep-18	Ok	N/A	
196	25/09/2017	Sep-18	Y	Sep-18		N/A	
196A	01/06/2018	Jun-19	Y	Jun-19	Screen planted on LM27	N/A	
197	25/09/2017	Sep-18	Y	Sep-18	Ok	N/A	
198	25/09/2017	Sep-18	Y	Sep-18		N/A	
199	25/09/2017	Sep-18	Y	Sep-18	Ok	N/A	
200	21/09/2016	Sep-17	Y	23/10/2017	Reduced numbers to 200 per a bed. Ok	N/A	
201	25/09/2017	Sep-18	Y	Sep-18	Ok	N/A	

Bed ID	Planting date	12 month review due	Compliance (Y/N)	Inspection date	Observation & action required	Action undertaken	Action date
202	21/09/2016	Sep-17	Y	23/10/2017	Ok	N/A	
203	25/09/2017	Sep-18	Y	Sep-18	Ok	N/A	
204			Deleted	23/10/2017	Moved - Trees banked	N/A	
205	25/09/2017	Sep-18	Y	Sep-18	Ok	N/A	
206	25/09/2017	Sep-18	Y	Sep-18		N/A	
207	25/09/2017	Sep-18	Y	Sep-18		N/A	
208	25/09/2017	Sep-18	Y	Sep-18		N/A	
209	25/09/2017	Sep-18	Y	Sep-18		N/A	
210	25/09/2017	Sep-18	Y	Sep-18		N/A	
211	25/09/2017	Sep-18	Y	Sep-18		N/A	
212	14/03/2018	Mar-19	Y	28/03/2019	Allocasuarina torulosa (35L) x7	N/A	
213	25/09/2017	Sep-18	Y	Sep-18		N/A	
214	25/09/2017	Sep-18	Y	Sep-18		N/A	
215	14/03/2018	Mar-19	N	07/06/2019	Plantings appear to be absent. Investigate replacement planting.	N/A	
216	14/03/2018	Mar-19	Y	28/03/2019		N/A	
217	14/03/2018	Mar-19	Y	28/03/2019		N/A	
218	14/03/2018	Mar-19	Y	28/03/2019		N/A	
219	14/03/2018	Mar-19	Y	28/03/2019		N/A	
220	14/03/2018	Mar-19	Y	28/03/2019		N/A	
221	14/03/2018	Mar-19	Y	28/03/2019		N/A	
222	14/03/2018	Mar-19	Y	28/03/2019		N/A	
223	14/03/2018	Mar-19	Y	28/03/2019		N/A	
224	14/03/2018	Mar-19	Y	28/03/2019		N/A	
225	16/11/2016	Nov-17	Y	13/10/2017	Replace dead trees	Dead trees replaced	Nov-17
226	16/11/2016	Nov-17	Y	13/10/2017	Replace dead trees	Dead trees replaced	Nov-17
227	16/11/2016	Nov-17	Y	13/10/2017		N/A	
228	16/11/2016	Nov-17	Y	13/10/2017	Ok	N/A	
229	25/09/2017	Sep-18	Y	Sep-18		N/A	
230	25/09/2017	Sep-18	Y	Sep-18		N/A	
231	14/03/2018	Mar-19	Y	28/03/2019		N/A	
232			Deleted		Native regrowth sufficient	N/A	
233			Deleted		Native regrowth sufficient	N/A	
234	02/02/2017	Feb-18	Y	Feb-18		N/A	
235	02/02/2017	Feb-18	Y	Feb-18		N/A	
236	14/03/2018	Mar-19	Y	28/03/2019	Some signs of Aphides and scales	N/A	
237	14/03/2018	Mar-19	Y	28/03/2019	Some signs of Aphides and scales	N/A	
238	14/03/2018	Mar-19	Y	28/03/2019	Some signs of Aphides and scales	N/A	
239	14/03/2018	Mar-19	Y	28/03/2019	Some signs of Aphides and scales	N/A	
240	02/02/2017	Feb-18	Y	Feb-18		N/A	
241	22/02/2017	Feb-18	Y	Feb-18		N/A	

Bed ID	Planting date	12 month review due	Compliance (Y/N)	Inspection date	Observation & action required	Action undertaken	Action date
242	22/02/2017	Feb-18	Y	Feb-18		N/A	
243			Deleted		Native regrowth sufficient	N/A	
244	14/03/2018	Mar-19	Y	28/03/2019		N/A	
245			Deleted		Regrowth sufficient	N/A	
246	02/02/2017	Feb-18	Y	Feb-18		N/A	
247	02/02/2017	Feb-18	Y	Feb-18		N/A	
248	02/02/2017	Feb-18	Y	Feb-18		N/A	
249	02/02/2017	Feb-18	Y	Feb-18		N/A	
250	14/03/2018	Mar-19	Y	28/03/2019		N/A	
251	14/03/2018	Mar-19	Y	28/03/2019		N/A	
252	14/03/2018	Mar-19	Y	28/03/2019		N/A	
253	14/03/2018	Mar-19	Y	28/03/2019		N/A	
254	02/02/2017	Feb-18	Y	Feb-18	Missing trees replaced	N/A	
255	02/02/2017	Feb-18	Y	Feb-18	Ok	N/A	
256	14/03/2018	Mar-19	Y	28/03/2019	Fauna underpass plantings approved as sufficient in consultation with EPA	N/A	
257	03/02/2017	Feb-18	Y	Feb-18	Ok	N/A	
258	03/02/2017	Feb-18	Y	Feb-18	Missing trees replaced	N/A	
259	14/03/2018	Mar-19	Y	28/03/2019	Fauna underpass plantings approved as sufficient in consultation with EPA	N/A	
260	14/03/2018	Mar-19	Y	28/03/2019	Fauna underpass plantings approved as sufficient in consultation with EPA	N/A	
261	03/02/2017	Feb-18	Y	Feb-18	Replace dead trees	Dead trees replaced	Nov-17
262	03/02/2017	Feb-18	Y	Feb-18	Replace dead trees	Dead trees replaced	Nov-17
263	03/02/2017	Feb-18	Y	Feb-18	Replace dead trees	Dead trees replaced	Nov-17
264	03/02/2017	Feb-18	Y	Feb-18	Ok	N/A	
265	03/02/2017	Feb-18	Y	Feb-18	Ok	N/A	
266	14/03/2018	Mar-19	Y	28/03/2019	Fauna underpass plantings approved as sufficient in consultation with EPA	N/A	
267	14/03/2018	Mar-19	Y	28/03/2019	Fauna underpass plantings approved as sufficient in consultation with EPA	N/A	
268	03/02/2017	Feb-18	Y	Feb-18	Ok	N/A	
269	06/02/2017	Feb-18	Y	Feb-18	Replace dead trees	Dead trees replaced	Nov-17
270	14/03/2018	Mar-19	Y	28/03/2019		N/A	
271	06/02/2017	Feb-18	Y	Feb-18		N/A	
272	14/03/2018	Mar-19	Y	28/03/2019	Fauna underpass plantings approved as sufficient in consultation with EPA	N/A	
273	30/04/2018	Apr-19	Y	07/06/2019	None. Casuarinas (from tubestock) are doing well.	N/A	
274	30/04/2018	Apr-19	Y	07/06/2019	None. Casuarinas (from tubestock) are doing well.	N/A	
275	30/04/2018	Apr-19	Y	07/06/2019	None. Casuarinas (from tubestock) are doing well.	N/A	
276	30/04/2018	Apr-19	Y	07/06/2019	None. Casuarinas (from tubestock) are doing well.	N/A	
277	05/07/2017	Jul-18	Y	07/06/2019	None. Casuarinas (from tubestock) are doing well.	N/A	
278	01/05/2018	May-19	Y	07/06/2019	None. Casuarinas (from tubestock) are doing well.	N/A	

Bed ID	Planting date	12 month review due	Compliance (Y/N)	Inspection date	Observation & action required	Action undertaken	Action date
278B	01/05/2018		Y	07/06/2019	None. Casuarinas (from tubestock) are doing well.	N/A	
279	01/05/2018	May-19	Y	07/06/2019	None. Casuarinas (from tubestock) are doing well.	N/A	
280	01/05/2018	May-19	Y	07/06/2019	None. Casuarinas (from tubestock) are doing well.	N/A	
281	01/05/2018	May-19	Y	07/06/2019	None. Casuarinas (from tubestock) are doing well.	N/A	
282	06/02/2017	Feb-18	Y	Feb-18	Replace dead trees	Dead trees replaced	Nov-17
283	14/03/2018	Mar-19	Y		Fauna underpass plantings approved as sufficient in consultation with EPA	N/A	
284	06/02/2017	Feb-18	Y	Feb-18	Replace dead trees	Dead trees replaced	Nov-17
285	27/07/2016	Jul-17	Y	17/10/2017	Ok	N/A	
286	07/02/2017	Feb-18	Y	Feb-18	Replace dead trees	Dead trees replaced	Nov-17
287	07/02/2017	Feb-18	Y	Feb-18	Ok	N/A	
288	27/07/2016	Jul-17	Y	17/10/2017	Ok	N/A	
289		-	Deleted			N/A	
290	27/07/2016	Jul-17	Y	17/10/2017	Ok	N/A	
291	27/07/2016	Jul-17	Y	17/10/2017	Ok	N/A	
292	27/07/2016	Jul-17	Y	17/10/2017	Ok	N/A	
293	27/07/2016	Jul-17	Y	17/10/2017	Ok	N/A	
294	27/07/2016	Jul-17	Y	17/10/2017	Ok	N/A	
295	27/07/2016	Jul-17	Y	17/10/2017	Ok	N/A	
296	27/07/2016	Jul-17	Y	17/10/2017	Ok	N/A	
297	27/07/2016	Jul-17	Y	17/10/2017	Ok	N/A	
298	15/09/2016	Sep-17	Y	13/10/2017	Replace dead trees	Dead trees replaced	Nov-17
299	15/09/2016	Sep-17	Y	13/10/2017	Replace dead trees	Dead trees replaced	Nov-17
300	15/09/2016	Sep-17	Y	13/10/2017	Replace dead trees	Dead trees replaced	Nov-17
301	20/09/2016	Sep-17	Y	17/10/2017	Ok	N/A	
302	01/05/2018	May-19	N	07/06/2019	Pocket plantings in scour rock have died. Investigate methodologies for replacing dead plants.		
303	27/07/2016	Jul-17	Y	17/10/2017	Ok	N/A	
304	01/05/2018	May-19	N	07/06/2019	Pocket plantings in scour rock have died. Investigate methodologies for replacing dead plants.		
305	27/07/2016	Jul-17	Y	17/10/2017	Ok	N/A	
306	27/07/2016	Jul-17	Y	17/10/2017	Ok	N/A	

### Native planting data Ku2K

Refined data provided by Roads and Maritime (extracted by Roads and Maritime from data collected by Roads and Maritime). Sites that have met the minimum 12 month criteria are highlighted. C'way = carriageway, NB = northbound, SB = southbound, Y = yes, N = no.

Identifier	C'way	Chainage	Description	Date planted	12 month inspection	12 month criteria Met	Comments
1	NB	24700	Reallocation of water quality basin tubestock planting	Dec-17	Dec-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
2	NB	24700	Koala feed tree reallocation	Dec-17	Dec-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
3	NB	24900	Rest area tubestock	Dec-17	Dec-18	N	Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018. Reassessment of suitability of some further failed species underway since January 2019.
4	NB	24900	Rest area feature trees	Nov-17	Nov-18	N	Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018. Further replacement of dead trees since January 2019 proposed in spring 2019.
5	NB	25000	Water quality basin	Feb-18	Feb-19	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
6	NB	25100	Rest area effluent irrigation area	Feb-18	Feb-19	Y	Continue to monitor for weeds
7	NB	25200	Glider Crossing	Aug-17	Aug-18	Y	Continue to monitor for weeds
8	NB	25300	Glider Crossing	Aug-17	Aug-18	Y	Continue to monitor for weeds
9	NB	25400	Reallocation of water quality basin tubestock planting	Aug-17	Aug-18	Y	Continue to monitor for weeds
10	NB	25400	Fauna culvert planting	Aug-17	Aug-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
11	NB	25400	Material Reuse Site 12	Aug-17	Aug-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
12	NB	25700	Fauna culvert planting	Aug-17	Aug-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
13	NB	25800	Fauna culvert planting	Aug-17	Aug-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018

Identifier	C'way	Chainage	Description	Date planted	12 month inspection	12 month criteria Met	Comments
14	NB	26400	Fauna culvert planting	Sep-17	Sep-18	Y	Continue to monitor for weeds
15	NB	26700	Tubestock tree planting	Aug-17	Aug-18	Y	Continue to monitor for weeds
16	NB	26800	Fauna culvert planting	Aug-17	Aug-18	Y	Continue to monitor for weeds
17	NB	26900	Tubestock tree planting	Jun-18	Jun-19	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
18	NB	27150	Bus Stop - Upper Smiths Creek Rd	Dec-17	Dec-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
19	NB	27500	Material Reuse Site 26	Dec-17	Dec-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
20	NB	27500	Fauna culvert planting	Dec-17	Dec-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
21	NB	28200	Reallocation of water quality basin tubestock planting	Jul-17	Jul-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
22	NB	28200	Bridge fauna path and creek crossing	Jul-17	Jul-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
23	NB	28300	Bridge fauna path and creek crossing	Jul-17	Jul-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
24	NB	28300	Tubestock tree planting	Jul-17	Jul-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
25	NB	28650	Reallocation of water quality basin tubestock planting	Jul-17	Jul-18	Y	Continue to monitor for weeds
26	NB	28650	Fauna culvert planting	Jul-17	Jul-18	Y	Continue to monitor for weeds
27	NB	29100	Kundabung Interchange feature trees	Apr-17	Apr-18	N	Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018. Further replacement of dead trees since January 2019 proposed in spring 2019.
28	NB	29300	Kundabung Interchange feature trees	Oct-17	Oct-18	N	Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018. Further replacement of dead trees since January 2019 proposed in spring 2019.



Identifier	C'way	Chainage	Description	Date planted	12 month inspection	12 month criteria Met	Comments
29	NB	29600	Tubestock tree planting	Oct-17	Oct-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
30	NB	29650	Bus Stop - Rodeo Dr	Dec-17	Dec-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
31	NB	30100	Fauna culvert planting	Aug-17	Aug-18	Y	Continue to monitor for weeds
32	NB	30600	Headlight screen planting	Sep-17	Sep-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
33	NB	30650	Bridge fauna path and creek crossing	Aug-17	Aug-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
34	NB	30700	Bridge fauna path and creek crossing	Aug-17	Aug-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
35	NB	30800	Headlight screen planting	Sep-17	Sep-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
36	NB	31000	Material Reuse Site 22	Jun-18	Jun-19	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
37	NB	31900	Fauna culvert planting	Aug-17	Aug-18	Y	Continue to monitor for weeds
38	NB	32350	Fauna culvert planting	Aug-17	Aug-18	Y	Continue to monitor for weeds
39	NB	32400	Fauna culvert planting	Dec-17	Dec-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
40	NB	32500	Material Reuse Site 18 (east Ravenswood Rd)	Feb-18	Feb-19	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
41	NB	32500	Material Reuse Site 18 (west Ravenswood Rd)	Aug-17	Aug-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
42	NB	32660	Fauna culvert planting	Aug-17	Aug-18	Y	Continue to monitor for weeds
43	NB	32800	Headlight screen planting	Aug-17	Aug-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
44	NB	33100	Fauna culvert planting	Dec-17	Dec-18	Y	Include in replacement plant program

Identifier	C'way	Chainage	Description	Date planted	12 month inspection	12 month criteria Met	Comments
45	NB	33400	Fauna culvert planting	Dec-17	Dec-18	Y	Include in replacement plant program
46	NB	33900	Glider Crossing	Mar-17	Mar-18	Y	Continue to monitor for weeds
47	NB	34100	Fauna culvert planting	Mar-17	Mar-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
48	NB	34600	Tubestock tree planting	Feb-18	Feb-19	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
49	NB	34700	Fauna culvert planting	Feb-18	Feb-19	Y	Continue to monitor for weeds
50	NB	35700	Glider Crossing	Mar-17	Mar-18	Y	Continue to monitor for weeds
51	NB	35700	Fauna culvert planting	Mar-17	Mar-18	Y	Continue to monitor for weeds
52	NB	35700	Reallocation of water quality basin tubestock planting	Mar-17	Mar-18	Y	Continue to monitor for weeds
53	NB	36100	Koala feed tree reallocation	Mar-17	Mar-18	Y	Continue to monitor for weeds
54	NB	36200	Tubestock tree planting	Mar-17	Mar-18	Y	Continue to monitor for weeds
55	NB	36300	Tubestock tree planting	Mar-17	Mar-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
56	NB	36350	Fauna culvert planting	Feb-18	Feb-19	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
57	NB	36400	Tubestock tree planting	Mar-17	Mar-18	Y	Continue to monitor for weeds
58	NB	36850	Tubestock tree planting	Jun-17	Jun-18	Y	Weed management required
59	NB	36900	Tubestock tree planting	Jun-17	Jun-18	Y	Weed management required
60	NB	37400	Headlight screen planting	Aug-17	Aug-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
61	NB	37700	Bridge fauna path and creek crossing	Feb-18	Feb-19	Y	Continue to monitor for weeds
62	NB	37800	Headlight screen planting	Aug-17	Aug-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018

Identifier	C'way	Chainage	Description	Date planted	12 month inspection	12 month criteria Met	Comments
63	SB	24400	Reallocation of water quality basin tubestock planting	Jul-16	Jul-17	Y	Continue to monitor for weeds
64	SB	24500	Koala feed tree reallocation	Nov-16	Nov-17	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
65	SB	24600	Effluent irrigation area	Jul-17	Jul-18	Y	Area inhibited by spread effluent irrigation and weed growth. Native and introduced grasses dominate with regular slashing required and ongoing.
66	SB	24700	Koala feed tree reallocation	Jul-17	Jul-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
67	SB	24800	Rest area feature trees	Mar-17	Mar-18	Y	Continue to monitor for weeds
68	SB	24800	Rest area tubestock	Apr-17	Apr-18	Y	Water during dry periods. Continue to monitor for weeds.
69	SB	25200	Glider Crossing	Jul-16	Jul-17	Y	Continue to monitor for weeds
70	SB	25300	Glider Crossing	Jul-16	Jul-17	Y	Continue to monitor for weeds
71	SB	25400	Culvert screen planting	Sep-16	Sep-17	Y	Continue to monitor for weeds
72	SB	25400	Fauna culvert planting	Jul-16	Jul-17	Y	Continue to monitor for weeds
73	SB	25550	Mingaletta bus stop	Jul-16	Jul-17	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
74	SB	25700	Fauna culvert planting	Jul-16	Jul-17	Y	Continue to monitor for weeds
75	SB	25700	Koala feed tree reallocation	Jul-16	Jul-17	Y	Planting area destroyed by inappropriate public car parking. Replanting required.
76	SB	25700	Reallocation of water quality basin tubestock planting	Jul-16	Jul-17	Y	Continue to monitor for weeds
77	SB	25800	Fauna culvert planting	Jul-16	Jul-17	Y	Continue to monitor for weeds
78	SB	25900	Tubestock tree planting	Aug-16	Aug-17	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
79	SB	26400	Fauna culvert planting	Sep-16	Sep-17	Y	Continue to monitor for weeds
80	SB	26800	Fauna culvert planting	Jul-16	Jul-17	Y	Continue to monitor for weeds

Identifier	C'way	Chainage	Description	Date planted	12 month inspection	12 month criteria Met	Comments
81	SB	27400	Bus Stop - Wharf Road	Dec-17	Dec-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
82	SB	27600	Tubestock tree planting	Jul-16	Jul-17	Y	Continue to monitor for weeds
83	SB	28100	Tubestock tree planting	Jul-16	Jul-17	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
84	SB	28200	Tubestock tree planting	Jul-16	Jul-17	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
85	SB	28200	Bridge fauna path and creek crossing	Jul-17	Jul-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
86	SB	28300	Tubestock tree planting	Jul-16	Jul-17	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
87	SB	28300	Bridge fauna path and creek crossing	Jul-17	Jul-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
88	SB	28350	Reallocation of water quality basin tubestock planting	Jul-17	Jul-18	Y	Continue to monitor for weeds
89	SB	28400	Water quality basin	Nov-16	Nov-17	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
90	SB	28700	Fauna culvert planting	Aug-16	Aug-17	Y	Continue to monitor for weeds
91	SB	28700	Reallocation of water quality basin tubestock planting	Aug-16	Aug-17	Y	Continue to monitor for weeds
92	SB	28800	Tubestock tree planting	Aug-16	Aug-17	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
93	SB	28800	Water quality basin	Aug-16	Aug-17	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
94	SB	29100	Tubestock tree planting	Nov-16	Nov-17	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
95	SB	29200	Kundabung Interchange feature trees	Apr-17	Apr-18	Y	Continue to monitor for weeds

Identifier	C'way	Chainage	Description	Date planted	12 month inspection	12 month criteria Met	Comments
96	SB	29200	Material Reuse Site 16	Nov-16	Nov-17	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
97	SB	29300	Kundabung Interchange feature trees	Oct-17	Oct-18	N	Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018. Further replacement of dead trees since January 2019 proposed in spring 2019.
98	SB	29500	Tubestock tree planting	Jun-18	Jun-19	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
99	SB	29800	Material Reuse Site 10	Mar-17	Mar-18	Y	Continue to monitor for weeds
100	SB	30100	Fauna culvert planting	Aug-16	Aug-17	Y	Continue to monitor for weeds
101	SB	30600	Tubestock tree planting	Nov-16	Nov-17	Y	Continue to monitor for weeds
102	SB	30650	Bridge fauna path and creek crossing	Aug-17	Aug-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
103	SB	30700	Bridge fauna path and creek crossing	Aug-17	Aug-18	Y	Include in replacement plant program
104	SB	30750	Tubestock tree planting	Jul-17	Jul-18	Y	Include in replacement plant program
105	SB	30800	Water quality basin	Jul-17	Jul-18	Y	Include in replacement plant program
106	SB	31200	Tubestock tree planting	Dec-16	Dec-17	Y	Continue to monitor for weeds
107	SB	31500	Headlight screen planting	Jul-17	Jul-18	Y	Include in replacement plant program
108	SB	31900	Fauna culvert planting	Dec-16	Dec-17	Y	Continue to monitor for weeds
109	SB	31900	Headlight screen planting	Jul-17	Jul-18	Y	Include in replacement plant program
110	SB	32300	Fauna culvert planting	Dec-16	Dec-17	Y	Continue to monitor for weeds
111	SB	32660	Fauna culvert planting	Jun-18	Jun-19	Y	Continue to monitor for weeds
112	SB	33000	Tubestock tree planting	Mar-17	Mar-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
113	SB	33100	Fauna culvert planting	Jan-17	Jan-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018

Identifier	C'way	Chainage	Description	Date planted	12 month inspection	12 month criteria Met	Comments
114	SB	33400	Fauna culvert planting	Jan-17	Jan-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
115	SB	33500	Tubestock tree planting	Jan-17	Jan-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
116	SB	33800	HVIB tubestock	Apr-17	Apr-18	Y	Continue to monitor for weeds
117	SB	33800	HVIB feature trees	Apr-17	Apr-18	Y	Continue to monitor for weeds
118	SB	33800	HVIB Effluent Irrigation area	Mar-18	Mar-19	Y	Continue to monitor for weeds
119	SB	33900	Glider Crossing	Jan-17	Jan-18	Y	Continue to monitor for weeds
120	SB	34100	Fauna culvert planting	Jan-17	Jan-18	Y	Continue to monitor for weeds
121	SB	34600	Koala feed tree reallocation	Feb-17	Feb-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
122	SB	34700	Fauna culvert planting	Feb-17	Feb-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
123	SB	34800	Tubestock tree planting	Jan-17	Jan-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
124	SB	34850	Water quality basin	Jan-17	Jan-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
125	SB	34900	Tubestock tree planting	Jan-17	Jan-18	Y	Continue to monitor for weeds
126	SB	35400	Water quality basin	Jan-17	Jan-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
127	SB	35400	Tubestock tree planting	Jan-17	Jan-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
128	SB	35600	Tubestock tree planting	Jan-17	Jan-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
129	SB	35700	Fauna culvert planting	Jan-17	Jan-18	Y	Continue to monitor for weeds
130	SB	35800	Koala feed tree reallocation	Jan-17	Jan-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018

Identifier	C'way	Chainage	Description	Date planted	12 month inspection	12 month criteria Met	Comments
131	SB	36300	Fauna culvert planting	Feb-17	Feb-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
132	SB	36400	Tubestock tree planting	Feb-17	Feb-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
133	SB	36500	Tubestock tree planting	Feb-17	Feb-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
134	SB	36800	Water quality basin	Jun-17	Jun-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
135	SB	36800	Tubestock tree planting	Jun-17	Jun-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
136	SB	36900	Tubestock tree planting	Jun-17	Jun-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
137	SB	36950	Water quality basin	Jun-17	Jun-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
138	SB	37300	Tubestock tree planting	Jan-17	Jan-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
139	SB	37700	Water quality basin	Apr-17	Apr-18	Y	Met in 2018/2019 monitoring. Replacement planting completed and accepted as compliant at start of Landscape Maintenance Period in November 2018
140	SB	37700	Bridge fauna path and creek crossing	Apr-17	Apr-18	Y	Weed management required





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## **Niche Environment and Heritage**

A specialist environmental and heritage consultancy.

### **Head Office**

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**September 2019**