



Annual Ecological Monitoring Report

**2015/2016 – Oxley Highway to Kempsey, Pacific Highway
Upgrade**

Prepared for Roads and Maritime Services

December 2016

Document control

Project no.: 1702 (PI7)

Project client: Road and Maritime Services

Project office: Port Macquarie

Document description: Oxley Highway to Kempsey, Pacific Highway Upgrade (OH2K) Annual Ecological Monitoring Report 2015/2015

Project Director: Rhidian Harrington

Project Manager: Chris McEvoy

Authors: Francesca Amorosi, Amanda Griffith

Internal review: Amanda Griffith, Rhidian Harrington, Chris McEvoy

Document status: Rev 1

Local Government Area: Port Macquarie

Author	Revision	Internal review	Date issued	Signature
F Amorosi, A Griffith	Rev0	R Harrington, C McEvoy	1/12/2016	RH
A Griffith	Rev1	Amanda Griffith	24/1/2017	AG

© Niche Environment and Heritage, 2016

Copyright protects this publication. Except for purposes permitted by the Australian Copyright Act 1968, reproduction, adaptation, electronic storage, and communication to the public is prohibited without prior written permission. Enquiries should be addressed to Niche Environment and Heritage, PO Box 2443, Parramatta NSW 1750, Australia, email: info@niche-eh.com.

Any third party material, including images, contained in this publication remains the property of the specified copyright owner unless otherwise indicated, and is used subject to their licensing conditions.

Cover photograph: Koala from unrelated project on Liverpool Plains and *Mixophyes iteratus* at Pipers Creek (photos by Rhidian Harrington and Francesca Amorosi respectively).

Executive summary

Context

This report details the findings of the ecological monitoring surveys undertaken from 22 July 2015 to 21 July 2016 as required for the Oxley Highway to Kempsey (OH2K) Pacific Highway upgrade project (the Project).

Aims

The Project has been developed to minimise impacts on a number of potentially affected threatened flora and fauna species. The purpose of the ecological monitoring program is to monitor the effectiveness of the biodiversity mitigation measures implemented as part of the Project. Threatened species monitored include:

- Koala (*Phascolarctos cinereus*)
- Spotted-tailed Quoll (*Dasyurus maculatus*)
- Giant Barred Frog (*Mixophyes iteratus*)
- Green-thighed Frog (*Litoria brevipalmata*)
- Yellow-bellied Glider (*Petaurus australis*)
- Brush-tailed Phascogale (*Phascogale tapoatafa*)
- Squirrel Glider (*Petaurus norfolcensis*)
- Threatened Microbats
- *Maundia triglochinos*.

Ecological monitoring of the following Project-related activities is also undertaken:

- Broad-scale road kill monitoring to monitor and record road impacts on all fauna within the Project area
- Pre-clearing and clearing surveys to minimise impacts to native flora and fauna as a result of vegetation clearing works
- Nest box installation
- Landscape monitoring to assess the success of revegetation efforts associated with the Project.

Methods

Each species/ecological component was surveyed in accordance with the monitoring methodology specified in Hyder (2014) and Lewis (2014). During the 2015-2016 period the following monitoring surveys were undertaken:

- Koala
- Giant Barred Frog
- Road kill
- Microbat roost boxes
- *Maundia triglochinos* habitat protection
- Landscape monitoring.

Monitoring of the Brush-tailed Phascogale, Squirrel Glider, Spotted-tailed Quoll, Yellow-bellied Glider and Green-thighed Frog was not required during the 2015-2016 monitoring and reporting period.

2015-2016 Key results

- Koala activity was recorded throughout the study area but mainly in the southern and central portions of the Project, on both control and impact sites (6 and 8 respectively) via SAT plots.
- Giant Barred Frogs were recorded at all four impact and two reference sites. Two “Barred-frog” tadpoles (considered highly likely to be those of the Giant Barred Frogs) were also detected at the Cooperabung Creek impact site. Based on the continued presence of individuals, including males, females and juvenile animals, populations of the Giant Barred Frog continue to persist at all the reference and impact sites. Chytrid fungus infection was detected for the first time in both Pipers Creek impact and reference sites, and in the Maria River impact site. Cooperabung Creek impact site remains the only site where Chytrid fungus has not been detected.
- Road kill monitoring results were similar to those reported in the 2014-2015 monitoring period, namely: a range of groups of fauna were recorded, with birds and large macropods being the most commonly recorded. There has been a general overall decline in road kill over the three periods of survey to date. No seasonal trends in road kill data are evident at this stage. Five high impact areas previously identified during the baseline and 2014/2015 construction phase monitoring (Sancrox interchange, Fernbank Creek, Telegraph Point, Wilson River and Pipers Creek) were again identified as high impact areas during the current monitoring.
- No Pre-clearing/clearing surveys have been reported on as part of this monitoring period, due to the fact that clearing has not been completed in either stage of the Project.
- The installation of the remaining 40 per cent of nest boxes is in progress. The results of this installation will be included in the 2016/2017 annual report.
- Bat roost box monitoring is indicating very low usage of the boxes by Microbats.
- *Maundia triglochinos* was detected at two of the three impact sites and one of the three control sites showing an increase in distribution from the 2014-2015 surveys (it was previously only detected at one of the impact sites). Flowering was recorded at one impact and its associated control site during spring and summer indicating that lifecycle processes for *Maundia triglochinos* are persisting during the construction phase as works are currently occurring adjacent to the known location of this species.
- At 12 months following revegetation only 43 locations of the 149 revegetated during 2015-2016 were due to be monitored for the landscape monitoring. Of these 43 areas the general vegetation condition was determined to be acceptable in 61% of cases.

Management implications

Giant Barred Frog - based on the newly identified presence of Chytrid fungus at the Piper’s Creek and Maria River impact sites, it is suggested that wash-down procedures (as currently present at Smiths Creek impact site) should be implemented at these sites in an effort to contain the spread of Chytrid fungus infection. It is also recommended that wash-down procedures are followed at Cooperabung Creek impact sites given its likely presence there also.

Microbats - it is recommended that monitoring of road structures that offer potential Microbat habitat within the study area be undertaken.

Table of Contents

Executive summary	iii
1. Introduction	1
1.1 Purpose.....	1
1.2 Background.....	1
1.3 Aim of the Ecological Monitoring Plan (EMP)	3
1.4 2015-2016 reporting objectives	3
2. Koala	5
2.1 Monitoring timing.....	5
2.2 Performance measures.....	5
2.3 Methods.....	5
2.4 Results	6
2.5 Discussion	6
3. Giant Barred Frog	7
3.1 Monitoring timing.....	7
3.2 Performance measures.....	7
3.3 Methods.....	7
3.4 Results	9
3.5 Discussion	11
4. Road Kill	15
4.1 Monitoring timing.....	15
4.2 Performance Measures	15
4.3 Methods.....	16
4.4 Results	16
4.5 Discussion	18
5. Microbat Roost Boxes	19
5.1 Monitoring timing.....	19
5.2 Performance measures.....	19
5.3 Methods.....	19
5.4 Results	19
5.5 Discussion	22
6. <i>Maundia triglochoides</i> Habitat Protection	26
6.1 Monitoring timing.....	26

6.2	Performance measures.....	26
6.1	Method.....	26
6.2	Results	26
6.3	Discussion	26
7.	Landscape Monitoring	28
7.1	Monitoring timing.....	28
7.2	Performance measures.....	28
7.3	Method	28
7.4	Results	28
7.5	Discussion	32
	References.....	33
	Annex 1. Koala monitoring report (Niche 2016a).....	35
	Annex 2. Giant Barred Frog report (Niche 2016b)	82
	Annex 3. Road kill report (Niche 2016c)	142
	Annex 4. Microbat roost box monitoring data.....	192
	Annex 5. <i>Maundia triglochinoidea</i> report (Niche 2016d).....	230
	Annex 6. Landscape monitoring data	257

List of Tables

Table 1:	Summary and schedule of monitoring requirements outlined in the EMP (Hyder 2014).	4
Table 2:	Road kill monitoring timing and location (current monitoring reporting period highlighted).....	15
Table 3:	Bat roost boxes installed.....	20
Table 4:	Landscape data collection during construction phases.....	29
Table 5:	Oxley Highway to Kundabung data interpretation in relation to performance measures.....	30
Table 6:	Kundabung to Kempsey 12 months inspection results	31
Table 7:	Microbat roost box details.....	192
Table 8:	6 th monitoring event – spring 2015.	194
Table 9:	7 th monitoring event – summer 2016.....	196
Table 10:	8 th monitoring event – autumn 2016.....	197
Table 11:	Prevailing weather conditions during Microbat roost box monitoring in spring 2015, summer 2016 and autumn 2016 surveys. Source: Bureau of Meteorology, Kempsey Airport AWS (station 059007).	199

Table 12: Oxley Highway to Kundabung two months (refer to column “Revegetation Performance After 2 Months of Sowing”) and 8 months inspection results 257

Table 13: Oxley Highway to Kundabung two months (refer to column “Revegetation Performance After 2 Months of Sowing’) and 12 months inspection results..... 282

Table 14: Kundabung to Kempsey ranking system..... 312

Table 15: Kundabung to Kempsey two month inspection results..... 312

Table 16: Kundabung to Kempsey eight month inspection results..... 316

Table 17: Kundabung to Kempsey twelve month inspection results 320

List of Plates

Plate 1: Artificial roost for *Myotis macropus* under bridge at Koala Beach NSW. Photo from Marshall (2011). 24

List of Graphs

Graph 1: Percentages of road kill records, according to seasons, during baseline and two first years of construction phase (2014/2015 and 2015/2016) 17

Graph 2: Bat roost box usage by Microbats during the 8 monitoring events. 21

Graph 3: Bat roost box usage by non-target native species during the eight monitoring events. 22

1. Introduction

1.1 Purpose

This report summarises the findings of the 2015/2016 ecological monitoring surveys undertaken as part of the Oxley Highway to Kempsey (OH2K) section of the Pacific Highway Upgrade Project. These were undertaken in accordance with the Oxley Highway to Kempsey Ecological Monitoring Program (EMP) (Hyder 2014) over the period 22 July 2015 to 21 July 2016. This report has been prepared as per the Minister's Condition of Approval (MCoA) for the Oxley Highway to Kempsey section of the Pacific Highway Upgrade Project, MCoA B10 (f), which requires the "Provision for annual reporting of monitoring results to the Director General and the EPA and DPI (Fishing and Aquaculture), or as otherwise agreed by the agencies".

Specifically, this document reports on the timing and results of monitoring activities undertaken, methodologies employed and progress/results measured against previously identified performance measures.

1.2 Background

The Oxley Highway to Kempsey section of the Pacific Highway Upgrade Project (the "Project") was approved in 2012 subject to various Minister's Conditions of Approval (MCoA) and Statement of Commitments (SoC). A subsequent approval with additional conditions of approval (CoA) was granted in 2014 by the then Department of the Environment (DoE) for Matters of National Environmental Significance (MNES) listed under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1995* (EPBC Act). Combined, these approvals outline the mitigation, offsetting and monitoring requirements for threatened species and ecological communities impacted by the Project.

Specifically, the Oxley Highway to Kempsey EMP (2014) was developed to address MCoA B10 and Department of the Environment Condition of Approval (CoA) 4. These conditions are detailed below.

MCoA B10

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 EPA 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).

Condition of Approval (CoA) 4

Prior to commencement of stage 2 and stage 3 of the action, the person taking the action must submit an Ecological Monitoring Program for approval by the Minister that determines the effectiveness of the mitigation measures implemented as part of the project. The Ecological Monitoring Program must be approved in writing by the Minister prior to commencement of stage 2 and stage 3, and must include:

a. The baseline data collected from surveys undertaken by a suitably qualified expert on the Koala, Spotted-tail Quoll and Giant-Barred Frog within all habitat areas outside areas to be cleared of vegetation for the proposed action, that are likely to contain these species and that are likely to be adversely impacted by the action (as determined by a suitably qualified expert). The data must address the densities, distribution, habitat use and movement patterns of these species;

b. The methodology to be implemented for the ongoing monitoring of road kill, the species densities, distribution, habitat use and movement patterns, and the use of fauna crossings during construction and operation of the action, including the timing, and duration of the methodology;

c. Goals and performance indicators to measure the success of proposed fauna crossings, which must be specific, measureable, achievable, realistic and timely (SMART), and be compared against baseline data described in condition 4a); and

d. Details of contingency measures that would be implemented in the event of changes to densities, distribution, habitat use and movement patterns that are attributable to the construction or operation of the project.

Monitoring must continue until mitigation measures can be demonstrated to have been effective for the Koala, Spotted-tail Quoll, and Giant-Barred Frog.

Should monitoring associated with this condition demonstrate that the use of fauna crossings and/or fencing is not achieving its intended purpose or is having a detrimental effect upon Koala, Spotted-tail Quoll,

and Giant-Barred Frog (as determined by the Minister), the Minister may require that the person taking the action implement alternative forms of mitigation and/or corrective actions to address the relevant impacts to Koala, Spotted-tail Quoll, and Giant-Barred Frog, such measures must be implemented as requested.

1.3 Aim of the Ecological Monitoring Plan (EMP)

The aim of the EMP is to:

- Outline the environmental context of the Project and identify potential impacts of the Project and the subsequent requirement for mitigation measures, which relate to:
 - Pre-clearing surveys and clearing procedures
 - Fauna underpasses
 - Rope bridges
 - Glider poles
 - Fauna fencing
 - Widened median
 - Nest boxes
 - Green-thighed Frog breeding ponds
 - Landscaping and revegetation.
- Detail the requirements for baseline monitoring of threatened species (known or likely to occur in the Project area that may be adversely affected by the Project) to be undertaken before construction of the Project commences, including the results of the baseline monitoring for the EPBC Act listed species.
- Describe the timing and methodology for monitoring of mitigation measures, during construction and upon completion of the Project, and detail performance measures that will measure the effectiveness of mitigation measures.
- Identify potential contingency measures that may be implemented if any mitigation measure proves to be insufficient.
- Describe the maintenance requirements that are relevant to the mitigation measures.
- Detail the reporting requirements related to monitoring events.

1.4 2015-2016 reporting objectives

The EMP details the schedule of ecological monitoring requirements for the life of the Project. These are shown in **Error! Reference source not found.** below.

The current report provides the findings of monitoring activities undertaken during the Construction phase of the Project between the 22 July 2015 and 21 July 2016, as identified in **Error! Reference source not found.**

As such, ecological monitoring components of the EMP reported on within this document include:

- Koala (2015-2016)
- Giant Barred Frog (2015-2016)
- Road kill (2015-2016)
- Nest boxes (2015-2016)
- Microbat roost boxes
- *Maundia* habitat protection (2015-2016)
- Landscape monitoring (2015-2016).

2. Koala

This section details the findings obtained from the first monitoring period following the baseline surveys. It represents the first monitoring survey for the construction phase of the Project (Year 1).

Summaries below describe the methods and results from Year 1 monitoring, and provide a comparison with baseline results to determine whether performance measures are being met and allow comment on whether additional measures need to be implemented. Full details of Year 1 monitoring are included in Niche (2016a) and presented in Annex 1.

2.1 Monitoring timing

The monitoring surveys were undertaken in late spring-summer 2015.

2.2 Performance measures

Monitoring requirements and performance measures outlined in the EMP for the Koala specify:

- *Monitoring is to be undertaken during baseline surveys and from Year 1 – Year 6 & 8, or until mitigation measures are demonstrated to be effective.*
- *Monitoring during Year 1 – 6 & 8 is undertaken at the Impact and Control sites where monitoring was undertaken during baseline surveys.*
- *Mitigation measures are demonstrated to be effective as defined in the EPBC approval when all monitoring events are considered at Year 8.*
- *Fauna fencing is installed at a minimum in areas identified in Schedule 3 of the EPBC approval at Year 4.*
- *No change 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.*

2.3 Methods

As with the baseline monitoring surveys, eight broad areas within a 20 km radius of the Project were surveyed and three types of monitoring sites were established within each:

- Treatment A: Sites with mitigation (i.e. sufficiently large culverts to allow Koalas to pass under the Highway and floppy top fencing).
- Treatment B: Sites where mitigation has not been proposed or only partial mitigation is proposed.
- Treatment C: Control or reference sites located in areas at least 3 km and often 5-10 km from the Project.

These eight broad areas included 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.

Koala Spot Assessment Technique

Seventy two baseline SAT plots were established by Lewis (2014). Of these 72 sites 24 were mitigation, three part mitigation, 21 no mitigation and 24 control sites. To ensure a balanced monitoring design between impact (mitigation and not mitigation) and control sites, additional “new” control plots were established during this first monitoring event in 2015.

In accordance with the baseline monitoring design, 24 of these new control sites (at least 3 km from the project) were grouped in clusters of three plots, one cluster for each of the eight broad areas.

Details of all the monitoring sites and their locations are presented in the Koala report (Niche 2016a) (Annex 1).

A total of 93 SAT plots were surveyed across the eight areas. These plots included the location of 69 of the existing 72 baseline SAT plots established by Lewis (2014), with the additional 24 control plots selected by Niche during the first monitoring event 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.

The presence (or absence) of scats was recorded, along with a number of other attributes including the species of the tree under which the scat was located. SAT plots were conducted from October to December 2015.

2.4 Results

The baseline surveys showed that the Koala was distributed across most of the study area apart from the Mingaletta-Smith Creek area, while in 2015 its recorded distribution was slightly more fragmented, particular in the northern portion of the project area. Koala presence was recorded in 83.33% of clusters during the baseline monitoring, while in 2015 Koala were present in only 45.16% of the clusters.

The overall Spot Assessment Technique (SAT) activity levels across the eight monitoring areas for the baseline survey was 4.91% (SD=7.95%), while for the 2015 monitoring it was 1.97% (SD=4.64%).

In both the baseline and 2015 surveys Koala were recorded more frequently in impact clusters than in control clusters. However, in 2015 there was no significant difference between control and impact sites.

2.5 Discussion

Koala activity levels between the baseline and Year 1 monitoring survey appear to have decreased slightly, for both control and impact sites. In 2015 impact sites recorded higher percentages of Koala presence than control sites. For this reason any decrease of Koala activity cannot be directly associated with the disturbance due to the Project. Therefore, with the data available to date, there is no observable change to the density, distribution, habitat use or movement patterns of Koala compared with the baseline surveys as a result of the Project.

SAT plots provide robust data for measuring Koala distribution, habitat use and activity levels, but only provide limited data on density, as it is not possible to determine the number of Koalas from scat records. Supplementing the SAT surveys with a direct survey technique such as spotlighting surveys would provide more robust data on Koala density.

Further information on Year 1 monitoring is included in Annex 1.

3. Giant Barred Frog

The following information is summarised from the 2015/2016 Giant Barred Frog monitoring report, including field surveys completed by Niche Environment and Heritage Pty Ltd (Niche 2015a, 2016b) (Annex 2).

3.1 Monitoring timing

Surveys for the Giant Barred Frog were undertaken in spring 2015, summer 2016 and autumn 2016.

3.2 Performance measures

Monitoring requirements and performance measures outlined in the EMP for the Giant Barred Frog specify:

- *Monitoring is undertaken during baseline surveys and Years 1 – 8 or until monitoring can demonstrate that mitigation measures are effective.*
- *Monitoring during Year 1 – 8 is undertaken at the Impact and Control sites where baseline monitoring was undertaken.*
- *Continued presence of Giant Barred Frogs during each survey event in Year 1 – 8 at sites where it was identified during baseline surveys.*
- *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).*
- *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.*

3.3 Methods

3.3.1 Monitoring sites

As per baseline survey, 2015/2016 monitoring was undertaken in four separate ‘treatment’ habitats, where the Pacific Highway crosses creek lines known to contain the Giant Barred Frog. These include Cooperabung Creek, Smiths Creek, Pipers Creek and Maria River. Two analogue “control” stream sites, termed reference sites for this study, were also surveyed, being upstream sections of Cooperabung Creek and Pipers Creek.

Each site comprises a one kilometre transect. The treatment 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.

During 2015/2016, five of the six transects were surveyed for their entire length. The Cooperabung Creek impact site was not surveyed for the full kilometre because access agreements with landowners could not be obtained for the final zone downstream, and for the first three zones upstream.

3.3.2 Survey method

The methods used to survey the six transects followed those described in the approved Giant Barred Frog Management Strategy (Lewis 2013a). Details regarding survey methodology undertaken can be found in

the Giant Barred Frog Annual Monitoring Report (Niche 2016b; Annex 2). In summary, the following was conducted at each site:

- Listening for calls
- Call playback
- Spotlight searches
- Record of sex, weight, snout vent length, age status (metamorph/juvenile/adult) and breeding condition (being the condition of the nuptial pads in males or in females whether they were gravid) for any individuals caught
- PIT tagging of previously unmarked individuals
- Sampling of captured animals for Chytrid Fungus
- Tadpole trapping (using dip-netting and trapping with baitfish traps)
- Recording of weather conditions (including temperature and humidity, % cloud cover and broad wind level)
- Habitat assessments
- Rainfall records for the previous 24 hours, 7 days and 30 days (from the Roads and Maritime Services Weather Stations Oxley Highway to Kempsey upgrade – Telegraph Point (station code RMSN1AWS)).

All three monitoring events (spring 2015, summer 2016 and autumn 2016) were conducted by Niche Environment and Heritage.

3.3.3 Water quality

Water quality measurements were conducted by the Roads and Maritime Services and data was available between 22 July 2015 and 21 July 2016 for this work (RMS 2016a, 2016b). Water quality data from both upstream and downstream sites was summarised for the following GBF habitats:

- Cooperabung Creek
- Smiths Creek
- Pipers Creek
- Maria Creek.

Water quality parameters interpreted for this monitoring included:

- electrical conductivity (EC)
- dissolved oxygen (DO)
- pH
- turbidity (NTU)
- total suspended solids (TSS)
- metals (AL, As, Cd, Cr, Cue, Fe, Pb, Mn, Hg, Ni, Ag and Zn)
- total nitrogen
- total phosphorus.

The median water quality value for downstream sites was compared with the site specific trigger values developed for the upstream site based on the 80th percentile and where relevant the 20th 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 Australia for slightly disturbed ecosystems for

freshwater systems. Trigger values were derived from 24 sampling events up to and including the month indicated, where data was available.

3.3.4 Analysis

Population estimates of the number of individuals present at each site were undertaken from the available mark-recapture data using the Chapman correction of the Lincoln-Petersen Model (hereafter called Chapman) to reduce variability in the estimates (see Niche 2016b, Annex 2 for details).

The Minimum Known to be Alive (MKTBA) was also calculated to provide a simple comparative measure of population size (see Niche 2016b, Annex 2 for details). This index is based on the number of new individuals encountered over multiple visits, where any new animals are summed, providing an aggregate total. Limitations of this method are that it does not account for any migration out of the population or any death, so may over-estimate the total population size if counts are completed over a long period of time. However, the same assumptions apply equally for the Chapman method.

3.4 Results

Weather conditions encountered during the current surveys were similar to those recorded during the baseline surveys.

A total of 162 records were made of Giant Barred Frogs during the 2015/2016 monitoring surveys, with frogs being recorded at all six sites, and during all three monitoring events. Frogs were captured on 146 occasions, including 13 recaptures. One frog was recaptured twice. The results clearly demonstrate that the summer surveys provide greater numbers of frog captures than spring or autumn. The highest counts obtained in any one survey were at the Pipers Creek Reference site (summer = 26) and lowest at the Smiths Creek Impact site (autumn = 1). The mean number of frogs per visit was relatively uniform across sites ($n = 6.0 - 8.67$) except for the Pipers Creek Reference site that had larger number of frogs present ($n = 18.33$).

The MKTBA count was highest at the Pipers Creek Reference Site ($n = 46$), but the estimate for the Cooperabung Creek reference site ($n = 15$) was in the same range as for the Impact Sites ($n = 14 - 24$). Variation around the population estimates derived using the Lincoln-Peterson equation with the Chapman Correction were generally very large, indicating little certainty in those estimates. For example, the Pipers Creek Reference site had a very similar overall population estimate to that for the Maria River Impact site (85 and 84 respectively), even though a much larger number of frogs were recorded at the Pipers Creek Reference Site. However, the variance estimates were 860 and 2,720 (i.e. more than ten times the counts), demonstrating that neither estimate can be treated with any confidence. The Pipers Creek Impact site had the lowest overall population estimate being 21.5 frogs.

Two 'Barred Frog' tadpoles (*Mixophyes* sp.) were caught using tadpole traps during the spring survey period at Cooperabung Creek Impact site. The tadpoles were highly likely to be Giant Barred Frogs, but positive identification is very difficult without removing animals from the field and access restrictions to the site did not allow this.

Tadpoles were infrequently observed at the other sampling sites, but were not able to be captured and their identity was uncertain.

Chytrid fungus sampling was carried out in all three monitoring events: spring 2015, summer 2016 and autumn 2016. During spring 2015, Chytrid fungus was detected at three of the six sites. Chytrid fungus was detected in Piper creek impact and reference sites and in Maria River impact site. In summer 2016, infected

frogs were recorded only in Pipers creek impact site. Chytrid fungus was not detected from any frogs during the autumn monitoring surveys. Chytrid fungus was detected during baseline survey in Cooperabung creek reference site and in Smiths creek impact site. Chytrid was not detected in these two sites during the 2015/2016 monitoring but once detected, it is presumed this pathogen will still be present at a location on a permanent basis. So far Cooperabung creek impact is the only site where Chytrid fungus has not been detected yet.

3.4.5 Water Quality

Cooperabung Creek

The majority of water quality parameters monitored during each sampling event for the downstream site in Cooperabung Creek conformed to the site specific trigger values. Parameters that were outside the site specific trigger value range included; electrical conductivity on six occasions, total nitrogen, total suspended solids and turbidity on three occasions, and dissolved oxygen and total phosphorus on one occasion. Of these, total nitrogen also exceeded the ANZECC default trigger value, while a very low turbidity reading was below the lower limit for the ANZECC default trigger value. For metals there were six occasions where zinc, four occasions for manganese, two occasions for aluminium, and one occasion for iron where they were detected at concentrations above the site specific trigger value. Of these zinc and aluminium were also found to be above ANZECC default trigger values.

Smiths Creek

The majority of water quality parameters monitored during each sampling event for the downstream site in Smiths Creek conformed to the site specific trigger values. Dissolved oxygen was found to be outside the range of the site specific trigger values on four occasions (two above and two below). The two low readings in December and April were well below the ANZECC default trigger values. Electrical conductivity was also found to be outside the site specific trigger value range on three occasions (two above and one below), with the low value also below the lower ANZECC default trigger value. Also turbidity on three occasions, total suspended solids and pH and on two occasions, and total nitrogen and total phosphorus on one occasion for each were also outside the range for the site specific trigger values. Of these only total phosphorus, which was slightly above, did not meet the ANZECC default guidelines. For metals, zinc on eight occasions, manganese on three occasions, and aluminium and iron on two occasions exceeded the site specific trigger values. Of these zinc and aluminium were also regularly well above the ANZECC default trigger value.

Pipers Creek

The majority of water quality parameters monitored during each sampling event for the downstream site in Pipers Creek conformed to the site specific trigger values. Electrical conductivity was found to be greater than the site specific trigger value on five occasions, but within the ANZECC default trigger value. Dissolved oxygen was also found on two occasions to be above the site specific trigger value but within ANZECC default trigger value. A very high result for turbidity was recorded in September, which was well above both the 80th percentile and ANZECC guideline trigger value, however this reflected similarly elevated upstream turbidity. The only other occurrence where turbidity did not meet the site specific trigger value was due to a low turbidity value. On one occasion pH was slightly above the site specific trigger value but remained within the ANZECC default trigger values. Total phosphorus was found to be above both trigger values in January. Four metals, zinc, aluminium, nickel and iron, were elevated at times throughout the 12 months.

Of these, aluminium and zinc did occur at times at relatively high concentrations that were well above both trigger values.

Maria River

The majority of water quality parameters monitored during each sampling event for the downstream site in Maria Creek conformed to the site specific trigger values. Parameters that exceeded the trigger values included electrical conductivity and total suspended solids on two occasions, and dissolved oxygen, and total phosphorus on one occasion for each. Of these only total phosphorus exceeded the ANZECC default trigger value. Turbidity was found to be low on two occasions and outside the range of the site specific trigger values, but within the ANZECC default trigger value. For metals, manganese was found to be above the site specific trigger value on seven occasions, but remained below the ANZECC default trigger value. Additionally, aluminium, arsenic, copper, iron and nickel were also found to exceed the site specific trigger value on occasions. Of these, only aluminium and copper occurred at concentrations above the ANZECC default trigger value as well.

3.5 Discussion

During baseline surveys, the Giant Barred Frog was recorded across all six monitoring sites in spring and summer and in four sites in autumn. No frogs were detected during the autumn 2014 survey in the Maria River Impact site or Pipers Creek Reference site. In contrast, during the 2015/2016 surveys, Giant Barred Frogs were recorded across all six sites in all three monitoring events.

In both the baseline and 2015/2016 surveys the counts varied across the three monitoring periods, with the highest numbers of frogs recorded/captured in all but one instance occurring in summer and the lowest always occurring in autumn. Autumn results were always substantially lower than the other two periods, reflecting low frog activity in autumn. Also, calling and reproduction has ceased by autumn making frogs less easy to detect.

Female frogs were readily detected in all three seasons, whereas male frogs were predominantly recorded in summer and juveniles mainly in autumn. This suggests differences in catchability of the sexes and age groups, depending on the season of the surveys. This does have a significant influence on recapture rates if males are only easily captured in the summer sampling period. Given the very limited number of recaptures for females, it also suggests that individuals are not active every night, and perhaps many nights, or different individuals are active at different times of the year.

MKTBA for the baseline survey and 2015/2016 surveys are relatively similar for the impact sites, with two sites having an increase in numbers, one a decrease and the other no change. The reference sites presented opposite results to each other with the Cooperabung Creek reference MKTBA decreasing between baseline and 2015/2016, whereas at the Pipers Creek reference site the MKTBA increased.

In 2015/2016 Giant Barred Frogs were distributed broadly across all six transects, including downstream of the Cooperabung Creek Impact site, which had relatively few frogs recorded there previously. Previously the creek in this section had been essentially dry with only the occasional shallow pool. In summer 2016 the creek was flowing across its length and large pool areas were available for the frog to call adjacent to and breed in.

Habitat use was broad with frogs being located in all of the available microhabitats.

The use of the Chapman correction again provided population estimates with significant variance and so it is difficult to draw meaningful conclusions from the results. The high variance in the estimates of the populations precludes any rigorous statistical comparisons of the results as the high variances make it impossible to detect differences in estimates between sites or between years. The general capture and population results to date do not show any clear indications of declines at any site.

These variances will decrease if recapture rates increase, but recapture rates during both the baseline and 2015/2016 surveys were very low. Modification of the prescribed survey methodology may improve recapture rates and in turn provide more robust population estimates.

There are no losses of populations and all sites continue to support frogs of both sexes and juvenile frogs.

The sampling carried out for Chytrid fungus has indicated that this pathogen is present in the study area, but that its prevalence varies between sites and times of sampling. The presence of Chytrid is expected as it was detected during the baseline surveys in the Smiths Creek Impact site and in the Cooperabung Creek Reference site. Chytrid fungus infection was detected for the first time in both Pipers Creek Impact and Reference sites and in Maria River Impact site in spring 2016, and again in Pipers Creek Impact site during the summer 2016 survey.

To contain the spread of the Chytrid fungus infection, it is important that the hygiene protocol for the control of disease in frogs Information Circular Number 6 (DECC 2008) be methodically and rigorously followed for footwear and all vehicles that enter Giant Barred Frog sites/habitat where Chytrid fungus has already been detected. It is recommended to keep and review periodically a register of the wash down stations/procedures. Wash down procedures are currently present at Smiths Creek Impact site and based on the 2015-2016 results, should be implemented also at Pipers Creek impact site and also at Maria River Impact site. It's also recommended that wash down procedures are followed at Cooperabung Creek Impact sites. Chytrid fungus has been previously recorded at Cooperabung Creek Reference site, upstream of the impact site and even if not detected so far at the impact site it is likely to be already present in this area.

No "Barred Frog" tadpoles have been recorded in any of the six sites during the baseline surveys. Tadpoles were collected only on one occasion and in only one of the six monitoring sites (spring 2015 in the Cooperabung Creek Impact site) during the 2015/2016 surveys. However, reproduction can and has been concluded to have been successful due to the presence of juvenile and sub-adult frogs at all sites. Both bait trapping and dip-netting have demonstrated a very low catching rate. There is no clear guidance in the EMP document (Hyder 2014) as to the reason to collect tadpoles nor a performance measure placed against the result and so the lack of success in capturing tadpoles does not influence the success of meeting the performance measures.

Review of water quality monitoring data indicated that electrical conductivity was found to be higher than the upstream trigger value regularly throughout the 12 months. However, these values, while slightly elevated, were well within ANZECC guideline trigger values and have been reported to be typically consistent between upstream and downstream values when elevated (RMS 2016a and 2016b), indicating that these exceedances are unlikely related to construction activities. Although other water quality parameters were exceeded (i.e. dissolved oxygen, pH, turbidity and total suspended solids), they were typically minimal, infrequent and likely to be short-term occurrences with minimal potential for ecological impact on Giant Barred Frog habitat. Further discussion of these results is provided in Appendix A of the 2015/16 Annual Report (Niche 2016b) (Annex 2).

Metal and nutrients were also found to exceed the 80th percentile based trigger value from the upstream site at times. Of these metals, aluminium, manganese and zinc were the most common metals found at elevated levels. Aluminium was regularly recorded above the trigger value and at levels ten times or more the ANZECC guideline trigger value. Zinc was also commonly above the trigger value and ANZECC default value. Manganese showed slight elevated concentrations at times above the trigger value, but typically remained well within ANZECC default values. Given that it has been reported that, “elevated levels of metals were generally experienced concurrently both upstream and downstream” and that where “differences between upstream and downstream locations were recorded, this typically coincided with monitoring locations persisting as isolated ponds” (RMS 2016a, and 2016b), it is likely that these typically short-term and infrequent elevations in metals are reflective of environmental variability at the subject sites and influences independent of the construction activities. There is no information available to indicate if such high levels of metals are likely to have negative impacts on the Giant Barred Frog, but if they are natural fluctuations for these creeks, then it would appear to be unlikely that they are having an impact.

3.5.6 Performance measures

- **Monitoring is undertaken during baseline surveys and Years 1 – 8 or until monitoring can demonstrate that mitigation measures are effective.**

This performance measure for 2015/2016 has been met. Giant Barred Frog monitoring has been undertaken in all six baseline sites.

- **Monitoring during Year 1 – 8 is undertaken at the Impact and Control sites where baseline monitoring was undertaken.**

This performance measure for 2015/2016 has been met. Giant Barred Frog monitoring has been undertaken in all six baseline sites, except for Cooperabung Creek impact site, which was not surveyed for the full kilometre because access agreements with landowners could not be obtained for the final zone downstream, and for the first three zones upstream. However, this section of stream was still monitored in the main, and population estimates were able to be determined.

- **Continued presence of Giant Barred Frogs during each survey event in Year 1 – 8 at sites where it was identified during baseline surveys.**

This performance measure has been met for 2015/2016. During the baseline surveys, the Giant Barred Frog was recorded at all six monitoring sites in spring and summer and in four sites in autumn. During 2015/2016 surveys the Giant Barred Frog was recorded at all six sites in all three monitoring events.

- **Mitigation measures are effective as defined in the EPBC approval when all monitoring events are considered at Year 8.**

Not applicable for 2015/2016 monitoring period as this is not the Year 8 period.

- **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).**

Several water quality parameters exceeded the 80th percentile values, but only on occasions and they appear more likely to be related to local stream variations rather than construction activity. Given the early stages of monitoring it is not reasonable to conclude that this is a result of impacts from road construction and so it is considered at this time that the performance measure has largely been met.

- **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.**

The data obtained on the population estimates and actual counts vary greatly between events and years, but the number of frogs recorded do not clearly indicate significant changes in any of the monitored populations between the baseline and 2015/2016 surveys. The distribution of frogs remains widespread across the sites and transects and habitat use similarly remains widespread across the sites and transects. However, the results do not allow for meaningful comment on movement patterns of frogs.

Based on the data obtained during the 2015/2016 monitoring event, all of the performance measures are considered to have been met.

4. Road Kill

The Road Kill monitoring results for the 2015/2016 monitoring period of the Oxley Highway to Kempsey section of the Project (collected by Roads and Maritime Services) are detailed in Niche (2016c) and summarised below. Niche (2016c) is included in Annex 3 of this report.

4.1 Monitoring timing

The approved EMP states the timing and location for road kill monitoring as detailed in Table 2 below. The 2015/2016 monitoring period included weekly monitoring undertaken between August 2015 and July 2016 during the construction period as highlighted in Table 2 below. This represents the second year of the construction phase monitoring.

Table 2: Road kill monitoring timing and location (current monitoring reporting period highlighted).

Project Phase	Timing of survey	Location
Baseline	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	Daily	Portion of existing highway adjacent to clearing operations.
One month following clearing operations	Daily	Portion of existing highway adjacent to clearing operations.
For the duration of construction	Weekly	Entire length of existing highway in Project area.
Within one month of opening of the Project	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)	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.

4.2 Performance Measures

The approved EMP specifies the following performance indicators for the road kill survey:

- *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 Years 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.*

4.3 Methods

Monitoring methodology followed that prescribed in the approved EMP (see Niche 2016c for details). Specifically, for each road kill observed, the following attributes were recorded:

- Geographic coordinates of the road kill location
- Species of road kill where possible
- For TSC Act or EPBC Act threatened species, sex and age class (juvenile or adult) and presence of pouch young (for marsupials) where possible and if safety limitations permit
- Local habitat attributes (at a point five metres from the road verge at the road kill location, including):
 - Structure and floristics of vegetation, including dominant species of each vegetation stratum, height and per cent cover
 - Presence and type of hydrological and surface drainage features
 - Presence and type of rocky features
 - Abundance and type of tree and log hollows
 - Presence, type and abundance of foraging resources
 - Presence and type of microhabitats.

4.4 Results

The data has been collected from Roads and Maritime Services and includes road kill records across the entire length of the existing Pacific Highway carriageway (extending from ch. 400 to ch. 37800) during all four seasons. The raw data are provided in Niche 2016c (Annex 3) and summarised below.

Limitations to data collection and assumptions regarding road kill species and counts remained the same for the current reporting period. Namely, due to safety concerns associated with slowing down on the highway to identify road kill:

- Most of the road kills recorded were not identified at the genus or species level but at the “vertebrate group” level only.
- Some carcasses could not be identified as a result of extensive collision damage. These road kill animals were classified as ‘Unknown’.
- Small sized animals had the potential to be partially or wholly removed by scavenger animals and/or their remains not readily identifiable from the vehicle.

As a result, it is possible to have under-counted animals like frogs, small mammals and birds.

4.4.1 Construction phase 2015/2016

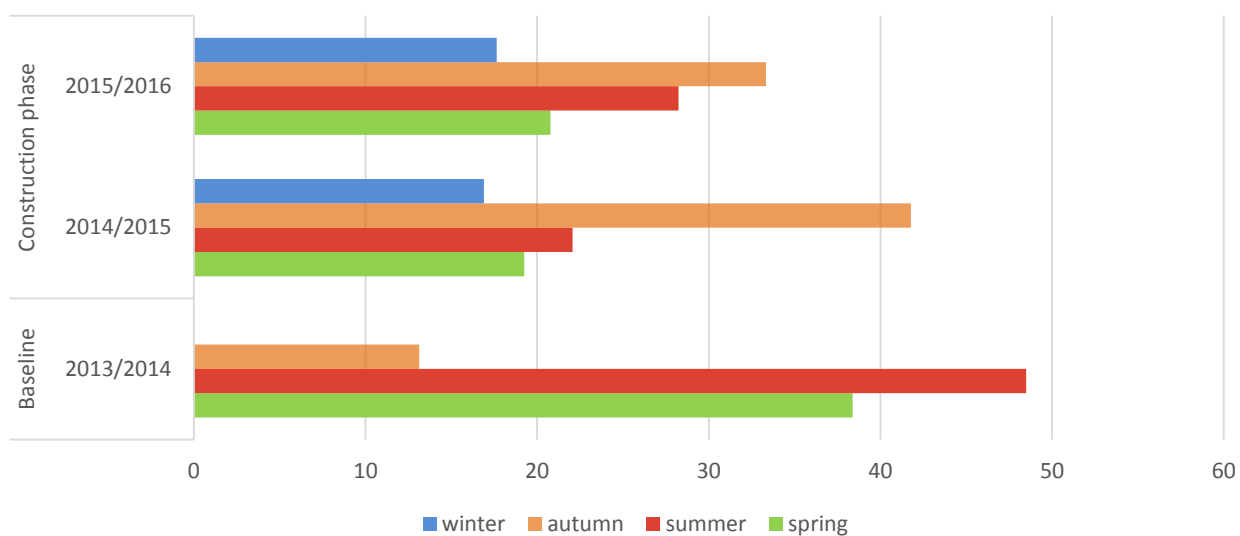
Survey effort for the construction phase 2015/2016 covered 49 weeks (12.7 weeks in spring, 12.4 in summer, 12.7 in autumn and 11.1 in winter, including 3.7 in winter 2015 and 7.4 in winter 2016) from 6 August 2015 to 22 July 2016.

A total of 255 road kill animals were recorded over the 49 weeks of monitoring. This included 53 in spring 2015, 72 in summer 2015-2016, 85 in autumn 2016, and 45 in late winter 2015 and early winter 2016.

A wide range of fauna were recorded as road kill. The fauna categories with the highest number of road kill were birds (31.4%) followed by large terrestrial mammals (kangaroos) (20.0%). “Unknown” and unidentified mammals made up approximately 28% of the road kill. Small terrestrial mammals and reptiles made up approximately 6% of the road kill each. Arboreal and flying mammals were also recorded (ten and three records respectively), introduced mammals were recorded twice and frogs once.

Comparison of the percentage of road kills recorded for each event were used to compare results across years and also identify seasonal differences in fauna categories affected. During the baseline monitoring, the lowest number of road kill was recorded in autumn while in both construction phases, autumn was the season with the highest number of road kill (Graph 1). Subsequent surveys and data would be required to determine more definitive patterns of seasonal road kill.

Graph 1: Percentages of road kill records, according to seasons, during baseline and two first years of construction phase (2014/2015 and 2015/2016)



In both years of the construction phase, birds were the taxa with the highest number of road kills, followed by large terrestrial mammals. The number of “unknown” and unidentified mammals was much greater in the most recent round of surveys compared to the previous two years, but reptile, arboreal mammals, medium-sized mammals and introduced mammals decreased compared to the previous two years. There has been an overall decline in road kill over the three periods of survey to date.

Data from the construction phase 2015/2016 indicated five high-impact areas for road kills. These include:

- 1800 – 3100 Sancrox interchange
- 4000 – 4900 Fernbank Creek
- 13200 – 14150 Wilson River
- 14400 – 17000 Telegraph Point
- 29400 – 30900 Pipers Creek.

All five high impact areas have been identified previously during the baseline monitoring (Sancrox interchange, Fernbank Creek and Telegraph Point) or during the construction phase 2014/2015 (Wilson River and Pipers Creek).

One individual threatened species, the Koala, was recorded as a road kill. It was located one kilometre north of Ravenswood Road on 22 December 2015.

4.5 Discussion

The following comments can be made about the results obtained compared to the listed performance measures:

- **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.**

The majority of the traffic remains on the existing Pacific Highway, and as such, new fauna mitigation measures will have little benefit in these areas. The full benefit of these structures will not be realised until the Project is operational and these structures are completed. This will be particularly evident in areas where large extents of the Project become operational simultaneously, and the existing highway will become a service road. The benefit of fauna mitigation in these areas will not be evident until the Project becomes operational.

- **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.**

To be able to compare different years data, a weekly road kill rate was calculated.

In spring the weekly road kill rate was approximately the same for the Baseline and construction phase 2014/2015 (Niche 2016d), but was much lower (approximately half) for the most recent monitoring period. Road kill rates for the summer months were greatest during the Baseline surveys and were consistently lower for the two subsequent rounds of construction monitoring (less than half that recorded in the first year). However, in autumn, the weekly road kill rate recorded during the construction phases was almost double that of the baseline survey, although the road kill rate recorded during the 2015/16 and 2014/15 surveys were similar. Winter surveys revealed approximately the same weekly road kill rate for each of the consecutive construction monitoring periods (as per requirements none were undertaken for the baseline surveys).

This performance measure was met in spring and summer but not in autumn for the 2015/2016 construction phase. There were more road kill recorded in autumn 2015/2016 than in the autumn surveys for the baseline monitoring periods. However, overall there has been a decline in the recorded road kill between baseline and the subsequent two monitoring events and therefore, overall, the performance measure has been met.

Data from future monitoring events will provide further information on seasonal and yearly variability in road kill rates and thus further inform progress against the stated performance measures.

Only one threatened species (one individual Koala) was recorded during the 2015/2016 construction phase while three individual threatened species (one Koala and two Grey-headed Flying-fox) were recorded as road kill during the baseline survey. In this respect, the performance criteria for the 2015/2016 period has been met.

- **Fauna exclusion fencing is installed at a minimum in the locations identified in Schedule 3 of the EPBC approval at Year 4.** Not applicable until Year 4.

5. Microbat Roost Boxes

5.1 Monitoring timing

Bat roost boxes were installed prior to the commencement of construction (Year 0) which was 6-12 months prior to the planned exclusion of bats from existing structures.

The approved EMP states the following monitoring timing:

- Monitoring of bat boxes will commence six months after their installation (Year 1), followed by quarterly inspections (each season) for two years (Years 2 and 3), before addressing corrective actions.
- After the first two years of monitoring, monitoring of the bat roost boxes will continue twice a year (summer and winter of Year 4, 6 and 8) up until Year 8.

5.2 Performance measures

The approved EMP and Construction Flora and Fauna Management sub-plans (Lend Lease 2014 and McConnell Dowell OHL JV 2014) specify the following performance indicators for success of bat roost boxes:

- *Use of bat roost boxes by Microbats*
- *Low rate of use of roost boxes by introduced fauna species*
- *Low level of maintenance of roost boxes.*

5.3 Methods

The approved EMP and in accordance with the *Microchiropteran Bat Management Strategy (MBMS)* (Lewis 2013c) states that bat roost box monitoring will involve a visual inspection of each bat roost box and at each monitoring period, the following information will be collected for each bat roost box:

- Inspection date, weather conditions (rain, wind, cloud cover, ambient temperature) and time each bat roost box was inspected.
- Bat roost box identification number.
- If the bat roost box is occupied by Microbats, and if so, the species present. If the bat roost box is not occupied by a native species, record any signs of use by Microbats.
- Presence of pest species such as European bees.
- Deterioration of the bat roost box and if any maintenance required.
- Any changes to the surrounding habitats, such as changes to flyways or vegetation structure.

5.4 Results

A total of 158 bat roost boxes were installed in late September / early October 2013. Table 3 summarises the type and location of roost boxes installed. For further details about the installation, please refer to RPS (2013). All boxes installed were tree mounted. The results presented in this report summarise the bat roost box monitoring undertaken during three monitoring events between 22 July 2015 and 21 July 2016:

- Event 6 – spring 2015
- Event 7 – summer 2016
- Event 8 – autumn 2016.

Autumn 2016 (Event 8) was the last quarterly inspection undertaken as part of the first two years monitoring. In accordance with the approved EMP and the Microchiropteran Bat Management Strategy (Lewis 2013c), after these two years of monitoring, corrective action will be addressed. To be able to identify the need of any corrective action the historical data (events one to five) is also presented in this report.

Table 3: Bat roost boxes installed

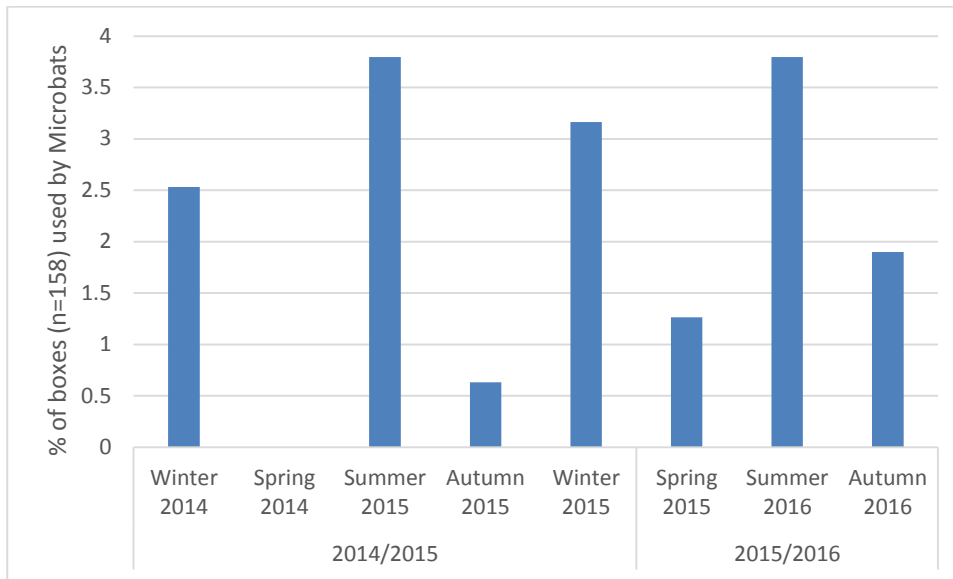
Location	Roost Box Type A (small slotted style bat box)	Roost Box Type B (wedge style)	Roost Box Type C (tree mounted removable slots)
K2K	31	32	28
OH2Ku	20	23	24
Total	51	55	52

The 2015/2016 data has been collected from two different sources. Sandpiper Ecological Surveys collected the data on behalf of Lendlease for the Project from Oxley Highway to Kundabung and Niche collected the data on behalf of McConnell Dowell OHL JV for the Project from Kundabung to Kempsey. Please see Annex 4 for the raw data and the single event reports from Niche and Sandpiper Ecological Surveys respectively.

In all three monitoring events all 158 bat roost boxes were inspected. However, and as in previous monitoring events, some difficulty was encountered inspecting the wedge-shaped boxes because they have a narrow (<15mm) entrance that limits the visibility to the floor of the box and provides only a partial view of the internal roof.

Microbats were recorded inhabiting bat roost boxes in each of the three 2015/2016 monitoring events, although the occupancy rate was low (Graph 2). Only two boxes (1.3%) were occupied in spring 2015, six boxes (3.8%) in summer 2016 and three boxes (1.9%) in autumn 2016. A similarly low Microbat occupancy rate was recorded in the first year of monitoring (Graph 2). In each year, summer was the season with the highest occupancy rate; six bat roost boxes out of 158 were inhabited by Microbats. The lowest level of occupancy were recorded in spring and autumn, followed by winter.

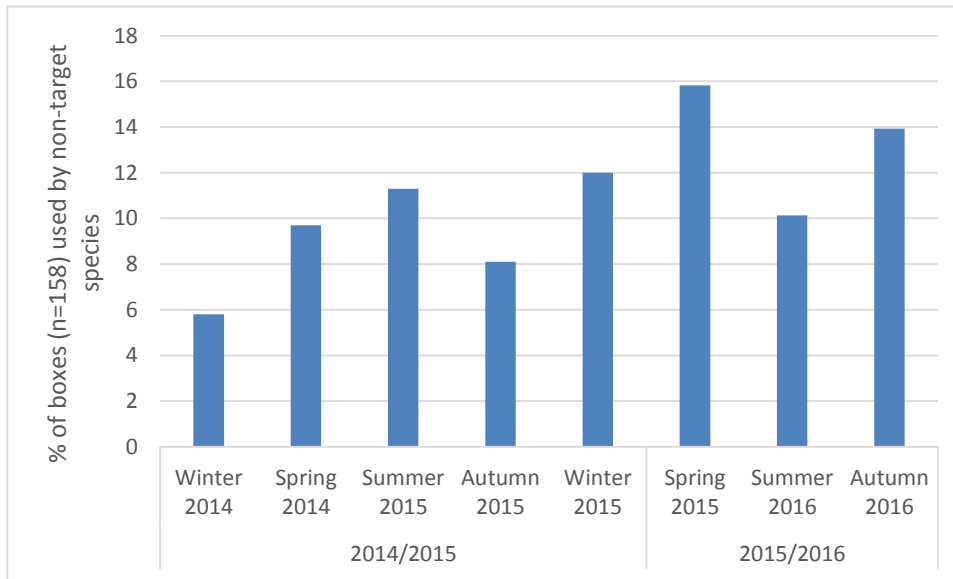
Graph 2: Bat roost box usage by Microbats during the 8 monitoring events.



As with the 2014/2015 monitoring, within the 2015/2016 surveys only the genus *Nyctophilus* (Long-eared Bat) was identified within the boxes. It was only possible to identify roosting bats to genus level in most cases as identification to species level would have required an unacceptable level of disturbance. In a few instances it was possible to identify the animals to species level within the boxes, including the Lesser Long-eared Bat (*Nyctophilus geoffroyi*) and Gould's Long-eared Bat (*Nyctophilus gouldi*).

Also, as with the first year of monitoring, the bat roost boxes have been used to a greater extent by non-target native fauna species. Twenty-five, 16 and 22 boxes were found in spring 2015, summer 2016 and autumn 2016 respectively with individuals and/or signs of non-target fauna species inhabiting them. This was evidenced by a number of boxes being found with leaf litter nests probably constructed by either the Antechinus (*Antechinus* sp.) or the Feathertail Glider (*Acrobates pygmaeus*). The numbers of boxes being used by non-target species increased from the 2014/2015 monitoring period reaching a peak in spring 2015 with 15.8 % being occupied by non-target species (Graph 3).

Graph 3: Bat roost box usage by non-target native species during the eight monitoring events.



An increased number of boxes (30 in spring 2015, 17 in summer 2016 and 26 in autumn 2016) were also found with insect material such as mud wasp nest, spider web, crystalized material and, in a few cases, active wasp or ants nest. These boxes weren't included in the non-target native species statistic because it was not possible to determine if they had been inhabited by native or introduced fauna species.

Only a few boxes (a maximum of eight in any single monitoring event) were identified as in need of minor maintenance. In spring 2015 the wire holding one box was tightening on the tree. In summer 2016 three boxes had the wire tightening on the tree, two boxes had minor deterioration, one had the back panel pushed forward and two had leaking roofs (it was possible to record the leaking inside the boxes because the survey was undertaken just after rain). In autumn 2016 for the same three boxes that had the wire tightening on the tree, two of the boxes presented minor deterioration and one had the back panel pushed forward. It was not possible to determine if these boxes were leaking as the survey was undertaken during dry conditions. In autumn 2016 one box required an internal clean-up because it was full of fine material, probably from an old termite nest.

5.5 Discussion

5.5.1 Management strategies and recommendations

Four species of Microbat were originally found inhabiting 27 (36%) of the 74 surveyed structures within the Project boundary, and they were:

- Little Bent-wing Bat (*Miniopterus australis*) found inhabiting ten structures including winter roost in Maria River bridges.
- Eastern Horseshoe Bat (*Rhinolophus megaphyllus*) detected at eight structures with most of these in the Cooperabung area.
- Southern Myotis (*Myotis macropus*) detected at six structures including a maternity roost in Smiths Creek bridge.
- Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*) restricted to one culvert (chainage 599011) near Haydons Wharf Road.

Three of these four bat species, Little Bent-wing Bat, Eastern Bent-wing Bat and Southern Myotis, are listed as Vulnerable under the TSC Act.

Autumn 2016 was the last round of Microbat roost box inspections to be undertaken as part of the first two years monitoring. In accordance with the approved EMP and the Microchiropteran Bat Management Strategy (Lewis 2013c) after these two years of monitoring, any corrective actions required need to be addressed.

Based on the last two years results, where none of the four bat species potentially impacted by the Project were recorded using any of the bat roost boxes, a combination of corrective actions are recommended to avoid, minimise and mitigate the impacts on these Microbat species.

The lack of usage of roost boxes by these species may be attributed to two main reasons: the location and the design of the roost boxes.

A comprehensive literature review revealed that Southern Myotis (*Myotis macropus*) have been recorded in timber roost boxes previously, but only if located directly above a water body. The Little Bent-wing Bat (*Miniopterus australis*), Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*) and Eastern Horseshoe Bat (*Rhinolophus megaphyllus*) are all cave dwelling bat species. In particular, the Little Bent-wing Bat and Eastern Bent-wing Bat have been found roosting in structures such as caves, tunnels, culverts and bridges, but never in timber boxes (Rueeger 2016, Rhodes and Darry 2011, Van Dyck and Strahan 2008, and Churchill 2008). Based on this information, it is unlikely that the target species will utilise the current roost boxes installed.

Alternative recommended actions that should be considered to address impact mitigation for these species are detailed below:

- Biannual monitoring of bat boxes should be replaced by an annual inspection (summer) in Year 4 and 6. Continual monitoring of the bat roost boxes is still important for monitoring other Microbat species and to keep checking the status of the nest boxes. Summer has been chosen because it is the season with the highest occupancy rate by Microbats recorded so far for the Project.
- Undertake preliminary inspections in summer and winter of all structures (culverts and bridges), within the Project, that are known or have the potential to be used by Microbats. The inspections should be undertaken as soon as possible in both summer and winter to identify the presence of any maternity (summer) and winter roosts. Maternity and winter roosts are critical in the Microbat lifecycle. Identification and protection of the roosts of these species, if they are still present within the Project boundary, will be essential to minimising and mitigating impacts on these Microbat species.
- Biannual monitoring in winter and summer of all structures (culverts and bridges) within the Project that are known or have the potential to be used by Microbats, should also be undertaken in Year 4 and Year 6. Monitoring over several years will provide information on the long-term use and thus importance/value of the structures in the landscape for mitigating impacts to the species.

Based on the results of the preliminary inspections, additional corrective actions (subject to the outcome of the above recommendations) may be required. These may include:

- Relocation of bat roost boxes directly above water bodies. Where possible, it would be preferable to attach them to a bridge or culvert structure, including new structures.
- Providing supplementary Microbat roosting habitat or by installing different design of timber and/or cement roost boxes on bridges and culverts (see Lewis 2013c and **Error! Reference source not**

found. Plate 1 below), including the newly built structures; or by removing the temporary exclusion material installed during the Microbats relocation process. Timing of installation/actions would be dependent on when construction works are completed for the different structures.

Plate 1: Artificial roost for *Myotis macropus* under bridge at Kioloa Beach NSW. Photo from Marshall (2011).



5.5.2 Performance measures

The following is a discussion of how the results obtained in the 2015/2016 monitoring events compared against the performance measures in the approved EMP.

Use of bat roost boxes by Microbats.

This performance measure has been met for the 2015/2016 monitoring period. Bat roost boxes have been used by Microbats in all three monitoring events with an average of 2.3% boxes occupied. The highest Microbat occupancy rate was recorded in summer 2016 where Microbats were recorded inhabiting six boxes (3.8%).

Only two species of bat have been identified using the bat roost boxes: Lesser Long-eared Bat and Gould's Long-eared Bat. Neither species is listed as threatened under either the NSW TSC Act or Commonwealth EPBC Act. None of the species recorded were identified as target species in the *Microchiropteran Bat Management Strategy* (Lewis 2013c).

Low rate of use of roost boxes by introduced fauna species.

Low rate was not defined in the EMP making it unclear as to what standard needs to be met. This year (and as per last year's report) an arbitrary threshold of >10% has been assigned. This value will be used hereafter as the performance measure.

Based on this proposed threshold, the performance measure as in the approved EMP has been met. No introduced fauna species have been recorded during the three monitoring events. The bat roost boxes with insect material were not included as being used by introduced fauna species because no identification of the species was possible. Also, they are not permanently used and, therefore, presumably still available for

use by Microbats. The number of bat roost boxes with insect material increased from Year 1 to Year 2 reaching its peak in spring 2015 with 30 (19%) boxes.

The number of bat roost boxes used by non-target native fauna species increased from Year 1 to Year 2 with percentages of occupancies between 10.1% and 15.8%.

During the 2015/2016 monitoring period an average of 28.7% of bat roost boxes were occupied by species other than Microbats. Corrective actions may be needed to remove insect and insect material from bat roost boxes in the future.

Low level of maintenance of roost boxes

The threshold to exceed a low rate was again not specified in the EMP and so again an arbitrary level of 10% has been set as the threshold. This value will be used unless a different threshold is specifically identified.

The performance measure as in the approved EMP has been met; a maximum of eight (5%) bat roost boxes per single monitoring events, during the 2015/2016 period, have needed minor maintenance. Note that the removal of insect nests or nesting material may in the future contribute to maintenance requirements for bat roost boxes.

Contingency measures to address failure of the Microbat roost box monitoring to achieve relevant performance criteria have not been identified in the EMP. Nest box contingency measures as per the EMP may be applicable to identify potential problems and provide recommendations for addressing them. For any recommendations and action required please see Section 5.5.1.

6. *Maundia triglochinos* Habitat Protection

The *Maundia* Habitat Protection results for the 2015/2016 monitoring period are detailed in Niche (2016d) and are summarised below. Niche (2016d) is included as **Error! Reference source not found.**

6.1 Monitoring timing

Monitoring occurred in spring (September) 2015, summer (December) 2015 and autumn (April) 2016.

6.2 Performance measures

The approved EMP specifies the following performance indicators for *Maundia triglochinos*:

Success (protection of retained populations) is indicated by:

- *Exclusion fencing, in place with signage identifying these as ‘no go’ zones*
- *Sediment control fencing in place*
- *Flowering and/or seeding is consistent with paired control and/or nearest reference site.*

6.1 Method

Three paired ‘impact - control’ monitoring sites were identified to Niche by Roads and Maritime Services staff in February 2015. Each monitoring location was surveyed in accordance with the monitoring method specified in the EMP. In summary the following measurements were undertaken at each site:

- Current extent of cover using the Braun-Blanquet scale (20m X 20m quadrat or 400 m²)
- Average water depth was estimated for the quadrat
- The extent of flowering or seeding (per cent of total number of observed plants within quadrat)
- Signs of recruitment
- Signs of disturbance (i.e. cattle) and to what extent/area
- Photo monitoring from a specific photo point.

6.2 Results

Maundia triglochinos was recorded at two of the three of the impact sites (MI01 and MI02) and only one of the three control sites (MC01) during the 2015/2016 monitoring.

Recruitment was not observed at any of the impact sites or any of the control sites.

Flowering was only recorded at MI01 and its paired control site MC01 during spring and summer. No other impact or control sites contained flowering individuals.

The monitoring data currently indicates that lifecycle processes for *Maundia triglochinos* are persisting during the construction phase with works currently occurring adjacent to the known location of this species. Further details are included in Niche (2016d) (**Error! Reference source not found.**).

6.3 Discussion

The *Maundia triglochinos* performance measures as per the monitoring program have been mostly achieved for 2015/2016 monitoring period.

Following is a discussion of how the results obtained to date compare against the performance measures from the approved EMP.

Exclusion fencing with signage identifying these as ‘no go’ zones

This performance measure for 2015/2016 monitoring period has been partially met. Exclusion fencing was in place at all impact monitoring sites. However, signage for the ‘No-go’ zones was only present at MI03.

Sediment control fencing in place

This performance measure for 2015/2016 monitoring period has been met for all impact sites. At two of the three impact sites, MI01 and MI03, sediment fencing was in place. At MI02 a sediment retention structure was installed.

Flowering and/or seeding is consistent with paired control and/or nearest reference site

This performance measure for 2015/2016 monitoring period has been met in spring and autumn, but not in the summer survey. Flowering, seeding and recruitment in spring and autumn was relatively consistent across all paired monitoring sites. In summer a substantial difference (over 15%) in flowering was recorded between MC01 (about 90% of plants were flowering) and MI01 (20% of flowering plants). However, this substantial difference cannot be directly attributed to the road impact, and is more likely the result of environmental variables between paired control and impact sites.

The differences between the percentages of individuals flowering across the paired sites could be attributed to a number of factors:

- Greater amount of shade present in MI01, given the site is located within a Swamp Sclerophyll Forest community, compared to the rather open landscape for MC01. A small portion of the MI01 quadrat is also shaded by the new bridge. Given the species grows in warm conditions, this variable may impact upon the flowering times at each of the two sites.
- Water flow, depth, turbidity, pH, nutrients, etc.
- Competition from other flora.

Signs of the habitat protection procedure not working will be based on the following:

- **Breached exclusion fencing**

No breaches in the exclusion fencing were detected during the 2015/2016 monitoring period.

- **No signage in place identifying the sensitive nature of the location as threatened species habitat**

Two of the three impact sites didn’t have signage in place identifying the sensitive nature of the locations. In order to meet this performance indicator, signage would need to be placed at the monitoring sites MI01 and MI02.

- **A significant (if statistics are used) or substantial difference (i.e. 15% allowance) between paired monitoring sites with regard to flowering/seeding and overall extent or recruitment**

Limitations in the monitoring design and method have prevented the use of statistical analyses to assess impact, but in spring and autumn flowering, seeding and recruitment were relatively consistent between the paired impact and control sites. In summer a substantial difference (over 15%) in flowering was recorded between MC01 (about 90% of plants were flowering) and MI01 (20% of flowering plants). However, this substantial difference cannot be attributed to the road impact only, and is more likely the result of environmental variables between paired control and impact sites.

7. Landscape Monitoring

Landscape monitoring involves assessing the efficacy of landscaping activities. Monitoring for this reporting period falls within the following dates: 22 June 2015 – 21 July 2016 for Kundabung to Kempsey and 22 June to 5 September 2016 for the Oxley Highway to Kundabung section of the Project.

7.1 Monitoring timing

The approved EMP states the timing and location for the landscaping monitoring surveys as follows:

- Monitoring of landscaping would commence two months after the establishment of rehabilitation sites, and be conducted again at eight 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.

7.2 Performance measures

The approved EMP specifies the following performance indicators for landscape monitoring.

Indicators of success will focus on the following:

- *Plant species must be representative of target vegetation community.*
- *Each area revegetated by native seeding must achieve the following minimum standards as assessed at 12 months following revegetation:*
 - *One native plant every 6 m²*
 - *Average minimum height of 15 cm, and*
 - *75% of required native vegetation species germinating and growing.*
- *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.*

7.3 Method

Each area revegetated by native seeding would be monitored using randomly placed 10 metre square grids placed on areas being assessed, with a minimum of three randomly placed grids per restored area. Native planted stock would not be included in these plant numbers.

All areas of native plant stock would be monitored to establish whether the performance measures in Section 7.2 have been met.

7.4 Results

The results presented in this report summarise the 2015-2016 data collected by two different sources, Lendlease for the section between Oxley Highway to Kundabung (OH2Ku) and McConnell Dowell OHL JV for the section Kundabung to Kempsey (K2K). This report includes data collected between 22 June 2015 and 21 July 2016 for the Kundabung to Kempsey section, and the 22 June 2015 and the 5 September 2016 for the

Oxley Highway to Kundabung section, due to the fact that it was preferable to include the data from the Oxley Highway to Kundabung section that was collected slightly outside the reporting period, as this should have been collected within the reporting period. Annex 6 contains the raw data obtained from Lendlease and McConnell Dowell OHL JV.

7.4.1 Data limitations and assumptions

In relation to the landscape monitoring, data was not always collected in the standardised manner indicated in the EMP and in some cases the parameters identified in the performance measures were not always specified in the data provided. Table 4 details the timing, location and party responsible for revegetation works and landscape monitoring data collection.

Table 4: Landscape data collection during construction phases.

Project phase	Period	Road portion	Data collected by	Frequency of data collection	Methodology requirement as stated in EMP	Location of Data in this report
Construction phase	July 2015-September 2016	OH2Ku	Lendlease	2, 8, 13 months	2, 8, 12 months	Annex 6
	July 2015 –July 2016	Ku2K	McConnell Dowell OHL JV	2, 8, 12 months	2, 8, 12 months	Annex 6

For both sections of the road, no information about plant species used during the revegetation process was provided. With respect to the 12 month inspections in the areas revegetated with native seeding in the Oxley Highway to Kundabung section, information with respect to plant growth, density and distribution was provided in most instances, however, the data provided was generally descriptive and subjective and did not specifically detail the information in a way that would allow for direct assessment against performance measures. In this section of the Upgrade, contractors used colour coded cells and/or descriptive text to measure/assess revegetation works (Annex 6, Table 12 and Table 13). These measurements did not fully align with parameters to be collected as identified in the performance measures. In order to be able to report against performance measures the results provided were interpreted (in consultation with the Roads and Maritime Services) according to the information in Table 5 below.

In the Oxley Highway to Kundabung section, landscape monitoring was undertaken as specified in the EMP at two, eight and 12 months following revegetation. However, in some cases, the inspection date was postponed up to six weeks due to the requirement to re-work and revegetate some sites.

Table 5: Oxley Highway to Kundabung data interpretation in relation to performance measures

Actions to Reach Performance Criteria (from OH2Ku data, Table 12 and Table 13).	Colour code (from OH2Ku data, Table 12 and Table 13).	Performance measures met?	Note
Nil	Colour coded green	Yes	
Watch and act and some minor treatments required	Colour coded yellow	Partially met	
Treatments required	Colour code red	No	
Blank	Not colour coded (blank cell)	N/A.	Revegetation needs or/had to be restarted because extra construction works have been undertaken in that location.

In the Kundabung to Kempsey section landscape monitoring was undertaken as specified in the EMP at two, eight and 12 months following regeneration. However, the contractors also used their own ranking system (presented in Table 14, Annex 6) that did not fully align with the parameters identified in the performance measures.

Based on the data provided, and determined in consultation with the Roads and Maritime Services, the parameters used to assess progress against the performance measures were: tree coverage, tree condition and ground coverage. Black text in Table 14 indicates the parameter was met, while red text indicates it was not met.

7.4.2 OH2Ku results

In the Oxley Highway to Kundabung section a total of 95 locations were revegetated by hydroseed and/or hydromulch between July 2015 and August 2016.

The revegetation works were undertaken at different times for different locations and as a result, some of the data collection periods fall outside of the 2015-2016 reporting period (data up to 5 September for the Oxley Highway to Kundabung section are included). All but two of the sites were inspected two months following the revegetation works. Of the 93 sites that were due for monitoring in this reporting period, 56 (59%) were able to be inspected eight months following revegetation and 40 (42%) were inspected 12-13 months following the revegetation works. In a few locations revegetation was restarted because extra construction works were undertaken in those locations.

At the two month inspection, it was too early to record any reliable data on tree coverage and condition.

At the eight month inspections, the general condition was determined to be acceptable in 45% of locations (25 of 56) (Annex 6, Table 12 column “Actions to Reach Performance Criteria” colour coded green and yellow) and in need of extra treatment in 9% of the locations (five of 56) (colour coded red). In 46% of locations (26 of 56) the inspection timeframes had to be restarted because extra construction works were required in these locations.

A total of 40 locations were revegetated between July and September 2015 and thus only 40 sites (of the 95) could be inspected at 12-13 months following revegetation. These results were used to assess progress

against the identified performance measures. The data interpretation in relation to performance measures has been classified according to Table 5.

Of the 40 revegetation areas, eight (20%) were in good general condition (colour coded green Table 12 and Table 13), 15 (38%) were in acceptable condition, with only the plant height not reaching the performance measure benchmark of 15 centimetres and some minor treatments being required (colour code yellow, Table 12 and Table 13). In three locations (8%) the general condition was determined to be poor and in 14 locations (35%) revegetation was restarted because extra construction works had been undertaken following the first revegetation event. Further details of the full data set are provided in Annex 6.

7.4.3 Kundabung to Kempsey results

In the Kundabung to Kempsey section a total of 54 locations were revegetated by hydroseed and/or hydromulch between July 2015 and July 2016.

The revegetation works were all undertaken at different times for different locations and, as a result, some of the data collection periods fell outside the 2015-2016 reporting period. All but three of the sites were inspected two months following the revegetation works, 30 were able to be inspected eight months following revegetation and three were inspected 12 months following the revegetation works.

At the two month inspections the only information that could be recorded was ground coverage. In most cases the revegetation works at this stage were determined to be acceptable. It was too early to record tree coverage and condition at this time.

At the eight month inspections, ground coverage was determined to be acceptable in 19 of the 30 locations (63%), in need of improvement in five (17%), in need of major improvement in four (13%) and was unacceptable in two locations (7%). It was still quite early to have reliable data for tree coverage and condition, and these parameters were recorded in only 10 of the 30 locations.

Only three locations have been monitored to date for the 12 month inspections (only three locations were revegetated in July 2015). The results for ground coverage, tree coverage and condition for these are presented in Table 6. These results were used to assess progress against the identified performance measures. Further details on the ranking system used in Table 6, and the full data set, is presented in Annex 6.

Table 6: Kundabung to Kempsey 12 months inspection results

	Tree Coverage*	Tree Condition	Ground Coverage
Fill 4	3 (2)	3 (Average height <15cm)	2 (Need major improvement)
Cut 5	4 (3-5)	3 (Average height <15cm)	4 (Acceptable)
Cut 6	4 (3-5)	4 (Average height >15cm)	4 (Acceptable)

* Tree Coverage = number natives per m² within randomly placed 10m² grid (not including landscape plants).
Red text indicates failure to meet identified performance measures

7.5 Discussion

Performance measures as per the EMP are specified following 12 months from revegetation and not before.

The majority of nominated revegetation sites were revegetated after July 2015 and therefore their progress against identified performance measures will be assessed and reported as part of the 2016-2017 reporting schedule. The 12 month monitoring event could be undertaken at only 43 locations out of 149 that were revegetated in 2015-2016. Because of that and because data were not always collected in a standardised way, results should be interpreted with caution in relation to performance measures.

7.5.4 Performance measures

During the 2015-2016 period all areas were revegetated by native seeding only. Only 43 locations were able to be assessed at this stage, having been established 12 months prior to this reporting period.

Performance measures, as identified in the EMP, have been fully met in 21% of locations. In the remaining 40% of the locations performance measures have been partially met and in most cases plant height didn't reach the benchmark of 15 centimetres. In 9% of cases revegetation condition was not acceptable and major treatment was required. For 30% of locations that were revegetated at the beginning of the 2015 monitoring period, performance measures are not applicable because these areas needed to be revegetated following extra construction works during 2015-2016 period.

7.5.5 Recommendations

As per the EMP, for areas revegetated by native seeding, as a minimum the following information should be collected at 12 months following revegetation :

- Native plant density
- Average minimum height
- Native vegetation diversity
- % weed cover.

For areas revegetated by native planting as a minimum the following information should be collected at 12 months following revegetation:

- Plant growth in cm following planting
- Plant survival rate
- % weed cover.

References

Churchill, S. K. (2008). Australian Bats. Allen and Unwin. Sydney.

DECC 2008. Hygiene protocol for the control of disease in frogs. Information Circular Number 6.

Department of Environment and Climate Change (NSW), Sydney South.

Hyder (2014). Oxley Highway to Kempsey Pacific Highway Upgrade Ecological Monitoring Program 19 September 2014. Prepared for Roads and Maritime Service by Smec Hyder Joint Venture.

Lend Lease (2014). Construction Flora and Fauna Management Sub-Plan: Oxley Highway to Kundabung. Prepared by Lend Lease for the Roads and Maritime Service, Sydney.

Lewis, B. D. (2014). Pacific Highway Upgrade: Oxley Highway to Kempsey Pre-construction Spring and Summer Baseline Monitoring. Report prepared for RPS-RMS by Lewis Ecological Surveys.

Lewis, B. D. (2013a). Pacific Highway Upgrade: Oxley Highway to Kempsey Giant Barred Frog Management Strategy. Prepared for Roads and Maritime Services by Lewis Ecological Surveys.

Lewis, B. D. (2013b). Pacific Highway Upgrade: Oxley Highway to Kempsey Green-thighed Frog Management Strategy. Prepared for Roads and Maritime Services by Lewis Ecological Surveys.

Lewis, B. D. (2013c). Pacific Highway Upgrade: Oxley Highway to Kempsey Microchiropteran Bat Management Strategy. Prepared for Roads and Maritime Services by Lewis Ecological Surveys.

Marshall, C. (2011). Investigation of the success of artificial roosts for *Myotis macropus* at Koala Beach NSW. Pages 322-323 in: The biology and conservation of Australian bats, B. Law, P. Eby, D. Lunney and L. Lumsden eds. Royal Zoological Society of NSW, Mosman.

McConnell Dowell OHL JV (2014). Construction Flora and Fauna Management Sub-Plan: Kundabung to Kempsey. Prepared by MacDonnell Dowell OHL JV for the Roads and Maritime Service, Sydney.

Naturecall Environmental (2015). Post Clearing Fauna Management Report - Pacific Highway Upgrade – Sancrox Interchange. Prepared for Ferrovial Agroman Australia.

Nelson, J., Belcher, C. and Scroggie, M. (2010). The distribution and status of the Spotted-tailed Quoll in the Snowy River and Alpine National Parks, and refinement of a remote camera survey protocol. Unpublished report to the Department of Sustainability, Environment, Water, Population and Communities. The Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, Heidelberg, Victoria.

Niche (2016a). Koala monitoring Year 1 (2015) Surveys – Oxley Highway to Kempsey, Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

Niche (2016b). Giant Barred Frog monitoring 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.

Niche (2016c). 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.

Niche (2016d). OH2K Pacific Highway Upgrade *Maundia triglochinoidea* Monitoring 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.

Niche (2105a). Giant Barred Frog monitoring Baseline Surveys – Oxley Highway to Kempsey, Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

Niche (2015b). Squirrel Glider monitoring Baseline Autumn 2014 Surveys – Oxley Highway to Kempsey Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

Rhodes, M. and Darry, J. (2011). The use of bat boxes by insectivorous bats and other fauna in the greater Brisbane region. Pages 424 - 442 in The biology and conservation of Australian bats, B. Law, P. Eby, D. Lunney and L. Lumsden eds. Royal Zoological Society of NSW, Mosman.

RMS (2016a). Oxley Highway to Kempsey Upgrade Project Construction water quality monitoring report - 22 July 2015 to 21 January 2016. Roads and Maritime Services NSW.

RMS (2016b). Oxley Highway to Kempsey Upgrade Project Construction water quality monitoring report - 21 January 2016 to 21 July 2016. Roads and Maritime Services NSW.

RPS (2013). Pacific Highway Upgrade: Oxley Highway to Kempsey Microchiropteran Roost Box Installation. Prepared by RPS Australia East Pty Ltd for Roads and Maritime Services.

Rueeger, N. (2016). Bat boxes — a review of their use and application, past, present and future. *Acta Chiropterologica*, 18(1): 279–299, 2016. Museum and Institute of Zoology PAS.

Van Dyck, S. & Strahan, R. (Eds.) (2008). The mammals of Australia. New Holland Pub Pty Limited.

Annex 1. Koala monitoring report (Niche 2016a)



Koala monitoring




Year 1 Surveys – Oxley Highway to Kempsey, Pacific Highway Upgrade

Prepared for Road and Maritime Services

27 July 2016

Document control

Document control item	Description
Project no.:	1702
Project client:	Road and Maritime Services
Project office:	Port Macquarie
Document description:	Koala Monitoring Report 2015
Project Director:	Rhidian Harrington
Project Manager:	Chris McEvoy
Authors:	Chelsea Hankin, Francesca Amorosi
Internal review:	Rhidian Harrington
Document status:	Rev1
Local Government Area:	Port Macquarie

Author	Revision	Internal review	Date issued	Signature
C Hankin	D1			
F Amorosi	Rev0	R Harrington	10/05/2016	
F Amorosi	Rev1	R Harrington	20/06/2016	
F Amorosi	Rev2	R Harrington	11/07/2016	

Niche Environment and Heritage

A specialist environmental and heritage consultancy.

Head Office

Level 1, 19 Sorrell Street
Parramatta NSW 2150
All mail correspondence to:
PO Box 2443
North Parramatta NSW 1750
Email: info@niche-eh.com

Sydney

0488 224 888

Central Coast

0488 224 999

Illawarra

0488 224 777

Armidale

0488 224 094

Newcastle

0488 224 160

Mudgee

0488 224 025

Port Macquarie

0488 774 081

Brisbane

0488 224 036

Cairns

0488 284 743

© Niche Environment and Heritage, 2016

Copyright protects this publication. Except for purposes permitted by the Australian *Copyright Act 1968*, reproduction, adaptation, electronic storage, and communication to the public is prohibited without prior written permission.

Enquiries should be addressed to Niche Environment and Heritage, PO Box 2443, Parramatta NSW 1750, Australia, email: info@niche-eh.com.

Any third party material, including images, contained in this publication remains the property of the specified copyright owner unless otherwise indicated, and is used subject to their licensing conditions.

Cover photograph: Koala from unrelated project on Liverpool Plains

Executive Summary

Context

This report documents findings from the Spring-Summer 2015 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 populations and habitat of the Koala within the study area.

Methods

Each monitoring location was surveyed in accordance with the monitoring method and design specified in SMEC-Hyder (2014).

Key results

The baseline surveys showed that the Koala was distributed across most of the study area apart from the Mingaletta-Smith Creek area, while in 2015 its recorded distribution was slightly more fragmented, particular in the northern portion of the project area. Koala presence was recorded in 83.33% of clusters during the baseline monitoring while in the 2015 monitoring Koala was present in only 45.16% of the clusters.

The overall Spot Assessment Technique (SAT) activity levels across the eight monitoring areas for the baseline survey was 4.91% (SD=7.95%), while for the 2015 monitoring it was 2.18% (SD=4.65%).

In both the baseline and 2015 surveys Koala were recorded more frequently in impact clusters than in control clusters. However, in 2015 there was no significant difference between control and impact sites.

Conclusions

Koala activity levels between the baseline and Year 1 monitoring survey appear to have decreased slightly, but for both control and impact sites. In 2015 impact sites recorded higher percentages of Koala presence than control sites. For this reason any decrease of Koala activity cannot be directly associated with the disturbance due to the Project. Therefore, with the data available to date, there is no observable change to the density, distribution, habitat use or movement patterns of Koala compared with the baseline surveys as a result of the Project.

SAT plots provide robust data compliance requirement of measuring Koala distribution, habitat use and activity levels, but only provide limited data on density, as it is not possible to determine the number of Koalas from scat records. Supplementing the SAT surveys with a direct survey technique such as spotlighting surveys would provide more robust data on Koala density.

Table of Contents

Executive Summary	i
1. Introduction	1
1.1 Context	1
1.2 Project objectives	2
1.3 Performance measures.....	2
1.4 Monitoring timing.....	2
1.5 Reporting	2
2. Survey Methodology	4
2.1 Project area	4
2.2 Monitoring design	4
2.3 Methodology	10
2.4 Analysis	11
3. Results	13
3.1 SAT plots	13
3.2 Tree species use.....	22
3.3 Weather conditions	23
4. Discussion	24
References	27
Annex 1. Koala SAT results – 2015 monitoring	28

List of Figures

Figure 1. Koala SAT plot locations 2015	12
Figure 2. Koala SAT plots results 2015.....	14
Figure 3. Koala baseline vs. 2015 monitoring.....	25

List of Tables

Table 1. Project MCoAs, SoCs and EPBC Act CoAs for the Koala.....	2
Table 2. Monitoring sites.....	4
Table 3. Koala SAT plots results 2015.....	15
Table 4. Summary of tree species used by koala during the SAT surveys.....	22
Table 5. Weather conditions during Spring-Summer 2015	23

List of Graphs

Graph 1. Percentage of clusters with Koala present by area 20

Graph 2. Koala present per treatment classes 21

Graph 3. Koala activity level per area and treatment classes 21

1. Introduction

1.1 Context

The Oxley Highway to Kempsey 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). Combined, these approvals outline 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 post construction periods.

Legal Status

The Koala (*Phascolarctos cinereus*) is listed as vulnerable under both the NSW *Threatened Species Conservation Act 1995* (TSC Act) and EPBC Act. Monitoring of the species is required under the Project's approval.

Monitoring Framework

The Project MCoA and SoC require the NSW Road and Maritime Services to manage and monitor the effectiveness of the biodiversity mitigation measures implemented as part of the Project. Monitoring of the Koala is to be performed in accordance with the Ecological Monitoring Program (EMP) (SMEC-Hyder 2014).

Baseline Data

In accordance with the EMP, baseline surveys for the Koala were undertaken to identify changes in habitat usage before and after construction of the Project, and to determine whether changes can be directly 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. The purpose of this baseline data is to enable before and after comparisons/analysis so that any change to the Koala population can be detected.

Purpose of this Report

This report details the findings obtained from the first monitoring period following the baseline surveys. It represents the first monitoring report for the construction phase of the Project.

The aim of this report is to summarise the methods and results of the spring-summer 2015 monitoring, and to compare the results with the baseline surveys to determine whether performance measures are being met and comment on whether additional measures need to be implemented.

1.2 Project objectives

The Project objectives for the Koala are specified in the MCoA, SoC and EPBC Act CoA, listed in Table 1.

Table 1. Project MCoAs, SoCs and EPBC Act CoAs for the Koala

Objective	Reference Number	Commitment	Timing
Determine the effectiveness of the flora and fauna mitigation measures.	SoC F21 MCoA 10	An adaptive monitoring program will be developed and implemented to allow the effectiveness of mitigation and offset measures to be assessed, and allow for their modification if necessary. The program will be for a minimum of six years after construction completion.	Pre-construction, construction and operation.
Prevention of wildlife mortality	SoC F19	Fauna exclusion fencing (e.g. floppy-top fencing) will be erected along the Proposal at appropriate locations to direct fauna movement towards wildlife crossing structures.	Construction.

1.3 Performance measures

The approved EMP specifies the following performance indicators for the Koala (SMEC-Hyder 2014):

- *Monitoring is undertaken during baseline surveys from Year 1 – Year 6 & 8, or until mitigation measures are demonstrated to be effective*
- *Monitoring during Year 1 – Year 6 & 8 is undertaken at the Impact and Control sites where monitoring was undertaken during baseline surveys*
- *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 & 8, and then when all monitoring events are considered at Year 8.*

1.4 Monitoring timing

The monitoring program specifies that monitoring of all sites will continue in Year 1, 2 and 3 (construction phase) once substantial construction has commenced. Following the completion of the project, monitoring will continue in Year 4, 5, 6 and 8 (operation phase) or until the mitigation measures can be demonstrated to have been effective for the koala. The location of field sites and the survey methodology are summarised in Section 2.

1.5 Reporting

Annual reporting of monitoring results will outline:

- A detailed description of the monitoring methodology employed
- 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 Infrastructure and the NSW Environment Protection Authority (EPA).

2. Survey Methodology

2.1 Project area

The Project is located on the NSW mid-north coast north from the Oxley Highway intersection with the Pacific Highway at Port Macquarie to south of the Kempsey bypass.

2.2 Monitoring design

In accordance with the baseline monitoring surveys, eight broad areas within a 20 km radius of the Project were surveyed and three types of monitoring sites were established within each:

- Treatment A: Sites with mitigation (i.e. sufficiently large culverts to allow Koalas to pass under the Highway and floppy top fencing)
- Treatment B: Sites where mitigation has not been proposed or only partial mitigation is proposed
- Treatment C: Control or reference sites located in areas at least 3 km and often 5-10 km from the Project.

These eight broad areas included 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.

Seventy two baseline SAT plots were established by Lewis (2014). Of these 72 sites 24 were mitigation, 3 part mitigation, 21 no mitigation and 24 control sites. To ensure a balanced monitoring design between impact (mitigation and not mitigation) and control sites, additional “new” control plots were established during the first monitoring event (2015) (this report).

In accordance with the baseline monitoring design these 24 “new” control sites were established at least 3 km from the project and they were grouped in clusters of 3 plots, one cluster for each of the eight broad areas.

Details of all the monitoring sites are presented in Table 2 and their locations in Figure 1.

Table 2. Monitoring sites

Monitoring Area	Treatment	Treatment sub category	Data Source	Site Name	Easting	Northing
South Sancrox	Impact	No Mitigation	Baseline	1 Sancrox East - Cassegrains	483348	6521736
South Sancrox	Impact	No Mitigation	Baseline	2 Sancrox East - Cassegrains	483455	6521789
South Sancrox	Impact	No Mitigation	Baseline	3 Sancrox East - Cassegrains	483412	6521882
South Sancrox	Impact	Mitigation	Baseline_Niche relocation	1 Sancrox South	483299	6520671
South Sancrox	Impact	Mitigation	Baseline_Niche relocation	2 Sancrox South	483254	6520383
South Sancrox	Impact	Mitigation	Baseline_Niche relocation	3 Sancrox South	483196	6520217
South Sancrox	Control	Control	Baseline	1 Cowarra State Forest	480608	6519056

Monitoring Area	Treatment	Treatment sub category	Data Source	Site Name	Easting	Northing
South Sancrox	Control	Control	Baseline	2 Cowarra State Forest	480658	6519496
South Sancrox	Control	Control	Baseline	3 Cowarra State Forest	481305	6519136
South Sancrox	Control	New Control	Niche	COWARRA NC1	479706	6518522
South Sancrox	Control	New Control	Niche	COWARRA NC2	479788	6517922
South Sancrox	Control	New Control	Niche	SAT COWARRA NC3	479795	6518227
North Sancrox	Impact	No Mitigation	Baseline	1 Sancrox North - Expressway Spares	483042	6521731
North Sancrox	Impact	No Mitigation	Baseline	2 Sancrox North - Expressway Spares	482869	6521683
North Sancrox	Impact	No Mitigation	Baseline	3 Sancrox North - Expressway Spares	482999	6521818
North Sancrox	Impact	Mitigation	Baseline	1 Fernbank Creek	483101	6523362
North Sancrox	Impact	Mitigation	Baseline	2 Fernbank Creek	483032	6523223
North Sancrox	Impact	Mitigation	Baseline	3 Fernbank Creek	483056	6523123
North Sancrox	Control	Control	Baseline	1 Lake Innes	488124	6518469
North Sancrox	Control	Control	Baseline	2 Lake Innes	488047	6518398
North Sancrox	Control	Control	Baseline	3 Lake Innes	488228	6518390
North Sancrox	Control	New Control	Niche	COWARRA NC3 -SAT COW4	479674	6516436
North Sancrox	Control	New Control	Niche	SAT COW5	479704	6516174
North Sancrox	Control	New Control	Niche	SAT COW6	479667	6515913
Cairncross State Forest (South)	Impact	No Mitigation	Baseline	1 Cairncross State Forest (South)	482428	6526536
Cairncross State Forest (South)	Impact	No Mitigation	Baseline	2 Cairncross State Forest (South)	482385	6526644
Cairncross State Forest (South)	Impact	No Mitigation	Baseline	3 Cairncross State Forest (South)	482393	6526416
Cairncross State Forest	Impact	No Mitigation	Baseline	16 Cairncross State Forest (south)	481655	6527256

Monitoring Area	Treatment	Treatment sub category	Data Source	Site Name	Easting	Northing
(south)						
Cairncross State Forest (south)	Impact	No Mitigation	Baseline	17 Cairncross State Forest (south)	481590	6527316
Cairncross State Forest (south)	Impact	No Mitigation	Baseline	18 Cairncross State Forest (south)	481637	6527175
Cairncross State Forest (South)	Impact	Mitigation	Baseline	4 Cairncross State Forest (South)	482249	6525930
Cairncross State Forest (South)	Impact	Mitigation	Baseline	5 Cairncross State Forest (South)	482125	6526077
Cairncross State Forest (South)	Impact	Mitigation	Baseline	6 Cairncross State Forest (South)	482488	6526226
Cairncross State Forest (South)	Control	Control	Baseline	1 Limeburners Creek ""The Hatch""	487011	6529909
Cairncross State Forest (South)	Control	Control	Baseline	2 Limeburners Creek ""The Hatch""	487014	6529455
Cairncross State Forest (South)	Control	Control	Baseline	3 Limeburners Creek ""The Hatch""	487035	6528694
Cairncross State Forest (South)	Control	New Control	Niche	SAT PEVI1	476817	6528422
Cairncross State Forest (South)	Control	New Control	Niche	SAT PEVI2	476730	6528225
Cairncross State Forest (South)	Control	New Control	Niche	CAIRCROSS NC1	475996	6528211
Cairncross State Forest (north)	Impact	No Mitigation	Baseline_Niche relocation	7 Cairncross State Forest (North)	481346	6530835
Cairncross State Forest (North)	Impact	No Mitigation	Baseline	8 Cairncross State Forest (North)	481695	6530786
Cairncross State Forest (North)	Impact	No Mitigation	Baseline	9 Cairncross State Forest (North)	481184	6530864

Monitoring Area	Treatment	Treatment sub category	Data Source	Site Name	Easting	Northing
Cairncross State Forest (North)	Impact	Mitigation	Baseline	10 Cairncross State Forest (north)	481238	6530264
Cairncross State Forest (North)	Impact	Mitigation	Baseline	11 Cairncross State Forest (north)	481173	6530319
Cairncross State Forest (North)	Impact	Mitigation	Baseline	12Cairncross State Forest (north)	481438	6530335
Cairncross State Forest (North)	Control	Control	Baseline	13 Cairncross State Forest (Pembrooke)	473751	6528881
Cairncross State Forest (North)	Control	Control	Baseline	14 Cairncross State Forest (Pembrooke)	473464	6528969
Cairncross State Forest (North)	Control	Control	Baseline	15 Cairncross State Forest (Pembrooke)	473424	6529115
Cairncross State Forest (North)	Control	New Control	Niche	SAT RR1	475284	6532709
Cairncross State Forest (North)	Control	New Control	Niche	SAT RR2	475113	6532603
Cairncross State Forest (North)	Control	New Control	Niche	SAT RR3	474816	6532732
Cooperabung Hill	Impact	No Mitigation	Baseline	1 Cooperabung	482793	6537012
Cooperabung Hill	Impact	No Mitigation	Baseline	2 Cooperabung	482755	6537093
Cooperabung Hill	Impact	No Mitigation	Baseline	3 Cooperabung	482876	6537115
Cooperabung Hill	Impact	Mitigation	Baseline_Niche relocation	4 Cooperabung	482481	6539327
Cooperabung Hill	Impact	Mitigation	Baseline_Niche relocation	5 Cooperabung	482364	6539761
Cooperabung Hill	Impact	Mitigation	Baseline	6 Cooperabung	482364	6538610
Cooperabung Hill	Control	Control	Baseline	1 Cooperabung Hill (Gum Scrub)	475489	6541854
Cooperabung Hill	Control	Control	Baseline	2 Cooperabung Hill (Gum Scrub)	475570	6541903

Monitoring Area	Treatment	Treatment sub category	Data Source	Site Name	Easting	Northing
Cooperabung Hill	Control	Control	Baseline	3 Cooperabung Hill (Gum Scrub)	475838	6541962
Cooperabung Hill	Control	New Control	Niche	SAT FL1	473693	6542127
Cooperabung Hill	Control	New Control	Niche	SAT ST1	473346	6543256
Cooperabung Hill	Control	New Control	Niche	SAT ST2	473682	6542890
Mingaletta to Smiths Creek	Impact	Mitigation	Baseline	1 Mingaletta-Smiths Creek	483304	6543632
Mingaletta to Smiths Creek	Impact	Mitigation	Baseline	2 Mingaletta-Smiths Creek	483444	6543585
Mingaletta to Smiths Creek	Impact	Mitigation	Baseline	3 Mingaletta-Smiths Creek	483100	6543670
Mingaletta to Smiths Creek	Control	Control	Baseline	1 Ballengara State Forest (Gregs Road)	477750	6543274
Mingaletta to Smiths Creek	Control	Control	Baseline	2 Ballengara State Forest (Gregs Road)	477644	6543623
Mingaletta to Smiths Creek	Control	Control	Baseline	3 Ballengara State Forest (Gregs Road)	477551	6543709
Mingaletta to Smiths Creek	Control	New Control	Niche	SAT BR1	477010	6544693
Mingaletta to Smiths Creek	Control	New Control	Niche	SAT BR2	476890	6544832
Mingaletta to Smiths Creek	Control	New Control	Niche	SAT BR3	476777	6544973
Kundabung Road to North of Pipers Creek	Impact	No Mitigation	Baseline	1 Kundabung	483095	6549036
Kundabung Road to North of Pipers Creek	Impact	No Mitigation	Baseline	2 Kundabung	482873	6549112
Kundabung Road to North of Pipers Creek	Impact	No Mitigation	Baseline	3 Kundabung	483285	6549374
Kundabung Road to North of Pipers Creek	Impact	Mitigation	Baseline	4 Kundabung	483369	6550655
Kundabung Road to North	Impact	Mitigation	Baseline	5 Kundabung	483331	6550938

Monitoring Area	Treatment	Treatment sub category	Data Source	Site Name	Easting	Northing
of Pipers Creek						
Kundabung Road to North of Pipers Creek	Impact	Mitigation	Baseline	6 Kundabung	483083	6550608
Kundabung Road to North of Pipers Creek	Control	Control	Baseline	1 Kumbatine National Park	476044	6549609
Kundabung Road to North of Pipers Creek	Control	Control	Baseline	2 Kumbatine National Park	476165	6549738
Kundabung Road to North of Pipers Creek	Control	Control	Baseline	3 Kumbatine National Park	475889	6549468
Kundabung Road to North of Pipers Creek	Control	New Control	Niche	SAT MAC1	476538	6552784
Kundabung Road to North of Pipers Creek	Control	New Control	Niche	SAT MAC2	476558	6552361
Kundabung Road to North of Pipers Creek	Control	New Control	Niche	SAT MAC3	476481	6552612
Maria River State Forest	Impact	Part Mitigation	Baseline_Niche relocation	1 Maria River	483074	6554460
Maria River State Forest	Impact	Part Mitigation	Baseline	2 Maria River	482836	6554330
Maria River State Forest	Impact	Part Mitigation	Baseline_Niche relocation	3 Maria River	482993	6554024
Maria River State Forest	Impact	Mitigation	Baseline	4 Maria River	482886	6552623
Maria River State Forest	Impact	Mitigation	Baseline	5 Maria River	482754	6552462
Maria River State Forest	Impact	Mitigation	Baseline	6 Maria River	483135	6552449
Maria River State Forest	Control	Control	Baseline	1 Maria River National Park	486965	6554366

Monitoring Area	Treatment	Treatment sub category	Data Source	Site Name	Easting	Northing
Maria River State Forest	Control	Control	Baseline	2 Maria River National Park	486971	6554479
Maria River State Forest	Control	Control	Baseline	3 Maria River National Park	487004	6554203
Maria River State Forest	Control	New Control	Niche	SAT CO1	486292	6552230
Maria River State Forest	Control	New Control	Niche	SAT CO3	486811	6552227
Maria River State Forest	Control	New Control	Niche	SAT MAR 1	486811	6552454

2.3 Methodology

2.3.1 Koala Spot Assessment Technique

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 utilised 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 minute 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. The activity level of a site is calculated as the percentage of surveyed trees within the site (of 30 trees) that has 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.

A total of 93 SAT plots were surveyed across the eight areas (Figure 1). These plots included the location of 69 of the existing 72 baseline SAT plots established by Lewis (2014), with the additional 24 control plots selected by Niche during the first monitoring event (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 propriety 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.

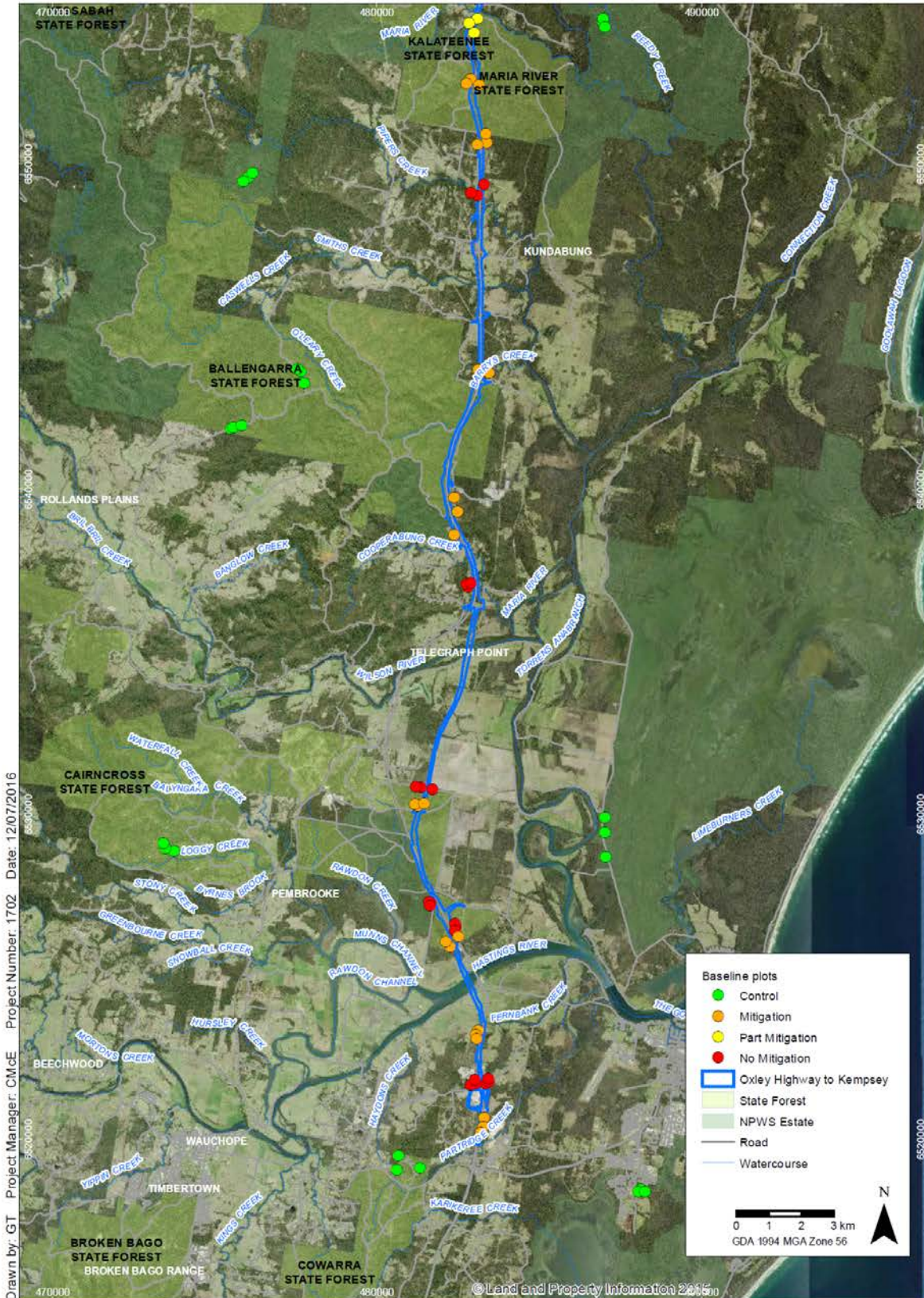
The presence (or absence) of scats was recorded, along with a number of other attributes including the species of the tree under which the scat was located. SAT plots were conducted from October to December 2015.

2.4 Analysis

The SAT results are presented separately by plot and by cluster, but most of the histograms and data analysis were undertaken by cluster only. Plots within the same cluster are not independent from each other and therefore cannot be used for most statistical analyses. Presence-absence of Koalas was allayed using data from clusters.

Given this is the first monitoring period after the baseline survey, statistical analysis was deemed unsuitable to determine a significant change in Koala tree use.

Figure 1. Koala SAT plot locations 2015



Drawn by: GT Project Manager: CMcE Date: 12/07/2016 Project Number: 1702

Koala SAT plot locations 2015

Oxley Highway to Kempsey - PI 5.1 Koala report

FIGURE 1

Imagery: (c) LPI NSW 2009

3. Results

3.1 SAT plots

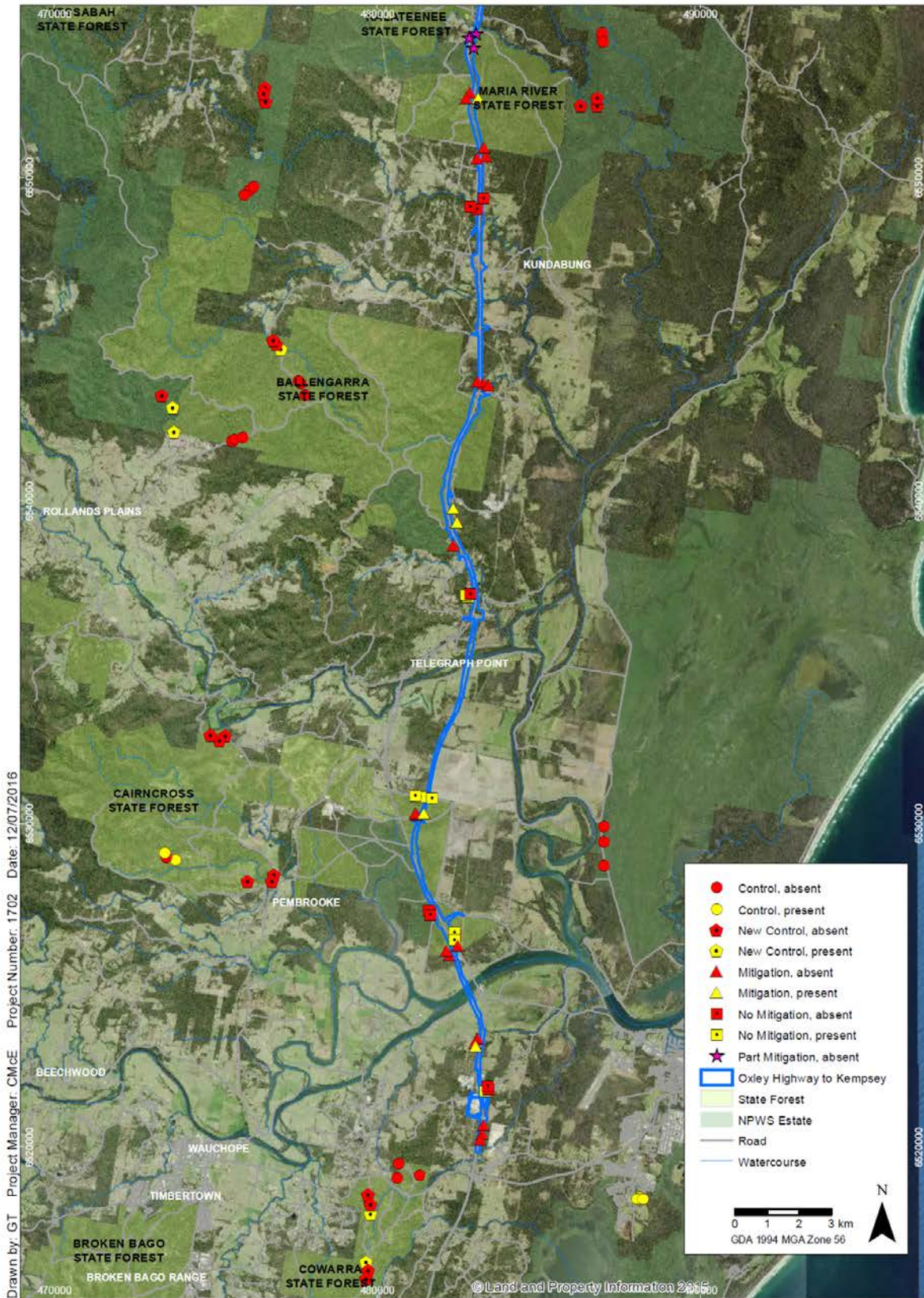
The mean SAT activity level across the 93 plots was 1.97% (SD=4.64%) (i.e. 1.97% of trees searched contained Koala faecal pellets). Koala activity was recorded from 22.81% of plots, ranging from 3.33% to 23.3% per plot.

The SAT plot activity was highest at the following locations:

- Cooperabung Hill area on the west side of the project between the Wilson River and Cooperabung Creek (chainage 18800) with activity levels reaching 23.3% (SD=8.89%)
- Southwest of Ballengarra State Forest (control sites for the Cooperabung Hill area)
- Cairncross State Forest (North) area on the east side of the road alignment (chainage 12200)
- Northeast of Lake Innes (control site for the Sancrox North area).

Based on the 2015 monitoring results Koala presence was mainly recorded in the southern and central portions of the Project area (Figure 2 and Table 3). The full data set collected during the monitoring survey is presented in Annex 1.

Figure 2. Koala SAT plots results 2015



Koala SAT plot results 2015

Oxley Highway to Kempsey - PI 5.1 Koala report

Table 3. Koala SAT plots results 2015.

Monitoring Area	Cluster	Treatment	Data Source	Site ID	Baseline Activity	2015 Year 1 Plot Activity	Baseline	2015 Year 1
South Sancrox	1	Mitigation	Baseline_Niche relocation	SANCROX S1	13.33	0	Present	Absent
		Mitigation	Baseline_Niche relocation	SANCROX S2	3.33	0		
		Mitigation	Baseline_Niche relocation	SANCROX S3	9.99	0		
	2	No Mitigation	Baseline	SANCROX E1	9.99	3.33	Present	Present
		No Mitigation	Baseline	SANCROX E2	0.00	0.00		
		No Mitigation	Baseline	SANCROX E3	0.00	0.00		
	3	Control	Baseline	COWARRA SF1	0.00	0.00	Present	Absent
		Control	Baseline	COWARRA SF2	3.33	0.00		
		Control	Baseline	COWARRA SF3	9.99	0.00		
	4	New Control	Niche	SAT COWARRA NC1		0.00	na	Present
		New Control	Niche	SAT COWARRA NC2		3.33		
		New Control	Niche	SAT COWARRA NC3		0.00		
North Sancrox	5	No Mitigation	Baseline	SANCROX N1	3.33		Present	no access
		No Mitigation	Baseline	SANCROX N2	0.00			
		No Mitigation	Baseline	SANCROX N3	0.00			
	6	Mitigation	Baseline	FERNBANK CK1	33.33	0.00	Present	Present
		Mitigation	Baseline	FERNBANK CK2	30	0.00		
		Mitigation	Baseline	FERNBANK CK3	23.33	6.66		
	7	Control	Baseline	LAKE INNES1	26.67	13.33	Present	Present

Monitoring Area	Cluster	Treatment	Data Source	Site ID	Baseline Activity	2015 Year 1 Plot Activity	Baseline	2015 Year 1
		Control	Baseline	LAKE INNES2	13.33	6.66		
		Control	Baseline	LAKE INNES3	3.33	6.66		
	8	New Control	Niche	SAT COW4		9.999.99	na	Present
		New Control	Niche	SAT COW5		0.00		
		New Control	Niche	SAT COW6		0.00		
Cairncross State Forest (South)	9	No Mitigation	Baseline	CAINCROSS SF1	0.00	0.00	Present	Present
		No Mitigation	Baseline	CAINCROSS SF2	3.33	6.66		
		No Mitigation	Baseline	CAINCROSS SF3	0.00	3.33		
	10	No Mitigation	Baseline	CAINCROSS SF16	0.00	0.00	Present	Absent
		No Mitigation	Baseline	CAINCROSS SF17	0.00	0.00		
		No Mitigation	Baseline	CAINCROSS SF18	13.33	0.00		
	11	Mitigation	Baseline	CAINCROSS SF4	3.33	0.00	Present	Absent
		Mitigation	Baseline	CAINCROSS SF5	3.33	0.00		
		Mitigation	Baseline	CAINCROSS SF6	0.00	0.00		
	12	Control	Baseline	LIMEBURNERS CK1	0.00	0.00	Present	Absent
		Control	Baseline	LIMEBURNERS CK2	3.33	0.00		
		Control	Baseline	LIMEBURNERS CK3	0.00	0.00		
	13	New Control	Niche	SAT PEVI1		0.00	na	Absent
		New Control	Niche	SAT PEVI2		0.00		
		New Control	Niche	SAT PEVI3		0.00		

Monitoring Area	Cluster	Treatment	Data Source	Site ID	Baseline Activity	2015 Year 1 Plot Activity	Baseline	2015 Year 1
Cairncross State Forest (north)	14	No Mitigation	Baseline_Niche relocation	CAINCROSS SF7	0.00	3.33	Absent	Present
		No Mitigation	Baseline	CAINCROSS SF8	0.00	20.00		
		No Mitigation	Baseline	CAINCROSS SF9	0.00	9.99		
	15	Mitigation	Baseline	CAINCROSS SF10	3.33	0.00	Present	Present
		Mitigation	Baseline	CAINCROSS SF11	3.33	0.00		
		Mitigation	Baseline	CAINCROSS SF12	6.67	3.33		
	16	Control	Baseline	CAINCROSS SF13	6.67	3.33	Present	Present
		Control	Baseline	CAINCROSS SF14	0.00	0.00		
		Control	Baseline	CAINCROSS SF15	0.00	3.33		
	17	New Control	Niche	SAT RR1		0.00	na	Absent
		New Control	Niche	SAT RR2		0.00		
		New Control	Niche	SAT RR3		0.00		
Cooperabung Hill	18	No Mitigation	Baseline	COOPERABUNG1	3.33	3.33	Present	Present
		No Mitigation	Baseline	COOPERABUNG2	0.00	23.33		
		No Mitigation	Baseline	COOPERABUNG3	9.99	0.00		
	19	Mitigation	Baseline_Niche relocation	COOPERABUNG4	0.00	3.33	Present	Present
		Mitigation	Baseline_Niche relocation	COOPERABUNG5	3.33	3.33		
		Mitigation	Baseline	COOPERABUNG6	0.00	0.00		
	20	Control	Baseline	COOP HILL1	6.67	0.00	Present	Absent
		Control	Baseline	COOP HILL2	0.00	0.00		

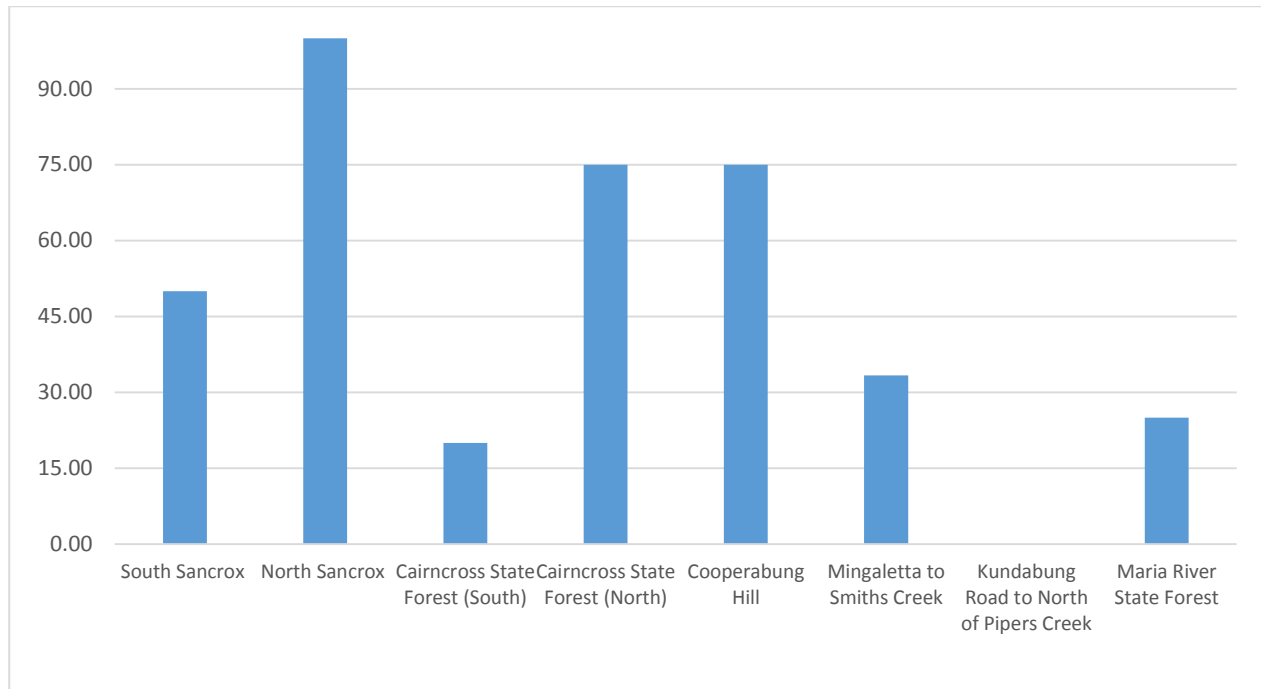
Monitoring Area	Cluster	Treatment	Data Source	Site ID	Baseline Activity	2015 Year 1 Plot Activity	Baseline	2015 Year 1
		Control	Baseline	COOP HILL3	0.00	0.00		
	21	New Control	Niche	SAT FL1		16.66	na	Present
		New Control	Niche	SAT ST1		0.00		
		New Control	Niche	SAT ST2		20.00		
Mingaletta to Smiths Creek	22	Mitigation	Baseline	MIN-SMITHS CK1	0.00	0.00	Absent	Absent
		Mitigation	Baseline	MIN-SMITHS CK2	0.00	0.00		
		Mitigation	Baseline	MIN-SMITHS CK3	0.00	0.00		
	23	Control	Baseline	BALLENGARA SF1	0.00	0.00	Absent	Absent
		Control	Baseline	BALLENGARA SF2	0.00	0.00		
		Control	Baseline	BALLENGARA SF3	0.00	0.00		
	24	New Control	Niche	SAT BR1		6.66	na	Present
		New Control	Niche	SAT BR2		0.00		
		New Control	Niche	SAT BR3		0.00		
Kundabung Road to North of Pipers Creek	25	No Mitigation	Baseline	KUNDABUNG 1	0.00	0.00	Present	Absent
		No Mitigation	Baseline	KUNDABUNG 2	9.99	0.00		
		No Mitigation	Baseline	KUNDABUNG 3	0.00	0.00		
	26	Mitigation	Baseline	KUNDABUNG 4	33.33	0.00	Present	Absent
		Mitigation	Baseline	KUNDABUNG 5	13.33	0.00		

Monitoring Area	Cluster	Treatment	Data Source	Site ID	Baseline Activity	2015 Year 1 Plot Activity	Baseline	2015 Year 1
		Mitigation	Baseline	KUNDABUNG 6	9.99	0.00		
	27	Control	Baseline	KUMBATINE NP1	3.33	0.00	Present	Absent
		Control	Baseline	KUMBATINE NP1	0.00	0.00		
		Control	Baseline	KUMBATINE NP1	0.00	0.00		
	28	New Control	Niche	SAT MAC1		0.00	na	Absent
		New Control	Niche	SAT MAC2		0.00		
		New Control	Niche	SAT MAC3		0.00		
Maria River State Forest	29	Part Mitigation	Baseline_Niche relocation	MARIA RIVER 1	0.00	0.00	Present	Absent
		Part Mitigation	Baseline	MARIA RIVER 2	3.33	0.00		
		Part Mitigation	Baseline_Niche relocation	MARIA RIVER 3	6.67	0.00		
	30	Mitigation	Baseline	MARIA RIVER 4	0.00	0.00	Absent	Present
		Mitigation	Baseline	MARIA RIVER 5	0.00	0.00		
		Mitigation	Baseline	MARIA RIVER 6	0.00	3.33		
	31	Control	Baseline	MARIA NP1	0.00	0.00	Present	Absent
		Control	Baseline	MARIA NP2	9.99	0.00		
		Control	Baseline	MARIA NP3	9.99	0.00		
	32	New Control	Niche	SAT CO1		0.00	na	Absent
		New Control	Niche	SAT CO3		0.00		
		New Control	Niche	SAT MAR 1		0.00		

The areas with the highest recorded Koala presence were: North Sancrox with three of three clusters positive for Koala presence; Cooperabung Hill and Cairncross State Forest (North) with three of four clusters containing Koala; and, South Sancrox with two of four clusters containing Koala.

No Koala scats were recorded in any of the four clusters surveyed in the Kundabung Road to north Pipers Creek area (Graph 1).

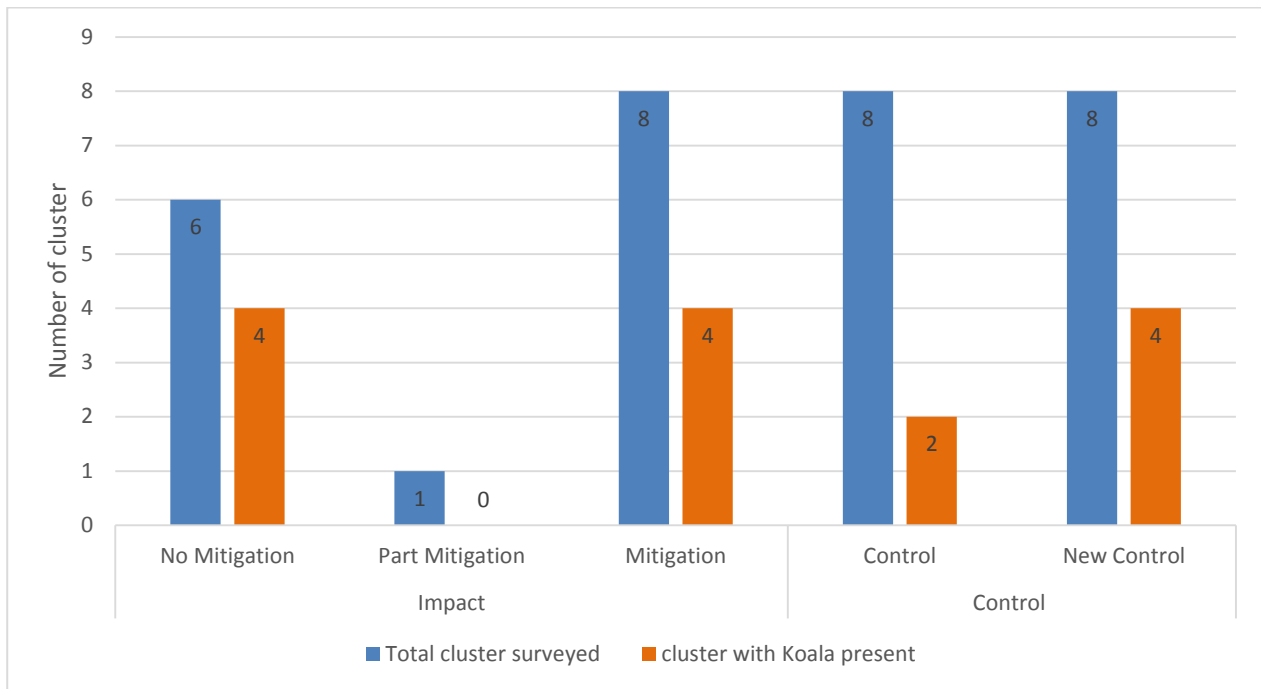
Graph 1. Percentage of clusters with Koala present by area



At a treatment level, Koala was present at 53.3% of impact clusters (8/15), but only 37.5% of control clusters (6/16).

Of the impact cluster 4/6 were No Mitigation, 0/1 Part Mitigation and 4/8 Mitigation had Koala present. Of the control clusters with Koala present 2/8 were Control, while 4/8 were new Control (Graph 2). In proportion to the number of clusters investigated per treatment class, the highest Koala presence was recorded in the No Mitigation class (66.7%) ,followed by Mitigation and New Control (50% each), and Control (25%). No Koalas were recorded in the Part Mitigation cluster.

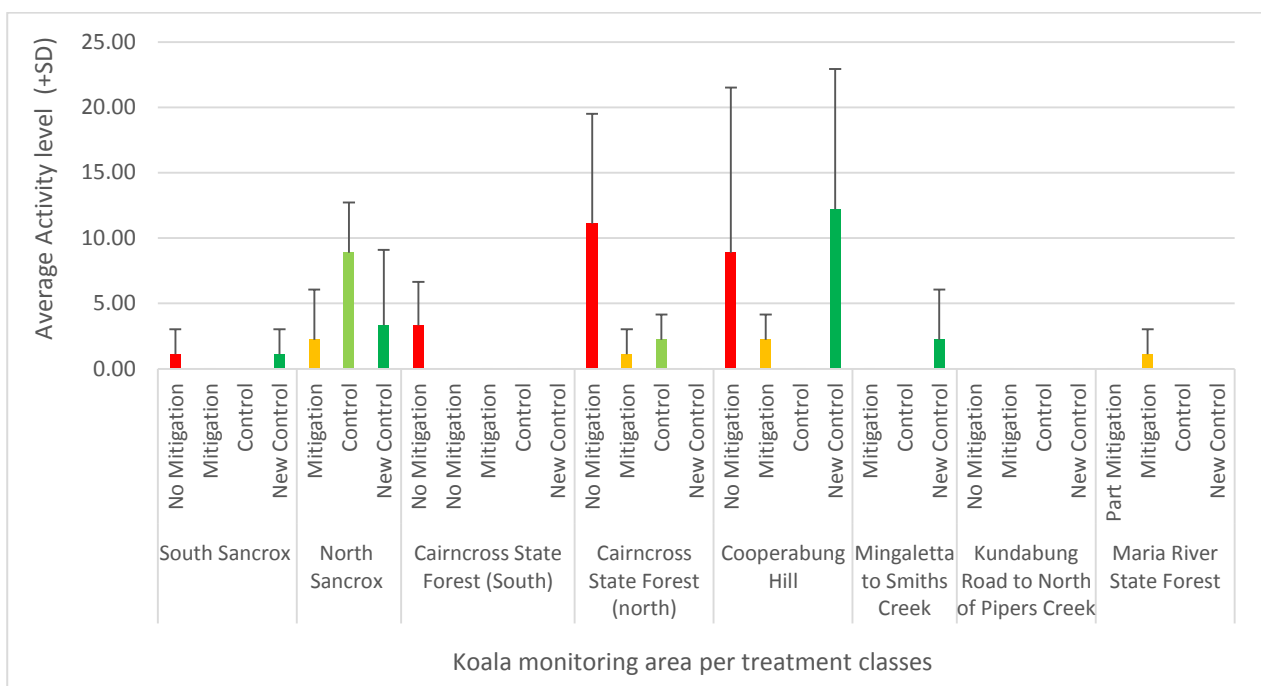
Graph 2. Koala present per treatment classes



If we compare the Koala presence/absence results between control and impact clusters using a chi-Square test there is no significant difference ($p < 0.05$). The chi-square statistic is 0.7837 and the p -value is 0.376017.

For coherence with the baseline surveys, the 2015 monitoring results are presented per koala activity level by treatment class, and by the eight broad areas as identified during the baseline survey (see Graph 3).

Graph 3. Koala activity level per area and treatment classes



3.2 Tree species use

A total of 2,790 trees were surveyed from 31 tree species. Koala scats were recorded from 17 tree species with overall tree use of 1.78% (Table 4). The tree species Koala scats were most commonly recorded beneath was Tallowwood (*Eucalyptus microcorys*), comprising 18.54% of all recorded feed tree species.

Proportionally, Koala scats were most frequently recorded beneath White Mahogany (*Eucalyptus acmenoides*) and Swamp Mahogany (*Eucalyptus robusta*), 13.3% and 13.03% respectively, and also Forest Red Gum (*Eucalyptus tereticornis*) and Thick-leaved Mahogany (*Eucalyptus carnea*), 6.67% and 5.88% respectively. However, these four tree species were uncommon at the SAT sites.

Other commonly used tree species included Tallowwood (*Eucalyptus microcorys*), Small-fruited Grey Gum (*Eucalyptus propinqua*), White Stringybark (*Eucalyptus globoidea*), Coastal Blackbutt (*Eucalyptus pilularis*) and Pink Bloodwood (*Corymbia intermedia*), with a percentage of use ranging from 1.26 to 2.78% (Table 4). Other species including Grey Ironbark (*Eucalyptus siderophloia*) and Turpentine (*Syncarpia glomulifera*) were used less often.

Table 4. Summary of tree species used by Koala during the SAT surveys

Common name	Species name	No. Trees surveyed	No. Trees with Koala scats	Proportion of use % per tree species
White Mahogany	<i>Eucalyptus acmenoides</i>	15	2	13.33
Swamp Mahogany	<i>Eucalyptus robusta</i>	23	3	13.04
Forest Red Gum	<i>Eucalyptus tereticornis</i>	45	3	6.67
Thick-leaved Mahogany	<i>Eucalyptus carnea</i>	17	1	5.88
Flooded Gum	<i>Eucalyptus grandis</i>	95	5	5.26
Broad-leaved Paperbark	<i>Melaleuca quinquenervia</i>	54	2	3.70
Prickly-leaved Tea Tree	<i>Melaleuca styphelioides</i>	28	1	3.57
Thin-leaved Stringybark	<i>Eucalyptus eugenoides</i>	98	3	3.06
Willow Bottlebrush	<i>Callistemon salignus</i>	37	1	2.70
Tallowwood	<i>Eucalyptus microcorys</i>	634	17	2.68
Small-fruited Grey Gum	<i>Eucalyptus propinqua</i>	270	4	1.48
Coastal Blackbutt	<i>Eucalyptus pilularis</i>	350	5	1.43
White Stringy bark	<i>Eucalyptus globoidea</i>	291	4	1.37
Pink Bloodwood	<i>Corymbia intermedia</i>	397	5	1.26
Forest Oak	<i>Allocasuarina torulosa</i>	314	3	0.96
Grey Ironbark	<i>Eucalyptus siderophloia</i>	139	1	0.72
Turpentine	<i>Syncarpia glomulifera</i>	305	1	0.33

3.3 Weather conditions

The weather conditions during the field surveys (from Kempsey weather station) are provided in Table 5.

Table 5. Weather conditions during Spring-Summer 2015

Date	Minimum temperature (°C)	Maximum temperature (°C)	Rainfall (mm)	Wind speed (km/hr)
27/10/2015	15	22	5.8	28
28/10/2015	11	21	2.6	11
29/10/2015	11	22	0	17
2/11/2015	15	31	0.4	37
3/11/2015	16	30	1.6	35
4/11/2015	19	24	36	37
5/11/2016	18	23	47	33
6/11/2015	18	30	10.6	33
7/12/2015	12	27	0	20
8/12/2015	14	29	0	28
9/12/2015	19	29	0	17
10/12/2015	18	29	40.2	15
21/12/2015	17	31	0	20
22/12/2015	21	26	0	20
23/12/2015	18	22	42	7

4. Discussion

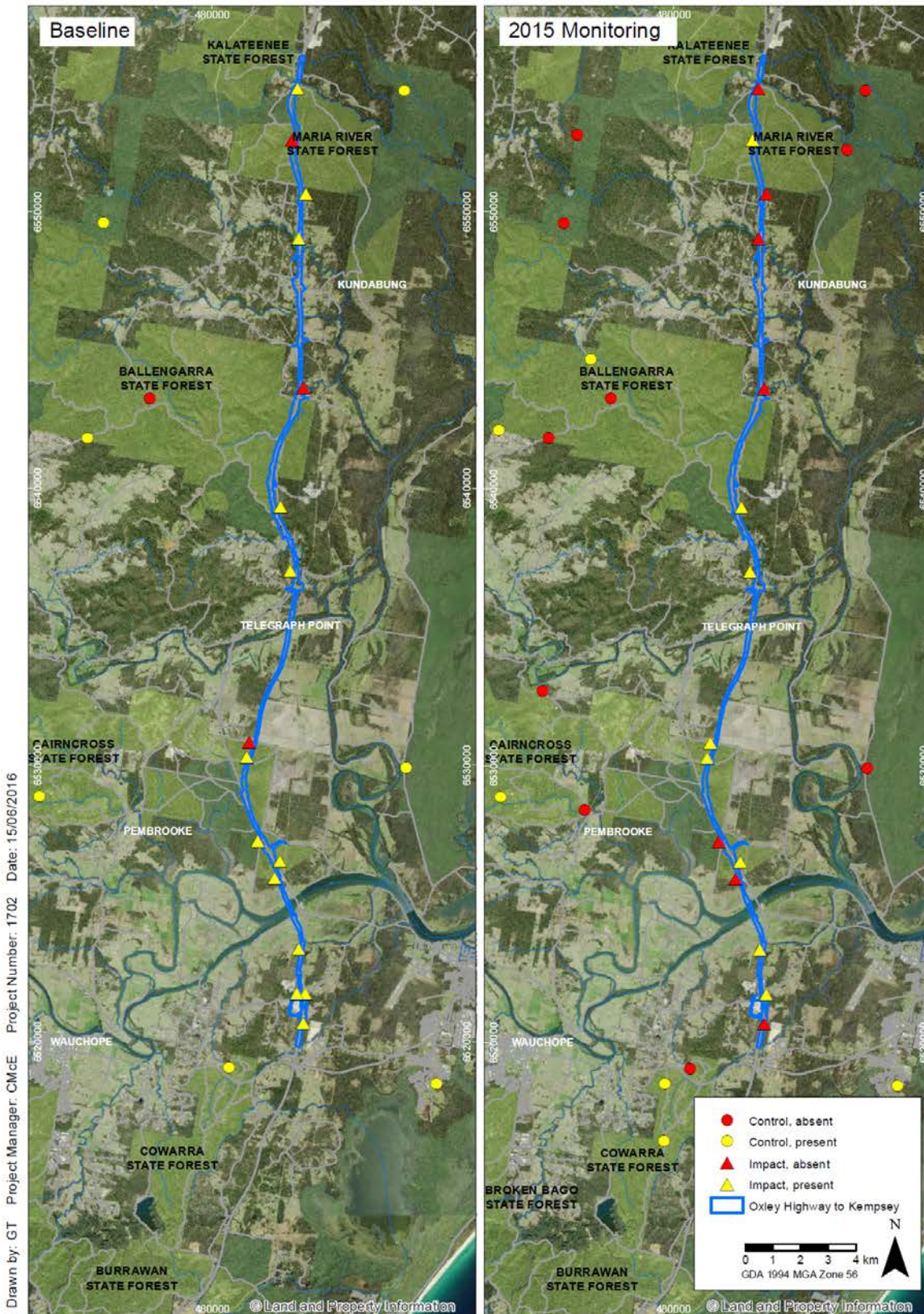
Results of SAT baseline surveys showed that Koalas were recorded across most of the study area, apart from the Mingaletta-Smith Creek area. During the 2015 monitoring Koala distribution was slightly patchier, in particular in the north portion of the Project, where Koala were only recorded from one site (Figure 3).

During the baseline monitoring Koala presence was recorded in 83.33% of clusters, while in the 2015 monitoring event Koala were present in only 45.16% of the clusters. The overall SAT activity levels across the eight monitoring areas for the baseline surveys was 4.91% (SD=7.95%), while for the 2015 monitoring it was 2.18% (SD=4.65%). Koala activity has decreased since the baseline but it is not possible to undertake any statistical analysis to compare the two monitoring periods because the baseline monitoring didn't have a balanced design (i.e. equal impact and control sites). This issues have been resolved in 2015 with the establishment of additional control sites. In both the baseline and 2015 surveys Koalas were more frequently recorded in impact clusters than in control clusters. In 2015 the difference in Koala numbers between control and impact sites was not significant.

The results of the 2015 (year 1) monitoring show that the average activity levels align with medium use on the east coast (low density area) (Philips and Callaghan, 2011), with some areas occasionally representing high use along the road corridor at Cooperabung Hill area and at Cairncross State Forest (North) area. High activity levels were also recorded in control locations southwest of Ballengarra State Forest and northeast of Lake Innes.

In future monitoring events it is recommended that the 2015 SAT plot monitoring design is maintained.

Figure 3. Koala baseline vs. 2015 monitoring



Drawn by: GT Project Manager: CMcE Project Number: 1702 Date: 15/06/2016

Koala baseline vs. 2015 monitoring
Oxley Highway to Kempsey - PI 5.1 Koala report

FIGURE 3

Imagery: (c) LPI NSW 2009

Path: T:\spatial\projects\1700\1702_OH2K_Ecology\Maps\PI_5_Ecology_OH2K\PI_51_Koala_SAT\Report\1702_Figure_3_PI51_SAT_BlvsMon.mxd

The tree species used by koala during the baseline and 2015 monitoring are almost the same, but the proportion of use for tree species it is not directly comparable because a larger sample of trees were used in 2015 compare to the baseline surveys (2,790 versus 2,160).

Following is a discussion of how the results obtained to date compare against the performance measures from the approved EMP (SMEC-Hyder 2014), and any recommendations arising from these results:

- **Monitoring is undertaken during baseline surveys from Year 1 – Year 6 & 8, or until mitigation measures are demonstrated to be effective.**
This performance measure for Year 1 has been met. SAT plots monitoring in 2015 has been undertaken as per baseline surveys.
- **Monitoring during Year 1 – Year 6 & 8 is undertaken at the Impact and Control sites where monitoring was undertaken during baseline surveys.**
This performance measure for Year 1 has been met for 95.83% of the sites. SAT plots monitoring has been undertaken in all baseline sites apart for one No Mitigation cluster in the North Sancrox area, where an access agreement with the landowner had not been finalised at the time of the survey. 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 propriety and access was not granted.
- **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 1.
- **Fauna fence is installed at a minimum in areas identified in Schedule 3 of the EPBC approval at Year 4.**
Not applicable for Year 1.
- **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.**
SAT plots provide robust data regarding Koala distribution, habitat use and activity levels, but only provide limited data on density as it is not possible to determine the number of Koala from scat records. Supplementing the SAT surveys with a direct survey technique such as spotlighting surveys would provide more robust data on Koala density.

Koala activity levels between the baseline and Year 1 monitoring survey has appears to have decreased slightly, but for both control and impact sites. In 2015 impact sites recorded higher percentages of Koala presence than control sites. For this reason any decrease of koala activity cannot be directly associated with the disturbance due to the Project. Therefore, with the data available to date, there is no observable change to the density, distribution, habitat use or movement patterns of Koala compared with the baseline surveys as a result of the Project.

References

Lewis, B.D (2014). Pacific Highway Upgrade: Oxley Highway to Kempsey Pre-construction Spring and Summer Baseline Monitoring. Report prepared for RPS-RMS by Lewis Ecological Surveys.

Niche (2015). OH2K Pacific Highway Upgrade Annual Ecological Monitoring Report 2015. Prepared for Roads and Maritime Services.

Phillips, S. and Callaghan, J. (2011). The Spot Assessment Technique: a tool for determining localised levels of habitat use by Koalas *Phascolarctos cinereus*. *Australian Zoologist* 35 (3), 774-780.

SMEC-Hyder (2014). Oxley Highway to Kempsey Pacific Highway Upgrade. Ecological Monitoring Program. SMEC-Hyder Joint Venture prepared for the Roads and Maritime Services.

Annex 1. Koala SAT results – 2015 monitoring

Area N.	Monitoring Area	Treatment	Treatment sub category	Site ID	Easting	Northing	2015_Activity	Selection criteria	DBH selection criteria tree	Radial Search area survey (distance from centre tree)	Note
1	South Sancrox	Impact	No Mitigation	SANCROX E1	483348	6521736	3.33	Tallowwood	31	40	
1	South Sancrox	Impact	No Mitigation	SANCROX E2	483455	6521789	0	Thin-leaved Stringybark	32	40	
1	South Sancrox	Impact	No Mitigation	SANCROX E3	483412	6521882	0	Tallowwood	43	40	
1	South Sancrox	Impact	Mitigation	SANCROX S1	483298.9	6520671	0	Thin-leaved Stringybark	57	80	Relocated inside RMS corridor
1	South Sancrox	Impact	Mitigation	SANCROX S2	483253.8	6520383	0	Tallowwood	30	80	Relocated inside RMS corridor
1	South Sancrox	Impact	Mitigation	SANCROX S3	483196.3	6520217	0	Tallowwood	48	80	Relocated inside RMS corridor
1	South Sancrox	Control	Control	COWARRA SF1	480608	6519056	0	Tallowwood			

Area N.	Monitoring Area	Treatment	Treatment sub category	Site ID	Easting	Northing	2015_Activity	Selection criteria	DBH selection criteria tree	Radial Search area survey (distance from centre tree)	Note
1	South Sancrox	Control	Control	COWARRA SF2	480658	6519496	0	Tallowwood			
1	South Sancrox	Control	Control	COWARRA SF3	481305	6519136	0	Tallowwood			
1	South Sancrox	Control	New Control	SAT COWARRA NC1	479706.5	6518522	0	Tallowwood		45	
1	South Sancrox	Control	New Control	SAT COWARRA NC2	479788.5	6517922	3.33	Tallowwood		45	
1	South Sancrox	Control	New Control	SAT COWARRA NC3	479795.2	6518227	0	Tallowwood	43	40	
2	North Sancrox	Impact	No Mitigation	SANCROX N1	483042	6521731		Swamp Mahogany			No access granted
2	North Sancrox	Impact	No Mitigation	SANCROX N2	482869	6521683		Tallowwood			No access granted
2	North Sancrox	Impact	No Mitigation	SANCROX N3	482999	6521818		Tallowwood			No access granted

Area N.	Monitoring Area	Treatment	Treatment sub category	Site ID	Easting	Northing	2015_Activity	Selection criteria	DBH selection criteria tree	Radial Search area survey (distance from centre tree)	Note
2	North Sancrox	Impact	Mitigation	FRENBANK CK1	483101	6523362	0	Tallowwood	64	50	
2	North Sancrox	Impact	Mitigation	FRENBANK CK2	483032	6523223	0	Tallowwood	38	50	
2	North Sancrox	Impact	Mitigation	FRENBANK CK3	483056	6523123	6.66	Tallowwood	46	50	
2	North Sancrox	Control	Control	LAKE INNES1	488124	6518469	13.33	Tallowwood		60	
2	North Sancrox	Control	Control	LAKE INNES2	488047	6518398	6.66	Swamp Mahogany		60	
2	North Sancrox	Control	Control	LAKE INNES3	488228	6518390	6.66	Swamp Mahogany		60	
2	North Sancrox	Control	New Control	SAT COW4	479673.5	6516436	10	Tallowwood			
2	North Sancrox	Control	New Control	SAT COW5	479703.9	6516174	0	Tallowwood	33	40	

Area N.	Monitoring Area	Treatment	Treatment sub category	Site ID	Easting	Northing	2015_Activity	Selection criteria	DBH selection criteria tree	Radial Search area survey (distance from centre tree)	Note
2	North Sancrox	Control	New Control	SAT COW6	479667.2	6515913	0	Tallowwood	29	40	
3	Cairncross State Forest (South)	Impact	No Mitigation	CAINCROSS SF1	482428	6526536	0	Tallowwood	36	50	
3	Cairncross State Forest (South)	Impact	No Mitigation	CAINCROSS SF2	482385	6526644	6.66	Tallowwood	55	50	
3	Cairncross State Forest (South)	Impact	No Mitigation	CAINCROSS SF3	482393	6526416	3.33	Tallowwood	54	50	
3	Cairncross State Forest (south)	Impact	No Mitigation	CAINCROSS SF16	481655	6527256	0	Tallowwood		50	
3	Cairncross State Forest (south)	Impact	No Mitigation	CAINCROSS SF17	481590	6527316	0	Tallowwood		50	
3	Cairncross State Forest (south)	Impact	No Mitigation	CAINCROSS SF18	481637	6527175	0	Tallowwood		50	
3	Cairncross State Forest (South)	Impact	Mitigation	CAINCROSS SF4	482249	6525930	0	Tallowwood			

Area N.	Monitoring Area	Treatment	Treatment sub category	Site ID	Easting	Northing	2015_Activity	Selection criteria	DBH selection criteria tree	Radial Search area survey (distance from centre tree)	Note
3	Cairncross State Forest (South)	Impact	Mitigation	CAINCROSS SF5	482125	6526077	0	Tallowwood			
3	Cairncross State Forest (South)	Impact	Mitigation	CAINCROSS SF6	482488	6526226	0	Blackbutt	74	45	
3	Cairncross State Forest (South)	Control	Control	LIMEBURNERS CK1	487011	6529909	0	Scribbly Gum		70	possible Koala scratches
3	Cairncross State Forest (South)	Control	Control	LIMEBURNERS CK2	487014	6529455	0	Scribbly Gum		70	
3	Cairncross State Forest (South)	Control	Control	LIMEBURNERS CK3	487035	6528694	0	Scribbly Gum		70	
3	Cairncross State Forest (South)	Control	New Control	SAT PEV1	476816.5	6528422	0	Tallowwood	47	30	
3	Cairncross State Forest (South)	Control	New Control	SAT PEV2	476729.8	6528225	0	Tallowwood	48	30	
3	Cairncross State Forest (South)	Control	New Control	SAT PEV3	475996.1	6528211	0	Tallowwood			

Area N.	Monitoring Area	Treatment	Treatment sub category	Site ID	Easting	Northing	2015_Activity	Selection criteria	DBH selection criteria tree	Radial Search area survey (distance from centre tree)	Note
4	Cairncross State Forest (north)	Impact	No Mitigation	CAINCROSS SF7	481346.4	6530835	3.33	Blackbutt	68	40	relocated in SF
4	Cairncross State Forest (north)	Impact	No Mitigation	CAINCROSS SF8	481695	6530786	20	Tallowwood	55	30	
4	Cairncross State Forest (north)	Impact	No Mitigation	CAINCROSS SF9	481184	6530864	10	Tallowwood	31	30	
4	Cairncross State Forest (north)	Impact	Mitigation	CAINCROSS SF10	481238	6530264	0	Swamp Mahogany			
4	Cairncross State Forest (north)	Impact	Mitigation	CAINCROSS SF11	481173	6530319	0	Tallowwood			
4	Cairncross State Forest (north)	Impact	Mitigation	CAINCROSS SF12	481438	6530335	3.33	Tallowwood	75	40	
4	Cairncross State Forest (north)	Control	Control	CAINCROSS SF13	473751	6528881	3.33	Tallowwood		45	
4	Cairncross State Forest (north)	Control	Control	CAINCROSS SF14	473464	6528969	0	Tallowwood		45	

Area N.	Monitoring Area	Treatment	Treatment sub category	Site ID	Easting	Northing	2015_Activity	Selection criteria	DBH selection criteria tree	Radial Search area survey (distance from centre tree)	Note
4	Cairncross State Forest (north)	Control	Control	CAINCROSS SF15	473424	6529115	3.33	Tallowwood		45	
4	Cairncross State Forest (north)	Control	New Control	SAT RR1	475283.5	6532709	0	Tallowwood	84	40	
4	Cairncross State Forest (north)	Control	New Control	SAT RR2	475112.7	6532603	0	Tallowwood	46	40	
4	Cairncross State Forest (north)	Control	New Control	SAT RR3	474815.7	6532732	0	Tallowwood	61	40	
5	Cooperabung Hill	Impact	No Mitigation	COOPERABUNG1	482793	6537012	3.33	Tallowwood	68	50	
5	Cooperabung Hill	Impact	No Mitigation	COOPERABUNG2	482755	6537093	23.33	Forest Red Gum	33	50	
5	Cooperabung Hill	Impact	No Mitigation	COOPERABUNG3	482876	6537115	0	Forest Red Gum	38	50	
5	Cooperabung Hill	Impact	Mitigation	COOPERABUNG4	482480.9	6539327	3.33	Tallowwood	38	25	Relocated about 500 m north in

Area N.	Monitoring Area	Treatment	Treatment sub category	Site ID	Easting	Northing	2015_Activity	Selection criteria	DBH selection criteria tree	Radial Search area survey (distance from centre tree)	Note
											SF
5	Cooperabung Hill	Impact	Mitigation	COOPERABUNG5	482363.7	6539761	3.33	Tallowwood	33	50	Relocated about 500 m North in SF
5	Cooperabung Hill	Impact	Mitigation	COOPERABUNG6	482364	6538610	0	Tallowwood		45	burn approx. 6 months prior
5	Cooperabung Hill	Control	Control	COOP HILL1	475489	6541854	0	Tallowwood		45	
5	Cooperabung Hill	Control	Control	COOP HILL2	475570	6541903	0	Tallowwood		45	
5	Cooperabung Hill	Control	Control	COOP HILL3	475838	6541962	0	Tallowwood		45	
5	Cooperabung Hill	Control	New Control	SAT FL1	473693	6542127	16.66	Flooded Gum			

Area N.	Monitoring Area	Treatment	Treatment sub category	Site ID	Easting	Northing	2015_Activity	Selection criteria	DBH selection criteria tree	Radial Search area survey (distance from centre tree)	Note
5	Cooperabung Hill	Control	New Control	SAT ST1	473346.4	6543256	0	Tallowwood			
5	Cooperabung Hill	Control	New Control	SAT ST2	473682.4	6542890	20	Flooded Gum			
6	Mingaletta to Smiths Creek	Impact	Mitigation	MIN-SMITHS CK1	483304	6543632	0	Tallowwood		45	
6	Mingaletta to Smiths Creek	Impact	Mitigation	MIN-SMITHS CK2	483444	6543585	0	Tallowwood		45	
6	Mingaletta to Smiths Creek	Impact	Mitigation	MIN-SMITHS CK3	483100	6543670	0	Forest Red Gum	38	40	
6	Mingaletta to Smiths Creek	Control	Control	BALLENGARA SF1	477750	6543274	0	Tallowwood		45	
6	Mingaletta to Smiths Creek	Control	Control	BALLENGARA SF2	477644	6543623	0	Small-fruited Grey Gum		45	
6	Mingaletta to Smiths Creek	Control	Control	BALLENGARA SF3	477551	6543709	0	Tallowwood		45	

Area N.	Monitoring Area	Treatment	Treatment sub category	Site ID	Easting	Northing	2015_Activity	Selection criteria	DBH selection criteria tree	Radial Search area survey (distance from centre tree)	Note
6	Mingaletta to Smiths Creek	Control	New Control	SAT BR1	477009.7	6544693	6.66	Tallowwood	38	40	
6	Mingaletta to Smiths Creek	Control	New Control	SAT BR2	476889.9	6544832	0	Tallowwood	51	40	
6	Mingaletta to Smiths Creek	Control	New Control	SAT BR3	476776.7	6544973	0	Flooded Gum	62	40	
7	Kundabung Road to North of Pipers Creek	Impact	No Mitigation	KUNDABUNG 1	483095	6549036	0	Tallowwood		45	
7	Kundabung Road to North of Pipers Creek	Impact	No Mitigation	KUNDABUNG 2	482873	6549112	0	Tallowwood	77	40	
7	Kundabung Road to North of Pipers Creek	Impact	No Mitigation	KUNDABUNG 3	483285	6549374	0	Tallowwood		45	
7	Kundabung Road to North of Pipers Creek	Impact	Mitigation	KUNDABUNG 4	483369	6550655	0	Tallowwood		45	

Area N.	Monitoring Area	Treatment	Treatment sub category	Site ID	Easting	Northing	2015_Activity	Selection criteria	DBH selection criteria tree	Radial Search area survey (distance from centre tree)	Note
7	Kundabung Road to North of Pipers Creek	Impact	Mitigation	KUNDABUNG 5	483331	6550938	0	Tallowwood		45	
7	Kundabung Road to North of Pipers Creek	Impact	Mitigation	KUNDABUNG 6	483083	6550608	0	Forest Red Gum	24	50	
7	Kundabung Road to North of Pipers Creek	Control	Control	KUMBATINE NP1	476044	6549609	0	Tallowwood			
7	Kundabung Road to North of Pipers Creek	Control	Control	KUMBATINE NP1	476165	6549738	0	Tallowwood			
7	Kundabung Road to North of Pipers Creek	Control	Control	KUMBATINE NP1	475889	6549468	0	Tallowwood			
7	Kundabung Road to North of Pipers Creek	Control	New Control	SAT MAC1	476537.9	6552784	0	Tallowwood			
7	Kundabung Road to North of Pipers Creek	Control	New Control	SAT MAC2	476558.1	6552361	0	White Stringy bark			

Area N.	Monitoring Area	Treatment	Treatment sub category	Site ID	Easting	Northing	2015_Activity	Selection criteria	DBH selection criteria tree	Radial Search area survey (distance from centre tree)	Note
7	Kundabung Road to North of Pipers Creek	Control	New Control	SAT MAC3	476480.9	6552612	0	Spotted Gum	59	45	
8	Maria River State Forest	Impact	Part Mitigation	MARIA RIVER 1	483074	6554460	0	Tallowwood		60	relocated about 50 m east as original point now cleared
8	Maria River State Forest	Impact	Part Mitigation	MARIA RIVER 2	482836	6554330	0	Tallowwood		50	burn in previous winter
8	Maria River State Forest	Impact	Part Mitigation	MARIA RIVER 3	482993.4	6554024	0	Tallowwood		50	relocated about 80 m east as original point now cleared
8	Maria River State Forest	Impact	Mitigation	MARIA RIVER 4	482886	6552623	0	Tallowwood			burn approx. 12 months prior
8	Maria River State Forest	Impact	Mitigation	MARIA RIVER 5	482754	6552462	0	Tallowwood			burn approx. 12 months prior

Area N.	Monitoring Area	Treatment	Treatment sub category	Site ID	Easting	Northing	2015_Activity	Selection criteria	DBH selection criteria tree	Radial Search area survey (distance from centre tree)	Note
8	Maria River State Forest	Impact	Mitigation	MARIA RIVER 6	483135	6552449	3.33	Tallowwood	35	50	
8	Maria River State Forest	Control	Control	MARIA NP1	486965	6554366	0	Tallowwood	39	30	
8	Maria River State Forest	Control	Control	MARIA NP2	486971	6554479	0	Tallowwood	51	30	
8	Maria River State Forest	Control	Control	MARIA NP3	487004	6554203	0	Tallowwood	53	30	
8	Maria River State Forest	Control	New Control	SAT CO1	486291.7	6552230	0	White Stringy bark			
8	Maria River State Forest	Control	New Control	SAT CO3	486811.4	6552227	0	Blackbutt	74	50	
8	Maria River State Forest	Control	New Control	SAT MAR 1	486810.5	6552454	0	Tallowwood			

Niche Environment and Heritage

A specialist environmental and heritage consultancy.

Head Office

Niche Environment and Heritage
PO Box W36 Parramatta NSW 2150
Email: info@niche-eh.com

All mail correspondence should be through our Head Office

Annex 2. Giant Barred Frog report (Niche 2016b)



Giant Barred Frog 2015-16 Monitoring

Oxley Highway to Kempsey, Pacific Highway Upgrade

Prepared for Road and Maritime Services

28 September 2016

Document control

Project no.: 1702

Project client: Road and Maritime Services

Project office: Port Macquarie

Document description: Monitoring Report

Project Director: Rhidian Harrington

Project Manager: Chris McEvoy

Authors: Francesca Amorosi, David Cummings

Internal review: Frank Lemckert, Chris McEvoy, Rhidian Harrington

Document status: Rev 1 - Final

Local Government Area: Port Macquarie

Author	Revision number	Internal review	Date issued	Signature
Francesca Amorosi	Rev D5	Rhidian Harrington Frank Lemckert	25/08/2016	R Harrington
Francesca Amorosi	Rev 0	Rhidian Harrington Frank Lemckert Chris McEvoy	27/09/2016	C McEvoy
Francesca Amorosi	Rev 1	Rhidian Harrington Frank Lemckert Chris McEvoy	28/09/2016	C McEvoy

© Niche Environment and Heritage, 2016

Copyright protects this publication. Except for purposes permitted by the Australian *Copyright Act 1968*, reproduction, adaptation, electronic storage, and communication to the public is prohibited without prior written permission. Enquiries should be addressed to Niche Environment and Heritage, PO Box 2443, Parramatta NSW 1750, Australia, email: info@niche-eh.com.

Any third party material, including images, contained in this publication remains the property of the specified copyright owner unless otherwise indicated, and is used subject to their licensing conditions.

Cover photograph: Giant Barred Frogs from Cooperabung Creek reference site (Photo: Frank Lemckert)

Niche Environment and Heritage

A specialist environmental and heritage consultancy.

Head Office

Level 1, 19 Sorrell Street
Parramatta NSW 2150
All mail correspondence to:
PO Box 2443
North Parramatta NSW 1750
Email: info@niche-eh.com

Sydney

0488 224 888

Central Coast

0488 224 999

Illawarra

0488 224 777

Armidale

0488 224 094

Newcastle

0488 224 160

Mudgee

0488 224 025

Port Macquarie

0488 774 081

Brisbane

0488 224 036

Cairns

0488 284 743

Executive summary

Context

This report documents findings for the 2015/2016 monitoring period (including spring 2015, summer 2016 and autumn 2016 surveys) for the Giant Barred Frog (*Mixophyes iteratus*) as required for the Oxley Highway to Kempsey (OH2K) Pacific Highway upgrade project (the Project).

Aims

The Giant Barred Frog monitoring program has the purpose of determining if the Project is having an impact upon populations and habitat of this species.

Methods

The Giant Barred Frog and its habitat is widely distributed within and outside the Project boundary. Six monitoring sites are identified (two reference and four impact). Each monitoring location was surveyed in accordance with the monitoring method and design specified in SMEC-Hyder (2014) and Lewis Ecological Surveys (2013).

Key results

A total of 162 records were made of frogs across the entire 2015/2016 monitoring period and Giant Barred Frogs were recorded at all six sites, and during all three monitoring periods. Summer surveys provided greater numbers of frog captures than in spring or autumn. The greatest counts obtained in any one survey were at the Pipers Creek Reference Site where 25 frogs were observed in the summer survey. The lowest counts obtained were at the Smiths Creek Impact Site in autumn, where only a single adult female frog was recorded.

Thirteen of the records were for recaptured individuals, representing 8% of all of the captures. This low recapture rate is resulting in population estimates with wide estimates of variance. Maximum population estimates are from the Pipers Creek Reference Site with 85 frogs (Variance = 860) and Maria River Impact site with 84 frogs (Variance = 2,720) and the lowest from the Pipers Creek Impact site with an estimate of 21.5 frogs (Variance = 24.7). High variance estimates preclude any meaningful statistical comparisons of the monitoring sites and periods.

Frogs were detected along all of the six transects and were recorded using a range of habitat types including *Lomandra*, leaf litter and bare earth. Female frogs were readily captured in all periods, whereas male frogs were captured predominantly in summer, reducing their chances of being recaptured.

Evidence of recruitment was noted at all six sites through the presence of juvenile and sub-adult frogs. Attempts to capture tadpoles resulted in two tadpoles being captured at one site over the entire survey period. The monitoring data currently indicates that lifecycle processes for Giant Barred Frog are persisting although it is not possible to make any conclusions about patterns of recruitment.

The sampling carried out for Chytrid fungus has indicated that this pathogen is present in the study area, but that its prevalence varies between sites and times of sampling. The presence of Chytrid is expected as it was detected during the baseline surveys in the Smiths Creek Impact site and in the Cooperabung Creek Reference site. Chytrid fungus infection was detected for the first time in both Pipers Creek Impact and Reference sites and in Maria River Impact site in spring 2016 and again in Pipers Creek Impact site during the summer 2016 survey.

Conclusions

There is evidence of compliance with performance indicators (i.e. persistence of Giant Barred Frog individuals and lifecycles). Chytrid testing has now confirmed Chytrid presence at Pipers Creek Impact site. No Chytrid fungus infection was detected at this site during the baseline surveys (it was only detected at Smiths Creek impact site and Cooperabung reference site).

Management implications

To contain the spread of the Chytrid fungus infection it is important that the hygiene protocol for the control of disease in frogs Information Circular Number 6 (DECC 2008) is methodically and rigorously followed for footwear but also for all vehicles that enter Giant Barred frog site/habitat where Chytrid fungus has already been detected. It is recommended to keep and review periodically a register of the wash down stations/procedures. Washdown procedures are currently present at Smiths Creek impact site and based on the 2015-2016 results should be implemented also at Pipers Creek impact site and also at Maria River Impact site. It also recommended to follow washdown procedures at Cooperabung Creek impact sites. Chytrid fungus has been previously recorded at Cooperabung Creek reference site, upstream of the impact site and even if not detected so far at the impact site, it is likely to be already present in this area.

Table of Contents

Executive summary	ii
1. Introduction	1
1.1 Context	1
1.2 Project objectives	2
1.3 Performance measures.....	2
1.4 Monitoring timing.....	3
1.5 Reporting	3
2. Survey Methods	4
2.1 Monitoring sites.....	4
2.2 Survey method	4
2.3 Water quality	5
2.4 Analysis.....	5
3. Results	7
3.1 Streamside search results.....	7
3.2 Tadpole trapping	8
3.3 Weather conditions	8
3.4 Chytrid Fungus.....	9
3.5 Habitat survey information	9
3.6 Water quality.....	9
3.7 Other observations.....	14
4. Discussion	15
4.1 Population estimates and comparisons	16
4.2 Chytrid sampling.....	16
4.3 Tadpole monitoring	17
4.4 Water quality.....	17
5. Performance Measures	18
5.5 Contingencies	19
References	20
Figures	21
Annex 1 – 2015/2016 data summary for each monitoring site	29
Cooperabung Creek Impact.....	29
Smiths Creek Impact.....	31

Pipers Creek Impact.....	33
Maria River Impact	35
Cooperabung Creek Reference.....	37
Pipers Creek Reference	39
Annex 2 – Giant Barred Frog individual frog data	41

List of Figures

Figure 1. Giant Barred Frog 2015 - 2016 monitoring: sites overview	22
Figure 2. Giant Barred Frog 2015 - 2016 monitoring: Cooperabung Creek Impact site.....	23
Figure 3. Giant Barred Frog 2015 - 2016 monitoring: Smiths Creek Impact site.....	24
Figure 4. Giant Barred Frog 2015 - 2016 monitoring: Pipers Creek Impact site	25
Figure 5. Giant Barred Frog 2015 - 2016 monitoring: Maria River Impact site	26
Figure 6. Giant Barred Frog 2015 - 2016 monitoring: Cooperabung Creek Reference site	27
Figure 7. Giant Barred Frog 2015 - 2016 monitoring: Pipers Creek Reference site	28

List of Graphs

Graph 1 Giant Barred Frogs recorded/captured, baseline vs. 2015/2016.....	15
----------------------------------------------------------------------------------	-----------

List of Tables

Table 1: Project MCoAs, SoCs and EPBC Act CoAs for the Giant Barred Frog.....	2
Table 2: Number of Giant Barred Frogs recorded at each site during 2015/2016 surveys	7
Table 3: Population estimates based on the Lincoln-Peterson Estimate with Chapman correction (variance is in brackets)	8
Table 4: Prevailing weather conditions recorded during spring 2015, summer 2016 and autumn 2016 field surveys.....	8
Table 5: Chytrid fungus detection/present within the Project sites.	9
Table 6: Water quality parameters that exceeded site specific trigger values at Cooperabung Creek.....	9
Table 7: Water quality parameters that exceeded site specific trigger values at Smith Creek	11
Table 8: Water quality parameters that exceeded site specific trigger values at Pipers Creek.....	12
Table 9: Water quality parameters that exceeded site specific trigger values at Maria Creek	13

Table 10: Comparison of baseline and 2015/2016 survey results	16
Table 11: Summary of field works and prevailing abiotic variables recorded on Cooperabung Creek impact site	29
Table 12: Habitat details recorded at Cooperabung Creek impact site	29
Table 13: Summary of captures at the Cooperabung Creek impact site.....	30
Table 14: Summary of field works and prevailing abiotic variables recorded at Smiths Creek impact site ...	31
Table 15: Habitat details recorded at Smiths Creek impact site	31
Table 16: Summary of findings from baseline surveys at the Smiths Creek impact site.....	32
Table 17: Summary of field works and prevailing abiotic variables recorded at Pipers Creek impacts site...	33
Table 18: Habitat details recorded at Pipers Creek impacts site.....	33
Table 19: Summary of findings from baseline field surveys at the Pipers Creek impacts site.....	34
Table 20: Summary of field works and prevailing abiotic variables recorded at Maria River impact site.....	35
Table 21: Habitat details recorded at Maria River impact site.....	35
Table 22: Summary of findings from baseline field surveys at the Maria River impact site	36
Table 23: Summary of field works and prevailing abiotic variables recorded at Cooperabung Creek reference site	37
Table 24: Habitat details recorded at Cooperabung Creek reference site.....	37
Table 25: Summary of findings from baseline field surveys at the Cooperabung Creek reference site	38
Table 26: Summary of field works and prevailing abiotic variables recorded at Pipers Creek reference site	39
Table 27: Habitat details recorded at recorded at Pipers Creek reference site.....	39
Table 28: Summary of finding from the baseline field surveys at the Pipers Creek reference site	40

1. Introduction

1.1 Context

The Oxley Highway to Kempsey section of the Pacific Highway Upgrade Project (the “Project”) was approved in 2012 subject to various Ministers Conditions of Approval (MCoA) and Statement of Commitments (SoC). A subsequent approval with additional conditions of consent (CoA) was granted in 2014 by the then Department of Environment (DoE) (now Department of the Environment and Energy; DEE) for matters of national environmental significance listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1995* (EPBC Act). Combined, these approvals outline the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project. The Giant Barred Frog was identified as requiring mitigation and monitoring outcomes through the course of the Projects’ construction and post construction period.

Legal Status

The Giant Barred Frog is listed as endangered on the New South Wales *Threatened Species Conservation Act* (TSC Act 1995) and Commonwealth EPBC Act. Monitoring of the species is required under the Project’s approval.

Monitoring Framework

The Project MCoA, SoC and EPBC Act CoA require the Roads and Maritime Services to manage and monitor the Giant Barred Frog. Management is to be performed in accordance with the Construction Environmental Management Plan (CEMP) and Construction Flora and Fauna Management Sub-Plans (CFFMSP) for the Oxley Highway to Kundabung section (Lend Lease 2014) and Kundabung to Kempsey section (McConnell Dowell OHL JV 2014). Appended to these sub-plans is the Giant Barred Frog Management Strategy (Lewis Ecological Surveys 2013); an important component of the species management and monitoring framework.

The design, methods and performance indicators that define the Giant Barred Frog monitoring program are specified in the approved Ecological Monitoring Plan (EMP) (SMEC-Hyder 2014) and Giant Barred Frog Management Strategy (Lewis Ecological Surveys 2013).

Baseline Data

Four distinct Giant Barred Frog sub-populations have been recorded in the Project area (SMEC-Hyder 2014). Known ‘impact’ sites within the Project area are listed below:

- Cooperabung Creek
- Smiths Creek
- Pipers Creek
- Maria River.

Baseline data is provided in Niche (2015) for these ‘impact’ sites. In addition, baseline data for two reference sites (Cooperabung Creek and Pipers Creek) is also provided in Niche (2015). The purpose of this data is to enable before and after comparisons / analysis, and thus determine whether there has been any change in Giant Barred Frog populations within the impact sites.

Purpose of this Report

This report details the findings obtained from the third monitoring period following the baseline surveys. It represents the second monitoring report for the construction phase of the Project.

The first aim of this report is to summarise the findings of spring 2015, summer 2016 and autumn 2016 Giant Barred Frog monitoring surveys (2015/2016), including the number of individuals recorded at each site, presence of Chytrid and the prevailing weather conditions.

A second aim is to compare the results with the baseline surveys to determine whether performance measures are being met and comment on whether additional measures need to be implemented.

1.2 Project objectives

The Project objectives for the Giant Barred Frog are specified in the MCoA, SoC and EPBC Act CoA and are listed in Table 1.

Table 1: Project MCoAs, SoCs and EPBC Act CoAs for the Giant Barred Frog

Objective	Reference Number	Commitment	Timing
Management of Giant Barred Frog and its habitat	MCoA B31(b)(v)	Management Strategy for the Giant Barred Frog.	Pre-construction and operation
Determine effectiveness of flora and fauna mitigation measures	SoC F21 MCoA 10	An adaptive monitoring program will be developed and implemented to allow the effectiveness of mitigation and offset measures to be assessed and allow for their modification if necessary. The program will be for a minimum of six years after construction completion.	Pre-construction, construction and operation
Prevention of wildlife mortality	SoC F19	Fauna exclusion fencing (e.g. floppy-top fencing) will be erected along the Proposal at appropriate locations to direct fauna movement towards wildlife crossing structures.	Construction

1.3 Performance measures

The approved EMP (SMEC-Hyder 2014) specifies the following performance indicators 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.
- Continued presence of Giant Barred Frogs during each survey event in Years 1 – 8 at sites where it was identified during baseline surveys.
- 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).
- 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.

1.4 Monitoring timing

The finalised Ecological Monitoring Program (EMP) required three baseline surveys for the Giant Barred Frog to be undertaken in spring, summer and autumn prior to the commencement of construction. The surveys are to cover four impact sites and two control sites.

Monitoring of all sites will continue tri-annually in years 1, 2 and 3 once substantial construction has commenced. Following the completion of the project, monitoring will continue for a further five years, or until the mitigation measures can be demonstrated to be effective. The location of field sites and the techniques employed are summarised in section 2.

1.5 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 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

As per baseline survey, 2015/2016 monitoring was undertaken in four separate ‘treatment’ habitats, where the Pacific Highway crosses creek lines known to contain the Giant Barred Frog. These include Cooperabung Creek, Smiths Creek, Pipers Creek and Maria River. Two analogue “control” stream sites, termed reference sites for this study, were also surveyed, being upstream sections of Cooperabung Creek and Pipers Creek.

Each site comprises a one kilometre transect. The treatment 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.

During 2015/2016, five of the six transects were surveyed for their entire length. The Cooperabung Creek impact site was not surveyed for the full kilometre because access agreements with landowners could not be obtained for the final zone downstream, and for the first three zones upstream.

The locations of all monitoring sites are shown on Figure 1 **Error! Reference source not found.**, with detailed locations for each site transect provided from Figure 2 to Figure 7.

2.2 Survey method

The methods used to survey the six transects follow those described in the approved Giant Barred Frog Management Strategy (Lewis 2013). Each one kilometre transect was searched for a minimum of 120 person minutes, but the time required to effectively survey a site depended on access and structure of the vegetation and so total person minutes spent on surveys varied between transects and sites. The time of arrival at the start of the survey transect was noted and the survey initiated by listening for vocalisations for 10 minutes. This was followed by calls played intermittently for 15 minutes and then listening for a further 10 minutes. Two or more surveyors then walked slowly down the sides of the stream using headlamps or spotlights to search for Giant Barred Frogs, using reflective eye shine to locate animals in the water or on the banks within 20 metres of the water. Additional call playback followed by periods of listening was undertaken at least every 50 metres along the transect. Time of finishing was recorded at the end of each transect.

When an animal was located, its position on the transect was recorded and the animal was captured, if possible. Once captured, the frog was checked to see if it had been previously marked with a Passive Integrated Transponder (PIT) tag and, if so, the number was recorded. If not, the animal was injected with a PIT tag for permanent identification. At the same time, the animal’s sex, weight, snout vent length, age status (metamorph/juvenile/adult) and breeding condition (being the condition of the nuptial pads in males or in females whether they were gravid) were all recorded and each individual was swabbed for the presence of Chytrid fungus.

Tadpole trapping was also undertaken as per the EMP. This consisted of two types of sampling. Dip-netting was undertaken through a series of 10 sweeps with a 20 centimetre diameter dip net completed every 50 metres of stream length. Tadpole trapping was undertaken by placing two standard baitfish traps (~300 millimetres by 200 millimetres) in pools in each of the ten 100 metre zones (i.e. a total of 20 traps per transect) and all left for a minimum of three hours before being inspected. Numbers and types of tadpoles captured by either method were recorded and then all tadpoles released.

The weather conditions recorded for each survey included temperature and humidity (either by windwatch or hygrometer), % cloud cover and broad wind level (scale of 0-3). Rainfall within the previous 24 hours, 7 days and 30 days was recorded from the Roads and Maritime Services Weather Stations Oxley Highway to Kempsey upgrade – Telegraph Point (station code RMSN1AWS). This data was collected to indicate the suitability of the weather conditions at the time of the surveys.

All three monitoring events (spring 2015, summer 2016 and autumn 2016) were conducted by Niche Environment and Heritage.

2.3 Water quality

Water quality measurements were conducted by the Roads and Maritime Services and data was available between 22 July 2015 and 21 July 2016 for this work (RMS 2016a, 2016b). Water quality data from both upstream and downstream sites was summarised for the following GBF habitats:

- Cooperabung Creek
- Smiths Creek
- Pipers Creek
- Maria Creek.

Water quality parameters interpreted for this monitoring included:

- electrical conductivity (EC)
- dissolved oxygen (DO)
- pH
- turbidity (NTU)
- total suspended solids (TSS)
- metals (AL, As, Cd, Cr, Cue, Fe, Pb, Mn, Hg, Ni, Ag and Zn)
- total nitrogen
- total phosphorus.

The median water quality value for downstream sites was compared with the site specific trigger values developed for the upstream site based on the 80th percentile and where relevant the 20th 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 Australia for slightly disturbed ecosystems for freshwater systems. Trigger values were derived from 24 sampling events up to and including the month indicated, where data was available.

2.4 Analysis

Population estimates of the number of individuals present at each site were undertaken from the available mark-recapture data using the Chapman correction of the Lincoln-Petersen Model (hereafter called Chapman) to reduce variability in the estimates.

The equation for the Chapman Correction used was:

$$N = \frac{(M+1)(C+1)}{R+1} - 1$$

Where:

N = Population Size Estimate

M = The total number of animals captured and marked on the first visit

C = The total number of animals located on the second visit

R = The number of animals on the first visit recaptured on the second visit.

A basic estimate of the variance of the population size was also provided using the following formula:

$$\text{Variance (N)} = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)(R+1)(R+2)}$$

The Minimum Known to be Alive (MKTBA) was also calculated (see Sutherland 2006) to provide a simple comparative measure of population size. This index is based on the number of new individuals encountered over multiple visits, where any new animals are summed, providing an aggregate total. Limitations of this method are that it does not account for any migration out of the population or any death, so may over-estimate the total population size if counts are completed over a long period of time. However, the same assumptions apply equally for the Chapman method.

3. Results

3.1 Streamside search results

A total of 162 records were made of Giant Barred Frogs during the 2015/2016 monitoring surveys, with frogs being recorded at all six sites, and during all three monitoring events (Table 2). Frogs were captured on 146 occasions, including 13 recaptures. One frog was recaptured twice. The results clearly demonstrate that the summer surveys provide greater numbers of frog captures than spring or autumn. The highest counts obtained in any one survey were at the Pipers Creek Reference site (summer = 26) and lowest at the Smiths Creek Impact site (autumn = 1). The mean number of frogs per visit was relatively uniform across sites ($n = 6.0 - 8.67$) except for the Pipers Creek Reference site that had larger number of frogs present ($n = 18.33$).

Table 2: Number of Giant Barred Frogs recorded at each site during 2015/2016 surveys

	Cooperabung Creek Impact	Smiths Creek Impact	Pipers Creek Impact	Maria River Impact	Cooperabung Creek Reference	Pipers Creek Reference
Spring	6	7	5	9	6	21
Summer	13	14	9	15	7	25
Autumn	2	1	7	4	5	9
Mean number of frogs per visit	7.00	7.33	6.00	9.33	6.00	18.33
Standard Error (SE)	3.21	3.76	1.53	3.18	0.58	4.81
MKTBA	16	21	14	24	15	46

The MKTBA count was highest at the Pipers Creek Reference Site ($n = 46$), but the estimate for the Cooperabung Creek reference site ($n = 15$) was in the same range as for the Impact Sites ($n = 14 - 24$). The raw data for the field surveys are presented in Annex 2.

The population estimates based on the Lincoln-Peterson equation with the Chapman Correction are provided in Table 3. Even with the Chapman correction the estimates of the variance associated with the counts were generally very large indicating little certainty in those estimates. For example, the Pipers Creek Reference site had a very similar overall population estimate to that for the Maria River Impact site (85 and 84 respectively), even though a much larger number of frogs were recorded at the Pipers Creek Reference Site. However, the variance estimates were 860 and 2,720 (i.e. more than 10 times the counts), demonstrating that neither estimate can be treated with any confidence. The Pipers Creek Impact site had the lowest overall population estimate being 21.5 frogs.

Table 3: Population estimates based on the Lincoln-Peterson Estimate with Chapman correction (variance is in brackets)

	Cooperabung Creek Impact	Smiths Creek Impact	Pipers Creek Impact	Maria River Impact	Cooperabung Creek Reference	Pipers Creek Reference
Spring 2015 vs Summer 2016	69 (1890)	39 (320)	19 (35)	80 (2592)	17.7 (31.1)	160.3 (4853.4)
Summer vs Autumn 2016	19 (90)	19 (90)	14 (9)	44 (720)	39 (560)	43 (209)
All visits	31 (240)	33 (272)	21.5 (24.7)	84 (2720)	69 (1820)	85 (860)

* The all visits data was analysed by comparing the autumn data against the combined spring and summer captures.

3.2 Tadpole trapping

Two ‘Barred Frog’ tadpoles *Mixophyes* sp. were caught using tadpole traps during the spring survey period at Cooperabung Creek Impact site. The tadpoles were highly likely to be Giant Barred Frogs, but positive identification is very difficult without removing animals from the field and access restrictions to the site did not allow this.

Tadpoles were infrequently observed at the other sampling sites, but were not able to be captured and their identity was uncertain.

3.3 Weather conditions

The prevailing weather conditions encountered during the field surveys are summarised in Table 4. More details of the prevailing micrometeorological conditions at the six sites during the field surveys are presented in Annex 1. Conditions were similar to those recorded during the baseline surveys.

Table 4: Prevailing weather conditions recorded during spring 2015, summer 2016 and autumn 2016 field surveys

Date	Maximum temperature (C)	Minimum temperature (C)	Humidity (%)	Rainfall in the last 24 hours (mm)	Rainfall in the last 7 days (mm)	Rainfall in the last 30 days (mm)
19/10/2015	26.0	14.6	80.7	0	17.6	77.8
20/10/2015	30.0	13.0	74.5	0	17.4	75.2
21/10/2015	30.3	15.6	72.7	0	17.4	68.2
01/02/2016	33.0	14.7	72.9	0	27.6	158.0
02/02/2016	28.1	18.9	73.9	0	22.2	158.0
03/02/2016	31.7	16.9	81	0	21.8	146.2
12/04/2016	25.4	14.7	77.2	14.2	23.0	68.6
13/04/2016	27.0	15.1	78.7	31.8	25.8	71.4
14/04/2016	24.1	11.1	85.5	39.4	26.4	72

3.4 Chytrid Fungus

Chytrid fungus sampling was carried out in all three monitoring events: spring 2015, summer 2016 and autumn 2016 surveys. During spring 2015, Chytrid fungus was detected at three of the six sites. Chytrid fungus was detected in Piper creek impact and reference sites and in Maria River impact site. In summer 2016, infected frogs were recorded only in Pipers creek impact site. Chytrid fungus was not detected from any frogs during the autumn monitoring surveys. Chytrid fungus was detected during baseline survey in Cooperabung creek reference site and in Smiths creek impact site. It was not detected in these two sites during the 2015/2016 monitoring but once detected, it is presumed this pathogen will still be present at a location on a permanent basis. So far Cooperabung creek impact is the only site where Chytrid fungus has not been detected yet (Table 5).

Table 5: Chytrid fungus detection/present within the Project sites.

	Cooperabung Creek Impact	Smiths Creek Impact	Pipers Creek Impact	Maria River Impact	Cooperabung Creek Reference	Pipers Creek Reference
Baseline	Chytrid fungus non detected	Chytrid fungus detected	Chytrid fungus non detected	Chytrid fungus non detected	Chytrid fungus detected	Chytrid fungus non detected
2015-2016	Chytrid fungus non detected	Chytrid fungus present	Chytrid fungus detected	Chytrid fungus detected	Chytrid fungus present	Chytrid fungus detected

3.5 Habitat survey information

Habitat information collected for each site is presented in Annex 1.

3.6 Water quality

A review of water quality monitoring data (RMS 2016a, 2016b) and comparison against the site specific trigger values (80th and 20th percentile) for the corresponding upstream sites allowed for the performance measure of water quality in GBF habitat to be assessed. These findings are presented as a summary of the relevant data in the sections below.

3.6.1 Cooperabung Creek

The majority of water quality parameters monitored during each sampling event for the downstream site in Cooperabung Creek conformed to the site specific trigger values. Parameters that were outside the site specific trigger value range included electrical conductivity on six occasions, total nitrogen, total suspended solids and turbidity on three occasions, and dissolved oxygen and total phosphorus on one occasion. Of these, total nitrogen also exceeded the ANZECC default trigger value, while a very low turbidity reading was also below the lower limit for the ANZECC default trigger value. For metals there were six occasions where zinc, four occasions for manganese, two occasions for aluminium, and one occasion for iron where they were detected at concentrations above the site specific trigger value. Of these zinc and aluminium were also found to be above ANZECC default trigger values (Table 6).

Table 6: Water quality parameters that exceeded site specific trigger values at Cooperabung Creek

Sampling event	Parameter	Value Downstream site (median)	Upstream Trigger (PM)	ANZECC default trigger value
August 2015	Zinc (mg/L)	0.015	0.006	0.008
September 2015	Electrical conductivity (uS/cm)	227	135-212 [#]	125-2200 ^{##}
	Turbidity (NTU)	38	10-33 [#]	6-50

Sampling event	Parameter	Value Downstream site (median)	Upstream Trigger (PM)	ANZECC default trigger value
	Zinc (mg/L)	0.01	0.006	0.008
	Total nitrogen (mg/L)	0.8	0.5	0.5
October 2016	Electrical conductivity (uS/cm)	225	135-207 [#]	125-2200 ^{##}
November 2015	Total suspended solids (mg/L)	6	5	NA
	Aluminium (mg/L)	0.49	0.37	0.055
	Total nitrogen (mg/L)	0.8	0.5	0.5
December 2015	Electrical conductivity (uS/cm)	225	140-203 [#]	125-2200 ^{##}
	Manganese (mg/L)	0.215	0.124	1.9
	Temperature (°C)	21	14.7-20.5 [#]	NA
January 2016	Total suspended solids (mg/L)	8	5	NA
February 2016	Zinc (mg/L)	0.011	0.005	0.008
March 2016	Electrical conductivity (uS/cm)	214	159-208 [#]	125-2200 ^{##}
	Total suspended solids (mg/L)	6	5	NA
	Manganese (mg/L)	0.1	0.081	1.9
	Zinc (mg/L)	0.008	0.005	0.008
April 2016	Electrical conductivity (uS/cm)	217	159-209 [#]	125-2200 ^{##}
	pH	7.8	6.8-7.5 [#]	6.5-8 ^{##}
	Manganese (mg/L)	0.161	0.099	1.9
	Zinc (mg/L)	0.011	0.006	0.008
May 2016	Dissolved oxygen (%)	57	42-79 [#]	85-110 ^{##}
	Turbidity (NTU)	3	11-28 [#]	6-50 ^{##}
	Total suspended solids (mg/L)	9	5	NA
	Iron (mg/L)	0.9	0.83	ID
	Manganese (mg/L)	0.191	0.099	1.9
	Zinc (mg/L)	0.008	0.006	0.008
June 2016	Electrical conductivity (uS/cm)	144	150-204 [#]	125-2200 ^{##}
	Dissolved oxygen (%)	87	43-85 [#]	85-110 ^{##}
	Turbidity (NTU)	47	11-40 [#]	6-50 ^{##}
	Total suspended solids (mg/L)	6	5	NA
	Aluminium (mg/L)	0.56	0.22	0.055
	Total nitrogen (mg/L)	0.6	0.5	0.5
	Total phosphorus (mg/L)	0.04	0.03	0.05

[#]Upper trigger value for the corresponding upstream site for the 80th percentile and where relevant includes the lower value derived from the 20th percentile

^{##}ANZECC upper default trigger value for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems for freshwater systems

NA – No ANZECC default trigger value available

ID – Insufficient representative data (ANZECC)

3.6.2 Smiths Creek

The majority of water quality parameters monitored during each sampling event for the downstream site in Smiths Creek conformed to the site specific trigger values. Dissolved oxygen was found to be outside the range of the site specific trigger values on four occasions (two above and two below). The two low readings in December and April were well below the ANZECC default trigger values. Electrical conductivity was also found to be outside the site specific trigger value range on three occasions (two above and one below), with the low value also below the lower ANZECC default trigger value. Also turbidity on three occasions, total suspended solids and pH and on two occasions, and total nitrogen and total phosphorus on one occasion for each were also outside the range for the site specific trigger values. Of these only total phosphorus, which was slightly above, did not meet the ANZECC default guidelines. For metals, zinc on eight occasions, manganese on three occasions, and aluminium and iron on two occasions exceeded the site specific trigger values. Of these zinc and aluminium were also regularly well above the ANZECC default trigger value (Table 7).

Table 7: Water quality parameters that exceeded site specific trigger values at Smith Creek

Sampling event	Parameter	Value Downstream site (median)	Upstream Trigger (PM)	ANZECC default trigger value
August 2015	pH	7.1	6.4-6.9 [#]	6.5-8 ^{##}
	Total suspended solids (mg/L)	15	10	NA
	Zinc (mg/L)	0.019	0.006	0.008
September 2015	Electrical conductivity (uS/cm)	307	127-295 [#]	125-2200 ^{##}
	Zinc (mg/L)	0.028	0.005	0.008
October 2015	Zinc (mg/L)	0.041	0.006	0.008
November 2015	Turbidity (NTU)	47	10-35 [#]	6-50 ^{##}
	Total suspended solids (mg/L)	7	6	NA
December 2015	Dissolved oxygen (%)	38	52-92 [#]	85-110 ^{##}
January 2016	pH	7.1	6.7-7 [#]	6.5-8 ^{##}
	Zinc (mg/L)	0.019	0.005	0.008
February 2016	Zinc (mg/L)	0.007	0.005	0.008
	Total phosphorus (mg/L)	0.05	0.03	0.05
March 2016	Manganese (mg/L)	0.121	0.064	1.9
	Zinc (mg/L)	0.008	0.005	0.008
April 2016	Dissolved oxygen (%)	29	32-75 [#]	85-110 ^{##}
	Iron (mg/L)	0.85	0.75	ID
	Manganese (mg/L)	0.209	0.09	1.9
	Zinc (mg/L)	0.012	0.006	0.008
May 2016	Electrical conductivity (uS/cm)	362	166-242 [#]	125-2200 ^{##}
	Dissolved oxygen (%)	77	28-67 [#]	85-110 ^{##}

Sampling event	Parameter	Value Downstream site (median)	Upstream Trigger (PM)	ANZECC default trigger value
	Turbidity (NTU)	6	12-25 [#]	6-50 ^{##}
	Iron (mg/L)	1.58	0.8	ID
	Manganese (mg/L)	0.348	0.147	1.9
	Zinc (mg/L)	0.015	0.007	0.008
June 2016	Electrical conductivity (uS/cm)	111	136-235 [#]	125-2200 ^{##}
	Dissolved oxygen (%)	91	28-88 [#]	85-110 ^{##}
	Turbidity (NTU)	41	13-38 [#]	6-50 ^{##}
	Aluminium (mg/L)	0.36	0.17	0.055
	Total nitrogen (mg/L)	0.6	0.4	0.5
July 2016	Aluminium (mg/L)	0.33	0.30	0.055

[#]Upper trigger value for the corresponding upstream site for the 80th percentile and where relevant includes the lower value derived from the 20th percentile

^{##}ANZECC upper default trigger value for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems for freshwater systems

NA – No ANZECC default trigger value available

ID – Insufficient representative data (ANZECC)

3.6.3 Pipers Creek

The majority of water quality parameters monitored during each sampling event for the downstream site in Pipers Creek conformed to the site specific trigger values. Electrical conductivity was found to be greater than the site specific trigger value on five occasions but within the ANZECC default trigger value. Dissolved oxygen was also found on two occasions to be above the site specific trigger value but within ANZECC default trigger value. A very high result for turbidity was recorded in September, which was well above both the 80th percentile and ANZECC guideline trigger value however this reflected similarly elevated upstream turbidity. The only other occurrence where turbidity did not meet the site specific trigger value was due to a low turbidity value. On one occasion pH was slightly above the site specific trigger value but remained within the ANZECC default trigger values. Total phosphorus was found to be above both trigger values in January. For metals, zinc, aluminium, nickel and iron were elevated at times throughout the 12 months. Of these aluminium and zinc did occur at times at relatively high concentrations that were well above both trigger values (Table 8).

Table 8: Water quality parameters that exceeded site specific trigger values at Pipers Creek

Sampling event	Parameter	Value Downstream site (median)	Upstream Trigger (PM)	ANZECC default trigger value
August 2015	Electrical conductivity (uS/cm)	369	178-276 [#]	125-2200 ^{##}
September 2015	Electrical conductivity (uS/cm)	384	178-314 [#]	125-2200 ^{##}
	Turbidity (NTU)	134	16-54 [#]	6-50 ^{##}
October 2015	Electrical conductivity (uS/cm)	375	178-351 [#]	125-2200 ^{##}
	Zinc (mg/L)	0.013	0.007	0.008

Sampling event	Parameter	Value Downstream site (median)	Upstream Trigger (PM)	ANZECC default trigger value
November 2015	Aluminium (mg/L)	0.58	0.23	0.055
December 2015	Dissolved oxygen (%)	30	39-81 [#]	85-110 ^{##}
January 2016	pH	7.2	6.6-7.1 [#]	6.5-8 ^{##}
	Iron (mg/L)	1.02	0.90	ID
	Total Phosphorus (mg/L)	0.07	0.03	0.05
February 2016	Iron (mg/L)	1.23	0.96	ID
April 2016	Electrical conductivity (uS/cm)	468	283-394 [#]	125-2200 ^{##}
	Manganese (mg/L)	0.299	0.207	1.9
	Zinc (mg/L)	0.011	0.007	0.008
May 2016	Electrical conductivity (uS/cm)	523	238-422 [#]	125-2200 ^{##}
	Dissolved oxygen (%)	64	26-59 [#]	85-110 ^{##}
	Nickel (mg/L)	0.002	0.001	0.011
July 2016	Dissolved oxygen (%)	78	26-76 [#]	85-110 ^{##}
	Turbidity (NTU)	15	16-49 [#]	6-50 ^{##}
	Aluminium (mg/L)	1.02	0.22	0.055

[#]Upper trigger value for the corresponding upstream site for the 80th percentile and where relevant includes the lower value derived from the 20th percentile

^{##}ANZECC upper default trigger value for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems for freshwater systems

NA – No ANZECC default trigger value available

ID – Insufficient representative data (ANZECC)

3.6.4 Maria River

The majority of water quality parameters monitored during each sampling event for the downstream site in Maria Creek conformed to the site specific trigger values. Parameters that exceeded the trigger values included electrical conductivity and total suspended solids on two occasions, and dissolved oxygen, and total phosphorus on one occasion for each. Of these only total phosphorus exceeded the ANZECC default trigger value. Turbidity was found to be low on two occasions and outside the range of the site specific trigger values, but within the ANZECC default trigger value (Table 9). For metals, manganese was found to be above the site specific trigger value on seven occasions, but remained below the ANZECC default trigger value. Additionally aluminium, arsenic, copper, iron and nickel were also found to exceed the site specific trigger value on occasions. Of these, only aluminium and copper occurred at concentrations above the ANZECC default trigger value as well (Table 9).

Table 9: Water quality parameters that exceeded site specific trigger values at Maria Creek

Sampling event	Parameter	Value Downstream site (median)	Upstream Trigger (PM)	ANZECC default trigger value
August 2016	Electrical conductivity (uS/cm)	329	107-240 [#]	125-2200 ^{##}
	Turbidity (NTU)	14	18-44 [#]	6-50 ^{##}
September 2015	Electrical conductivity (uS/cm)	317	127-277 [#]	125-2200 ^{##}

Sampling event	Parameter	Value Downstream site (median)	Upstream Trigger (PM)	ANZECC default trigger value
	Manganese (mg/L)	0.372	0.186	1.9
October 2015	Manganese (mg/L)	0.372	0.186	1.9
November 2015	Aluminium (mg/L)	0.95	0.83	0.055
December 2015	Dissolved oxygen (%)	21	25-72 [#]	85-110 ^{##}
	Arsenic (mg/L)	0.002	0.001	0.024
	Copper (mg/L)	0.002	0.001	0.0014
	Iron (mg/L)	1.26	1.06	ID
	Manganese (mg/L)	0.205	0.175	1.9
	Nickel (mg/L)	0.002	0.001	0.011
January 2016	Total suspended solids (mg/L)	16	5-14 [#]	NA
	Total Phosphorus (mg/L)	0.06	0.04	0.05
February 2016	Total suspended solids (mg/L)	19	5-14 [#]	NA
	Iron (mg/L)	1.22	1.15	ID
	Manganese (mg/L)	0.002	0.001	1.9
March 2016	Arsenic (mg/L)	0.002	0.001	0.024
	Manganese (mg/L)	0.182	0.174	1.9
April 2016	Manganese (mg/L)	0.223	0.198	1.9
May 2016	Arsenic (mg/L)	0.002	0.001	0.024
	Iron (mg/L)	1.15	1.01	ID
	Manganese (mg/L)	0.220	0.208	1.9
June 2016	Aluminium (mg/L)	0.77	0.42	0.055
July 2016	Turbidity (NTU)	11	24-65 [#]	6-50 ^{##}
	Nickel (mg/L)	0.002	0.001	0.011

[#]Upper trigger value for the corresponding upstream site for the 80th percentile and where relevant includes the lower value derived from the 20th percentile

^{##}ANZECC upper default trigger value for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems for freshwater systems

NA – No ANZECC default trigger value available

ID – Insufficient representative data (ANZECC)

3.7 Other observations

Exotic predators or competitors were not noted during any of the monitoring survey periods. Exotic fish have been notable by their absence. There has been no indication of disturbance of habitat by pigs nor significant evidence of fox or cat activity that may impact on this species. Cattle activity at Smiths Creek was evident during the autumn survey and did cause some obvious disturbance to the banks of the creek.

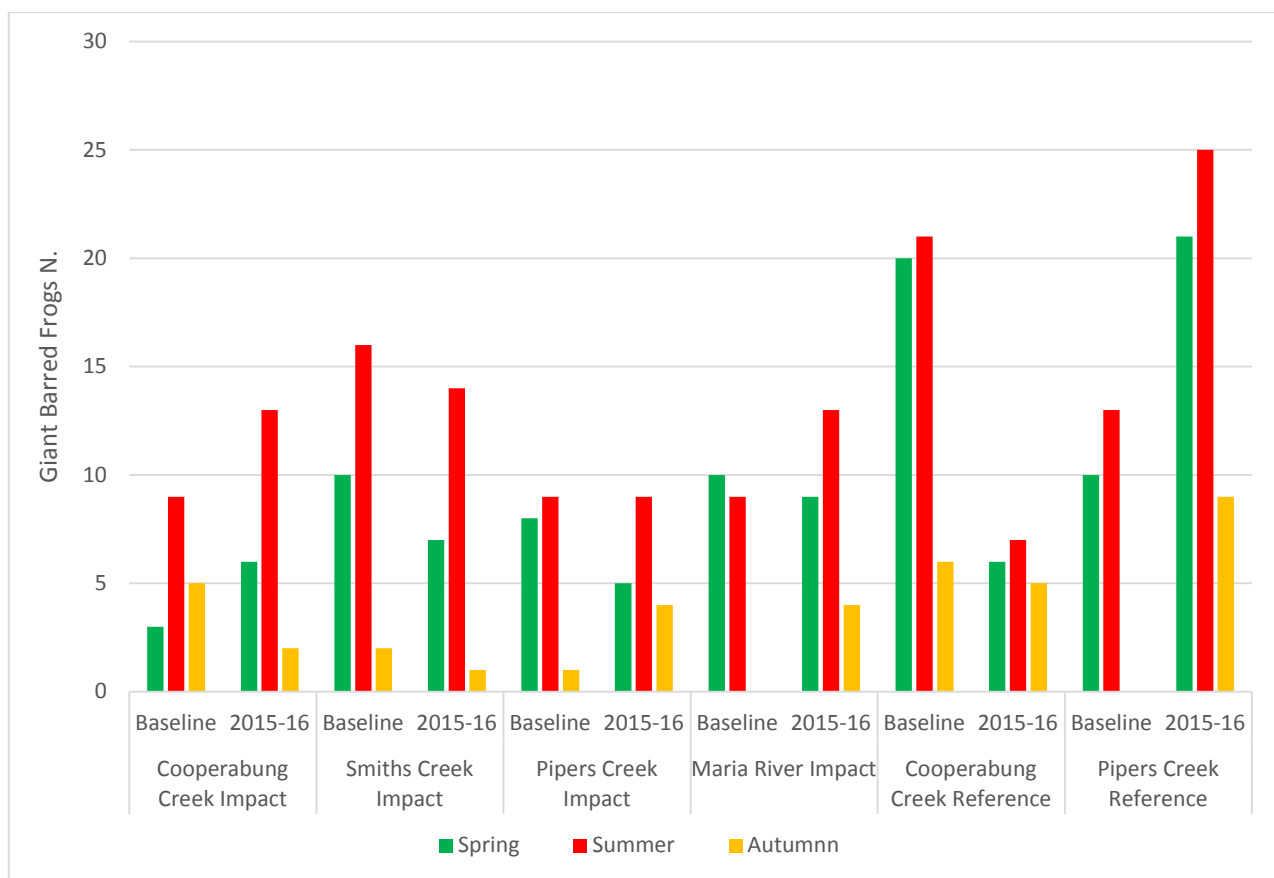
4. Discussion

During baseline surveys, the Giant Barred Frog was recorded across all six monitoring sites in spring and summer and in four sites in autumn (**Graph 1**; Table 10). No frogs were detected during the autumn 2014 survey in the Maria River Impact site or Pipers Creek Reference site. In contrast, during the 2015/2016 surveys, Giant Barred Frogs were recorded across all six sites in all three monitoring events (**Graph 1**).

In both the baseline and 2015/2016 surveys the counts clearly varied across the three monitoring periods, with the highest numbers of frogs recorded/captured in all but one instance occurring in summer and the lowest always occurring in autumn. Autumn results were always substantially lower than the other two periods, reflecting low frog activity in autumn. Also, calling and reproduction has ceased by autumn making frogs less easy to detect.

Notably, within these results was the distribution of records for the three categories of frogs. Females were readily detected in all three seasons, whereas male frogs were predominantly recorded in summer and juveniles mainly in autumn. This suggests differences in catchability of the sexes and age groups, depending on the season of the surveys. This does have a significant influence on recapture rates if males are only easily captured in the summer sampling period. Given the very limited number of recaptures for females, it also suggests that individuals are not active every night, and perhaps many nights, or different individuals are active at different times of the year.

Graph 1 Giant Barred Frogs recorded/captured, baseline vs. 2015/2016



MKTBA for the baseline survey and 2015/2016 surveys are relatively similar for the impact sites, with two sites having an increase in numbers, one a decrease and the other no change. The reference sites

presented opposite results to each other with the Cooperabung Creek reference MKTBA decreasing between baseline and 2015/2016, whereas at the Pipers Creek reference site the MKTBA increased.

In 2015/2016 Giant Barred Frogs were distributed broadly across all six transects, including downstream of the Cooperabung Creek Impact site, which had relatively few frogs recorded there previously. Previously the creek in this section had been essentially dry with only the occasional shallow pool. In summer 2016 the creek was flowing across its length and large pool areas were available for the frog to call adjacent to and breed in.

Habitat use was broad with frogs being located in all of the available microhabitats.

Table 10: Comparison of baseline and 2015/2016 survey results

	Coop Creek Impact		Smiths Creek Impact		Pipers Creek Impact		Maria River Impact		Coop Creek Reference		Pipers Creek Reference	
	Base-line	2015/2016	Base-line	2015/2016	Base-line	2015/2016	Base-line	2015/2016	Base-line	2015/2016	Base-line	2015/2016
Mean number of frogs per visit	5.67	7.00	9.33	7.33	6.00	6.00	6.33	9.33	15.67	6.00	7.67	18.33
Standard Error (SE)	1.76	3.21	4.06	3.76	2.52	1.53	3.18	3.18	4.84	0.58	3.93	4.81
MKTBA	15	16	26	21	14	14	15	24	45	15	23	46

4.1 Population estimates and comparisons

The use of the Chapman correction again provided population estimates with significant variance and so it is difficult to draw meaningful conclusions from the results. The high variance in the estimates of the populations precludes any rigorous statistical comparisons of the results as the high variances make it impossible to detect differences in estimates between sites or between years. The general capture and population results to date do not show any clear indications of declines at any site.

These variances will decrease if recapture rates increase, but recapture rates during both the baseline and 2015/2016 surveys were very low. Modification of the prescribed survey methodology may improve recapture rates and in turn provide more robust population estimates.

There are no losses of populations and all sites continue to support frogs of both sexes and juvenile frogs.

4.2 Chytrid sampling

The sampling carried out for Chytrid fungus has indicated that this pathogen is present in the study area, but that its prevalence varies between sites and times of sampling. The presence of Chytrid is expected as it was detected during the baseline surveys in the Smiths Creek Impact site and in the Cooperabung Creek Reference site. Chytrid fungus infection was detected for the first time in both Pipers Creek Impact and Reference sites and in Maria River Impact site in spring 2016 and again in Pipers Creek Impact site during the summer 2016 survey.

To contain the spread of the Chytrid fungus infection, it is important that the hygiene protocol for the control of disease in frogs Information Circular Number 6 (DECC 2008) be methodically and rigorously followed for footwear but also for all vehicles that enter Giant Barred frog site/habitat where Chytrid fungus has already been detected. It is recommended to keep and review periodically a register of the wash down stations/procedures. Washdown procedures are currently present at Smiths Creek impact site and based on the 2015-2016 results, should be implemented also at Pipers Creek impact site and also at Maria River Impact site. It also recommended to follow washdown procedures at Cooperabung Creek impact sites. Chytrid fungus has been previously recorded at Cooperabung Creek reference site, upstream of the impact site and even if not detected so far at the impact site it is likely to be already present on this area.

4.3 Tadpole monitoring

No “Barred Frog” tadpoles have been recorded in any of the six sites during the baseline surveys. Tadpoles were collected only on one occasion and in only one of the six monitoring sites (spring 2015 in the Cooperabung Creek Impact site) during the 2015/2016 surveys. However, reproduction can and has been concluded to have been successful due to the presence of juvenile and sub-adult frogs at all sites. Both bait trapping and dip-netting have demonstrated a very low catching rate. There is no clear guidance in the EMP document (SMEC-Hydr 2014) as to the reason to collect tadpoles nor a performance measure placed against the result and so the lack of success in capturing tadpoles does not influence the success of meeting the performance measures.

4.4 Water quality

Review of water quality monitoring data indicated that electrical conductivity was found to be higher than the upstream trigger value regularly throughout the 12 months. However, these values, while slightly elevated, were well within ANZECC guideline trigger values and have been reported to be typically consistent between upstream and downstream values when elevated (RMS 2016), indicating that these exceedances are unlikely related to construction activities. Although other water quality parameters were exceeded (i.e. dissolved oxygen, pH, turbidity and total suspended solids) they were typically minimal, infrequent and likely to be short-term occurrences with minimal potential for ecological impact on Giant Barred Frog habitat. Further discussion of these results is provided in Appendix A of the 2015/16 Annual Report.

Metal and nutrients were also found to exceed the 80th percentile based trigger value from the upstream site at times. Of these metals, aluminium, manganese and zinc were the most common metals found at elevated levels. Aluminium was regularly recorded above the trigger value and at levels 10 times or more the ANZECC guideline trigger value. Zinc was also commonly above the trigger value and ANZECC default value. While manganese showed slight elevated concentrations at times above the trigger value, but typically remained well within ANZECC default values. Given that it has been reported that, “elevated levels of metals were generally experienced concurrently both upstream and downstream” and that where “differences between upstream and downstream locations were recorded, this typically coincided with monitoring locations persisting as isolated ponds” (RMS 2016), it is likely that these typically short-term and infrequent elevations in metals are reflective of environmental variability at the subject sites and influences independent of the construction activities. There is no information available to indicate if such high levels of metals are likely to have negative impacts on the Giant Barred Frog, but if they are natural fluctuations for these creeks, then it would appear to be unlikely that they would have an impact.

5. Performance Measures

- **Monitoring is undertaken during baseline surveys and Years 1 – 8 or until monitoring can demonstrate that mitigation measures are effective.**

This performance measure for 2015/2016 has been met. Giant Barred Frog monitoring has been undertaken in all six baseline sites.

- **Monitoring during Year 1 – 8 is undertaken at the Impact and Control sites where baseline monitoring was undertaken.**

This performance measure for 2015/2016 has been met. Giant Barred Frog monitoring has been undertaken in all six baseline sites, except for Cooperabung Creek impact site that was not surveyed for the full kilometre because access agreements with landowners could not be obtained for the final zone downstream, and for the first three zones upstream. However, this section of stream was still monitored in the main, and population estimates were able to be completed.

- **Continued presence of Giant Barred Frogs during each survey event in Year 1 – 8 at sites where it was identified during baseline surveys.**

This performance measure has been met for 2015/2016. During the baseline surveys, the Giant Barred Frog was recorded at all six monitoring sites in spring and summer and in 4 sites in autumn. During 2015/2016 surveys the Giant Barred Frog was recorded at all six sites in all three monitoring events.

- **Mitigation measures are effective as defined in the EPBC approval when all monitoring events are considered at Year 8.**

Not applicable for 2015/2016 monitoring period as this is not the Year 8 period.

- **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).**

Several water quality parameters exceeded the 80th percentile values, but only on occasions and they appear to be more likely be related to local stream variations rather than construction activity. Given the early stages of monitoring it is not reasonable to conclude that this is a result of impacts from road construction and so it is considered at this time that the performance measure has largely been met.

- **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.**

The data obtained on the population estimates and actual counts vary greatly between events and years, but the number of frogs recorded do not clearly indicate significant changes in any of the monitored populations between the baseline and 2015/2016 surveys. The distribution of frogs remains widespread across the sites and transects and habitat use similarly remains widespread across the sites and transects. However, the results do not allow for meaningful comment on movement patterns of frogs.

Based on the data obtained, all of the performance measures for 2015/2016 are considered to have been met.

5.5 Contingencies

The EMP describes contingencies for potential problems identified in the construction and post construction period. For the Giant Barred Frog, the contingencies measures state that:

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.

No actions are required to be taken at this time as there is no indication of any decline in the Giant Barred Frog population.

References

Department of Environment and Climate Change (NSW) 2008. Hygiene protocol for the control of disease in frogs. Information Circular Number 6. DECC (NSW), Sydney South.

Kruger, K.M. & Hero, J.M. (2007). Large-scale seasonal variation in the prevalence and severity of chytridiomycosis. *Journal of Zoology* 271: 352-359.

Lend Lease (2014). Construction Flora and Fauna Management Sub-Plan: Oxley Highway to Kundabung. Prepared by Lend Lease for the Roads and Maritime Service, Sydney.

Lewis (2013). Pacific Highway Upgrade: Oxley Highway to Kempsey Giant Barred Frog Management Strategy. Prepared for Roads and Maritime Services by Lewis Ecological Surveys.

MacDonnell Dowell OHL JV (2014). Construction Flora and Fauna Management Sub-Plan: Kundabung to Kempsey. Prepared by MacDonnell Dowell OHL JV for the Roads and Maritime Service, Sydney.

Niche (2015). Giant Barred Frog monitoring: Baseline Surveys – Oxley Highway to Kempsey, Pacific Highway Upgrade. Report prepared for Roads and Maritime Services by Niche Environment and Heritage Pty Ltd.

RMS (2016a). Oxley Highway to Kempsey Upgrade Project Construction water quality monitoring report - 22 July 2015 to 21 January 2016. Roads and Maritime Services NSW.

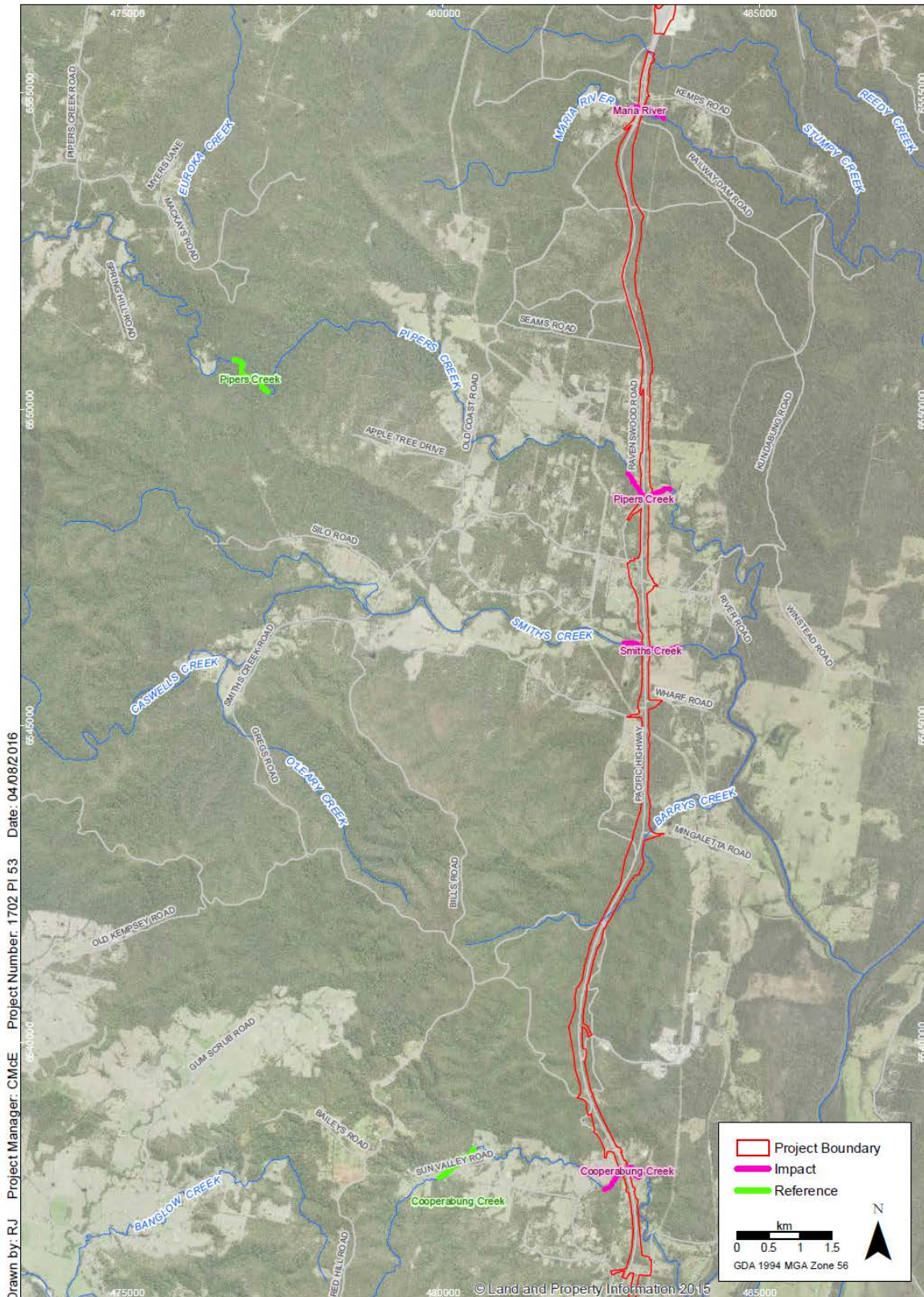
RMS (2016b). Oxley Highway to Kempsey Upgrade Project Construction water quality monitoring report - 21 January to 21 July 2016. Roads and Maritime Services NSW.

SMEC-Hyder (2014). Oxley Highway to Kempsey Pacific Highway Upgrade: Ecological Monitoring Program. Prepared by SMEC Hyder Joint Venture for the Roads and Maritime Service, Sydney (final revision).

Sutherland, W. (2006). *Ecological Census Techniques: a Handbook*, Cambridge University Press, Cambridge.

Figures

Figure 1. Giant Barred Frog 2015 - 2016 monitoring: sites overview



Giant Barred Frog 2015 - 2016 monitoring: sites overview
Pacific Highway Upgrade - Oxley Highway to Kempsey

Figure 2. Giant Barred Frog 2015 - 2016 monitoring: Cooperabung Creek Impact site



Giant Barred Frog 2015 - 2016 monitoring: Cooperabung Creek Impact site
Pacific Highway Upgrade - Oxley Highway to Kempsey

FIGURE 2

Figure 3. Giant Barred Frog 2015 - 2016 monitoring: Smiths Creek Impact site



Giant Barred Frog 2015 - 2016 monitoring: Smiths Creek Impact site
Pacific Highway Upgrade - Oxley Highway to Kempsey

FIGURE 3

Figure 4. Giant Barred Frog 2015 - 2016 monitoring: Pipers Creek Impact site



Giant Barred Frog 2015 - 2016 monitoring: Pipers Creek Impact site
Pacific Highway Upgrade - Oxley Highway to Kempsey

FIGURE 4

Figure 5. Giant Barred Frog 2015 - 2016 monitoring: Maria River Impact site



Giant Barred Frog 2015 - 2016 monitoring: Maria River Impact Site
Pacific Highway Upgrade - Oxley Highway to Kempsey

FIGURE 5

Figure 6. Giant Barred Frog 2015 - 2016 monitoring: Cooperabung Creek Reference site



Giant Barred Frog 2015 - 2016 monitoring: Cooperabung Creek Reference Site
Pacific Highway Upgrade - Oxley Highway to Kempsey

FIGURE 6

Figure 7. Giant Barred Frog 2015 - 2016 monitoring: Pipers Creek Reference site



Giant Barred Frog 2015 - 2016 monitoring: Pipers Creek Reference Site
Pacific Highway Upgrade - Oxley Highway to Kempsey

Annex 1 – 2015/2016 data summary for each monitoring site

Cooperabung Creek Impact

A summary of the date and time of the transect surveys and the abiotic conditions recorded during the fieldwork at the Cooperabung Creek Impact site is presented in Table 11.

Table 11: Summary of field works and prevailing abiotic variables recorded on Cooperabung Creek impact site

Date	Time	Air Temp. °C	Water Temp. °C	Humidity %	Steam Depth (cm)	Wind	Cloud Cover %	Rain	
20/10/2015	Start	7:30:00 PM	24.1	24	72.4	100	0	30	0
21/10/2015	Finish	8:45:00 PM	21.8	22.5	85.6	70	0	30	0
3/02/2016	Start	1:16:00 AM	28.2	25.1	70	100	0	10	0
3/02/2016	Finish	3:06:00 AM	24.2	23.4	83.3	70	0	10	0
14/04/2016	Start	9:45:00 PM	17.3	20	94	150	0	25	0
14/04/2016	Finish	12:15:00 AM	16.7	19.8	99	70	0	0	0

Habitat details recorded at Cooperabung Creek Impact site are presented in Table 12.

Table 12: Habitat details recorded at Cooperabung Creek impact site

Zone	OS %	Shrub %	Ground cover %	leaf litter %	Bare Earth %	Cattle	Pools	Riffles	Depth of deepest Pool (cm)	Fence breaches (if applicable)
Clz6	60	40	95	5	1	No	1	0	150	1
Clz7	80	15	75	25	5	No	1	1	60	n/a
Clz8	80	35	55	5	40	No	3	2	70	n/a
Clz9	85	30	60	30	20	No	2	1	40	n/a
Clz5	75	40	30	10	30	No	2	0	50	1
Clz4	80	40	35	40	5	No	1	0	40	n/a
Clz3	70	20	55	15	10	No	3	1	40	n/a
Clz2	20	15	95	5	0	No	4	1	70	n/a

Number of Giant Barred Frogs Recorded:

Spring - Six Giant Barred Frogs were recorded/captured during the survey. They comprised three sub adult, two female and one males. At the time of the survey, male frog displayed 'no colour' of nuptial pads. One of the female was clearly gravid. This gravid female was a recapture from spring 2013. During the first time capture (FTC) this individual wasn't gravid and was located less than 50 metres downstream.

Summer – Thirteen Giant Barred Frogs were recorded/captured during the survey. They comprised two juveniles, one sub-adult, one female and nine males. At the time of the survey, all male frogs displayed dark nuptial pad colours indicating that all males were in a reproductive state to commence breeding.

Autumn – Two Giant Barred Frogs were recorded/captured during the autumn survey including one female and one sub adult. On two occasion during year 1 surveys the Giant Barred Frogs were distributed on both the eastern and western side of the study transect.

Evidence of Breeding Recorded: Via the presence of three sub-adult frogs in spring, two juveniles and one sub-adult frog in summer survey and two sub-adults in autumn.

Table 13: Summary of captures at the Cooperabung Creek impact site

	Spring 2015	Summer 2016	Autumn 2016
Number of frogs recorded	6	13	2
Number of adult males	1	9	0
Number of adult females	2	1	1
Number of subadults	3	1	1
Number of juveniles	0	2	0
Number of recaptures	1	0	0
Number of frogs with Chytrid/ swabbed	/6	/10	/1
Number of tadpoles caught in bait traps/nets	2	0	0

Zones Inhabited By Giant Barred Frogs: Restricted to zones Clz3, Clz4, Clz6, Clz7, Clz8, Clz9, Clz10 lie within and both upstream and downstream of the existing carriageway. In contrast to the baseline surveys, in 2015-2016 no frogs were recorded in zone Clz5 that forms part of the construction footprint.

Spring Sampling of Chytrid: All frogs swabbed tested negative for Chytrid.

Summer Sampling of Chytrid: All frogs swabbed tested negative for Chytrid.

Autumn Sampling Chytrid: All frogs swabbed tested negative for Chytrid.

Giant Barred Frog Tadpoles: Two *Mixophyes* tadpoles were captured in two big and low flowing pools in zones Clz2 and CLz3 but the species of *Mixophyes* could not be determined.

Habitat: Microhabitat within these zones included flood debris as overhang shelter, grass and leaf litter. Frogs were located on litter. Females were occasionally located foraging within Lomandra.

Water Levels: Mean depth 500 mm west and 800 mm east. During the baseline surveys the mean depth was 700 mm west and 50 mm east. The level of water on the eastern side dramatically increased during the 2015/2016 surveys and that could be one of the main reasons why Giant Barred Frogs have been recorded for the first time on the eastern side of the existing carriageway.

Smiths Creek Impact

A summary of the date and time of the transect surveys and the abiotic conditions recorded during the fieldwork at the Smiths Creek Impact site is presented in Table 14.

Table 14: Summary of field works and prevailing abiotic variables recorded at Smiths Creek impact site

Date	Time	Air Temp. °C	Water Temp. °C	Humidity %	Steam Depth (cm)	Wind	Cloud Cover %	Rain	
21/10/2015	Start	11:00:00 PM	19.9	19.5	84.5	10	0	30	0
21/10/2015	Finish	1:30:00 AM	17.3	18.7	94.8	10	0	30	0
2/02/2016	Start	11:25:00 PM	21.6	21.6	85.1	10	0	0	0
2/02/2016	Finish	2:45:00 AM	18.8	21.1	98	10	0	0	0
13/04/2016	Start	9:45:00 PM	18.7	19	99	10	0	100	1/3
13/04/2016	Finish	12:10:00 AM	18.1	19	99	10	0	100	1/3

Habitat details recorded at Smiths Creek impact site are presented in Table 15.

Table 15: Habitat details recorded at Smiths Creek impact site

Zone	OS %	Shrub %	Ground cover %	leaf litter %	Bare Earth %	Cattle	Pools	Riffles	Depth of deepest Pool (cm)	Fence breaches (if applicable)
Slz6	50	20	20	20	80	Yes	1	0	120	2
Slz7	50	10	80	10	20	Yes	1	0	120	n/a
Slz8	60	15	10	25	20	Yes	1	0	120	n/a
Slz9	<5	15	90	10	10	Yes	2	1	70	n/a
Slz10	<5	20	80	30	10	Yes	2	0	50	n/a
Slz5	60	50	20	40	80	No	4	1	40	0
Slz4	80	50	40	25	60	No	5	2	40	n/a
Slz3	70	80	80	10	20	No	3	0	50	n/a
Slz2	40	40	20	45	80	No	3	3	20	n/a
Slz1	80	40	80	25	20	No	1	1	50	n/a

Number of Giant Barred Frogs Recorded:

Spring – Seven Giant Barred Frogs were recorded/captured during the survey. They comprised one sub-adult, four female and two males. At the time of the survey, male frogs all displayed ‘no colour’ on nuptial pads. No females were gravid.

Summer – Fourteen Giant Barred Frogs were recorded/captured during the survey. One frog was a recapture. They comprised two juveniles, one sub-adult, one female and ten males. At the time of the

survey, male frogs all displayed dark nuptial pad colours indicating that all males were in a reproductive state.

Autumn – One Giant Barred Frog was recorded/captured during the survey, and was an adult female.

Evidence of Breeding Recorded: Via the presence of one sub-adult frog in spring, two juveniles and one sub-adult frog in summer survey.

Table 16: Summary of findings from baseline surveys at the Smiths Creek impact site

	Spring 2015	Summer 2016	Autumn 2016
Number of frogs recorded	7	14	1
Number of adult males	2	10	0
Number of adult females	4	1	1
Number of subadults	1	1	0
Number of juveniles	0	2	0
Number of recaptures	0	1	0
Number of frogs with Chytrid/ swabbed	/7	/13	/1
Number of tadpoles caught in bait traps/nets	0	0	0

Zones Inhabited By Giant Barred Frogs: In spring and summer distributed across the transect, except within the construction footprint . In autumn the only frog recorded was upstream of the existing carriageway.

Spring Sampling of Chytrid: All frogs swabbed tested negative for Chytrid.

Summer Sampling of Chytrid: All frogs swabbed tested negative for Chytrid.

Autumn Sampling Chytrid: All frogs swabbed tested negative for Chytrid.

Giant Barred Frog Tadpoles: No *Mixophyes* tadpoles were recorded or observed across the transect.

Habitat: Microhabitat within these zones included flood debris as overhang shelter, grass and leaf litter. High level of ground disturbance due to high level of cattle activity was recorded downstream of the existing carriageway during the autumn survey.

Water Levels: Mean depth 500 mm west, 400 mm east.

Pipers Creek Impact

A summary of the date and time of the transect surveys and the abiotic conditions recorded during the fieldwork for the Pipers Creek Impact site is presented in Table 17.

Table 17: Summary of field works and prevailing abiotic variables recorded at Pipers Creek impacts site

Date	Time	Air Temp. °C	Water Temp. °C	Humidity %	Steam Depth (cm)	Wind	Cloud Cover %	Rain	
20/10/2015	Start	11:20:00 PM	19.8	19.6	84.5	100	2	25	0
20/10/2015	Finish	1:30:00 AM	17.2	18.9	94.8	100	2	25	0
2/02/2016	Start	8:58:00 PM	24.5	24.3	80.2	100	1	10	0
2/02/2016	Finish	11:20:00 PM	21.3	23.4	90.4	100	0	10	0
13/04/2016	Start	6:10:00 PM	22.8	22	74	100	2	30	0
13/04/2016	Finish	9:00:00 PM	18.9	20	97	100	2	90	1/3

Habitat details recorded at Pipers Creek impact site are presented in Table 18

Table 18: Habitat details recorded at Pipers Creek impacts site

Zone	OS %	Shrub %	Ground cover %	leaf litter %	Bare Earth %	Cattle	Pools	Riffles	Depth of deepest Pool (cm)	Fence breaches (if applicable)
Plz5	80	20	80	40	2	No	1	0	40	0
Plz4	60	40	30	40	10	No	1	0	200	n/a
Plz3	70	50	80	35	2	No	1	0	105	n/a
Plz2	60	35	70	35	10	No	1	0	110	n/a
Plz1	65	45	50	45	10	No	1	0	100	n/a
Plz6	35	40	80	20	2	No	1	0	200	0
Plz7	85	20	40	15	20	No	3	1	100	n/a
Plz8	60	35	70	50	1	No	2	5	40	n/a
Plz9	50	40	90	5	2	No	2	1	100	n/a
Plz10	60	45	60	5	35	No	2	1	70	n/a

Number of Giant Barred Frogs Recorded:

Spring – A total of five Giant Barred Frogs were recorded/captured, including two adult males and two females.

Summer – Nine Giant Barred Frogs were recorded/captured during the survey. They comprised one sub-adult, six males and two females. At the time of the survey, male frogs all displayed dark nuptial pad colours indicating that all males were in a reproductive state.

Autumn – Seven Giant Barred Frogs were recorded/captured during the autumn survey including three males, two females, one unknown adult (it was unable to be captured) and one sub-adult. Two recaptures were recorded in summer and three in autumn. One adult male was recaptured in all three monitoring events and on all three occasions it was located in approximately the same area.

Evidence of Breeding Recorded: one sub-adult frog was recorded in summer, and one sub adult was recorded in the autumn survey.

Table 19: Summary of findings from baseline field surveys at the Pipers Creek impacts site

	Spring 2015	Summer 2016	Autumn 2016
Number of frogs recorded	5	9	7
Number of adult males	2	6	3
Number of adult females	3	2	2
Number of subadults	0	1	1
Number of juveniles	0	0	0
Number of recaptures	0	2	3
Number of frogs with Chytrid/ swabbed	/5	/9	/5
Number of tadpoles caught in bait traps/nets	0	0	0

Zones Inhabited By Giant Barred Frogs: Recorded from zones Plz7-Plz10 downstream and zone Plz4-Plz5 upstream. No frogs were identified within the construction footprint, as expected because the frog proof fence kept animals outside the construction area.

Spring Sampling of Chytrid: two of the five frogs swabbed tested positive for Chytrid.

Summer Sampling of Chytrid: seven of the nine frogs swabbed tested positive for Chytrid.

Autumn Sampling Chytrid: All frogs swabbed tested negative for Chytrid.

Giant Barred Frog Tadpoles: No tadpoles were recorded or observed.

Habitat: Microhabitat use included above and partially buried within leaf litter, and on bare ground.

Water Levels: Mean depth 1,000 mm west, 1,500 mm east. Over 2,000 mm in the deepest pool.

Maria River Impact

A summary of the date and time of the transect surveys and the abiotic conditions recorded during the fieldwork for the Maria River Impact site is presented in Table 20.

Table 20: Summary of field works and prevailing abiotic variables recorded at Maria River impact site

Date	Time		Air Temp. °C	Water Temp. °C	Humidity %	Steam Depth (cm)	Wind	Cloud Cover %	Rain
20/10/2015	Start	7:30:00 PM	23.4	22.3	72.4	40	2	10	0
20/10/2015	Finish	11:00:00 PM	21.1	21.9	75.3	40	2	20	0
1/02/2016	Start	9:19:00 PM	25.6	26.3	80.6	30	0	100	0
1/02/2016	Finish	11:20:00 AM	23.3	25.9	86	30	0	90	0
14/04/2016	Start	6:20:00 PM	19.5	19	92	50	0	20	0
14/04/2016	Finish	9:10:00 PM	17.4	18.5	99	50	0	20	0

Habitat details recorded at Maria River impact site are presented in Table 21

Table 21: Habitat details recorded at Maria River impact site

Zone	OS %	Shrub %	Ground cover %	leaf litter %	Bare Earth %	Cattle	Pools	Riffles	Depth of deepest Pool (cm)	Fence breaches (if applicable)	Zone
MIz6	20	15	75	5	5	No	1	0	50	3	MI5
MIz7	40	20	60	15	20	No	1	0	50	n/a	MI4
MIz8	70	10	10	20	80	No	4	0	40	n/a	MI3
MIz9	60	20	20	20	60	No	2	0	50	n/a	MI2
MIz10	10	40	40	5	20	No	2	0	100	n/a	MI1
MIz5	50	30	20	10	50	No	1	0	120	0	MI6
MIz4	15	30	30	20	40	No	1	0	120	n/a	MI7
MIz3	10	85	5	15	10	Yes	1	0	100	n/a	MI8
MIz2	3	90	10	5	0	No	1	0	100	n/a	MI9
MIz1	0	95	5	5	0	No	1	0	100	n/a	MI10

Number of Giant Barred Frogs Recorded:

Spring – A total of nine Giant Barred Frogs were recorded/captured during the spring survey, including three males, five female and one sub-adult. At the time of the survey, male frogs all displayed light nuptial pad colours, apart from one individual that exhibited light and dark nuptial pad colours.

Summer – Thirteen Giant Barred Frogs were recorded, comprising one male, nine female, one sub-adult and two juveniles. At the time of the survey, male frogs all displayed dark nuptial pad colours indicating

that all males were in a reproductive state. Six females were gravid or semi-gravid, two were not gravid and two adult females were unable to be captured.

Autumn – Four Giant Barred Frogs were recorded/captured during the survey, including two female and two sub-adults.

Evidence of Breeding Recorded: Yes, via the presence of one sub-adult frogs in spring and one sub-adult and two juvenile frogs in summer and two sub-adults in autumn.

Table 22: Summary of findings from baseline field surveys at the Maria River impact site

	Spring 2015	Summer 2016	Autumn 2016
Number of frogs recorded	9	15	4
Number of adult males	3	5	0
Number of adult females	5	8	2
Number of sub-adults	1	1	2
Number of juveniles	0	1	0
Number of recaptures	0	0	0
Number of frogs with Chytrid/ swabbed	/5	/11	/4
Number of tadpoles caught in bait traps/nets	0	0	0

Zones Inhabited By Giant Barred Frogs: Giant Barred Frogs recorded from zones MIz6 to MIz10 downstream and zone MIz4 to MIz5 upstream.

Spring Sampling of Chytrid: two of the eight frogs swabbed tested positive for Chytrid.

Summer Sampling of Chytrid: All frogs swabbed tested negative for Chytrid.

Autumn Sampling Chytrid: All frogs swabbed tested negative for Chytrid.

Giant Barred Frog Tadpoles: No tadpoles were recorded or observed.

Habitat: Microhabitat within these zones included flood debris as overhang shelter, grass and leaf litter. Lantana is very abundant along both side of the river banks and is the dominant vegetation from MIz1 to MIz5.

Water Levels: Mean depth 450 mm west, 400 mm east.

Cooperabung Creek Reference

A summary of the date and time of the transect surveys and the abiotic conditions recorded during the fieldwork for the Cooperabung Creek Reference site is presented in Table 23.

Table 23: Summary of field works and prevailing abiotic variables recorded at Cooperabung Creek reference site

Date	Time	Air Temp. °C	Water Temp. °C	Humidity %	Steam Depth (cm)	Wind	Cloud Cover %	Rain	
21/10/2015	Start	8:50:00 PM	21.8	21.1	68.2	30	0	20	0
21/10/2015	Finish	10:40:00 PM	19.1	19.9	84.5	30	0	20	0
1/02/2016	Start	12:47:00 AM	21.3	26.5	88.9	40	1	10	0
1/02/2016	Finish	3:30:00 AM	19.1	25.6	97.6	40	0	10	0
12/04/2016	Start	11:00:00 PM	19.3	20.8	89	40	0	30	0
12/04/2016	Finish	1:30:00 AM	16.7	20.2	89	40	0	30	0

Habitat details recorded at Cooperabung Creek reference site are presented in Table 24

Table 24: Habitat details recorded at Cooperabung Creek reference site

Zone	OS %	Shrub %	Ground cover %	leaf litter %	Bare Earth %	Cattle	Pools	Riffles	Depth of deepest Pool (cm)	Fence breaches (if applicable)
CRz1	70	40	20	35	5	No	6	6	15	n/a
CRz2	60	5	70	15	20	No	5	4	15	n/a
CRz3	55	20	55	20	5	No	1	1	40	n/a
CRz4	30	15	65	15	5	No	3	4	35	n/a
CRz5	50	20	30	30	20	No	3	2	40	n/a
CRz6	50	20	40	5	35	No	3	3	20	n/a
CRz7	20	20	65	10	5	No	5	4	35	n/a
CRz8	70	15	65	15	5	No	1	1	45	n/a
CRz9	90	5	20	35	40	No	1	1	40	n/a
CRz10	80	10	55	20	15	No	2	2	20	n/a

Number of Giant Barred Frogs Recorded:

Spring – Six Giant Barred Frogs were recorded/captured, including one adult male, four females and one sub-adult. No juveniles were present.

Summer - Seven Giant Barred Frogs were recorded/captured, consisting of six adult males and one female. Male frogs all displayed dark nuptial pad colours. Two frogs were recaptures, both from spring 2015.

Autumn – Five Giant Barred Frogs were recorded/captured consisting of one male, two females, one sub-adult and one juvenile.

Evidence of Breeding Recorded: one sub-adult frog in spring, one sub-adult and one juvenile frog in autumn.

Table 25: Summary of findings from baseline field surveys at the Cooperabung Creek reference site

	Spring 2015	Summer 2016	Autumn 2016
Number of frogs recorded	6	7	5
Number of adult males	1	6	1
Number of adult females	4	1	2
Number of sub-adults	1	0	1
Number of juveniles	0	0	1
Number of recaptures	0	2	0
Number of frogs with Chytrid/ swabbed	/6	/7	/4
Number of tadpoles caught in bait traps/nets	0	0	0

Zones Inhabited By Giant Barred Frogs: Broadly distributed from zone CRz2-CRz9, and consistently presence in the middle and lower reaches of the transect.

Spring Sampling of Chytrid: All frogs swabbed tested negative for Chytrid.

Summer Sampling of Chytrid: All frogs swabbed tested negative for Chytrid.

Autumn Sampling Chytrid: All frogs swabbed tested negative for Chytrid.

Giant Barred Frog Tadpoles: No tadpoles were recorded or observed.

Habitat: Microhabitat found being used included above and partially buried within leaf litter (some of which included Lomandra shelters), pasture grass, within the undercut of the bank, and on dirt and rock.

Water Levels: Range from 150 to 450 mm.

Pipers Creek Reference

A summary of the date and time of the transect surveys and the abiotic conditions recorded during the fieldwork for the Pipers Creek Reference site is presented in Table 26.

Table 26: Summary of field works and prevailing abiotic variables recorded at Pipers Creek reference site

Date	Time		Air Temp. °C	Water Temp. °C	Humidity %	Steam Depth (cm)	Wind	Cloud Cover %	Rain
19/10/2015	Start	8:00:00 PM	21.9	22.1	72.2	50	0	0	0
19/10/2015	Finish	1:00:00 AM	20	19.9	84.4	50	0	0	0
3/02/2016	Start	8:15:00 PM	27.1	23.1	89.9	20	0	0	0
3/02/2016	Finish	12:05:00 AM	26	22.8	88.6	20	0	0	0
12/04/2016	Start	6:30:00 PM	21.6	19	83	18	0	30	0
12/04/2016	Finish	10:10:00 PM	17.2	18.8	99	18	0	30	0

Habitat details recorded at Pipers Creek reference site are presented in Table 27

Table 27: Habitat details recorded at recorded at Pipers Creek reference site

Zone	OS %	Shrub %	Ground cover %	leaf litter %	Bare Earth %	Presence of Cattle	Pools	Riffles	Depth of deepest Pool (cm)	Fence breaches (if applicable)
PRz5	55	15	80	15	5	No	1	2	90	n/a
PRz4	50	30	68	30	2	No	1	3	20	n/a
PRz3	70	20	70	20	10	No	3	1	70	n/a
PRz2	60	15	80	15	5	No	4	0	90	n/a
PRz1	45	10	85	10	5	No	4	2	120	n/a
PRz6	70	20	70	20	10	No	2	1	25	n/a
PRz7	85	20	20	20	60	No	2	1	35	n/a
PRz8	85	10	30	10	60	No	3	0	40	n/a
PRz9	15	35	35	35	30	No	1	0	40	n/a
PRz10	60	15	35	15	50	No	1	0	40	n/a

Number of Giant Barred Frogs Recorded:

Spring – A total of twenty one Giant Barred Frogs were recorded during the survey, comprising eight adult males, three females and ten sub-adults. At the time of the survey, male frogs displayed a range of nuptial pad colours with one frog each exhibiting ‘no colour’, light nuptials or medium nuptials, and three frogs exhibiting dark nuptials, indicating most males were in a reproductive state.

Summer – Twenty five Giant Barred Frogs were recorded/captured during the survey, including eighteen adult males, three females, two sub-adults and two juvenile. At the time of the survey, male frogs displayed

a range of nuptial pad colours with six frog exhibiting moderate nuptial pad colour and twelve frogs exhibiting dark nuptials, indicating most males were in a reproductive state. Two frogs were recaptures.

Autumn – Nine Giant Barred Frogs were recorded/captured during the survey, including two adult males, two females, one sub-adult and four juveniles. Two frogs were recaptures, both from spring 2015.

Evidence of Breeding Recorded: Via the presence of ten sub-adults in spring, two sub-adults and two juveniles in summer, and one sub-adult and four juveniles in autumn.

Table 28: Summary of finding from the baseline field surveys at the Pipers Creek reference site

	Spring 2015	Summer 2016	Autumn 2016
Number of frogs recorded	21	26	9
Number of adult males	8	21	2
Number of adult females	3	3	2
Number of subadults	10	1	1
Number of juveniles	0	1	4
Number of recaptures	0	2	2
Number of frogs with chytrid/ swabbed	/21	/24	/6
Number of tadpoles caught in bait traps/nets	0	0	0

Zones Inhabited By Giant Barred Frogs: Broadly distributed from zones PRz3-PRz9.

Spring Sampling of Chytrid: three of the 21 frogs swabbed tested positive for Chytrid.

Summer Sampling of Chytrid: All frogs swabbed tested negative for Chytrid.

Autumn Sampling Chytrid: All frogs swabbed tested negative for Chytrid.

Giant Barred Frog Tadpoles: No tadpoles were recorded or observed.

Habitat: Microhabitat within these zones included above, partially buried and completely buried within leaf litter, sheltering under Lomandra, and within holes in the bank.

Water Levels: Range from 200 mm to 1,200 mm.

Annex 2 – Giant Barred Frog individual frog data

Location		Season	Sex	Age	Reproductive Status	Length	Weight	Distance to water	Pit Tag No.	First Time Capture/Recapture	Swabbed	Zone	Microhabitat	Activity	Notes
Impact	Cooperabung Creek	Spring	prob. Male	Adult	Uncoloured Nuptial Pads	80.0	100.0	0.1	00077E7BFB	First Time Capture	Y	Clz4	On ground		
Impact	Cooperabung Creek	Spring	Unknown	Sub Adult	Immature	55.7	38.0	4.0	00077E7E98	First Time Capture	Y	Clz4			
Impact	Cooperabung Creek	Spring	Unknown	Sub Adult	Immature	57.0	46.0	3.0	00077E7FFD	First Time Capture	Y	Clz4	On litter		
Impact	Cooperabung Creek	Spring	Unknown	Sub Adult	Immature	66.0	52.0	3.0	00077E8018	First Time Capture	Y	Clz4	bank on litter		
Impact	Cooperabung Creek	Spring	Female	Adult	Gravid	96.9	178.0	2.0	000735B40B	Recapture	Y	Clz3			Recap. Spring 2013
Impact	Cooperabung Creek	Spring	Female	Adult	Non Gravid	83.0	105.0	0.3	00077E7F53	First Time Capture	Y	Clz4	On ground		
Impact	Cooperabung Creek	Summer	Male	Adult	Dark Nuptial Pads	73.3	61.0	3.5	0007921ACC	First Time Capture	Y	Clz9	On steep slope	Calling	
Impact	Cooperabung Creek	Summer	Male	Adult	n/a	n/a	n/a	0.0	n/a	Not Captured	n/a	Clz9			
Impact	Cooperabung Creek	Summer	Male	Adult	Dark Nuptial Pads	75.6	56.0	2.0	00079205FF	First Time Capture	Y	Clz10	On ground		
Impact	Cooperabung Creek	Summer	Male	Adult	n/a	n/a	n/a	n/a	n/a	Not Captured	n/a	Clz7		Calling	
Impact	Cooperabung Creek	Summer	Unknown	Juvenile	Immature	n/a	n/a	3.0	n/a	Not Captured	n/a	Clz7	On litter		
Impact	Cooperabung Creek	Summer	Male	Adult	Dark Nuptial	76.2	55.0	2.0	000791E9CA	First Time Capture	Y	Clz7	On bank under overhanging veg		
Impact	Cooperabung Creek	Summer	Male	Adult	Dark Nuptial Pads	76.9	57.0	6.0	000791EB9F	First Time Capture	Y	Clz6	On brick next to causeway		
Impact	Cooperabung Creek	Summer	Female	Adult	Gravid	96.6	128.0	0.5	000791E8C5	First Time Capture	Y	Clz7			
Impact	Cooperabung Creek	Summer	Unknown	Juvenile	Immature	52.4	12.0	4.0	000791EAA5	First Time Capture	Y	Clz4	On litter		
Impact	Cooperabung Creek	Summer	Male	Adult	n/a	n/a	n/a	1.0	n/a	Not Captured	n/a	Clz8		Calling in	

Location	Season	Sex	Age	Reproductive Status	Length	Weight	Distance to water	Pit Tag No.	First Time Capture/Recapture	Swabbed	Zone	Microhabitat	Activity	Notes
													stream	
Impact	Cooperabung Creek	Summer	Male	Adult	Dark Nuptial Pads	74.0	65.0	1.0	000791EBBD	First Time Capture	Y	Clz8	Calling in stream	
Impact	Cooperabung Creek	Summer	Unknown	Sub Adult	Immature	51.5	10.0	3.0	000791E973	First Time Capture	Y	Clz4	On dirt under trees	
Impact	Cooperabung Creek	Summer	Male	Adult	Dark Nuptial Pads	74.2	60.0	2.0	000791E8E2	First Time Capture	Y	Clz10	On ground	
Impact	Cooperabung Creek	Autumn	Female	Adult	Unknown	n/a	n/a	5.0	n/a	Not Captured	n/a	Clz9	On dirt	
Impact	Cooperabung Creek	Autumn	Unknown	Sub Adult	Non Gravid	64.0	44.0	3.0	0007921B50	First Time Capture	Y	Clz3	leaf matter under Lomandra	
Impact	Maria River	Spring	Female	Adult	Gravid	85.0	105.0	5.0	0077E6AC9	First Time Capture	Y	Mlz10	On litter	
Impact	Maria River	Spring	Unknown	Sub Adult	Immature	47.0	42.0	4.0	00077E7F92	First Time Capture	Y	Mlz10	On ground	
Impact	Maria River	Spring	Male	Adult	n/a	n/a	n/a	n/a	n/a	No Captured	n/a	Mlz9	Calling	
Impact	Maria River	Spring	Female	Adult	Non Gravid	80.0	60.0	0.1	00077E6D1C	First Time Capture	Y	Mlz9	On bank	
Impact	Maria River	Spring	Female	Adult	Non Gravid	91.4	90.0	4.0	00077E7DA0	First Time Capture	N	Mlz8	On litter	
Impact	Maria River	Spring	Female	Adult	Gravid	91.1	120.0	2.0	00077E7F09	First Time Capture	N	Mlz8	On litter	
Impact	Maria River	Spring	Male	Adult	One Dark/ One light Nuptial Pad	77.2	60.0	1.5	0007634268	First Time Capture	Y	Mlz7	On litter	
Impact	Maria River	Spring	Male	Adult	Light Nuptial Pads	70.7	48.0	3.0	00077E8083	First Time Capture	N	Mlz7	On litter near lantana	
Impact	Maria River	Spring	Female	Adult	Gravid	93.9	125.0	4.0	00077E8C90	First Time Capture	Y	Mlz5	On litter	
Impact	Maria River	Summer	Female	Adult	Gravid	95.0	106.0	13.0	00077E7F84	First Time Capture	Y	Mlz9	On litter on top of bank	
Impact	Maria River	Summer	Female	Adult	Semi-Gravid	92.8	102.0	7.0	00077E6D41	First Time Capture	Y	Mlz10	On ground under shrub	

Location		Season	Sex	Age	Reproductive Status	Length	Weight	Distance to water	Pit Tag No.	First Time Capture/Recapture	Swabbed	Zone	Microhabitat	Activity	Notes
Impact	Maria River	Summer	Male	Adult	n/a	n/a	n/a	n/a	n/a	Not captured	n/a	Mlz8	n/a	Calling male	
Impact	Maria River	Summer	Unknown	Juvenile	Immature	35.0	10.0	0.4		First Time Capture	Y	Mlz4	On litter		
Impact	Maria River	Summer	Female	Adult	Gravid	103.8	200.0	1.5	00077E6CCA	First Time Capture	Y	Mlz6			
Impact	Maria River	Summer	Female	Adult	Semi-Gravid	90.4	110.0	2.0	0007634C7C	First Time Capture	Y	Mlz5	On litter		
Impact	Maria River	Summer	Female	Adult	Semi-Gravid	94.3	125.0	2.0	0007634C1C	First Time Capture	Y	Mlz5	On litter		
Impact	Maria River	Summer	Male	Adult	Dark Nuptial Pads	72.0	48.0	0.5	007634710	First Time Capture	Y	Mlz8	On litter		
Impact	Maria River	Summer	Unknown	Sub Adult	Immature	45.0	10.0	5.0	0007634735	First Time Capture	Y	Mlz8	On litter		
Impact	Maria River	Summer	Female	Adult	Non Gravid	83.4	68.0	2.5	00077E7EBD	First Time Capture	Y	Mlz8	On ground		
Impact	Maria River	Summer	Female	Adult	n/a	n/a	n/a	n/a	n/a	Not Captured	n/a	Mlz5			
Impact	Maria River	Summer	Female	Adult	n/a	n/a	n/a	n/a	n/a	Not Captured	n/a	Mlz5			
Impact	Maria River	Summer	Male	Adult	Dark Nuptial pads	83.2	60.0	0.6	00077E7F26	First Time Capture	Y	Mlz5	In streamside veg	Calling male	
Impact	Maria River	Summer	Male	Adult	n/a	n/a	n/a	n/a	n/a	Not captured	n/a	Mlz5	n/a	Calling male	
Impact	Maria River	Summer	Male	Adult	Mod Nuptial pads	71.7	40.0	9.5	00077E6A51	First Time Capture	Y	Mlz5	On ground under tree branches		
Impact	Maria River	Autumn	Unknown	Sub Adult	Immature	54.0	24.0	4.0	000791EAE6	First Time Capture	Y	Mlz10	On dirt		
Impact	Maria River	Autumn	Female	Adult	Non Gravid	96.2	155.0	5.0	000791E98D	First Time Capture	Y	Mlz8	On litter		
Impact	Maria River	Autumn	Female	Adult	Non Gravid	92.3	130.0	6.0	000791E955	First Time Capture	Y	Mlz7	On litter		
Impact	Maria River	Autumn	Unknown	Sub Adult	Immature	56.0	29.0	2.0	0007634AC3	First Time Capture	Y	Mlz4	On moss on bottom of tree		

Location		Season	Sex	Age	Reproductive Status	Length	Weight	Distance to water	Pit Tag No.	First Time Capture/Recapture	Swabbed	Zone	Microhabitat	Activity	Notes
Impact	Pipers Creek	Spring	Female	Adult	Gravid	87.0	105.0	8.0	00077E7DA3	First Time Capture	Y	Plz3			
Impact	Pipers Creek	Spring	Female	Adult	Mod. Gravid	84.9	120.0	3.0	00077E7EE7	First Time Capture	Y	Plz9		Amongst Lamondra	
Impact	Pipers Creek	Spring	Male	Adult	Dark Nuptial Pads	70.7	45.0	2.0	00077E7F06	First Time Capture	Y	Plz9			
Impact	Pipers Creek	Spring	Female	Adult	Non Gravid	83.6	87.0	10.0	00077E7FB5	First Time Capture	Y	Plz8	On debris at base of tree		
Impact	Pipers Creek	Spring	Male	Adult	Dark Nuptial Pads	60.0	50.0	2.0	00077E6D19	First Time Capture	Y	Plz8	On ground		
Impact	Pipers Creek	Summer	Male	Adult	Dark Nuptial Pads	72.1	43.0	1.7	00077E7F06	Recapture	Y	Plz9	On bank	Calling male	Recap. Spring 2015
Impact	Pipers Creek	Summer	Female	Adult	Semi-Gravid	94.2	130.0	0.0	000791E995	First Time Capture	Y	Plz9	Under Lomandra		
Impact	Pipers Creek	Summer	Female	Adult	Gravid	91.3	140.0	2.0	000791EBEF	First Time Capture	Y	Plz8	On log		
Impact	Pipers Creek	Summer	Male	Adult	Dark Nuptial Pads	73.1	60.0	0.3	00077E6D19	Recapture	Y	Plz8	On dirt		Recap. Spring 2015
Impact	Pipers Creek	Summer	Male	Adult	Dark Nuptial Pads	81.0	50.0	0.4	000791EA2C	First Time Capture	Y	Plz9	On ground	Calling male	
Impact	Pipers Creek	Summer	Male	Adult	Dark Nuptial Pads	66.7	49.0	3.0	0007920747	First Time Capture	Y	Plz9	On ground	Calling male	
Impact	Pipers Creek	Summer	Male	Adult	Dark Nuptial Pads	72.2	52.0	4.0	000792057C	First Time Capture	Y	Plz8	On ground	Calling male	
Impact	Pipers Creek	Summer	Male	Adult	Dark Nuptial Pads	71.3	60.0	3.0	000791E9C9	First Time Capture	Y	Plz9		Calling male	
Impact	Pipers Creek	Summer	Unknown	Sub Adult	Immature	58.4	28.0	0.7	00079207EC	First Time Capture	Y	Plz5	On litter		
Impact	Pipers Creek	Autumn	Unknown	Sub Adult	Immature	0.0	0.0	4.0	n/a	Not Captured	n/a	Plz10	Southern bank of creek		No safe access
Impact	Pipers Creek	Autumn	Male	Adult	Medium Nuptial Pads	50.1	62.0	3.0	000775ED19	Recapture	Y	Plz8	On litter		Recap. Spring 2015 and Summer 2016

Location		Season	Sex	Age	Reproductive Status	Length	Weight	Distance to water	Pit Tag No.	First Time Capture/Recapture	Swabbed	Zone	Microhabitat	Activity	Notes
Impact	Pipers Creek	Autumn	Female	Adult	Non Gravid	98.7	115.0	4.0	00077E7FB5	Recapture	Y	Plz8	On leaf litter		Recap. Spring 2015
Impact	Pipers Creek	Autumn	Female	Adult	Non Gravid	92.0	140.0	0.5	0007634951	First Time Capture	Y	Plz3	Sitting on leaf		
Impact	Pipers Creek	Autumn	Male	Adult	Dark Nuptial Pads	65.7	50.0	8.0	00079207EC	Recapture	Y	Plz5	On litter		Recap. Summer 2016
Impact	Pipers Creek	Autumn	Unknown	Adult	n/a	n/a	n/a	n/a	n/a	Not Captured	n/a	Piz4	On litter		
Impact	Pipers Creek	Autumn	Male	Adult	Unknown	70.4	62.0	2.0	0007920501	First Time Capture	Y	Plz5	Steep embankment on leaf litter		
Impact	Smiths Creek	Spring	Male	Adult	Uncoloured Nuptial Pads	71.1	67.0	3.0	00077E8044	First Time Capture	Y	Slz7	On ground at base of tree		
Impact	Smiths Creek	Spring	Female	Adult	Not Gravid	86.1	92.5	3.0	00077E6AD1	First Time Capture	Y	Slz7	On ground at base of tree		
Impact	Smiths Creek	Spring	Female	Adult	Not Gravid	84.6	90.0	12.0	00077E6D37	First Time Capture	Y	Slz6	On ground at base of tree		
Impact	Smiths Creek	Spring	Prob. Female	Adult	No Nuptial Pads	76.1	60.0	3.0	00077E6A5F	First Time Capture	Y	Slz6	On ground at base of tree		
Impact	Smiths Creek	Spring	Male	Adult	Uncoloured Nuptial Pads	69.0	60.0	3.0	00077E7EE0	First Time Capture	Y	Slz2	Up on steep bank on litter		
Impact	Smiths Creek	Spring	Unknown	Sub Adult	Immature	54.5	19.0	3.0	00077E6A31	First Time Capture	Y	Slz2	Up on steep bank on litter		
Impact	Smiths Creek	Spring	Female	Adult	Non Gravid	86.5	104.0	5.0	00077E6A8B	First Time Capture	Y	Slz1	Under log on litter		
Impact	Smiths Creek	Summer	Male	Adult	n/a	n/a	n/a	n/a	n/a	Not Captured	n/a	Slz7		Calling	
Impact	Smiths Creek	Summer	Female	Adult	Gravid	100.4	120.0	10.0	00077E6A5F	Recapture	Y	Slz6			Recapture from Spring 2015

Location		Season	Sex	Age	Reproductive Status	Length	Weight	Distance to water	Pit Tag No.	First Time Capture/Recapture	Swabbed	Zone	Microhabitat	Activity	Notes
Impact	Smiths Creek	Summer	Female	Adult	Gravid	89.5	120.0	6.0	000791EC77	First Time Capture	Y	Slz4	On litter		
Impact	Smiths Creek	Summer	Male	Adult	Dark Nuptial Pads	71.4	58.0	1.0	000791E992	First Time Capture	Y	Slz1	Under Lomandra		
Impact	Smiths Creek	Summer	Male	Adult	Dark Nuptial Pads	73.0	62.0	2.0	000791E9FB	First Time Capture	Y	Slz1	On litter		
Impact	Smiths Creek	Summer	Male	Adult	Dark Nuptial Pads	72.1	54.0	2.0	000763463C	First Time Capture	Y	Slz1	On litter		
Impact	Smiths Creek	Summer	Male	Adult	Dark Nuptial Pads	68.8	60.0	0.5	000791EB9B	First Time Capture	Y	Slz2	Under Lomandra		
Impact	Smiths Creek	Summer	Male	Adult	Dark Nuptial Pads	77.1	70.0	1.0	000791EBB3	First Time Capture	Y	Slz2	On litter		
Impact	Smiths Creek	Summer	Male	Adult	Dark Nuptial Pads	70.6	46.0	1.0	000791EC22	First Time Capture	Y	Slz2	On litter		
Impact	Smiths Creek	Summer	Male	Adult	Dark Nuptial Pads	74.2	54.0	1.5	000791E8FB	First Time Capture	Y	Slz2	On litter		Odd colour on belly
Impact	Smiths Creek	Summer	Male	Adult	Dark Nuptial Pads	67.5	44.0	1.5	000791EB5D	First Time Capture	Y	Slz1	On ground in depression		
Impact	Smiths Creek	Summer	Male	Adult	Dark Nuptial Pads	72.4	49.0	2.0	00077E6B54	First Time Capture	Y	Slz2	Under shrub on ground	Calling	
Impact	Smiths Creek	Summer	Unknown	Juvenile	Immature	35.0	15.0	2.0	n/a	Not marked	Y	Slz2	On ground on litter and dirt		
Impact	Smiths Creek	Summer	Female	Adult	n/a	n/a	n/a	10.0	n/a	Not Captured	n/a	Slz2	On litter		
Impact	Smiths Creek	Autumn	Female	Adult	Non Gravid	92.0	130.0	6.0	000791EA56	First Time Capture	Y	Slz4	On litter		
Reference	Cooperabung Creek	Spring	Female	Adult	Gravid	93.0	132.0	0.0	00077E7FEB	First Time Capture	Y	CRz9	On gravel		
Reference	Cooperabung Creek	Spring	Female	Adult	Non Gravid	80.0	107.0	3.0	00077E7E2D	First Time Capture	Y	CRz9	On ground		
Reference	Cooperabung Creek	Spring	Unknown	Sub Adult	Immature	68.0	52.0	1.0	00077E6D49	First Time Capture	Y	CRz8	On ground		
Reference	Cooperabung Creek	Spring	Female	Adult	Gravid	90.0	145.0	2.0	0007635887	First Time Capture	Y	CRz5	On ground		

Location		Season	Sex	Age	Reproductive Status	Length	Weight	Distance to water	Pit Tag No.	First Time Capture/Recapture	Swabbed	Zone	Microhabitat	Activity	Notes
Reference	Cooperabung Creek	Spring	Male	Adult	Dark Nuptial Pads	71.5	70.5	4.0	00077E6AB1	First Time Capture	Y	CRz5	On ground		
Reference	Cooperabung Creek	Spring	Female	Adult	Non Gravid	85.0	74.5	1.0	00077E7E31	First Time Capture	Y	CRz5	On ground		
Reference	Cooperabung Creek	Summer	Male	Adult	Dark Nuptial Pads	74.5	65.0	1.0	00077E6AB1	Recapture	Y	CRz4	Above litter	Fighting with below	Recapture from Spring 2015
Reference	Cooperabung Creek	Summer	Male	Adult	Dark Nuptial Pads	76.6	70.0	1.0	not recorded	First Time Capture	Y	CRz4	Above litter	Fighting with above	
Reference	Cooperabung Creek	Summer	Male	Adult	Dark Nuptial Pads	78.3	52.0	0.2	00077E6AA0	First Time Capture	Y	CRz4	On ground		
Reference	Cooperabung Creek	Summer	Female	Adult	Gravid	92.3	165.0	0.1	00677E7FEB	Recapture	Y	CRz4	On ground very edge of bank		Recapture from Spring 2015
Reference	Cooperabung Creek	Summer	Male	Adult	Dark Nuptial Pads	78.6	57.0	0.5	000791EB0D	First Time Capture	Y	CRz5	On litter build up, 40cm above ground in dead branch		
Reference	Cooperabung Creek	Summer	Male	Adult	n/a	n/a	n/a	n/a	n/a	Not captured	n/a	CRz5	n/a	Calling male	
Reference	Cooperabung Creek	Summer	Male	Adult	Dark Nuptial Pads	69.9	60.0	0.1	0007634FB8	First Time Capture	Y	CRz2	On gravel		
Reference	Cooperabung Creek	Summer	Male	Adult	Dark Nuptial Pads	80.4	85.0	0.4	0007634838	First Time Capture	Y	CRz2	Above litter		
Reference	Cooperabung Creek	Autumn	Unknown	Sub Adult	Immature	45.6	17.0	3.0	000791EAB4	First Time Capture	Y	CRz6	On rock		
Reference	Cooperabung Creek	Autumn	Unknown	Sub Adult	Immature	53.0	25.0	1.0	000791E8FF	First Time Capture	Y	CRz6	On litter		
Reference	Cooperabung Creek	Autumn	Female	Adult	Non Gravid	89.6	130.0	1.0	00079204EA	First Time Capture	Y	CRz6	On dirt		
Reference	Cooperabung Creek	Autumn	Female	Adult	Non Gravid	90.5	105.0	0.2	00079205AE	First Time Capture	Y	CRz4	On dirt		
Reference	Cooperabung Creek	Autumn	Male	Adult	n/a	n/a	n/a	0.5	n/a	Not Captured	n/a	CRz3	On bank/dirt		

Location		Season	Sex	Age	Reproductive Status	Length	Weight	Distance to water	Pit Tag No.	First Time Capture/Recapture	Swabbed	Zone	Microhabitat	Activity	Notes
Reference	Pipers Creek	Spring	Unknown	Sub Adult	Immature	46.4	18.8	2.0	00077E69A5	First Time Capture	Y	PRz43	On ground		
Reference	Pipers Creek	Spring	Unknown	Sub Adult	Immature	51.4	24.0	4.0	00077E6A43	First Time Capture	Y	PRz8	On ground		
Reference	Pipers Creek	Spring	Unknown	Sub Adult	Immature	50.7	24.5	4.0	00077E7FF9	First Time Capture	Y	PRz8	On ground		
Reference	Pipers Creek	Spring	Unknown	Sub Adult	Immature	50.0	19.0	2.5	00077E7F1A	First Time Capture	Y	PRz8	On litter		
Reference	Pipers Creek	Spring	Unknown	Sub Adult	Immature	46.5	16.5	4.0	00077E6C1D	First Time Capture	Y	PRz8	On ground		
Reference	Pipers Creek	Spring	Male	Adult	Light Nuptial Pads	64.3	40.0	2.0	007633E02	First Time Capture	Y	PRz8	on ground		
Reference	Pipers Creek	Spring	Male	Adult	Dark Nuptial Pads	71.8	58.0	1.0	00077E7E92	First Time Capture	Y	PRz7	On ground		
Reference	Pipers Creek	Spring	Female	Adult	Gravid	98.9	155.0	1.5	00077E69AF	First Time Capture	Y	PRz7	On ground		
Reference	Pipers Creek	Spring	Male	Adult	Dark Nuptial Pads	72.9	55.8	3.0	00077E8D1F	First Time Capture	Y	PRz7	On ground		
Reference	Pipers Creek	Spring	Male	Adult	Light Nuptial Pads	59.6	31.0	1.0	00077E8019	First Time Capture	Y	PRz7	On ground		
Reference	Pipers Creek	Spring	Male	Adult	Light Nuptial Pads	68.6	40.0	2.0	00077E6D03	First Time Capture	Y	PRz7	On ground		
Reference	Pipers Creek	Spring	Unknown	Sub Adult	Immature	50.7	21.3	6.0	00077E8057	First Time Capture	Y	PRz7	On litter		
Reference	Pipers Creek	Spring	Unknown	Sub Adult	Immature	57.6	26.5	3.0	00077E7E09	First Time Capture	Y	PRz7	On litter		
Reference	Pipers Creek	Spring	Unknown	Sub Adult	Immature	50.7	24.9	5.0	00077E7D78	First Time Capture	Y	PRz7	On moss under log		
Reference	Pipers Creek	Spring	Prob. Female	Adult	No Nuptial Pads	76.1	69.0	4.0	007633434	First Time Capture	Y	PRz7	On ground		
Reference	Pipers Creek	Spring	Male	Adult	Light Nuptial Pads	57.3	30.8	3.0	00077E7FE8	First Time Capture	Y	PRz7	On litter		
Reference	Pipers Creek	Spring	Unknown	Sub Adult	Immature	51.4	18.0	2.0	00077E80E2	First Time Capture	Y	PRz6	On litter		
Reference	Pipers Creek	Spring	Prob. Female	Sub Adult	No Nuptial Pads	64.9	41.0	2.0	00077EGBB1	First Time Capture	Y	PRz6	On moss		

Location		Season	Sex	Age	Reproductive Status	Length	Weight	Distance to water	Pit Tag No.	First Time Capture/Recapture	Swabbed	Zone	Microhabitat	Activity	Notes
Reference	Pipers Creek	Spring	Prob. Male	Sub Adult	Light Nuptial Pads	60.1	38.0	0.6	00077E80D9	First Time Capture	Y	PRz6	On litter		
Reference	Pipers Creek	Spring	Male	Adult	Light Nuptial Pads	77.7	68.0	1.0	00077I80A7	First Time Capture	Y	PRz6	On a log	Calling	
Reference	Pipers Creek	Spring	Unknown	Sub Adult	Immature	54.9	21.0	1.5	00077E6CB3	First Time Capture	Y	PRz6	On moss		
Reference	Pipers Creek	Summer	Male	Adult	Moderate Nuptial Pads	72.4	41.0	2.3	00079206D3	First Time Capture	Y	PRz8	On litter	Calling	
Reference	Pipers Creek	Summer	Female	Adult	Gravid	n/a	n/a	n/a	000791E91F	First Time Capture	Y	PRz8	On litter		
Reference	Pipers Creek	Summer	Male	Adult	Mod Nuptial pads	n/a	n/a	n/a	000791EB7A	First Time Capture	Y	PRz8	On litter		
Reference	Pipers Creek	Summer	Male	Adult	Dark Nuptial Pads	71.9	55.0	0.7	0007920736	First Time Capture	Y	PRz8	On litter		
Reference	Pipers Creek	Summer	Male	Adult	Dark Nuptial Pads	71.5	50.0	2.0	00079219F8	First Time Capture	Y	PRz8	On base of tree		
Reference	Pipers Creek	Summer	Unknown	Juvenile	Immature	n/a	n/a	1.0	n/a	Not Captured	n/a	PRz7	On litter		
Reference	Pipers Creek	Summer	Male	Adult	Moderate Nuptial Pads	67.6	43.0	1.5	00077E80E2	Recapture	Y	PRz8	On litter	Calling	Recap. Spring 2015
Reference	Pipers Creek	Summer	Male	Adult	Dark Nuptial Pads	69.4	38.0	6.0	000791EC31	First Time Capture	Y	PRz6	On litter		
Reference	Pipers Creek	Summer	Male	Adult	Moderate Nuptial Pads	66.1	40.0	2.5	00079206C4	First Time Capture	Y	PRz7	On litter		
Reference	Pipers Creek	Summer	Male	Adult	Dark Nuptial Pads	73.0	58.0	0.7	0007920640	First Time Capture	Y	PRz6	On moss		
Reference	Pipers Creek	Summer	Male	Adult	Moderate Nuptial Pads	75.0	50.0	2.0	000791EA9A	First Time Capture	Y	PRz6	On ground		
Reference	Pipers Creek	Summer	Male	Adult	Dark Nuptial Pads	80.4	60.0	3.0	0007926027	First Time Capture	Y	PRz6	On ground		
Reference	Pipers Creek	Summer	Male	Adult	Dark Nuptial Pads	69.9	42.0	1.5	000791EC03	First Time Capture	Y	PRz6	At base of tree on litter		
Reference	Pipers Creek	Summer	Male	Adult	Dark Nuptial Pads	81.2	67.0	2.0	000791EBB6	First Time Capture	Y	PRz4	In Lomandra	Calling	

Location		Season	Sex	Age	Reproductive Status	Length	Weight	Distance to water	Pit Tag No.	First Time Capture/Recapture	Swabbed	Zone	Microhabitat	Activity	Notes
Reference	Pipers Creek	Summer	Female	Adult	Gravid	94.2	150.0	2.5	00079217BF	First Time Capture	Y	PRz5	On ground		
Reference	Pipers Creek	Summer	Male	Adult	Moderate Nuptial Pads	75.2	54.0	0.0	000791EAAF	First Time Capture	Y	PRz4	Edge of water		
Reference	Pipers Creek	Summer	Unknown	Sub Adult	Immature	60.9	20.0	1.0	000791EA75	First Time Capture	Y	PRz5	On litter		
Reference	Pipers Creek	Summer	Male	Adult	Dark Nuptial Pads	68.6	52.0	0.7	00079206E5	First Time Capture	Y	PRz5	Under Lomandra		
Reference	Pipers Creek	Summer	Male	Adult	Dark Nuptial Pads	64.2	42.0	0.5	0007921942	First Time Capture	Y	PRz3	On dirt		
Reference	Pipers Creek	Summer	Male	Adult	Dark Nuptial Pads	73.0	63.0	1.0	00079206D6	First Time Capture	Y	PRz3	Under Lomandra		
Reference	Pipers Creek	Summer	Male	Adult	Dark Nuptial Pads	75.0	46.0	5.0	000792068F	First Time Capture	Y	PRz3	On ground on steep bank		
Reference	Pipers Creek	Summer	Male	Adult	Mod Nuptial pads	n/a	60.0	5.0	000791EBA3	First Time Capture	Y	PRz3	On ground on steep bank		
Reference	Pipers Creek	Summer	Female	Adult	Moderate Gravid	81.7	65.0	4.0	0007923BFA	First Time Capture	Y	PRz4	On ground		
Reference	Pipers Creek	Summer	Male	Adult	Dark Nuptial Pads	75.0	65.0	2.0	0007925F61	First Time Capture	Y	PRz3	On litter		
Reference	Pipers Creek	Summer	Male	Adult	Moderate Nuptial Pads	71.3	57.0	4.5	00077E7D76	Recapture	Y	PRz3	On ground	Calling	
Reference	Pipers Creek	Autumn	Male	Adult	Moderate Nuptial Pads	70.0	48.0	2.5	000791EC27	First Time Capture	Y	PRz8	Base of tree, leaf matter		
Reference	Pipers Creek	Autumn	Female	Adult	Non Gravid	85.3	103.0	7.0	00077E6A43	Recapture	Y	PRz8	Base of tree, on leaf		Recap. Spring 2015
Reference	Pipers Creek	Autumn	Unknown	Sub Adult	Immature	n/a	n/a	n/a	n/a	Not Captured	n/a	PRz7			
Reference	Pipers Creek	Autumn	Unknown	Sub Adult	Immature	44.1	16.0	3.0	000791E8EB	First Time Capture	Y	PRz8	On rock		
Reference	Pipers Creek	Autumn	Unknown	Sub Adult	Immature	0.0	0.0	0.0	n/a	Not Captured	n/a	PRz8	On litter		
Reference	Pipers Creek	Autumn	Female	Adult	Non gravid	92.0	115.0	3.5	00077E6D03	Recapture	Y	PRz7	Base of tree, top of leaf		Recap. Spring 2015

Location		Season	Sex	Age	Reproductive Status	Length	Weight	Distance to water	Pit Tag No.	First Time Capture/Recapture	Swabbed	Zone	Microhabitat	Activity	Notes
Reference	Pipers Creek	Autumn	Unknown	Sub Adult	Immature	48.0	16.0	3.0	00079205AB	First Time Capture	Y	PRz6	Above leaf matter	Jumping	
Reference	Pipers Creek	Autumn	Unknown	Sub Adult	Immature	46.4	18.0	5.0	000791EC0D	First Time Capture	Y	PRz6	Under Lomandra	Jumping	
Reference	Pipers Creek	Autumn	Male	Adult	Unknown	n/a	n/a	n/a	n/a	Not Captured	n/a	PRz5		Calling	

Niche Environment and Heritage

A specialist environmental and heritage consultancy.

Head Office

Niche Environment and Heritage
PO Box W36 Parramatta NSW 2150
Email: info@niche-eh.com

All mail correspondence should be through our Head Office

Annex 3. Road kill report (Niche 2016c)

Road Kill Report




**2015/2016 – Oxley Highway to Kempsey, Pacific Highway
Upgrade**

Prepared for Road and Maritime Services

October 2016

Document control

Item	Description
Project no.:	1702
Project client:	Road and Maritime Services
Project office:	Port Macquarie
Document description:	OH2K Road Kill Report 2015/2016
Project Director:	Rhidian Harrington
Project Manager:	Chris McEvoy
Authors:	Francesca Amorosi
Internal review:	Amanda Griffith
Document status:	Final
Local Government Area:	Port Macquarie

Author	Revision	Internal review	Date issued	Signature
F Amorosi	D1	Amanda Griffith		
F Amorosi	D2	Bruce Blunden	4 October 2016	
F Amorosi	R0	Frank Lemckert	5 October 2016	

© Niche Environment and Heritage, 2016

Copyright protects this publication. Except for purposes permitted by the Australian *Copyright Act 1968*, reproduction, adaptation, electronic storage, and communication to the public is prohibited without prior written permission. Enquiries should be addressed to Niche Environment and Heritage, PO Box 2443, Parramatta NSW 1750, Australia, email: info@niche-eh.com.

Any third party material, including images, contained in this publication remains the property of the specified copyright owner unless otherwise indicated, and is used subject to their licensing conditions.

Executive summary

Context

This report details the findings of the road kill surveys undertaken from the 22 of July 2015 up to 21 July 2016 as required for the Oxley Highway to Kempsey (OH2K) Pacific Highway upgrade project (the Project).

Aims

The Road Kill Survey is designed to monitor the effectiveness of flora and fauna mitigation measures on the OH2K Pacific Highway Upgrade.

Methods

This survey was conducted weekly for the period 22 of July 2015 to 21 July 2016 in accordance with the monitoring methodology specified in the Oxley Highway to Kempsey Ecological Monitoring Program (Hyder, 2014).

Key results

Road kill monitoring results were similar to those reported in the 2014-2015 monitoring period, namely: a range of groups of fauna were recorded, with birds and large macropods being the most commonly recorded, and the majority of road kill occurred within sites adjacent to riparian vegetation.

Conclusions

The surveys for 2015/2016 show a reduced road kill rate compared to the baseline surveys in spring and summer (Lewis 2014) and therefore are in line with the performance measures for these seasons. Data from future monitoring events will provide further information on seasonal and yearly variability in road kill rates and thus inform progress against stated performance measures.

Only one threatened species (one individual Koala) was recorded during the construction phase 2015/2016 while three individual threatened species (one Koala and two Grey-headed Flying-foxes) were recorded as road kill during the baseline survey. In this respect, the performance criteria for the 2015/2016 period have been met.

Management implications

No specific management implications have resulted from the monitoring undertaken to date.

Table of Contents

Executive summary	iii
1. Introduction	5
1.1 Purpose.....	5
1.2 Background.....	5
2. Road Kill	7
2.1 Monitoring timing.....	7
2.2 Performance Measures	7
2.3 Methods.....	7
2.4 Results	8
2.5 Discussion	14
References	16
Annex 1. Road Kill Data	17

List of Tables

Table 1: Road kill monitoring timing and location	7
Table 2: Threatened species road kill during construction phase 2015/2016.	11
Table 3: Comparison of baseline monitoring results against construction phases (road kill weekly rate).....	15
Table 4. Road kill locations and animal details.....	17
Table 5: Road kill habitat details	29

List of Figures

Figure 1: Seasonal distribution of road kill along the OH2K project (baseline monitoring vs. construction phase 2015-2016).....	Error! Bookmark not defined.
Figure 2: Distribution of threatened species road kill along the OH2K project (baseline monitoring vs. construction phase 2015-2016).....	Error! Bookmark not defined.

List of Graphs

Graph 1: Percentages of road kill records, according to seasons, during baseline and two first years of construction phase (2014/2015 and 2015/2016)	10
Graph 2: Percentage of road kill records, according to fauna categories, during baseline and two first years of construction phase (2014/2015 and 2015/2016)	10

1. Introduction

1.1 Purpose

This report summarises the findings of the 2015/2016 road kill monitoring surveys undertaken as part of the Oxley Highway to Kempsey (OH2K) section of the Pacific Highway Upgrade Project. These were undertaken in accordance with the Oxley Highway to Kempsey Ecological Monitoring Program (EMP) 2014, Hyder Consulting Pty Ltd (Hyder 2014) over the period 22 of July 2015 to 21 July 2016. This report has been prepared as per the Minister's Condition of Approval (MCoA) for the Oxley Highway to Kempsey section of the Pacific Highway Upgrade Project, MCoA B10 (f) which requires the "Provision for annual reporting of monitoring results to the Director General and the EPA and DPI (Fishing and Aquaculture), or as otherwise agreed by the agencies".

Specifically, this document reports on the timing and results of monitoring activities undertaken, methodology employed and progress/results measured against previously identified performance measures.

1.2 Background

The Oxley Highway to Kempsey section of the Pacific Highway Upgrade Project (the "Project") was approved in 2012 subject to various MCoA and Statement of Commitments (SoC). A subsequent approval with additional conditions of consent (CoA) was granted in 2014 by the Department of Environment (DoE) for Matters of National Environmental Significance (MNES) listed under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1995* (EPBC Act). Combined, these approvals outline the mitigation, offsetting and monitoring requirements for threatened species and ecological communities impacted by the Project.

Specifically, the Oxley Highway to Kempsey EMP (2014) was developed to address MCoA B10 and Department of the Environment CoA 4. These conditions are detailed below.

MCoA B10

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 EPA 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).

Condition of Approval (CoA) 4

Prior to commencement of stage 2 and stage 3 of the action, the person taking the action must submit an Ecological Monitoring Program for approval by the Minister that determines the effectiveness of the mitigation measures implemented as part of the project. The Ecological Monitoring Program must be approved in writing by the Minister prior to commencement of stage 2 and stage 3, and must include:

a. The baseline data collected from surveys undertaken by a suitably qualified expert on the Koala, Spotted-tail Quoll and Giant-Barred Frog within all habitat areas outside areas to be cleared of vegetation for the proposed action, that are likely to contain these species and that are likely to be adversely impacted by the action (as determined by a suitably qualified expert). The data must address the densities, distribution, habitat use and movement patterns of these species;

b. The methodology to be implemented for the ongoing monitoring of road kill, the species densities, distribution, habitat use and movement patterns, and the use of fauna crossings during construction and operation of the action, including the timing, and duration of the methodology;

c. Goals and performance indicators to measure the success of proposed fauna crossings, which must be specific, measurable, achievable, realistic and timely (SMART), and be compared against baseline data described in condition 4a); and

d. Details of contingency measures that would be implemented in the event of changes to densities, distribution, habitat use and movement patterns that are attributable to the construction or operation of the project.

Monitoring must continue until mitigation measures can be demonstrated to have been effective for the Koala, Spotted-tail Quoll, and Giant-Barred Frog.

Should monitoring associated with this condition demonstrate that the use of fauna crossings and/or fencing is not achieving its intended purpose or is having a detrimental effect upon Koala, Spotted-tail Quoll, and Giant-Barred Frog (as determined by the Minister), the Minister may require that the person taking the action implement alternative forms of mitigation and/or corrective actions to address the relevant impacts to Koala, Spotted-tail Quoll, and Giant-Barred Frog, such measures must be implemented as requested.

2. Road Kill

2.1 Monitoring timing

The approved EMP (Hyder 2014) states the timing and location for road kill monitoring as detailed in Table 1 below.

Table 1: Road kill monitoring timing and location

Project Phase	Timing of survey	Location
Baseline	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	Daily	Portion of existing highway adjacent to clearing operations
One month following clearing operations	Daily	Portion of existing highway adjacent to clearing operations
For the duration of construction	Weekly	Entire length of existing highway in Project area
Within one month of opening of the Project	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)	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

2.2 Performance Measures

The approved EMP (Hyder 2014) specifies the following performance indicators for the road kill survey:

- 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 Years 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.

2.3 Methods

Monitoring methodology followed that prescribed in the approved EMP (Hyder 2014) and detailed below.

“Baseline road kill surveys will involve a vehicle being driven along the entire length of the existing highway in the Project area and identifying dead wildlife (road kill) seen on the roads and within three metres of the road edge. Both driver and passenger will search the left-hand side of the road and its verge for road kill. When a road kill is observed from the vehicle, a closer inspection of the carcass will be undertaken where access is possible and where safety limitations permit. If safe access is not possible, due to local traffic conditions, binoculars will be used to try to identify carcasses. Road kill fauna will be identified to species level where possible, with reference to field guides. Those too seriously damaged to be accurately identified will be recorded as “unknown”. Upon identification of the road kill, the animal should be removed if safe to do so, so as to avoid double counting during subsequent surveys”.

For each road kill observed, the following attributes were recorded:

- Geographic coordinates of the road kill location.
- Species of road kill where possible.

If the animal was identified as a TSC Act or EPBC Act threatened species, the following information was also recorded:

- Sex and age class (juvenile or adult) where possible and safety limitations permit.
- Presence of pouch young (for marsupials) where possible and safety limitations permit.

In addition, local habitat attributes were recorded at a point five metres from the road verge at the road kill location, including:

- Structure and floristics of vegetation, including dominant species of each vegetation stratum, height and per cent cover
- Presence and type of hydrological and surface drainage features
- Presence and type of rocky features
- Abundance and type of tree and log hollows
- Presence, type and abundance of foraging resources
- Presence and type of microhabitats.

2.4 Results

The results presented in this report summarise the 2015/2016 monitoring undertaken weekly between August 2015 and July 2016. This is the second year of the construction phase monitoring. The data has been collected by Road and Maritime Services and is summarised below. The raw data is provided in Annex 1.

2.4.1 Data limitations and assumptions

Due to safety concerns associated with slowing down on the highway to identify road kill, data collection was limited in some circumstances. In summary:

- Most of the road kills recorded were not identified at the genus or species level but at the “vertebrate group” level only.
- Some carcasses could not be identified as a result of extensive collision damage. These road kill animals were classified as ‘Unknown’.
- Small sized animals had the potential to be partially or wholly removed by scavenger animals and/or their remains not readily identifiable from the vehicle.

As a result, it is possible to have under-counted animals like frogs, small mammals and birds.

2.4.2 Construction phase 2015/2016

For consistency with previous monitoring periods, results for this year's surveys have been considered in relation to the following:

- Location (using a hand held GPS (GDA94)) to identify any focal points or hot spots.
- Season and fauna categories recorded to assess in relation to the types of mitigation measures being proposed.
- Legislative status of road kill under the *TSC Act (1995)* and *EPBC Act (1999)*.

Survey effort for the construction phase 2015/2016 covered 49 weeks (12.7 weeks in spring, 12.4 in summer, 12.7 in autumn and 11.1 in winter (including 3.7 in winter 2015 and 7.4 in winter 2016) from the 6th of August 2015 to the 22nd of July 2016.

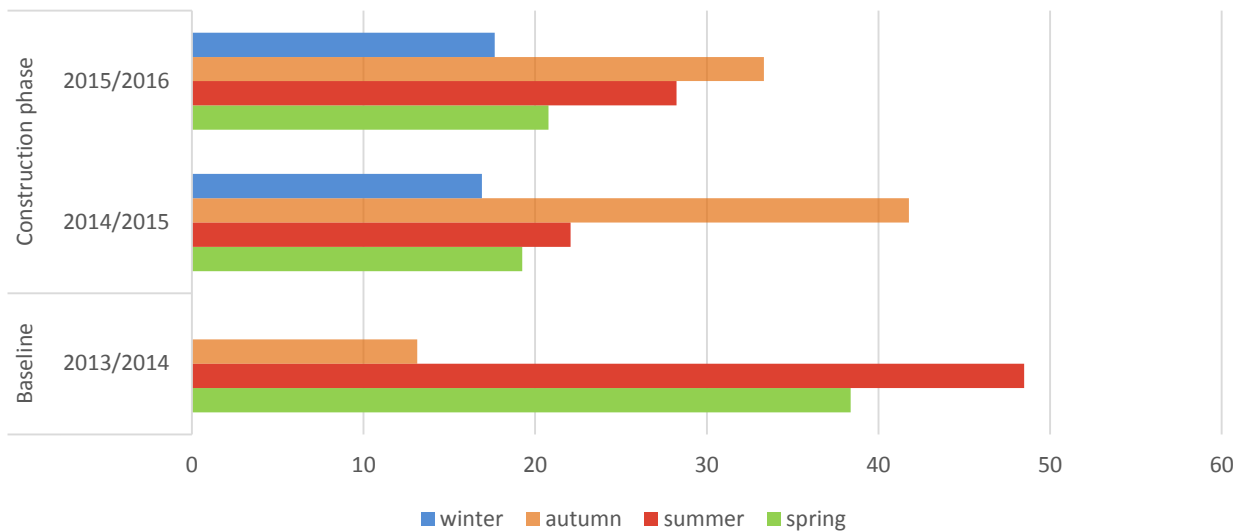
A total of 255 road kill animals were recorded over the 49 weeks of monitoring. This included 53 in spring 2015, 72 in summer 2015-2016, 85 in autumn 2016, and 45 in late winter 2015 and early winter 2016.

A wide range of fauna were recorded as road kill. The fauna categories with the highest number of road kill were birds (80 observations, 31.4% of the road kill) followed by large terrestrial mammals (kangaroos) (51 observations, 20.0% of the road kill). "Unknown" and unidentified mammals made up approximately 28% of the road kill. Small terrestrial mammals and reptiles made up approximately 6% of the road kill each. Arboreal and flying mammals were also recorded (10 and three records respectively), introduced mammals were recorded twice and only one road kill frog was recorded. (Graph 2).

These number of road kills recorded are not directly comparable with previous survey results because the survey effort for the construction phase 2015/2016 covered 49 weeks (12.7 weeks in spring, 12.4 in summer, 12.7 in autumn and 11.1 in winter including 3.7 in winter 2015 and 7.4 in winter 2016) as opposed to just 12 weeks for the baseline monitoring (4 weeks in spring, 4 in summer and 4 in autumn) and 38 weeks for construction phase 2014/2015 (4 weeks in spring, 12.9 in summer, 13.1 in autumn and 8.3 in winter). Baseline and construction phase monitoring were also generally undertaken daily, providing some added variation in results. However, the percentage of road kills recorded for each event can be used to reasonably compare different year's results and also identify any seasonal differences in fauna categories affected.

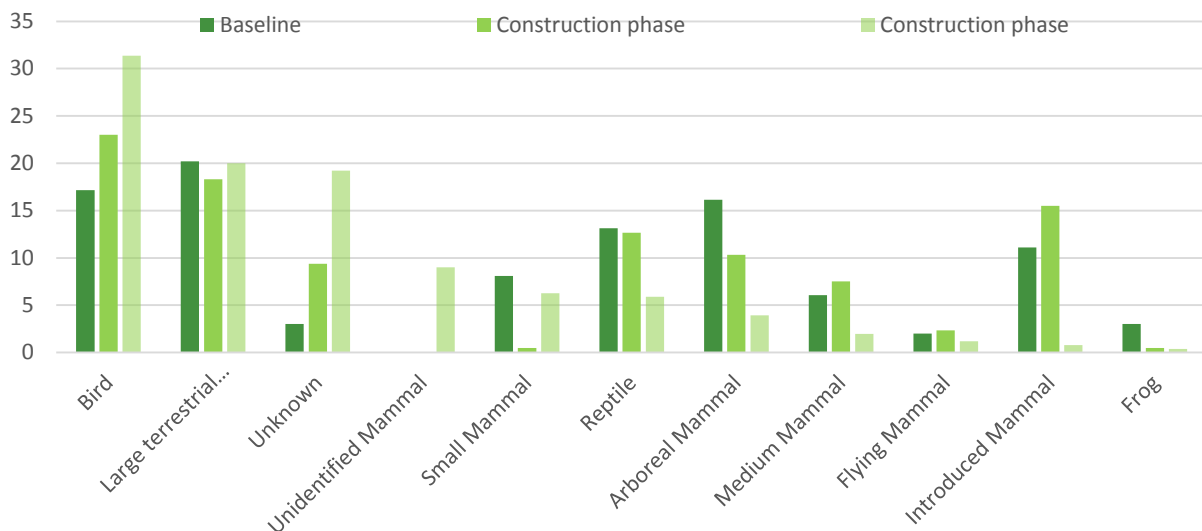
During the baseline monitoring, the lowest number of road kill was recorded in autumn (13% of observed road kills) while in both construction phases, autumn was the season with the highest number (41.9% in 2014/2015 and 33.3% in 2015/2016 of the road kill), indicating little pattern in road kill results in relation to season (Graph 1).

Graph 1: Percentages of road kill records, according to seasons, during baseline and two first years of construction phase (2014/2015 and 2015/2016)



In both years of the construction phase, birds were the fauna category with the highest number of road kill followed by large terrestrial mammals. The number of “unknown” and unidentified mammals was much greater in the most recent round of surveys compared to the previous two years, but reptile, arboreal mammals, medium mammals and introduced mammals has decreased compared to the previous two years (Graph 2). There has been a general overall decline in road kill over the three periods of survey to date.

Graph 2: Percentage of road kill records, according to fauna categories, during baseline and two first years of construction phase (2014/2015 and 2015/2016)



Road kills have been recorded across the entire length of the existing Pacific Highway carriageway during all four seasons with records extending from ch. 400 to ch. 37800.

Data from the construction phase 2015/2016 indicated five high impact areas - for road kills. These are shown in Figure 1 and listed below:

- 1800 – 3100 (Sancrox interchange). Mostly cleared area with remaining patches of wet sclerophyll forest and/or moist floodplain forest close by.

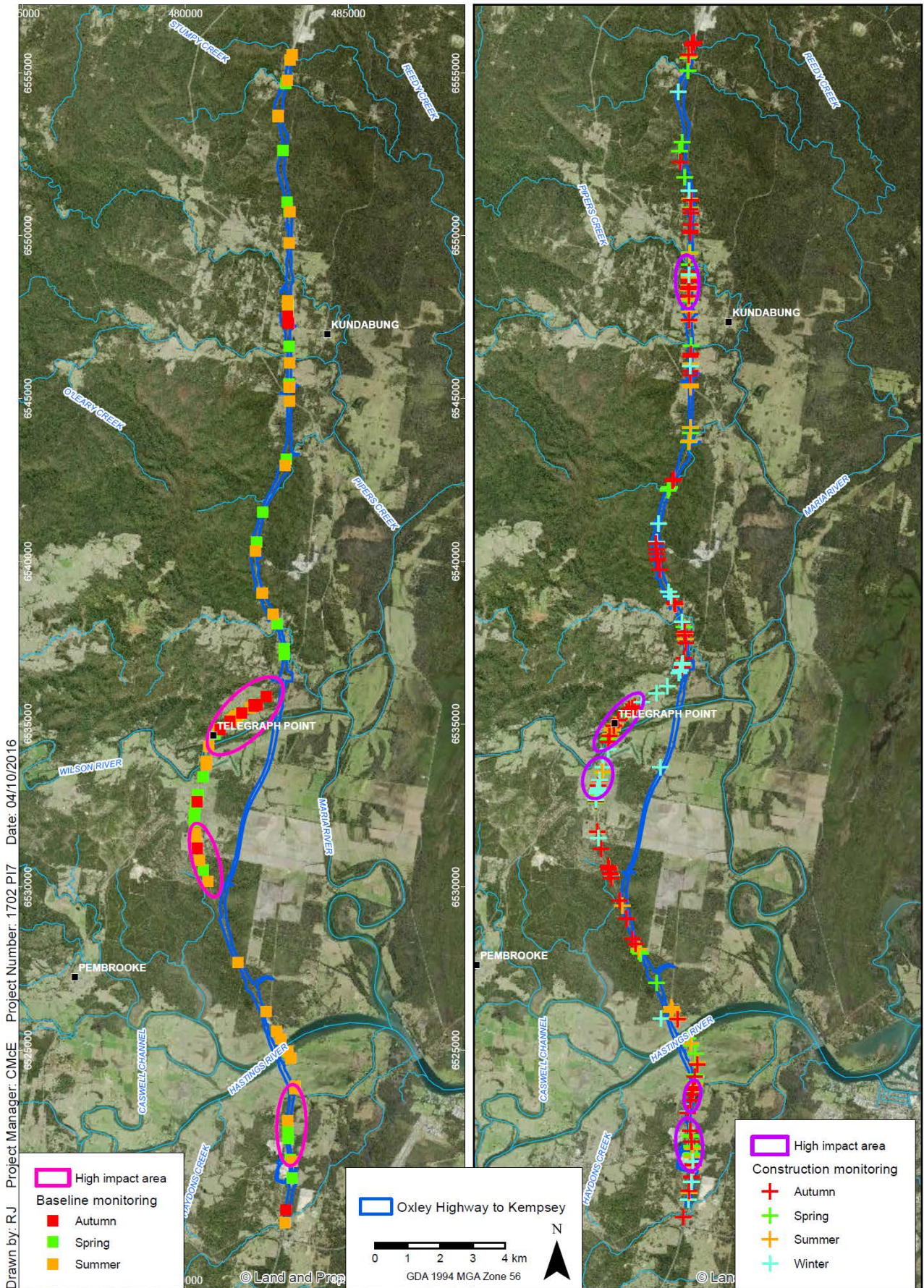
- 4000 – 4900 (Fernbank Creek). Part of a narrow, vegetated habitat linkage running in an east-west direction.
- 13200 – 14150 (Wilson River). Associated with an open floodplain area. This will become a service road once the Project has been constructed.
- 14400 – 17000 (Telegraph Point). This area will become a service road once the Project has been constructed.
- 29400 – 30900 (Pipers Creek). Associated with fragmented moist slopes forest.

All five high impact areas have been identified previously or during the baseline monitoring (Sancrox interchange, Fernbank Creek and Telegraph Point) or during the construction phase 2014/2015 (Wilson River and Pipers Creek).

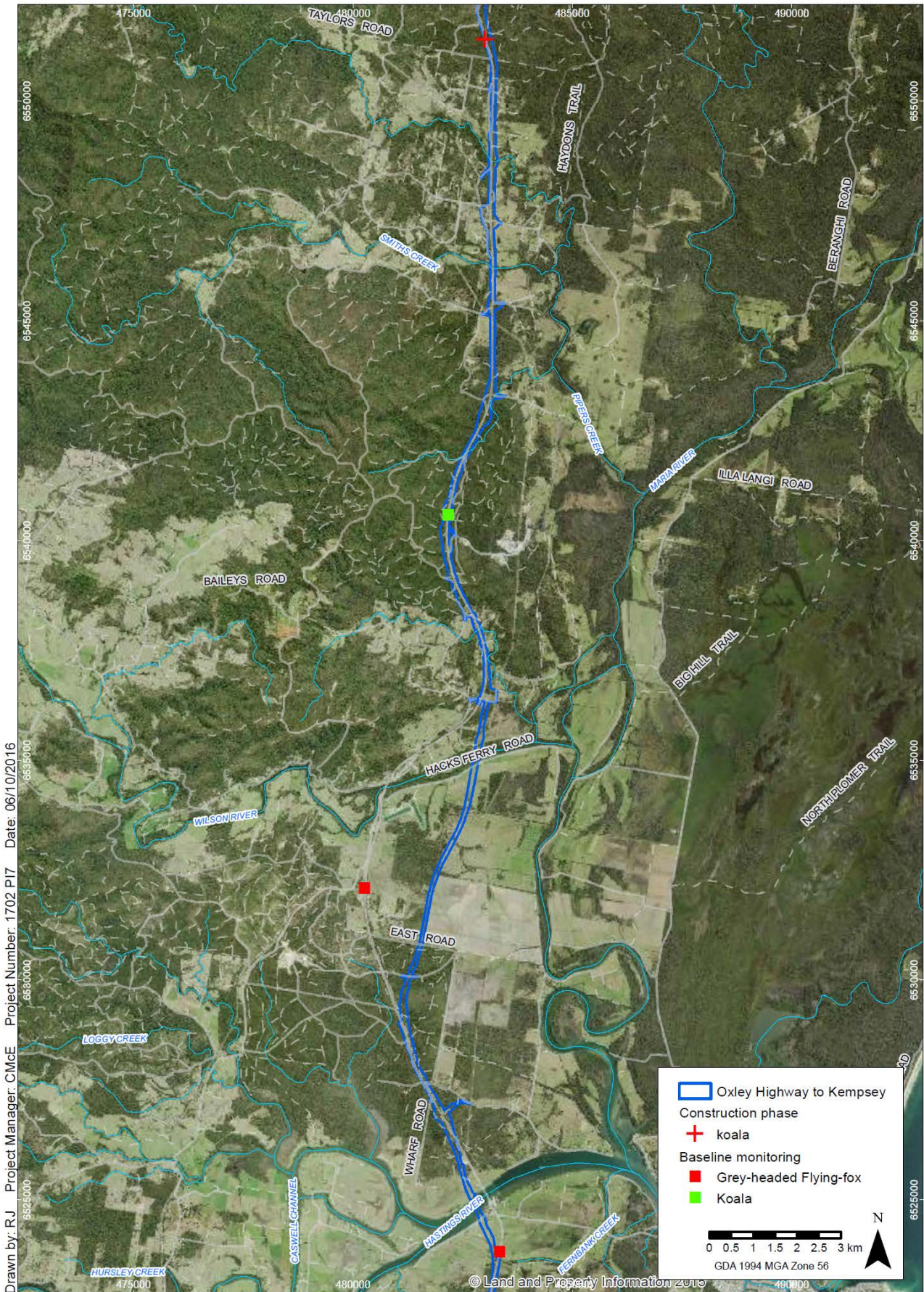
During the 49 weeks of survey effort in the 2015/2016 period one individual threatened species, the Koala, was recorded as road kill (Table 2 and Figure 2).

Table 2: Threatened species road kill during construction phase 2015/2016.

Season	Date	Species detected	Location
Summer	22-December-2015	Koala	1km north of Ravenswood Rd



Seasonal distribution of road kill along the OH2K project (baseline monitoring vs. construction phase 2015-2016)
Pacific Highway Upgrade - Oxley Highway



Threatened species road kill distribution along the OH2K project (baseline monitoring v. construction phase 2015-2016)
Pacific Highway Upgrade - Oxley Highway

2.5 Discussion

The following comments can be made about the results obtained compared to the listed performance measures:

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.

Majority of the traffic remains on the existing Pacific Highway, and as such, new fauna mitigation measures will have little benefit in these areas. The full benefit of these structures will not be realised until traffic is switched onto the new carriageways and these structures are completed. This is particularly evident in areas where the traffic will be switched onto a whole new alignment, and the existing highway will become a service road. The benefit of fauna mitigation in these areas will not be evident until the Project becomes operational.

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.

This performance measure was met in spring and summer but not in autumn for the 2015/2016 construction phase. There were more road kill recorded in autumn 2015/2016 than in the autumn surveys for the baseline monitoring periods. Overall there has been a decline in the recorded road kill between baseline and the subsequent two monitoring events and the overall performance measure has been met.

To be able to compare different year's data, a weekly road kill rate was calculated. The weekly rate was calculated as the number of road kill recorded per season divided the number of weeks surveyed in each season. The results are presented in Table 3.

In spring the weekly road kill rate was approximately the same for the Baseline and construction phase 2014/2015 (Niche 2016), but was much lower (approximately half) for the most recent monitoring period. Road kill rates for the summer months were greatest during the Baseline surveys and were consistently lower for the two subsequent rounds of construction monitoring (less than half that recorded in the first year). However, in autumn, the weekly road kill rate recorded during the construction phases was almost double that of the baseline survey, however the road kill rate recorded during the 2015/16 and 2014/15 surveys were similar. Winter surveys revealed approximately the same weekly road kill rate for each of the consecutive construction monitoring periods (as per requirements none were undertaken for the baseline surveys).

While there is some variability in the data at this stage (trends in road kill rates are not consistent across all seasons), the surveys for 2015/2016 show a reduced road kill rate compared to the baseline surveys in spring and summer (Lewis 2014) and therefore are in line with the performance measures in these seasons. Data from future monitoring events will provide further information on seasonal and yearly variability in road kill rates and thus inform progress against stated performance measures.

Overall the weekly road kill rates have declined from baseline and the performance measure therefore has been met.

Table 3: Comparison of baseline monitoring results against construction phases (road kill weekly rate)

		spring	summer	autumn	winter
Baseline monitoring	2013/2014	9.5	12.0	3.3	n/a
Construction phase	2014/2015	10.3	3.6	6.8	4.3
	2015/2016	4.2	5.8	6.7	4.1

Only one threatened species (one individual Koala) was recorded during the 2015/2016 construction phase while three individual threatened species (one Koalas and two Grey-headed Flying-fox) were recorded as road kill during the baseline survey. In this respect, the performance criteria for the 2015/2016 period has been met.

Fauna exclusion fencing is installed at a minimum in the locations identified in Schedule 3 of the EPBC approval at Year 4.

Not applicable until Year 4.

References

Hyder Consulting Pty Ltd (2014). Oxley Highway to Kempsey Pacific Highway Upgrade Ecological Monitoring Program 19 September 2014. Prepared for Roads and Maritime Service by Smec Hyder Joint Venture.

Lewis, B.D (2014). Pacific Highway Upgrade: Oxley Highway to Kempsey Pre-construction Spring and Summer Baseline Monitoring. Report prepared for RPS-RMS by Lewis Ecological Surveys.

Niche (2106). Annual Ecological Monitoring Report 2015 – Oxley Highway to Kempsey, Pacific Highway Upgrade. Prepared for Roads and Maritime Services.

Annex 1. Road Kill Data

Data provided by Roads and Maritime Services.

To be able to display all the information provided for each record the data are separated in two tables one with the location and the animal details (Table 4) and one with the habitat details (Table 5). An “ID record” column has been added to the original data to be able to combine the data for each record in both tables.

Table 4. Road kill locations and animal details

ID record	Week Number	Date	Start Time	Finish Time	Location description	Latitude	Longitude	Species	Assigned Vertebrate Group	Sex	Age	Pouch Young
	Week 1	06/08/2015	11:40am	12:15pm	Hastings River to Barrys Creek			No new road kill identified				
1	Week 2	13/08/2015	12:00pm	12:50pm	northbound lane, south of Wilmaria Rd	31°18'50.4"	152°48'44.6"	crow	bird	unknown	adult	na
2					southbound lane, south of Bill Hill Rd	31°21'51.6"	152°47'51.7"	eastern grey kangaroo	mammal	unknown	adult	unknown
	Week 3	20/08/2015	10:20am	11:20am	Hastings River to Barrys Creek			No new road kill identified				
3	Week 4	27/08/2015	1:25pm	2:50pm	southbound lane, north of Dennis Bridge	31°24.252'	152°48.812'	wallaby	mammal	unknown	adult	unknown
4					northbound, turning lane into Mooney Street	31°20.073'	152°48.812'	brush tailed possum	mammal	unknown	adult	unknown
5					southbound lane, north of Haydons Wharf Rd	31°20.073'	152°47.709'	kookaburra	bird	unknown	adult	na
6	Week 5	03/09/2015	1:25pm	3:10pm	northbound lane, south of Kempsey Interchange	31°08.839'	152°49.187'	kookaburra	bird	unknown	adult	na
7					northbound lane, north of Yarabee Rd	31°16.330'	152°48.750'	kookaburra	bird	unknown	adult	na
8					southbound lane, south of Haydons Wharf Rd	31°17.157'	152°48.979'	tawny frog mouth	bird	unknown	adult	na
9					northbound lane, north of Fernbank Ck	31°25.221'	152°49.491'	eastern grey kangaroo	mammal	unknown	adult	unknown
10	Week 6	10/09/2015	8:45am	10:40am	southbound lane, north of Barrys Ck (K2K)	31°15'26.2"	152°48'59.3"	snake	reptile	unknown	adult	na
11					southbound lane, adjacent Cassegrain wines	31°25.802'	152°49.345'	brush tailed possum	mammal	unknown	adult	unknown
12	Week 7	17/09/2015	8:45am	10:25am	southbound, south of Kempsey Interchange	31°08.067'	152°49.431'	bird (probable owl)	bird	unknown	adult	na
13					Mooney St Intersection median turning lane	31°26.713'	152°49.435'	long nosed bandicoot	mammal	unknown	adult	unknown
14	Week 8	24/09/2015	2:45pm	4:00pm	southbound lane, south of the Wilson River Bridge	31°19.780'	152°47.799'	unidentifiable mammal	mammal	unknown	unknown	unknown

ID record	Week Number	Date	Start Time	Finish Time	Location description	Latitude	Longitude	Species	Assigned Vertebrate Group	Sex	Age	Pouch Young
15					southbound lane north of the Port Macquarie interchange	31°27.262'	152°49.344'	red necked wallaby	mammal	unknown	adult	unknown
16					Ravenswood Rd intersection median turning lane	31°11'31.4"	152°49'24.0"	magpie	bird	unknown	adult	na
17					northbound, south of Haydons Wharf Rd	31°18'30.4"	152°49'10.9"	fox	mammal	unknown	adult	na
18					southbound lane, driveway south of Wilmaria Rd	31°18.731'	152°48.951'	long nosed bandicoot	mammal	male	adult	na
19	Week 9	01/10/2015	8:10am	10:00am	southbound lane, Hastings River Bridge	31°24'34.8"	152°49'20.2"	kookaburra	bird	unknown	adult	na
20	Week 10	08/10/2015	10:00am	11:20am	southbound lane, south of Fernbank Ck bridge	31°25'19.5"	152°49'27.8"	turtle/tortoise	reptile	unknown	adult	na
21					northbound lane, south of Glen Ewan Rd	31°24'34.8"	152°49'20.2"	kookaburra	bird	unknown	adult	na
22					Mobbs Rd, median turning lane	31°14'26.1"	152°49'24.4"	goanna	reptile	unknown	adult	na
23					southbound lane, north of Smiths Ck Rd	31°12'18.0"	152°49'23.0"	unidentified mammal	mammal	unknown	unknown	unknown
24	Week 11	14/10/2015	10:50am	11:55am	southbound, south of Fernbank Ck Bridge (gate 7)	31°25'26.8"	152°49'25.7"	wallaby	mammal	unknown	unknown	unknown
25					southbound, south of Cooperabung Close	31°17'44.4"	152°49'16.4"	echidna	mammal	unknown	sub-adult	unknown
26					southbound, north of Heavy Vehicle Checking Bay Kundabung	31°13'14.6"	152°49'24.9"	unidentifiable bird	bird	unknown	unknown	unknown
27	Week 12	21/10/2015			northbound, adjacent rest area south of Kempsey	31°09'50.0"	152°49'12.5"	Noisy Friarbird	bird	unknown	adult	unknown
28					northbound, Ravenswood Rd intersection north	31°11'51.2"	152°49'23.4"	unidentifiable	unknown	unknown	unknown	unknown
29					southbound, approx. 1km north of Mingaletta Rd	31°14'31.1"	152°49'24.4"	unidentifiable	unknown	unknown	unknown	unknown
30	Week 13	30/10/2015	7:10am	8:25am	southbound lane, south of Cooperabung Close	31°19'10.3"	152°48'08.8"	unidentified bird	bird	unknown	adult	na
31					southbound, south of Wilson River Bridge	31°20'18.6"	152°47'37.9"	wallaby	mammal	unknown	sub adult	unknown
32					southbound lane, south of Pembroke Rd	31°20'29.0"	152°47'35.6"	wallaby	mammal	unknown	adult	unknown
33					southbound lane, south of Pembroke Rd	31°20'28.7"	152°47'35.8"	kookaburra	bird	unknown	adult	na
34	Week 14	05/11/2012	2:05pm	3:10pm	northbound, Barrys Ck	31°15'25.3"	152°48'59.5"	bird	bird	unknown	unknown	na
35					southbound, Barrys Ck	31°15'25.2"	152°49'00.1"	bird	bird	unknown	unknown	na

ID record	Week Number	Date	Start Time	Finish Time	Location description	Latitude	Longitude	Species	Assigned Vertebrate Group	Sex	Age	Pouch Young
36					northbound, 400m south of Hastings River Dr	31°24'41.8"	152°49'24.2"	bird	bird	unknown	unknown	na
37					southbound, 50m south of Blackmans Point Rd	31°23'10.2"	152°48'25.3"	bird	bird	unknown	unknown	na
38	Week 15	13/11/2015	7:00am	8:20am	northbound, start of BP Rd diversion	31°23'39.5"	152°48'44.3"	bird	bird	unknown	unknown	na
39					northbound Blackmans Point Rd	31°23'08.4"	152°48'23.6"	unidentifiable	unknown	unknown	unknown	na
40					northbound, north of Kempsey rest area	31°09'41.3"	152°49'15.8"	small bird	bird	unknown	adult	na
41					southbound, Smiths Ck Rd construction gate	31°12'19.6"	152°49'23.2"	unidentifiable	unknown	unknown	unknown	na
42					southbound, Wilson River Bridge	31°19'35.7"	152°47'49.2"	unidentifiable mammal	mammal	unknown	unknown	unknown
43					southbound, Blackmans Point Rd	31°23'09.3"	152°48'25"	unidentifiable mammal	mammal	unknown	unknown	unknown
44	Week 16	20/11/2015			northbound on bridge north of Telegraph Point turnoff	31°19'04.3"	152°48'18.8"	small bird	bird	unknown	adult	na
45					southbound Fernbank Ck bridge	31°25'17.8"	152°49'28.1"	kookaburra	bird	unknown	adult	na
46					northbound south of Hastings River Dr	31°24'50.3"	152°49'29.2"	small brown mammal	mammal	unknown	unknown	unknown
47	Week 17	26/11/2015	12:00pm	1:20pm	northbound, approximately 800m north of Mingaletta Rd	31°13'03.8"	152°49'25.1"	unidentifiable large mammal	mammal	unknown	unknown	na
48					southbound, south of Kempsey rest area	31°26'23.8"	152°49'30.6"	unidentifiable	unknown	unknown	unknown	na
49					Ravenswood Rd intersection median turning lane	31°11'31.4"	152°49'24.0"	bird	bird	unknown	unknown	na
50					south of Barrys Creek	31°15'28.3'	152°48'58.5'	kangaroo	mammal	unknown	unknown	unknown
51					southbound, north of Rollands Plains Rd	31°19'08.3"	152°48'12.1"	bird	bird	unknown	unknown	na
52					southbound, Mooney St	31°19'38.5"	152°47'48.7"	unidentifiable	unknown	unknown	unknown	unknown
53					southbound, south of Moonee St	31°20'10.4"	152°47'41.3"	turtle/tortoise	reptile	unknown	unknown	na
54					southbound, south of Pembroke Rd	31°20'39.5"	152°47'34.1"	unidentifiable	unknown	unknown	unknown	unknown
55					southbound, south of Hastings River Bridge	31°24'40.0"	152°49'23.5"	unidentifiable	mammal	unknown	unknown	unknown
56					southbound, south of Fernbank Creek Bridge	31°25'20.1"	152°49'27.5"	unidentifiable	mammal	unknown	unknown	unknown

ID record	Week Number	Date	Start Time	Finish Time	Location description	Latitude	Longitude	Species	Assigned Vertebrate Group	Sex	Age	Pouch Young
57					southbound, Cassegrain Winery	31°26'22.5"	152°49'24.7"	unidentifiable	unknown	unknown	unknown	unknown
58					northbound, south of Sancrox Bridge	31°26'53"	152°49'25"	unidentifiable	unknown	unknown	unknown	unknown
59	Week 18	03/12/2015	10:00am	11:20am	southbound, south of Pembroke Rd	31°20'32.5"	152°47'34.9"	small mammal	mammal	unknown	unknown	na
60	Week 19	11/12/2015	1:15pm	2:35pm	Mooney St intesection	31°19'38.8"	152°47'48.4"	small mammal	mammal	unknown	unknown	unknown
61					north of Mooney St	31°19'33.9"	152°47'49.4"	unidentifiable	unknown	unknown	unknown	unknown
62					Cooperabung Drive	31°18'24.6"	152°49'13.5"	brush tailed possum	mammal	unknown	unknown	unknown
63					southbound, north of Ravenswood Rd	31°10'15.7"	152°49'18.2"	snake	reptile	unknown	unknown	na
64					southbound, Bill Hill Rd	31°21'44.4"	152°47'48.4"	kangaroo	mammal	male	adult	na
65					southbound, Fernbank Ck bridge	31°25'18.1"	152°49'28.0"	kookaburra	bird	unknown	adult	na
66					adjacent Cassegrain Winery	31°26'11.7"	152°49'23.3"	kangaroo/wallaby	mammal	unknown	unknown	unknown
67					northbound, Sancrox	31°26'33.2"	152°49'25.2"	kookaburra	bird	unknown	adult	na
68					northbound, north of Fernbank Ck Bridge	31°25'11.2"	152°49'29.3"	kangaroo	mammal	unknown	adult	unknown
69	Week 20	15/12/2015	3:10pm	4:25pm	northbound, Kundabung	31°11'42.8"	152°49'23.5"	brush tailed possum	mammal	unknown	adult	no
70					southbound, south of Pembroke Rd	31°20'27.8"	152°47'35.9"	galah	bird	unknown	adult	na
71	Week 21	21/12/2015	9:15am	10:45am	northbound, north of Ravenswood Rd	31°10'47.1"	152°49'25.0"	small unidentifiable	mammal	unknown	unknown	unknown
72					northbound, north of south Kempsey rest area	31°08'17.1"	152°49'22.6"	small unidentifiable	mammal	unknown	unknown	unknown
73					southbound, south of south Kempsey rest area	31°08'29.7"	152°49'22.2"	medium brown unidentifiable	mammal	unknown	unknown	unknown
74					north of Cairncross Waste Management	31°08'29.7"	152°49'22.2"	wallaby	mammal	unknown	unknown	unknown
75					northbound, south of Sancrox Rd	31°26'31.7"	152°49'24.8"	kookaburra	bird	unknown	adult	unknown
76		22/12/2015	am		1km north of Ravenswood Rd	31°10'15.9"	152°49'17.9"	koala	mammal	CALLLED IN BY COMMUNITY MEMBER, DETAILS NOT KNOWN		

ID record	Week Number	Date	Start Time	Finish Time	Location description	Latitude	Longitude	Species	Assigned Vertebrate Group	Sex	Age	Pouch Young
77	Week 22	29/12/2015	10:10am	11:25am	northbound, south of Sancrox Rd	31°26'29.8"	152°49'24.7"	kookaburra	bird	unknown	adult	na
78					northbound adjacent Cassegrain	31°26'06.9"	152°49'22.4"	unidentifiable	unknown	unknown	unknown	unknown
79					northbound, Ravenswood Rd intersection north	31°10'46.4"	152°49'25.1"	bird	bird	unknown	adult	na
80					median turning lane, Mingaletta Rd	31°14'39.8"	152°49'22.0"	mammal	mammal	unknown	unknown	unknown
81					northbound, north of Mooney St	31°19'37.1"	152°47'48.4"	unidentifiable	unknown	unknown	unknown	unknown
82					southbound, Pembroke Rd	31°20'27.4"	152°47'36.2"	galah	bird	unknown	adult	na
83					southbound, approach to Wilson River Bridge	31°19'27.2"	152°47'52.8"	bird	bird	unknown	unknown	na
84					southbound, adjacent Cassegrain vineyard	31°26'13.2"	152°49'23.4"	unidentifiable	unknown	unknown	unknown	unknown
85					southbound, adjacent Cassegrain driveway	31°26'23.9"	152°49'24.9"	mammal	mammal	unknown	unknown	unknown
86	Week 23	08/01/2016	8:20am	9:30am	north of Smiths Creek Rd	31°12'04.4"	152°49'22.7"	unidentifiable	mammal	unknown	unknown	unknown
87					southbound, south of Hastings River Bridge	31°24'39.8"	152°49'23.5"	identifiable small	mammal	unknown	unknown	unknown
88					northbound, north of Fernbank Ck	31°24'59.3"	152°49'31.5"	identifiable	mammal	unknown	unknown	unknown
89	Week 23	15/01/2016	11:10am	12:20am	south of Sancrox	31°26'44.9"	152°49'26.0"	bird	bird	unknown	adult	na
90					northbound, south of Pembroke Rd	31°20'33.4"	152°47'34.3"	unidentifiable	unknown	unknown	unknown	unknown
91					northbound, north of Mooney St	31°20'18.1"	152°47'37.8"	unidentifiable	mammal	unknown	unknown	unknown
92					northbound, south of Wilson River Bridge	31°19'32.8"	152°47'49.7"	brush tailed possum	mammal	unknown	adult	unknown
93					Mingaletta Rd turning lane	31°14'39.1"	152°49'22.9"	small mammal	mammal	unknown	unknown	unknown
94					south of Wilson River, median	31°19'33.0"	152°47'50.1"	small mammal	mammal	unknown	unknown	unknown
95					southbound, bridge south of Mooney St	31°20'08.6"	152°47'41.8"	python	reptile	unknown	adult	na
96	Week 24	21/01/2016	10:15am	11:20am	middle of road, south of Moorside Dr	31°21'09.3"	152°47'35.1"	owl/tawny frogmouth	bird	unknown	adult	na
97					little bridge over Cooperabung Dr, Telegraph Point	31°19'03.7"	152°48'19.4"	unidentifiable (probably small)	unknown	unknown	unknown	unknown
98					Mobbs Rd median turning lane	31°14'25.6"	152°49'24.3"	bird	bird	unknown	adult	na

ID record	Week Number	Date	Start Time	Finish Time	Location description	Latitude	Longitude	Species	Assigned Vertebrate Group	Sex	Age	Pouch Young
99					northbound, north of Wilson River Bridge	31°19'27.3"	152°47'52.2"	unidentifiable	small mammal	unknown	unknown	unknown
100					southbound, Wilson River Bridge	31°19'31.1"	152°47'50.7"	small unidentifiable	mammal	unknown	adult	unknown
101					southbound merging lane, main compound	31°24'05.9"	152°49'02"	bird	bird	unknown	unknown	na
102					northbound, north of McInerney's driveway	31°24'14.8"	152°49'07.5"	bird	bird	unknown	unknown	na
103					southbound, south of Fernbank Ck	31°25'21.9"	152°49'27.1"	unidentifiable	small mammal	unknown	unknown	unknown
104	Week 25	29/01/2016	7:30am	8:40am	southbound, north of Fernbank Ck	31°26'24.9"	152°49'25.1"	small unidentifiable	unknown	unknown	unknown	unknown
105					northbound, north of Wilson River Bridge	31°19'21.5"	152°47'55.9"	maggie lark	bird	unknown	adult	unknown
106					northbound, south of Ravenswood Rd (southern end)	31°11'32.6"	152°49'23.7"	small unidentifiable	reptile	unknown	unknown	na
107	Week 26	03/02/2016	7:15am	8:30am	southbound, north of main compound	31°24'07.9"	152°49'00.1"	wallaby	mammal	unknown	adult	unknown
108					northbound, south of Upper Smiths Ck Rd	31°13'45.5"	152°49'24.3"	rabbit	mammal	unknown	adult	na
109					northbound, Rodeo Drive (north)	31°11'55.9"	152°49'23.2"	black bird	bird	unknown	adult	na
110					southbound, pet motel Kempsey	31°08'15.6"	152°49'23.5"	wallaby	mammal	unknown	adult	unknown
111					southbound, Kundabung Dr	31°12'30.3"	152°49'23.4"	bird	bird	unknown	unknown	na
112					southbound, Mingaletta Rd	31°14'39.1"	152°49'23.1"	unidentifiable	unknown	unknown	unknown	unknown
113					Wilson River Bridge	31°19'32.9"	152°47'50.0"	unidentifiable	unknown	unknown	unknown	unknown
114					northbound, McInerney driveway	31°24'16.6"	152°49'08.7"	unidentifiable small	mammal	unknown	unknown	unknown
115	Week 27	12/02/2016			northbound south of Wilson River Bridge	31°19'32.7"	152°47'49.8"	frog	reptile	unknown	unknown	na
116					northbound north of Wilson River Bridge	31°19'24.7"	152°47'53.7"	bird	bird	unknown	unknown	na
117					northbound, north of Haydons Wharf Road	31°17'56.3"	152°49'18.1"	unidentifiable small mammal	mammal	unknown	unknown	unknown
118					northbound kundabung	31°13'21.5"	152°49'24.7"	unidentifiable	unknown	unknown	unknown	unknown
119					northbound, south of Kundabung Dr	31°12'39.4"	152°49'23.5"	duck	bird	unknown	unknown	na

ID record	Week Number	Date	Start Time	Finish Time	Location description	Latitude	Longitude	Species	Assigned Vertebrate Group	Sex	Age	Pouch Young
120					northbound, north of Smiths Creek Rd	31°12'17.6"	152°49'22.7"	magpie	bird	unknown	unknown	na
121					southbound, north of Riverview Close	31°19'22.1"	152°47'55.5"	possum	mammal	unknown	unknown	unknown
122	Week 28	19/02/2016	8:20am	9:25am	northbound, south of Fernbank Ck	31°25'20.2"	152°49'27.1"	turtle	reptile	unknown	adult	na
123					northbound, 200m north of Haydons Wharf Rd	31°17'52.2"	152°49'17.3"	kookaburra	bird	unknown	adult	na
124					northbound, 220m north of Haydons Wharf Rd	31°17'51.8"	152°49'17.5"	bird	bird	unknown	unknown	na
125					(old truck stop)	31°13'14.7"	152°49'25.0"	small unidentifiable mammal	mammal	unknown	unknown	unknown
126					southbound, north of Blackmans Point Rd	31°23'05.8"	152°48'23.0"	unidentifiable mammal	mammal	unknown	unknown	unknown
127	Week 29	25/02/2016	10:00am	11:05am	(gate 12)	31°12'07.3"	152°49'23.4"	bird	bird	unknown	unknown	na
128					turning lane south of Pembroke Rd	31°20'29.6"	152°47'35.6"	bird	bird	unknown	unknown	na
129					southbound, south of Bill Hill Rd	31°21'50.7"	152°47'51.1"	wallaby	mammal	unknown	adult	unknown
130					southbound, south of Sancrox Rd	31°26'32.7"	152°49'25.8"	unidentifiable mammal	mammal	unknown	unknown	unknown
131	Week 30	04/03/2016	11:20am	12:55pm	northbound, south of the Wilson River Bridge	31°19'33.3"	152°47'49.5"	brush tail possum	mammal	unknown	adult	unknown
132					northbound, Cooperabung Drive turning lane	31°17'22.1"	152°49'06.3"	black flying fox	mammal	unknown	adult	na
133					northbound, north of Smiths Creek Rd	31°12'08.5"	152°49'22.2"	bird	bird	unknown	adult	na
134					southbound, Pembroke Rd	31°20'27.8"	152°47'36.1"	kangaroo	mammal	unknown	adult	unknown
135					southbound, compound entrance	31°24'03.4"	152°49'01.3"	unidentified mammal	mammal	unknown	unknown	unknown
136	Week 31	11/03/2016	11:05am	12:15pm	northbound, adjacent start of widened median	31°22'22.3"	152°48'04.0"	snake	reptile	unknown	unknown	na
137					Cooperabung median acceleration lane	31°17'22.2"	152°49'06.3"	Tawny Frog Mouth	bird	unknown	adult	na
138					northbound, (adjacent Gate 12)	31°12'08.2"	152°49'22.7"	bird	bird	unknown	adult	na
139					southbound, south of Wilson River Bridge	31°19'33.3"	152°47'49.8"	unidentifiable mammal	mammal	unknown	unknown	unknown
140					northbound, start of project	31°27'08.7"	152°49'21.5"	possum	mammal	unknown	adult	unknown
141	Week 32	18/03/2016	9:05am	10:00am	northbound, south of Upper Smiths Ck Rd	31°13'43.1"	152°49'24.4"	small unidentifiable	mammal	unknown	unknown	unknown

ID record	Week Number	Date	Start Time	Finish Time	Location description	Latitude	Longitude	Species	Assigned Vertebrate Group	Sex	Age	Pouch Young
142					northbound, north of Ravenswood	31°10'37.8"	152°49'24.3"	macropod	mammal	unknown	unknown	unknown
143	Week 33	24/03/2016	1:00pm	2:05pm	southbound, north of the Wilson River	31°19'22.2"	152°47'55.9"	kangaroo	mammal	unknown	unknown	unknown
144					northbound, Cooperabung Drive	31°17'22.1"	152°49'06.4"	kangaroo/wallaby	mammal	unknown	unknown	unknown
145					Yarabee Rd	31°24'07.4"	152°49'02.4"	kangaroo	mammal	unknown	unknown	unknown
146	Week 34	01/04/2016	11:05am	12:00pm	approximately 500m south of Fernbank Creek	31°25'36.7"	152°49'23.5"	unidentifiable	unknown	unknown	unknown	unknown
147					northbound, south of Bill Hill Rd	31°21'50.0"	152°47'50.3"	wallaby	mammal	unknown	unknown	unknown
148					north of Yarabee Rd	31°16'31.2"	152°48'45.1"	wallaby	mammal	unknown	unknown	unknown
149					south of Barrys Creek	31°15'18.5"	152°49'03.7"	wallaby	mammal	unknown	unknown	unknown
150					northbound, north of Ravenswood Rd (south)	31°11'10.0"	152°49'24.5"	unidentified	mammal	unknown	unknown	unknown
151					south of Kempsey interchange	31°08'04.2"	152°49'27.5"	kookaburra	bird	unknown	adult	na
152					southbound, Ravenswood Rd	31°10'51.2"	152°49'25.6"	red bellied black snake	reptile	unknown	adult	na
153					southbound, north of Smiths Creek Rd	31°13'11.9"	152°49'25.2"	unidentifiable	unknown	unknown	unknown	unknown
154					southbound, Yarabee acceleration lane	31°16'37.3"	152°48'46.1"	bird	bird	unknown	unknown	na
155					south of Cooperabung Drive	31°17'21.8"	152°49'06.5"	unidentifiable	unknown	unknown	unknown	unknown
156					southbound, north of Wilson River	31°19'23.0"	152°47'55.2"	unidentifiable	unknown	unknown	unknown	unknown
157					southbound, north of Bill Hill Rd	31°21'42.9"	152°47'47.8"	lace monitor	reptile	unknown	adult	na
158	Week 35	08/04/2016	11:30am	12:20	northbound, south of Bill Hill Rd	31°21'51.0"	152°47'50.7"	Tawny Frog Mouth	bird	unknown	adult	na
159					northbound, Bill Hill Rd	31°21'46.3"	152°47'48.7"	wallaby	mammal	unknown	unknown	unknown
160					southbound, north of Smiths Ck Rd	31°11'58.3"	152°49'23.6"	small mammal	mammal	unknown	unknown	unknown
161					southbound, Yarabee acceleration lane	31°16'36.5"	152°48'46.4"	bird	bird	unknown	unknown	na
162					southbound, south of Wilson River Bridge	31°19'33.2"	152°47'50.1"	brushtailed possum	mammal	unknown	adult	unknown
163					southbound, south of Fernbank Ck	31°25'26.3"	152°49'26.1"	black flying fox	mammal	unknown	adult	na

ID record	Week Number	Date	Start Time	Finish Time	Location description	Latitude	Longitude	Species	Assigned Vertebrate Group	Sex	Age	Pouch Young
164					southbound, adjacent to Cassegrain buildings	31°26'07.4"	152°49'22.9"	bird	bird	unknown	adult	na
165	Week 36	15/04/2016	7:30am	9:00am	northbound, north of Fernbank Ck	31°25'12.7"	152°49'28.8"	small mammal	mammal	unknown	unknown	unknown
166					northbound, approx. 200m south of Bill Hill Rd	31°21'55.0"	152°47'52.2"	wallaby	mammal	unknown	unknown	unknown
167					median, Pembroke Rd	31°20'25.6"	152°47'36.2"	lorikeet	bird	unknown	adult	na
168					median, 500m south of Yarabee Rd	31°16'47.2"	152°48'48.3"	small unidentifiable	unknown	unknown	unknown	unknown
169					median, 500m north of Yarabee Rd	31°16'21.5"	152°48'44.6"	unidentifiable mammal	unknown	unknown	unknown	unknown
170					northbound, south of Smiths Ck Rd	31°12'38.8"	152°49'23.0"	small mammal	mammal	unknown	unknown	unknown
171					northbound, south of Ravenswood Rd (northern end)	31°11'09.7"	152°49'24.4"	small mammal	mammal	unknown	unknown	unknown
172					median, south Bloodwood Rest Area	31°10'01.2"	152°49'13.3"	magpie	bird	unknown	adult	na
173					northbound, south of Kempsey Interchange	31°08'02.9"	152°49'26.2"	unidentifiable	unknown	unknown	unknown	unknown
174					southbound, north Ravenswood	31°10'39.0"	152°49'25.4"	small unidentifiable	unknown	unknown	unknown	unknown
175					southbound, north of Smiths Ck Rd	31°12'14.1"	152°49'23.1"	small mammal	unknown	unknown	unknown	unknown
176					southbound, Yarabee Rd acceleration lane	31°16'36.9"	152°48'46.1"	bird	bird	unknown	unknown	unknown
177					southbound, Moonee St	31°17'19.7"	152°49'05.4"	black flying fox	mammal	unknown	adult	na
178	Week 37	22/04/2016	11:25pm	12:40pm	southbound, north of Sancrox Rd	31°26'17.6"	152°49'24.2"	bird	bird	unknown	unknown	na
179					northbound, north of Port Macquarie Interchange	31°27'32.5"	152°49'15.2"	unidentifiable mammal	mammal	unknown	unknown	unknown
180					northbound, south of Fernbank Ck	31°25'30.5"	152°49'24.4"	bird	bird	unknown	unknown	unknown
181					northbound, 400m north Blackmans Pt Rd	31°22'55.7"	152°48'16.2"	kangaroo	mammal	unknown	unknown	unknown
182					northbound, north of Mahogany Rd	31°22'17.2"	152°48'01.6"	kangaroo	mammal	unknown	unknown	unknown
183					northbound, south of Pear Tree Rd	31°21'25.9"	152°47'39.4"	bird	bird	unknown	unknown	na
184					northbound, north of Haydons Wharf Rd	31°18'15.8"	152°49'16.7"	bird	bird	unknown	unknown	na

ID record	Week Number	Date	Start Time	Finish Time	Location description	Latitude	Longitude	Species	Assigned Vertebrate Group	Sex	Age	Pouch Young
185					northbound, Ravenswood Rd	31°10'48.0"	152°49'25.2"	unidentified mammal	mammal	unknown	unknown	unknown
186					southbound, between Rodeo Dr south and Smiths Ck Rd	31°12'05.5"	152°49'23.4"	unidentified mammal	mammal	unknown	unknown	unknown
187					southbound Moores Rd	31°19'16.9"	152°48'00.3"	lizard	reptile	unknown	unknown	na
188					southbound, south of Pembroke Rd	31°20'37.9"	152°47'34.3"	kangaroo	mammal	unknown	unknown	unknown
189	Week 38	29/04/2016	6:50am	9:45am	northbound, McInerney driveway	31°24'16.0"	152°49'08.2"	small marsupial	mammal	unknown	unknown	unknown
190	Week 39	06/05/2016	8:25am	9:55am	northbound, south of Rodeo Dr	31°13'14.8"	152°49'24.5"	small mammal	mammal	unknown	unknown	unknown
191					northbound, between Smiths Ck Rd and Rodeo (nth)	31°12'05.3"	152°49'22.7"	unidentifiable	unknown	unknown	unknown	unknown
192					southbound, Cooperabung acceleration lane	31°17'21.6"	152°49'06.4"	unidentifiable mammal	mammal	unknown	unknown	unknown
193					southbound, north of Haydons Wharf Rd	31°17'39.8"	152°49'15.1"	wood ducks	bird	unknown	ducklings	na
194					southbound, north of Blackmans Point Rd	31°23'00.8"	152°48'19.6"	unidentifiable	unknown	unknown	unknown	unknown
195					southbound, adjacent Cassegrain	31°26'18.2"	152°49'24.2"	bird	bird	unknown	unknown	na
196					northbound, south of Fernbank Ck	31°25'24.0"	152°49'26.1"	medium identifiable	unknown	unknown	unknown	unknown
197	Week 40	13/05/2016	11:20am	12:30pm	southbound, adjacent Cassegrain	31°26'07.0"	152°49'22.9"	small mammal	mammal	unknown	unknown	unknown
198					northbound, Mahogany Rd	31°22'35.2"	152°48'09.5"	unidentifiable mammal	mammal	unknown	unknown	unknown
199					southbound, Pembroke Rd	31°20'29.9"	152°47'35.6"	wallaby	mammal	female	adult	empty
200					median acceleration lane north of Bill Hill Rd	31°21'08.7"	152°47'35.4"	small unidentifiable	unknown	unknown	unknown	unknown
201	Week 41	20/05/2016	11:05am	12:30pm	northbound, across from Mahogany Rd	31°22'35.5"	152°48'09.5"	small kangaroo or wallaby	mammal	unknown	unknown	unknown
202					northbound, north of Pembroke Rd	31°20'24.9"	152°47'35.9"	bird	bird	unknown	unknown	na
203					northbound, north of Pembroke Rd	31°20'22.7"	152°47'36.4"	lizard	reptile	unknown	adult	na
204					northbound, north of Moores Rd	31°19'06.9"	152°48'13.0"	kookaburra	bird	unknown	adult	na
205					northbound, north of Upper Smiths Ck Rd	31°13'33.0"	152°49'24.2"	unidentifiable mammal	mammal	unknown	unknown	unknown

ID record	Week Number	Date	Start Time	Finish Time	Location description	Latitude	Longitude	Species	Assigned Vertebrate Group	Sex	Age	Pouch Young
206					northbound, between Ravenswood Rds	31°11'03.3"	152°49'24.4"	wallaby	mammal	unknown	adult	unknown
207					southbound, Mooney St	31°19'39.0"	152°47'48.6"	small unidentifiable	unknown	unknown	unknown	unknown
208					northbound, south of Sancrox Bridge	31°26'53.2"	152°49'24.7"	bird	bird	unknown	unknown	na
209	Week 42	26/05/2016	12:15pm	1:30pm	northbound, Cooperabung Dr Tele Point	31°19'09.2"	152°48'09.4"	wallaby	mammal	unknown	adult	unknown
210					northbound, between Ravenswood Rds	31°11'11.5"	152°49'24.3"	unidentifiable	unknown	unknown	unknown	unknown
211					northbound, south of Sancrox bridge	31°26'54.0"	152°49'24.6"	unidentifiable	unknown	unknown	unknown	unknown
212					northbound, north of Sancrox bridge	31°26'37.8"	152°49'25.7"	unidentifiable	unknown	unknown	unknown	unknown
213					northbound, north of Sancrox bridge	31°26'41.4"	152°49'25.9"	unidentifiable	unknown	unknown	unknown	unknown
214					northbound, Mahogany Rd	31°26'41.4"	152°49'25.9"	fox	mammal	unknown	adult	na
215					northbound, Cairncross waste station	31°21'45.3"	152°47'48.4"	Tawny Frog Mouth	bird	unknown	adult	na
216	Week 43	03/06/2016	11:20am	12:15pm	northbound, Pembroke Rd turning lane	31°20'28.6"	152°47'35.2"	unidentifiable	unknown	unknown	unknown	unknown
217					northbound, Cooperabung Dr overbridge	31°19'04.0"	152°48'19.1"	wallaby	mammal	unknown	adult	unknown
218					northbound, south of Cooperabung Close	31°17'52.7"	152°49'17.6"	wood duck	bird	unknown	adult	na
219					northbound, south of Cooperabung Close	31°17'49.5"	152°49'17.0"	wood duck	bird	unknown	adult	na
220					southbound, north of Barrys Creek	31°15'16.9"	152°49'04.9"	bird	bird	unknown	unknown	na
221					southbound, south of Cooperabung Drive overbridge	31°19'05.7"	152°48'16.6"	bird	bird	unknown	unknown	na
222					northbound, south of Sancrox Bridge	31°27'06.7"	152°49'22.0"	unidentifiable	mammal	unknown	unknown	unknown
223					northbound, north of Sancrox bridge	31°26'40.9"	152°49'25.9"	bird	bird	unknown	unknown	na
224					northbound, south of Fernbank Ck	31°25'49.2"	152°49'20.6"	unidentifiable	unknown	unknown	unknown	unknown
225	Week 44	10/06/2016	7:00am	8:30am	northbound, south of Pipers Ck Bridge	31°12'00.4"	152°49'22.9"	fox	mammal	unknown	adult	na
226					northbound, south of Hastings River Dr	31°25'00.8"	152°49'31.5"	fox	mammal	unknown	adult	na

ID record	Week Number	Date	Start Time	Finish Time	Location description	Latitude	Longitude	Species	Assigned Vertebrate Group	Sex	Age	Pouch Young
227	Week 45	17/06/2016	11:30am	12:30pm	median north of Pembrooke Rd	31°20'17.6"	152°47'38.3"	fox	mammal	unknown	unknown	na
228					northbound, south of Pipers Ck Bridge	31°11'50.3"	152°49'23.4"	unidentifiable	mammal	unknown	unknown	unknown
229	Week 46	23/06/2016	10:20am	11:30am	northbound, across from Watt Rd	31°18'59.4"	152°48'27.4"	unidentifiable	unknown	unknown	unknown	unknown
230					median, south of Haydons Wharf Rd	31°18'24.7"	152°49'13.9"	wallaby	mammal	unknown	unknown	unknown
231					northbound, south of Cooperabung Close	31°18'00.5"	152°49'18.3"	bird	bird	unknown	unknown	na
232					median, south of Barrys Ck Rd	31°16'27.0"	152°48'44.9"	unidentifiable	unknown	unknown	unknown	unknown
233					northbound, K2K gate 12	31°12'07.5"	152°49'22.7"	mammal	mammal	unknown	unknown	unknown
234					northbound, south of pet boarding Kempsey	31°08'13.9"	152°49'23.1"	lizard	reptile	unknown	unknown	na
235					southbound, south of Stumpy Ck bridge	31°08'01.0"	152°49'29.1"	unidentifiable	unknown	unknown	unknown	unknown
236					southbound, north of Wharf Rd	31°13'29.3"	152°49'24.9"	unidentifiable	unknown	unknown	unknown	unknown
237	Week 47	01/07/2016	11:40am	12:50pm	northbound, south of Haydons Wharf Rd	31°18'27.5"	152°49'12.0"	wallaby	mammal	unknown	unknown	unknown
238					northbound, Cut 23	31°16'01.0"	152°48'47.3"	unidentifiable	unknown	unknown	unknown	unknown
239					northbound, south of Sancrox bridge	31°26'58.1"	152°49'24.1"	unidentifiable	unknown	unknown	unknown	unknown
240	Week 48	08/07/2016	11:00am	12:25pm	northbound, north of Haydons Wharf Rd	31°18'21.0"	152°49'15.2"	bird	bird	unknown	unknown	na
241					median, south of Cooperabung Ck	31°17'39.5"	152°49'14.5"	bird	bird	unknown	unknown	na
242					median, north of Pembrooke Rd	31°20'16.7"	152°47'38.4"	fox	mammal	unknown	adult	na
243					bridge, south of Pembrooke	31°20'36.8"	152°47'34.3"	bird	bird	unknown	unknown	na
244					bridge, south of Pembrooke	31°20'36.9"	152°47'34.3"	rabbit	mammal	unknown	adult	na
245	Week 49	13/07/2016	10:00am	12:00pm	northbound, Mooney St	31°20'27.9"	152°47'35.5"	diamond python	reptile	unknown	adult	na
246					northbound, south of Pipers Ck	31°11'53.5"	152°49'23.0"	unidentifiable	unknown	unknown	unknown	unknown
247					southbound, south of Pembrooke Rd	31°20'29.8"	152°47'35.5"	unidentifiable	unknown	unknown	unknown	unknown
248	Week 50	22/07/2016	11:25am	12:15pm	median, Haydons Wharf Rd	31°18'22.4"	152°49'14.8"	kookaburra	bird	unknown	unknown	na

ID record	Week Number	Date	Start Time	Finish Time	Location description	Latitude	Longitude	Species	Assigned Vertebrate Group	Sex	Age	Pouch Young
249					Kundabung (dam house)	31°13'24.4"	152°49'24.6"	bird	bird	unknown	unknown	na
250					southbound, north of Ravenswood Rd (north)	31°10'29.6"	152°49'23.4"	unidentifiable	unknown	unknown	unknown	unknown
251					southbound, north of Cooperabung Drive	31°17'14.4"	152°49'01.9"	bandicoot	mammal	adult	unknown	unknown
252					southbound, adjacent Watt Rd	31°18'59.9"	152°48'27.5"	bird	bird	unknown	unknown	na
253					median, north of Pembroke Rd	31°20'25.3"	152°47'36.2"	unidentifiable	unknown	unknown	unknown	unknown
254					southbound, north of East Rd	31°21'14.9"	152°47'36.9"	magpie	bird	adult	unknown	unknown
255					northbound, north of Sancrox bridge	31°26'37.3"	152°49'25.7"	small unidentifiable	mammal	unknown	unknown	unknown

Table 5: Road kill habitat details

ID record	Broad Habitat Type	Overstorey	Mid Stratum	Shrub layer	Groundcover	Hydrological Features	Rock	Log	Hollow Bearing Trees	Foraging resources Associated with fauna	Likely Attractant	Comments
1	dry sclerophyll forest	allocasuarina, tallowwood, mahogany	absent	lantana		none	none	none	none	potential past roadkill	unknown	
2	dry sclerophyll forest	Eucalypt species (predominantly blackbutt, tallowwood)	absent	lantana, blackberry, purple top verbena	pasture grasses dominated by setaria and rhodes grass	none	none	none	none	roadside grass	an open grassed area on the side of the road	kangaroo had been hit several days earlier and moved by road services potentially during recent roadside mowing.
3	grassland	absent	absent	absent	pasture grasses dominated by setaria and rhodes grass	drainage line parallel to highway	none	none	none	roadside grass	an open grassed area on the side of the road	
4	grassland	absent	absent	lantana, wild tobacco, purple top verbena, regrowth eucalypt species	pasture grasses dominated by setaria	none	none	none	none	Possibly blossoms in nearby eucalypts	Possibly blossoms in nearby eucalypts	
5	dry sclerophyll forest	tallowwood, grey gum,	regrowth allocasuarinas	absent	absent	none	none	none	none	unknown	unknown	roadside barrier in place

ID record	Broad Habitat Type	Overstorey	Mid Stratum	Shrub layer	Groundcover	Hydrological Features	Rock	Log	Hollow Bearing Trees	Foraging resources Associated with fauna	Likely Attractant	Comments
		spotted gum										
6	dry sclerophyll forest	blackbutt, tallowwood	swamp oaks, malaleuca	acacias, lantana	absent	adjacent to Maria River	none	none	unknown	possible prey such as small reptiles	nearby vegetation	
7	none, cleared	na	na	na	na	none	none	none	none	possible prey such as small reptiles	food	roadside barrier in place
8	dry sclerophyll forest	tallowwood, grey gum, spotted gum	regrowth allocasuarinas	absent	absent	none	none	none	none	possible prey such as small reptiles	food	
9	grassland	absent	absent	wild tobacco, lantana	rhodes grass	Fernbank Ck	none	none	none	grasses	potentially food	
10	none, cleared	na	na	na	na	Barrys Ck, approximately 100m to the south	none	none	none	small mammals	Barrys Ck	
11	none, cleared	na	na	na	na	none	none	none	none	no	unsure	
12	none, cleared	na	na	na	na	Maria Ck	none	none	none	unknown	unknown	
13	grassland	na	occasional swamp oak regrowth	verbena, sateria	pasture grasses	Wilson River and associated floodplain	none	none	none	insects and roots	unknown	
14	wet sclerophyll forest	absent	swamp oaks, malaleuca	lantana, acacia, morning glory, easter cassia	pasture grasses	Wilson River and associated floodplain	none	none	none	na	unknown	
15	dry sclerophyll forest	Blackbutt	allocasuarinas	lantana, seteria	absent	small creek within 100m	none	none	unknown	grasses	unknown	
16	dry sclerophyll forest	ironbark	absent	lantana, verbena	pasture grasses	none	none	none	none	carriion, fruits, berries, grains	possible scavenging of previous roadkill	
17	none, cleared	na	na	na	na	none	none	none	none	berries, grasses, small mammals	unknown	roadside barrier in place
18	dry sclerophyll forest	tallowwood	allocasuarina regrowth	absent	bracken fern	none	none	none	none	insects and other small invertebrate	unknown, possible breeding	
19	none, bridge	na	na	na	na	Hastings River	none	none	na	unlikely	unknown	was on the bridge itself
20	wet sclerophyll forest	absent	melaleucas, allocasuarinas	lantana, morning glory	pasture grasses	Fernbank Ck	none	none	none	unknown	moving to a different water source	

ID record	Broad Habitat Type	Overstorey	Mid Stratum	Shrub layer	Groundcover	Hydrological Features	Rock	Log	Hollow Bearing Trees	Foraging resources Associated with fauna	Likely Attractant	Comments
21	grassland	absent	absent	absent	pasture grasses dominated by rhodes grass and setaria	none	none	none	na	possible prey such as small reptiles	food	
22	dry sclerophyll forest	grey gums, mahogany, blackbutt	regrowth swamp oaks	absent	absent	none	none	none	none	unknown	unknown	
23	none, cleared	na	na	na	na	none	none	none	none	na	na	roadside barriers in place
24	cleared both sides of the road (project related)	na	na	na	na	na	na	na	na	grasses	unknown	roadside barriers in place
25	cleared both sides of the road (project related)	na	na	na	na	na	na	na	na	ants	unknown	
26	cleared	na	na	na	na	dam, Smiths Ck	none	none	none	unknown	unknown	
27	dry sclerophyll forest	blackbutt	allocasuarinas	acacias	pasture grasses	none	none	none	none	unsure	unknown	photo
28	dry sclerophyll forest	ironbark	absent	lantana	pasture grasses	none	none	none	none	unknown	unknown	
29	none, cleared	na	na	na	na	none	none	none	none	unknown	unknown	
30	cleared both sides of the road (project related)	na	na	na	pasture grass	none	none	none	na	unknown	unknown	
31	wet sclerophyll forest	Swamp Oak	absent	lantana	pasture grass	Wilson River approximately 200m to the north	none	none	none	open grasslands both sides of the highway	unknown	
32	grassland	absent	absent	bracken fern	verbena, pasture grass	drainage line approximately 300m away	none	none	none	open grasslands both sides of the highway	unknown	not adjacent project works
33	grassland	absent	absent	bracken fern	verbena, pasture grass	directly adjacent drainage line	none	none	none	open grasslands both sides of the highway	unknown	not adjacent project works
34	dry sclerophyll forest	tallowwood, grey gum, mahogany	lillipilli	lantana	absent	Barrys Ck	none	none	none	unknown	Barrys Ck	
35	none, cleared	na	na	na	na	Barrys Ck, approximately 100m to the south	none	none	none	small mammals	Barrys Ck	

ID record	Broad Habitat Type	Overstorey	Mid Stratum	Shrub layer	Groundcover	Hydrological Features	Rock	Log	Hollow Bearing Trees	Foraging resources Associated with fauna	Likely Attractant	Comments
36	grassland	absent	absent	lantana	tobacco	seteria, pasture grasses	none	none	none	grasses	roadside grass	
37	cleared	na	na	na	na	none	none	none	none	no	no	roadside barrier in place
38	dry sclerophyll forest	blackbutt, tallowwood	swamp oaks, malaleuca	acacias, lantana	absent	close to Maria River	none	none	none	possibly roadkill or flowering trees	possibly roadkill or flowering trees	roadside barrier in place
39	dry forest	tallowwood, white mahogany	casuarina	bracken fern	dianella	none	none	none	none	unknown	unknown	project works on opposite side of road
40	dry sclerophyll forest	blackbutt	allocalcasuarinas	acacias	pasture grasses	none	none	none	none	possibly flowering trees	possibly flowering trees	
41	cleared for construction	na	na	na	na	none	none	none	none	no	unknown	entrance road off highway into construction site
42	none, over water	na	na	na	na	Wilson River	none	none	none	no	unknown	On bridge deck
43	cleared for construction	na	na	na	na	none	na	na	na	no	unknown	concrete barrier in place
44	moist slopes forest	blackbutt, tallowwood, ironbark	grey gum, turpentine	casuarina, tea-tree	dianella	none	none	none	none	no	unknown	not adjacent project works
45	na, on bridge	na	na	na	na	Fernbank Creek	none	yes	potentially	fruits, berries, grains, insects	food	on the bridge deck
46	grassland	absent	lantana	tobacco	seteria, pasture grasses	none	none	none	none	grasses	food	not adjacent project works
47	moist foresxt	blackbutt, tallowwood, grey gum	turpentine	absent	blady grass, ferns, lomandra	none	none	none	none	no	unknown	in middle of road
48	cleared	cleared	cleared	cleared	cleared	adjacent Scrubby Ck	none	none	none	unknown	unnknown	in middle of road
49	dry sclerophyll forest	ironbark	absent	lantana	pasture grasses	none	none	none	none	unknown	unknown	in middle of road
50	cleared	na	na	na	na	Barrys Creek	none	none	none	none	none	concrete barrier in place
51	moist floodplain	tallowwood, blackbutt, white mahogany	turpentine	acacia	na	none	none	none	none	none	unknown	not adjacent project works
52	grassland	absent	absent	lantana, wild tobacco, purple top verbena, regrowth	pasture grasses dominated by setaria	none	none	none	none	Possibly blossoms in nearby eucalypts		not adjacent project works

ID record	Broad Habitat Type	Overstorey	Mid Stratum	Shrub layer	Groundcover	Hydrological Features	Rock	Log	Hollow Bearing Trees	Foraging resources Associated with fauna	Likely Attractant	Comments
				eculalypt species								
53	grassland	absent	absent	lantana, wild tobacco, purple top verbena, regrowth eculalypt species	pasture grasses dominated by setaria	a lowpoint that holds water within 40m	none	none	none	not known	not known	not adjacent project works
54	grassland	absent	absent	lantana, wild tobacco, purple top verbena, regrowth eculalypt species	pasture grasses dominated by setaria	drainage line/small creek within 50m	none	none	none	not known	not known	not adjacent project works
55	predominantly cleared	absent	casuarinas	lantana, wild tobacco, cassia	absent	Hastings River	none	none	none	water source	water source	not directly adjacent works
56	wet sclerophyll forest	absent	melaleucas, allocasuarinas	lantana, morning glory	pasture grasses	Fernbank Ck	none	none	none	unknown	not known	
57	mostly cleared, regrowth eucalypts	absent	absent	regrowth eucalypts	native grasses	unnamed creek approximately 20m	none	none	none	not known	not known	directly adjacent project
58	cleared	cleared	cleared	cleared	cleared	none	none	none	none	not known	not known	directly adjacent project works, concrete barrier in place
59	grassland	absent	absent	bracken fern	verbena, pasture grass	directly adjacent drainage line	none	none	none	open grasslands both sides of the highway	unknown	not adjacent project works
60	grassland	absent	absent	bracken fern	verbena, pasture grass	none	none	none	potentially	open grasslands both sides of the highway	unknown	not adjacent project works
61	swamp oak forest	absent	Swamp Oaks	lantana	pasture grasses	within a few hundred m of the Wilson River	none	none	none	nearby open grasslands and close to water	unknown	not adjacent project works
62	cleared	cleared	cleared	cleared	cleared	none	none	none	none	not known	not known	directly adjacent project works, in median
63	cleared	cleared	cleared	cleared	cleared	none	none	none	none	not known	not known	directly adjacent project works, concrete barrier

ID record	Broad Habitat Type	Overstorey	Mid Stratum	Shrub layer	Groundcover	Hydrological Features	Rock	Log	Hollow Bearing Trees	Foraging resources Associated with fauna	Likely Attractant	Comments
												in place
64	moist forest	blackbutt, tallowwood, grey gum	turpentine	absent	lomandra, ferns	none	none	yes	potentially	not known	not known	not directly adjacent works
65	Paperbark swamp forest	absent	melaleucas	absent	sedges	Fernbank Ck	none	some fallen melaleucas	yes	not known	not known	
66	mostly cleared, regrowth eucalypts	absent	absent	regrowth eucalypts	native grasses	unnamed creek approximately 20m	none	none	none	not known	not known	directly adjacent project
67	cleared	cleared	cleared	cleared	cleared	cleared	none	none	none	not known	not known	directly adjacent project works
68	roadside vegetation adjacent cleared pastures	casuarina, poplars	lantana, casia, wild tobacco	absent	setaria, pasture grasses	none	none	none	none	not known	not known	
69	moist forest	blackbutt, tallowwood, spotted gum, ironbark	turpentine	paperbarks, tea tree	absent	Pipers Creek	none	none	none	no	unknown	
70	grassland	absent	absent	lantana, wild tobacco, purple top verbena, regrowth eucalypt species	pasture grasses dominated by setaria	drainage line/small creek within 50m	none	none	none	not known	not known	not adjacent project works
71	partially cleared, moist forest	absent	turpentine, allocasuarinas	acacia, tea trees	pasture grasses including setaria	none	none	none	none	not known	not known	adjacent project works, barrier southbound
72	moist forest	blackbutt, tallowwood, spotted gum, ironbark	turpentine	absent	native grasses	close to Scrubby Ck	none	none	none	not known	not known	adjacent project works
73	riparian	flooded gums, red gums, tallowwood	absent	lantana, tobacco	lomandra, ferns	adjacent Scrubby Ck	none	none	potentially	food/water source	not known	
74	dry forest	blackbutt, tallowwood, bloodwood, stringybark	turpentine	acacia	absent	none	none	yes	potentially	no	not known	not directly adjacent works
75	cleared	cleared	cleared	cleared	cleared	none	none	none	none	not known	not known	directly adjacent project works

ID record	Broad Habitat Type	Overstorey	Mid Stratum	Shrub layer	Groundcover	Hydrological Features	Rock	Log	Hollow Bearing Trees	Foraging resources Associated with fauna	Likely Attractant	Comments
76												
77	cleared	cleared	cleared	cleared	cleared	cleared	none	none	none	not known	not known	directly adjacent project works
78	predominantly cleared	absent	absent	regrowth	cleared	none	none	none	none	not known	not known	monitoring was undertaken during christmas school holidays and following a rain event, as such roadkill is likely to remain on the road for very long affecting what can be found during a weekly monitoring event
79	partially cleared, moist forest	absent	turpentine, allocasuarinas	acacia, tea trees	pasture grasses including setaria	none	none	none	none	not known	not known	adjacent project works, barrier southbound
80	cleared	cleared	cleared	cleared	cleared	none	none	none	none	not known	not known	entry to site gate
81	grassland	absent	absent	bracken fern	verbena, pasture grass	directly adjacent drainage line	none	none	none	open grasslands both sides of the highway	unknown	not adjacent project works
82	grassland	absent	absent	bracken fern	verbena, pasture grass	adjacent drainage line	none	none	potentially	open grasslands both sides of the highway	unknown	not adjacent project works
83	cleared	garden species	garden species	absent	absent	Wilson River	none	none	none	not known	not known	not adjacent project works
84	predominantly cleared	absent	absent	regrowth	cleared	none	none	none	none	not known	not known	
85	predominantly cleared	absent	absent	regrowth	cleared	none	none	none	none	not known	not known	
86	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	directly adjacent project works
87	predominantly cleared	absent	casuarinas	lantana, wild tobacco, cassia	absent	Hastings River	none	none	none	water source	water source	not directly adjacent works
88	roadside vegetation adjacent cleared pastures	absent	lantana, cassia, wild tobacco	absent	setaria, pasture grasses	none	none	none	none	no	unknown	not directly adjacent works

ID record	Broad Habitat Type	Overstorey	Mid Stratum	Shrub layer	Groundcover	Hydrological Features	Rock	Log	Hollow Bearing Trees	Foraging resources Associated with fauna	Likely Attractant	Comments
89	cleared	cleared	cleared	cleared	cleared	a lowpoint with a series of drainage lines nearby	none	none	none	no	unknown	concrete barriers in place
90	grassland	absent	absent	bracken fern	verbena, pasture grass	drainage line approximately 300m away	none	none	none	open grasslands both sides of the highway	unknown	not adjacent project works
91	swamp oak forest	absent	Swamp Oaks	lantana	pasture grasses	within a few hundred m of the Wilson River	none	none	none	nearby open grasslands and close to water	unknown	not adjacent project works
92	swamp oak forest	absent	Swamp Oaks	lantana	pasture grasses	within a few hundred m of the Wilson River	none	none	none	nearby open grasslands and close to water	unknown	not adjacent project works
93	cleared	cleared	cleared	cleared	cleared	close to Barrys Ck	none	none	none	no	unknown	concrete barrier on one side of the road, un-cleared bush on the other
94	swamp oak forest	absent	Swamp Oaks	lantana	pasture grasses	within a few hundred m of the Wilson River	none	none	none	nearby open grasslands and close to water	unknown	not adjacent project works
95	grassland	absent	absent	lantana, wild tobacco, purple top verbena, regrowth eucalypt species	pasture grasses dominated by setaria	none	none	none	none	not known	not known	not adjacent project works
96	dry forest	blackbutt, tallowwood, bloodwood, stringybark	turpentine	absent	absent	none	none	none	potentially	no	not known	not directly adjacent works
97	moist forest	blackbutt, tallowwood, ironbark	she-oaks	acacia, tea tree	pasture grasses	none	none	none	none	no	unknown	not directly adjacent works
98	cleared	cleared	cleared	cleared	cleared	none	none	none	none	possibly roadkill for food	possibly roadkill	concrete barriers in place
99	cleared	cleared	cleared	cleared	pasture grasses	within a few hundred m of the Wilson River	none	none	none	no	unknown	not directly adjacent works

ID record	Broad Habitat Type	Overstorey	Mid Stratum	Shrub layer	Groundcover	Hydrological Features	Rock	Log	Hollow Bearing Trees	Foraging resources Associated with fauna	Likely Attractant	Comments
100	over water	over water	over water	over water	over water	over the Wilson River	none	none	none	no	unknown	not directly adjacent works
101	dry forest	blackbutt, tallowwood, stringybark, spotted gum	she-oaks	acacia	blady grass	none	none	none	none	no	unknown	
102	grassland	absent	absent	bracken fern	verbena, pasture grass	drainage line approximately 300m away	none	none	none	open grasslands both sides of the highway	unknown	not adjacent project works
103	Paperbark swamp forest	swamp oaks	paperbarks	lantana, wild tobacco	pasture grass	Fernbank Ck	none	none	none	no	unknown	
104	Paperbark swamp forest	swamp oaks	paperbarks	lantana, wild tobacco, cassia	pasture grass	Fernbank Ck	none	none	none	no	unknown	
105	cleared	cleared	cleared	cleared	pasture grasses	within a few hundred m of the Wilson River	none	none	none	no	unknown	not directly adjacent works
106	dry forest	blackbutt, tallowwood, stringybark, spotted gum	she-oaks	acacia	blady grass	none	none	none	none	no	unknown	
107	dry forest	blackbutt, tallowwood, stringybark, spotted gum	she-oaks	acacia	blady grass	none	none	none	none	no	unknown	
108	cleared	cleared	cleared	cleared	grass	none	none	none	none	no	unknown	cleared area due to previous land use
109	moist forest	blackbutt, tallowwood, mahogany	turpentine, she-oaks	absent	blady grass	none	none	none	none	no	unknown	
110	cleared	absent	absent	absent	lawn grass	none	none	none	none	no	unknown	
111	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	construction site, concrete barriers in place
112	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	construction site, concrete barriers in place
113	bridge	bridge	bridge	bridge	bridge	Wilson River	none	none	none	no	unknown	not adjacent project works
114	Paperbark swamp forest	swamp oaks	paperbarks	lantana, wild tobacco	pasture grass	none	none	none	none	no	unknown	

ID record	Broad Habitat Type	Overstorey	Mid Stratum	Shrub layer	Groundcover	Hydrological Features	Rock	Log	Hollow Bearing Trees	Foraging resources Associated with fauna	Likely Attractant	Comments
115	swamp oak forest	absent	Swamp Oaks	lantana	pasture grasses	within a few hundred m of the Wilson River	none	none	none	nearly open grasslands and close to water	unknown	not adjacent project works
116	cleared	cleared	cleared	cleared	pasture grasses	within a few hundred m of the Wilson River	none	none	none	no	unknown	not directly adjacent works
117	cleared	cleared	cleared	cleared	cleared	minor stream within 100m	none	none	none	water source	water source	concrete barriers in place on both sides of road
118	moist floodplain forest	blackbutt, tallowwood, mahogany, ironbark	turpentine, paperbark, she-oaks	absent	gahnia	none	none	none	none	no	unknown	
119	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	
120	moist forest	blackbutt, tallowwood, spotted gum, ironbark	turpentine, she-oaks, papaerbarks	acacias, tea tree	gahnia	none	none	none	none	no	unknown	
121	cleared	garden species	garden species	absent	absent	Wilson River	none	none	none	not known	not known	not adjacent project works
122	cleared	cleared	cleared	cleared	cleared	Fernbank Ck	none	none	none	no	unknown	
123	cleared	cleared	cleared	cleared	cleared	none	none	none	none	unknown	unknown	
124	cleared	cleared	cleared	cleared	cleared	Cooperabung Ck within 150m	none	none	none	no	unknown	concrete barriers both sides of the road
125	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	concrete barriers in place
126	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	concrete barriers in place
127	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	concrete barriers in place
128	grassland	absent	absent	bracken fern	verbena, pasture grass	drainage line approximately 300m away	none	none	none	open grasslands both sides of the highway	unknown	not adjacent project works
129	dry forest	spotted gum, ironbark, grey gum	turpentine	absent	blady grass	none	present	none	potentially	no	unknown	not adjacent project works
130	cleared	cleared	cleared	cleared	blady grass	none	none	none	none	no	unknown	

ID record	Broad Habitat Type	Overstorey	Mid Stratum	Shrub layer	Groundcover	Hydrological Features	Rock	Log	Hollow Bearing Trees	Foraging resources Associated with fauna	Likely Attractant	Comments
131	swamp oak forest	absent	Swamp Oaks	lantana	pasture grasses	within a few hundred m of the Wilson River	none	none	none	nearby open grasslands and close to water	unknown	not adjacent project works
132	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	concrete barrier in place NB
133	moist forest	blackbutt, tallowwood, spotted gum, ironbark	turpentine, she-oaks, papaerbarks	acacias, tea tree	gahnia	none	none	none	none	no	unknown	
134	grassland	absent	absent	bracken fern	verbena, pasture grass	drainage line approximately 300m away	none	none	none	open grasslands both sides of the highway	unknown	not adjacent project works
135	dry forest	blackbutt, tallowwood, stringybark, spotted gum	she-oaks	acacia	blady grass	none	none	none	none	no	unknown	
136	dry forest	blackbutt, tallowwood, stringybark, spotted gum	she-oaks	acacia	blady grass	none	none	present	none	no	unknown	not adjacent project works
137	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	concrete barrier in place NB
138	moist forest	blackbutt, tallowwood, spotted gum, ironbark	turpentine, she-oaks, papaerbarks	acacias, tea tree	gahnia	none	none	none	none	no	unknown	
139	grassland	absent	absent	bracken fern	verbena, pasture grass	drainage line approximately 300m away	none	none	none	open grasslands both sides of the highway	unknown	not adjacent project works
140	cleared	absent	absent	absent	absent	none	none	none	none	no	unknown	
141	absent	absent	absent	bracken fern	pasture grass	none	none	none	none	grasses	unknown	
142	cleared	absent	absent	absent	pasture grass	none	none	none	none	no	unknown	
143	cleared	garden species	garden species	absent	absent	Wilson River	none	none	none	not known	not known	not adjacent project works
144	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	very squashed
145	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	
146	cleared	cleared	cleared	cleared	cleared	Fernbank Ck	none	none	none	no	unknown	

ID record	Broad Habitat Type	Overstorey	Mid Stratum	Shrub layer	Groundcover	Hydrological Features	Rock	Log	Hollow Bearing Trees	Foraging resources Associated with fauna	Likely Attractant	Comments
147	dry forest	blackbutt, tallowwood, bloodwood, stringybark	turpentine	acacia	absent	none	none	yes	potentially	no	not known	not directly adjacent works
148	cleared	cleared	cleared	cleared	cleared	small drainage line	none	none	none	no	unknown	concrete barriers in place
149	cleared	cleared	cleared	cleared	cleared	small drainage line	none	none	none	no	unknown	middle of road
150	moist forest	blackbutt, tallowwood, spotted gum, ironbark	turpentine, she-oaks, papaerbarks	acacias, tea tree	gahnia	none	none	none	none	no	unknown	
151	cleared	cleared	cleared	cleared	cleared	Scrubby Creek nearby	none	none	none	no	unknown	
152	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	concrete barriers in place
153	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	concrete barriers in place
154	moist forest	blackbutt, tallowwood, spotted gum, ironbark	turpentine, she-oaks, papaerbarks	acacias, tea tree	gahnia	none	none	none	none	no	unknown	
155	cleared	cleared	cleared	cleared	cleared	Cooperabung Ck within 150m	none	none	none	no	unknown	concrete barriers on northbound lane
156	cleared	garden species	garden species	absent	absent	Wilson River	none	none	none	not known	not known	not adjacent project works
157	dry forest	blackbutt, tallowwood, bloodwood, stringybark	turpentine	acacia	absent	none	none	none	none	no	not known	not directly adjacent works
158	dry forest	blackbutt, tallowwood, bloodwood, stringybark	turpentine	acacia	absent	none	none	yes	potentially	no	not known	not directly adjacent works
159	dry forest	blackbutt, tallowwood, bloodwood, stringybark	turpentine	acacia	absent	none	none	yes	potentially	no	not known	not directly adjacent works
160	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	concrete barriers in place
161	moist forest	blackbutt, tallowwood, spotted gum,	turpentine, she-oaks, papaerbarks	acacias, tea tree	gahnia	none	none	none	none	no	unknown	

ID record	Broad Habitat Type	Overstorey	Mid Stratum	Shrub layer	Groundcover	Hydrological Features	Rock	Log	Hollow Bearing Trees	Foraging resources Associated with fauna	Likely Attractant	Comments
		ironbark										
162	swamp oak forest	absent	Swamp Oaks	lantana	pasture grasses	within a few hundred m of the Wilson River	none	none	none	nearby open grasslands and close to water		
163	Swamp Forest	absent	paperbarks, mahogany	lantana, crofton weed	pasture grasses	near Fernbank Creek	none	none	none	nearby water	unknown	
164	predominantly cleared	absent	absent	regrowth	cleared	none	none	none	none	not known	not known	
165	predominantly cleared	poplars	absent	lantana, wild tobacco	cobblers pegs, pasture grass	Fernbank Ck	none	none	none	not known	not known	
166	dry forest	blackbutt, tallowwood, bloodwood, stringybark	turpentine	acacia	absent	none	none	yes	potentially	no	not known	not directly adjacent works
167	grassland	absent	absent	bracken fern	verbena, pasture grass	drainage line approximately 300m away	none	none	none	open grasslands both sides of the highway	unknown	not adjacent project works
168	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	not known	
169	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	not known	
170	cleared	cleared	cleared	cleared	cleared	adjacent small drainage line	none	none	none	no	unknown	
171	dry forest	blackbutt, tallowwood	absent	verbena, sateria	pasture grass	none	none	none	none	no	unknown	
172	dry forest	blackbutt, tallowwood, bloodwood, stringybark	turpentine	acacia	absent	none	none	yes	potentially	no	not known	
173	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	not known	
174	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	not known	
175	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	not known	
176	moist forest	blackbutt, tallowwood, spotted gum, ironbark	turpentine, she-oaks, papaerbarks	acacias, tea tree	gahnia	none	none	none	none	no	unknown	
177	swamp oak forest	absent	Swamp Oaks	lantana	pasture grasses	within a few hundred m of the Wilson	none	none	none	nearby open grasslands and close to water	unknown	not adjacent project works

ID record	Broad Habitat Type	Overstorey	Mid Stratum	Shrub layer	Groundcover	Hydrological Features	Rock	Log	Hollow Bearing Trees	Foraging resources Associated with fauna	Likely Attractant	Comments
						River						
178	predominantly cleared	absent	absent	regrowth	cleared	none	none	none	none	not known	not known	
179	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	not known	concrete barriers in place
180	cleared	cleared	cleared	cleared	cleared	Fernbank Ck within 200m	none	none	none	no	not known	
181	dry forest	blackbutt, tallowwood, bloodwood, stringybark	turpentine	acacia	absent	none	none	none	none	no	not known	
182	dry forest	blackbutt, tallowwood, bloodwood, stringybark	turpentine	acacia	absent	none	none	none	none	no	not known	
183	dry forest	blackbutt, tallowwood, bloodwood, stringybark	turpentine	acacia	absent	none	none	yes	none	no	not known	
184	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	not known	concrete barrier in place on both sides of the road
185	moist forest	blackbutt, tallowwood	she-oaks	verbena, sateria	pasture grass	none	none	none	none	no	not known	
186	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	not known	
187	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	not known	
188	grassland	absent	absent	bracken fern	verbena, pasture grass	drainage line approximately 300m away	none	none	none	open grasslands both sides of the highway	unknown	not adjacent project works
189	Paperbark swamp forest	swamp oaks	paperbarks	lantana, wild tobacco	pasture grass	none	none	none	none	no	unknown	not adjacent project works
190	mostly cleared	absent	absent	bracken fern and other weeds	pasture grass	none	none	none	none	no	unknown	
191	moist forest	Mahogany, blackbutt, tallowwood, stringybark	turpentine	bracken fern	absent	none	none	none	none	no	unknown	
192	pasture	absent	absent	absent	pasture grasses and weeds	none	none	none	none	no	unknown	

ID record	Broad Habitat Type	Overstorey	Mid Stratum	Shrub layer	Groundcover	Hydrological Features	Rock	Log	Hollow Bearing Trees	Foraging resources Associated with fauna	Likely Attractant	Comments
193	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	concrete barriers in place
194	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	
195	predominantly cleared	absent	absent	regrowth	cleared	none	none	none	none	not known	not known	
196	moist forest	absent	paperbarks	lantana	pasture grass	Fernbank Ck	none	none	none	no	unknown	
197	predominantly cleared	absent	absent	regrowth	cleared	none	none	none	none	not known	not known	
198	dry forest	blackbutt, tallowwood, bloodwood, stringybark	turpentine	acacia	absent	none	none	none	none	no	not known	
199	grassland	absent	absent	bracken fern	verbena, pasture grass	drainage line approximately 300m away	none	none	none	open grasslands both sides of the highway	unknown	not adjacent project works
200	dry forest	blackbutt, tallowwood, bloodwood, stringybark	turpentine	acacia	absent	none	none	none	none	no	not known	
201	dry forest	blackbutt, tallowwood, bloodwood, stringybark	turpentine	acacia	absent	none	none	none	none	no	not known	
202	grassland	absent	absent	bracken fern	verbena, pasture grass	drainage line approximately 300m away	none	none	none	open grasslands both sides of the highway	unknown	not adjacent project works
203	grassland	absent	absent	bracken fern	verbena, pasture grass	drainage line approximately 300m away	none	none	none	open grasslands both sides of the highway	unknown	not adjacent project works
204	moist forest	blackbutt, tallowwood	she-oaks	verbena, sateria	pasture grass	none	none	none	none	no	not known	
205	grassland	absent	absent	absent	pasture grass	none	none	none	none	open grassland	unknown	
206	moist forest	blackbutt, tallowwood	she-oaks	verbena, sateria	pasture grass	none	none	none	none	no	not known	
207	grassland	absent	absent	bracken fern	verbena, pasture grass	drainage line approximately 300m away	none	none	none	open grasslands both sides of the highway	unknown	not adjacent project works
208	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	
209	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	concrete barriers in place

ID record	Broad Habitat Type	Overstorey	Mid Stratum	Shrub layer	Groundcover	Hydrological Features	Rock	Log	Hollow Bearing Trees	Foraging resources Associated with fauna	Likely Attractant	Comments
210	moist forest	blackbutt, tallowwood	she-oaks	verbena, sateria	pasture grass	none	none	none	none	no	not known	
211	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	
212	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	
213	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	
214	dry forest	blackbutt, tallowwood, bloodwood, stringybark	turpentine	acacia	absent	none	none	none	none	no	not known	
215	dry forest	blackbutt, tallowwood, bloodwood, stringybark	turpentine	acacia	absent	none	none	none	none	no	not known	
216	grassland	absent	absent	bracken fern	verbena, pasture grass	drainage line approximately 300m away	none	none	none	open grasslands both sides of the highway	unknown	not adjacent project works
217	unknown	pine trees	bamboo	weeds	absent	none	none	none	none	no	unknown	not adjacent project works
218	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	concrete barriers in place
219	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	concrete barriers in place
220	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	
221	previously cleared	absent	cassia, garden species	absent	pasture/roadside grasses	none	none	none	none	no	unknown	not adjacent project works
222	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	
223	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	
224	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	
225	predominantly cleared	absent	absent	bracken fern, lantana	pasture grasses	Pipers Creek within 100m	none	none	none	no	unknown	
226	previously cleared	absent	cassia	lantana, wild tobacco	pasture grasses	Hastings River	none	none	none	no	unknown	not directly adjacent works
227	grassland	absent	absent	bracken fern	verbena, pasture grass	drainage line approximately 300m away	none	none	none	open grasslands both sides of the highway	unknown	not adjacent project works
228	predominantly cleared	absent	absent	bracken fern, lantana	pasture grasses	Pipers Creek within 100m	none	none	none	no	unknown	

ID record	Broad Habitat Type	Overstorey	Mid Stratum	Shrub layer	Groundcover	Hydrological Features	Rock	Log	Hollow Bearing Trees	Foraging resources Associated with fauna	Likely Attractant	Comments
229	moist forest re-growth	absent	regrowth eucalypts	tea trees	pasture grass	none	none	none	none	no	unknown	not adjacent to work
230	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	concrete barriers in place
231	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	concrete barriers in place
232	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	
233	moist forest	blackbutt, tallowwood, spotted gum, ironbark	turpentine, she-oaks, papaerbarks	acacias, tea tree	gahnia	none	none	none	none	no	unknown	
234	cleared	absent	absent	absent	pasture grasses, verbena, sateria	none	none	none	none	no	unknown	
235	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	
236	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	
237	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	
238	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	
239	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	
240	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	
241	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	concrete barriers in place
242	grassland	absent	absent	bracken fern	verbena, pasture grass	drainage line approximately 300m away	none	none	none	open grasslands both sides of the highway	unknown	not adjacent project works
243	riparian	papaerbarks, turpentine	swamp oaks	lantana, castor oil plant	absent	small creek directly adjacent	none	none	none	water source	unknown	not adjacent works
244	riparian	papaerbarks, turpentine	swamp oaks	lantana, castor oil plant	absent	small creek directly adjacent	none	none	none	water source	unknown	not adjacent works
245	swamp oak forest	absent	Swamp Oaks	lantana	pasture grasses	within a few hundred m of the Wilson River	none	none	none	nearby open grasslands and close to water	unknown	not adjacent project works
246	predominantly cleared	absent	absent	bracken fern, lantana	pasture grasses	Pipers Creek within 100m	none	none	none	no	unknown	

ID record	Broad Habitat Type	Overstorey	Mid Stratum	Shrub layer	Groundcover	Hydrological Features	Rock	Log	Hollow Bearing Trees	Foraging resources Associated with fauna	Likely Attractant	Comments
247	grassland	absent	absent	bracken fern	verbena, pasture grass	drainage line approximately 300m away	none	none	none	open grasslands both sides of the highway	unknown	not adjacent project works
248	cleared	cleared	cleared	cleared	cleared	drainage line within 100m	none	none	none	unknown	unknown	
249	cleared	cleared	cleared	cleared	cleared	drainage line within 100m	none	none	none	unknown	unknown	
250	cleared	cleared	cleared	cleared	cleared	none	none	none	none	unknown	unknown	
251	dry forest	absent	turpentine	lantana, verbena, acacias	roadside grass	small drainage line within 30m	none	none	none	no	unknown	
252	regrowth	absent	turpentine regrowth	absent	roadside grasses	none	none	none	none	no	unknown	not directly adjacent works
253	grassland	absent	absent	bracken fern	verbena, pasture grass	drainage line approximately 300m away	none	none	none	open grasslands both sides of the highway	unknown	not adjacent project works
254	cleared	absent	absent	absent	roadside grasses	none	none	none	none	no	unknown	not directly adjacent works
255	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	

Niche Environment and Heritage

A specialist environmental and heritage consultancy.

Head Office

Niche Environment and Heritage

PO Box 2443 North Parramatta NSW 1750

Email: info@niche-eh.com

All mail correspondence should be through our Head Office

Annex 4. Microbat roost box monitoring data

Table 7: Microbat roost box details.

Box	Roost Box Type	Height of Roost Box (m)	Aspect	Tenure	APO (MRS Identifier)	Easting (GDA1994 MGA 56)	Northing (GDA1994 MGA 56)
2	Dark green wedge box	3.3	North-east	Private property (Tipping)	72	483308.2507	6546220.627
3	Light green box	3.2	North	Private property (Tipping)	72	483303.8392	6546224.456
4	Black slot box	3.1	North	Private property (Tipping)	72	483300.1451	6546233.754
5	Light green wedge box	3.3	North-east	Private property (Tipping)	72	483303.765	6546264.738
6	Light green box	3.3	North-east	Private property (Tipping)	72	483290.786	6546260.629
7	Hollow home standard box	3.8	North	Private property (Tipping)	72	483285.4427	6546262.768
8	Hollow home standard box	3.6	North-west	Private property (Tipping)	72	483364.6935	6546214.528
9	Black wedge box	3.6	North	Private property (Tipping)	72	483362.8052	6546214.258
10	Dark green slot box	3.6	North-east	RMS. Within project boundary	-	483088.8618	6546635.822
11	Light green wedge box	3	North	RMS. Within project boundary	-	483103.5806	6546630.993
12	Hollow home standard box	3.6	North	RMS. Within project boundary	-	483099.2928	6546659.418
13	Hollow home standard box	3.6	North	RMS. Within project boundary	-	483108.4539	6546628.604
14	Black wedge box	3.6	North-west	RMS. Within project boundary	-	483094.3948	6546658.888
15	Dark green box	3.4	North-west	RMS. Within project boundary	-	483090.2553	6546663.497
16	Light green slot box	2.9	North	Private property (Toepfer)	63	483297.4404	6544838.048
17	Black wedge box	3.1	North	Private property (Toepfer)	63	483293.8617	6544837.358
18	Dark green box	3.5	North-west	Private property (Toepfer)	63	483266.3041	6544791.538
19	Hollow home narrow box	3.5	North-west	Private property (Toepfer)	63	483272.6204	6544814.953
20	Light green wedge box	3.1	North-west	Private property (Toepfer)	63	483268.7779	6544829.45
21	Hollow home slot box	3.3	North-west	Private property (Toepfer)	63	483295.3048	6544846.946
22	Black slot box	3	North-west	Private property (Hambly)	81	483299.9719	6548665.049
23	Hollow home narrow box	3.8	North-west	Private property (Hambly)	81	483308.9929	6548656.581
24	Light green wedge box	3.5	North-west	Private property (Hambly)	81	483331.133	6548673.088
25	Light green wedge box	3.7	North	RMS. Within project boundary	-	483256.4091	6548645.343
26	Black box	3	North	RMS. Within project boundary	-	483246.9841	6548641.664
27	Hollow home slot box	3	North	RMS. Within project boundary	-	483293.4989	6548662.37
28	Hollow home narrow box	3.7	North-west	RMS. Within project boundary	-	483127.9306	6548695.633
29	Dark green slot box	3	North	RMS. Within project boundary	-	483135.6817	6548673.658

Box	Roost Box Type	Height of Roost Box (m)	Aspect	Tenure	APO (MRS Identifier)	Easting (GDA1994 MGA 56)	Northing (GDA1994 MGA 56)
30	Hollow home standard box	3.6	North	Private property (Brayley)	70	483118.7695	6546265.858
31	Dark green wedge box	3.4	North-east	RMS. Within project boundary	-	482880.8439	6542409.253
32	Hollow home narrow box	3.3	North-west	Private property (Brayley)	70	483112.849	6546281.694
35	Light green slot box	3	North	Private property (Brayley)	70	483059.9271	6546309.169
36	Hollow home slot box	3.1	North-west	RMS. Within project boundary	-	482870.7922	6542405.373
37	Hollow home narrow box	3.5	North	RMS. Within project boundary	-	482873.3237	6542400.274
38	Light green box	3.6	North-west	RMS. Within project boundary	-	482861.1116	6542374.4
46	Light green box	4	North-west	RMS. Within project boundary	-	483133.3234	6554724.566
47	Hollow home narrow box	3.8	North-west	State Forest	87	483146.3766	6554719.227
49	Dark green wedge box	3.5	North-west	RMS. Within project boundary	-	483141.3054	6554709.099
50	Dark green slot box	3.4	North	RMS. Within project boundary	-	483030.3988	6554308.511
51	Hollow home standard box	4	North	State Forest	87	483151.5879	6554744.552
52	Hollow home narrow box	3.6	North-west	State Forest	87	483073.8214	6554383.555
53	Dark green box	3.3	North	State Forest	87	483081.6879	6554377.806
54	Hollow home standard box	3.7	North	RMS. Within project boundary	-	483040.0134	6554316.769
55	Hollow home narrow box	3.6	North	State Forest	87	483051.2937	6554332.976
56	Black wedge box	3.7	North-west	State Forest	87	483051.0629	6554342.454
57	Dark green wedge box	3.5	North	State Forest	57	482769.6848	6542094.168
58	Black slot box	3.1	North	State Forest	57	482779.166	6542118.566
59	Hollow home standard box	3.8	North-west	State Forest	57	482729.6069	6542081.099
61	Hollow home narrow box	3.3	North-west	State Forest	57	482733.5319	6542073.671
62	Light green wedge box	3.2	North	State Forest	57	482726.5147	6542070.142
63	Black box	3.1	North	RMS. Within project boundary	-	482721.5836	6542109.474
64	Hollow home slot box	3.3	North-west	State Forest	57	482859.0254	6542360.363
65	Hollow home standard box	3.5	North	State Forest	57	482834.4693	6542316.172
66	Dark green box	3.2	North	RMS. Within project boundary	-	482836.976	6542340.487
67	Black box	3.3	North-east	RMS. Within project boundary	-	482839.0375	6542332.138
68	Black wedge box	3.5	North	State Forest	57	482828.6889	6542290.127
95	Hollow home slot box	3.8	North-west	State Forest	57	483195.2662	6543189.204
96	Hollow home slot box	3.8	North	State Forest	57	483201.0218	6543172.447
97	Hollow home standard box	3.7	North	State Forest	57	483179.8464	6543172.387
98	Dark green wedge box	4	North-west	RMS. Within project boundary	0	483172.4912	6543194.823

Box	Roost Box Type	Height of Roost Box (m)	Aspect	Tenure	APO (MRS Identifier)	Easting (GDA1994 MGA 56)	Northing (GDA1994 MGA 56)
99	Black box	3.1	North-east	State Forest	57	483175.1875	6543170.218
100	Light green slot box	3.4	North-east	State Forest	57	483189.189	6543197.612
101	Black slot box	3.5	North	State Forest	57	483179.5661	6543166.269
130	Hollow home narrow box	3.6	North	Private property (Parkin property)	58	483338.8593	6543361.719
131	Dark green slot box	3.6	North-west	Private property (Parkin property)	58	483322.1945	6543388.723
132	Hollow home slot box	3.7	North	Private property (Parkin property)	58	483280.0747	6543367.618
133	Hollow home slot box	3.6	North-east	Private property (Parkin property)	58	483287.5372	6543386.294
134	Hollow home slot box	3.1	North-east	Private property (Parkin property)	58	483302.0499	6543360.639
135	Black slot box	3.2	North	Private property (Parkin property)	58	483303.1878	6543387.404
136	Hollow home slot box	3.8	North	Private property (Parkin property)	58	483297.8032	6543381.775
137	Hollow home slot box	3.3	North-west	Private property (Parkin property)	58	483343.1059	6543367.418
138	Hollow home standard box	3.7	North	Private property (Parkin property)	58	483305.6698	6543364.228
139	Hollow homes standard box	3.9	North	Private property (Mobbs)	60	483279.2996	6543729.284
140	Hollow home slot box	3.6	North-west	Private property (Mobbs)	60	483287.9247	6543727.064
28B	Black wedge box	3.4	North	RMS. Within project boundary	-	483126.8009	6548693.244

Table 8: 6th monitoring event – spring 2015.

Box	Bats Recorded	Species Name	Number	Other Species	Comments
2	No	N/A	N/A	No	Not much visibility inside the box. Gap too narrow
3	No	N/A	N/A	No	Leaf nest, possible Antechinus or Feather-tailed Glider
4	No	N/A	N/A	No	
5	No	N/A	N/A	No	Leaves in box, possible Antechinus or Feather-tailed Glider
6	No	N/A	N/A	No	Leaves nest, possible Antechinus or Feather-tailed Glider
7	No	N/A	N/A	No	Green leaves in box, possible Antechinus or Feather-tailed Glider
8	No	N/A	N/A	No	
9	No	N/A	N/A	No	Leaf nest, possible Antechinus or Feather-tailed Glider and spider web
10	No	N/A	N/A	No	
11	No	N/A	N/A	No	Leaves in box, possible Antechinus or Feather-tailed Glider
12	No	N/A	N/A	No	
13	No	N/A	N/A	No	Insect material
14	No	N/A	N/A	No	Leaves in box, possible Antechinus or Feather-tailed Glider
15	No	N/A	N/A	No	spider web
16	No	N/A	N/A	No	
17	No	N/A	N/A	No	Leaf nest, possible Antechinus or Feather-tailed Glider
18	Yes	<i>Nyctophilus</i> sp.	1	No	Between tree and nest box. It flew off during inspection. Leaf nest, possible Antechinus or Feather-tailed Glider
19	No	N/A	N/A	No	
20	No	N/A	N/A	No	limited visibility gap too narrow
21	No	N/A	N/A	No	
22	No	N/A	N/A	No	
23	No	N/A	N/A	No	spider web

Box	Bats Recorded	Species Name	Number	Other Species	Comments
24	No	N/A	N/A	No	Leaves in box, possible Antechinus or Feather-tailed Glider
25	No	N/A	N/A	No	Leaf nest, possible Antechinus or Feather-tailed Glider
26	No	N/A	N/A	No	Leaf nest, possible Antechinus or Feather-tailed Glider
27	No	N/A	N/A	No	spider material
28	No	N/A	N/A	No	
29	No	N/A	N/A	No	spider material (web and eggs)
30	No	N/A	N/A	No	
31	No	N/A	N/A	No	Leaf nest, possible Antechinus or Feather-tailed Glider
32	No	N/A	N/A	No	
35	No	N/A	N/A	No	few leaves
36	No	N/A	N/A	No	cricket and spider
37	No	N/A	N/A	No	
38	No	N/A	N/A	No	insect material
46	No	N/A	N/A	No	Leaf nest, possible Antechinus or Feather-tailed Glider
47	No	N/A	N/A	No	spider and spider web
49	No	N/A	N/A	No	Leaf nest, possible Antechinus or Feather-tailed Glider
50	No	N/A	N/A	No	
51	No	N/A	N/A	No	
52	No	N/A	N/A	No	
53	No	N/A	N/A	No	
54	No	N/A	N/A	No	spider material
55	No	N/A	N/A	No	
56	No	N/A	N/A	No	
57	No	N/A	N/A	No	limited visibility, gap too narrow to fit endoscope
58	No	N/A	N/A	No	
59	No	N/A	N/A	No	spider and spider web
61	No	N/A	N/A	No	insect material
62	No	N/A	N/A	No	possible bat scat
63	No	N/A	N/A	No	Leaf nest, possible Antechinus or Feather-tailed Glider
64	No	N/A	N/A	No	cave cricket and wasp nest
65	No	N/A	N/A	No	insect material and mud wasp nest
66	No	N/A	N/A	No	Leaf nest, possible Antechinus or Feather-tailed Glider
67	No	N/A	N/A	No	Leaf nest, possible Antechinus or Feather-tailed Glider
68	No	N/A	N/A	No	Leaves in box, possible Antechinus or Feather-tailed Glider
95	No	N/A	N/A	No	insect material
96	No	N/A	N/A	No	mud wasp nests
97	No	N/A	N/A	No	
98	No	N/A	N/A	No	spider material
99	No	N/A	N/A	No	Leaf nest, possible Antechinus or Feather-tailed Glider
100	No	N/A	N/A	No	
101	No	N/A	N/A	No	cricket and leaves in box, Possible Antechinus or Feather-tailed Glider
130	No	N/A	N/A	No	spider
131	No	N/A	N/A	No	
132	No	N/A	N/A	No	insect material
133	Yes	<i>Nyctophilus gouldi</i>	1		
134	No	N/A	N/A	No	cricket and spider web
135	No	N/A	N/A	No	mud wasp nest
136	No	N/A	N/A	No	mud wasp nest
137	No	N/A	N/A	No	mud wasp nest
138	No	N/A	N/A	No	mud wasp nest
139	No	N/A	N/A	No	mud wasp nest
140	No	N/A	N/A	No	insect material
28B	No	N/A	N/A	No	

Table 9: 7th monitoring event – summer 2016.

Box	Bats Recorded	Species Name	Number	Other Species	Comments
2	No	N/A	N/A	No	Leaf nest, Possible Antechinus or Feather-tailed Glider
3	No	N/A	N/A	No	Leaves in box, possible Antechinus or Feather-tailed Glider nest
4	No	N/A	N/A	Antechinus sp.	Leaf nest, Antechinus
5	No	N/A	N/A	No	Leaves in box, possible Antechinus or Feather-tailed Glider nest
6	No	N/A	N/A	No	Leaves in box, possible Antechinus or Feather-tailed Glider nest
7	No	N/A	N/A	No	green leaves in box, possible Antechinus or Feather-tailed Glider
8	No	N/A	N/A	No	
9	No	N/A	N/A	No	Some leaves
10	No	N/A	N/A	No	
11	No	N/A	N/A	No	
12	No	N/A	N/A	No	
13	No	N/A	N/A	No	insect material
14	No	N/A	N/A	No	
15	No	N/A	N/A	No	
16	No	N/A	N/A	No	
17	No	N/A	N/A	No	Leaf nest, possible Antechinus or Feather-tailed Glider
18	No	N/A	N/A	No	
19	No	N/A	N/A	No	
20	No	N/A	N/A	No	limited visibility gap too narrow for fit endoscope
21	Yes	<i>Nyctophilus geoffroyi</i>	1	No	
22	No	N/A	N/A	No	
23	No	N/A	N/A	No	
24	No	N/A	N/A	No	Some leaves
25	No	N/A	N/A	No	Leaves in box, possible Antechinus or Feather-tailed Glider nest
26	No	N/A	N/A	No	Some leaves
27	No	N/A	N/A	No	
28	No	N/A	N/A	No	
29	No	N/A	N/A	No	
30	No	N/A	N/A	No	
31	No	N/A	N/A	No	Leaves in box, possible Antechinus or Feather-tailed Glider nest
32	No	N/A	N/A	No	
35	No	N/A	N/A	No	
36	No	N/A	N/A	No	
37	No	N/A	N/A	No	
38	No	N/A	N/A	No	
46	No	N/A	N/A	Ants	Lots of leaves
47	No	N/A	N/A	No	insect material
49	No	N/A	N/A	No	small leaf litter
50	No	N/A	N/A	No	
51	No	N/A	N/A	No	
52	No	N/A	N/A	No	
53	No	N/A	N/A	No	
54	No	N/A	N/A	No	
55	No	N/A	N/A	No	
56	No	N/A	N/A	No	
57	No	N/A	N/A	No	
58	No	N/A	N/A	No	
59	No	N/A	N/A	No	
61	Yes	<i>Nyctophilus gouldi</i>	1	No	
62	No	N/A	N/A	cricket	
63	No	N/A	N/A	No	Leaves in box, possible Antechinus or Feather-tailed Glider nest

Box	Bats Recorded	Species Name	Number	Other Species	Comments
64	No	N/A	N/A	No	
65	No	N/A	N/A	No	
66	No	N/A	N/A	No	Recent leaves nest, possible Antechinus or Feather-tailed Glider
67	No	N/A	N/A	No	Some leaves
68	No	N/A	N/A	No	Leaf nest, possible Antechinus or Feather-tailed Glider
95	No	N/A	N/A	No	insect material
96	No	N/A	N/A	No	
97	No	N/A	N/A	No	
98	No	N/A	N/A	No	limited visibility gap too narrow for fit endoscope
99	No	N/A	N/A	No	Old leaves nest
100	No	N/A	N/A	No	
101	No	N/A	N/A	No	
130	No	N/A	N/A	No	
131	No	N/A	N/A	No	
132	Yes	<i>Nyctophilus gouldi</i>	1	No	
133	No	N/A	N/A	No	
134	No	N/A	N/A	No	
135	No	N/A	N/A	No	
136	No	N/A	N/A	No	
137	No	N/A	N/A	No	mud wasp nest
138	No	N/A	N/A	No	mud wasp nest
139	No	N/A	N/A	No	mud wasp nest
140	No	N/A	N/A	No	insect material
28B	No	N/A	N/A	No	small leaf litter

Table 10: 8th monitoring event – autumn 2016.

Box	Bats Recorded	Species Name	Number	Other Species	Comments
2	No	N/A	N/A	No	Spider web
3	No	N/A	N/A	No	Lots of leaves in box. Possible Antechinus or Feather-tailed Glider nest
4	No	N/A	N/A	Suspected Antechinus nest	Leafnest, Antechinus
5	No	N/A	N/A	No	Lots of leaves in box. Possible Antechinus or Feather-tailed Glider nest
6	No	N/A	N/A	No	Lots of leaves in box. Possible Antechinus or Feather-tailed Glider nest
7	No	N/A	N/A	No	
8	No	N/A	N/A	No	
9	No	N/A	N/A	No	Lots of leaves in box. Possible Antechinus or Feather-tailed Glider nest
10	No	N/A	N/A	No	
11	No	N/A	N/A	No	Fresh leaf litter
12	No	N/A	N/A	No	
13	No	N/A	N/A	No	Crystallised insect material
14	No	N/A	N/A	No	Spider web
15	No	N/A	N/A	No	
16	No	N/A	N/A	No	
17	No	N/A	N/A	No	Lots of leaves in box. Possible Antechinus or Feather-tailed Glider nest
18	No	N/A	N/A	No	small leaf litter, possible old nest of antechinus or glider
19	No	N/A	N/A	No	
20	No	N/A	N/A	No	Spider web

Box	Bats Recorded	Species Name	Number	Other Species	Comments
21	No	N/A	N/A	No	
22	No	N/A	N/A	No	
23	No	N/A	N/A	No	
24	No	N/A	N/A	No	Lots of leaves in box. Possible Antechinus or Feather-tailed Glider nest
25	No	N/A	N/A	No	Lots of leaves in box. Possible Antechinus or Feather-tailed Glider nest
26	No	N/A	N/A	No	Lots of leaves in box. Possible Antechinus or Feather-tailed Glider nest
27	No	N/A	N/A	No	
28	No	N/A	N/A	No	some insect material
29	No	N/A	N/A	No	
30	No	N/A	N/A	No	
31	No	N/A	N/A	No	Lots of leaves in box. Possible Antechinus or Feather-tailed Glider nest
32	No	N/A	N/A	No	
35	No	N/A	N/A	No	Fresh leaf litter - possible nest of antechinus or glider
36	No	N/A	N/A	No	Wasp nest
37	No	N/A	N/A	No	
38	No	N/A	N/A	No	Small amount of leaf litter
46	No	N/A	N/A	No	Lots of leaves with very fine leaf litter accumulating
47	No	N/A	N/A	No	old insect nest
49	No	N/A	N/A	No	small leaf litter
50	No	N/A	N/A	No	
51	No	N/A	N/A	No	
52	No	N/A	N/A	No	
53	No	N/A	N/A	No	
54	No	N/A	N/A	No	
55	No	N/A	N/A	No	
56	No	N/A	N/A	No	
57	No	N/A	N/A	No	
58	No	N/A	N/A	No	
59	No	N/A	N/A	No	mud wasp nest
61	No	N/A	N/A	No	mud wasp nest
62	No	N/A	N/A	Wasps	active wasp nest
63	No	N/A	N/A	No	Lots of leaves in box, possible Antechinus or Feather-tailed Glider nest. Some insect material.
64	No	N/A	N/A	No	
65	No	N/A	N/A	Wasps	active wasp nest
66	No	N/A	N/A	No	Lots of leaves in bottom half of box, top empty.
67	No	N/A	N/A	No	Lots of leaves at bottom of box, crystallised insect material in the top
68	No	N/A	N/A	No	Lots of leaves in box. Possible Antechinus or Feather-tailed Glider nest
95	No	N/A	N/A	No	Crystallised insect material
96	No	N/A	N/A	No	
97	No	N/A	N/A	No	
98	No	N/A	N/A	No	
99	No	N/A	N/A	No	Lots of leaves in box. Possible Antechinus or Feather-tailed Glider nest
100	No	N/A	N/A	No	
101	No	N/A	N/A	No	
130	No	N/A	N/A	No	
131	No	N/A	N/A	No	
132	No	N/A	N/A	No	Crystallised insect material
133	No	N/A	N/A	No	
134	No	N/A	N/A	No	
135	No	N/A	N/A	No	
136	No	N/A	N/A	No	
137	No	N/A	N/A	No	

Box	Bats Recorded	Species Name	Number	Other Species	Comments
138	No	N/A	N/A	No	
139	No	N/A	N/A	No	mud wasp nest
140	No	N/A	N/A	No	Crystallised insect material
28B	No	N/A	N/A	No	

Table 11: Prevailing weather conditions during Microbat roost box monitoring in spring 2015, summer 2016 and autumn 2016 surveys. Source: Bureau of Meteorology, Kempsey Airport AWS (station 059007).

Season	Date	Maximum temperature (C)	Minimum temperature (C)	Rainfall	Max Wind gust (Km/h)
spring	26/10/2015	32.7	12.3	0	54
spring	27/10/2015	21.8	15.3	5.8	46
summer	27/01/2016	26.5	17.2	4.6	28
summer	28/01/2016	24.4	20.4	3.2	24
autumn	04/05/2016	27.1	7.5	0.2	41
autumn	05/05/2016	26.8	9.9	0.2	24

Annex 5. *Maundia triglochinos* report (Niche 2016d)



Maundia triglochinos monitoring 2015-2016

Oxley Highway to Kempsey, Pacific Highway Upgrade

Prepared for Roads and Maritime Services

12 August 2016

Document control

Document control item	Description
Project no.:	1702
Project client:	Roads and Maritime Services
Project office:	Newcastle
Document description:	<i>Maundia triglochinos</i> Monitoring 2016
Project Director:	Dr Rhidian Harrington
Project Manager:	Chris McEvoy
Authors:	Luke Baker, Francesca Amorosi
Internal review:	Rhidian Harrington
Document status:	Revision 1
Document address:	P:\Projects\1000s\1700s\1702 Oxley Highway to Kempsey Environmental Services\Report\PI 5 Ecological Monitoring and Reporting OH2K\PI 516 Habitat Protection Monitoring - <i>Maundia</i> \2016\
Local Government Area:	Hastings

Document revision status

Author	Revision number	Internal review	Date issued
Luke Baker	D1	Francesca Amorosi	30/06/2016
Francesca Amorosi	D2	Rhidian Harrington	12/07/2016
Francesca Amorosi	Rev0	Rhidian Harrington	27/07/2016
Francesca Amorosi	Rev1	Rhidian Harrington	12/08/2016

© Niche Environment and Heritage, 2016

Copyright protects this publication. Except for purposes permitted by the Australian Copyright Act 1968, reproduction, adaptation, electronic storage, and communication to the public is prohibited without prior written permission. Enquiries should be addressed to Niche Environment and Heritage, PO Box 2443, Parramatta NSW 1750, Australia, email: info@niche-eh.com.

Any third party material, including images, contained in this publication remains the property of the specified copyright owner unless otherwise indicated, and is used subject to their licensing conditions.

Cover photograph: Maundia triglochinos; flowers, inflorescence and habit

Niche Environment and Heritage

A specialist environmental and heritage consultancy.

Head Office

Level 1, 19 Sorrell Street
Parramatta NSW 2150

All mail correspondence to:
PO Box 2443

North Parramatta NSW 1750

Email: info@niche-eh.com

Sydney

0488 224 888

Central Coast

0488 224 999

Illawarra

0488 224 777

Armidale

0488 224 094

Newcastle

0488 224 160

Mudgee

0488 224 025

Port Macquarie

0488 774 081

Brisbane

0488 224 036

Cairns

0488 284 743

Executive summary

Context

This report documents the 2015/2016 monitoring period (spring 2015, summer 2015 and autumn 2016) for *Maundia triglochinos* as required for the Oxley Highway to Kempsey (OH2K) Pacific Highway upgrade project (the Project). This report follows on from the autumn 2015 monitoring.

Aims

Roads and Maritime Services is required to manage and monitor the effectiveness of the biodiversity mitigation measures implemented as part of the project. This includes *Maundia triglochinos*, and monitoring is to be performed in accordance with the Performance Indicators of the Ecological Monitoring Program (Hyder 2014). The aim of the *Maundia triglochinos* monitoring program is to determine whether the Project is meeting the performance indicators for the species, and provide corrective actions where required.

Methods

The 2015/2016 monitoring period is consistent with the methods used in 2015. Three paired ‘impact - control’ monitoring sites were identified to Niche by Roads and Maritime Services staff in February 2015. Each monitoring location was surveyed in accordance with the monitoring method specified in Hyder (2014).

Key results

Maundia triglochinos was recorded at two of the impact sites (MI01 and MI02) and only one control site (MC01) during the 2015/2016 monitoring.

Recruitment was not observed at any of the impact sites or any of the paired control sites.

Flowering was only recorded at MI01 and its paired control site MC01 during spring and summer. No other impact or control sites contained flowering individuals.

Conclusions

The *Maundia triglochinos* performance measures as per monitoring program have been mostly achieved for 2015/2016 monitoring period. Exclusion fencing to protect the locations of *Maundia triglochinos* within the Project boundary were in place in all sites. Signage of “No go” zones were present in one site. Sedimentation fencing and/or protection structures were installed in all three impact sites.

In spring and autumn flowering, seeding and recruitment across the paired impact and control sites was relatively consistent. In summer a substantial difference (over 15%) in flowering was recorded between MC01 (about 90% of plants were flowering) and MI01 (20% of flowering plants). However, this substantial difference cannot be directly attributed to the road impact only, but more likely is the result of environmental variables between paired control and impact sites.

Management implications

Adjustments to the monitoring design should be considered to improve the statistical robustness of the data collected if access to sites on private lands is expected to be prevented in the future. Establishing additional monitoring sites in independent locations is an option for allowing statistic comparisons between sites.

Table of Contents

Executive summary	iii
1. Introduction	1
1.1 Context	1
1.2 Project objectives	2
1.3 Performance measures.....	3
1.4 Monitoring timing.....	3
1.5 Reporting	3
1.6 Limitations	3
2. Methods.....	5
2.1 Project Area	5
2.2 Monitoring design	5
2.3 Method	5
2.4 Analyses	6
3. Results	7
3.1 Recruitment.....	7
3.2 Flowering/Seeding.....	7
4. Discussion	9
5. Recommendations.....	10
5.1 Contingencies	10
5.2 Corrective actions to meet performance criteria.....	10
5.3 Addressing disturbance impacts at monitoring sites	10
5.4 Plan review	10
References.....	12
Annex 1 - 2015/ 2016 Monitoring results	15
Annex 2 - 2015/2016 Photo Monitoring	17

List of Figures

Figure 1. Regional location – OH2K Maundia Monitoring..... 13

Figure 2. OH2K Maundia Monitoring Sites..... 14

List of Tables

Table 1. Project SoC and MCoA relevant to the monitoring program 2

Table 2. Paired ‘Impact –Control’ monitoring sites..... 5

Table 3. Braun-Blanquet cover abundance scale used in each 400 m2 quadrat 5

1. Introduction

1.1 Context

The Oxley Highway to Kempsey 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). Combined, these approvals outline the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project. *Maundia triglochinos* was one threatened plant species identified as requiring mitigation and monitoring through the course of the Projects’ construction and post construction period.

1.1.1 Location

Maundia triglochinos is listed as vulnerable on the New South Wales *Threatened Species Conservation Act 1995* (TSC Act). Monitoring of the species is required under the Project’s approval. The design, methods and performance indicators for this monitoring is specified in the approved Ecological Monitoring Program (EMP) for the Project (Hyder 2014).

1.1.2 Monitoring framework

The Project MCoA and SoC require the Roads and Maritime Services to manage and monitor the effectiveness of the biodiversity mitigation measures implemented as part of the Project. This includes *Maundia triglochinos* monitoring to be performed in accordance with the Ecological Monitoring Program (EMP) (Hyder 2014).

The EMP defines where *Maundia triglochinos* was recorded within the Project corridor and the direct impacts from the Project. The EMP state the following:

“Three distinct sub-populations of *M. triglochinos* were recorded in the project area (Table 16).

Table 16: *Maundia triglochinos* in the project area

Location	<i>M. triglochinos</i> recorded and assumed to occur within and adjacent to the Project corridor	<i>M. triglochinos</i> within Project corridor	<i>M. triglochinos</i> directly impacted by the Project (concept design)
Fembank Creek (Ch.4450-5080)	1.61 ha	0.75 ha	0.42 ha
Wilson River Floodplain – wetlands (Ch.15,890)	0.06 ha	0.03 ha	-
Wilson River Floodplain – canal (Ch.13,900-14,100)	0.12 ha	0.09 ha	0.06 ha
Barrys Creek	0.001 ha	-	-
Total	1.791 ha	0.87 ha	0.48 ha

”

The following management and monitoring guidance was provided for *Maundia triglochinos* in the Construction Flora and Fauna Management Sub Plan (CFFMSP) (Lend Lease 2014, FF16 in Table 5-1):

“A specific Environmental Work Method Statement shall be developed for all works within and adjacent to known populations of *Maundia triglochinos*. This EWMS will include but not be limited to:

- Specific methodologies for the construction of the twin bridges over Fernbank Creek.
- Installation of sediment retention and protective fencing with sensitive area signage where works are within 100m of populations of or potential habitat for *Maundia triglochinos*.
- Installation of exclusion fencing and signage around all populations of *Maundia triglochinos* to be retained adjacent to the Project and in Fernbank Creek below the bridge.
- Implementation of any specific weed controls measures required.

Populations of *Maundia triglochinos* will be monitored in accordance with the approved Ecological Monitoring Program for the Project”.

1.1.3 Baseline data

Three distinct potential sub-populations of *Maundia triglochinos* have been previously recorded in the Project boundary (Hyder 2014):

- Fernbank Creek (Ch. 4,450-5,080)
- Wilson River Floodplain – canal (Ch. 13,900-14,100)
- Wilson River Floodplain – wetlands (Ch. 15,890).

Hyder (2014) details the extent of *Maundia triglochinos* within the Project corridor (i.e. habitat area including area directly impacted by the Project (concept design)).

1.1.4 Purpose of this report

This report details the findings obtained from the second monitoring period following the baseline surveys. It represents the second monitoring report for the construction phase of the Project.

The aim of this report is to summarise the methods and results of the spring 2015, summer 2015 and autumn 2016 monitoring, and to determine whether performance measures are being met and comment on whether additional measures need to be implemented, as per the EMP (Hyder 2014).

1.2 Project objectives

The Project objectives for *Maundia triglochinos* are specified in the Project’s SoC and MCoA, as listed in Table 1.

Table 1. Project SoC and MCoA relevant to the monitoring program

Objective	Reference Number	Commitment	Timing
Avoid or protect individual threatened plant species where possible.	SoC F9 MCoA B31(b)	Threatened plants in proximity to the Proposal that are to be retained will be identified by pre construction surveys and protected during construction through exclusion fencing and education of construction workers through the site induction process.	Pre-construction and construction.
Determine effectiveness of	SoC F21	An <i>adaptive</i> monitoring program will be	Pre-construction,

Objective	Reference Number	Commitment	Timing
flora and fauna mitigation measures.	MCoA B10	developed and implemented to allow the effectiveness of mitigation and offset measures to be assessed and allow for their modification if necessary. The program will be for a minimum of six years after construction completion.	construction and operation.

1.3 Performance measures

The approved EMP specifies the following performance indicators for *Maundia triglochinos* (Hyder 2014).

Indicators of success will focus on the following:

- *Exclusion fencing with signage identifying these as ‘no go’ zones.*
- *Sediment control fencing in place.*
- *Flowering and/or seeding is consistent with paired control and/or nearest reference site.*

Signs of the habitat protection procedure not working will be based on the following:

- *Breached exclusion fencing.*
- *No signage in place identifying the sensitive nature of the location as threatened species habitat. A significant (if statistics are used) or substantial difference (i.e. 15% allowance) between paired monitoring sites with regard to flowering/seeding and overall extent or recruitment.*

1.4 Monitoring timing

The monitoring program specifies that monitoring would commence in the summer of Year 1 (construction phase) and be undertaken three times a year until Year 4 (operation phase) of the Project. The location of field sites and the survey methodology are summarised in Section 2.

1.5 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 Director General of the Department of Planning and Environment and the Environment Protection Authority.

1.6 Limitations

The following limitation were present during the current monitoring period:

- Detection of *Maundia triglochinos* was not possible in areas where water depth was relatively high. The number and cover abundance of seedling and recruiting individuals was not able to be recorded in such areas.
- The lack of *Maundia triglochinos* at the control sites presented difficulties in pair site comparisons.

- Other variables, including shade, soil quality, water temperature, width of the habitat at each monitoring site, flora competition or water flow rate, that may impact upon the population were not recorded as part of the monitoring program.
- Analysis is limited to the current data set.

2. Methods

2.1 Project Area

The Project is located north from the Oxley Highway intersection with the Pacific Highway at Port Macquarie on the mid-north coast of New South Wales. An overview of the Project boundary and monitoring sites is provided in Figure 1.

2.2 Monitoring design

Monitoring design is consistent with that specified in Hyder (2014). Three paired ‘impact-control’ monitoring sites have been established for the monitoring of *Maundia triglochoides*. Each site includes one Impact location within the Project boundary and one Control location outside the Project boundary. The site locations are shown in Figure 2, with details provided in Table 2.

Table 2. Paired ‘Impact –Control’ monitoring sites

Site	Chainage (Location)	Description	Easting of Impact Plot	Northing of Impact Plot	Easting of Control Plot	Northing of Control Plot
1	4,450 - 5,080	Hastings River floodplain	483251	6523788	483113	6523992
2	13,900 – 14,100	Wilson River floodplain	481919	6532555	481900	6532520
3	15,890	Wilson River drainage channel	482762	6534479	482775	6534886

All six locations have been surveyed during the three monitoring events, but access to MC01 wasn’t granted and the assessment was undertaken from the boundary fence.

2.3 Method

Measurements collected at each of the monitoring sites included the following parameters:

- Current extent of cover using the Braun-Blanquet scale (20 m X 20 m quadrat or 400 m²).
- Average water depth was estimated for the quadrat.
- The extent of flowering or seeding (per cent of total number of observed plants within quadrat).
- Signs of recruitment.
- Signs of disturbance (i.e. cattle) and to what extent/area.
- Specific photo point installed.

The Braun-Blanquet scale used in this monitoring program is provided in Table 3. The scale is a standard used frequently in flora assessments.

Table 3. Braun-Blanquet cover abundance scale used in each 400 m2 quadrat

Score	Cover Abundance Category
1	1-5% cover - rare
2	1-5% cover - common
3	6-25% cover
4	26-50% cover
5	51-75% cover
6	76-100% cover

During the 2015/2016 monitoring period cover abundance was also recorded as percent cover using 5% increments to be able to identify “substantial difference” (i.e. 15% allowance) between paired monitoring sites. It is not possible to determine whether a substantial difference has occurred using the Braun-Blanquet Scale score of ‘3’ (i.e. 5-25% cover) or above, as the percent range exceeds the 15% threshold for detecting change.

2.4 Analyses

Hyder (2014) recommends that impact and control sites would be paired to enable a paired t-test or a non-parametric equivalent (e.g. Mann Whitney) in order to determine if the site achieves performance criteria.

Hyder (2014) also specifies the following approach:

“A significant (if statistics are used) or substantial difference (i.e. 15% allowance) between paired monitoring sites”.

Many of the paired impact-control sites established in the EMP are spatially close to each other and are unlikely to be independent. For example, most control sites located downstream of their paired impact site continue to be influenced by livestock grazing, while the impact site is no longer subject to this land use activity (due to Project boundary fencing) and this could be the reason for any observed changes.

Site independence is a fundamental assumption required by all statistical analyses. Additionally, the dataset is non-normal and could not be normalised with standard transformations. Therefore the use of statistical analyses for this data is not appropriate.

It is likely that in future monitoring years, the use of such statistical tests to analyse the paired monitoring data and other potential measures for monitoring change may be possible and reported on.

3. Results

Maundia triglochinosides was recorded at two of the impact sites (MI01 and MI02) and only one control site (MC01) during the 2015/2016 monitoring period.

Maundia triglochinosides was recorded at MI01 during all seasons. The cover abundance of *Maundia triglochinosides* at MI01 scored a cover abundance value of ‘three’ across all seasons. The paired control site MC01 only contained *Maundia triglochinosides* during spring and summer. Both seasons scored a similar cover abundance value to MI01 (score of three).

In autumn 2016, for the first time since the start of the construction phase, *Maundia triglochinosides* was recorded at MI02, although the species was not recorded during spring or summer. A low cover abundance score (score of one) was given for autumn. Its paired control site did not contain any *Maundia triglochinosides* across the monitoring period.

Impact monitoring site MI03, nor its paired control site MC03, did not contain any *Maundia triglochinosides* during any of the monitoring seasons. It should be noted that water depth for this monitoring site was relatively high (500 to 700 mm) during the spring and summer monitoring, which may explain the absence of plants at these sites.

3.1 Recruitment

Recruitment was not observed at any of the impact sites or any of the paired control sites, demonstrating consistency across all sites.

It should be noted that water depth at a monitoring site greatly impacts the ability to observe recruiting individuals of the species.

3.2 Flowering/Seeding

Flowering was only recorded at MI01 and its paired control site MC01 during spring and summer. No other impact or control sites contained flowering individuals.

During spring, flowering individuals made up 30 percent of those individuals recorded at MI01. In spring some flowering was also recorded in MC01, but the percentages couldn’t be quantified because access to site wasn’t granted and most of the plants were under water. In summer 20 percent of plants recorded at MI01 were flowering and 90 percent at MC01. Both sites did not contain any flowering individuals during autumn, which is predicted given the species generally flowers during the warmer months.

A summary of *Maundia triglochinosides* results for the 2015/2016 monitoring period are also presented in Annex 1.

During the three monitoring events the exclusion fencing was in place at each of the impact sites and no fence breaches were detected.

Signage for the ‘No-go’ zones was only present at MI03. No signage was present at MI01 and MI02 during the 2015/2016 monitoring period.

Sediment and erosion control fencing was installed at MI01 and at MI03 during all three monitoring events, at MI02 sediment and erosion control fencing wasn’t present but instead a sediment retention structure was in place.

A summary of all mitigation measures in place at each location is presented in Annex 1.

Results of the photo monitoring undertaken during the three monitoring events are presented in Annex 2.

4. Discussion

Following is a discussion of how the results obtained to date compare against the performance measures from the approved EMP (Hyder 2014):

Exclusion fencing with signage identifying these as ‘no go’ zones.

This performance measure for 2015/2016 monitoring period has been partially meet. Exclusion fencing was in place at all impact monitoring sites. However, signage for the ‘No-go’ zones was only present at MI03.

Sediment control fencing in place.

This performance measure for 2015/2016 monitoring period has been meet for all impact sites. At two of the three impact sites, MI01 and MI03, sedimentation fencing was in place. At MI02 a sediment retention structure was installed.

Flowering and/or seeding is consistent with paired control and/or nearest reference site.

This performance measure for 2015/2016 monitoring period has been meet in spring and autumn, but not in the summer survey. Flowering, seeding and recruitment in spring and autumn was relatively consistent across all paired monitoring sites. In summer a substantial difference (over 15%) in flowering was recorded between MC01 (about 90% of plants were flowering) and MI01 (20% of flowering plants). However, this substantial difference cannot be directly attributed to the road impact, and is more likely the result of environmental variables between paired control and impact sites.

The differences between the percentages of individuals flowering across the paired sites could be attributed to a number of factors:

- Greater amount of shade present in MI01, given the site is located within a Swamp Sclerophyll Forest community, compared to the rather open landscape for MC01. A small portion of the MI01 quadrat is also shaded by the new bridge. Given the species grows in warm conditions, this variable may impact upon the flowering times at each of the two sites.
- Water flow, depth, turbidity, pH, nutrients, etc.
- Competition from other flora.

Signs of the habitat protection procedure not working will be based on the following:

- **Breached exclusion fencing.**
 - No breaches in the exclusion fencing were detected during the 2015/2016 monitoring period.
- **No signage in place identifying the sensitive nature of the location as threatened species habitat.**
 - Two of the three impact sites didn’t have signage place identifying the sensitive nature of the locations. In order to meet this performance indicator, signage would need to be placed at the monitoring sites MI01 and MI02.
- **A significant (if statistics are used) or substantial difference (i.e. 15% allowance) between paired monitoring sites with regard to flowering/seeding and overall extent or recruitment.**
 - Limitations in the monitoring design and method have prevented the use of statistical analyses to assess impact, but in spring and autumn flowering, seeding and recruitment were relatively consistent between the paired impact and control sites. In summer a substantial difference (over 15%) in flowering was recorded between MC01 (about 90% of plants were flowering) and MI01 (20% of flowering plants). However, this substantial difference cannot be attributed to

the road impact only, and is more likely the result of environmental variables between paired control and impact sites.

5. Recommendations

5.1 Contingencies

As discussed in the Niche (2015) monitoring report, the EMP describes contingencies for potential problems identified in the construction and post construction period. MCoA B10€ requires specific contingency measures to be developed. No specific contingency measures were defined for *Maundia triglochinos* within the EMP. It is recommended that the Roads and Maritime Services develop contingency measures for *Maundia triglochinos*.

5.2 Corrective actions to meet performance criteria

For meeting the performance measures is also recommended that:

- ‘No-go’ signage is installed at sites MI01 and MI02.

5.3 Addressing disturbance impacts at monitoring sites

The following disturbance issues were observed during the monitoring:

- Evidence of weed spraying within close proximity to MI01 during the Autumn 2016 survey. Following an outbreak of *Salvinia molesta* extensive weed spraying has been undertaken prior to this monitoring event. This weed control was undertaken under the supervision of the Port Macquarie Hastings Council weed officer and in consultation with the Environmental Review Group. *Salvinia* is a Class 3 weed in the Port Macquarie Hastings Council area, requiring it to be fully and continuously suppressed and destroyed under the *Noxious Weeds Act 1993*. The Port Macquarie Hastings Council weed officer determined weed spraying to be the most appropriate methodology in this case. Short-term impacts to non-target vegetation was anticipated, however this short term impact was considered to be a more favourable outcome than long term weed infestation.
- Cattle grazing at MC01.
- *Melaleuca quinquenervia* with cut branches near MI02 monitoring site. This clearing falls within the approved project clearing limits as part of the boundary fence line clearing.
- Whilst not necessarily a result of human disturbance, the spreading abundance and cover of native water dependant species, such as *Persicaria* spp., *Eleocharis* spp. and *Baumea* spp., have resulted in areas of potential *Maundia* habitat becoming fragmented.

To address such disturbance issues the following should be considered:

- Where possible, limit any weed management upstream or within close proximity to ‘no-go’ zones to hand weeding and slashing.
- Where possible, no cutting of over-hanging branches within or in immediately proximity to the monitoring sites.
- If possible, prevent cattle from entering control monitoring sites or alternately relocate the control site to an area were cattle disturbance is absent.

5.4 Plan review

Project MCoA B10(a) states:

“An adaptive monitoring program will be developed and implemented to allow the effectiveness of mitigation and offset measures to be assessed and allow for their modification if necessary. The program will be for a minimum of three years after construction completion.”

Below are points that could be considered for the purpose of improving the monitoring program.

Limitations in the monitoring design and method prevent the use of statistical analyses to assess impact of the road between paired monitoring sites, and it is recommended that independent and accessible control sites be added to the design to enable statistically robust data to be collected.

Recording extra variables, including shade, soil quality, temperature, width of the habitat at each monitoring site, flora competition and water flow rate, would help interpret the results with respect to differences in flowering, recruitment and seeding between paired sites.

Observations to date have found *Maundia triglochinos* present at only three of the six designated monitoring locations. However, there is no evidence that the species was present in the other three sites prior to this monitoring event. Therefore, the current monitoring program has a limited capacity to detect change in all six monitoring locations (three paired impact/control sites) as the sampling design means that it can only detect change at three locations and at one of the paired sites. The design could be altered to spatially independent and replicated sampling at the single location where *Maundia triglochinos* occurs.

References

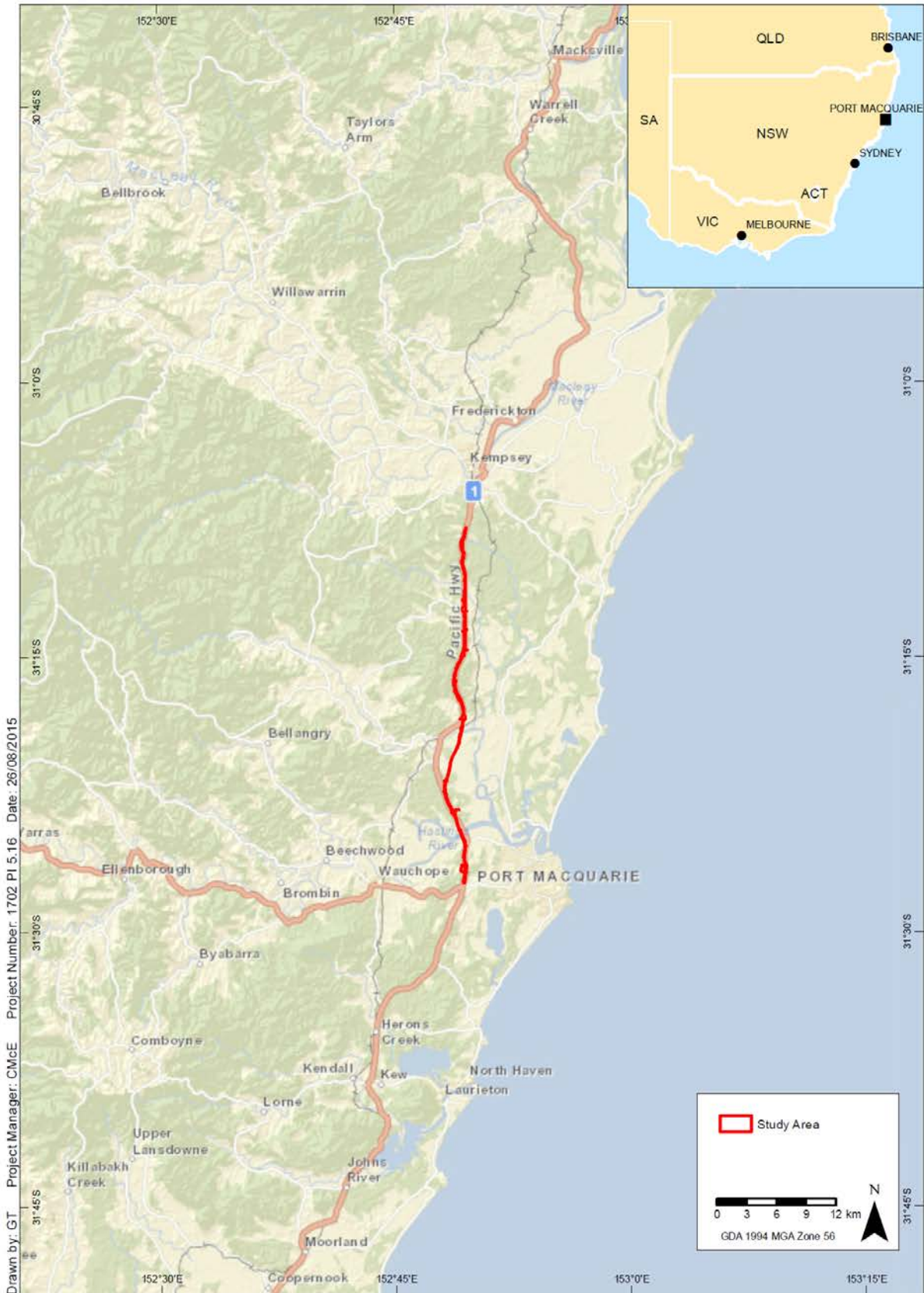
Hyder (2014). Oxley Highway to Kempsey Pacific Highway Upgrade: Ecological Monitoring Program. Prepared by SMEC Hyder Joint Venture for the Roads and Maritime Services, Sydney.

Lend Lease (2014). Pacific Highway Upgrade – Oxley Highway to Kundabung – Construction Flora and Fauna Management Sub Plan. Prepared by Lend Lease for the Roads and Maritime Services, Sydney.

Morrison, D.A. (2002). How to improve statistical analysis in parasitology research publications. *International Journal for Parasitology* 32: 1065-1070.

Niche (2015). OH2K Pacific Highway Upgrade *Maundia triglochinos* Monitoring 2015, Prepared for Roads and Maritime Services, Sydney.

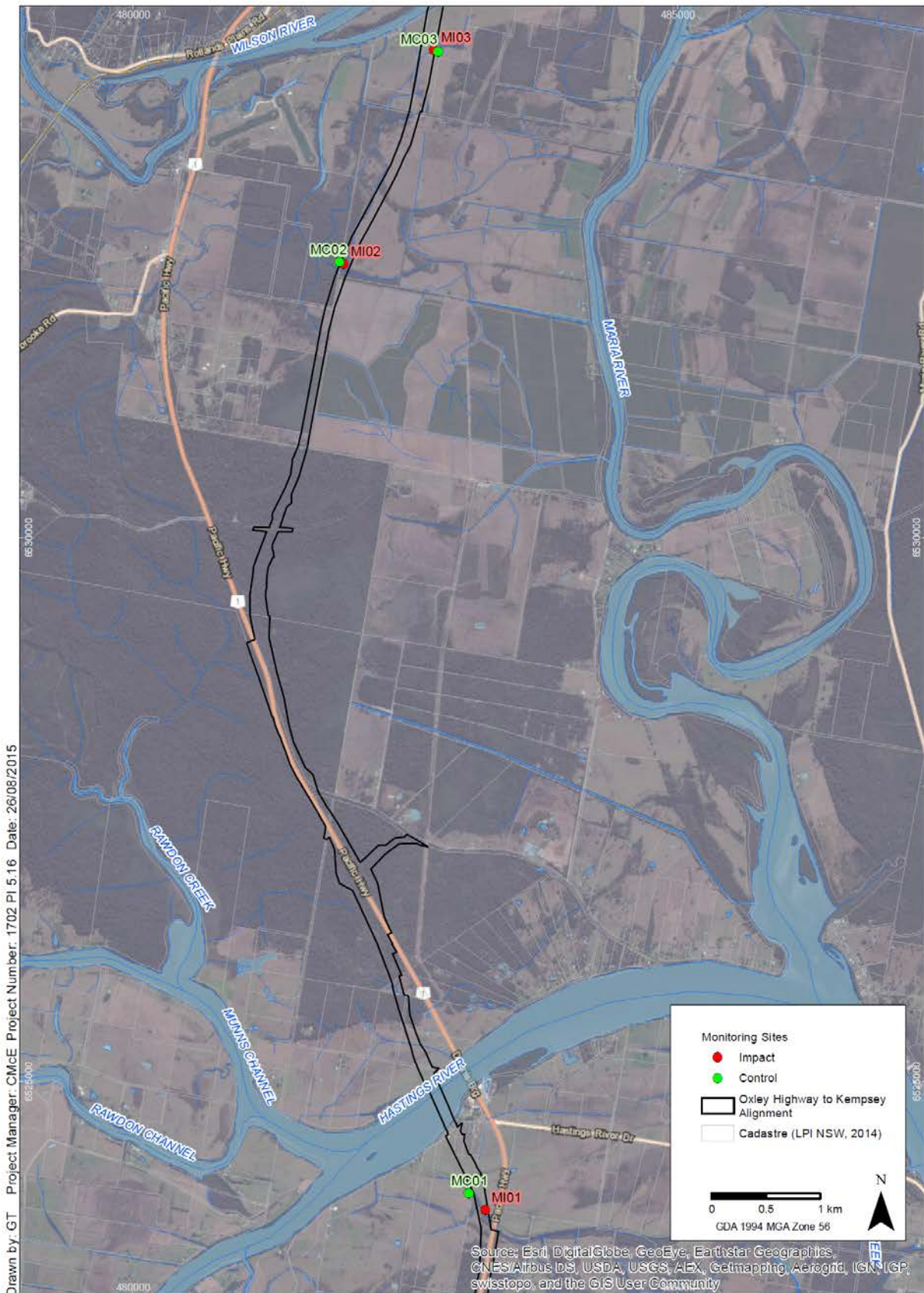
Figure 1. Regional location – OH2K Maundia Monitoring



Regional Location - OH2K Maundia Monitoring
Pacific Highway Upgrade - Oxley Highway to Kempsey & Frederickton to Eungai

FIGURE 1

Figure 2. OH2K Maundia Monitoring Sites



OH2K Maundia Monitoring Sites

Pacific Highway Upgrade - Oxley Highway to Kempsey & Frederickton to Eungai

Annex 1 - 2015/ 2016 Monitoring results

Summary of Mitigation Measures in place

Site	Design	Easting	Northing	Inspection Date			Fencing			No go Signs			Sed control		
				Spring	Summer	Autumn	Spring	Summer	Autumn	Spring	Summer	Autumn	Spring	Summer	Autumn
MI01	impact	483251	6523788	23/09/2015	03/12/2015	20/04/2016	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes
MC01	control	483113	6523992	23/09/2015	03/12/2015	20/04/2016	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
MI02	impact	481919	6532555	23/09/2015	03/12/2015	20/04/2016	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes
MC02	control	481900	6532520	23/09/2015	03/12/2015	20/04/2016	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
MI03	impact	482762	6534479	23/09/2015	03/12/2015	20/04/2016	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
MC03	control	482775	6534486	23/09/2015	03/12/2015	20/04/2016	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

n/a = not applicable

Summary of *Maundia triglochinos* results

Site	Design	Easting	Northing	Inspection Date			Maundia present			Braun-Blanquet Score			% Cover (5% increment)			Water Depth (mm)			% Flowering/ Seeding			Recruitment		
				Spring	Summer	Autumn	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut
MI01	impact	483251	6523788	23/09/2015	03/12/2015	20/04/2016	Y	Y	Y	3	3	3	15	10	5	50-100	5-10	200	30	20	N	N	N	N
MC01	control	483113	6523992	23/09/2015	03/12/2015	20/04/2016	Y	Y	N	3	3	0	15	15	0	100-300	5-20	100-200	Unk	90	N	N	N	N
MI02	impact	481919	6532555	23/09/2015	03/12/2015	20/04/2016	N	N	Y	0	0	1	0	0	<5	0	10-300	300	N	N	N	N	N	N
MC02	control	481900	6532520	23/09/2015	03/12/2015	20/04/2016	N	N	N	0	0	0	0	0	0	0	0	0	N	N	N	N	N	N
MI03	impact	482762	6534479	23/09/2015	03/12/2015	20/04/2016	N	N	N	0	0	0	0	0	0	500-600	600-700	0	N	N	N	N	N	N
MC03	control	482775	6534486	23/09/2015	03/12/2015	20/04/2016	N	N	N	0	0	0	0	0	0	500-600	600-700	0	N	N	N	N	N	N







n/a = not applicable

Unk = unknown







Y = Yes

N = No

Annex 2 - 2015/2016 Photo Monitoring

Site ID	Spring (September 2015)	Summer (December 2015)	Autumn (April 2016)
MI01			
MCO 1			

Site ID	Spring (September 2015)	Summer (December 2015)	Autumn (April 2016)
MI02			
MCO 2	<p data-bbox="443 927 658 951">Photo not available</p>		

Site ID	Spring (September 2015)	Summer (December 2015)	Autumn (April 2016)
MI03			
MCO 3			

Niche Environment and Heritage

A specialist environmental and heritage consultancy.

Head Office

Niche Environment and Heritage

PO Box 2443 North Parramatta NSW 1750

Email: info@niche-eh.com


All mail correspondence should be through our Head Office


Annex 6. Landscape monitoring data


Oxley Highway to Kundabung (OH2Ku) section. Data provided by Lend Lease.

Table 12: Oxley Highway to Kundabung two months (refer to column “Revegetation Performance After 2 Months of Sowing”) and 8 month inspection results



General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Cover crop Strike at time of sowing.	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 4	NB								
Fill 4	NB	Native Grasses							
Fill 4	NB								
Cut 5	NB	Tall shrubs/Frangible Shrubs	Hydromulch Woodfibre	Aug-15 and Sep-15. Following Rework	Poor initially, resprayed and then better.	Poor	Good, lots of diversity with average heights of natives between 30-60cm.	NIL	
Fill 5	A	Frangible Shrubs/Native Grasses							

General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Cover crop Strike at time of sowing.	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Fill 5	B	Frangible Shrubs/Native Grasses							
Fill 5	C								
Fill 5	D	Pasture Grasses							
Fill 5	E	Pasture Grasses							
Cut 6	NB	Native Grasses	Hydromulch Woodfibre	Jul-2015	Poor	Poor cover crop, occasional native	Poor, occasional native	Weed treatment, retopsoil and re spray following verge placement.	
Cut 6	SB	Native Grasses	Hydromulch Woodfibre	Jul-2015	Poor	Poor cover crop, occasional native	Poor, occasional native	Weed treatment, retopsoil and re spray following verge placement.	

General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Cover crop Strike at time of sowing.	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Fill 6	NB	Frangible Shrubs/Native Grasses	Hydromulch Woodfibre	Jul-2015	Good	Good cover crop. Some emerging natives.	NA - good natives at base but restart 8 month period due to extensive rework post verge placement.		
Fill 6	SB	Native Grasses	Hydromulch Woodfibre	Jul-2015/Aug-2016	Good	Good cover crop. No natives as yet - Jul 15.	NA - good natives at base but restart 8 month period due to extensive rework post verge placement.		
Cut 7	NB	Frangible Shrubs	Hydromulch Woodfibre	Jul-2015	Average	Average cover crop, some natives.	Good in patches, minimal weeds.	Watch and act.	


General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Cover crop Strike at time of sowing.	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 7	SB	Frangible Shrubs	Hydromulch Woodfibre	Jul-2015	Average	Average cover crop, some natives.	Excellent diversity, minimal weeds.	NIL	
Fill 7	NB	Frangible Shrubs/Native Grasses	Hydromulch Woodfibre	Jul-2015	Average	Poor	Small fill, restart 8 months when verge completed and re topsoiled.		



General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Cover crop Strike at time of sowing.	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Fill 7	SB	Frangible Shrubs/Native Grasses	Hydromulch Woodfibre	Jul-2015	Average	Poor cover crop, some natives.	Poor in southern half (weeds dominating) Northern portion has natives and native grass.	Weed treatment on south half of batter (Sth of C7.21) potential respray following verge/topsoil completion.	
Cut 8	NB	Tall shrubs/Frangible Shrubs	Hydromulch Woodfibre	Jul-2015	Patchy, areas that slumped were re-treated.	Average cover crop, some natives.	Good native diversity, patchy in distribution.	Watch and act. Scoured sections require touch up.	


General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Cover crop Strike at time of sowing.	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 8	SB	Tall shrubs/Fragible Shrubs	Hydromulch Woodfibre	Jul-2015	Patchy	Average cover crop, some natives.	Good native diversity, a few weeds.	Watch and act, may need to spray weeds.	
B0778L	NB	Tall Shrubs	Hydromulch Woodfibre	Sep-2015	Good cover	Good cover crop. No natives.	Poor. Scattered natives but dense grass cover.	Watch and act.	



General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Cover crop Strike at time of sowing.	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 9	NB	Frangible Shrubs	Hydromulch Woodfibre	Aug and Sep 2015	Good	Good cover crop. No natives.	Low native numbers but stable batter.	Watch and act.	<p>03/05/16</p> 
Cut 9	SB	Frangible Shrubs	Hydromulch Woodfibre	Aug and Sep 2015	Average.	Average cover crop, some natives.	Good native diversity with both grasses and shrubs.	NIL	 <p>03/05/16</p>



General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Cover crop Strike at time of sowing.	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Blackman s Point Interchange	West								
Blackman s Point Interchange	East	Frangible Shrubs	Hydromulch Woodfibre	Sep-2015	Good	Good cover crop strike.	Most sections will require rework post verge etc in finishing. Restart 8 months.		
Blackman s Point Road									
Fill 9	NB	Tall Shrubs	Hydromulch Woodfibre	Sep-2015	Good	Good cover crop strike.	Will be reworked post verge placement, restart 8 months.		
Fill 9	SB	Tall Shrubs	Hydromulch Woodfibre	April 2016	Very good				
Cut 10	NB	Native Grasses	Hydromulch Woodfibre	Nov-2015	Poor				
Fill 10	NB	Native Grasses							

General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Cover crop Strike at time of sowing.	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Fill 10	SB	Tall shrubs/Native Grasses	Hydromulch Woodfibre	aug-2015	Patchy	Poor		Rework after verge placement.	
Cut 11	NB	Frangible Shrubs	Hydromulch Woodfibre	Nov-2015	Patchy	Patchy cover crop strike. Some native strike.	Good native distribution, should achieve target.	Fix deep scour at southern end, find source.	



General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Cover crop Strike at time of sowing.	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 11	SB	Tall shrubs/Fragmible Shrubs	Hydromulch Woodfibre	Sep-2015	Patchy ~40%	Patchy with some emerging natives.	Good diversity in top half of batter. Will get better over time.	NIL	
Cut 11	Centre	Tall shrubs/Fragmible Shrubs	Hydromulch Woodfibre	sep-2015 (only eastern side, northern most corner)	Good 60%	Good cover crop with some natives.	scattered natives, small section of batter only though. Restart 8 months with remainder.		



General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Cover crop Strike at time of sowing.	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Fill 11	NB	Native Grasses	Hydromulch Woodfibre	Nov-2015	Patchy 40%	Poor	Extremely shallow batter.		
Fill 11	SB	Native Grasses	Hydromulch Woodfibre	Mar-2016	Good 70-80%	Good cover crop. No natives.			



General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Cover crop Strike at time of sowing.	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 12	NB	Tall shrubs/Frangible Shrubs	Hydromulch Woodfibre	Nov-2015	Good 60-70%	Good cover crop strike. No natives.	Poor native strike to date.	Watch and act. May need patchy respray.	
Cut 12	SB	Frangible Shrubs	Hydromulch Woodfibre	Sep-2015	Patchy 30-40%	Patchy cover crop.	scattered natives. Not great diversity.	Watch and act. Potential for re hydro seed with natives and cc only.	


General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Cover crop Strike at time of sowing.	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 13	NB	Frangible Shrubs	Hydromulch Woodfibre	16 September 2015	Good at north end. South end not yet sprayed.	Good at north end	Good at north end.	Watch and act @ north end. Spray south end.	
Fill 13	A	Native Grasses	Hydromulch Woodfibre	Sep-2015	Good	Good cover crop. No natives.	NB batter is patchy with poor native diversity. SB very good minimal weeds.	Watch and act.	03/05/16 



General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Cover crop Strike at time of sowing.	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Fill 13	B	Native Grasses	Hydromulch Woodfibre	15/12/15	Exemplary	Exemplary	Pasture grass well established.		
Fill 13	C			Jul-2016					
Fill 13	D	Pasture Grasses	Hydromulch Woodfibre	May-2016, Jul-2016					
Fill 13	E	Tall Shrubs	Hydromulch Woodfibre	15 Dec 2015	Good	Good cover crop. Poor native strike.	Poor	Rework once permanent works are completed.	
Fill 13	F	Tall shrubs/Fragible Shrubs	Hydromulch Woodfibre	July-Aug 2015	Patchy 60%	Patchy. No natives.	Poor NB, with weeds (except very low portion of batter with some good native strike) SB no natives, grasses and weeds, majority not topsoiled restart 8 months when ramps removed.	Weeds spray as required, re-spray in patches NB potentially.	

General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Cover crop Strike at time of sowing.	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 14	NB	Frangible Shrubs	Hydromulch Woodfibre	Sep-2015	Poor	Poor strike. Some natives.	Bottom half of batter OK. Top half has nothing and rocky topsoil.	Top half of batter will require re-spray, over hinge point to open drain as well. Topsoil reworking would be beneficial but access is largely restrained.	
Cut 14	SB	Frangible Shrubs	Hydromulch Woodfibre	Sep-2015	Poor	Poor strike. Some natives.	Scattered natives.	Reinspect in two months, with potential for patchy respray in areas where there is no growth.	


General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Cover crop Strike at time of sowing.	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Fill 14	NB	Frangible Shrubs/Native Grasses	Hydromulch Woodfibre	Sep-2015	Poor	Poor	Restart 8 months post re topsoiling etc		
Fill 14	SB	Frangible Shrubs/Native Grasses	Hydromulch Woodfibre	Sep-2015	Poor	Poor	Restart 8 months post re topsoiling etc		


General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Cover crop Strike at time of sowing.	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 15	NB	Frangible Shrubs	Hydromulch Woodfibre	Nov-2015	50-70%	Reasonable strike with some natives.	Good native diversity in top 3m, stable batter. Lower sections mainly still cover crop and un treated.	Watch and act	
Cut 15	SB	Frangible Shrubs	Hydromulch Woodfibre	Nov-2015		Poor	Restart 8 months when finished.		



General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Cover crop Strike at time of sowing.	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Fill 15	NB								
Fill 15	SB								
Haydons Wharf Interchange	East Inside	Frangible Shrubs	Hydromulch Woodfibre	November 2015	Good - 80%	Good cover crop. No natives.	Over grown with pasture grass, no natives visible. No issues with ground cover.	Potentially slash... watch and act	
Haydons Wharf Interchange	West								

General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Cover crop Strike at time of sowing.	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 16	NB	Frangible Shrubs	Hydromulch Woodfibre	Sep-2015	Good 80%	Good cover crop. No natives.	Dominated by pasture grasses, no native visible. Very stable batter.	Watch and act. Need to check with Urban design team in regards to impacts of pasture grass (RFI to leave as is).	
Cut 17	NB	Frangible Shrubs	Hydromulch Woodfibre	Sep-2015	Patchy	Patchy strike with no natives.	Poor native strike, but they are present with minimal weeds	Watch and act	

General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Cover crop Strike at time of sowing.	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Fill 17	NB	Tall shrubs/Native Grasses	Hydromulch Woodfibre	Sep-2015	Excellent 80-90%	Good cover crop. No natives.	Covered in pasture grass, very stable.	Ties in with existing landscape, RFI to Urban design team to leave as is.	
Cut 18	NB	Frangible Shrubs/Native Grasses	Hydromulch Woodfibre	Sep-15 (reworked March 2016), May-2016	Unknown	Good cover crop. No natives.	Reworked recently. Restart.		
Fill 18	NB	Tall Shrubs	Hydromulch Woodfibre	Nov-2015/Aug-2016	Good	Good cover crop. No natives.	Poor		

General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Cover crop Strike at time of sowing.	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 19A	NB	Tall shrubs/Native Grasses	Hydromulch Woodfibre	Jun-2015	Good	Good cover crop. No natives.	Restart monitoring after first inspection due to large stockpile placed against batter		
Cut19B	NB	Tall Shrubs	Hydromulch Woodfibre	Jun-2015, May-02016	Good	Good cover crop. No natives.	Dominated by long grass, scattered natives on edges.	Watch and act	
Fill 19	NB								
Cut 20	NB	Tall Shrubs	Hydromulch Woodfibre	15/12/2015	Good strike at top. Poor strike at bottom.	Good strike at top. Poor strike at bottom. No natives.	Poor		

General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Cover crop Strike at time of sowing.	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Fill 20	NB								
Cut 21	NB	Tall Shrubs	Hydromulch Woodfibre	15/12/2015	Good	Good cover crop. No natives.	Poor		
Fill 21	NB	Tall Shrubs		Not yet sprayed.					
Cut 22	NB	Tall Shrubs	Hydromulch Woodfibre	Sep-2015, May-2016	Poor	Poor cover crop strike. Some natives.	Good native diversity, good density in some areas. Poor ground cover.	Watch and act. Patchy respray over areas that aren't showing growth in 2 months.	
Fill 22	NB	Tall Shrubs	Hydromulch Woodfibre	May-2016/Aug-2016					

General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Cover crop Strike at time of sowing.	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 23	NB	Tall Shrubs	Hydromulch Woodfibre	Top (Sep-2015)	Poor	Poor cover crop strike. Some native strike.	Good native diversity, low density. Patchy areas with nothing growing at all.	Watch and act. Patchy respray required in areas not showing growth in two months.	
Fill 23	NB	Frangible Shrubs	Hydromulch Woodfibre	29/06/2015	Good 50-70%	Good cover crop. No natives.	Poor	Scarify and respray.	

General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Cover crop Strike at time of sowing.	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Fill 23	SB	Frangible Shrubs	Hydromulch Woodfibre	East (Sep-2015) Resprayed March 2016	Good 50-70%	Good cover crop. No natives.	Restart 8 months following first inspection.		
Cut 24	SB	Tall shrubs/Frangible Shrubs	Hydromulch Woodfibre	Top (Sep-2015)	Poor - 20-50%	Poor cover crop strike. Some native strike.	Good native strike, weedy patch in lower batter	Watch and act. May need patchy re-spray and weed treatment.	





General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Cover crop Strike at time of sowing.	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Fill 24	SB	Frangible Shrubs	Hydromulch Woodfibre	Sep-2015	Good	Good cover crop. Some native strike.	Some native strike.	Watch and act.	


Table 13: Oxley Highway to Kundabung two months (refer to column “Revegetation Performance After 2 Months of Sowing”) and 12 months inspection results

General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 1	NB	Tall Shrubs	Hydromulch Woodfibre	Mar-2016	Good 100%	Very good cover crop strike. No native strike.	No natives yet.	8 months = Nov 16.	
Fill 1	NB	Frangible Shrubs	Hydromulch Woodfibre	Mar-2016	Good 100%	Very good cover crop strike. No native strike.	No natives yet.	8 months = Nov 16.	
Cut 2A	NB	Tall Shrubs	Hydromulch Woodfibre	Feb-2016	Good 85%	Very good cover crop strike. No native strike.	No natives yet.	8 months = Oct 16.	
Cut 2B	NB	Tall Shrubs	Hydromulch Woodfibre	Feb-2016	Good 85%	Very good cover crop strike. No native strike.	No natives yet.	8 months = Oct 16.	
Fill 2	NB	Tall Shrubs	Hydromulch Woodfibre	Feb-2016/spray extra patches May16	Good 60%	Very good cover crop strike. No native strike.		No natives yet.8 months = Nov 16.	
Cut 3	NB	Frangible Shrubs/Native Grasses	Hydromulch Woodfibre	Feb-2016/May16/Jul-2016	Patchy	Patchy cover crop strike. No native strike.		8 months = Oct 16, Jan 17, Mar 17.	



General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Fill 3	NB	Native Grasses	Hydromulch Woodfibre	Feb-2016/Ma y16		Good cover crop strike. No native strike.		8 months = Oct 16.	
Cut 4	NB			Not sprayed yet.					
Fill 4	NB	Native Grasses	Hydromulch Woodfibre	Jul-2016	2 mths = good.	Good cover crop strike. No native strike.			
Fill 4	NB (sth of Sancrox Road)			Not yet sprayed.					
Cut 5	NB	Tall shrubs/Frangible Shrubs	Hydromulch Woodfibre	Aug-15 and Sep-15. Following Rework	Poor initially, resprayed and then better.	Good, lots of diversity with average heights of natives between 30-60cm.		NIL	
Fill 5	A	Frangible Shrubs/Native Grasses	Hydromulch Woodfibre	Jul-2016, Aug-2016		Poor for Jul sow		8 mths = Mar 17	



General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Fill 5	B	Frangible Shrubs/Native Grasses	Hydromulch Woodfibre	Jul-2016	Not growing yet	Poor		8 mths = Mar 17	
Fill 5	C								
Fill 5	D	Pasture Grasses	Hydromulch Woodfibre	Aug-2016				8 mths = April 17	
Fill 5	E	Pasture Grasses	Hydromulch Woodfibre	Aug-2016				8 mths = April 17	
Cut 6	NB	Native Grasses	Hydromulch Woodfibre	Jul-2015	Poor	Poor cover crop, occasional native	Poor, occasional native	Weed treatment, re-topsoil and respray following verge placement. Investigate substitution of native grasses with an alternative seed mix through RFI.	

General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 6	SB	Native Grasses	Hydromulch Woodfibre	Jul-2015	Poor	Poor cover crop, occasional native	Poor, occasional native	Weed treatment, re-topsoil and re spray following verge placement. Investigate substitution of native grasses with an alternative seed mix through RFI.	
Fill 6	NB	Frangible Shrubs/Native Grasses	Hydromulch Woodfibre	Jul-2015	Good	Good cover crop. Some emerging natives.		Reworked Aug 16. No topsoil or respray as yet.	
Fill 6	SB	Native Grasses	Hydromulch Woodfibre	Jul-2015/Aug-2016	Good	Good cover crop. No natives as of Jul 15.		Reworked Aug 16. No topsoil or respray as yet.	
Cut 7	NB	Frangible Shrubs	Hydromulch Woodfibre	Jul-2015	Average	Average cover crop, some natives.	Good - height 60 - 70cm. Minimal weeds. Good diversity. Meets 12 month requirements.	NIL	


General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 7	SB	Frangible Shrubs	Hydromulch Woodfibre	Jul-2015	Average	Average cover crop, some natives.	Good - height 60 - 70cm. Minimal weeds. Good diversity. Meets 12 month requirements.	NIL	
Fill 7	NB	Frangible Shrubs/Native Grasses	Hydromulch Woodfibre		Yet to be sprayed.	Poor	Small fill, restart 8 months when verge completed and re topsoiled.		


General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Fill 7	SB	Frangible Shrubs/Native Grasses	Hydromulch Woodfibre	Jul-2015	Average	Poor cover crop, some natives.	Some natives popping up.	Re-sprayed top half after verge. Restart monitoring period after verge.	
Cut 8	NB	Tall shrubs/Frangible Shrubs	Hydromulch Woodfibre	Jul-2015	Patchy, areas that slumped were re-treated.	Average cover crop, some natives.	Good native diversity.	Meets all 12 month requirements.	

General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 8	SB	Tall shrubs/Frangible Shrubs	Hydromulch Woodfibre	Jul-2015	Patchy	Average cover crop, some natives.	Good native diversity, a few weeds but not too bad.	Meets all 12 month requirements.	
B0778L	NB	Tall Shrubs	Hydromulch Woodfibre	Sep-2015	Good cover	Good cover crop. No natives.	Good native diversity, a few weeds but not too bad.	Meets all 12 month requirements.	

General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 9	NB	Frangible Shrubs	Hydromulch Woodfibre	Aug and Sep 2015	Good	Good cover crop. No natives.	No natives but stable batter.	Oversow with frangible shrub hydroseed.	
Cut 9	SB	Frangible Shrubs	Hydromulch Woodfibre	Aug and Sep 2015	Average.	Average cover crop, some natives.	Good native diversity with both grasses and shrubs.	Watch and act + oversow with hydroseed at northern end.	


General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Blackman's Point Interchange	West	Tall Shrubs		Reworked. Restart monitoring once sprayed.					
Blackman's Point Interchange	East	Frangible Shrubs	Hydromulch Woodfibre	Sep-2015	Good	Good cover crop strike.	Most sections will require rework post verge etc in finishing. Restart 8 months.		
Blackman's Point Road	Blackman's Point Road	Frangible Shrubs/Native Grasses	Hydromulch Woodfibre	6 April 2016	Good				
Fill 9	NB	Tall Shrubs		To be retreated after verge placement.		Good cover crop strike.		Re-start monitoring period after verge placement and removal of temp batter chutes.	
Fill 9	SB	Tall Shrubs	Hydromulch Woodfibre	April 2016	Good	Good cover crop strike.	Will be reworked post verge placement, restart 8 months.	8mths = Nov 16	


General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 10	NB	Native Grasses	Hydromulch Woodfibre	Nov-2015	Poor		Poor	Rework after verge placement.	
Fill 10	NB	Native Grasses	Hydromulch Woodfibre	2 December 2015	Poor		Poor	Rework after verge placement. RFI out native grasses.	
Fill 10	SB	Tall shrubs/Native Grasses	Hydromulch Woodfibre	2 December 2015	Patchy	Poor	Poor	Rework after verge placement. RFI out native grasses.	
Cut 11	NB	Frangible Shrubs	Hydromulch Woodfibre	Nov-2015	Patchy	Patchy cover crop strike. Some native strike.	Good native distribution, should achieve target.	Watch and act. Would meet 8 month criteria.	


General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 11	SB	Tall shrubs/Fragible Shrubs	Hydromulch Woodfibre	Sep-2015	Patchy ~40%	Patchy with some emerging natives.	Good diversity in top half of batter. Will get better over time.	Watch and act. Would meet 8 month criteria.	
Cut 11	Centre	Tall shrubs/Fragible Shrubs	Hydromulch Woodfibre	sep-2015 (only eastern side, northern most corner)	Good 60%	Good cover crop with some natives.		Restart. More material added. Not yet sprayed.	



General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Fill 11	NB	Native Grasses	Hydromulch Woodfibre	Nov-2015	Patchy 40%	Poor	Extremely shallow batter.		
Fill 11	SB	Native Grasses	Hydromulch Woodfibre	Mar-2016	Good 70-80%				
Fill 11	SB	Native Grasses	Hydromulch Woodfibre	Mar-2016	Good - 70 - 80%	Good cover crop. No natives.		8 months = Nov 16	
Cut 12	NB	Tall shrubs/Frangible Shrubs	Hydromulch Woodfibre	Nov-2015	Good 60-70%	Good cover crop strike. No natives.		Has been reworked. Restart monitoring following hydromulching.	



General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 12	SB	Frangible Shrubs	Hydromulch Woodfibre	Sep-2015	Patchy 30-40%	Patchy cover crop.	scattered natives. Not great diversity.	Good north of bridge. Hydromulch whole area south of bridge while reworking the areas where necessary.	
Fill 12	NB	Frangible Shrubs	Hydromulch Woodfibre	Nov-2015	Patchy 50%	Patchy cover crop with strong native emergence.	Good native strike early	Watch and act.	



General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Fill 12	SB	Frangible Shrubs	Hydromulch Woodfibre	Nov-2015	70% in good areas.	Good cover crop with some natives.	Good native strike in some areas.	Watch and act. Batter chutes and stockpile still need to be sprayed.	
Cut 13	NB	Frangible Shrubs	Hydromulch Woodfibre	16 September 2015	Good at north end. South end not yet sprayed.	Good at north end	Good at north end.	Watch and act @ north end. Spray south end.	

General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Fill 13	A	Native Grasses	Hydromulch Woodfibre	Sep-2015	Good	Good cover crop. No natives.	NB batter is patchy with poor native diversity. SB very good minimal weeds.	Both NB and SB patchy (due to native grass mix?). Restart after verge placement.	
Fill 13	B	Native Grasses	Hydromulch Woodfibre	15/12/15	Exemplary	Exemplary	Pasture grass well established.	Nil	
Fill 13	C	Pasture Grasses	Hydromulch Woodfibre	Jul-2016	Good NB. SB not sprayed.	Good strike on NB.	Pasture Grass Strike is good.	8 months = March 2017	
Fill 13	D	Pasture Grasses	Hydromulch Woodfibre	May-2016 (NB), Jul-2016 (SB)	Good	Good strike.	N/A	8 months = Jan 17, Mar 17	

General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Fill 13	E NB	Tall Shrubs	Hydromulch Woodfibre	15 Dec 2015	Good	Good cover crop. Poor native strike.	Poor	Rework once permanent works are completed.	
Fill 13	E SB	Tall Shrubs			Good	Good cover crop. Poor native strike.		Stockpile placed on top of revegetation. Restart monitoring once area has been reworked.	
Fill 13	F	Tall shrubs/Fragible Shrubs	Hydromulch Woodfibre	July-Aug 2015	Patchy.	Patchy. No natives.	No native strike.	Whole area has been reworked. Restart monitoring when resprayed.	

General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 14	NB	Frangible Shrubs	Hydromulch Woodfibre	Sep-2015	Poor	Poor strike. Some natives.	Good	Meets 12 month requirements.	
Cut 14	SB	Frangible Shrubs	Hydromulch Woodfibre	Sep-2015	Poor	Poor strike. Some natives.	Scattered natives.	Re-scarify top section.	



General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Fill 14	NB	Frangible Shrubs/Native Grasses	Hydromulch Woodfibre	Sep-2015	Poor	Poor	Poor	Restart 8 months post re-topsoiling	
Fill 14	SB	Frangible Shrubs/Native Grasses	Hydromulch Woodfibre	Sep-2015	Poor	Poor	Poor	Restart 8 months post tine and respray.	



General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 15	NB	Frangible Shrubs	Hydromulch Woodfibre	Nov-2015	50-70%	Reasonable strike with some natives.	Good native diversity in top 3m, stable batter. Lower sections mainly still cover crop and un treated.	Watch and act. Bottom tier to be sprayed.	
Cut 15	SB	Frangible Shrubs	Hydromulch Woodfibre	Nov-2015		Poor	Restart 8 months when finished.		
Fill 15	NB								



General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Fill 15	SB								
Haydons Wharf Interchange	East Inside	Frangible Shrubs	Hydromulch Woodfibre	November 2015	Good - 80%	Good cover crop. No natives.	Over grown with pasture grass, though some natives popping up! No issues with ground cover.	Potentially slash, watch and act.	
Haydons Wharf Interchange	West								


General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 16	NB	Frangible Shrubs	Hydromulch Woodfibre	Sep-2015	Good	Good cover crop. No natives.	Natives scattered across stable batter.	Watch and act. Raise RFI to leave as is along with Fill 16.	
Fill 16	NB	Frangible Shrubs	Hydromulch Woodfibre	Sep-2015	Good 80%	Good cover crop. No natives.	Dominated by pasture grasses, no native visible. Very stable batter.	Watch and act. Need to check with Urban design team in regards to impacts of pasture grass (RFI to leave as is).	



General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 17	NB	Frangible Shrubs	Hydromulch Woodfibre	Sep-2015	Patchy	Patchy strike with no natives.	Good. Ends need spraying.	Minor spraying	
Fill 17	NB	Tall shrubs/Native Grasses	Hydromulch Woodfibre	11/7/16	None. Only recently sprayed.	Good cover crop. No natives.	Covered in pasture grass, very stable.	Ties in with existing landscape, RFI to Urban design team to leave as is.	
Cut 18	NB	Frangible Shrubs/Native Grasses	Hydromulch Woodfibre	Sep-15 (reworked March 2016), May-2016	Unknown	Good cover crop. No natives.	Reworked recently. Restart.		



General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Fill 18	NB	Tall Shrubs	Hydromulch Woodfibre	Nov-2015 (bottom 3/4s of fill)/Aug-2016 (top 1/4 of fill)	Good	Good cover crop. No natives.	Poor. Mainly grass cover.	Continue to monitor native recruitment.	
Cut 19A	NB	Frangible Shrubs	Hydromulch Woodfibre	Resprayed on 15 December 2015 following stockpiling against batter.	Good	Good cover crop. No natives.	Good at top and poorer for resprayed area. Some weeds have been sprayed in re-hydromulched section.	Watch and act	



General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut19B	NB	Tall Shrubs	Hydromulch Woodfibre	Jun-2015, May-02016	Good	Good cover crop. No natives.	Dominated by long grass, scattered natives on edges. Has improved since last inspection with more maturing natives.	Watch and act	
Fill 19	NB	Tall Shrubs	Hydromulch Woodfibre	18/05/2016	Good	Good cover crop with no natives.	None		



General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 20	NB	Tall Shrubs	Hydromulch Woodfibre	15/12/2015	Good strike at top. Poor strike at bottom.	Good strike at top. Poor strike at bottom. No natives.	Poor	Selectively re-scarify and hydromulch lower section where 100% bare. High weeds on bottom of batter but not noxious so no need for spraying.	
Fill 20	NB	Tall Shrubs	Hydromulch Woodfibre	8/3/2016	Good, except for old basin footprint.	Good cover crop except for old basin footprint. No natives.	One or two natives.	Tyne and respray old basin footprint.	

General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 21	NB	Tall Shrubs	Hydromulch Woodfibre	15/12/2015	Good	Good cover crop. No natives.	Poor	Watch and act	
Fill 21	NB	Tall Shrubs		Not yet sprayed.					

General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 22	NB	Tall Shrubs	Hydromulch Woodfibre	Sep-2015, May-2016	Good	Poor cover crop strike. Some natives.	Good native diversity, good density in some areas.	Good strike and diversity. Nil.	
Fill 22	NB	Tall Shrubs	Hydromulch Woodfibre	May-2016/Aug-2016	Good	Good cover crop. Some natives.	Few natives.	8 months = Jan 2017	

General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 23	NB	Tall Shrubs	Hydromulch Woodfibre	Top (Sep-2015)	Middle section patchy with some natives popping up.	Poor cover crop strike. Some native strike.	Good native diversity, low density. Patchy areas with nothing growing at all.	Watch and act. Patchy respray required in areas not showing growth in two months.	
Fill 23	NB	Frangible Shrubs	Hydromulch Woodfibre	29/06/2015	Poor	Poor	Poor	Scarify and respray.	

General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 23	SB	Frangible Shrubs	Hydromulch Woodfibre	Sep-2015	Good	Good cover crop strike. Some native strike.	Scattered natives emerging	Watch and act.	
Fill 23	NB	Frangible Shrubs	Hydromulch Woodfibre	East (Sep-2015) Resprayed March 2016	Good 50-70%	Good cover crop. No natives.	Restart 8 months following first inspection.	Watch and act.	

General Location	Specific Location	Vegetation Community Type	Treatment	Date of Sowing	Covercrop Strike at time of sowing	Revegetation Performance After 2 Months of Sowing	Native Seed Strike	Actions to Reach Performance Criteria	Photograph
Cut 24	SB	Tall shrubs/Frangible Shrubs	Hydromulch Woodfibre	Sep-2015	Poor - 20-50%	Poor cover crop strike. Some native strike.	Good native strike	Watch and act.	
Fill 24	SB	Frangible Shrubs	Hydromulch Woodfibre	Sep-2015	Good	Good cover crop. Some native strike.	Some native strike.	Watch and act.	

Kundabung to Kempsey (K2K) section. Data provided by McConnell Dowell OHL JV.

Table 14: Kundabung to Kempsey ranking system

Ranking	Ground Cover	Topsoil Depth	Topsoil Quality	Batter Rills		Mulch Cover	Tree Coverage	Tree Condition	Ground Coverage	Native Overall Rating	N/A	Nothing sprayed, planted, etc to date
				No.	Type							
0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	HS	Hydroseed
1	0-20%	None	0-20%	>5	Deep	0-20%	0	Dead	Unacceptable	Unacceptable	Hd	Hand placed
2	21-40%	Minimal / Excess	21-40%	4-5	Medium	21-40%	1	Poor	Needs major improvement	Needs major improvement	TM	Tree Mulch
3	41-60%	Acceptable	41-60%	3-4	Shallow	41-60%	2	Average height <15cm	Needs improvement	Needs improvement	LL	Leaf Litter
4	61-80%	Good	61-80%	1-2	Minimal	61-80%	3-5	Average height >15cm	Acceptable	Acceptable	DGM	Decomposed Grass Mulch
5	81-100%	Excellent	81-100%	None	None	81-100%	>5	Average height >30cm	Good	Good		

N/A - Nothing sprayed, planted, etc to date. Tree Coverage = number natives per m² within randomly placed 10m² grid (not including landscape plants). * - Desirable species: Weed Ratio as percentage of cover crop and native species that make up the ground cover.

Table 15: Kundabung to Kempsey two month inspection results

Location			Hydroseed / hydromulch Date	Tubestock Date	Topsoil Depth	Topsoil Quality (content / compaction)	Batter Slumps / Rills		Mulch		Trees and Shrubs		% Required Native Species	Ground Coverage	Desirable species : Weed Ratio	Native Overall Rating	Natives Noted During Field Inspection	Noxious Weeds Noted During Field Inspection	Sowing Methods / Comments / Action Recommended	Actions / Recommendations
Cut/Fill	C'way	Bench					No.	Type	Type	Ranking	Coverage	Condition								
Fill 4	SB		16-Jul-15		4	2	5	5	HM	2	0	0	0	2	4	0			Hydromulch coverage on fill batter below specification standard. High clay content in topsoil resulting in compact hard surface.	

Location			Hydroseed / hydromulch Date	Tubestock Date	Topsoil Depth	Topsoil Quality (content / compaction)	Batter Slumps / Rills		Mulch		Trees and Shrubs		% Required Native Species	Ground Coverage	Desirable species : Weed Ratio	Native Overall Rating	Natives Noted During Field Inspection	Noxious Weeds Noted During Field Inspection	Sowing Methods / Comments / Action Recommended	Actions / Recommendations
Cut/Fill	C'way	Bench					No.	Type	Type	Ranking	Coverage	Condition								
Cut 5	SB		16-Jul-15		4	4	5	5	HM	4	0	0	0	4	4	0			Northern end of cut 5 sprayed 30-7-2015	
Cut 6	SB		30-Jul-15		4	4	5	5	HM	4	0	0	0	4	4	0				
Fill 2	SB		06-Aug-15		4	2	5	5	HM	2	0	0	0	3	0	0			Hydromulch coverage on fill batter below specification standard. High clay content in topsoil resulting in compact hard surface.	
Fill 9	SB	Drainage	06-Aug-15		4	4	5	5	HM	4	0	0	0	4	0	0			Outside of drain feeding B28.10	
Cut 10	NB	Off ramp drain	25-Aug-16		4	4	5	5	HM	4	0	0	0	4	0	0				
Cut 3	NB	Top	Sep-2015		4	4	5	5	HM	4	0	0	0	4	0	0				
Cut 3	NB	Bottom	Sep-2015		4	4	5	5	HM	4	0	0	0	4	0	0				
Fill 4	SB	Nth MINGALETTA	Sep-2015		4	4	5	5	HM	4	0	0	0	4	0	0				
Fill 5	SB	Drainage	Sep-2015		4	4	5	5	HM	4	0	0	0	4	0	0				
Fill 5	SB		Sep-2015		4	4	5	5	HM	4	0	0	0	4	0	0				
Fill 6	SB		Sep-2015		4	3	5	5	HM	4	0	0	0	4	0	0				
Cut 7	SB		Sep-2015		4	4	5	5	HM	4	0	0	0	2	0	0				
Cut 11	SB		Sep-2015		4	4	5	5	HM	4	0	0	0	4	0	0				
Cut 18	SB		Sep-2015		4	0	5	5	HM	2	0	0	0	1	0	0			Hydromulch coverage not to standard.	
Cut 18	NB		Sep-2015		4	0	5	5	HM	3	0	0	0	1	0	0				

Location			Hydroseed / hydromulch Date	Tubestock Date	Topsoil Depth	Topsoil Quality (content / compaction)	Batter Slumps / Rills		Mulch		Trees and Shrubs		% Required Native Species	Ground Coverage	Desirable species : Weed Ratio	Native Overall Rating	Natives Noted During Field Inspection	Noxious Weeds Noted During Field Inspection	Sowing Methods / Comments / Action Recommended	Actions / Recommendations
Cut/Fill	C'way	Bench					No.	Type	Type	Ranking	Coverage	Condition								
Fill 20	SB		Sep-2015		4	4	5	5	HM	4	0	0	0	4	0	0			Southern half of batter hydromulch Sept 15.	
Fill 20	NB		Sep-2015		4	4	5	5	HM	4	0	0	0	4	0	0			Southern half of batter hydromulch Sept 15.	
Cut 20	SB	Top	Sep-2015		4	3	5	5	HM	4	0	0	0	4	0	0			Batter track rolled in wrong direction leaving vertical cleat marks	
Fill 7	SB		Oct-2015		4	4	5	5	HM	4	0	0	0	4	0	0				
Fill 8	SB		Oct-2015		4	4	5	5	HM	4	0	0	0	4	0	0			bottom section of batter sprayed Oct15	
Cut 8	SB		Oct-2015		4	4	5	5	HM	4	0	0	0	4	0	0			Northern end of cut 8 hydromulched 29-10-2015	
Fill 12	SB	nth C30.10	Oct-2015		4	4	5	5	HM	4	0	0	0	3	0	0				
Cut 12	SB		Oct-2015		2	2	5	5	HM	4	0	0	0	2	0	0			Topsoil application thin and compacted	
Cut 13	SB		Oct-2015		4	4	5	5	HM	4	0	0	0	4	0	0				
Fill 11	SB		Nov-2015		4	3	5	5	HM	4	0	0	0	3	0	0			High clay content in topsoil causing compaction issues.	
Fill 11	NB		Nov-2015		4	2	5	5	HM	4	0	0	0	2	0	0			topsoil smeared into a compact surface layer.	
Fill 18	NB		Nov-2015		4	3	5	5	HM	4	0	0	0	3	0	0			Batter part sprayed Nov-15 and part sprayed Dec-15.	
Fill 22	NB		Nov-2015		4	4	5	5	HM	4	0	0	0	4	0	0			Area on southern side of C36.40 - tall shrubs sprayed Nov-15 and frangible shrubs sprayed Dec-15.	

Location			Hydroseed / hydromulch Date	Tubestock Date	Topsoil Depth	Topsoil Quality (content / compaction)	Batter Slumps / Rills		Mulch		Trees and Shrubs		% Required Native Species	Ground Coverage	Desirable species : Weed Ratio	Native Overall Rating	Natives Noted During Field Inspection	Noxious Weeds Noted During Field Inspection	Sowing Methods / Comments / Action Recommended	Actions / Recommendations
Cut/Fill	C'way	Bench					No.	Type	Type	Ranking	Coverage	Condition								
Cut 17	SB		Dec-2015		4	3	5	5	HM	4	0	0	0	4	0	0			Topsoil high clay content that settled in cleat marks following rain.	
Cut 20	SB	Middle	Dec-2015		4	3	5	5	HM	4	0	0	0	4	0	0			Batter track rolled in wrong direction leaving vertical cleat marks	
Cut 21	NB		Dec-2015		4	4	5	5	HM	4	0	0	0	4	0	0				
Cut 21	SB		Dec-2015		4	4	5	5	HM	4	0	0	0	4	0	0				
Fill 9	SB		Jan-2016		4	2	5	5	HM	4	0	0	0	2	0	0			Batter above drain - smeared clay surface created hard compact surface not suitable for hydromulch. Suggested keeping surface well watered to avoid crusting but this did not happen.	
Fill 10	NB	Smiths Creek to C28.68	Jan-2016		4	4	5	5	HM	4	0	0	0	4	0	0				
Cut 15	SB		Jan-2016		4	4	5	5	HM	4	0	0	0	4	0	0				
Cut 10	SB		Feb-2016		4	4	5	5	HM	4	0	0	0	3	0	0				
Cut 10	NB	Off ramp	Feb-2016		4	4	5	5	HM	4	0	0	0	3	0	0				
Site 2	NB	Material Reuse Site No 2	Feb-2016		4	4	5	5	HM	4	0	0	0	4	0	0				
Fill 14	SB		Mar-2016		4	4	5	5	HM	4	0	0	0	4	0	0				
Cut 14	SB		Mar-2016		4	4	5	5	HM	4	0	0	0	4	0	0				

Location			Hydroseed / hydromulch Date	Tubestock Date	Topsoil Depth	Topsoil Quality (content / compaction)	Batter Slumps / Rills		Mulch		Trees and Shrubs		% Required Native Species	Ground Coverage	species : Weed Ratio	Native Overall Rating	Natives Noted During Field Inspection	Noxious Weeds Noted During Field Inspection	Sowing Methods / Comments / Action Recommended	Actions / Recommendations
Cut/Fill	C'way	Bench					No.	Type	Type	Ranking	Coverage	Condition								
Fill 15	SB		Mar-2016		4	4	5	5	HM	4	0	0	0	4	0	0				
Cut 16	SB		Mar-2016		4	4	5	5	HM	4	0	0	0	4	0	0				
Fill 21	SB		Mar-2016		4	4	5	5	HM	4	0	0	0	4	0	0				
Fill 10	SB		Apr-2016		4	4	5	5	HM	4	0	0	0	4	0	0				
Site 16	SB	Material Reuse Site No 16	Apr-2016		4	4	5	5	HM	4	0	0	0	4	0	0			Noted high amount of ducks feeding on east facing batter.	
Fill 16	SB		Apr-2016		4	4	5	5	HM	4	0	0	0	4	0	0				
Fill 21	NB		Apr-2016		4	4	5	5	HM	4	0	0	0	3	0	0				
Fill 23	SB		Apr-2016		4	4	5	5	HM	4	0	0	0	4	0	0				
Fill 17	NB		May-2016		4	4	5	5	HM	4	0	0	0	0	0	0				

Table 16: Kundabung to Kempsey eight month inspection results

Location			Hydroseed / hydromulch Date	Tubestock Date	Topsoil Depth	Topsoil Quality (content / compaction)	Batter Slumps / Rills		Mulch		Trees and Shrubs		% Required Native Species	Ground Coverage	species : Weed Ratio	Native Overall Rating	Natives Noted During Field Inspection	Noxious Weeds Noted During Field Inspection	Sowing Methods / Comments / Action Recommended	Actions / Recommendations
Cut/Fill	C'way	Bench					No.	Type	Type	Ranking	Coverage	Condition								

Fill 4	SB		Jul-2015		4	2	5	5	HM	2	0	0	0	2	4	0		Hydromulch coverage on fill batter below specification standard. High clay content in topsoil resulting in compact hard surface.
Cut 5	SB		Jul-2015		4	4	5	5	HM	4	0	0	0	4	4	0		Northern end of cut 5 sprayed 30-7-2015
Cut 6	SB		Jul-2015		4	4	5	5	HM	4	0	0	0	4	4	0		
Fill 1	SB		Aug-2015		4	2	5	5	HM	2	0	0	0	3	0	0		Hydromulch coverage on fill batter below specification standard. High clay content in topsoil resulting in compact hard surface. Note verge to hinge of drain hydromulched March 2016.
Fill 2	SB		Aug-2015		4	2	5	5	HM	2	0	0	0	3	0	0		Hydromulch coverage on fill batter below specification standard. High clay content in topsoil resulting in compact hard surface. Note verge to hinge of drain hydromulched March 2016.
Fill 9	SB	drainage	Aug-2015		4	4	5	5	HM	4	0	0	0	4	0	0		Outside of drain feeding B28.10

Cut 10	NB	Off ramp drain	Aug-2015		4	4	5	5	HM	4	0	0	0	4	0	0			
Cut 3	NB	Top	Sep-2015		4	4	5	5	HM	4	0	0	0	4	0	0			
Cut 3	NB	Bottom	Sep-2015		4	4	5	5	HM	4	0	0	0	4	0	0			
Fill 4	SB	Nth Mingaletta	Sep-2015		4	4	5	5	HM	4	0	0	0	4	0	0			
Fill 5	SB	Drainage	Sep-2015		4	4	5	5	HM	4	0	0	0	4	0	0			
Fill 5	SB		Sep-2015		4	4	5	5	HM	4	0	0	0	4	0	0			
Fill 6	SB		Sep-2015		4	3	5	5	HM	4	0	0	0	4	0	0			
Cut 7	SB		Sep-2015		4	4	5	5	HM	4	0	0	0	2	0	0			
Cut 11	SB		Sep-2015		4	4	5	5	HM	4	0	0	0	4	0	0			
Cut 18	SB		Sep-2015		4	0	5	5	HM	2	0	0	0	1	0	0			Hydromulch coverage not to standard. Southern end of cut hydromulched Mar-16.
Cut 18	NB		Sep-2015		4	0	3	1	HM	3	0	0	0	1	0	0			Rilling possibly from water flow over top of batter with no catch drain in design.
Fill 20	SB		Sep-2015		4	4	5	5	HM	4	0	0	0	4	0	0			Southern half of batter hydromulch Sept 15
Fill 20	NB		Sep-2015		4	4	5	5	HM	4	0	0	0	4	0	0			Southern half of batter hydromulch Sept 15
Cut 20	SB	Top	Sep-2015		4	3	5	5	HM	4	0	0	0	4	0	0			Batter track rolled in wrong direction leaving vertical cleat marks
Fill 7	SB		Oct-2015		4	4	5	5	HM	4	3	3	0	4	4	0			Slightly down on coverage numbers. Continue to monitor.

Fill 8	SB		Oct-2015		4	4	5	5	HM	4	3	3	0	4	4	0			Bottom section of batter sprayed Oct15	Upper batter requires hydromulch following completion of verge works.
Cut 8	SB		Oct-2015		4	4	5	5	HM	4	4	3	0	4	5	0			Northern end of cut 8 hydromulched 29-10-2015	Progressing well with good variation of natives. Continue to monitor to ensure height of natives reaches standard.
Fill 12	SB		Oct-2015		4	4	5	5	HM	4	3	3	0	3	4	0				Satisfactory progression - continue to monitor.
Cut 12	SB		Oct-2015		2	2	5	5	HM	4	1	2	0	2	3	0			Topsoil application thin and compacted	Limited native stike - continue to monitor following herbice application April 2016 to control weeds.
Cut 13	SB		Oct-2015		4	4	5	5	HM	4	3	3	0	4	2	0			Weeds sprayed April 2016	Continue to monitor following herbicide application to control weeds.
Fill 11	SB		Nov-2015		4	3	5	5	HM	4	3	3	3	3	3	3			High clay content in topsoil causing compaction issues	Bottom of batter progresssing well. Continue to monitor for top of batter and potential weeds / invasive grasses.

Fill 11	NB		Nov-2015		4	2	5	5	HM	4	3	4	3	2	3	3			topsoil smeared into a compact surface layer. Top of batter sprayed Feb-16 onto smeared topsoil.	Bottom of batter progressing well. Continue to monitor for top of batter and potential weeds / invasive grasses.
Fill 18	NB		Nov-2015		4	3	5	5	HM	4	3	3	2	3	4	3			Batter part sprayed Nov-15 and part sprayed Dec-15	Satisfactory progression - continue to monitor
Fill 22	NB		Nov-2015		4	4	5	5	HM	4	2	3	3	4	3	3			Area on southern side of C36.40 - tall shrubs sprayed Nov-15 and frangible shrubs sprayed Dec-15. Area north of C36.40 sprayed March 2016.	Continue to monitor native coverage and weed / invasive grasses. Noted some carpet grass and couch growing suggesting some cross contamination with a pasture grass load.

Table 17: Kundabung to Kempsey twelve month inspection results

Location			Hydroseed / hydromulch Date	Tubestock Date	Topsoil Depth	Topsoil Quality (content / compaction)	Batter Slumps / Rills		Mulch		Trees and Shrubs		% Required Native Species	Ground Coverage	Native species : Weed Ratio	Native Overall Rating	Natives Noted During Field Inspection	Noxious Weeds Noted During Field Inspection	Sowing Methods / Comments / Action Recommended	Actions / Recommendations
Cut/Fill	C'way	Bench					No.	Type	Type	Ranking	Coverage	Condition								

Fill 4	SB		Jul-2015		4	2	5	5	HM	2	3	3	2	2	4	3			Hydromulch coverage on fill batter below specification standard. High clay content in topsoil resulting in compact hard surface. Areas Resprayed July 2016	Continue to monitor following respray.
Cut 5	SB		Jul-2015		4	4	5	5	HM	4	4	3	4	4	4	4			Northern end of cut 5 sprayed 30-7-2015.	Progressing well with good variation of natives. Continue to monitor to ensure height of natives reaches standard.
Cut 6	SB		Jul-2015		4	4	5	5	HM	4	4	4	4	4	4	4				Progressing well - meets specified standard for native height and species diversity.

Niche Environment and Heritage

A specialist environmental and heritage consultancy.

Head Office

Niche Environment and Heritage

PO Box 2443 North Parramatta NSW 1750

Email: info@niche-eh.com

All mail correspondence should be through our Head Office