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Annual Ecological Monitoring Report 2016/2017

Oxley Highway to Kempsey, Pacific Highway Upgrade

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Cover photograph: OH2K aerial fauna crossings (photo by Jodie Danvers).

Executive summary

Context

This report documents findings for the 2016/2017 monitoring of threatened species and mitigation measures associated with the Oxley Highway to Kempsey (OH2K) Pacific Highway upgrade (the Project), as required by the Oxley Highway to Kempsey (OH2K) Ecological Monitoring Program (EMP, RMS 2016). The purpose of the EMP is to monitor the effectiveness of the biodiversity mitigation measures implemented as part of the Project by monitoring both threatened species and mitigation measures.

The EMP details the schedule of ecological monitoring requirements for the life of the Project. Those monitoring components that were undertaken during the 2016/2017 monitoring period and that are reported on in this document are highlighted below in bold.

Threatened species identified within the EMP 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 triglochinoides***.

Mitigation measures specified in the EMP include:

- **Pre-clearing and clearing procedures**
- Fauna underpasses
- Rope Bridges
- Glider poles
- Fauna fencing
- Widened median
- **Nest boxes**
- **Microbat roost boxes**
- **Green-thighed Frog breeding ponds**
- ***Maundia triglochinoides* habitat protection**
- **Landscaping and revegetation**

Key results and implications

- Koala:
  - Koala scats were found to be present within 10 of the 27 sites surveyed (37%).
  - Mean activity level across the sites was 0.7% (SD = 1.1%), which is lower than for the previous two rounds of survey (baseline and 2015).
  - Results indicate a decline in the presence and activity of Koalas across the Project area and in surrounding areas within control sites.
  - There was no significant difference between Koala presence at control and impact sites which is consistent with the 2015 result.
  - **Monitoring related performance measures have to date been met**.

- **The performance measure related to population changes has not been met** due to the observed decrease in Koala activity, however this declining trend has been observed at both control and impact sites and cannot therefore be attributed to Project related activities.

- Giant Barred Frog:
  - A total of 149 Giant Barred Frogs were recorded across three survey events with 32% (n = 40) of those captured being recaptures.
  - Frogs were recorded at all sites during all seasons with the exception of Pipers Creek impact site where no frogs were recorded during the autumn survey.
  - All sites showed evidence of breeding.
  - Chytrid fungus was detected for the first time at the Cooperabung Creek impact site. Chytrid fungus is now therefore considered to be present at all monitoring sites.
  - All sites had at least one water quality parameter for one or more monthly results for which the median downstream value exceeded the 80th percentile of the upstream value.
  - **All performance measures were met excluding: the presence of Giant Barred Frogs during each survey event where it was identified during baseline surveys for Pipers Creek impact site (autumn survey), and the water quality measure for Maria River.** However, as autumn surveys have shown reduced activity during almost all survey events and frog detection can vary between survey events, the absence of records of the species during this single survey cannot yet be considered as indicating the absence of this species from this site, where it was detected in the spring and summer surveys. The incident at Maria River was addressed immediately and procedures were put in place to avoid recurrence.
  - A number of general recommendations have been made including: consideration of continued Lantana control to improve monitoring efficiency, implementation of Chytrid fungus hygiene protocol at all impact sites and the cessation of Chytrid swabbing of frogs.
- Road kill:
  - A total of 134 road kill animals were recorded over 53 weeks of monitoring, in comparison to 100 records for 12 weeks of baseline surveys.
  - The 2016/2017 monitoring period recorded a lower average weekly road kill than baseline surveys for all seasons.
  - One threatened species, the Koala, was recorded on two occasions as road kill during the current monitoring period (one beyond the northern boundary of the OH2K project).
  - **The performance indicator of success relating to reduced road kill incidence has been met. Other performance indicators relating to mitigation measures (rope bridges, fauna fencing and underpasses) are not yet relevant as structures are still under construction.**
- Pre-clearing and clearing procedures:
  - A total of 414 individual fauna were successfully captured and released/re-located.
  - One Koala was captured and managed in accordance with the OH2K Koala Protocol.
  - Reported mortality of native fauna resulting from clearing operations was low at 4.8 % of the recorded number of successfully relocated individuals.
  - 21% of captured aquatic fauna died in transit, mostly from captures at two sites. Most deaths occurred at two sites and mitigation measures were put in place to prevent continued loss.
  - No threatened fauna mortalities due to clearing operations were reported.
  - As expected, the number of hollow-bearing trees cleared after finalisation of clearing plans was less than predicted in the Nest Box Plan of Management.

- **All performance indicators of success were met excluding mortality rates of aquatic fauna**, however mitigation measures were applied to avoid continued loss.

Nest boxes:

- Of the 425 nest boxes 66 (16%) were occupied and 234 (55%) showed signs of use in either Event 1 or Event 2 (or both). Therefore, a total of 300 nest boxes (71%) were occupied or showed signs of use by vertebrate fauna at least once during Year 1.
- Fourteen species were identified during monitoring.
- Exotic birds were not recorded using nest boxes and 13% of nest boxes showed signs of use by European Bees however only 6% showed use exclusively by European Bees.
- Excluding the boxes requiring replacement due to wildfire, only 3% of boxes required maintenance/replacement.
- **All performance indicators of success have been met except for design-specific use of 4 of the 9 nest box types.** Nest box types P/L (medium parrots/lorikeets), Co (cockatoos), SO (small owls) and LFO (large forest owls) did not show signs of use by target fauna, however these nest box types were used by other vertebrate fauna groups. The target fauna of these boxes were not recorded using any nest box type, with the exception of a single Lorikeet record from a SG (small glider) box. Additional monitoring events are required to determine either the success of these box types or the need to review the use of these nest box types as compensatory habitat.

- Microbat roost boxes:
  - Non-target microbat species were recorded in 4% of the installed roost boxes during both Event 9 and Event 10.
  - 7% of boxes were used by mud wasps and 24% by other native non-target vertebrate fauna.
  - Excluding those damaged by wildfire, only 3% of roost boxes required maintenance.
  - **All performance indicators of success have been met, however, the absence of target species and the very low rate of use by microbat species indicates that the use of timber roost boxes as a management measure for these species has to date been unsuccessful**.
  - An inspection of additional structures (culverts and bridges) within the Ku2K section during Event 10 found two species of microbats at six culverts: the vulnerable Little Bent-wing Bat (*Miniopterus australis*) and Southern Myotis (*Myotis macropus*), both of which were identified during *Microchiropteran Bat Management Strategy* surveys.
  - An inspection of the structures in the OH2Ku section of the Project was not undertaken in summer 2017. An inspection should be undertaken as soon as possible to determine the use of these structures by target species.
  - Subject to the outcome of additional structure monitoring, additional corrective actions may be required.
- Green-thighed Frog breeding ponds:
  - Stage 1 surveys recorded Green-thighed Frogs at the Collombatti reference site and at two ponds at Site 3. All ponds at Sites 1, 3 and 4E contained 10 – 40 cm of water, while ponds at Site 4W were found to contain no water.
  - Stage 2 surveys recorded no Green-thighed Frogs. All ponds at Sites 1 and 3 held water and all ponds at Site 4 were dry.
  - Gambusia (*Gambusia holbrooki*) was identified at the Collombatti reference site and Site 1.
  - **Performance indicators of success have not been met for some or all of the constructed pond sites.**

- **Performance indicators of unsuccessful mitigation have been met for some or all of the ponds at each of the constructed pond sites**.
- A number of recommendations to meet performance criteria have been made.

- *Maundia triglochinoides* habitat protection:
  - Maundia was recorded at two of the impact sites and only one control site.
  - At Site 1, Maundia was consistently present at the impact site, while only recorded during spring at the paired control site.
  - Maundia was also found to be present at Site 2 impact site and not at its paired control site.
  - Recruitment was observed at both the impact sites where it was recorded.
  - Flowering was recorded at Site 1 at both the impact and its paired control site during spring surveys.
  - **The Maundia performance measures have been mostly met**. However to fulfil all required aspects of the performance measures, recommendations have been made to verify and replace exclusion fencing, sediment control measures and signage at relevant sites.
- Landscaping and revegetation:
  - 70 sites underwent an 8 month inspection during the current monitoring period.
  - 90 sites were included in the 12 month inspection assessment, **30 of these (33%) were found to meet all performance indicators of success**.
  - **Of the 90 sites that underwent a twelve month assessment, 60 did not meet the performance indicators.** While formal monitoring of these sites is no longer required, these sites should continue to be monitored and all actions deemed appropriate, such as herbicide treatment, respraying or reworking, should be undertaken.

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1. Introduction

1.1 Context

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

Note that threatened species identified within the EMP that were listed under the repealed NSW *Threatened Species Conservation Act 1995* (TSC Act) are now listed under the NSW *Biodiversity Conservation Act 2016* (BC Act). References made to TSC Act listed species within the EMP are therefore taken as referring to BC Act listed species.

For a number of the monitoring components the Project has been divided into two sections:

- Oxley Highway to Kundabung (Ch. 0 - 24040), hereafter referred to as OH2Ku.
- Kundabung to Kempsey (Ch. 24040 - 37850), hereafter referred to as Ku2K.

1.2 Purpose of this report

This report summarises the findings of the 2016/2017 ecological monitoring surveys undertaken as part of the OH2K section of the Pacific Highway Upgrade Project. These were undertaken in accordance with the EMP from July 2016 to June-July 2017. Specifically, this document reports on the timing and results of monitoring activities undertaken, methodologies employed and progress/results measured against previously identified performance measures.

The EMP details the schedule of ecological monitoring requirements for the life of the Project. These are shown in Table 1.

Monitoring components of the EMP that were undertaken during the 2016/2017 monitoring period and are reported on in this document are:

- Koala (spring 2016)
- Giant Barred Frog (spring 2016, summer 2017, autumn 2017)
- Road kill (weekly July 2016 - July 2017)
- Pre-clearing and clearing procedures (OH2Ku November 2014 – June 2017)
- Nest boxes (Event 1: winter 2016 and Event 2: summer 2016)
- Microbat roost boxes (Event 9: winter 2016 and Event 10: summer 2017)
- Green-thighed Frog breeding ponds (summer 2017)
- *Maundia triglochinoides* habitat protection (spring 2016, summer 2017, autumn 2017)
- Landscaping and revegetation (July 2016 – June 2017)

Table 1: Summary and schedule of monitoring requirements outlined in the EMP (RMS 2016).

Mitigation Measure	Baseline Surveys						Construction Phase														Operation Phase																					
	Year 0 (2013-2014)						Year 1 (2015)					Year 2 (2016)					Year 3 (2017)					Year 4 (2018)					Year 5 (2019)					Year 6 (2020)					Year 7 (2021)					Year 8 (2022)				
	S	Su	A	W	S	Su	Su	A	W	S	Su	Su	A	W	S	Su	Su	A	W	S	Su	Su	A	W	S	Su	Su	A	W	S	Su	Su	A	W	S	Su	Su	A	W	S	Su	Su	A	W	S	Su
Koala																																											
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Squirrel Glider																																											
Road Kill@																																											
Pre-clearing / clearing^																																											
Fauna underpasses																																											
Rope Bridges																																											
Glider Poles																																											
Fauna Fencing																																											
Widened Median																																											
Nest boxes															1		2																											
Bat Roost Boxes*				1	2	3	4	5	6	7	8	9		10																													
Maundia Habitat Protection																																											
Green-thighed frog ponds																				#					#					#					#								
Landscape monitoring																																											

- Su A W S = Summer, Autumn, Winter, Spring.
- @during clearing operations, daily for one month following clearing operations, for eight weeks post opening
- # timing is dependent on rainfall; * numbers are monitoring event numbers; ^only OH2Ku reported

Completed

Existing Niche Contract

Additional monitoring completed as part of EPBC

Lewis Ecological

Construction Contractor

2. Koala

The Koala monitoring results for the 2016/2017 monitoring period are detailed in Niche (2017c). This report is included in Annex 1 and key details are summarised below.

2.1 Monitoring framework and timing

The EMP specifies that monitoring of all sites will occur 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. Monitoring is to occur once a year during spring-summer.

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

- *Spring-summer 2015*: Niche 2016b.
- *Spring- summer 2016*: Niche2017c.

The 2017 report represents the second of three necessary construction monitoring reports for the Koala. The final construction surveys will be undertaken in spring-summer 2017 and be the subject of the final report for construction monitoring for the Koala. Operational monitoring is projected to commence in spring-summer 2018.

2.2 Monitoring sites

Eight broad areas within a 20 km radius of the Project were surveyed and three types of monitoring sites were established within each area: mitigation, no or partial mitigation, control. A total of 82 SAT plots were surveyed across the eight monitoring areas.

2.3 Key results

A total of 82 plots across 27 sites were surveyed in spring-summer 2016. Koala scats were found to be present within 10 of the 27 sites surveyed (37%) and the mean activity level (measured as the number of scats within plots) across the sites was 0.7% (SD = 1.1%). The distribution and activity level of Koalas recorded during the current survey is lower than for the previous two rounds of survey (baseline and 2015) and results indicate a decline in the presence and activity of Koalas across the Project area and in surrounding areas within control sites.

Koalas were recorded more frequently at impact sites (42%) than at control sites (33%), which is consistent with results observed in the previous two monitoring events. There was no significant difference between Koala presence at control and impact sites which is also consistent with the 2015 result.

Surveyed trees included 32 tree species, of which Koala scats were recorded at seven (22%). The tree species Koala scats were most commonly recorded beneath were Tallowwood (*Eucalyptus microcorys*) and Small-fruited Grey Gum (*E. propinqua*), which together comprised 30% of all surveyed tree species. Tree species use was not dissimilar to that recorded in the baseline (Lewis 2014) or 2015 monitoring events.

2.4 Conclusions and management implications

Koala presence and activity levels appear to have decreased between the baseline, 2015 and 2016 monitoring events, but for both control and impact sites. In each of the surveys undertaken to date, impact sites recorded higher percentages of Koala presence than control sites. For this reason any decrease in Koala presence/activity cannot currently be directly or solely attributed to disturbance due to the Project.

It is also likely that Koala distribution/abundance would have been affected by the wildfire that occurred across the northern parts of the Project prior to the surveys in spring 2016. Continued monitoring data will assist in determining if the results reflect broader trends in population dynamics.

SAT plots provide data in compliance with the requirement of measuring Koala distribution, habitat use and activity levels, but do not provide any 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 against which the performance measure relating to this variable may be effectively assessed.

3. Giant Barred Frog

The Giant Barred Frog results for the 2016/2017 monitoring period are detailed in Niche (2017a). This report is included in Annex 2 and key details are summarised below.

3.1 Monitoring framework and timing

The design, methods and performance indicators that define the Giant Barred Frog monitoring program are specified in the EMP and Giant Barred Frog Management Strategy (GBFMS, Lewis 2013b). Where there are discrepancies between the EMP and the GBFMS, the EMP takes precedence. The EMP requires monitoring of the Giant Barred Frog three times a year (spring, summer and autumn), in the middle of the season, within one week of rainfall of 10 mm within a 24 hour period, in years 1, 2 and 3 once substantial construction commenced. Following the completion of the project, monitoring will continue in the same manner for a further five consecutive years, or until the mitigation measures can be demonstrated to be effective. To date, these monitoring events have been reported as follows:

- *Autumn 2015*: Niche 2015a.
- *Spring 2015, summer and autumn 2016*: Niche 2016a.
- *Spring 2016, summer autumn 2017*: Niche 2017a.

To complete the required three cycles of construction monitoring, a spring and a summer survey remain. These surveys will be undertaken in spring 2017 and summer 2018 and be the subject of the final report for construction monitoring for the Giant Barred Frog. The 2017 report therefore represents the third of four necessary construction monitoring reports for the Giant Barred Frog. Operational monitoring is projected to commence in autumn 2018.

3.2 Monitoring sites

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

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

3.3 Key results

A total of 149 Giant Barred Frogs were recorded across the three monitoring events during the 2016/2017 monitoring period, with 32% (n = 40) of those captured being recaptures. Frogs were recorded at all sites during all seasons with the exception of Pipers Creek impact site where no frogs were recorded during the autumn survey.

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

Chytrid fungus was detected for the first time at the Cooperabung Creek impact site. Chytrid fungus is now therefore considered to be present at all monitoring sites.

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

3.4 Conclusions and management implications

Performance measures related to Giant Barred Frog population and habitat use monitoring have to date been met.

The performance measure related to continued presence of Giant Barred Frogs during each survey event where it was identified during baseline surveys was met for 5 of 6 sites. Giant Barred Frogs were not recorded at Pipers Creek impact site during the autumn survey where it was recorded during baseline surveys (Niche 2015b). However, as autumn surveys have shown reduced activity during almost all survey events and frog detection can vary between survey events, the absence of records of the species during this single survey cannot yet be considered as indicating the absence of this species from this site, where it was detected spring and summer surveys.

The water quality performance measure was met for all sites except Maria River. Other values above the 80th percentile trigger value were not considered to be attributable to construction activities. The incident at Maria River was addressed immediately and procedures were put in place to avoid recurrence

A number of general recommendations have been made including consideration of continued Lantana control to improve monitoring efficiency, implementation of Chytrid fungus hygiene protocol (DECC 2008) at all impact sites and the cessation of Chytrid swabbing of frogs.

4. Road Kill

The road kill monitoring results for the 2016/2017 monitoring period are detailed in Niche (2017e). This report is included in Annex 3 and key details are summarised below. The results are based on data collected by Roads and Maritime Services.

4.1 Monitoring framework and timing

The monitoring framework provided within the EMP and the reporting status is shown in Table 2. The 2016/2017 monitoring period involved weekly monitoring of the entire length of the existing highway from the 27 July 2016 to the 28 July 2017, a total of 53 monitoring events, and represents the second construction phase monitoring period.

Table 2: Road kill monitoring

Project Phase	Monitoring event: report	Timing of survey	Location
Baseline	*spring 2013, summer 2014, autumn 2014:* Niche 2015c	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	*November 2014- July 2015*: Niche 2015c	Daily	Portion of existing highway adjacent to clearing operations
One month following clearing operations			
For the duration of construction	*8 August 2015 – 22 July 2016*: Niche 2016e *27 July 2016 – 28 July 2017*: Niche 2017e	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 Monitoring sites

The entire length of the OH2K section of the existing highway was monitored.

4.3 Key results

The results summarise the 2016/2017 weekly monitoring undertaken from the 27 July 2016 to the 28 July 2017, a total of 53 monitoring events. A total of 134 road kill animals were recorded over 53 weeks of monitoring, in comparison to 100 records for 12 weeks of baseline surveys. The 2016/2017 monitoring period recorded a lower average weekly road kill than baseline surveys for all seasons when considering the entire monitoring period, and when considering only the same four week period of construction surveys during each season as the baseline surveys. One threatened species, the Koala, was recorded on two

occasions as road kill during the current monitoring period at the northern end of the Project area within 3 km of each other, with one occurring beyond the northern boundary of the OH2K project.

4.4 Conclusions and management implications

Current trends indicate an overall reduction in road kill incidence during construction activities. The surveys for 2016/2017 show a reduced road kill rate compared to the baseline surveys in spring, summer and autumn, as such the performance indicator relating to reduced road kill incidence has been met. Other performance indicators relating to mitigation measures (rope bridges, fauna fencing and underpasses) are not yet relevant as structures are still under construction.

There are no current recommendations based on the outcomes of the 2016/2017 monitoring period. Continued monitoring of road kill upon completion of mitigation measures will provide further information as to the effectiveness of these measures.

5. Pre-clearing and clearing procedures

Reporting for pre-clearing and clearing procedures for the 2016/2017 monitoring period includes two reports for the OH2Ku section, which have been provided by Sandpiper Ecological Surveys. Reporting for the Ku2K section will be provided upon completion of all clearing procedures.

Reporting is as follows:

- OH2Ku: current report.
  - *3rd November 2014 – 25th August 2015*: Phase 1 clearing report (Sandpiper 2017a).
  - *September 2015 – June 2017:* Phase 2 clearing report (Sandpiper 2017b).

These reports are provided in Annex 4 and the results are summarised below.

- Ku2K: A single report will be provided for all clearing undertaken in the Ku2K section upon completion of clearing procedures, as per the EMP. These results will be presented in the 2017/2018 OH2K annual report.

5.1 Monitoring framework and timing

The EMP specifies that pre-clearing flora and fauna surveys will be conducted prior to Stage 1 removal of vegetation (i.e. non-habitat trees) and that inspections of habitat trees and fauna rescue procedures will be undertaken during Stage 2 clearing. The EMP details pre-clearing and clearing procedures and details the type of data to collect for target species and activities.

5.2 Performance measures

The EMP specifies the performance measures for pre-clearing and clearing.

The performance of pre-clearing and clearing procedures will be assessed against:

- *Low rates of fauna injury and mortality resulting from clearing operations, and no mortality of TSC Act and EPBC Act threatened species.*
- *Stop work implemented immediately when fauna observed and successful capture and release of fauna displaced by clearing operations (ie being released within 1 hour without mortality, unless the animal is injured and is instead managed in accordance with the Fauna Handling and Rescue Procedure in the FFMP).*
- *Immediate contact with Project Ecologist / Suitably Qualified Expert or wildlife carer when injured fauna are identified.*
- *Accurate quantification of fauna habitat features and hollow-bearing trees being removed against the predicted quantities identified in the Nest Box Management Plan*. [sic]

5.3 Monitoring sites

This report refers to clearing surveys undertaken in the OH2Ku section only. Surveys were undertaken within the clearing footprint each day of clearing operations along the OH2Ku section of the upgrade.

5.4 Key results

Results of phase 1 and phase 2 clearing reports have been combined to provide the summary of results for the entire November 2014 – June 2017 period. The results presented below have been extracted from the reports and summarised in order to more clearly address the performance measures, as per the EMP.

5.4.1 Fauna injury/mortality and capture/release results

Terrestrial fauna

A total of 414 individuals were captured and relocated. Twenty individuals (excluding eggs), including euthanased individuals, died during clearing operations. Deaths occurred by vehicle strike and during hollow-bearing tree removal. The 20 dead individuals represents 4.8% of the number of individuals relocated.

Aquatic fauna

A total of 30,765 aquatic fauna were captured. Of these, 8,431 Mosquito Fish (*Gambusia holbrooki*), two Goldfish (*Carassius auratus*) and 14 Silver Perch (*Bidyanus bidyanus*) were euthanased. Of the remaining 22,318 fish, 4,729 individuals died in transit (21%), and the remaining 17,589 were successfully relocated. The majority (99%) of those individuals that died in transit were of three species of Gudgeon, and mostly from two sites. The deaths represented 22% of captured Gudgeons. A number of mitigation measures were applied to the methods to avoid further mortality.

Threatened fauna

Twelve threatened species were recorded, of which 12 species are listed on the *NSW Threatened Species Conservation (TSC) Act 1995* and three are also listed on the *Commonwealth Environment Protection and Biodiversity Conservation (EPBC) Act 1999*. There were no reported deaths of threatened fauna.

5.4.2 Injured fauna protocol

Six injured individuals and three eggs damaged during hollow-bearing tree removal were euthanased either immediately or after being taken into care, depending on the severity on injury. Five individuals were taken into care but later died while in care. A single Koala was transferred to Port Macquarie Koala Hospital after capture but was successfully released in good health after one week of care.

5.4.3 Fauna habitat features and hollow-bearing trees

Hollow-bearing trees

The *Nest Box Plan of Management* (NBPoM, Lewis 2013a) identified a total of 603 hollow-bearing trees in the road corridor along the entire OH2K section of the upgrade. Initial habitat surveys marked 468 hollow-bearing trees within the OH2Ku section, while a reassessment during pre-clearing surveys determined only 443 to contain hollows. Clearing involved the actual removal of 311 hollow-bearing trees. As expected, the NBPoM reported a higher number of hollow-bearing trees within the clearing zone based on a ground assessment of hollow-bearing trees within the road corridor. The number of hollow-bearing trees removed was reduced from that expected once detailed clearing plans were established and clearing was undertaken.

Nest box calculations

Re-calculation of the number of nest boxes required resulted in a reduction from 469 (Stage 1) to 114 (Stage 2). The initial, larger estimate is considered to be due to an initial overestimate of hollows present, due to perspective differences from ground inspections; the 20% error factored into calculations that assumes an underestimate; inclusion of non-viable hollows; and changes in clearing boundaries.

5.5 Discussion

A summary of the OH2Ku clearing survey results in relation to the performance indicators are provided in Table 3. Ku2K clearing survey results will be discussed in the 2017/2018 OH2K annual report.

Table 3: Pre-clearing and clearing procedures performance measures

Performance indicators of success	Discussion
Low rates of fauna injury and mortality resulting from clearing operations, and no mortality of TSC Act and EPBC Act threatened species.	**This performance indicator has been met for terrestrial fauna**. Reported mortality of native fauna resulting from clearing operations was low at 4.8 % of the recorded number of successfully relocated individuals. **This performance indicator has not been met for aquatic fauna.** 21% of captured aquatic fauna died in transit, mostly from captures at two sites. Mitigation measures were applied to avoid further loss. **This performance indicator has been met for threatened fauna.** No threatened fauna mortalities due to clearing operations were reported.
Stop work implemented immediately when fauna observed and successful capture and release of fauna displaced by clearing operations (i.e. being released within 1 hour without mortality, unless the animal is injured and is instead managed in accordance with the Fauna Handling and Rescue Procedure in the FFMP.	**This performance indicator has been met.** A total of 414 individuals were successfully captured and released. One Koala was captured and managed in accordance with the OH2K Koala Protocol.
Immediate contact with Project Ecologist / Suitably Qualified Expert or wildlife carer when injured fauna are identified.	**This performance indicator has been met.** Injured fauna were euthanased or transferred to care where appropriate.
Accurate quantification of fauna habitat features and hollow-bearing trees being removed against the predicted quantities identified in the Nest Box Management Plan.	**This performance indicator has been met.** An expected reduction in the number of hollow-bearing trees cleared occurred after finalisation of clearing plans.

5.6 Recommendations

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those that are considered to be relevant to the pre-clearing and clearing procedures are listed and discussed for the OH2Ku section in Table 4.

A number of points were raised that should be considered in future clearing operations. These are discussed in detail in the Phase 1 report (Sandpiper 2017a) and are summarised below.

- The implementation of a staged clearing process whereby HBTs are retained for at least two nights may be a key factor to the successful minimisation of mortalities of local fauna.
- Further consideration of the HBT removal process is warranted as harvesters are often unable to gently fell large HBT's.
- Consideration should be given to timing of clearing as clearing during the breeding season for native birds (i.e. October – January) can cause considerable mortality of chicks and eggs.

Table 4: Pre-clearing and clearing procedures contingency measures

Potential Problem	Contingency Measure proposed in EMP	Action
Previously undetected fauna is located prior to clearing.	Notify Environmental Manager and EPA within 24 hours. Project ecologist to record location of species immediately with GPS. Project ecologist to relocate and release fauna into suitable adjoining habitat. Obtain approval from relevant authorities to relocate threatened species if required, at least 24 hours before relocation is conducted.	No species unknown to the area were reported for the OH2Ku section. **This potential problem was not encountered.**
Previously undetected flora species is located prior to clearing.	Notify Environmental Manager and EPA. Project ecologist to record location of species with GPS. Delineate threatened species with highly visible tape to protect it from clearing. Seek approval from relevant authorities to translocate species if required.	No previously undetected flora species were reported. **This potential problem was not encountered.**
Identification of previously undocumented EEC.	Notify Environmental Manager and EPA. Project ecologist to delineate boundaries of the EEC with a GPS and highly visible tape. Consult with relevant authorities for management of additional EEC	No previously undetected EEC was reported. **This potential problem was not encountered.**
High rates of fauna injury and mortality resulting from clearing operations	Immediately commence review of clearing procedures and complete review prior to clearing recommencing. Modify habitat tree retention times and/or Stage 2 (habitat tree felling) clearing procedures prior to clearing recommencing. Review approach of clearing contractor prior to clearing recommencing.	Reported mortality of terrestrial native fauna resulting from clearing operations was low at 4.8 %. **This potential problem was not encountered for terrestrial fauna, however** 21% of captured aquatic fauna died in transit. **These contingency measures were therefore relevant.** Most deaths occurred at two sites and mitigation measures were put in place to prevent further loss. These strategies included: ▪ Reduced use of the seine net. ▪ Dragging the seine net through the surface 10 - 20 cm for the first few shots. ▪ Gradual deployment of the seine net and returning fish to the water for later capture to reduce fish captured and processing times.

6. Nest boxes

The nest box data for the 2016/2017 monitoring period has been provided by two sources. The OH2Ku section was monitored by Sandpiper Ecological Services and the Ku2K section was monitored by Lewis Ecological Surveys. OH2Ku results are presented in two separate reports for the winter (Event 1, Sandpiper 2017e) and summer (Event 2, Sandpiper 2017d) monitoring, while Ku2K presents both Event 1 and Event 2 in a single report (Lewis 2017b). These reports are provided in Annex 5. The results are summarised below.

6.1 Monitoring framework and timing

The EMP specifies that nest boxes were to be installed in Year 1 (2015) and Year 2 (2016) (construction phase) with monitoring to commence in summer and winter shortly after the installation period (2016) and will continue in Year 4 (2018), Year 6 (2020) and Year 8 (2022).

To date, two monitoring events have occurred:

- *Event 1-winter 2016*: current report.
  - OH2Ku: 20 – 23rd June 2016 and 8 – 9th August 2016 (Sandpiper 2017e, d).
  - Ku2K: 20th August – 25th September 2016 (Lewis 2017b).
- *Event 2-summer 2017*: current report.
  - OH2Ku: 16 – 20th January 2017 and 13 - 14th March 2017 (Sandpiper 2017e, d).
  - Ku2K: 9 – 14th March 2017 (Lewis 2017b).

Events 1 and 2 were the first biannual inspections after installation. Due to the installation of nest boxes occurring in early 2016 monitoring commenced in winter 2016, six months ahead of the scheduled first monitoring event in summer 2017. An additional biannual monitoring event will therefore occur in winter 2017 (Event 3).

Biannual construction monitoring will continue in winter 2017 (Event 3). Three years (Years 4, 6 and 8) of biannual operational monitoring will commence in summer 2018.

6.2 Performance measures

The EMP specifies the performance measures for nest boxes.

Indicators of success of nest boxes include:

- *Use of nest boxes by a wide range of native fauna species.*
- *Use of nest boxes designed for specific species by those same species.*
- *Low rate of use of nest boxes by introduced fauna species.*
- *Low level of maintenance of nest boxes.*

6.3 Nest boxes monitored

The *Nest Box Plan of Management* (NBPoM, Lewis 2013a) describes the number, type and distribution of nest boxes required to mitigate the loss of hollows, and the ongoing management of the nest boxes. The boxes were installed in two phases: 60% prior to or during clearing to provide temporal refuge habitat and the remaining 40% once a final count of functional tree hollows was made during the clearing supervision.

Phase 2 calculations required an additional four boxes for OH2Ku and 101 for Ku2K. The number of nest boxes installed and monitored are provided in Table 5. Phase 2 installations for OH2Ku were undertaken prior to Event 2, and are now complete for Ku2K, with the final 101 boxes installed in winter 2017. The nest box installation area was divided into zones to provide clusters of nest boxes in areas requiring mitigation for the loss of hollows.

Table 5: Nest box installation and monitoring

	Specified in the EMP	Phase 1 installation / Nest boxes monitored Event 1 (winter 2016)	Phase 2 calculation: additional boxes	Nest boxes monitored Event 2 (summer 2017)	Nest boxes to be monitored Event 4 (summer 2018)
OH2Ku	469	263	4 (installed prior to Event 2)	269*	269
Ku2K	254	156	101 (installed winter 2017^)	156	257
	723	**419**		**425**	**526**

* = two extra boxes were installed due to Masked Owl observations during clearing; ^ = 53 of the phase 2 nest boxes were installed prior to Event 3 monitoring, the remaining 48 were installed post-monitoring and will be will be monitored for the first time during summer 2018 (Event 4).

6.4 Methods

The EMP, in accordance with the NBPoM, states that monitoring will involve a visual inspection of each nest box, and at each monitoring period, the following information will be collected:

- Inspection date, weather conditions (rain, wind, cloud cover, ambient temperature) and time each nest box was inspected.
- Nest box identification number.
- If the nest box is occupied by native fauna, and if so, the species. If the nest box is not occupied by a native species, record any signs of use by native species, such as feathers, droppings, scats, hair or nesting material.
- If the nest box is occupied by a pest species such as European bees, or Common Myna.
- Deterioration of the nest box and if any maintenance required.
- Any changes to the surrounding habitats, such as clearing or installation of wildlife crossing structures.

6.5 Key results

6.5.1 Seasonal results

To provide an overall representation of nest box results for the Project, OH2Ku and Ku2K results have been grouped in the following summary.

Event 1 - winter 2016

A total of 419 nest boxes were monitored. Of these 44 (11%) were occupied at the time of surveys and a further 173 (41%) showed signs of use by vertebrate fauna. A total of 217 nest boxes (52%) were therefore either occupied or showed signs of use by vertebrate fauna during the winter surveys.

Event 2 - summer 2017

A total of 425 nest boxes were monitored. However, a wildfire event in early November 2016 in the northern area of the Ku2K section resulted in the loss of 31 nest boxes. As such only 394 nest boxes were

available to fauna at the time of Event 2-summer 2017 monitoring. These boxes were replaced at the time of monitoring however we have excluded these boxes from calculations of rates of occupation and use during Event 2, as these boxes were not available to fauna. Of the 394 nest boxes available to fauna during Event 2 monitoring, 30 (8%) were occupied at the time of surveys and a further 165 (42%) showed signs of use by vertebrate fauna. A total of 195 nest boxes (49%) were therefore either occupied or showed signs of use by vertebrate fauna during the summer surveys.

Deceased adult and juvenile Chocolate Wattled Bats (*Chalinolobus morio*) were recorded in a wedge-shaped microbat roost box. The cause of death of these animals is unknown but possibly due to the blocking of free movement from the roost by a leaf nest and/or extreme heat experienced during summer 2017.

6.5.2 Year 1 results

Range of fauna

Of the 425 nest boxes 66 (16%) were occupied and 234 (55%) showed signs of use in either Event 1 or Event 2 (or both). Therefore, a total of 300 nest boxes (71%) were occupied or showed signs of use by vertebrate fauna at least once during Year 1. Year 1 recorded a total of 14 species as follows:

- Mammals:
  - Arboreal mammals: Short-eared Possum (*Trichosurus caninus*), Common Brushtail Possum (*Trichosurus vulpecula*), Yellow-bellied Glider (*Petaurus australis*), Sugar Glider (*Petaurus breviceps*), Greater Glider (*Petauroides volans*), Common Ringtail Possum (*Pseudocheirus peregrinus*) and Feathertail Glider (*Acrobates pygmaeus*).
  - Scansorial mammals: Brown Antechinus (*Antechinus stuartii*).
  - Flying mammals: Gould's Long-eared Bat (*Nyctophilus gouldi*) and Chocolate Wattled Bat.
- Birds: Australian Owlet Nightjar (*Aegotheles chrisoptus*) and Scaly-breasted Lorikeet (*Trichoglossus chlorolepidotus*).
- Reptiles: Lace Monitor (*Varanus varius*) and Carpet Python (*Morelia spilota*).

Of particular note was the detection of the Greater Glider, listed as vulnerable under the EPBC Act, and the Yellow-bellied Glider, listed as vulnerable under the NSW *Biodiversity Conservation Act 2016* (BC Act) (previously listed under the repealed NSW *Threatened Species Conservation Act 1995* (TSC Act)).

Design-specific use

The NBPoM proposed the installation of the following types of nest boxes:

- Scansorial fauna (Antechinus) (SF)
- Small gliders (Feathertail Glider and Sugar Glider) (SG)
- Larger gliders (Squirrel Glider, Yellow-bellied Glider, Greater Glider) (LG)
- Possums (Common Brushtail Possum, Short-eared Possum and Common Ringtail Possum) (Po)
- Microchiropteran bats (fluttering and direct flying species that utilise tree hollows) (MB)
- Medium sized parrots/lorikeets (P/L)
- Cockatoo (Black Cockatoos)(Co)
- Small Owls (Southern Boobook and Barn Owl) (SO)
- Large Forest Owls (Masked Owl, Sooty Owl, Powerful Owl) (LFO)

Fauna observed to be occupying nest boxes at the time of monitoring or that were positively identified from feathers have been grouped into the above target groups and their nest box use is provided in Table 6. Possums and reptiles were recorded in a variety of nest box types and sizes. The Owlet Nightjars were also found in boxes of variable type and size with the single Scaly-breasted Lorikeet record in a SG box, which is similar in dimensions to, but with a smaller entrance and shallower than, the PL boxes. Scansorial fauna and small gliders were found in boxes other than SF and SG boxes, but mostly in smaller sized nest box types. Large gliders were recorded in LG boxes and in the larger LFO box and the microbat records were from MB type boxes. Cockatoo, small owl and large forest owl nest boxes were not used by their target fauna, and these bird groups were not recorded using nest boxes.

Use of nest boxes by ant or wasp species was observed in 62 (15%) nest boxes.

Table 6: Nest box use

	Nest box type								
Fauna group	**SF**	**SG**	**LG**	**Po**	**MB**	**P/L**	**Co**	**SO**	**LFO**
Scansorial fauna	1	2			1			1	
Small Gliders	8	12			1	4			
Large Gliders			2						1
Possums			6	10		1	1	1	1
Micro-bats					3				
Parrots/lorikeets		1							
Cockatoos									
Small Owls									
Large Forest Owls									
Other birds			1	3				2	1
Reptiles	1		1	2		1		1	

Use by introduced species

The NBPoM identifies native and non-native pest species including the European Bee (*Apis mellifera*), exotic birds including Common Myna (*Acridotheres tristis*) and Common Starling (*Sturnus vulgaris*), and termites and ants. These fauna are considered pests for the nest box program as they compete with native/target fauna for nesting resources, create nests/hives that exclude target fauna, and introduce maintenance and longevity issues.

Introduced pest species include the European Bee and exotic birds. Exotic birds were not recorded using the nest boxes while a total of 54 nest boxes (13%) showed signs of use by European Bees. However the majority of the bee hives had been destroyed by the Small Hive Beetle. Of the 54 nest boxes that showed signs of use by European Bees, 27 (50%) also showed signs of use or were occupied by vertebrate fauna and only four were observed to be fresh or active at the time of monitoring (one of which was no longer active during Event 2).

Maintenance

Excluding nest boxes that were destroyed by the November 2016 wildfire, there were 13 nest boxes (3%) that required maintenance. Maintenance actions included tightening of wires, unblocking of drainage holes and replacement due to termite damage. Termites had caused considerable damage to six boxes since installation, with five requiring replacement.

6.6 Discussion

A summary of Event 1 and Event 2 monitoring results in relation to the performance indicators are provided in Table 7.

Table 7: Nest box performance indicators of success

Performance indicators of success	Discussion
Use of nest boxes by a wide range of native fauna species.	**This performance indicator has been met.** Fourteen species were identified during monitoring. Notable absentees were larger forest birds. Hollow-dependant hylid tree frogs were not observed, however some of these species may prefer hollows that retain water, which nest boxes are designed not to do.
Use of nest boxes designed for specific species by those same species.	**This performance indicator has been met by 5 of the 9 nest box types.** Nest box types SF, SG, LG, Po and MB boxes all recorded use by target species. Nest box types P/L, Co, SO and LFO did not show signs of use by target fauna (however these nest box types were used by other vertebrate fauna groups). The target fauna of these boxes were not recorded using any nest box type, with the exception of a single Lorikeet record from a SG box. Additional monitoring events are required to determine either the success of these box types or the need to review the use of these nest box types as compensatory habitat.
Low rate of use of nest boxes by introduced fauna species.*	**This performance indicator has been met.** Exotic birds were not recorded using nest boxes and 13% of nest boxes showed signs of use by European Bees however only 6% showed use exclusively by European Bees. The majority of hives had been destroyed by the Small Hive Beetle and only 4 nest boxes showed signs of recent use by this pest.
Low level of maintenance of nest boxes.*	**This performance indicator has been met.** Excluding the boxes requiring replacement due to wildfire, only 3% of boxes required maintenance/replacement.

*= as per the bat roost boxes (Niche 2015c), these levels/rates were not specified in the EMP, as such an arbitrary level/rate of ≤10% has been assigned.

6.7 Recommendations

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those that are considered to be relevant to the nest box monitoring program are listed and discussed in Table 8.

Year 1 monitoring has shown high rates of use of nest boxes by vertebrate fauna. Future monitoring events will provide information regarding the ongoing use of the nest boxes and potentially the importance of artificial nest boxes after wildfire. The current recommendation is to continue monitoring as per the EMP.

Table 8: Nest box contingency measures

Potential Problem	Contingency Measure proposed in EMP	Discussion of proposed measure
Nest box being used by non-target species.	Review number and design of next boxes.	All nest box types showed use by non-target vertebrate fauna. As generalists, reptiles were expected, and observed to use a range of nest box types. LG boxes showed a relatively high use by possums which may exclude/compete with the targeted large gliders. Additional monitoring events are required to determine a trend or an increase in use of other box types by possums. Future consideration of exclusion methods for Brushtail Possums, such as installing metal guards around trees, to prevent predation and resource competition may be necessary. At this stage, the level of use by non-target vertebrate fauna is not considered to warrant contingency measures. At this stage, the use of 15% (with only 2% showing signs of dual occupancy) of nest boxes by ants and wasps is not considered to warrant contingency measures. However should future monitoring observe ongoing use by these pest species and apparent singular use (i.e. no signs of dual occupancy), contingency measures may be required. **This contingency measure is not considered relevant.**
Nest boxes become occupied by exotic or invasive fauna such as European Bees.	Review/modify nest box design to exclude undesirable species, treat nest boxes to deter/eradicate pest species, or relocate nest boxes.	Exotic birds were not recorded using nest boxes and 13% of nest boxes showed signs of use by European Bees however only 6% showed use exclusively by European Bees. The majority of hives had been destroyed by the Small Hive Beetle and only 4 nest boxes showed signs of recent use by this pest. **This contingency measure is not considered relevant.**
Poor uptake or usage by native fauna species.	Review the types and numbers of nest box designs, their location or positioning within the tree.	Fourteen species were identified during monitoring and 71% of nest boxes were occupied or showed signs of use by vertebrate fauna during Year 1. **This contingency measure is not considered relevant.**
Nest boxes deteriorating rapidly and requiring maintenance.	Identify causes of nest box failure, modify design and construct accordingly.	Only 3% of boxes required maintenance/replacement. Of these boxes six were severely damaged by termites and the remaining boxes required wire tightening and unblocking of drainage holes. **This contingency measure is not considered relevant.**

7. Microbat roost boxes

The microbat roost box data for the 2016/2017 monitoring period has been provided by two sources. The OH2Ku section was monitored by Sandpiper Ecological Services (Sandpiper 2016 and Sandpiper 2017c) and the Ku2K section was monitored by Lewis Ecological Surveys (Lewis 2016 and Lewis 2017a). The reports and results are provided in Annex 6 and in Table 22 and Table 23, results are summarised below.

7.1 Monitoring framework and timing

Bat roost boxes were installed prior to the commencement of construction (Year 0) in 2013, which was 6-12 months prior to the planned exclusion of bats from existing structures. The EMP states the following regarding 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."

To date, the following construction monitoring events have occurred:

- *Event 1-winter 2014, Event 2-spring 2014, Event 3-summer 2015, Event 4-autumn 2015, Event 5-winter 2015* (Niche 2015c).
- *Event 6-spring 2015, Event 7-summer 2016, Event 8-autumn 2016* (Niche 2016d).
- *Event 9-winter 2016* Ku2K: 4 – 22nd August 2016 (Lewis 2016 and current report).
- *Event 9-spring 2016* OH2Ku: 26 – 27th September (Sandpiper 2016 and current report).
- *Event 10-summer 2017*: current report.
  - OH2Ku: 11th January 2017 (Sandpiper 2017c).
  - Ku2K: 27 – 28th February 2017 (Lewis 2017a).

Events 9 and 10 were the first biannual inspections after two years (Events 1- 8) of quarterly inspections. The EMP states that after two years of quarterly monitoring corrective actions will be addressed. Events 9 and 10 therefore provide results for the continued monitoring of roost boxes as well as the results of corrective actions undertaken after Event 8. Due to the installation of bat roost boxes occurring in 2013 instead of 2014, an additional three biannual monitoring events will be undertaken (Events 9 – 11).

Biannual construction monitoring will continue in winter 2017 (Event 11). Three years (Years 4, 6 and 8) of biannual operational monitoring will commence in summer 2018.

7.2 Performance measures

The EMP specifies the performance indicators for microbat roost boxes.

Indicators of success of bat roost boxes include:

- *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.*

7.3 Microbat boxes and structures monitored

A total of 158 bat roost boxes were installed in late September/early October 2013. All installed boxes were initially tree mounted. Four boxes were destroyed in a wildfire in November 2016. These boxes will be replaced, but relocated to underpass structures.

In addition to the bat roost boxes, 32 newly installed structures were identified during Event 9 and monitored during Event 10 as part of the recommended corrective actions (Niche 2016d). Table 9 summarises the numbers of roost boxes and culverts monitored during Event 9 and 10.

The four relocated boxes and additional underpass structures will be monitored during Event 11 (winter 2017), along with the existing roost boxes.

Table 9: Bat roost box monitoring

	Event 9 Spring/Winter 2016		Event 10 Summer 2017	
	Boxes	**New structures**	**Boxes**	**New structures**
Ku2K (winter)	75	6	71	32
OH2Ku (spring)	83	0	83	0
Total	158	0	154	32

7.4 Methods

The EMP, in accordance with the *Microchiropteran Bat Management Strategy* (MBMS) (Lewis 2013d), 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.

7.5 Key results

To provide an overall representation of microbat roost box results for the Project, OH2Ku and Ku2K results have been grouped in the following summary. Field data are provided in Annex 6 and in Table 22 and Table 23.

7.5.1 Roost boxes

- Event 9 - winter/spring 2016: A total of 158 roost boxes were inspected, of which a single roost box was found to contain microbats.

- Event 10 – summer 2017: A total of 154 roost boxes were inspected as four roost boxes were destroyed in a wildfire in November 2016. Five roost boxes were found to contain microbats.

Use by microbats

Six (4%) microbat boxes recorded microbat species. The microbat species recorded were Long-eared Bats (*Nyctophilus* spp.), which were not identified in the MBMS as inhabiting the mitigated structures.

The target species, i.e. those identified during MBMS surveys: Little Bent-wing Bat (*Miniopterus australis*), Eastern Horseshoe Bat (*Rhinolophus megaphyllus*), Southern Myotis (*Myotis macropus*) and Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*), have to date not been recorded using the installed microbat roost boxes. As discussed in Niche 2016d, three of these target species are cave dwelling bats (Little Bent-wing Bat, Eastern Horseshoe Bat and Eastern Bent-wing Bat), and the Southern Myotis has only been found to use timber roost boxes when positioned directly over water. As previously discussed (Niche report), it is considered unlikely that these species will use the bat roost boxes currently installed due to their location and design.

Use by introduced/non-target species

Forty-eight (30%) bat roost boxes were found to show evidence of use by wasps, and likely use by Feathertail Gliders and *Antechinus* spp., in the form of mud wasp nests (11 boxes, 7%), and leaf nests and scats (37 boxes, 23%). Peron's Tree Frog (*Litoria peronii*) was recorded in one box.

Maintenance

Maintenance was required in the form of vegetation clearing at four boxes (8, 35, 139 and 140) (3%) and four boxes were replaced/relocated after fire damage (49, 52, 54 and 58). Static termite activity at two boxes (61 and 68) will continue to be monitored.

7.5.2 Corrective actions results

As required by the EMP, a number of corrective actions based on the absence of the target species from roost boxes were recommended at the end of two years of quarterly monitoring (Events 1 – 8) (Niche 2016d). The outcomes of the corrective actions undertaken in 2016/2017 are provided below and recommendations are discussed in Table 10.

Additional structures monitoring

During Event 9 six additional structures were opportunistically inspected within the Ku2K section of the Project to determine the habitat potential of these structures. All six were found to have roosting microbats, notably the vulnerable (NSW *BC Act*) Little Bent-wing Bat (*Miniopterus australis*). It was determined that additional structures would be monitored in summer 2017 (Event 10) and winter 2017 (Event 11). Thirty-two newly installed structures were monitored within the Ku2K section of the Project. These structures include box culverts, pipe culverts and bridges, and are detailed in Table 24 (Annex 6). Twenty-nine of these structures are considered likely to provide suitable microbat roost habitat. A number of the structures had been recently completed but were considered likely to provide future roost habitat for microbats in winter months.

Two species of microbats were recorded at six culverts during Event 10: the vulnerable Little Bent-wing Bat, and Southern Myotis, both of which were identified during MBMS surveys. A separate report on the

additional structure monitoring will be prepared at the completion of the winter 2017 (Event 11) monitoring event. The outcome of this report will determine the need for, and type of, contingency measures for the microbat roost box monitoring program. Additional structure monitoring of the OH2Ku section of the Project had not been undertaken at the time of this report.

Table 10: Bat roost box 2015/2016 recommendations discussion

Recommendation (Niche 2016d)	Action / result
Annual monitoring of roost boxes to replace biannual monitoring	Biannual monitoring of bat roost boxes is to continue as per the EMP.
Preliminary summer and winter inspection of additional structures within the Project with the potential to be used by microbats.	OH2Ku: Inspection of additional structures in this section of the Project has not yet been undertaken. Ku2K: First monitoring was undertaken in summer 2017 (Event 10). Second monitoring is scheduled for winter 2017 (Event 11). To be reported on after winter 2017.
Continued biannual (Year 4 and 6) inspection of additional structures.	Continued monitoring of additional structures will be assessed based on the outcome of the 2017 summer/winter monitoring of these structures throughout the Project. If the structures are determined to provide suitable roosting habitat for the targeted species monitoring will not be continued.
Removal of temporary exclusion material from selected culverts that are not scheduled for demolition.	Microbat exclusion has been removed from the existing Pipers Creek, Stumpy Creek and Maria River bridges. The exclusion material that remains in place at Haydens Wharf will be removed once the new culverts are installed.
Subject to the outcome of the above recommendations, additional corrective actions may be required:	
Relocation of bat roost boxes directly above water.	The need to relocate installed roost boxes will be assessed based on the outcome of the summer/winter 2017 additional structures monitoring.
Provisions of supplementary roosting habitat of different design / material in culverts and bridges	The four boxes that were burnt will be replaced and relocated to suitable underpass structures. The need to provide supplementary habitat in, or modify, culvert and bridge habitat to make it more suitable will be assessed based on the outcome of the summer/winter 2017 additional structures monitoring.

7.6 Discussion

A summary of Event 9 and Event 10 monitoring results in relation to the performance indicators are provided in Table 11.

Table 11: Bat roost box performance indicators of success

Performance indicators of success	Discussion
Use of bat roost boxes by microbats.	**This performance indicator has been met**. Non-target microbat species were recorded in 4% of the installed roost boxes during both Event 9 and Event 10. The absence of target species and the very low rate of use by microbat species indicates that the use of timber roost boxes as a management measure for these species has to date been unsuccessful.
Low rate of use of roost boxes by introduced fauna species*.	**This performance indicator has been met**. 7% of boxes were used by mud wasps and 24% by other native non-target vertebrate fauna.
Low level of maintenance of roost boxes*.	**This performance indicator has been met.** Excluding those damaged by wildfire, only 3% of roost boxes required maintenance.

*= as per the Niche 2015c, these levels/rates were not specified in the EMP, as such an arbitrary level/rate of ≤10% has been assigned.

7.7 Recommendations

As previously established (Niche 2016d), based on the ecology of the target species, timber roost boxes installed on trees do not provide compensatory roost habitat for the target species and alternate measures have been recommended.

The EMP lists potential problems and contingency measures for various components of the monitoring program, however specific contingency measures for microbat roost box monitoring have not been provided within the EMP. As such, recommendations proposed in Niche 2016d and their continued relevance, along with additional recommendations proposed after Event 9 and Event 10 are presented in Table 12.

Table 12: Bat roost box recommendations

Recommendation	Action
Preliminary summer and winter inspection of additional structures within the Project with the potential to be used by microbats.	OH2Ku: As an inspection of the structures in the OH2Ku section of the Project was not undertaken in summer 2017, an inspection should be undertaken as soon as possible to determine the use of these structures by target species.
Continued biannual (Year 4 and 6) inspection of additional structures.	The need for continued monitoring should be assessed once additional structures in both OH2Ku and Ku2K have been inspected and monitoring should be implemented prior to the next bat roost box monitoring event (summer 2018). If the additional structures are determined to provide suitable roosting habitat continued monitoring is not required.
Subject to the outcome of the above recommendations, additional corrective actions may be required:	
Relocation of bat roost boxes directly above water.	The need to relocate installed roost boxes will be assessed based on the outcome of the summer/winter 2017 additional structures monitoring.
Provisions of supplementary roosting habitat of different design / material in culverts and bridges	The four boxes that were burnt will be replaced and relocated to suitable underpass structures. The need to provide supplementary habitat in, or modify, culvert and bridge habitat to make it more suitable will be assessed based on the outcome of the summer/winter 2017 additional structures monitoring.
Enhancement of habitat within artificial structures.	The need to enhance culvert and bridge habitat to make it more suitable will be assessed based on the outcome of the summer/winter 2017 additional structures monitoring.

8. Green-thighed Frog breeding ponds

The Green-thighed Frog breeding ponds results for the 2016/2017 monitoring period are detailed in Niche (2017b). This report is included in Annex 7 and key details are summarised below.

8.1 Monitoring framework and timing

Green-thighed Frog monitoring is to be performed in accordance with the EMP and the Green-thighed Frog Management Strategy (Lewis 2013c), with the EMP taking precedence where inconsistencies occur. Construction will involve direct and indirect impacts on known Green-thighed Frog habitat areas, which will prevent post-construction monitoring of these sites. Therefore monitoring will be of purpose-built constructed breeding ponds, as per the EMP.

The EMP states: *"Monitoring will be undertaken on five occasions commencing in Years 3-7 (construction and operation phase). Each monitoring event should be at least 10-12 months apart but ultimately dependant on rainfall events. On each occasion the site would be surveyed for 30 minutes during Stage 1 and for 20 minutes during stage 2 (see section 4.9.3). Four of the five monitoring events are to occur during the operational phase of the Project (Years 4-7). The first round of monitoring (Year 3) is to commence once the vegetation on the edges of the constructed ponds is considered sufficient (>20% groundcover), to be determined by a suitably qualified Ecologist. The timing would be staggered accordingly for either stage of the Upgrade."*

The Green-thighed Frog Management Strategy requires a two-component approach to Green-thighed Frog monitoring:

- Monitoring of breeding ponds, and
- Monitoring the integrity of the frog fences.

The monitoring of frog fencing will be undertaken as part of the fauna fence monitoring (in conjunction with underpass monitoring periods). These results will be included in the reporting for the fauna fence monitoring component of the Project.

The summer 2017 monitoring represents the first of five monitoring events. The current report summarises the methods and results of the summer 2017 monitoring, and discusses if performance measures are being met, as per the EMP.

8.2 Sites monitored

The monitoring sites correspond to the proposed pond locations as required by the EMP and are described in Table 13. The Collombatti site was used as the reference site.

Table 13: Green-thighed Frog survey sites

Site Name (map ID)	Proposed frog pond sites (EMP)
Collombatti Reference (Ref)	As required by Stage 1 surveys: "*Upon the study area receiving the required rainfall, a reference site would be visited to determine the extent of Green-thighed Frog activity"*
1W and 1E	Ch.9050-9350. Five ponds to be constructed on each side of the carriageway (10 in total)
3W	Ch.30660. Five ponds to be constructed on the western side of the carriageway
4W and 4E	Ch.33650. Five ponds to be constructed on each side of the carriageway (10 in total)

8.3 Key results

Stage 1 surveys were undertaken on the 16th March 2017. Green-thighed Frogs were recorded at the Collombatti reference site and at two ponds at Site 3. All ponds at sites 1, 3 and 4E contained 10 – 40 cm of water, while ponds at site 4W were found to contain no water.

Stage 2 surveys were undertaken on the 28th April 2017, 43 days after Stage 1 surveys. No Green-thighed Frogs were recorded. All ponds at Sites 1 and 3 held water and all ponds at Site 4 were dry.

Gambusia (*Gambusia holbrooki*) was identified at the Collombatti reference site and Site 1.

8.4 Conclusions and management implications

Performance indicators of success have not been met for some or all of the constructed pond sites.

Performance indicators of unsuccessful mitigation have been met for some or all of the ponds at each of the constructed pond sites.

Contingency measures and corrective actions provided in the EMP and Green-thighed Frog Management Strategy, respectively, are considered relevant to a number or all ponds at all three monitoring sites. A number of recommendations to meet performance criteria should be considered and include:

- Laying a semi-permeable layer within the ponds to improve water retention.
- Reviewing surrounding drainage.
- Installation of water staffs with graduated water depth indicators.
- Additional surveys in adjacent habitat to assess the continued presence and activity of the Green-thighed Frog in the general area.
- Interim site visits to determine the hydroperiod of the ponds.

9. *Maundia triglochinoides* Habitat Protection

The Maundia habitat protection results for the 2016/2017 monitoring period are detailed in Niche (2017d). This report is included in Annex 8 and key details are summarised below.

9.1 Monitoring framework and timing

The monitoring program specifies that monitoring would commence in the summer of Year 1 (construction phase) and be undertaken three times a year in summer, autumn and spring until Year 4 (operation phase) of the Project. To date, these monitoring events have been reported as follows:

- *Summer and autumn 2015*: Niche 2015d.
- *Spring 2015, summer and autumn 2016*: Niche 2016c.
- *Spring 2016, summer autumn 2017*: Niche 2017d.

The current report summarises the methods and results of the spring 2016 (November 2016), summer 2017 (February 2017) and autumn 2017 (May 2017) monitoring and discusses if performance measures have been met, as per the EMP and represents the third of four necessary reports for Maundia.

9.2 Monitoring sites

Three paired 'impact-control' sites were monitored. Each site includes one Impact location within the Project boundary and one Control location outside the Project boundary (Table 14).

Table 14: Maundia paired 'Impact –Control' monitoring sites

Site	Chainage (Location)	Description	Easting of Impact Plot (MI)	Northing of Impact Plot (MI)	Easting of Control Plot (MC)	Northing of Control Plot (MC)
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

9.3 Key results

Maundia was recorded at two of the impact sites (MI01 and MI02) and only one control site (MC01) during the three monitoring events in 2016/2017. At Site 1, Maundia was consistently present at the impact site, while only recorded during spring at the paired control site. In spring, a substantial difference (over 15%) in flowering was recorded between MC01 (about 90% of plants were flowering) and MI01 (10% of plants flowering). Maundia was also found to be present at Site 2 impact site and not at its paired control site.

Recruitment was observed at both the impact sites where it was recorded (MI01 and MI02).

Flowering was recorded at MI01 and its paired control site MC01 during spring surveys. Flowering individuals were not recorded at MI02.

Although comparison to pre-impact data is not possible, at the three sites where Maundia has been recorded by Niche, MI01, MC01, MC02, the percent cover abundance is relatively consistent across the monitoring periods (Niche 2015d, Niche 2016c, and Niche 2017d).

9.4 Conclusions and management implications

The Maundia performance measures have been mostly met for the 2016/2017 monitoring period. However to fulfil all required aspects of the performance measures, recommendations have been made to verify and replace exclusion fencing, sediment control measures and signage at relevant sites.

The substantial differences recorded between paired impact control sites cannot be directly attributed to the road impact only, but more likely are the result of environmental variables between paired control and impact sites.

It is recommended that verification and replacement of exclusion fencing, sediment control and signage where relevant be undertaken.

It is also advised that on-going management of disturbance impacts be undertaken at the impact sites following recommended guidelines.

10. Landscape Monitoring

The landscaping and revegetation data for the 2016/2017 monitoring period has been provided by two sources: OH2Ku was provided by Lendlease and Ku2K was provided by Roads and Maritime Services. The data are provided in Annex 9. The results are summarised below.

10.1 Monitoring framework and timing

The EMP specifies the timing of the landscaping and revegetation monitoring as follows:

- Monitoring of landscaping would be conducted at 8 months and 12 months. The need for additional monitoring would be determined following analysis of the monitoring data.
- Maintenance of the landscaping and weeds would continue for the duration of the three year maintenance period or until such time as the revegetation is determined successful and is no longer requiring active management to maintain its survival.

To date, landscape and revegetation monitoring events have been reported on as follows:

- *2015/2016 monitoring*: Niche 2016d
- *2016/2017 monitoring*: current report.

Maintenance will continue for all sites for three years or until revegetation is determined successful, as per the EMP. Monitoring is to continue until all sites have undergone a 12 month inspection. Those sites that have not met the performance indicators at the 12 month inspection will be moved into the non-conformance system and, as per the EMP, will be closed out to the satisfaction of Roads and Maritime Services and the Landscape Representative or the Project Ecologist. These sites do not require any further formal monitoring. A final assessment of the success of the revegetation will be made at the end of the maintenance period and the need for further monitoring will be determined.

10.2 Performance measures

The EMP specifies the following performance indicators for landscaping and revegetation:

Indicators of success of landscaping and revegetation include:

- *Each area revegetated by native seeding must achieve the following minimum standards as assessed at 12 months following revegetation:*
  - *One native plant every 6 m^2*
  - *Average minimum height of 15 cm, and*
  - *Native vegetation diversity to be assessed to the satisfaction of the Landscape Representative or the Project Ecologist.*
- *All areas required to be revegetated by native planting must achieve the following minimum standards as assessed at 12 months following revegetation:*
  - *Minimum plant growth of 30 cm following planting.*
  - *Minimum plant survival rate of 80%.*
- *Weed cover is less than 5% per restored area.*

Native planting occurred after July 2016, as such performance indicators relating to revegetation by native planting are not relevant for the 2016/2017 monitoring period. The 12 month inspection of these sites will occur during the 2017/2018 monitoring period.

10.3 Monitoring sites

A total of 168 landscaping and revegetation monitoring sites exist within the Project for both the OH2Ku and Ku2K sections. Of the 168 sites, 50 have either not yet reached the 8 month monitoring point or have not yet been treated. As such, this report considers the 118 sites for which the 8 month, 12 month or both the 8 and 12 month monitoring events occurred within the July 2016 – July 2017 monitoring period. The number of sites at each monitoring stage is provided in Table 15.

Table 15: Landscaping and revegetation monitoring stage

Section (data source)	8 month inspection (also 12 month)	12 month inspection (also 8 month)	Not commenced	Total
OH2Ku (Lendlease)	35 (19)	41 (19)	30	87
Ku2K (McConnell Dowell OHL JV)	35 (28)	54 (28)	20	81
Total	70	95	50	168

10.4 Methods

Monitoring of landscaping would be conducted at 8 months and 12 months.

10.4.1 Data limitations and assumptions

As discussed in Niche 2016d, a number of limitations exist in relation to the landscape monitoring data. These include:

- Data collection was not standardised.
- Parameters identified in the performance measures were not always specified in the data provided.
- Species information was not provided.
- Where information with respect to plant growth, density and distribution was provided the data provided was generally descriptive and does not allow for direct assessment against performance measures.

Roads and Maritime undertook a data extraction that considered both recorded parameters as well as the descriptive records for each site. Based on the data provided, and determined in consultation with Roads and Maritime Services, performance measures were assessed according to the data extracted by Roads and Maritime Services.

10.5 Key results

This report presents results of the 8 and 12 month inspections that occurred during the July 2016 – June 2017 monitoring period. Field data for all sites are provided in Annex 9.

10.5.2 Eight month inspection

A total of 70 sites underwent an 8 month inspection during the current monitoring period. Inspection results are provided in Table 16 and Table 17. Forty-seven of these sites also underwent a 12 month inspection, of which 14 (30%, highlighted) were found to meet all 12 month minimum requirements. Twelve month monitoring results for the remaining sites will be reported on in the 2017/2018 annual report.

Table 16: Landscaping and revegetation data – 8 month only inspection OH2Ku

Location	Inspection date	8 month inspection comments	12 month criteria met
Cut 1	Nov-16	No native strike	N
Fill 1	Nov-16	No native strike	N
Cut 2A	Oct-16	Low native strike	Y
Cut 2B	Oct-16	Low native strike	Y
Fill 2	Jun-17	Poor native strike, cover crop has died off. Well aided with native planting	NA
Fill 3	Jan-17	Minimal strike of natives. Dry conditions limiting growth. Batters stable from cover crop mix. Possible re-work / re-spray required	Y
Cut 4	Jun-17	Minimal native strike. Dryer conditions limiting growth. Batters stable. Re-spray / planting required	NA
Fill 4	Mar-17	Minimal strike of natives. Batters stable from cover crop mix. May require weed spraying	NA
Fill 5	Jun-17	Minimal native strike. Batters stable from cover crop. Weed spraying required.	NA
Fill 5	Mar-17	Finishing works to be completed before hydromulching to be re-sprayed. Cover crop keeping batters stable with minimal natives	NA
Fill 5	Apr-17	To be restarted once topsoiled and sprayed	NA
Fill 5	Apr-17	To be restarted once topsoiled and sprayed	NA
Fill 6	Apr-17	Some natives present. Weed treatment required.	NA
Blackmans Point Road	Dec-16	Good cover crop strike	Y
Cut 10	Jul-16	Cover crop strike poor (mon done in Sept-16)	N
Fill 10	Aug-16	Poor. To be reworked after verge placement (mon done Sept-16)	N
Cut 11	Jul-16	Good native distribution, should achieve target (mon. done Sept-16)	Y
Cut 12	Jul-16	Good cover crop strike. No natives. Has now been reworked (mon. done in Sept-16)	N
Cut 12	Jun-17	Natives evident with good size	NA
Fill 12	Jul-16	Patchy cover crop with strong native emergence. Good native strike early (mon. done in Sept-16)	Y
Fill 12	Jul-16	Good native strike in some areas. Batter chutes and stockpile still to be sprayed (mon. done in Sept-16)	Y
Fill 13	Aug-16	Pasture grass well established (mon. done in Sept-16)	Y
Fill 13	Mar-17	Pasture Grass strike is good.	NA
Fill 13	Mar-17	Good strike. Weed treatment required	NA
Fill 13	Jun-17	Good cover crop. Poor native strike. Rework once permanent works completed.	NA
Fill 13	Jun-17	Good cover crop, poor native strike. Stockpile placed on top of reveg. Restart monitoring once area has been reworked.	NA
Cut 18	Jan-17	Poor. Mainly grass cover. Limited growth due to dryer conditions. Possible rework/ spraying required.	N
Fill 18	Jun-17	Poor. Mainly grass cover. Weed treatment required	NA
Cut 19A	Aug-16	Good at top and poorer for resprayed area. Some weeds have been sprayed in re-hydromulched section (mon. done in Sept-16)	N
Cut19B	Jun-17	Dominated by long grass, scattered natives on edges. Has improved since last inspection with more maturing natives.	NA
Cut 20	Aug-16	Good strike at top. Poor strike at bottom. No natives. Selectively re-scarify and hydromulch lower section where 100% bare. High weeds on bottom of batter but not noxious so no need for spraying (mon. done Sept-16)	N
Cut 21	Aug-16	Good cover crop. No natives (mon. done Sept-16)	N
Fill 22	Jun-17	Good native diversity, good density in some areas.	NA
Fill 23	Feb-17	Poor/ minimal native growth. However cover crop providing stability (mon. done in Mar-17)	Y
Fill 23	Nov-16	Good cover crop. No natives.	N

NB = northbound, SB = southbound, NA = not applicable as 12 month inspection date not reached.

Table 17: Landscaping and revegetation – 8 month inspection data Ku2k

Location	Inspection Date	8 month inspection comments	12 month criteria met
Cut 3	May-17	Weed growth out pacing native regrowth in and around rest area. Manage weeds and monitor	NA
Cut 3	Feb-17	Poor native growth and ground cover	N
Fill 9	Sep-16	Limited growth on batter, requires rework and respray. Note, signs of invasive grasses likely to be issue on batter.	N
Fill 10	Dec-16	Good ground cover but poor native growth	N
Fill 10	Sep-16	Good ground cover but poor native growth	N
Cut 10	Oct-16	High weeds and poor growth	N
Cut 10	Apr-17	Quantity, variety and condition meets standard.	NA
Cut 10	Oct-16	Good ground cover but poor native growth. Resprayed Oct-16 with frangible mix following RMS landscape advice	N
Site 16	Dec-16	Good ground cover but poor native growth	**Y**
Site 2	Oct-16	Poor ground cover and natives	N
Fill 11	Jul-16	Bottom of batter progressing well. Continue to monitor for top of batter and potential weeds / invasive grasses. High soil compaction issues.	N
Fill 11	Jul-16	Bottom of batter progressing well. Continue to monitor for top of batter and potential weeds / invasive grasses. High soil compaction issues.	N
Site 10	Jun-17	Good ground cover and low weeds	NA
Site 5B	Jun-17	Good ground cover and low weeds	NA
Fill 14	Nov-16	Good ground cover	**Y**
Cut 14	Nov-16	Good ground cover	**Y**
Fill 15	Nov-16	Good ground cover	**Y**
Cut 15	Sep-16	Good ground cover and low weeds	**Y**
Fill 16	Dec-16	Good ground cover and low weeds	N
Cut 16	Nov-16	Good ground cover and low weeds. Re-hydromulched Sept-16.	N
Fill 17	Jan-17	Good ground cover and low weeds	N
Cut 17	Aug-16	Good ground cover. Topsoil high clay content	N
Fill 18	Jul-16	Batter part sprayed Nov-15 and part sprayed Dec-15. Good progression with low weeds	N
Fill 18	Feb-17	Poor cover crop strike	N
Cut 19	May-17	Poor cover crop strike. Hydroseed application April 2017 with additional cover crop, natives and 25L/Ha liquid lime.	NA
Cut 20	Aug-16	Batter track rolled in wrong direction leaving vertical cleat marks. Limited native strike but good cover crop	N
Cut 20	Apr-17	Good ground cover and low weeds	NA
Cut 20	May-17	Section of batter topsoiled with weedy topsoil. Monitor and suppress weeds as required. Hydroseed application April 2017 with additional cover crop, natives and 25L/Ha liquid lime.	NA
Fill 21	Nov-16	Good ground cover. Additional areas sprayed Oct-16	N
Fill 21	Dec-16	Poor cover crop strike	N
Cut 21	Aug-16	Limited native strike, although good cover crop and low weeds	N
Cut 21	Aug-16	Progressing well with good variation of natives. Continue to monitor to ensure height of natives reaches standard.	N
Fill 22	Dec-16	Part spray April -16, Jan-16. Poor strike	N
Fill 22	Jul-16	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.	N
Fill 23	Dec-16	Good ground cover. Additional area sprayed Dec-16	N

NB = northbound, SB = southbound, NA = not applicable as 12 month inspection date not reached.

10.5.3 Twelve month inspection

Twelve month inspection results are provided in Table 18 and Table 19. A total of 95 sites underwent a twelve month inspection during the current monitoring period. Of these sites, five were resprayed or reworked, as such, monitoring for these sites is to recommence and they have been excluded from calculations.

Of the 90 sites, 30 (33%, highlighted and in bold) were found to fulfil all performance indicators of success.

Of those that did not achieve minimum requirements for all performance indicators, 38 (42%) achieved some minimum requirements but not all, and the remaining 22 (24%) did not meet any of the performance indicators. Table 20 shows the results for each of the performance indicators. A weed cover of < 5% was achieved most frequently at 66% of sites, while average minimum height of 15 cm was achieved at 33% of sites. Note that as all monitored sites were treated with hydroseed/hydromulch/woodfibre, only the performance indicators relating to revegetation by native seeding have been considered.

Table 18: Landscaping and revegetation – 12 month inspection data OH2Ku.

Location	Inspection date	12 month performance criteria					12 month inspection comments
		W	De	H	Di	O	
Cut 1	Mar-17	N	N	N	N	N	No native strike & requires weed spraying
Fill 1	Mar-17	N	N	N	N	N	No native strike & requires weed spraying
Cut 2A	Feb-17	Y	Y	Y	Y	**Y**	Poor native strike but still meets 12 month criteria. Batter stable (mon. done Mar-17)
Cut 2B	Feb-17	Y	Y	Y	Y	**Y**	Poor native strike but still meets 12 month criteria. Batter stable (mon. done Mar-17)
Fill 3	May-17	Y	Y	Y	Y	**Y**	Minimal strike of natives however still meets 12 month criteria. Dry conditions limiting growth. Batters stable.
Cut 5	Sep-16	Y	Y	Y	Y	**Y**	Good, lots of diversity with average heights of natives between 30-60cm.
Cut 6	Jul-16	N	N	N	N	N	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 (mon. done Sept-16)
Cut 6	Jul-16	N	N	N	N	N	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 (mon. done Sept-16)
Fill 6	Jul-16					NA	Reworked Aug 16. No topsoil or respray as yet. Mon. to be restarted
Cut 7	Jul-16	Y	Y	Y	Y	**Y**	Good - height 60 - 70cm. Minimal weeds. Good diversity (mon. done Sept-16)
Cut 7	Jul-16	Y	Y	Y	Y	**Y**	Good - height 60 - 70cm. Minimal weeds. Good diversity (mon. done Sept-16)
Fill 7	Jul-16	N	Y	N	Y	N	Some natives popping up. Top half re-sprayed after verge placement. Continued monitoring to determine whether this meets requirements (mon. done Sept-16).
Cut 8	Jul-16	Y	Y	Y	Y	**Y**	Good native diversity (mon. done Sept-16).
Cut 8	Jul-16	Y	Y	Y	Y	**Y**	Good native diversity, a few weeds but not too bad (mon. done Sept-16).
B0778L	Sep-16	Y	Y	Y	Y	**Y**	Good native diversity, a few weeds but not too bad.
Cut 9	Sep-16	Y	Y	N	N	N	No natives but stable batter. Oversow with frangible shrub hydroseed.
Cut 9	Sep-16	Y	Y	Y	Y	**Y**	Good native diversity with both grasses and shrubs. Oversow with hydroseed with northern end.
Blackmans Pt I/change	Sep-16					NA	Most sections will require rework post verge etc. in finishing. Restart 8 months. Mon. to be restarted
Blackmans Point Road	Apr-17	Y	Y	Y	Y	**Y**	Good strike and diversity of natives.
Cut 10	Nov-16	Y	Y	Y	N	N	Poor cover (still one every 6m2), although difficult with native grasses

Fill 10	Dec-16	N	N	N	N	N	Poor cover, requires rework / respray
Cut 11	Nov-16	Y	Y	Y	Y	**Y**	Good native distribution
Cut 11	Sep-16	Y	Y/ N	Y/ N	Y/ N	N	Good diversity in top half of batter. Will get better over time. Patchy. Y - top half of batter, N - lower part of batter (hydromulched later)
Cut 11	Sep-16					NA	Good cover crop with some natives. Monitoring to be re-started as more material added which is yet to be re-sprayed.
Cut 12	Nov-16					NA	Has been reworked. Restart monitoring following hydromulching. June-16 inspection indicates that this batter would meet criteria.
Fill 12	Nov-16	Y	Y	Y	Y	**Y**	Good native strike early
Fill 12	Nov-16	Y	Y	Y	Y	**Y**	Good native strike in some areas.
Cut 13	Sep-16	Y/ N	Y/ N	Y/ N	Y/ N	N	Good at north end, respray south end. Y - north end, N - south end
Fill 13	Dec-16	Y	Y	Y	Y	**Y**	Grass well established.
Fill 13	Aug-16					NA	No native strike. Whole area has been reworked. Restart monitoring when resprayed (monitoring done in Sept-16).
Fill 14	Sep-16	Y	N	N	N	N	Poor. Monitoring to restart after tyne / respray. Jun-17 monitoring indicates good cover crop strike.
Fill 16	Sep-16	Y	N	N	N	N	Dominated by pasture grasses, no native visible. Very stable batter. Consider changing requirement to pasture grass due to surrounding landscape being dominated by pasture grass.
Cut 18	May-17	N	N	N	N	N	Poor. Mainly grass cover. Limited growth due to dryer conditions. Weed treatment required.
Cut 19A	Dec-16	N	Y	N	N	N	Good at top and poorer for resprayed area. Some weeds have been sprayed in re-hydromulched section.
Cut 20	Dec-16	N	N	N	N	N	Good strike at top but poor at bottom. Selectively re-scarify and hydromulch lower section where 100% bare. High weeds on bottom of batter but not noxious so no need for spraying.
Cut 21	Dec-16	N	N	N	N	N	Top 2/3 of the batter to be worked upon the removal of topsoil stockpile. Bottom 1/3 to be sprayed if required.
Cut 23	Sep-16	Y	N	N	Y	N	Some native strike & more scattered natives emerging. Jun-17 inspection indicates that this now meets 12-month criteria.
Fill 23	Jun-17	Y	Y	Y	Y	**Y**	Majority meets 12 month requirements. Minor weed spraying required
Fill 23	Mar-17	N	Y	N	N	N	Poor/ minimal native growth. Cover crop providing stability.
Cut 24	Sep-16	Y	Y	Y	Y	**Y**	Good native strike.
Fill 24	Sep-16	Y	Y	Y	Y	**Y**	Some native strike.

NB = northbound, SB = southbound, T = treatment, HW = Hydromulch Woodfibre, W = Weed cover, De = native plant every 6 m^2, H = average height >15 cm, Di = diversity, O = overall, NA = not applicable as monitoring to be restarted.

Table 19: Landscaping and revegetation –12 month inspection data Ku2K.

Location	Inspection date	12 month inspection criteria					12 month inspection comments
		W	De	H	Di	O	
Fill 1	Aug-16	Y	N	N	N	N	Large areas of native grass seed mix on batters not striking - continue to monitor
Fill 2	Aug-16	Y	N	N	N	N	Large areas of native grass seed mix on batters not striking - continue to monitor
Cut 3	Sep-16	Y	Y	N	Y	N	Progressing well with good variation of natives. Continue to monitor to ensure height of natives reaches standard.
Cut 3	Sep-16	Y	N	N	N	N	Batter stripped and hydromulch reapplied (jun-17 inspection indicates all 12-month requirements except height have now been met)

Cut 3	Jun-17	N	N	N	N	N	Weed growth out pacing native regrowth in and around rest area. Weed management required (native grass seed mix)
Fill 4	Jul-16	Y	Y	N	N	N	High clay content in topsoil resulting in compact hard surface. Areas Resprayed July 2016 (Jul-17 inspection indicates that this area now meets all 12-month requirements)
Fill 4	Sep-16	Y	Y	Y	Y	**Y**	Good strike of natives on lower fill levels. Continue to monitor upper fill levels resprayed following verge works.
Fill 5	Sep-16	Y	Y	Y	Y	**Y**	Good strike of natives on lower fill levels. Continue to monitor upper fill levels resprayed following verge works.
Fill 5	Sep-16	Y	N	N	N	N	Continue to monitor following respray
Cut 5	Jul-16	Y	Y	N	Y	**Y^**	Progressing well with good variation of natives. Continue to monitor to ensure height of natives reaches standard (Jun-17 inspection indicates that height now meets requirements)
Fill 6	Sep-16	Y	Y	N	N	N	Strike of natives could be better. Continue to monitor (Jun-17 inspection indicates all 12-month requirements have now been met)
Cut 6	Jul-16	Y	Y	Y	Y	**Y**	Progressing well - meets specified standard for native height and species diversity.
Fill 7	Oct-16	Y	Y	N	N	N	Slightly down on coverage numbers. Continue to monitor (Jun-17 inspection indicates all 12-month requirements have now been met)
Cut 7	Sep-16	N	Y	N	N	N	Coverage poor. Continue to monitor but respray may be required.
Fill 8	Oct-16	Y	Y	N	N	N	Bottom section of batter sprayed Oct15. Top Hydromulched July 2016. Continue to monitor following hydromulch of upper batters (Jun-17 inspection indicates all 12-month requirements have now been met)
Cut 8	Oct-16	Y	Y	N	Y	**Y^**	Progressing well with good variation of natives. Continue to monitor to ensure height of natives reaches standard (Jun-17 inspection indicates that height now meets requirements)
Fill 9	Aug-16	N	N	N	N	N	Invasive grass species dominant, weed control unlikely to be effective given proximity of neighbouring paddock. Propose to leave 'as is'.
Fill 9	Jan-17	N	N	N	N	N	Invasive grass species dominant, weed control unlikely to be effective given proximity of neighbouring paddock. Propose to leave 'as is'.
Fill 10	Apr-17	N	Y	N	N	N	Invasive grass species dominant in patches, weed control unlikely to be effective given proximity of neighbouring paddock. Propose to leave 'as is'.
Fill 10	Jan-17	N	Y	N	N	N	Progressing - continue to monitor
Cut 10	Feb-17	N	N	N	N	N	Mulch ratio in topsoil to high. Resprayed Oct-16 with frangible mix (was pasture grass) following RMS landscape advice. Continue to monitor following re-spray
Cut 10	Feb-17	N	N	N	N	N	Resprayed Oct-16 with frangible mix (was pasture grass) following RMS landscape advice. Continue to monitor following re-spray
Site 16	Apr-17	Y	Y	Y	Y	**Y**	Majority of stockpile is good, some large bare patches to monitor.
Site 2	Feb-17	N	N	N	N	N	Pasture grass mix.
Fill 11	Nov-16	N	Y	N	N	N	Bottom of batter progressing well. Continue to monitor for top of batter and potential weeds / invasive grasses.
Fill 11	Nov-16	N	Y	Y	N	N	Bottom of batter progressing well. Continue to monitor for top of batter and potential weeds / invasive grasses.
Cut 11	Sep-16	Y	Y	Y	Y	**Y**	Progressing well - meets specified standard for native height and species diversity.
Fill 12	Oct-16	Y	Y	N	Y	N	Additional areas sprayed Oct-16. Progressing well - continue to monitor
Cut 12	Oct-16	N	N	N	N	N	Topsoil application thin and compacted. Limited native strike - continue to monitor following herbicide application April 2016 to control weeds.
Fill 13	Sep-16	N	N	N	N	N	Area along drain sprayed Sept-15 remainder sprayed Dec-2015. Issues with topsoil compaction. Monitor weeds and invasive grasses.
Cut 13	Oct-16	Y	Y	N	N	N	Good ground cover. Continue to monitor following herbicide application to control weeds.
Fill 14	Mar-17	Y	Y	Y	Y	**Y**	Good ground cover (pasture grass mix).

Cut 14	Mar-17	Y	Y	Y	Y	**Y**	Good ground cover (pasture grass mix).
Fill 15	Mar-17	Y	Y	Y	Y	**Y**	Good ground cover (pasture grass mix).
Cut 15	Jan-17	Y	Y	Y	Y	**Y**	Good ground cover & low weeds (pasture grass & native grass mix).
Fill 16	Apr-17	Y	N	N	N	N	Good ground cover & low weeds, however also low natives (native grass mix).
Cut 16	Mar-17	Y	N	N	N	N	Cut face had hydroseed (cover crop and natives +lime) applied Dec-16. Area above cut and around state forest access track only hydromulched Sept-16.
Fill 17	May-17	Y	N	N	N	N	Good ground cover, low natives.
Cut 17	Dec-16	Y	N	N	N	N	Good ground cover, low natives. Topsoil high clay content that settled in cleat marks following rain.
Fill 18	Nov-16	Y	Y	N	N	N	Batter part sprayed Nov-15 and part sprayed Dec-15. Good progression - continue to monitor.
Fill 18	Jun-17	Y	N	N	N	N	Poor cover crop and native strike
Cut 18	Sep-16	N	N	N	N	N	Limited native strike - implement watering regime and continue to monitor. Hydromulch coverage not to standard. Southern end of cut hydromulched Mar-16 (resprayed again in Oct-16)
Cut 18	Sep-16	N	N	N	N	N	Limited native strike - implement watering regime and continue to monitor. Rilling repaired and catch drain installed at top of cut.
Fill 20	Sep-16	N	N	N	N	N	Areas sprayed Oct 2015 progressing well. Area sprayed Sept 2015 requires further monitoring to ensure native strike. May have been weedy topsoil.
Fill 20	Sep-16	Y	Y	Y	Y	**Y**	Areas sprayed Oct 2015 progressing well. Area sprayed Sept and December 2015 requires further monitoring to ensure native strike (Jun-17 inspection indicates all 12-month requirements have now been met)
Cut 20	Sep-16	Y	Y	N	N	N	Good ground cover & low weeds, however also low natives. Batter track rolled in wrong direction leaving vertical cleat marks
Cut 20	Dec-16	Y	N	N	N	N	Good ground cover & low weeds, however also low natives. Batter track rolled in wrong direction leaving vertical cleat marks
Fill 21	Mar-17	Y	N	N	N	N	Additional areas sprayed Oct-16
Fill 21	Apr-17	Y	N	N	N	N	Hydroseed application April 2017 with additional cover crop, natives and 25L/Ha liquid lime.
Cut 21	Dec-16	Y	N	N	N	N	Good cover crop, but limited native strike - continue to monitor (Jun-17 monitoring indicates that this batter meets all 12-month criteria except height).
Cut 21	Dec-16	Y	Y	N	Y	N	Progressing well with good variation of natives. Continue to monitor to ensure height of natives reaches standard.
Fill 22	Apr-17	N	N	N	N	N	Part spray April -16, Jan-16. Low cover crop and natives.
Fill 22	Nov-16	N	N	N	N	N	Good cover crop. 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.
Fill 23	Apr-17	N	N	N	N	N	Additional area sprayed Dec-16. Monitor again in Dec-17.

NB = northbound, SB = southbound, T = treatment, HW = Hydromulch Woodfibre, W = Weed cover, De = native plant every 6 m^2, H = average height >15 cm, Di = diversity, O = overall, ^ = June 17 monitoring confirms height requirement met.

Table 20: Landscaping and revegetation performance indicator results

Performance indicator	Number of 12 month inspection sites where indicator met	Percentage of 12 month assessed sites (n = 90)
One native plant every 6 m2	50	56%
Average minimum height of 15 cm	30	33%
Native vegetation diversity	35	39%
Weed cover <5%	59	66%

10.6 Discussion

A summary of the 2016/2017 monitoring results in relation to the performance measures is provided in Table 21. Note that as native planting occurred after July 2016 the performance indicators relating to revegetation by native planting are not relevant for the 2016/2017 monitoring period.

Of the 168 monitoring locations, 90 of these have undergone a 12 month assessment. As such, only these 90 locations have been considered below in relation to the performance measures, as required by the EMP.

Table 21: Landscaping and revegetation performance measures

Performance indicators of success	Discussion
Each area revegetated by native seeding must achieve the following minimum standards as assessed at 12 months following revegetation:	
One native plant every 6 m^2	**This performance indicator has been met for 50 sites.** This represents 56% of the sites that have reached the 12 month inspection event.
Average minimum height of 15 cm	**This performance indicator has been met for 30 sites.** This represents 33% of the sites that have reached the 12 month inspection event.
Native vegetation diversity to be assessed to the satisfaction of the Landscape Representative or the Project Ecologist	**This performance indicator has been met for 35 sites.** This represents 39% of the sites that have reached the 12 month inspection event.
Weed cover is less than 5% per restored area.	**This performance indicator has been met for 59 sites.** This represents 66% of the sites that have reached the 12 month inspection event.
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.	These performance indicators are not yet relevant as 12 month inspection dates for native planting sites have not yet been reached.
Minimum plant survival rate of 80%.	
Weed cover is less than 5% per restored area.	

10.7 Recommendations

The EMP lists potential problems and contingency measures for various components of the monitoring program, however specific contingency measures for landscaping and revegetation monitoring have not been provided within the EMP. However, the EMP states:

"Maintenance of the landscaping and weeds would continue for the duration of the three year maintenance period as outlined in Section 6 or until such time as the revegetation is determined successful and is no longer requiring active management to maintain its survival." And*, "If these performance indicators are not achieved a non-conformance would be raised, to be closed out to the satisfaction of Roads and Maritime, and the Landscape Representative or the Project Ecologist."*

Of the 90 sites that underwent a twelve month assessment, 60 did not meet the performance indicators. Although formal monitoring is no longer required at these sites, it is recommended that monitoring should continue while monitoring of other sites is ongoing, and all actions deemed appropriate, such as herbicide treatment, respraying or reworking, should be undertaken. This may result in more sites reaching minimum standards, as growth and density may improve with time. A complete assessment of landscaping and revegetation works should be undertaken once all sites have undergone a twelve month assessment, as per the EMP.

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Annex 1. Koala monitoring 2016/2017 (Niche 2017c)

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Environment and Heritage

Koala Monitoring 2016

Year 2 Surveys – Oxley Highway to Kempsey, Pacific Highway Upgrade

Prepared for Roads and Maritime Services

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Cover photograph: Koala from unrelated project on Liverpool Plains (Photo: Matthew Stanton)

Executive Summary

Context

This report documents findings from the spring-summer 2016 monitoring period for the Koala, as required for the Oxley Highway to Kempsey (OH2K) Pacific Highway upgrade project (the Project).

Aims

The aim of the Koala monitoring program is to determine whether the Project is having an impact on Koala populations 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 the Oxley Highway to Kempsey Pacific Highway Upgrade Ecological Monitoring Program (EMP, RMS 2016). Surveys were undertaken in November and December 2016.

Key results

A total of 82 plots across 27 sites were surveyed in spring-summer 2016. Koalas were found to be present within 10 of the 27 sites surveyed (37%) and the mean activity level (measured as the number of scats within plots) across the sites was 0.7% (SD = 1.1%). The distribution and activity level of Koalas recorded during the current survey is lower than for the previous two rounds of survey (baseline and 2015) and results indicate a decline in the presence and activity of Koalas across the Project area and in surrounding areas within control sites.

Koalas were recorded more frequently at impact sites (42%) than at control sites (33%), which is consistent with results observed in the previous two monitoring events. There was no significant difference between Koala presence at control and impact sites which is also consistent with the 2015 result.

Surveyed trees included 32 tree species, of which Koala scats were recorded at seven (22%). The tree species Koala scats were most commonly recorded beneath were Tallowwood (*Eucalyptus microcorys*) and Small-fruited Grey Gum (*E. propinqua*), which together comprised 30% of all surveyed tree species. Tree species use was not dissimilar to that recorded in the baseline or 2015 monitoring events.

Conclusions

Koala presence and activity levels appear to have decreased between the baseline, 2015 and 2016 monitoring events, but for both control and impact sites. In each of the surveys undertaken to date, impact sites recorded higher percentages of Koala presence than control sites. For this reason any decrease in Koala presence/activity cannot currently be directly or solely attributed to disturbance due to the Project.

It is also likely that Koala distribution/abundance would have been affected by the wildfire that occurred across the northern parts of the Project prior to the surveys in spring 2016. Continued monitoring data will assist in determining if the results reflect broader trends in population dynamics.

SAT plots provide data in compliance with the requirement of measuring Koala distribution, habitat use and activity levels, but do not provide any 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 against which the performance measure relating to this variable may be effectively assessed.

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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). The Ecological Monitoring Program (hereafter referred to as the EMP) (RMS 2016) combines these approval conditions and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project. The Koala was identified as requiring mitigation and monitoring during the Project's construction and post construction periods.

1.1.1 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.

1.1.2 Monitoring Framework

The design, methods and performance indicators that define the Koala monitoring program are specified in the EMP. The monitoring program specifies that monitoring of all sites 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.

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

- *Spring-summer 2015*: Niche 2016.
- *Spring- summer 2016*: current report.

This report therefore represents the second of three necessary construction monitoring reports for the Koala. The final construction surveys will be undertaken in spring-summer 2017 and be the subject of the final report for construction monitoring for the Koala. Operational monitoring is projected to commence in spring-summer 2018.

1.1.3 Baseline Data

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

1.1.4 Purpose of this Report

This report details the findings obtained from the 2016 monitoring period, following on from the baseline surveys and 2015 surveys. This 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-summer 2016 monitoring, and to compare the results with the baseline surveys to determine whether performance measures are being met and comment on whether additional measures should be considered.

1.2 Performance measures

The approved EMP specifies the following performance measures for the Koala (RMS 2016):

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

1.3 Monitoring timing

Monitoring is to occur once a year during spring-summer.

1.4 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 Environment and the NSW Environment Protection Authority (EPA).

2. Survey Methodology

2.1 Monitoring design

Surveys were undertaken in November and December 2016. 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 three kilometres, and often 5-10 km from the Project.

These eight broad areas include South Sancrox, North Sancrox, Cairncross State Forest (South), Cairncross State Forest (North), Cooperabung Hill, Mingaletta Road to Smiths Creek, Kundabung Road to North of Pipers Creek and Maria River State Forest.

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 sites (mitigated and not mitigated) and control sites, an additional 24 control plots were established during the first monitoring event in 2015 (Niche 2016). In accordance with the baseline monitoring design these additional 24 control sites were established at least three kilometres from the project and they were grouped in clusters of three plots, one cluster for each of the eight broad areas.

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

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

Table 1: 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
	Impact	No Mitigation	Baseline	2 Sancrox East - Cassegrains	483455	6521789
	Impact	No Mitigation	Baseline	3 Sancrox East - Cassegrains	483412	6521882
	Impact	Mitigation	Baseline_Niche relocation	1 Sancrox South	483299	6520671
	Impact	Mitigation	Baseline_Niche relocation	2 Sancrox South	483254	6520383
	Impact	Mitigation	Baseline_Niche relocation	3 Sancrox South	483196	6520217

Monitoring Area	Treatment	Treatment sub category	Data Source	Site Name	Easting	Northing
	Control	Control	Baseline	1 Cowarra State Forest	480608	6519056
	Control	Control	Baseline	2 Cowarra State Forest	480658	6519496
	Control	Control	Baseline	3 Cowarra State Forest	481305	6519136
	Control	New Control	Niche	COWARRA NC1	479706	6518522
	Control	New Control	Niche	COWARRA NC2	479788	6517922
	Control	New Control	Niche	SAT COWARRA NC3	479795	6518227
North Sancrox	Impact*	No Mitigation	Baseline	1 Sancrox North - Expressway Spares	483042	6521731
	Impact*	No Mitigation	Baseline	2 Sancrox North - Expressway Spares	482869	6521683
	Impact*	No Mitigation	Baseline	3 Sancrox North - Expressway Spares	482999	6521818
	Impact	Mitigation	Baseline	1 Fernbank Creek	483101	6523362
	Impact	Mitigation	Baseline	2 Fernbank Creek	483032	6523223
	Impact	Mitigation	Baseline	3 Fernbank Creek	483056	6523123
	Control	Control	Baseline	1 Lake Innes	488124	6518469
	Control	Control	Baseline	2 Lake Innes	488047	6518398
	Control	Control	Baseline	3 Lake Innes	488228	6518390
	Control	New Control	Niche	COWARRA NC3 -SAT COW4	479674	6516436
	Control	New Control	Niche	SAT COW5	479704	6516174
	Control	New Control	Niche	SAT COW6	479667	6515913
Cairncross State Forest (South)	Impact	No Mitigation	Baseline	1 Cairncross State Forest (South)	482428	6526536
	Impact	No Mitigation	Baseline	2 Cairncross State Forest (South)	482385	6526644
	Impact	No Mitigation	Baseline	3 Cairncross State Forest (South)	482393	6526416
	Impact	No Mitigation	Baseline	16 Cairncross State Forest (south)	481655	6527256
	Impact	No Mitigation	Baseline	17 Cairncross State Forest (south)	481590	6527316
	Impact	No Mitigation	Baseline	18 Cairncross State Forest (south)	481637	6527175
	Impact	Mitigation	Baseline	4 Cairncross State Forest (South)	482249	6525930
	Impact	Mitigation	Baseline	5 Cairncross State Forest (South)	482125	6526077

Monitoring Area	Treatment	Treatment sub category	Data Source	Site Name	Easting	Northing
	Impact	Mitigation	Baseline	6 Cairncross State Forest (South)	482488	6526226
	Control	Control	Baseline	1 Limeburners Creek ""The Hatch""	487011	6529909
	Control	Control	Baseline	2 Limeburners Creek ""The Hatch""	487014	6529455
	Control	Control	Baseline	3 Limeburners Creek ""The Hatch""	487035	6528694
	Control	New Control	Niche	SAT PEVI1	476817	6528422
	Control	New Control	Niche	SAT PEVI2	476730	6528225
	Control	New Control	Niche	Cairncross NC1	475996	6528211
Cairncross State Forest (north)	Impact	No Mitigation	Baseline_Niche relocation	7 Cairncross State Forest (North)	481346	6530835
	Impact	No Mitigation	Baseline	8 Cairncross State Forest (North)	481695	6530786
	Impact	No Mitigation	Baseline	9 Cairncross State Forest (North)	481184	6530864
	Impact	Mitigation	Baseline	10 Cairncross State Forest (north)	481238	6530264
	Impact	Mitigation	Baseline	11 Cairncross State Forest (north)	481173	6530319
	Impact	Mitigation	Baseline	12Cairncross State Forest (north)	481438	6530335
	Control	Control	Baseline	13 Cairncross State Forest (Pembrooke)	473751	6528881
	Control	Control	Baseline	14 Cairncross State Forest (Pembrooke)	473464	6528969
	Control	Control	Baseline	15 Cairncross State Forest (Pembrooke)	473424	6529115
	Control	New Control	Niche	SAT RR1	475284	6532709
	Control	New Control	Niche	SAT RR2	475113	6532603
	Control	New Control	Niche	SAT RR3	474816	6532732
Cooperabung Hill	Impact	No Mitigation	Baseline	1 Cooperabung	482793	6537012
	Impact	No Mitigation	Baseline	2 Cooperabung	482755	6537093
	Impact	No Mitigation	Baseline	3 Cooperabung	482876	6537115
	Impact	Mitigation	Baseline_Niche relocation	4 Cooperabung	482481	6539327
	Impact	Mitigation	Baseline_Niche relocation	5 Cooperabung	482364	6539761
	Impact	Mitigation	Baseline	6 Cooperabung	482364	6538610

Monitoring Area	Treatment	Treatment sub category	Data Source	Site Name	Easting	Northing
	Control	Control	Baseline	1 Cooperabung Hill (Gum Scrub)	475489	6541854
	Control	Control	Baseline	2 Cooperabung Hill (Gum Scrub)	475570	6541903
	Control	Control	Baseline	3 Cooperabung Hill (Gum Scrub)	475838	6541962
	Control	New Control	Niche	SAT FL1	473693	6542127
	Control	New Control	Niche	SAT ST1	473346	6543256
	Control	New Control	Niche	SAT ST2	473682	6542890
Mingaletta to Smiths Creek	Impact	Mitigation	Baseline	1 Mingaletta-Smiths Creek	483304	6543632
	Impact	Mitigation	Baseline	2 Mingaletta-Smiths Creek	483444	6543585
	Impact	Mitigation	Baseline	3 Mingaletta-Smiths Creek	483100	6543670
	Control	Control	Baseline	1 Ballengara State Forest (Gregs Road)	477750	6543274
	Control	Control	Baseline	2 Ballengara State Forest (Gregs Road)	477644	6543623
	Control	Control	Baseline	3 Ballengara State Forest (Gregs Road)	477551	6543709
	Control	New Control	Niche	SAT BR1	477010	6544693
	Control	New Control	Niche	SAT BR2	476890	6544832
	Control	New Control	Niche	SAT BR3	476777	6544973
Kundabung Road to North of Pipers Creek	Impact	No Mitigation	Baseline	1 Kundabung	483095	6549036
	Impact	No Mitigation	Baseline	2 Kundabung	482873	6549112
	Impact	No Mitigation	Baseline	3 Kundabung	483285	6549374
	Impact	Mitigation	Baseline	4 Kundabung	483369	6550655
	Impact	Mitigation	Baseline	5 Kundabung	483331	6550938
	Impact	Mitigation	Baseline	6 Kundabung	483083	6550608
	Control	Control	Baseline	1 Kumbatine National Park	476044	6549609
	Control	Control	Baseline	2 Kumbatine National Park	476165	6549738
	Control	Control	Baseline	3 Kumbatine National Park	475889	6549468
	Control	New Control	Niche	SAT MAC1	476538	6552784
	Control	New Control	Niche	SAT MAC2	476558	6552361
	Control	New Control	Niche	SAT MAC3	476481	6552612

Monitoring Area	Treatment	Treatment sub category	Data Source	Site Name	Easting	Northing
Maria River State Forest	Impact	Part Mitigation	Baseline_Niche relocation	1 Maria River	483074	6554460
	Impact	Part Mitigation	Baseline	2 Maria River	482836	6554330
	Impact	Part Mitigation	Baseline_Niche relocation	3 Maria River	482993	6554024
	Impact	Mitigation	Baseline	4 Maria River	482886	6552623
	Impact	Mitigation	Baseline	5 Maria River	482754	6552462
	Impact	Mitigation	Baseline	6 Maria River	483135	6552449
	Control	Control	Baseline	1 Maria River National Park	486965	6554366
	Control	Control	Baseline	2 Maria River National Park	486971	6554479
	Control	Control	Baseline	3 Maria River National Park	487004	6554203
	Control	New Control	Niche	SAT CO1	486292	6552230
	Control	New Control	Niche	SAT CO3	486811	6552227
	Control	New Control	Niche	SAT MAR 1	486811	6552454

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

2.2 Methods

2.2.1 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:

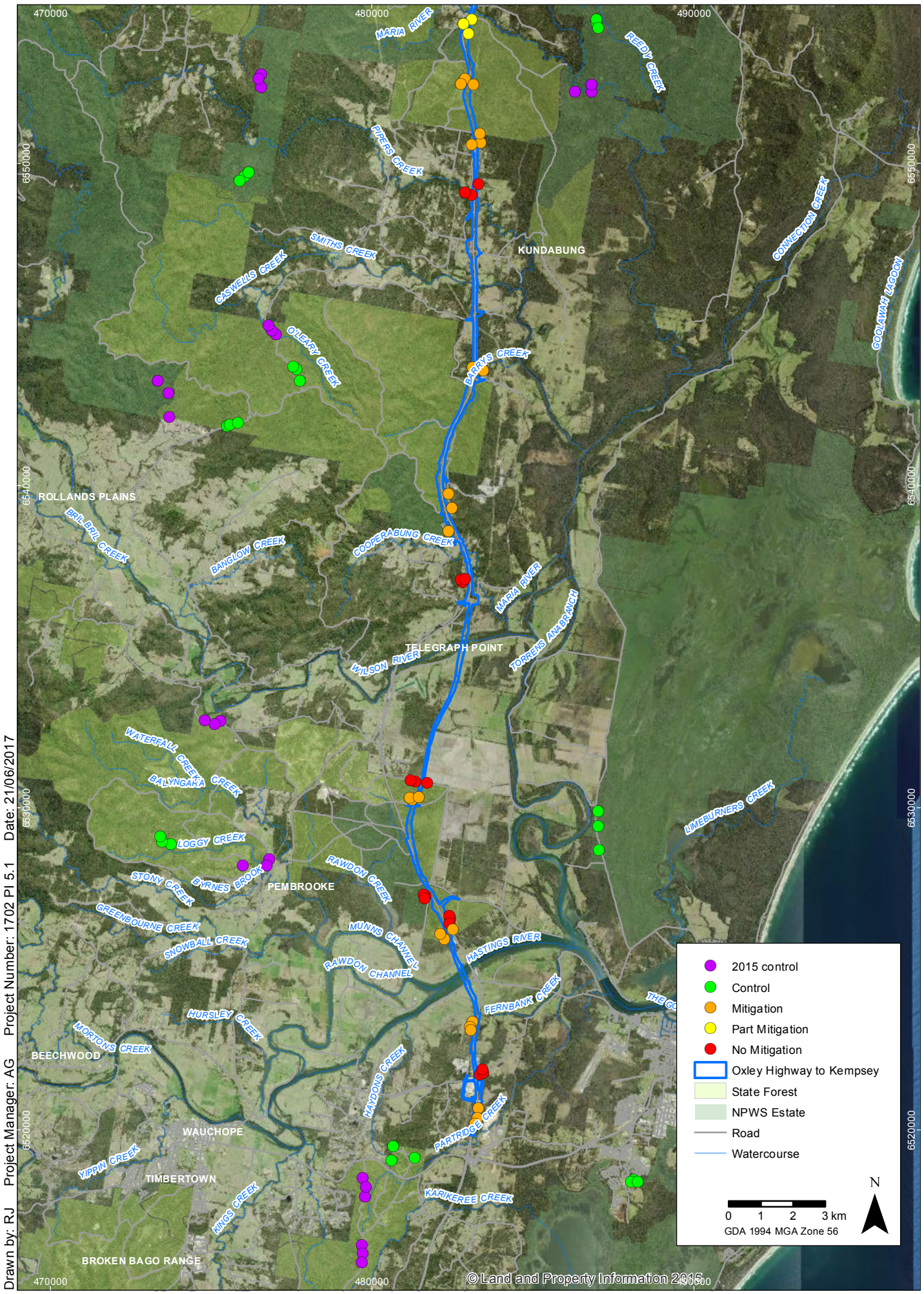
1. Locate and mark a tree that is:
   a) A tree of any species beneath which one or more Koala faecal pellets have been observed; and/or
   b) A tree in which a Koala has been observed; and/or
   c) Any other tree known or considered to be important for Koalas or of interest for other assessment purposes.
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 have a Koala faecal pellet recorded within its search area. The result is used to assess whether the site supports “Low”, “Medium (normal)” or “High” Koala activity.
5. 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.

2.2.2 Analysis

The SAT results are presented separately by plot and by cluster, but most of the histograms and data analysis were present 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 determined using data from clusters.

Statistical analysis was undertaken to assess changes in Koala tree use. Based on the methods used to collect the data and the location of the plots it was determined that a Chi-square test was the most suitable statistical test to use. This test compares proportions of plots with and without Koala scats and so is amenable to data that detects presence or absence. It also does not require equal numbers of impact and control sites to be sampled as numbers of plots expected to be “used” and “unused” can be worked out based on proportions of the number of plots actually sampled.



Drawn by: RJ Project Manager: AG Project Number: 1702 PI 5.1 Date: 21/06/2017

Koala SAT plot locations 2016

Oxley Highway to Kempsey - PI 5.1 Koala report

FIGURE 1

Imagery: (c) LPI NSW 2012-2014

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3. Results and Discussion

3.1 SAT plots

The full data set collected during the monitoring survey is presented in Annex 1. It was noted that on a number of occasions the marked tree did not correspond with the baseline and 2015 monitoring SCT (selection criteria tree) species. As such, for clarity of results and to facilitate future monitoring, the DBH (diameter at breast height) is provided for the marked tree, and this tree will be considered as the SCT for the current and future monitoring events.

Results of the SAT plot surveys are shown in Table 2. Of the 93 accessible SAT plots, a total of 82 SAT plots were surveyed across the eight monitoring areas (Figure 1). Eleven plots could not be surveyed or accessed for safety reasons as these sites were completely burnt during recent wildfires. These included six impact plots from Maria River State Forest, three control plots from Maria River National Park and two impact plots along Kundabung Road to the North of Pipers Creek.

A total of 2,460 trees were assessed across the 82 plots (30 at each plot). Of the 82 surveyed plots, Koala scats were recorded from 15% (12 of 82) of the individual plots. When grouped according to site, Koala scats were recorded at 37% of sites across the survey area (10 of 27) (Graph 1). The mean SAT activity level, measured as the proportion of trees within each site with scats present, was 0.7% across the 27 sites (SD = 1.1) and ranged from 0 to 4.4%. This was lower than the mean activity recorded across the sites in 2015 (2.0% ± SD3.5) and for the baseline surveys (4.9% ± SD6.8). This is considered low use in the east coast, low density area according to Phillips and Callaghan (2011); with normal use being classified as 3.3%-12.6%.

Graph 2 shows Koala activity at each of the eight monitoring areas. While the SAT plot activity was generally low, it was highest at the following locations:

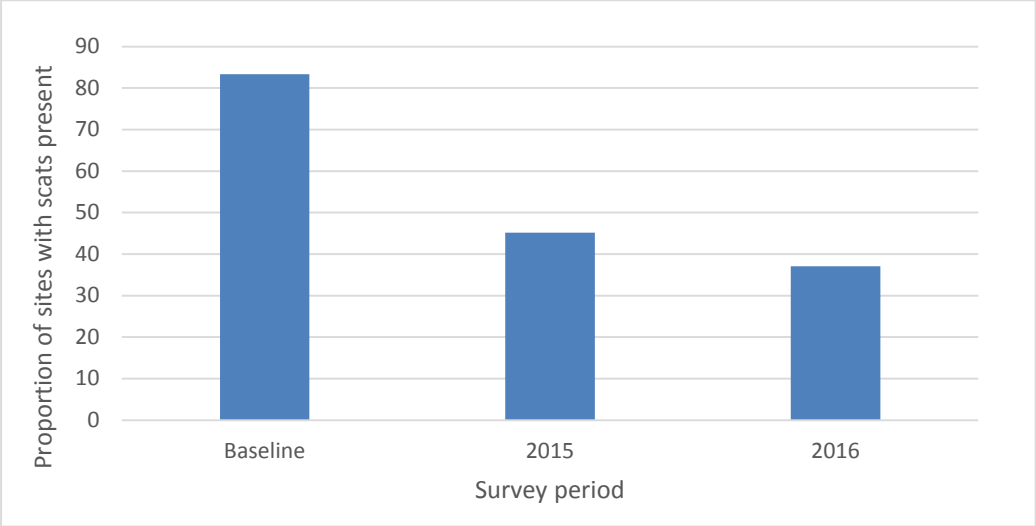
- North Sancrox (2.2%): scats were present at all three clusters in the North Sancrox area including Fernbank Creek, Lake Innes and Cowarra State Forest, with scats being recorded at all three plots at the Fernbank Creek impact site cluster.
- Maria River State Forest (2.2%): scats were recorded at two of the three control plots within Maria River National Park.

One Koala was recorded within one of the SAT plots (Maria River NP3) in Maria River National Park. This site had recently been burnt as part of a NSW National Parks and Wildlife Service back-burning operation in an effort to combat a local wildfire. There was no understorey or ground-cover vegetation present within this site – it had all been burnt, but the canopy was still intact. The Koala, which appeared to be healthy, was found resting in a Tallowwood Tree (*Eucalyptus microcorys*).

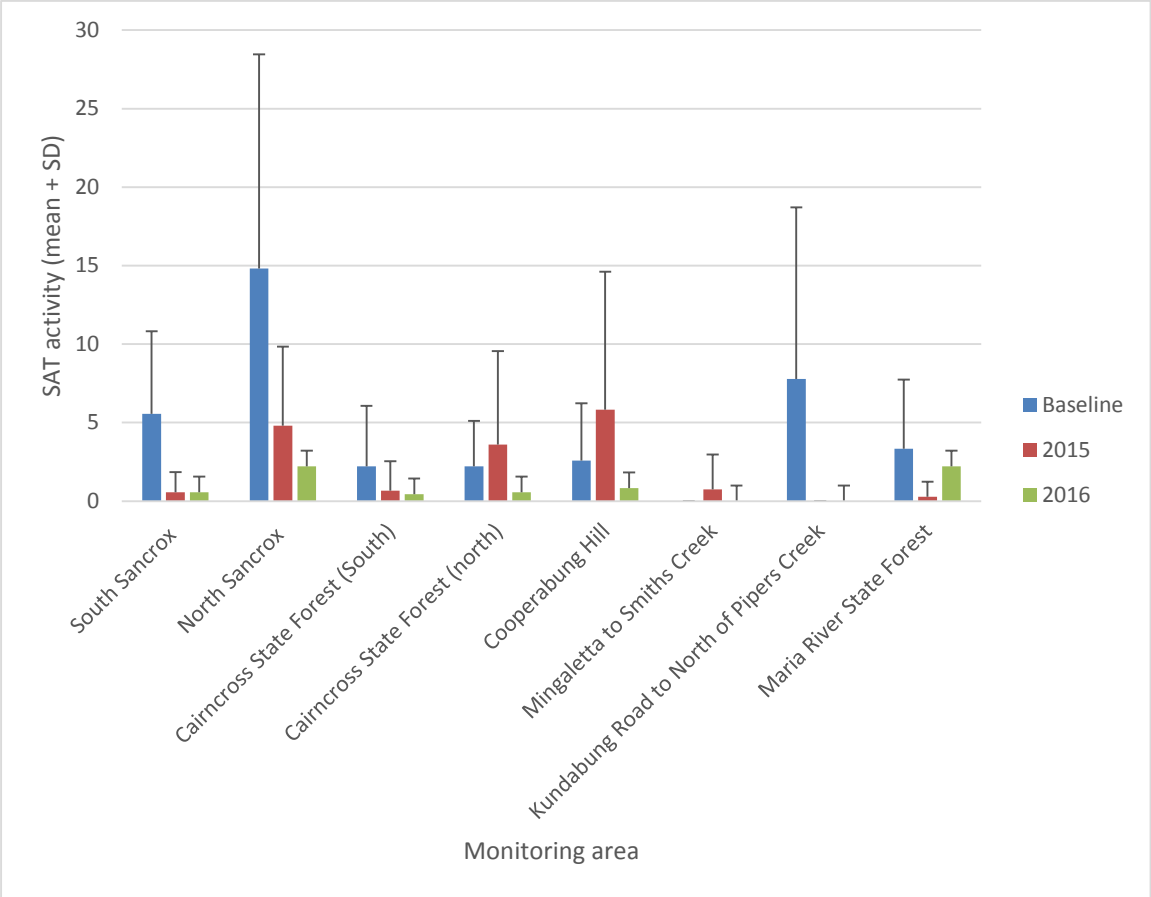
Comparison of the data with previous years (Graph 1 and Graph 2) demonstrates a clear difference in the presence of Koalas, with 83% of sites recording Koala activity in the Baseline surveys and only 37% during the current survey period (Graph 1). Similarly, activity levels across the eight monitoring areas were generally, but not always, greater in the baseline surveys and also usually greater in the 2015 surveys, but with less of a clear difference (Graph 2).

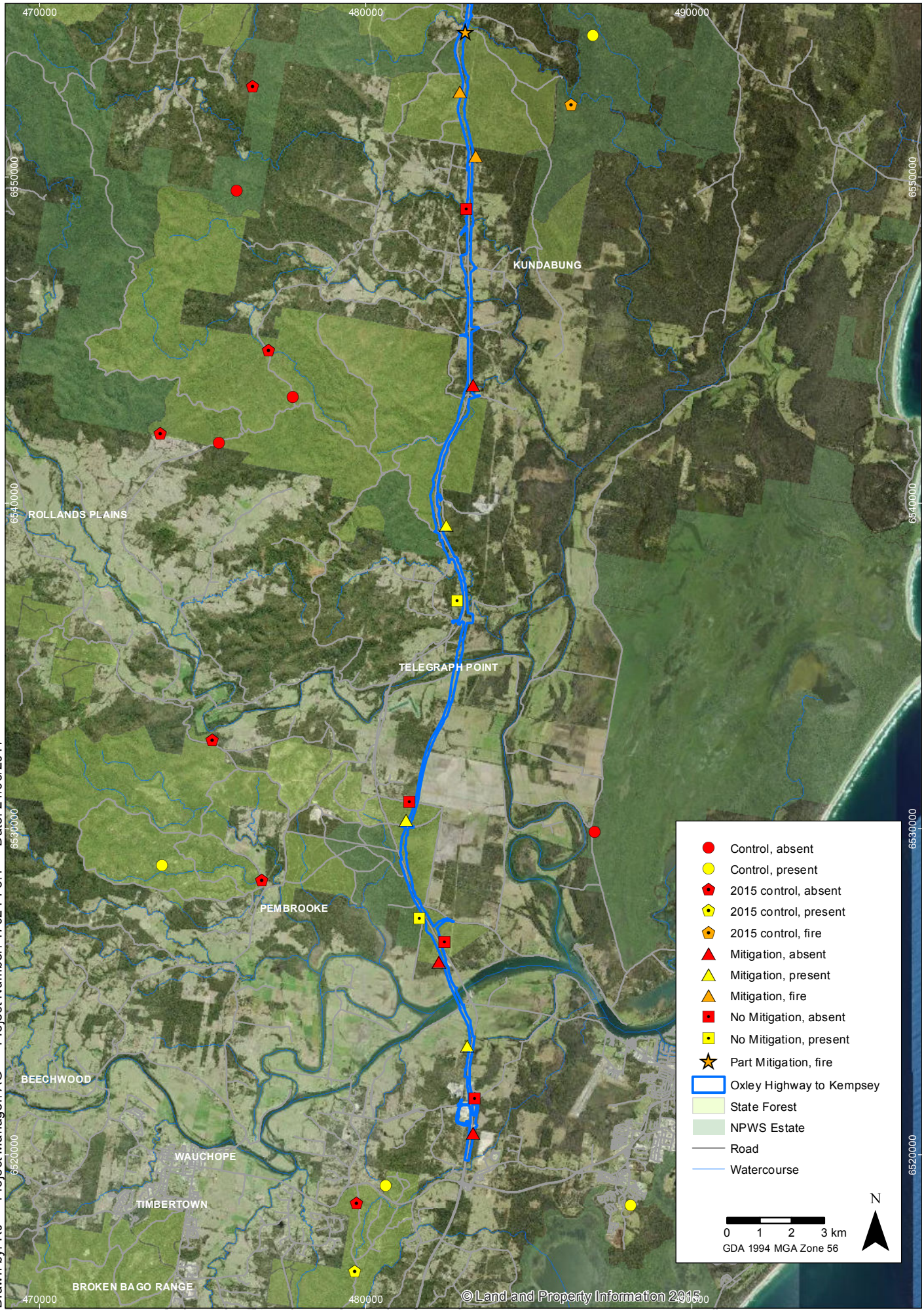
Koala presence was mainly recorded in the southern and central portions of the Project area (Figure 2), however, four of the sites in the north of the alignment were completely burnt and so could not be accessed. It is likely that Koala distribution/abundance would have been affected by the wildfire across the northern parts of the Project area (Figure 2 and Table 2).

Graph 1: Proportion of sites with scats present for each monitoring event to date



Graph 2: Observed Koala activity across the eight monitoring areas





Drawn by: RJ Project Manager: AG Project Number: 1702 PI 5.1 Date: 21/06/2017

Koala SAT plot results 2016

Oxley Highway to Kempsey - PI 5.1 Koala report

FIGURE 2

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Imagery: (c) LPI 2012-2014

Table 2: Koala SAT plots results 2016

Monitoring Area	Cluster no.	Treatment	Data Source	Site ID	Activity (%) Baseline	Activity (%) 2015	Activity (%) 2016	Scat presence (per cluster) Baseline	Scat presence (per cluster) 2015	Scat presence (per cluster) 2016
South Sancrox	1	No Mitigation	Baseline	SANCROX E1	10.0	3.3	0.0	present	present	absent
			Baseline	SANCROX E2	0.0	0.0	0.0			
			Baseline	SANCROX E3	0.0	0.0	0.0			
	2	Mitigation	Baseline_Niche relocation	SANCROX S1	13.3	0.0	0.0	present	absent	absent
			Baseline_Niche relocation	SANCROX S2	3.3	0.0	0.0			
			Baseline_Niche relocation	SANCROX S3	10.0	0.0	0.0			
	3	Control	Baseline	COWARRA SF1	0.0	0.0	0.0	present	absent	present
			Baseline	COWARRA SF2	3.3	0.0	0.0			
			Baseline	COWARRA SF3	10.0	0.0	6.7			
	4	New Control	Niche	SAT COWARRA NC1	-	0.0	0.0	not monitored	present	absent
			Niche	SAT COWARRA NC2	-	3.3	0.0			
			Niche	SAT COWARRA NC3	-	0.0	0.0			
North Sancrox	5	No Mitigation	Baseline	SANCROX N1	3.3	no access	no access	present	no access	no access
			Baseline	SANCROX N2	0.0	no access	no access			
			Baseline	SANCROX N3	0.0	no access	no access			
	6	Mitigation	Baseline	FERNBANK CK1	33.3	0.0	3.3	present	present	present
			Baseline	FERNBANK CK2	30.0	0.0	6.7			
			Baseline	FERNBANK CK3	23.3	6.7	3.3			
	7	Control	Baseline	LAKE INNES1	26.7	13.3	0.0	present	present	present
			Baseline	LAKE INNES2	13.3	6.7	3.3			
			Baseline	LAKE INNES3	3.3	6.7	0.0			

Monitoring Area	Cluster no.	Treatment	Data Source	Site ID	Activity (%) Baseline	Activity (%) 2015	Activity (%) 2016	Scat presence (per cluster) Baseline	Scat presence (per cluster) 2015	Scat presence (per cluster) 2016
	8	New Control	Niche	SAT COW4	-	10.0	0.0	not monitored	present	present
			Niche	SAT COW5	-	0.0	0.0			
			Niche	SAT COW6	-	0.0	3.3			
Cairncross State Forest (South)	9	No Mitigation	Baseline	CAIRNCROSS SF1	0.0	0.0	0.0	present	present	absent
			Baseline	CAIRNCROSS SF2	3.3	6.7	0.0			
			Baseline	CAIRNCROSS SF3	0.0	3.3	0.0			
	10	No Mitigation	Baseline	CAIRNCROSS SF16	0.0	0.0	3.3	present	absent	present
			Baseline	CAIRNCROSS SF17	0.0	0.0	3.3			
			Baseline	CAIRNCROSS SF18	13.3	0.0	0.0			
	11	Mitigation	Baseline	CAIRNCROSS SF4	3.3	0.0	0.0	present	absent	absent
			Baseline	CAIRNCROSS SF5	3.3	0.0	0.0			
			Baseline	CAIRNCROSS SF6	0.0	0.0	0.0			
	12	Control	Baseline	LIMEBURNERS CK1	0.0	0.0	0.0	present	absent	absent
			Baseline	LIMEBURNERS CK2	3.3	0.0	0.0			
			Baseline	LIMEBURNERS CK3	0.0	0.0	0.0			
	13	New Control	Niche	SAT PEVI1	-	0.0	0.0	not monitored	absent	absent
			Niche	SAT PEVI2	-	0.0	0.0			
			Niche	SAT PEVI3	-	0.0	0.0			
Cairncross State Forest (north)	14	No Mitigation	Baseline_Niche relocation	CAIRNCROSS SF7	0.0	3.3	0.0	absent	present	absent
			Baseline	CAIRNCROSS SF8	0.0	20.0	0.0			
			Baseline	CAIRNCROSS SF9	0.0	10.0	0.0			
	15	Mitigation	Baseline	CAIRNCROSS SF10	3.3	0.0	0.0	present	present	present

Monitoring Area	Cluster no.	Treatment	Data Source	Site ID	Activity (%) Baseline	Activity (%) 2015	Activity (%) 2016	Scat presence (per cluster) Baseline	Scat presence (per cluster) 2015	Scat presence (per cluster) 2016
			Baseline	CAIRNCROSS SF11	3.3	0.0	3.3			
			Baseline	CAIRNCROSS SF12	6.7	3.3	0.0			
	16	Control	Baseline	CAIRNCROSS SF13	6.7	3.3	3.3	present	present	present
			Baseline	CAIRNCROSS SF14	0.0	0.0	0.0			
			Baseline	CAIRNCROSS SF15	0.0	3.3	0.0			
	17	New Control	Niche	SAT RR1	-	0.0	0.0	not monitored	absent	absent
			Niche	SAT RR2	-	0.0	0.0			
			Niche	SAT RR3	-	0.0	0.0			
Cooperabung Hill	18	No Mitigation	Baseline	COOPERABUNG1	3.3	3.3	0.0	present	present	present
			Baseline	COOPERABUNG2	0.0	23.3	3.3			
			Baseline	COOPERABUNG3	10.0	0.0	0.0			
	19	Mitigation	Baseline_Niche relocation	COOPERABUNG4	0.0	3.3	6.7	present	present	present
			Baseline_Niche relocation	COOPERABUNG5	3.3	3.3	0.0			
			Baseline	COOPERABUNG6	0.0	0.0	0.0			
	20	Control	Baseline	COOP HILL1	6.7	0.0	0.0	present	absent	absent
			Baseline	COOP HILL2	0.0	0.0	0.0			
			Baseline	COOP HILL3	0.0	0.0	0.0			
	21	New Control	Niche	SAT FL1	-	16.7	0.0	not monitored	present	absent
			Niche	SAT ST1	-	0.0	0.0			
			Niche	SAT ST2	-	20.0	0.0			
	22	Mitigation	Baseline	MIN-SMITHS CK1	0.0	0.0	0.0	absent	absent	absent
			Baseline	MIN-SMITHS CK2	0.0	0.0	0.0			

Monitoring Area	Cluster no.	Treatment	Data Source	Site ID	Activity (%) Baseline	Activity (%) 2015	Activity (%) 2016	Scat presence (per cluster) Baseline	Scat presence (per cluster) 2015	Scat presence (per cluster) 2016
Mingaletta to Smiths Creek			Baseline	MIN-SMITHS CK3	0.0	0.0	0.0			
	23	Control	Baseline	BALLENGARA SF1	0.0	0.0	0.0	absent	absent	absent
			Baseline	BALLENGARA SF2	0.0	0.0	0.0			
			Baseline	BALLENGARA SF3	0.0	0.0	0.0			
	24	New Control	Niche	SAT BR1	-	6.7	0.0	not monitored	present	absent
			Niche	SAT BR2	-	0.0	0.0			
			Niche	SAT BR3	-	0.0	0.0			
Kundabung Road to North of Pipers Creek	25	No Mitigation	Baseline	KUNDABUNG 1	0.0	0.0	0.0	present	absent	absent
			Baseline	KUNDABUNG 2	10.0	0.0	0.0			
			Baseline	KUNDABUNG 3	0.0	0.0	0.0			
	26	Mitigation	Baseline	KUNDABUNG 4	33.3	0.0	fire	present	absent	no access - fire
			Baseline	KUNDABUNG 5	13.3	0.0	fire			no access - fire
			Baseline	KUNDABUNG 6	10.0	0.0	0.0			absent
	27	Control	Baseline	KUMBATINE NP1	3.3	0.0	0.0	present	absent	absent
			Baseline	KUMBATINE NP2	0.0	0.0	0.0			
			Baseline	KUMBATINE NP3	0.0	0.0	0.0			
	28	New Control	Niche	SAT MAC1	-	0.0	0.0	not monitored	absent	absent
			Niche	SAT MAC2	-	0.0	0.0			
			Niche	SAT MAC3	-	0.0	0.0			
Maria River State Forest	29	Part Mitigation	Baseline_Niche relocation	MARIA RIVER 1	0.0	0.0	fire	present	absent	no access - fire
			Baseline	MARIA RIVER 2	3.3	0.0	fire			
			Baseline_Niche relocation	MARIA RIVER 3	6.7	0.0	fire			

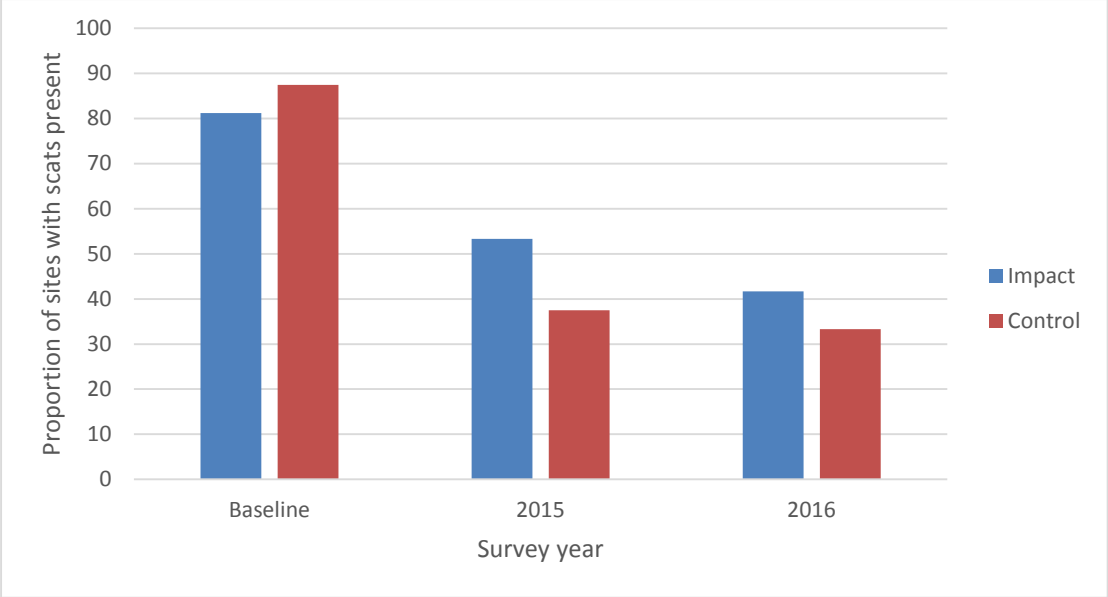
Monitoring Area	Cluster no.	Treatment	Data Source	Site ID	Activity (%) Baseline	Activity (%) 2015	Activity (%) 2016	Scat presence (per cluster) Baseline	Scat presence (per cluster) 2015	Scat presence (per cluster) 2016
	30	Mitigation	Baseline	MARIA RIVER 4	0.0	0.0	fire	absent	present	no access - fire
			Baseline	MARIA RIVER 5	0.0	0.0	fire			
			Baseline	MARIA RIVER 6	0.0	3.3	fire			
	31	Control	Baseline	MARIA NP1	0.0	0.0	0.0	present	absent	present
			Baseline	MARIA NP2	10.0	0.0	3.3			
			Baseline	MARIA NP3	10.0	0.0	3.3			
	32	New Control	Niche	SAT CO1	-	0.0	fire	not monitored	absent	no access – fire
			Niche	SAT CO3	-	0.0	fire			
			Niche	SAT MAR 1	-	0.0	fire			

3.2 Impact v control sites analysis

At a treatment level, the number of Koala scats recorded at impact sites was greater than at the control sites (42% cf 33%) (Graph 3). This result is similar to that of last year (53% of impact sites cf 38% of control sites) although, as noted previously, with lower numbers of Koala scats in 2016 compared to 2015 and also the baseline surveys.

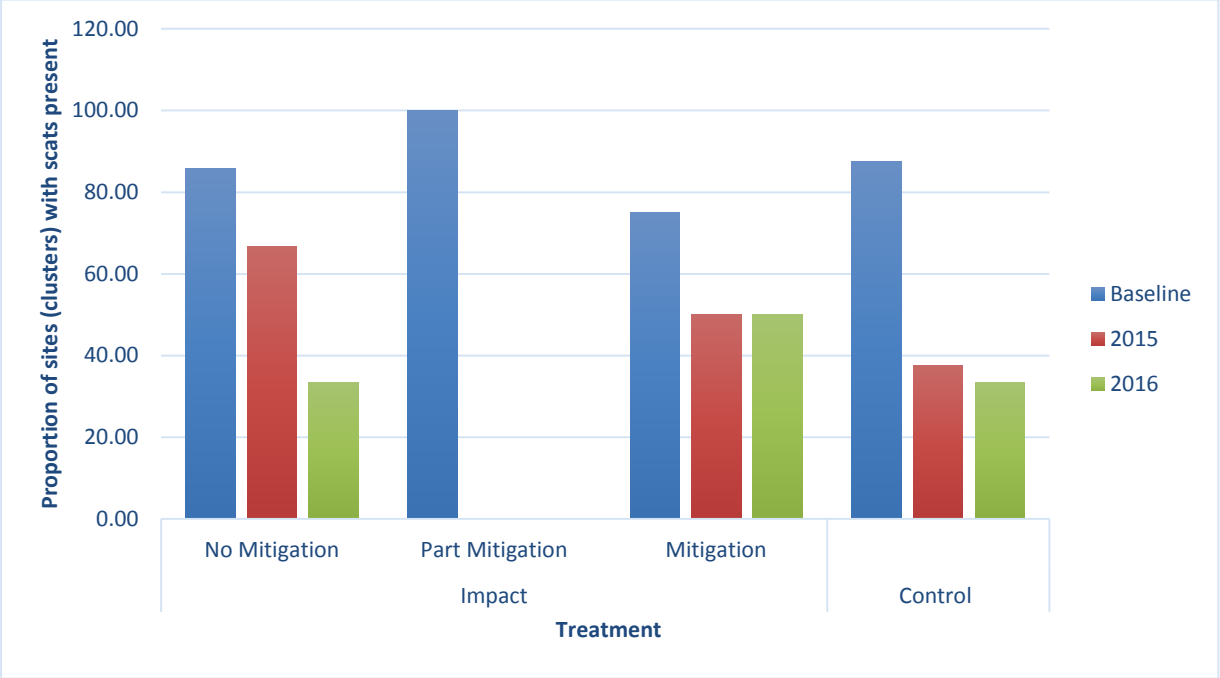
If we compare the Koala presence/absence results between control and impact clusters there is no significant difference in Koala presence at impact and control sites between the baseline and 2016 surveys, or 2015 and 2016 surveys ($X^2 = 0.241$, df = 3, $p < 0.05$ and $X^2 = 0.767$, df = 3, $p < 0.05$).

Graph 3: Koala presence per treatment class



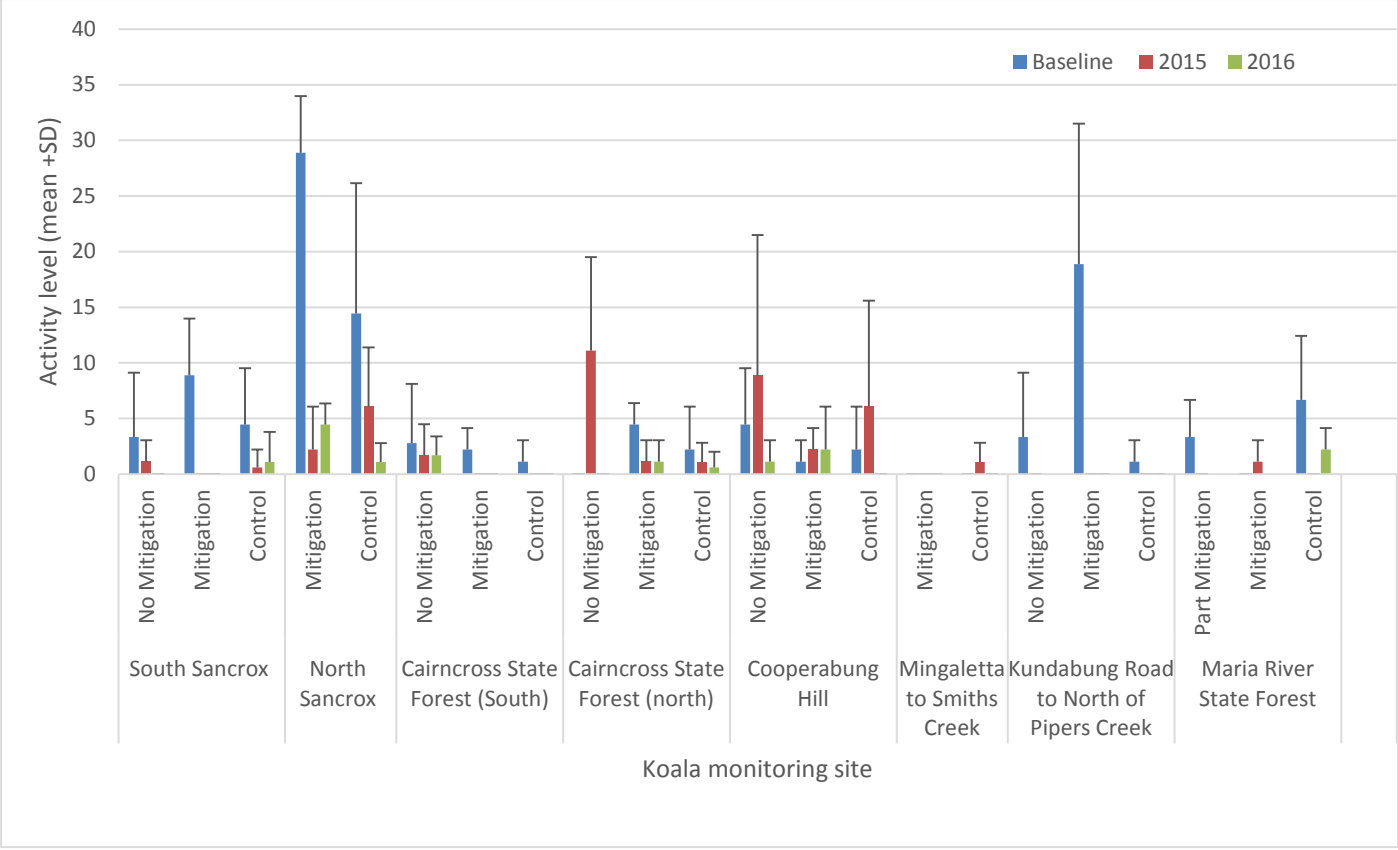
Review of Koala presence within the different impact/control categories does not reveal any clear trends regarding Koala presence or absence from these sites according to the treatment group or year (Graph 4). For example the proportion of scats found within the control sites in 2015 and2016 decreased markedly from the baseline, but there was little difference in the survey results at the control sites between 2015 and 2016. At the impact sites, 50% of the sites with mitigation had Koala scats in 2015 and 2016, while at the unmitigated sites, there was a reduction in the number of Koala scats from 2015 to 2016. No Koala scats were recorded in the part-mitigation site in 2015 and the site could not be surveyed due to fire in 2016. Two of the mitigation sites and one of the control sites also could not be surveyed due to fire.

Graph 4: Koala presence at the different treatment sites



Koala activity at each of the sites is shown in Graph 5. Koala activity was generally lower in 2016 than either of the two previous surveys, and as mentioned previously, there were a greater number of sites with no Koala activity recorded. Further monitoring data would be required to determine if the results reflect broader trends in population dynamics.

Graph 5. Koala activity at each site (mean ± SD)



3.2.1 Tree species use

A total of 2,460 trees were surveyed within the 82 plots. Koala scats were recorded at 15 (0.61%) of the trees surveyed. Surveyed trees included 32 tree species of which Koala scats were recorded at seven (22%) (Table 3). The tree species Koala scats were most commonly recorded beneath were Tallowwood (*Eucalyptus microcorys*) and Small-fruited Grey Gum (*E. propinqua*), which together comprised 30% of all surveyed tree species.

Proportionally, Koala scats were found most frequently beneath Prickly-leaved Tea Tree (*Melaleuca styphelioides*) and Swamp Mahogany (*E. robusta*), 5.6% and 2.7% respectively. However, these two tree species were relatively uncommon at the SAT sites (these species representing only 2.2% of the surveyed trees).

Other tree species used included Coastal Blackbutt (*Eucalyptus pilularis*), Pink Bloodwood (*Corymbia intermedia*) and Forest Oak (*Allocasuarina torulosa*), with a percentage of use ranging from 0.49% to 1.9% (Table 4).

These results are not dissimilar to those of 2015 with Koalas recorded using a similar suite of species.

Table 3: Summary of tree species used by Koala during the SAT surveys

Common name	Species name	Total trees assessed	No. trees with Koala scats	Proportional use (% scats per tree species)
Prickly-leaved Tea Tree	*Melaleuca styphelioides*	18	1	5.6
Swamp Mahogany	*Eucalyptus robusta*	37	1	2.7
Small-fruited Grey Gum	*Eucalyptus propinqua*	209	4	1.9
Coastal Blackbutt	*Eucalyptus pilularis*	165	2	1.2
Pink Bloodwood	*Corymbia intermedia*	222	2	0.90
Tallowwood	*Eucalyptus microcorys*	531	4	0.75
Forest Oak	*Allocasuarina torulosa*	205	1	0.49
Grey Ironbark	*Eucalyptus siderophloia*	94	0	0
Turpentine	*Syncarpia glomulifera*	118	0	0
White Stringy bark	*Eucalyptus globoidea*	97	0	0
White Mahogany	*Eucalyptus acmenoides*	39	0	0
Broad-leaved Paperbark	*Melaleuca quinquenervia*	29	0	0
Thin-leaved Stringybark	*Eucalyptus eugenioides*	77	0	0
Flooded Gum	*Eucalyptus grandis*	51	0	0
Forest Red Gum	*Eucalyptus tereticornis*	21	0	0
Thick-leaved Mahogany	*Eucalyptus carnea*	40	0	0
Red Mahogany	*Eucalyptus resinifera*	74	0	0
Red Bloodwood	*Corymbia gummifera*	99	0	0
Brush Box	*Lophostemon confertus*	60	0	0
Black She0ak	*Allocasuarina littoralis*	31	0	0
Cheese Tree	*Glochidian ferdinandi*	6	0	0

Cabbage Gum	*Eucalyptus amplifolia*	6	0	0
Narrow-leaved Paperbark	*Melaleuca linariifolia*	70	0	0
Blue Gum	*Eucalyptus saligna*	35	0	0
Red Ironbark	*Eucalyptus fibrosa*	3	0	0
Scribbly Gum	*Eucalyptus haemostoma*	43	0	0
	Melaleuca sieberii	8	0	0
Green Wattle	*Acacia irrorata*	5	0	0
Swamp Paperbark	*Melaleuca ericifolia*	1	0	0
	Corymbia spp.	4	0	0
Spotted Gum	*Corymbia maculata*	43	0	0
Grey Ironbark	*Eucalyptus paniculata*	8	0	0
	Melaleuca sp.	2	0	0
Scribbly Gum	*Eucalyptus signata*	7	0	0
Unidentified sp.		2	0	0

3.2.2 Weather conditions

The weather conditions during the field surveys (from Kundabung weather station) are provided in Table 4.

Table 4: Weather conditions during spring-summer 2016

Time	Rainfall (mm)	Temp (°C) (max)	Temp (°C) (min)	Wind speed (km/h)
01/11/2016	13.4	24.44	12.89	1.07
02/11/2016	0.2	25.1	10.72	1.05
14/11/2016	0	26	12.96	1.27
15/11/2016	0	24.35	11.28	1.48
16/11/2016	0	26.92	9.24	1.24
17/11/2016	0	26.2	13.11	1.38
20/11/2016	0	29.41	16.24	1.42
21/11/2016	0	31.77	13.03	1.59
29/11/2016	7	33.7	13.48	1.43
01/12/2016	1	28.94	14.03	1.6
02/12/2016	0	35.62	17.34	1.16
05/12/2016	25	35.47	20.28	1.86
06/12/2016	1.2	32.8	21.04	1.16
07/12/2016	2.2	23.89	19.77	1.14
08/12/2016	1.4	29.02	19.29	1.89

4. Summary and Conclusion

4.1 Summary

Results of SAT baseline surveys showed that Koalas were recorded across most of the study area, apart from the Mingaletta-Smiths Creek area. During the 2015 monitoring, Koala distribution was slightly patchier, in particular in the northern portion of the Project, where Koalas were only recorded from one site. During the current monitoring period Koala presence was mainly recorded in the southern and central portions of the Project area (Figure 2), however, four of the sites (13%) in the north of the alignment were completely burnt and so could not be accessed. It is likely that Koala distribution/abundance would have been affected by the wildfire across the northern parts of the Project area which occurred just prior to the spring 2016 surveys.

Comparison of the current results with 2015 and baseline surveys indicates a downward trend in Koala presence and activity across the Project area and surrounding area within control sites. Koalas were recorded at 83%, 45% and 37% of sites during the baseline, 2015 and 2016 surveys respectively; and SAT activity levels across the eight monitoring areas decreased from 4.8% (SD = 4.7%, baseline) to 2.1% (SD = 3.0%, 2015) to 0.9% (SD = 0.9%, 2016). Koala activity has decreased since the baseline. However, while the establishment of additional control sites has resulted in a more balanced design (which may allow for statistical analysis), the lack of results means that statistical analysis is not possible.

In all three surveys undertaken to date, Koalas were more frequently recorded in impact clusters than in control clusters. Between 2015 and the current survey there was no significant difference in the number of Koalas recorded at the control and impact sites, indicating there is no evidence to indicate that the Project may be affecting the local Koala population.

The results of the 2016 (year 2) monitoring, also observed during the 2015 monitoring, show that the average activity levels align with the category of low use on the east coast (low density area), based on the categories defined by Phillips and Callaghan (2011). This is a reduction down from the moderate (normal) category observed during baseline surveys.

The tree species used by Koalas during the baseline and 2015 monitoring were similar to those recorded in the current survey.

Koala activity was generally lower in 2016 than either of the two previous surveys, and as mentioned previously, there were a greater number of sites with no Koala activity recorded. Further monitoring data would be required to determine if the results reflect temporal trends in population dynamics.

4.2 Performance measures

Table 5 provides details on how the results obtained to date compare against the performance measures from the EMP, and any recommendations arising from these results.

At this stage there is insufficient data to attribute the observed reduction in Koala presence/activity to Project-related activities as this trend was observed for both impact and control sites. It is also likely that Koala distribution/abundance would have been affected by the wildfire that occurred across the northern parts of the Project area prior to the surveys in spring 2016. Further monitoring data will provide further opportunities to determine trends in the Koala population that will assist in assessment of the results against the performance criteria which states “no change” to Koala “densities, distribution, habitat use and movement patterns compared to baseline data”.

Table 5. Performance measures

Performance measure	Response
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 2 has been met**. SAT plot monitoring in 2016 has been undertaken as per the 2015 and baseline surveys.
Monitoring during Year 1 – Year 6 & 8 is undertaken at the Impact and Control sites where monitoring was undertaken during baseline surveys, subject to ongoing landowner agreement. Where landowner agreement cannot be obtained and the process in Section 3.1.2 of the EMP has been followed, this performance indicator will also be considered to have been met	**This performance measure for Year 2 has been met**. Year 2 monitoring was undertaken at the same sites as surveyed in 2015 – with the exception of a number of the sites which could not be accessed due to wildfire. In 2015, eight of the baseline plots had to be relocated to nearby locations because they had been established in the construction site itself or because they were located on private property and access was not possible. Three of the baseline monitoring plots that could not be accessed could not be relocated because there weren't any suitable sites nearby. These three plots were all part of the same cluster (impact, no mitigation) located in the North Sancrox area. Details of all 96 monitoring plots are presented in Table 1 and the location of the 93 accessible monitoring plots are shown in Figure 1.
Mitigation measures are demonstrated to be effective as defined in the EPBC approval when all monitoring events are considered at Year 8.	Not applicable for Year 2.
Fauna fence is installed at a minimum in areas identified in Schedule 3 of the EPBC approval at Year 4.	Not applicable for Year 2.
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.	**This performance measure has not been met.** The 2016 monitoring results indicate a reduction in the presence and activity of Koalas across the Project area from the baseline and 2015 surveys. However this result is consistent across both the impact and control sites with no significant difference in the proportion of sites with Koalas between the impact and control sites. As such, any observed decrease in Koala presence/activity should not be directly attributed to disturbance due to the Project. It is also likely that Koala distribution/abundance would have been affected by the wildfire that occurred across the northern parts of the Project are prior to the surveys in spring 2016. Further monitoring data will assist in determining if the results reflect broader trends in population dynamics. SAT plots provide data in compliance with the requirement of measuring Koala distribution, habitat use and activity levels, but do not provide any 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 against which the performance measure relating to this variable may be assessed.

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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.

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Annex 1. Koala SAT results – 2016 monitoring

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

Area N	Monitoring area	Treatment	Treatment sub-category	Site_ID	Easting	Northing	Activity	Previous SCT	New SCT	DBH (cm)	Radial (m)	Notes
1	South Sancrox	Impact	No Mitigation	SANCROX E1	483348	6521736	0.0	Tallowwood	Tallowwood	46	30	
1	South Sancrox	Impact	No Mitigation	SANCROX E2	483455	6521789	0.0	Tallowwood	Thin-leaved Stringybark	31	25	
1	South Sancrox	Impact	No Mitigation	SANCROX E3	483412	6521882	0.0	Tallowwood	Tallowwood	44.9	30	
1	South Sancrox	Impact	Mitigation	SANCROX S1	483299	6520671	0.0	Tallowwood	Blackbutt	54.5	50	
1	South Sancrox	Impact	Mitigation	SANCROX S2	483254	6520383	0.0	Tallowwood	Thin-leaved Stringybark	54	30	
1	South Sancrox	Impact	Mitigation	SANCROX S3	483196	6520217	0.0	Tallowwood	Tallowwood	46.9	30	
1	South Sancrox	Control	Control	COWARRA SF1	480608	6519056	0.0	Tallowwood	Small-fruited Grey Gum	60.5	20	
1	South Sancrox	Control	Control	COWARRA SF2	480658	6519496	0.0	Tallowwood	Blackbutt	101	20	
1	South Sancrox	Control	Control	COWARRA SF3	481305	6519136	6.7	Tallowwood	Small-fruited Grey Gum	34	15	
1	South Sancrox	Control	New Control	SAT COWARRA NC1	479706	6518522	0.0	Tallowwood	Blackbutt	71	30	
1	South Sancrox	Control	New Control	SAT COWARRA NC2	479788	6517922	0.0	Tallowwood	Tallowwood	47	25	
1	South Sancrox	Control	New Control	SAT COWARRA NC3	479795	6518227	0.0	Tallowwood	Blackbutt	57	20	
2	North Sancrox	Impact	No Mitigation	SANCROX N1	483042	6521731		Swamp Mahogany				No access
2	North Sancrox	Impact	No Mitigation	SANCROX N2	482869	6521683		Tallowwood				No access
2	North Sancrox	Impact	No Mitigation	SANCROX N3	482999	6521818		Tallowwood				No access
2	North Sancrox	Impact	Mitigation	FERNBANK CK1	483101	6523362	3.3	Tallowwood	Tallowwood	61.8	40	
2	North Sancrox	Impact	Mitigation	FERNBANK CK2	483032	6523223	6.7	Tallowwood	Tallowwood	39.7	40	
2	North Sancrox	Impact	Mitigation	FERNBANK CK3	483056	6523123	3.3	Tallowwood	Tallowwood	45	30	
2	North Sancrox	Control	Control	LAKE INNES1	488124	6518469	0.0	Tallowwood	Tallowwood	45	30	
2	North Sancrox	Control	Control	LAKE INNES2	488047	6518398	3.3	Swamp Mahogany	Swamp Mahogany	103	30	
2	North Sancrox	Control	Control	LAKE INNES3	488228	6518390	0.0	Swamp Mahogany	Thin-leaved Paperbark	28	30	
2	North Sancrox	Control	New Control	SAT COW4	479674	6516436	0.0	Tallowwood	Blackbutt	68.5	30	

Area N	Monitoring area	Treatment	Treatment sub-category	Site_ID	Easting	Northing	Activity	Previous SCT	New SCT	DBH (cm)	Radial (m)	Notes
2	North Sancrox	Control	New Control	SAT COW5	479704	6516174	0.0	Tallowwood	Tallowwood	34.5	15	
2	North Sancrox	Control	New Control	SAT COW6	479667	6515913	3.3	Tallowwood	Tallowwood	54	25	
3	Cairncross State Forest (South)	Impact	No Mitigation	CAIRNCROSS SF1	482428	6526536	0.0	Tallowwood	Tallowwood	35.4	20	
3	Cairncross State Forest (South)	Impact	No Mitigation	CAIRNCROSS SF2	482385	6526644	0.0	Tallowwood	Tallowwood	56.1	30	
3	Cairncross State Forest (South)	Impact	No Mitigation	CAIRNCROSS SF3	482393	6526416	0.0	Tallowwood	Tallowwood	29.8	30	
3	Cairncross State Forest (south)	Impact	No Mitigation	CAIRNCROSS SF16	481655	6527256	3.3	Tallowwood	Tallowwood	38.5	30	
3	Cairncross State Forest (south)	Impact	No Mitigation	CAIRNCROSS SF17	481590	6527316	3.3	Tallowwood	Tallowwood	45.5	30	
3	Cairncross State Forest (south)	Impact	No Mitigation	CAIRNCROSS SF18	481637	6527175	0.0	Tallowwood	Tallowwood	51.5	35	
3	Cairncross State Forest (South)	Impact	Mitigation	CAIRNCROSS SF4	482249	6525930	0.0	Tallowwood	Tallowwood	57.4	30	
3	Cairncross State Forest (South)	Impact	Mitigation	CAIRNCROSS SF5	482125	6526077	0.0	Tallowwood	Tallowwood	64.2	20	
3	Cairncross State Forest (South)	Impact	Mitigation	CAIRNCROSS SF6	482488	6526226	0.0	Tallowwood	Blackbutt*	71.6	20	
3	Cairncross State Forest (South)	Control	Control	LIMEBURNERS CK1	487011	6529909	0.0	Scribbly Gum	Scribbly Gum	94	60	Not tagged
3	Cairncross State Forest (South)	Control	Control	LIMEBURNERS CK2	487014	6529455	0.0	Scribbly Gum	Scribbly Gum	81	60	Not tagged
3	Cairncross State Forest (South)	Control	Control	LIMEBURNERS CK3	487035	6528694	0.0	Scribbly Gum	Scribbly Gum	75	45	Not tagged
3	Cairncross State Forest (South)	Control	New Control	SAT PEVI1	476817	6528422	0.0	Tallowwood	Sydney Blue Gum	58		
3	Cairncross State Forest (South)	Control	New Control	SAT PEVI2	476730	6528225	0.0	Tallowwood	Sydney Blue Gum	40	30	
3	Cairncross State Forest (South)	Control	New Control	SAT PEVI3	475996	6528211	0.0		Sydney Blue Gum	55	30	
4	Cairncross State Forest (north)	Impact	No Mitigation	CAIRNCROSS SF7	481346	6530835	0.0	Blackbutt	Blackbutt	64.5	30	
4	Cairncross State Forest (north)	Impact	No Mitigation	CAIRNCROSS SF8	481695	6530786	0.0	Forest Red Gum	Pink Bloodwood	28.3	30	
4	Cairncross State Forest (north)	Impact	No Mitigation	CAIRNCROSS SF9	481184	6530864	0.0	Tallowwood	Tallowwood	42.2	40	
4	Cairncross State Forest (north)	Impact	Mitigation	CAIRNCROSS SF10	481238	6530264	0.0	Swamp Mahogany	Swamp Mahogany	37.8	30	
4	Cairncross State Forest (north)	Impact	Mitigation	CAIRNCROSS SF11	481173	6530319	3.3	Tallowwood	Tallowwood	64.2	40	
4	Cairncross State Forest (north)	Impact	Mitigation	CAIRNCROSS SF12	481438	6530335	0.0	Tallowwood	Tallowwood	72		
4	Cairncross State Forest (north)	Control	Control	CAIRNCROSS SF13	473751	6528881	3.3	Tallowwood	Small-fruited Grey Gum	44	40	
4	Cairncross State Forest (north)	Control	Control	CAIRNCROSS SF14	473464	6528969	0.0	Tallowwood	Sydney Blue Gum	86	30	
4	Cairncross State Forest (north)	Control	Control	CAIRNCROSS SF15	473424	6529115	0.0	Tallowwood	Sydney Blue Gum	80		
4	Cairncross State Forest (north)	Control	New Control	SAT RR1	475284	6532709	0.0	Tallowwood	Tallowwood	78	30	

Area N	Monitoring area	Treatment	Treatment sub-category	Site_ID	Easting	Northing	Activity	Previous SCT	New SCT	DBH (cm)	Radial (m)	Notes
4	Cairncross State Forest (north)	Control	New Control	SAT RR2	475113	6532603	0.0	Tallowwood	Small-fruited Grey Gum	54		
4	Cairncross State Forest (north)	Control	New Control	SAT RR3	474816	6532732	0.0	Tallowwood	Tallowwood	61	20	
5	Cooperabung Hill	Impact	No Mitigation	COOPERABUNG1	482793	6537012	0.0	Tallowwood	Tallowwood	68	60	
5	Cooperabung Hill	Impact	No Mitigation	COOPERABUNG2	482755	6537093	3.3	Tallowwood	Small-fruited Grey Gum	26.8	50	
5	Cooperabung Hill	Impact	No Mitigation	COOPERABUNG3	482876	6537115	0.0	Tallowwood	Tallowwood	49.7	35	
5	Cooperabung Hill	Impact	Mitigation	COOPERABUNG4	482481	6539327	6.7	Tallowwood	Tallowwood	34	30	
5	Cooperabung Hill	Impact	Mitigation	COOPERABUNG5	482364	6539761	0.0	Forest Red Gum	Tallowwood	25.7	30	
5	Cooperabung Hill	Impact	Mitigation	COOPERABUNG6	482364	6538610	0.0	Tallowwood	Tallowwood	73	40	
5	Cooperabung Hill	Control	Control	COOP HILL1	475489	6541854	0.0	Tallowwood	Tallowwood	41.8	30	
5	Cooperabung Hill	Control	Control	COOP HILL2	475570	6541903	0.0	Tallowwood	Tallowwood	31.5	25	
5	Cooperabung Hill	Control	Control	COOP HILL3	475838	6541962	0.0	Tallowwood	Tallowwood	28.7	30	
5	Cooperabung Hill	Control	New Control	SAT FL1	473693	6542127	0.0		Tallowwood	45.4	25	
5	Cooperabung Hill	Control	New Control	SAT ST1	473346	6543256	0.0		Tallowwood	64.5	15	
5	Cooperabung Hill	Control	New Control	SAT ST2	473682	6542890	0.0		Tallowwood	31.5	20	
6	Mingaletta to Smiths Creek	Impact	Mitigation	MIN-SMITHS CK1	483304	6543632	0.0	Tallowwood	Blackbutt	42	20	
6	Mingaletta to Smiths Creek	Impact	Mitigation	MIN-SMITHS CK2	483444	6543585	0.0	Tallowwood	Tallowwood	58	40	
6	Mingaletta to Smiths Creek	Impact	Mitigation	MIN-SMITHS CK3	483100	6543670	0.0	Tallowwood	Small-fruited Grey Gum	37.6		
6	Mingaletta to Smiths Creek	Control	Control	BALLENGARA SF1	477750	6543274	0.0	Tallowwood	Tallowwood	37	30	
6	Mingaletta to Smiths Creek	Control	Control	BALLENGARA SF2	477644	6543623	0.0	Small-fruited Grey Gum	Small-fruited Grey Gum	23.5	30	
6	Mingaletta to Smiths Creek	Control	Control	BALLENGARA SF3	477551	6543709	0.0	Tallowwood	Tallowwood	42.5	25	
6	Mingaletta to Smiths Creek	Control	New Control	SAT BR1	477010	6544693	0.0	Tallowwood	Sydney Blue Gum	42.5	20	
6	Mingaletta to Smiths Creek	Control	New Control	SAT BR2	476890	6544832	0.0	Tallowwood	Sydney Blue Gum	49	25	
6	Mingaletta to Smiths Creek	Control	New Control	SAT BR3	476777	6544973	0.0	Tallowwood	Flooded Gum	60.5	20	
7	Kundabung Road to North of Pipers Creek	Impact	No Mitigation	KUNDABUNG 1	483095	6549036	0.0	Tallowwood	Tallowwood	65.5	60	
7	Kundabung Road to North of Pipers Creek	Impact	No Mitigation	KUNDABUNG 2	482873	6549112	0.0	Tallowwood	Tallowwood	73.5	30	
7	Kundabung Road to North of Pipers Creek	Impact	No Mitigation	KUNDABUNG 3	483285	6549374	0.0	Tallowwood	Tallowwood	65	40	
7	Kundabung Road to North of Pipers Creek	Impact	Mitigation	KUNDABUNG 4	483369	6550655	fire	Tallowwood				Burnt

Area N	Monitoring area	Treatment	Treatment sub-category	Site_ID	Easting	Northing	Activity	Previous SCT	New SCT	DBH (cm)	Radial (m)	Notes
7	Kundabung Road to North of Pipers Creek	Impact	Mitigation	KUNDABUNG 5	483331	6550938	fire	Tallowwood				Burnt
7	Kundabung Road to North of Pipers Creek	Impact	Mitigation	KUNDABUNG 6	483083	6550608	0.0	Forest Red Gum	Grey Ironbark	55	40	
7	Kundabung Road to North of Pipers Creek	Control	Control	KUMBATINE NP1	476044	6549609	0.0	Tallowwood	Tallowwood	35.5	20	
7	Kundabung Road to North of Pipers Creek	Control	Control	KUMBATINE NP2	476165	6549738	0.0	Tallowwood	Tallowwood	37.5	15	
7	Kundabung Road to North of Pipers Creek	Control	Control	KUMBATINE NP3	475889	6549468	0.0	Tallowwood	Tallowwood	56.5	20	
7	Kundabung Road to North of Pipers Creek	Control	New Control	SAT MAC1	476538	6552784	0.0		Red Mahogany	83.6	15	
7	Kundabung Road to North of Pipers Creek	Control	New Control	SAT MAC2	476558	6552361	0.0		Spotted Gum	51.5	20	
7	Kundabung Road to North of Pipers Creek	Control	New Control	SAT MAC3	476481	6552612	0.0	Spotted Gum	Spotted Gum	58	15	
8	Maria River State Forest	Impact	Part Mitigation	MARIA RIVER 1	483074	6554460	fire	Tallowwood				Burnt
8	Maria River State Forest	Impact	Part Mitigation	MARIA RIVER 2	482836	6554330	fire	Tallowwood				Burnt
8	Maria River State Forest	Impact	Part Mitigation	MARIA RIVER 3	482993	6554024	fire	Tallowwood				Burnt
8	Maria River State Forest	Impact	Mitigation	MARIA RIVER 4	482886	6552623	fire	Tallowwood				Burnt
8	Maria River State Forest	Impact	Mitigation	MARIA RIVER 5	482754	6552462	fire	Tallowwood				Burnt
8	Maria River State Forest	Impact	Mitigation	MARIA RIVER 6	483135	6552449	fire	Tallowwood				Burnt
8	Maria River State Forest	Control	Control	MARIA NP1	486965	6554366	0.0	Tallowwood	Pink Bloodwood	28	40	
8	Maria River State Forest	Control	Control	MARIA NP2	486971	6554479	3.3	Tallowwood	Tallowwood	61.5	40	
8	Maria River State Forest	Control	Control	MARIA NP3	487004	6554203	3.3	Tallowwood	Tallowwood	36	30	Koala present-tallowwood
8	Maria River State Forest	Control	New Control	SAT CO1	486292	6552230	fire					Burnt
8	Maria River State Forest	Control	New Control	SAT CO3	486811	6552227	fire	Blackbutt				Burnt
8	Maria River State Forest	Control	New Control	SAT MAR 1	486811	6552454	fire					Burnt

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Annex 2. Giant Barred Frog monitoring 2016/2017 (Niche 2017a)

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Environment and Heritage

Giant Barred Frog Monitoring 2016/2017

Oxley Highway to Kempsey, Pacific Highway Upgrade

Prepared for Roads and Maritime Services

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Cover photograph: Giant Barred Frogs (Photos: Frank Lemckert)

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Executive summary

Context

This report documents findings for the 2016/2017 monitoring period (including spring 2016, summer 2017 and autumn 2017 surveys) for the Giant Barred Frog (*Mixophyes iteratus*), as required by the Oxley Highway to Kempsey (OH2K) Ecological Monitoring Program (EMP, RMS 2016).

The Giant Barred Frog is one of the threatened species identified as requiring mitigation and monitoring throughout the course of the construction and operational periods of the Oxley Highway to Kempsey (OH2K) Pacific Highway upgrade (the Project).

Aims

The aim of the Giant Barred Frog monitoring program is to determine whether the Project is meeting the performance indicators for the species, and provide corrective actions where required.

Methods

Six sites (two reference and four impact) have been monitored. Each monitoring location was surveyed in accordance with the monitoring method and design specified in the EMP.

Key results

A total of 149 Giant Barred Frogs were recorded during the 2016/2017 monitoring period and 32% (n = 40) of those captured were recaptures. Frogs were recorded at all sites during all seasons with the exception of Pipers Creek impact site where no frogs were recorded during the autumn survey.

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

Chytrid fungus was detected for the first time at the Cooperabung Creek impact site. Chytrid fungus is now therefore considered to be present at all monitoring sites.

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

Conclusions

Monitoring related performance measures and Giant Barred Frog population and habitat use related performance measures have to date been met.

The performance measure related to continued presence of Giant Barred Frogs during each survey event where it was identified during baseline surveys was met for 5 of 6 sites. Giant Barred Frogs were not recorded at Pipers Creek impact site during the autumn survey where it was recorded during baseline surveys. However, as autumn surveys have shown reduced activity during almost all survey events and frog detection can vary between survey events, the absence of records of the species during this single survey cannot yet be considered as indicating the absence of this species from this site, where it was detected spring and summer surveys.

The water quality performance measure was was met for all sites except Maria River. Other values above the 80Th percentile trigger value were not considered to be attributable to construction activities. The incident at Maria River was addressed immediately and procedures were put in place to avoid reoccurrence.

Management implications

A number of general recommendations have been made including consideration of continued Lantana control to improve monitoring efficiency, implementation of Chytrid fungus hygiene protocol at all impact sites and the cessation of Chytrid swabbing of frogs.

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1. Introduction

1.1 Context

The Oxley Highway to Kempsey (OH2K) section of the Pacific Highway Upgrade Project (the Project) was approved in 2012 subject to various Ministers Conditions of Approval (MCoA) and a Statement of Commitments (SoC). A subsequent approval with additional conditions of consent (CoA) was granted in 2014 by the Commonwealth Department of Environment (DoE) for matters of national environmental significance (MNES) listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1995* (EPBC Act). The Ecological Monitoring Program (hereafter referred to as the EMP) (RMS 2016) combines these approval conditions and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project. The Giant Barred Frog (*Mixophyes iteratus*) was one threatened species identified as requiring mitigation and monitoring through the course of the Projects' construction and post construction period.

1.1.1 Legal Status

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

1.1.2 Monitoring Framework

The design, methods and performance indicators that define the Giant Barred Frog monitoring program are specified in the EMP and Giant Barred Frog Management Strategy (GBFMS, Lewis 2013). Where there are discrepancies between the EMP and the GBFMS, the EMP takes precedence (Section 1.2 RMS 2016).

The EMP requires monitoring of the Giant Barred Frog three times a year (spring, summer and autumn) in years 1, 2 and 3 once substantial construction commenced. Following the completion of the project, monitoring will continue in the same manner for a further five consecutive years, or until the mitigation measures can be demonstrated to be effective. To date, these monitoring events have been reported as follows:

- *Autumn 2015*: Niche 2015a.
- *Spring 2015, summer and autumn 2016*: Niche 2016.
- *Spring 2016, summer autumn 2017*: current report.

To complete the required three cycles of construction monitoring, a spring and a summer survey remain. These surveys will be undertaken in spring 2017 and summer 2018 and be the subject of the final report for construction monitoring for the Giant Barred Frog. This report therefore represents the third of four necessary construction monitoring reports for the Giant Barred Frog. Operational monitoring is projected to commence in autumn 2018.

1.1.3 Baseline Data

The EMP specifies the following regarding the Giant Barred Frog:

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

Creek and Maria River. Areas of suitable habitat for the Giant Barred Frog were also identified at both Stumpy Creek and Barrys Creek"

The EMP lists six sites to be monitored:

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

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

1.1.4 Purpose of this Report

This report details the findings obtained from the third monitoring report for the construction phase of the Project.

The aims of this report are to summarise the methods and results of the spring 2016, summer 2017 and autumn 2017 monitoring and determine if performance measures are being met, as per the EMP.

1.2 Performance measures

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

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

1.3 Monitoring timing

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

1.4 Reporting

Annual reporting of monitoring results will outline:

- Detailed description of monitoring methodology employed.
- Results of the monitoring period.

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

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

1.5 Limitations

The following limitations to the monitoring procedure were encountered:

- An increasing density of Lantana (*Lantana camera*) at a number of sites, notably Maria River impact site and Pipers Creek impact site, is hampering survey efforts. Safe navigation of the creek lines has become difficult due to low vision and steep creek beds. Giant Barred Frogs were not detected during autumn surveys at Pipers Creek impact site.

2. Survey Methods

2.1 Monitoring sites

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

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

Reference sites are located several kilometres upstream of the Project footprint.

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

2.2 Giant Barred Frog survey method

Surveys were undertaken in accordance with the EMP.

A 2 hour minimum search time at each site was employed, however access and movement difficulties due to dense vegetation often resulted in increased survey time. Surveys involved passive listening, call playback (upon arrival and at intervals during searches), active searching (within 20 m of creek bank) and habitat surveys. In accordance with the EMP, the following habitat data was collected within each of the 100 m zones:

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

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

- Location according to demarcated survey zone.
- Distance from stream edge.
- Sex (male, female, unknown).
- Breeding condition with:
    - Males assessed on the colouration of their nuptial pads (i.e. no colour, light, moderate, dark).
    - Females based on whether they are gravid or not gravid (egg bearing).

- Snout-vent length (millimetres).
- Weight (grams).
- General condition of the frog, including a swab sample to test for the presence of Chytrid fungus.

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 where 0 = no wind). Rainfall (mm) 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.

2.3 Water quality

Water quality monitoring was undertaken by Roads and Maritime Services between 22 July 2016 and 21 July 2017 and is presented in two six-monthly reports (RMS 2017a, 2017b). At the time of this report, the second six-monthly report (RMS 2017b) was not available, however analysed data and highlighted issues were provided to Niche by Roads and Maritime Services. This report summarises water quality data from both upstream and downstream sites for Cooperabung Creek, Smiths Creek, Pipers Creek, and Maria Creek.

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

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.

3. Results

3.1 2016/2017 Giant Barred Frog monitoring results

Field data are presented in Annex 1 and Annex 2.

3.1.1 Survey results

A total of 149 Giant Barred Frogs were recorded during the 2016/2017 monitoring surveys. Frogs were recorded at all six sites during all but one monitoring event (Table 1). Of the 149 frogs recorded, 126 were captured, of which 40 were recaptures (32%). During construction one tagged Giant Barred Frog was relocated from the construction footprint to a suitable release site 190 m upstream along Cooperabung Creek.

As in previous surveys, captures were higher during summer surveys than spring and autumn at four sites. Pipers Creek reference site recorded the greatest mean number of frogs, while Cooperabung Creek reference site recorded a mean number of frogs similar to the impact sites.

The MKTBA count was the highest at the Pipers Creek reference site (n = 38), while the estimate for the Cooperabung Creek reference site (n = 8) was lower than the impact sites (n = 11 – 26).

Table 1: Giant Barred Frogs recorded at each site during 2016/2017 surveys

	Cooperabung Creek impact	Smiths Creek impact	Pipers Creek impact	Maria River impact	Cooperabung Creek reference	Pipers Creek reference
Spring	8	3	7	13	3	17
Summer	9	21	5	13	7	30
Autumn	2	5	0	1	3	2
Mean number of frogs per survey	6.33	9.67	4.00	9.00	4.33	16.33
Standard Error (SE)	2.19	5.70	2.08	4.00	1.33	8.09
MKTBA	15	26	11	24	8	38

3.1.2 Evidence of breeding

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

Table 2: Breeding evidence records

		Juveniles	Sub-adults	Gravid females	Nuptial pads
Cooperabung Creek impact	Spring		2		Light to dark
	Summer	2	1	2	Dark
	Autumn		1	1	
Maria River impact	Spring		2	5	Mostly light
	Summer			6	Mostly dark
	Autumn			1	
Pipers Creeks impact	Spring	2	2	2	
	Summer			1	Light
	Autumn				
Smiths Creek impact	Spring		1		Light
	Summer		3	3	Light to dark
	Autumn	1	1		Moderate
Cooperabung Creek reference	Spring			3	
	Summer				Dark
	Autumn		1	1	Moderate
Pipers Creek reference	Spring	2		3	Dark
	Summer	1	1	8	Light to dark
	Autumn		1		

3.1.3 Weather conditions

The prevailing weather conditions encountered during the field surveys are summarised in Table 3. 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 3: Weather conditions: spring 2016, summer 2017 and autumn 2017 surveys

Date	Min temp (˚C)	Max temp (˚C)	Humidity (%)	Rainfall 24 hours (mm)	Rainfall 7 days (mm)	Rainfall 30 days (mm)
26/10/2016	8.5	29.9	48-30	0	20.6	33.4
27/10/2016	11.3	31.6	47-29	0	20.6	33.4
28/10/2016	13.3	25.9	74-59	0.6	16.6	34
31/10/2016	15.8	29.6	80-68	1.8	29	60.2
17/01/2017	17.8	34.6	70-47	1.6	16.2	35.2
18/01/2017	19.7	42	35-22	0	16.2	35
19/01/2017	20.4	24.6	76-84	0.2	12.4	35.2
26/04/2017	16.8	20.9	87-77	0.2	11.4	91.6
27/04/2017	7.4	20.8	56-49	1.4	12.6	92.6
28/04/2017	13.2	21.6	61-53	1.2	12.6	92.6

3.1.4 Chytrid Fungus

Chytrid fungus sampling was carried out in all three monitoring events. Sampling has again indicated that this pathogen is present in the study area, but that its prevalence varies between sites and times of sampling. Table 4 presents current and previous monitoring event results. During the current monitoring period Chytrid fungus was detected during spring and summer at the Piper Creek reference site and, for the first time, at the Cooperabung Creek impact site (previously detected at the upstream Cooperabung Creek reference site). It was also detected at the Cooperabung reference site during spring. Chytrid fungus was not detected during the autumn monitoring surveys.

Chytrid fungus was not detected at three sites in the 2016/2017 monitoring, however it has been previously detected at these sites during either baseline surveys or previous monitoring events. It is presumed however that this pathogen will remain at a location on a permanent basis.

Chytrid fungus is therefore considered to be present at all monitoring sites.

Table 4: Chytrid fungus detection/present within the Project sites.

	Cooperabung Creek Impact	Smiths Creek Impact	Pipers Creek Impact	Maria River Impact	Cooperabung Creek Reference	Pipers Creek Reference
Baseline	not detected	detected	not detected	not detected	detected	not detected
2015/2016	not detected	not detected	detected	detected	not detected	detected
2016/2017	detected	not detected	not detected	not detected	detected	detected

3.1.5 Habitat survey information

Habitat information collected for each site is presented in Annex 1. Microhabitat use was highly variable. Frogs were recorded on and buried within leaf litter, using flood debris as shelter, within the creeks, on rocks and under logs and vegetation. During inspection of the frog fence a number of maintenance issues were noted where the fence was considered unlikely to impede frog movement in its current condtion, notably vegetation growth and fence gaps. For the purpose of this report these issues have been recorded in Annex 1 as a fence breach. No frogs were found to have breached the frog fences at any sites (i.e observed on the wrong side of the fence). It is also noted that no exotic fish have been observed at any of the sites during the 2016/2017 monitoring period.

Of particular relevance however is the increasing density of Lantana (*Lantana camera*) at a number of sites, notably Maria River impact site and Pipers Creek impact site. At the eastern end of Maria River and the western side of the Pipers Creek impact site, the lantana is now thick enough to substantially hamper survey efforts. Walking along the banks is difficult and vision is obscured. Safe navigation of the creek lines has become difficult due to low vision and steep creek beds.

3.2 Comparison with baseline surveys

Graph 1 and Table 5 present the Giant Barred Frog records for baseline and the 2016/2017 monitoring period.

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

The 2016/2017 monitoring recorded Giant Barred Frogs at all six monitoring sites in spring and summer and at five sites in autumn. Frogs were not recorded at Pipers Creek impact site during the autumn 2017 survey.

Frogs were therefore recorded during 2016/2017 surveys at the two sites where they were not recorded during the autumn baseline surveys, however they were not recorded at the Pipers Creek impact site in the autumn 2016/2017 surveys, where they were recorded during baseline surveys.

MKTBA for the baseline survey and 2016/2017 surveys are relatively similar for the impact sites. The MKTBA for the Cooperabung Creek reference site is lower than the baseline survey, while Pipers Creek reference is greater.

Graph 1: Giant Barred Frog records: baseline and 2016/2017 monitoring

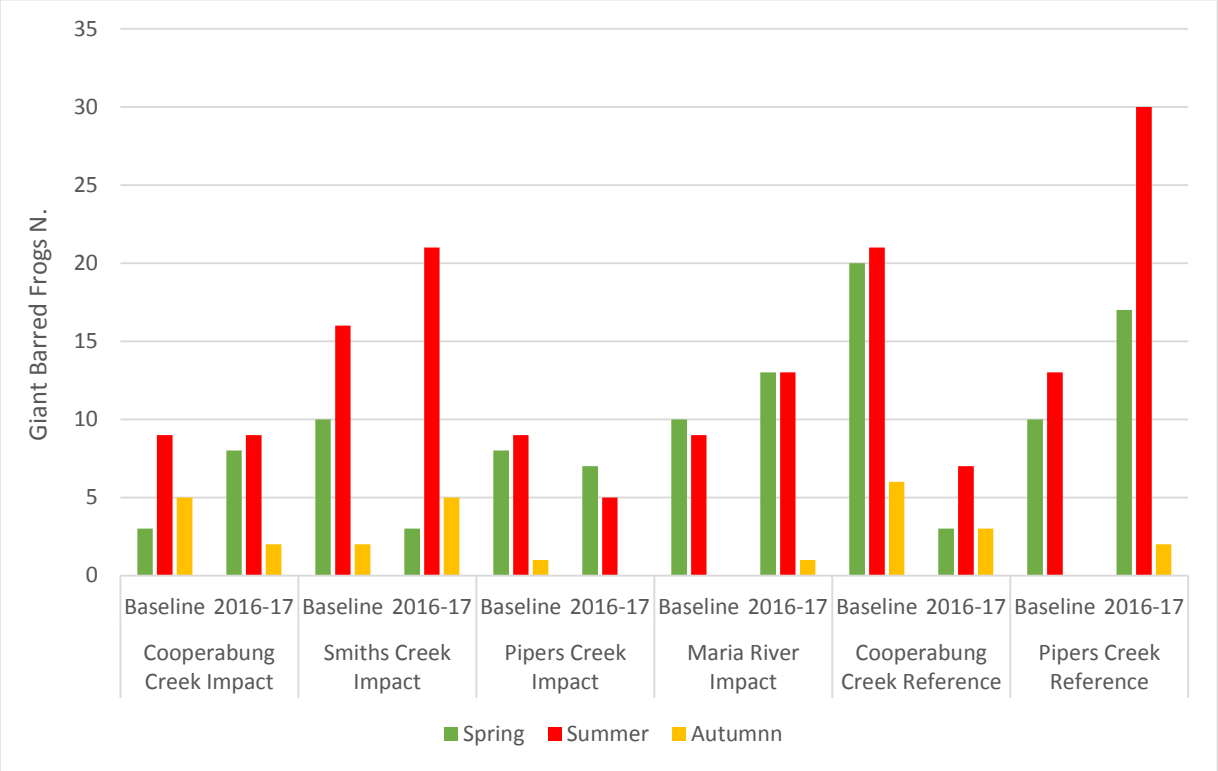

Table 5: Comparison of baseline and 2016/2017 survey results

	Cooperabung Creek Impact		Smiths Creek Impact		Pipers Creek Impact		Maria River Impact		Cooperabung Creek Reference		Pipers Creek Reference	
	Base-line	2016 2017	Base-line	2016 2017	Base-line	2016 2017	Base-line	2016 2017	Base-line	2016 2017	Base-line	2016 2017
Mean number of frogs per visit	5.67	6.33	9.33	9.67	6.00	4.00	6.33	9.00	15.67	4.33	7.67	16.33
Standard Error (SE)	1.76	2.19	4.06	5.70	2.52	2.08	3.18	4.00	4.84	1.33	3.93	8.09
MKTBA	15	15	26	26	14	11	15	24	45	8	23	38

3.3 Water quality

Water quality monitoring was undertaken by Roads and Maritime and is presented in two reports (RMS 2017a, 2017b). Presented here is a summary of the data collected for Cooperabung Creek, Smiths Creek, Pipers Creek and Maria River, for the purpose of assessing the outcomes against the water quality performance measure specified in the EMP. Annex 3 presents data extracted from the water quality reports and shows only those sampling results where the calculated median value was either above the 80th percentile or below the 20th percentile at the downstream site.

3.3.1 Parameters

Table 6 presents the number of occasions downstream (DS) median values were greater than the 80th percentile, and of these, the number that exceeded the ANZECC trigger value. All sites had at least one parameter for one or more monthly results for which the median downstream value exceeded the 80th percentile of the upstream value. These are discussed below.

Electrical conductivity: Higher than the upstream trigger value regularly throughout the 12 months. These values, while slightly elevated, were well within ANZECC guideline trigger values and mostly reflected upstream values. Water quality monitoring reporting considered impacts attributable to construction to be negligible to minor.

Dissolved oxygen: Variable results throughout the year and for sites, which may be due to algae outbreaks triggering fluctuations in dissolved oxygen. Water quality monitoring reporting considered impacts attributable to construction to be negligible.

Turbidity: Variable results throughout the year and for sites. A particularly high turbidity recorded at Maria River was reported and this is discussed in Section 3.3.2. Other events of high downstream turbidity occurred during periods when there was little to no flow between upstream and downstream. Water quality monitoring reported no obvious signs of construction activities causing elevated turbidity.

Nitrogen and Phosphorus: Variable results throughout the year and for sites. Levels were generally consistent with upstream values. Differences between upstream and downstream was generally when the sampling points were isolated ponds. Water quality monitoring reporting considered impacts attributable to construction to be negligible.

Metals: Variable results throughout the year and for sites. Limited variation occurred with the exception of aluminium, iron, magnesium and zinc. Levels were generally consistent with upstream values. Differences between upstream and downstream was generally when the sampling points were isolated ponds. Water quality monitoring reporting considered elevated metal parameters unlikely to be attributable to construction related activities.

Water quality monitoring reporting suggested that results were not inconsistent with the variability and levels experienced during the pre-construction and previous construction monitoring periods.

Table 6: Triggered water quality parameters per site

Parameter	Number of samples where DS median value > 80th % (# DS value exceeds ANZECC trigger)			
	Cooperabung Creek	Smiths Creek	Pipers Creek	Maria River
Temperature ˚C	4	2	3	3
Electrical Conductivity uS/cm	8	6	0	8
Dissolved oxygen %	3 (1)	2	3 (2)	5 (5)
pH	0	0	0	0
Turbidity (NTU)	0	2 (2)	0	1 (1)
Total suspended solids mg/L	0	3	0	0
Aluminium mg/L	2 (1)	3 (3)	1	2 (2)
Arsenic mg/L	0	0	0	3
Cadmium mg/L	0	0	0	0
Chromium mg/L	0	0	0	0
Copper mg/L	0	1 (1)	0	2 (2)
Iron mg/L	0	0	2	4
Lead mg/L	0	0	0	0
Manganese mg/L	4	3	2	4
Mercury mg/L	0	0	0	0
Nickel mg/L	2	3	0	3
Silver mg/L	0	0	0	0
Zinc mg/L	4 (4)	2 (2)	2 (2)	3 (3)
Total nitrogen mg/L	0	2 (2)	1 (1)	3 (3)
Total phosphorus mg/L	0	0	2	3 (3)

3.3.2 Incident

In March 2017 there was a reported incident involving a basin. Water quality monitoring reported the following regarding the incident: "*The monitoring result at Maria River in March 2017 was found to be attributable to construction. In this instance, it was found that a low-flow valve had not been fully closed, and some water had been draining from the basin prior to it being treated and discharged in accordance with the EPL. The basin valve was closed immediately and the cause investigated. The sediment basin checklist now includes a requirement to inspect the low-flow valve during all basins inspections, and specifically after completion of a discharge. The issue was raised as an incident in accordance with the CEMP and the EPA notified as required under the EPL"*

4. Discussion

4.1 Performance Measures

A summary of 2016/ 2017 survey results in relation to the performance measures are provided in Table 7.

Table 7: Performance measures and discussion of 2016/2017 results.

Performance measure	Discussion
Monitoring is undertaken during baseline surveys and Years 1 – 8 or until monitoring can demonstrate that mitigation measures are effective.	**This performance measure has been met for Year 1 (2015/2016) and Year 2 (2016/2017).** Giant Barred Frog monitoring has been undertaken at all six sites according to the EMP to date.
Monitoring during Year 1 – 8 is undertaken at the Impact and Control sites where baseline monitoring was undertaken, subject to landowner agreement.	**This performance measure has been met for Year 1 (2015/2016) and Year 2 (2016/2017).** Giant Barred Frog monitoring has been undertaken in all six baseline sites, where landowner agreement permitted.
Continued presence of Giant Barred Frogs during each survey event in Year 1 – 8 at sites where it was identified during baseline surveys, subject to access due to landowner agreement.	**This performance measure has been met for all sites in Year 1 (2015/2016) and 5 of 6 sites in Year 2 (2016/2017).** Baseline: recorded at all six monitoring sites in spring and summer and at four sites in autumn. Frogs were not recorded at the Maria River impact site and Pipers Creek reference site during the autumn 2014 baseline survey. 2015/2016: detected at all six sites during all surveys. 2016/2017: detected at all six sites in spring and summer and five sites in autumn. Not recorded at Pipers Creek impact site during the autumn 2017 survey where it was detected during baseline surveys.
Mitigation measures are effective as defined in the EPBC approval when all monitoring events are considered at Year 8.	This performance measure is not yet applicable.
Median values of all downstream water quality monitoring at GBF habitat or potential habitat locations during construction and operation (Year 1 – 6) is less than the 80th percentile value of the upstream site (where 80th percentile is the value at which median values at the downstream site are above 80% of the recorded background water quality records), where this change is found to be attributable to construction or operation.	**This performance measure has been met for all sites except Maria River.** All sites had at least one parameter for one or more monthly results for which the median downstream value exceeded the 80th percentile of the upstream value. However, water quality monitoring considered impacts attributable to construction to be negligible to minor for all parameters excluding the incident at Maria River.
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.	**This performance measure has been met for all sites in relation to Giant Barred Frog presence and habitat use.** Recorded numbers and recorded locations vary between season and year at all sites and no clear decline in numbers or changes in habitat use has been observed. The data collected however does not allow for discussion of movement patterns.

5. Recommendations

5.1 Contingency Measures

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those that are considered to be relevant to the Giant Barred Frog monitoring program are listed and discussed in Table 8.

Table 8: Contingency measures

Potential problem	Contingency measure proposed in EMP	Discussion of proposed measure
Decline in presence of target species recorded at Impact sites after the upgrade has been completed, when compared to change in Control sites.	The cause of the decline in populations at impacts sites will be investigated in consultation with EPA and DoTE within two weeks of results reported by ecologist. 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.	**This contingency measure is not yet relevant as the upgrade is not yet complete.** However, to date, no obvious, decline in the presence of Giant Barred Frogs has been observed during construction monitoring.

5.2 Corrective action to meet performance criteria

A summary of those performance indicators that were not met in the 2016/2017 monitoring period and recommended corrective actions are provided in Table 9.

Table 9: Corrective actions

Performance measure	Action
Continued presence of Giant Barred Frogs during each survey event in Year 1 – 8 at sites where it was identified during baseline surveys, subject to access due to landowner agreement.	**This performance measure has been met for 5 of 6 sites in Year 2 (2016/2017).** Giant Barred Frogs were not recorded at Pipers Creek impact site during the autumn 2017 survey, where it was detected during baseline surveys. Autumn surveys have shown reduced activity during almost all survey events and frog detection can vary between survey events, as such, no records of the species during this single survey cannot yet be considered as indicating the absence of this species from this site, where it was detected in the spring and summer surveys. It is worthwhile noting that Pipers Creek impact site has been highlighted as a site where Lantana is substantially hindering monitoring efforts. It is recommended that monitoring continue as per the EMP. If further monitoring fails to detect the species at this site, corrective actions will be required.
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 this change is found to be attributable to construction or operation.	**This performance measure has been met for all sites except Maria River** . All sites had at least one parameter for one or more monthly results for which the median downstream value exceeded the 80th percentile of the upstream value. Short-term elevations are reflective of environmental variability and ongoing weather conditions and are therefore considered unlikely to have an impact on Giant Barred Frogs. Water quality monitoring considered impacts attributable to construction to be negligible to minor for all parameters excluding an incident at Maria River. Immediate actions were taken at Maria River and procedures put in place to avoid reoccurrence. Recommendations are therefore to continue construction management measures to minimise impacts, ongoing review of water quality results and amend activities where necessary.

5.3 General Recommendations

Issues encountered and considerations for ongoing monitoring are discussed in Table 10.

Table 10: Recommendations

Consideration	Recommendation
Lantana density along creek lines	While Lanatana control has been previously undertaken within these areas, consideration should be given to continued Lantana control, notably along Maria River and Pipers Creek impact sites. Current density is hindering monitoring efforts. Frogs were not recorded at Pipers Creek impact site during autumn surveys. Control efforts should include progressive bush regeneration works, targeting the progressive removal of Lantana. It is recommended that such work be undertaken by suitably qualified bush regenerators, using a combination of hand weeding and cut and paint techniques. Initial works would need to be followed-up at suitable intervals to ensure that all Lantana is removed. Given the location of Lantana along the banks of the creek, the removal of lantana should be strategic (i.e. not removing all lantana at once) to avoid the risk of erosion and loss of fauna habitat e.g. bird habitat. It is recommended that initial works begin within areas least affected by Lantana and progressively working toward the most infested areas.
Chytrid fungus hygiene protocol	Chytrid fungus is considered to be present at all six sites. 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. Wash-down procedures should now be implemented at all impact sites. It is recommended to keep and review periodically a register of the wash down stations/procedures. This is not necessarily to consider exchange between Giant Barred Frog sites, where Chytrid fungus is present, but between these sites and other construction sites throughout the Project footprint.
Chytrid fungus swabbing	As Chytrid fungus is present at all monitoring sites, consideration should be given to discontinuing the additional swabbing process to reduce the time and handling of individuals of this species. The swabbing of frogs has been conducted to inform the presence of the fungus and implement control measures to prevent its transfer from infected sites to non-infected sites. Given that it has now been recorded from all sites this attempt to control its spread within Giant Barred Frog sites is no longer relevant, and monitoring of the sites to inform where control measures need to be employed would not be of any value.

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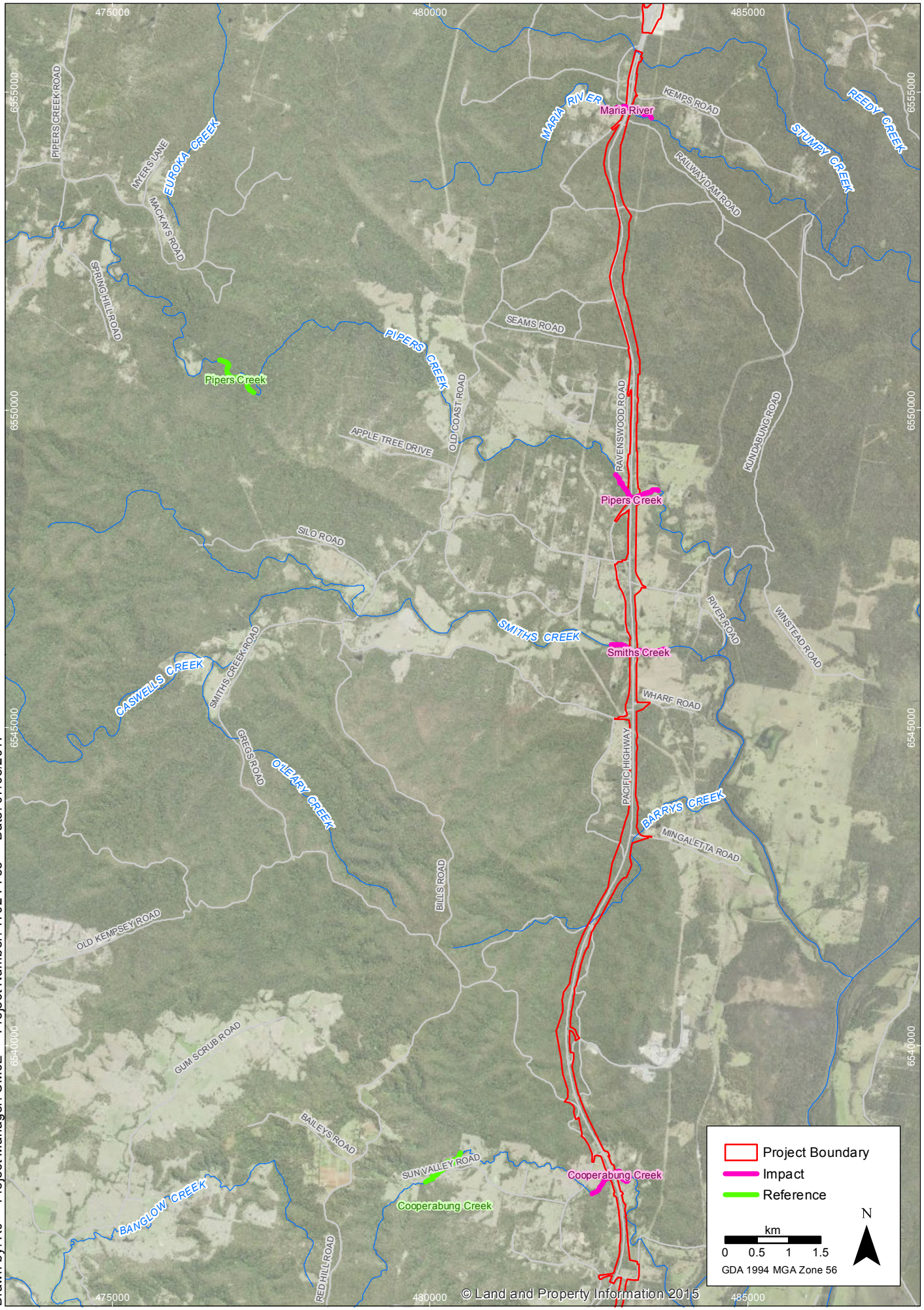

Drawn by: RJ Project Manager: CMcE Project Number: 1702 PI 53 Date: 07/08/2017

Giant Barred Frog 2016 - 2017 monitoring: sites overview

Pacific Highway Upgrade - Oxley Highway to Kempsey

FIGURE 1

Imagery: (c) LPI 2014-10-06

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Drawn by: RJ Project Manager: CMcE Project Number: 1702 PI 53 Date: 07/08/2017

Giant Barred Frog 2016 - 2017 monitoring: Cooperabung Creek Impact site

Pacific Highway Upgrade - Oxley Highway to Kempsey

FIGURE 2

niche Environment and Heritage

Imagery: (c) LPI 2014-10-06

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Giant Barred Frog 2016 - 2017 monitoring: Smiths Creek Impact site

Pacific Highway Upgrade - Oxley Highway to Kempsey

FIGURE 3

niche Environment and Heritage

Imagery: (c) LPI 2014-10-06

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Drawn by: RJ Project Manager: CMcE Project Number: 1702 PI 53 Date: 07/08/2017

Giant Barred Frog 2016 - 2017 monitoring: Pipers Creek Impact site

Pacific Highway Upgrade - Oxley Highway to Kempsey

FIGURE 4

niche Environment and Heritage

Imagery: (c) LPI 2014-10-06

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Drawn by: RJ Project Manager: CMcE Project Number: 1702 PI 53 Date: 07/08/2017

Giant Barred Frog 2016 - 2017 monitoring: Maria River Impact Site

Pacific Highway Upgrade - Oxley Highway to Kempsey

FIGURE 5

niche Environment and Heritage

Imagery: (c) LPI 2014-10-06

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Drawn by: RJ Project Manager: CMcE Project Number: 1702 PI 53 Date: 07/08/2017

Giant Barred Frog 2016 - 2017 monitoring: Cooperabung Creek Reference Site

Pacific Highway Upgrade - Oxley Highway to Kempsey

FIGURE 6

niche Environment and Heritage

Imagery: (c) LPI 2014-10-06

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Giant Barred Frog 2016 - 2017 monitoring: Pipers Creek Reference Site

Pacific Highway Upgrade - Oxley Highway to Kempsey

FIGURE 7

niche Environment and Heritage

Imagery: (c) LPI 2014-10-06

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Annex 1 – 2016/2017 data summary for each monitoring site

Cooperabung Creek Impact

Table 11: Summary of field work and prevailing abiotic variables: Cooperabung Creek impact site

Date	Time		Air Temp. °C	Water Temp. °C	Humidity %	Stream Depth (cm)	Wind (0-3, 0=no wind)	Cloud Cover %	Rain (mm)
27/10/2017	Start	9:45:00 PM	20.8	19	77	20	1	60	1
27/10/2017	Finish	12:30:00 AM	17.2	19	89	45	0	100	0
19/01/2017	Start	10:45:00 PM	22.5	23	78.2	50	0	100	0
19/01/2017	Finish	1:00:00 AM	23.9	23	77.9	25	0	100	0
28/04/2017	Start	7:20:00 PM	17.5	17.9	65	30	1	0	0
28/04/2017	Finish	8:22:00 PM	16.6	16	83	30	0	0	0

Table 12: Habitat details: 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)	Frogs detected
CIz6	60	40	80	10	20	No	1	0	150	0	Yes
CIz7(A)	60	30	40	20	30	No	2	0	80	n/a	Yes
CIz7(B)	80	30	60	20	10	No	1	0	50	n/a	Yes
CIz8	70	15	75	15	10	No	1	2	45	n/a	
CIz9	45	35	70	15	30	No	2	2	20	n/a	Yes
CIz5	85	10	60	30	20	No	2	0	30	3	Yes
CIz4	65	10	40	45	10	No	1	0	60	n/a	Yes
CIz3	80	10	75	15	5	No	1	1	80	n/a	
CIz2	20	20	50	5	40	No	2	1	80	n/a	Yes

Table 13: Summary of captures: Cooperabung Creek impact site

	Spring 2016	Summer 2017	Autumn 2017
Number of frogs recorded	8	9	2
Number of adult males	5	3	0
Number of adult females	1	3	1
Number of sub-adults	2	1	1
Number of juveniles	0	2	0
Number of recaptures	1	4	0
Number of frogs with Chytrid/ swabbed	2/7	1/9	0/2

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

Water Levels: Mean depth 62.5 cm west and 73.3 cm east.

Smiths Creek Impact

Table 14: Summary of field work and prevailing abiotic variables: Smiths Creek impact site

Date	Time		Air Temp. °C	Water Temp. °C	Humidity %	Stream Depth (cm)	Wind (0-3, 0=no wind)	Cloud Cover %	Rain (mm)
31/10/2016	Start	11:00:00 PM	18.3	29.8	76	50	0	50	0
31/10/2016	Finish	1:45:00 AM	18.2	18	79	70	0	50	0
18/01/2017	Start	11:30:00 PM	25.6	26.2	77.8	50	1.5	100	1
18/01/2017	Finish	2:30:00 AM	23.6	26.2	83.6	100	1.5	100	0
27/04/2017	Start	7:30:00 PM	17.2	16.8	53	50	1	40	0
27/04/2017	Finish	9:00:00 PM	16.7	16.8	79	50	2	0	0

Table 15: Habitat details: 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)	Frogs detected
SIz5	25	40	40	15	20	No	2	3	20	1	Yes
SIz3-4	30	15	40	25	15	No	1	0	60	n/a	Yes
SIz2-3	65	10	20	15	40	No	1	0	200	n/a	Yes
SIz1-2	70	15	35	20	35	No	1	0	50	n/a	Yes
SIz1	75	20	25	10	45	No	2	1	60	n/a	Yes
SIz6	0	10	100	5	5	No	1	0	100	1	Yes
SIz7	15	25	30	10	10	No	1	0	80	n/a	Yes
SIz8	70	35	10	30	30	Yes	2	0	20	n/a	Yes
SIz9	25	15	15	15	30	Yes	1	0	50	n/a	Yes
SIz10	15	40	20	15	35	Yes	1	0	40	n/a	Yes

Table 16: Summary of captures: Smiths Creek impact site

	Spring 2016	Summer 2017	Autumn 2017
Number of frogs recorded	3	21	5
Number of adult males	0	11	1
Number of adult females	1	4	1
Number of sub-adults	1	3	1
Number of juveniles	0	0	1
Number of recaptures	0	3	0
Number of frogs with Chytrid/ swabbed	0/2	0/19	0/4

Habitat: Microhabitat within these zones included flood debris as overhang shelter, grass and leaf litter.

Water Levels: Mean depth 92.5 cm west, 51.0 cm east.

Pipers Creek Impact

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

Date	Time		Air Temp. °C	Water Temp. °C	Humidity %	Stream Depth (cm)	Wind (0-3, 0=no wind)	Cloud Cover %	Rain (mm)
27/10/2016	Start	8:00:00 PM	24.8	21	60		1	33	0
27/10/2017	Finish	9:30:00 PM	20.4	20	75		2	60	1
19/01/2017	Start	1:16:00 AM	23	23.1	81.8	100	0	100	1
19/01/2017	Finish	3:06:00 AM	23	23.1	78.3	50	0	100	1
28/04/2017	Start	5:40:00 PM	18.9	17.9	65	80	0	0	0
28/04/2017	Finish	6:58:00 PM	18.1	17.9	65	80	0	0	0

Table 18: Habitat details recorded: 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)	Frogs detected
PIz5	35	50	15	10	35	No	1	0	200	0	
Piz4	45	10	5	15	70	No	1	0	100	n/a	Yes
Piz3	75	10	10	10	80	No	1	0	100	n/a	Yes
Piz2	15	45	10	20	50	No	1	0	150	n/a	Yes
Piz1	5	50	15	15	30	No	2	0	30	n/a	Yes
PIz6	15	35	30	20	60	No	1	0	50	2	
PIz7	20	40	50	5	20	Yes	1	0	200	few	
PIz8	50	30	20	15	60	Yes	1	0	100	n/a	Yes
PIz9	85	10	25	10	60	Yes	3	2	70	n/a	Yes
PIz10	50	30	20	10	50	Yes	3	2	30	n/a	

Table 19: Summary of captures: Pipers Creek impacts site

	Spring 2016	Summer 2017	Autumn 2017
Number of frogs recorded	7	5	0
Number of adult males	1	2	0
Number of adult females	2	1	0
Number of sub-adults	1	0	0
Number of juveniles	2	0	0
Number of recaptures	1	1	0
Number of frogs with Chytrid/ swabbed	0/6	1/4	0

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

Water Levels: Mean depth 95.0 cm west, 108.3 cm east. Over 200 cm in the deepest pool.

Maria River Impact

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

Date	Time		Air Temp. °C	Water Temp. °C	Humidity %	Stream Depth (cm)	Wind (0-3, 0=no wind)	Cloud Cover %	Rain (mm)
31/10/2016	Start	7:45:00 PM	22.3	20.3	62	50	0	100	0
30/10/2016	Finish	10:30:00 PM	19.7	20.3	74	100	0	100	0
18/01/2017	Start	8:30:00 PM	30.5	27.8	68.6	50	2	50	0
18/01/2017	Finish	11:00:00 PM	26.6	27.8	77	50	2	50	0
27/04/2017	Start	5:38:00 PM	18.7	18.9	53	70	0	100	0
27/04/2017	Finish	7:02:00 PM	17.2	17.1	53	90	1	50	0

Table 21: Habitat details: 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)	Frogs detected
MIz6-7	20	10	15	40	30	No	1	0	100	1	Yes
MIz7-8	35	25	15	25	30	No	3	2	60	n/a	Yes
MIz8-9	65	5	10	25	30	No	3	2	50	n/a	Yes
MIz9-10	15	45	20	10	20	No	2	0	60	n/a	
MIz10	5	55	25	5	10	No	1	0	50	n/a	
MIz6	15	10	30	20	25	No	2	1	30	1	Yes
MIz5	15	10	10	20	50	No	1	0	80	n/a	Yes
MIz5-4	20	50	10	15	20	No	1	0	60	n/a	Yes
MIz4	15	80	<5	<5	<5	No	1	0	25	n/a	Yes
MIz4-3	20	80	5	<5	<5	No	1	0	40	n/a	Yes

Table 22: Summary of captures: Maria River impact site

	Spring 2016	Summer 2017	Autumn 2017
Number of frogs recorded	13	13	1
Number of adult males	5	5	0
Number of adult females	5	6	1
Number of sub-adults	1	0	0
Number of juveniles	0	0	0
Number of recaptures	5	3	0
Number of frogs with Chytrid/ swabbed	0/12	0/11	0/1

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 51.3 cm west, 58.3 cm east.

Cooperabung Creek Reference

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

Date	Time		Air Temp. °C	Water Temp. °C	Humidity %	Stream Depth (cm)	Wind (0-3, 0=no wind)	Cloud Cover %	Rain (mm)
26/10/2016	Start	12:10:00 AM	15.1	18.5	83.5	10	2	100	0
26/10/2016	Finish	1:45:00 AM	14	18.5	79	40	0	0	0
17/01/2017	Start	2:45:00 AM	23.4	23.7	87	30	0	0	0
17/01/2017	Finish	4:15:00 AM	24	23.7	88.2	30	0	0	0
26/04/2017	Start	9:28:00 PM	16.2	18.2	53	30	0	0	0
26/04/2017	Finish	10:47:00 PM	13	18.2	53	40	0	0	0

Table 24: Habitat details: 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)	Frogs detected
CRz1	15	55	35	65	0	No	2	1	20	n/a	Yes
CRz2	35	45	35	65	0	No	3	2	25	n/a	Yes
CRz3	45	25	75	25	0	Yes	1	1	30	n/a	Yes
CRz4	15	60	80	20	0	Yes	2	2	35	n/a	Yes
CRz5	35	50	5	70	25	Yes	2	2	30	n/a	Yes
CRz6	20	60	3	90	7	No	2	2	40	n/a	Yes
CRz7	5	45	40	60	0	No	2	3	35	n/a	Yes
CRz8	40	10	90	5	5	Yes	1	1	25	n/a	Yes
CRz9	65	10	10	85	15	Yes	2	1	25	n/a	Yes
CRz10	60	10	15	80	5	Yes	2	1	30	n/a	Yes

Table 25: Summary of captures: Cooperabung Creek reference site

	Spring 2016	Summer 2017	Autumn 2017
Number of frogs recorded	3	7	3
Number of adult males	0	5	1
Number of adult females	3	1	1
Number of sub-adults	0	0	1
Number of juveniles	0	0	0
Number of recaptures	1	4	1
Number of frogs with Chytrid/ swabbed	1/2	0/6	0/3

Habitat: Microhabitat found being used included above and partially buried within leaf litter (some of which included Lomandra shelters) and on rock.

Water Levels: Range from 25.0 to 100 cm.

Pipers Creek Reference

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

Date	Time		Air Temp. °C	Water Temp. °C	Humidity %	Stream Depth (cm)	Wind (0-3, 0=no wind)	Cloud Cover %	Rain (mm)
26/10/2016	Start	7:39:00 PM	19.9	21	72.7	30	0	100	0
26/10/2016	Finish	11:34:00 PM	16.1	21	89.6	30	0	0	0
17/01/2016	Start	9:00:00 PM	27	26	78.5	20	0	0	0
17/01/2016	Finish	12:30:00 AM	24	26	86.4	20	0	0	0
26/04/2017	Start	6:20:00 PM	19.2	17.7	53	20	0	20	0
26/04/2017	Finish	8:32:00 PM	16.8	17.7	53	60	0	0	0

Table 27: Habitat details: Pipers Creek reference site

Zone	OS %	Shrub %	Ground cover %	Leaf litter %	Bare Earth %	Cattle	Pools	Riffles	Depth of deepest Pool (cm)	Fence breaches (if applicable)	Frogs detected
PRz5	70	40	50	50	0	No	3	2	40	n/a	Yes
PRz4	30	50	15	50	35	No	2	1	40	n/a	Yes
PRz3	60	20	35	40	25	No	1	1	75	n/a	Yes
PRz2	50	35	60	5	45	No	3	2	25	n/a	Yes
PRz1	55	40	40	5	55	No	1	2	40	n/a	Yes
PRz6	65	50	35	30	45	No	1	1	30	n/a	Yes
PRz7	40	40	20	75	5	No	1	1	100	n/a	Yes
PRz8	35	40	25	70	5	No	1	0	100	n/a	Yes
PRz9	60	30	70	20	10	No	1	0	70	n/a	Yes
PRz10	85	25	25	35	40	No	1	1	50	n/a	Yes

Table 28: Summary of captures: Pipers Creek reference site

	Spring 2016	Summer 2017	Autumn 2017
Number of frogs recorded	17	30	2
Number of adult males	6	18	1
Number of adult females	5	6	0
Number of sub-adults	0	1	1
Number of juveniles	2	1	0
Number of recaptures	5	11	0
Number of frogs with Chytrid/ swabbed	3/12	1/25	0/1

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 25.0 cm to 100 cm.

Annex 2 - Giant Barred Frog individual frog data

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

Location		Season	Sx	Age	Reproductive Status	L	W	DW	Pit_Tag_Co	Capture/Recapture	S	Z	Microhabitat	Activity
I	Cooperabung Creek	Spring	M	Adult						Not captured	N	Clz3		calling
I	Cooperabung Creek	Spring	M	Adult	Dark nuptial pads	59.5	42.0	4.0	000791E92F	Captured	Y	Clz5	Leaf litter under shrub	sitting
I	Cooperabung Creek	Spring	M	Adult	Dark nuptial pads	68.2	55.0	7.0	0007A3B45A	Captured	Y	Clz4	Under log	sitting
I	Cooperabung Creek	Spring	M	SA	Immature	582.0	45.0	9.0	000763515D	Capture	Y	Clz7	On litter	sitting
I	Cooperabung Creek	Spring	U	SA	Immature	50.0	34	10.0	00077E7E55	Capture	Y	Clz4	On litter	sitting
I	Cooperabung Creek	Spring	F	Adult	Moderate nuptial pads	87.0	90	13	0007833272	Capture	Y	Clz4	On litter	sitting
I	Cooperabung Creek	Spring	M	Adult	Moderate nuptial pads	69.0	62.0	4.5	00079205FF	Recapture	Y	Clz9	On litter	sitting
I	Cooperabung Creek	Spring	M	Adult	Light nuptial pads	65.0	55.0	16.0	00076346EC	Capture	Y	Clz4	On litter	sitting
I	Cooperabung Creek	Summer	F	Adult	Gravid	95.0	156.0	10.0	99100100062D127	Recapture	Y	Clz6	In Litter	Sitting
I	Cooperabung Creek	Summer	F	Adult	Gravid	100.0	160.0	15.0	0007D2632D	Capture	Y	Clz4	On litter	Sitting
I	Cooperabung Creek	Summer	F	Adult	Not Gravid	80.0	79	25.0	0007A3B78C	Capture	Y	Clz7	At base of tree on litter	Sitting
I	Cooperabung Creek	Summer	M	Adult	Dark Nuptial Pads	75.0	73.0	15.0	00079205FF	Recapture	Y	Clz2	On litter	Sitting
I	Cooperabung Creek	Summer	M	Adult	Dark Nuptial Pads	71.2	63	12	0007A3C3CE	Capture	Y	Clz1	At base of tree on litter	Sitting
I	Cooperabung Creek	Summer	M	Adult	Dark Nuptial Pads	72.5	73.0	6.0	0007A0DF410	Capture	Y	Clz7	On litter	Sitting
I	Cooperabung Creek	Summer	F	J	Not Gravid	79.5	65	10.0	000791E973	Recapture	Y	Clz6	in Litter	Sitting
I	Cooperabung Creek	Summer	M	J	Dark Nuptial Pads	77.0	71.0	10.0	0007359AS0	Recapture	Y	Clz7	At base of tree on litter	Sitting
I	Cooperabung Creek	Summer	U	SA		66.9	45.0	20.0	0007A0FD23	Capture	Y	CIz7	On litter	Sitting
I	Cooperabung Creek	Autumn		SA		52.7	12.0	4.5	0007635IE5	Capture	Y	CIz9	On litter	Sitting
I	Cooperabung Creek	Autumn	F	Adult	Moderately Gravid	95.0	130.0	5.0	00077E808F	Capture	Y	CIz4	On litter	Sitting
I	Maria River	Spring	F	Adult	Gravid	94.4	153.0	5.0	0007A2F3C5	Capture	Y	MIz8	On litter	Sitting
I	Maria River	Spring	F	Adult	Gravid	95.0	124.0	6.0	00079FD11C	Capture	Y	MIz7	On litter	Sitting

Location		Season	Sx	Age	Reproductive Status	L	W	DW	Pit_Tag_Co	Capture/Recapture	S	Z	Microhabitat	Activity
I	Maria River	Spring	M	Adult	Light nuptial pads	72.9	62.0	5.0	00077E7F26	Recapture	Y	MIz7	On litter	Sitting
I	Maria River	Spring	M	Adult	Light nuptial pads	75.7	69.0	7.0	00079FFA24	Capture	Y	MIz6	On litter	Sitting
I	Maria River	Spring		SA				4.0		Not captured	N	MIz5	On litter	Sitting
I	Maria River	Spring	F	Adult	Gravid	95.9	130	6.0	000791E958	Recapture	Y	MIz8	On litter	Sitting
I	Maria River	Spring	F	Adult	Gravid	104.9	160.0	6.0	0007634B30	Recapture	Y	MIz9	On litter	Sitting
I	Maria River	Spring	F	Adult	Gravid	96.2	115.0	13.0	0007634B30	Capture	Y	MIz17	On litter	Sitting
I	Maria River	Spring	M	Adult	Light nuptial pads	85.4	91.0	9.0	00077E7EBD	Recapture	Y	MIz8	On litter	Sitting
I	Maria River	Spring	M	Adult	Light nuptial pads	60.9	35.0	5.0	0007634AC3	Recapture	Y	MIz5	On litter	Sitting
I	Maria River	Spring	M	Adult	Light nuptial pads	77.8	60	2.0	00077E6BEA	Capture	Y	MIz7	On litter	Sitting
I	Maria River	Spring	U	SA		66.3	35.0	4.0	0007634BCE	Capture	Y	MIz7	On litter	Sitting
I	Maria River	Spring			Dark nuptial pads	70.2	80.0	13.0	0007635742	Capture	Y	MIz7	On litter	Sitting
I	Maria River	Summer	F	Adult	Gravid	102.0	176.0	1.0	00077E6C90	Recapture	Y	MIz7	On log	Sitting
I	Maria River	Summer	F	Adult	Gravid	93.8	140.0	0.5	00079EA489	Recapture	Y	MIz5	On bank	Sitting
I	Maria River	Summer	F	Adult	Gravid	112.2	165.0	2.0	0007634B30	Recapture	Y	MIz3	Under Litter	Sitting
I	Maria River	Summer	F	Adult	Gravid	97.3	135.0	0.0	0007D2A06E	Capture	Y	MIz7	On log	Sitting
I	Maria River	Summer	F	Adult	Gravid	102.5	135.0	1.0	0007A1021C	Capture	Y	MIz5	On litter	Sitting
I	Maria River	Summer	F	Adult	Gravid	96.2	167	4	0007A2E4F9	Capture	Y	MIz3	Under Litter	Sitting
I	Maria River	Summer	M	Adult	Moderate Nuptial Pads	70.0	42.0	7.0	00079206EB	Capture	Y	MIz7	On litter	Sitting
I	Maria River	Summer	M	Adult	Dark Nuptial Pads	89.3	75.0	3.0	0007D1ACFA	Capture	Y	MIz5	On litter	Jumpng
I	Maria River	Summer	M	Adult	Dark Nuptial Pads	71.0	70.0	5.0	0007A3A292	Capture	Y	MIz2	On litter	Sitting
I	Maria River	Summer	M	Adult	Dark Nuptial Pads	67.0	56	5	0007D1E5BB	Capture	Y	MIz3	On bank	Sitting
I	Maria River	Summer	M	Adult	Dark Nuptial Pads	68.7	61.0	10.0	0007A113B6	Capture	Y	MIz4	On litter	Sitting
I	Maria River	Summer						3.0		Not captured	N	MIz1	Under Litter	Sitting
I	Maria River	Summer						3.0		Not captured	N	MIz3	On bank	Sitting
I	Maria River	Autumn	F	Adult	Moderately Gravid	98.6	133	10	0007634952	Capture	Y	MIz9	Leaf litter	Sitting

Location		Season	Sx	Age	Reproductive Status	L	W	DW	Pit_Tag_Co	Capture/Recapture	S	Z	Microhabitat	Activity
I	Pipers Creek	Spring	U	J	n/a	46.5	16	2	000763533F	Capture	Y	PIz9	On grass	Sitting
I	Pipers Creek	Spring	U	J	n/a	39.0	16.0	4.0	000763533F	Capture	Y	PIz9	On grass	Sitting
I	Pipers Creek	Spring	U	SA	n/a	49.9	19.0	0.7	0007A3B4AD	Capture	Y	PIz8		
I	Pipers Creek	Spring	F	Adult	Gravid	94.5	253.0	6.0	0007633338	Capture	Y	PIz2	On litter	
I	Pipers Creek	Spring	F	Adult	Gravid	99.5	165	12	00077E7DA3	Recapture	Y	PIz8		
I	Pipers Creek	Spring	M					10.0		Not captured	N	PIz1	On Ground	
I	Pipers Creek	Spring	U	SA		53.6	26.0	5.0	00076356BC	Capture	Y	PIz2	On litter	Calling
I	Pipers Creek	Summer	F	Adult	Gravid	98.8	65.0	8.0	0007A0F015	Capture	Y	PIz3	Under Litter	Sitting
I	Pipers Creek	Summer	M	Adult	Light Nuptial Pads	60.7	93.0	12.0	0007A3B4AD	Recapture	Y	PIz3	On litter	Sitting
I	Pipers Creek	Summer	M	Adult	Light Nuptial Pads	66.9	31.0	10.0	000792057C	Capture	Y	PIz3	On litter	Sitting
I	Pipers Creek	Summer		Adult		62.5	34.0	8.0	0007A0EC64	Not Captured	Y	PIz9	In Litter	Sitting
I	Pipers Creek	Summer						12.0		Not Captured	N	PIz4	In Litter	Sitting
I	Smiths Creek	Spring	F	Adult	Light nuptial pads	76.8	83.0	2.0	0007A3C879	Capture	Y	SIz2	On Litter	Sitting
I	Smiths Creek	Spring		Adult						Not captured	N			
I	Smiths Creek	Spring	U	SA		50.4	20.0	4.0	000791EA05	Capture	Y	SIz4	Wood debris	Sitting
I	Smiths Creek	Summer	F?	Adult	Not Gravid	62.6	33.0	3.0	00077A0E9CC	Capture	Y	SIz1	On litter	Sitting
I	Smiths Creek	Summer	F	Adult	Gravid	105.6	145.0	8.0	0007921840	Capture	Y	SIz7	On litter	Sitting
I	Smiths Creek	Summer	F	Adult	Gravid	90.0	150.0	5.0	00077E7EE0	Capture	Y	SIz7	On litter	Sitting
I	Smiths Creek	Summer	F	Adult	Gravid	81.4	95.0	10.0	0007D1D046	Capture	Y	SIz6	On litter	Sitting
I	Smiths Creek	Summer	M	Adult	Light Nuptial Pads	68.9	55.0	10.0	0007A3A906	Recapture	Y	SIz4	On litter	Sitting
I	Smiths Creek	Summer	M	Adult	Dark Nuptial Pads	64.1	61.0	6.0	0007D26801	Recapture	Y	SIz5	In litter	Sitting
I	Smiths Creek	Summer	M	Adult	Moderate Nuptial Pads	62.0	39	8	0007D1CB91	Not Captured	N	SIz5	On litter	Sitting
I	Smiths Creek	Summer	M	Adult	Moderate Nuptial Pads	64.1	41	1.0	0007A0E076	Not Captured	N	SIz8	In litter	Sitting
I	Smiths Creek	Summer	M	Adult	Dark Nuptial Pads	67.2	53.0	3.0	0007A11983	Capture	Y	SIz6	On litter	Sitting
I	Smiths Creek	Summer	M	Adult	Light Nuptial Pads	62.5	37.0	3.0	0007D1E29B	Capture	Y	SIz10	On litter	Sitting

Location		Season	Sx	Age	Reproductive Status	L	W	DW	Pit_Tag_Co	Capture/Recapture	S	Z	Microhabitat	Activity
I	Smiths Creek	Summer	M	Adult	Dark Nuptial Pads	72.4	52.0	3.0	0007A3BD29	Capture	Y	SIz9	In grass	Sitting
I	Smiths Creek	Summer	M	Adult	Light Nuptial Pads	61.1	32.0	10.0	000791EA05	Capture	Y	SIz10	On litter	Sitting
I	Smiths Creek	Summer	M	Adult	Dark Nuptial Pads	84.5	76.0	5.0	000763463C	Capture	Y	SIz8	On litter	Sitting
I	Smiths Creek	Summer	M	Adult	Dark Nuptial Pads	78.1	63.0	7.0	00077E6B54	Capture	Y		In litter	Sitting
I	Smiths Creek	Summer						10.0		Recapture	Y		On bank	Sitting
I	Smiths Creek	Summer						5.0		Capture	Y	SIz7	On litter	Sitting
I	Smiths Creek	Summer						6.0		Capture	Y	SIz5	In litter	Sitting
I	Smiths Creek	Summer		SA		61.2	32.0	4.0	00079EA483	Capture	Y	SIz10	On litter	Sitting
I	Smiths Creek	Summer		SA		54.4	30.0	6.0	0007A0F7D7	Capture	Y	SIz6	On litter	Sitting
I	Smiths Creek	Summer		SA		52.3	24.0	12.0	0007A0EF07	Capture	Y		On litter	Sitting
I	Smiths Creek	Summer	M	Adult	Moderate Nuptial Pads	72.9	64.0	3.0	0007A0F8D0	Capture	Y	SIz6	In litter	Sitting
I	Smiths Creek	Autumn		J				1.5		Not captured	N	SIz5	In privet	Sitting
I	Smiths Creek	Autumn	M	Adult	Moderate Nuptial Pads	72.1	61	3.0	0007634E98	Capture	Y	SIz8	On litter	Sitting
I	Smiths Creek	Autumn		SA		68.7	61.0	5.0	0007634EE6	Capture	Y	SIz9	On litter	Sitting
I	Smiths Creek	Autumn	U					8.0		Not Captured	Y	SIz12	Under log	Sitting
I	Smiths Creek	Autumn	F	Adult				2.0		Not Captured	Y	SIz12	On litter	Sitting
Ref	Cooperabung Creek	Spring	F	Adult	Gravid	90.0	110.0	0.5	00079204EA	Recapture	Y	CRz3	Open ground	Sitting
Ref	Cooperabung Creek	Spring	F	Adult	Gravid	93.0	128.0	5.0	0007634827	Capture	Y	CRz1	Open ground	Sitting
Ref	Cooperabung Creek	Spring	F	Adult	Gravid	95.1	110.0	5.0	000763550A	Capture	Y	CRz2	Under leaf litter	Half buried
Ref	Cooperabung Creek	Summer	F	Adult	Gravid	109.5	179.0	3.0	00077E7FEB	Recapture	Y	CRz3	Under Lomandra	Sitting
Ref	Cooperabung Creek	Summer	M	Adult	Dark Nuptial Pads	77.8	64.0	1.0	00077E6AA0	Recapture	Y	CRz3	Under Lomandra	Sitting
Ref	Cooperabung Creek	Summer	M	Adult	Dark Nuptial Pads	75.5	75.0	2.0	00077E6AB1	Recapture	Y	CRz3	On litter	Sitting
Ref	Cooperabung Creek	Summer	M	Adult	Dark Nuptial Pads	79.4	75.0	2.0	00077E6CE7	Recapture	Y	CRz3	On litter	Sitting
Ref	Cooperabung Creek	Summer	M	Adult	Dark Nuptial Pads	67.9	57.0	1.0	1375334	Capture	Y	CRz10	On rock	Sitting

Location		Season	Sx	Age	Reproductive Status	L	W	DW	Pit_Tag_Co	Capture/Recapture	S	Z	Microhabitat	Activity
Ref	Cooperabung Creek	Summer	M	Adult	Dark Nuptial Pads	74.2	55.0	3.0	1374657	Capture	Y	CRz10	Base of tree	Sitting
Ref	Cooperabung Creek	Summer									N	CRz3		Calling
Ref	Cooperabung Creek	Autumn	M	Adult	Light Nuptial Pads	77.6	61	4.0	0007633E38	Capture	Y	CRz5	On Litter	Sitting
Ref	Cooperabung Creek	Autumn		SA		57.3	20.0	1.5	0077E8102	Capture	Y	CRz4	In Litter	Sitting
Ref	Cooperabung Creek	Autumn	F	Adult	Moderately Gravid	98.0	158	2.0	000763550A	Recapture	Y	CRz3	In Litter	Sitting
Ref	Pipers Creek	Spring	F	Adult	Gravid	91.0	128.0	10.0	0007633434	Recapture	Y	PRz2	Open ground	Sitting
Ref	Pipers Creek	Spring	F	Adult	Gravid	95.4	101.0	2.0	000792078E	Capture	Y	PRz1	In litter	Sitting
Ref	Pipers Creek	Spring	F	Adult	Gravid	98.8	111.0	5.0	000791EC0F	Capture	Y	PRz5	Under Lomandra	Sitting
Ref	Pipers Creek	Spring	F			77.5	86.0	7.0	00076350FA	Capture	Y	PRz6	Open ground	Sitting
Ref	Pipers Creek	Spring	F?			88.9	109.0	2.0	00077E80D9	Recapture	Y	PRz2	Under Litter	Buried
Ref	Pipers Creek	Spring	J		Juvenile	53.3	22	3	000791EC0D	Recapture	Y	PRz2	On ground	Sitting
Ref	Pipers Creek	Spring	J		Juvenile	54.5	19.0	0.5			Y	PRz6	On ground	Buried
Ref	Pipers Creek	Spring	M			75.5	57.0	2.0	000791EBA3	Recapture	Y	PRz4	Under Lomandra	Sitting
Ref	Pipers Creek	Spring	M			75.0	67	2.0	000791EC27	Recapture	Y	PRz3	Open ground	Sitting
Ref	Pipers Creek	Spring	M							Not captured	N			
Ref	Pipers Creek	Spring	M	Adult	Dark nuptial pads	73.8	56.0	3.0	000634742	Capture	Y	PRz7	On path	Jumpng
Ref	Pipers Creek	Spring	M			79.8	73.0	3.0	000791EB5B	Capture	Y	PRz1	Under Palm	Sitting
Ref	Pipers Creek	Spring	M		Dark nuptial pads	73.3	62.0	1.5	000791E994	Capture	Y	PRz4	Under Lomandra	Sitting
Ref	Pipers Creek	Spring	F?							Not captured	N			
Ref	Pipers Creek	Spring	U							Not captured	N			
Ref	Pipers Creek	Spring	U					4.0		Not captured	N			
Ref	Pipers Creek	Spring	U							Not captured	N			
Ref	Pipers Creek	Summer	F	Adult	Gravid	105.6	150.0	10.0	00079217BF	Recapture	Y	PRz5	On litter	Sitting
Ref	Pipers Creek	Summer	F	Adult	Moderate Gravid	90.6	133.0	4.0	000763S0FA	Recapture	Y	PRz2	On litter	Sitting
Ref	Pipers Creek	Summer	F	Adult	Gravid	94.0	165.0	15.0	00077E8009	Recapture	Y	PRz1	On litter	Sitting

Location		Season	Sx	Age	Reproductive Status	L	W	DW	Pit_Tag_Co	Capture/Recapture	S	Z	Microhabitat	Activity
Ref	Pipers Creek	Summer	F	Adult	Moderately Gravid	89.9	120.0	1.0	00077E8057	Recapture	Y	PRz8	On litter under log	Sitting
Ref	Pipers Creek	Summer	F	Adult	Gravid	95.5	126.0	7.0	00070276F1	Recapture	Y	PRz8	On litter	Sitting
Ref	Pipers Creek	Summer	F	Adult	Moderately Gravid	88.4	120.0	10.0	1372278	Capture	Y	PRz5	On litter	Sitting
Ref	Pipers Creek	Summer	F	Adult	Gravid	91.6	135.0	5.0	1373862	Capture	Y	PRz1	On litter	Sitting
Ref	Pipers Creek	Summer	M	Adult	Dark Nuptial Pads	73.4	65.0	10.0	000791EAAF	Recapture	Y	PRz4	On litter	Sitting
Ref	Pipers Creek	Summer	M	Adult	Moderate Nuptial Pads	79.4	70.0	4.0	000791EBA3	Recapture	Y	PRz2	On litter	Sitting
Ref	Pipers Creek	Summer	M	Adult	Dark Nuptial Pads	72.5	65.0	3.0	00079206C4	Recapture	N	PRz2	On litter	Sitting
Ref	Pipers Creek	Summer	M	Adult	Moderate Nuptial Pads	85.8	73.0	2.0	000791E994	Recapture	Y	PRz7	On log	Sitting
Ref	Pipers Creek	Summer	M	Adult	Dark Nuptial Pads	70.5	66.0	1.0	0007020600	Recapture	Y	PRz8	On litter	Sitting
Ref	Pipers Creek	Summer	M	Adult						Not Captured	N	PRz7		Calling
Ref	Pipers Creek	Summer	M	Adult	Dark Nuptial Pads	79.4	66.0	2.0	1372640	Capture	Y	PRz5	On log	Sitting
Ref	Pipers Creek	Summer	M	Adult	Light Nuptial Pads	69.3	52.0	10.0	1376148	Capture	Y	PRz5	On ground	Sitting
Ref	Pipers Creek	Summer	M	Adult	Dark Nuptial Pads	70.0	60.0	1.0	1372856	Capture	Y	PRz5	On litter	Sitting
Ref	Pipers Creek	Summer	M	Adult	Dark Nuptial Pads	73.6	57.0	1.0	137325?	Capture	Y	PRz5	Under Lomandra	Sitting
Ref	Pipers Creek	Summer	M	Adult	Moderate Nuptial Pads	73.7	60.0	0.0	1373270	Capture	Y	PRz4	On rock	Sitting
Ref	Pipers Creek	Summer	M	Adult	Dark Nuptial Pads	73.3	48.0	3.0	1376288	Capture	Y	PRz3	Under Lomandra	Sitting
Ref	Pipers Creek	Summer	M	Adult	Dark Nuptial Pads	72.7	60.0	5.0	1328439	Capture	Y	PRz3	On Litter, under log	sitting
Ref	Pipers Creek	Summer	M	Adult	Dark Nuptial Pads	76.5	80.0	2.0	1374700	Capture	Y	PRz2	On rock, in creek	sitting
Ref	Pipers Creek	Summer	M	Adult	Moderate Nuptial Pads	72.7	58.0	1.0	1375092	Capture	Y	PRZ1	On rock	Sitting
Ref	Pipers Creek	Summer	M	Adult	Light Nuptial Pads	70.6	47.0	2.0	1373280	Capture	Y	PRz1	On log	Sitting
Ref	Pipers Creek	Summer	M	Adult	Dark Nuptial Pads	69.8	62.0	12.0	1372746	Capture	Y	PRz7	On litter	Sitting
Ref	Pipers Creek	Summer	M	Adult	Dark Nuptial Pads	71.8	51.0	0.5	1372623	Capture	Y	PRz9	On rock	Sitting
Ref	Pipers Creek	Summer	F	J	Moderately Gravid	87.7	110	8.0	00077E6D03	Recapture	N	PRz7	Base of tree	Sitting
Ref	Pipers Creek	Summer	U					10.0		Not Captured	Y	PRz2	On litter	Sitting
Ref	Pipers Creek	Summer	U					7.0		Not Captured	N	PRz8	On litter	Sitting

Location		Season	Sx	Age	Reproductive Status	L	W	DW	Pit_Tag_Co	Capture/Recapture	S	Z	Microhabitat	Activity
Ref	Pipers Creek	Summer	U					7.0		Not Captured	N	PRz8	On litter	Sitting
Ref	Pipers Creek	Summer	M	SA		57.6	25.0	1.0	1373646	Capture	Y	PRz8	On litter	Sitting
Ref	Pipers Creek	Autumn	M	Adult						Not Captured	Y	PRz2	Under litter	Sitting
Ref	Pipers Creek	Autumn	U	SA		55.2	20.0	15.0	000791EC91	Capture	Y	PRz1	On litter	Sitting

Annex 3 - Water Quality data (extracted from RMS 2017a and RMS 2017b)

Table 29: Triggered water quality parameters: Cooperabung Creek

Parameter	ANZECC trigger value	Median downstream site value (Upstream 20th % - 80th % trigger range) Values in black = < 20th % Values in red = > 80th % Shaded cells = outside/above ANZECC trigger											
		Aug 16	Sept 16	Oct 16	Nov 16	Dec 16	Jan 17	Feb 17	Mar 17	Apr 17	May 17	Jun 17	Jul 17
Temperature ˚C	NA	13.0 (14.4-21.8)				22.2 (14.3-21.2)	23.3 (14.3-21.2)	26.2 (14.4-21.5)	22.2 (14.4-21.1)				12.4 (15.0-20.8)
Electrical Conductivity uS/cm	125 – 2200		216 (143-204)	321 (143-208)	287 (167-227)	471 (177-231)	604 (177-231)	588 (178-230)	481 (167-248)	258 (165-248)		178 (180-248)	
Dissolved oxygen %	85 – 110	91 (45-89)		41 (43-89)			87 (38-84)	103 (38-84)					
pH	6.5 – 8				7.0 (7.1-7.6)	6.9 (7.3-7.7)	6.8 (7.3-7.7)	7.1 (7.2-7.6)	6.4 (7.0-7.6)	6.7 (6.8-7.5)			
Turbidity (NTU)	6 – 50		7 (12-32)	5 (10-32)		7 (9-23)							
Total suspended solids mg/L	-												
Aluminium mg/L	0.055	0.35 (0.03-0.32)					0.01 (0.03-0.26)	0.01 (0.03-0.26)				0.43 (0.03-0.24)	
Arsenic mg/L	0.024												
Cadmium mg/L	0.0002												
Chromium mg/L	0.001												
Copper mg/L	0.0014												
Iron mg/L	ID	0.33 (0.38-0.78)		0.27 (0.43-0.78)		0.10 (0.48-0.85)	0.12 (0.48-0.85	0.14 (0.48-0.85)		0.33 (0.4-0.85)			0.35 (0.37-0.78)
Lead mg/L	0.0034												
Manganese mg/L	1.9			0.208 (0.022-0.107)	0.294 (0.022-0.107)		0.271 (0.022-0.136)	0.599 (0.022-0.136)				0.022 (0.024-0.136)	
Mercury mg/L	0.0006												
Nickel mg/L	0.011					0.002 (0.001-0.001)			0.002 (0.001-0.001)				
Silver mg/L													
Zinc mg/L	0.008					0.023 (0.005-0.007)	0.021 (0.005-0.007)	0.018 (0.005-0.007)	0.023 (0.005-0.008)				
Total nitrogen mg/L	0.5										0.1 (0.2-0.5)		
Total phosphorus mg/L	0.05												

Table 30: Triggered water quality parameters: Smiths Creek

Parameter	ANZECC trigger value	Median downstream site value (Upstream 20th % - 80th % trigger range) Values in black = < 20th % Values in red = > 80th % Shaded cells = outside/above ANZECC trigger											
		Aug 16	Sept 16	Oct 16	Nov 16	Dec 16	Jan 17	Feb 17	Mar 17	Apr 17	May 17	Jun 17	Jul 17
Temperature ˚C	NA	12.6 (14.5-21.3)				24.8 (14.0-20.1)	21.5 (14.0-21.0)					14.4 (16.4-23.9)	11.3 (15.1-23.9)
Electrical Conductivity us/cm	125 – 2200			285 (168-242)	255 (168-244)	675 (174-255)	718 (174-265)	971 (174-351)	629 (183-365)	192 (205-365)		169 (190-365)	
Dissolved oxygen %	85 – 110											87 (17-81)	95 (17-84)
pH	6.5 – 8					6.7 (6.8-7.3)							
Turbidity (NTU)	6 – 50			8 (10-23)	53 (10-32)				70 (13-43)				10 (12-26)
Total suspnd solids mg/L	-				8 (5-5)	13 (5-6)		9 (5-8)					
Aluminium mg/L	0.055	0.69 (0.05-0.47)				0.03 (0.05-0.16)	0.02 (0.04-0.13)	0.01 (0.02-0.12)		0.20 (0.02-0.13)		0.43 (0.05-0.27)	
Arsenic mg/L	0.024												
Cadmium mg/L	0.0002												
Chromium mg/L	0.001												
Copper mg/L	0.0014						0.003 (0.001-0.001)						
Iron mg/L	ID	0.43 (0.45-0.80)	0.32 (0.42-0.77)			0.26 (0.40-0.85)			0.16 (0.37-1.43)				
Lead mg/L	0.0034												
Manganese mg/L	1.9	0.010 (0.011-0.147)				0.661 (0.011-0.205)	0.481 (0.011-0.212)	0.985 (0.011-0.266)				0.009 (0.011-0.217)	
Mercury mg/L	0.0006												
Nickel mg/L	0.011						0.002 (0.001-0.001)	0.003 (0.001-0.001)	0.002 (0.001-0.001)				
Silver mg/L													
Zinc mg/L	0.008				0.011 (0.005-0.008)						0.016 (0.005-0.008)		
Total nitrogen mg/L	0.5					1.0 (0.2-0.4)			0.8 (0.2-0.7)				
Total phosphorus mg/L	0.05		0.01 (0.02-0.06)	0.01 (0.02-0.05)				0.01 (0.02-0.08)					

Table 31: Triggered water quality parameters: Pipers Creek

Parameter	ANZECC trigger value	Median downstream site value (Upstream 20th % - 80th % trigger range) Values in black = < 20th % Values in red = > 80th % Shaded cells = outside/above ANZECC trigger											
		Aug 16	Sept 16	Oct 16	Nov 16	Dec 16	Jan 17	Feb 17	Mar 17	Apr 17	May 17	Jun 17	Jul 17
Temperature ˚C	NA	12.4 (14.2-22.3)				27.2 (14.2-21.7)	22.8 (14.2-22.0)	27.0 (14.2-24.0)			16.6 (16.8-24.1)	13.9 (16.8-24.1)	11.2 (14.9-24.1)
Electrical Conductivity uS/cm	125 – 2200									64 (268-495)		264 (273-495)	
Dissolved oxygen %	85 – 110	87 (26-81)					12 (37-81)					81 (33-73)	83 (33-76)
pH	6.5 – 8										6.9 (7.0-7.2)		
Turbidity (NTU)	6 – 50		15 (16-47)	10 (16-47)						2 (14-46)	11 (12-51)		11 (12-47)
Total suspended solids mg/L	-												
Aluminium mg/L	0.055	0.56 (0.04-0.27)					0.01 (0.02-0.18)						
Arsenic mg/L	0.024												
Cadmium mg/L	0.0002												
Chromium mg/L	0.001												
Copper mg/L	0.0014												
Iron mg/L	ID										0.82 (0.34-0.69)		0.68 (0.36-0.64)
Lead mg/L	0.0034												
Manganese mg/L	1.9	0.014 (0.018-0.266)					0.535 (0.023-0.294)	0.372 (0.023-0.294)					
Mercury mg/L	0.0006												
Nickel mg/L	0.011												
Silver mg/L													
Zinc mg/L	0.008						0.018 (0.005-0.008)	0.009 (0.005-0.008)					
Total nitrogen mg/L	0.5			0.2 (0.3-0.6)					1.1 (0.3-0.6)				
Total phosphorus mg/L	0.05		0.01 (0.02-0.03)	0.01 (0.02-0.03)			0.04 (0.01-0.03)		0.04 (0.01-0.03)				

Table 32: Triggered water quality parameters: Maria River

Parameter	ANZECC trigger value	Median downstream site value (Upstream 20th % - 80th % range) Values in black = < 20th % Values in red = > 80th %											
		Aug 16	Sept 16	Oct 16	Nov 16	Dec 16	Jan 17	Feb 17	Mar 17	Apr 17	May 17	Jun 17	Jul 17
Temperature ˚C	NA	12.9 (14.2-22.2)				24.7 (13.9-21.5)	21.9 (13.9-21.4)	24.9 (13.9-23.1)				14.1 (16.2-24.2)	11.1 (15.2-24.2)
Elctrical Cndctvty uS/cm	125 – 2200		283 (177-236)	303 (186-285)	298 (196-285)	317 (196-285)	391 (187-285)	485 (187-246)	305 (192-286)				283 (192-255)
Dissolved oxygen %	85 – 110	55 (16-48)	56 (16-50)					64 (17-43)	60 (17-51)				50 (15-43)
pH	6.5 – 8		6.1 (6.3-7.0)						6.2 (6.4-7.0)	6.0 (6.4-7.0)	6.3 (6.5-7.0)	6.1 (6.4-7.0)	
Turbidity (NTU)	6 – 50		9 (22-65)	8 (13-58)					80 (11-34)				0 (12-42)
Total suspnd solids mg/L	-	5 (6-14)	5 (6-14)			13 (5-11)	11 (5-9)	16 (5-9)	41 (5-9)				
Aluminium mg/L	0.055	0.61 (0.04-0.57)				0.02 (0.03-0.42)		0.01 (0.02-0.33)				0.58 (0.03-0.53)	
Arsenic mg/L	0.024				0.002 (0.001-0.001)	0.002 (0.001-0.001)	0.005 (0.001-0.002)						
Cadmium mg/L	0.0002												
Chromium mg/L	0.001												
Copper mg/L	0.0014					0.240 (0.001-0.001)			0.002 (0.001-0.001)				
Iron mg/L	ID					1.57 (0.46-1.06)	3.84 (0.46-1.18)	1.71 (0.46-1.29)	0.35 (0.38-1.29)		1.34 (0.55-1.29)		
Lead mg/L	0.0034												
Manganese mg/L	1.9	0.031 (0.055-0.206)			0.282 (0.055-0.206)	0.301 (0.074-0.221)	0.451 (0.074-0.231)	0.439 (0.074-0.279)				0.034 (0.055-0.253)	
Mercury mg/L	0.0006												
Nickel mg/L	0.011								0.002 (0.001-0.001)	0.002 (0.001-0.001)	0.003 (0.001-0.001)		
Silver mg/L													
Zinc mg/L	0.008						0.011 (0.005-0.007)		0.014 (0.005-0.007)		0.009 (0.005-0.008)		
Total nitrogen mg/L	0.5		1.0 (0.5-0.8)	0.4 (0.5-0.7)		1.0 (0.4-0.6)	0.9 (0.4-0.7)	1.2 (0.5-0.8)				0.5 (0.6-0.9)	0.4 (0.6-0.9)
Total phosphorus mg/L	0.05					0.06 (0.01-0.05)	0.06 (0.01-0.05)		0.07 (0.01-0.05)			0.01 (0.03-0.05)	0.01 (0.02-0.05)

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Annex 3. Road Kill monitoring 2016/2017 (Niche 2017e)

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Road Kill Monitoring 2016/2017

Oxley Highway to Kempsey, Pacific Highway Upgrade

Prepared for Road and Maritime Services

20 September 2017

Document control

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Project Director:	Rhidian Harrington
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Cover photograph: Fauna fence spring 2017 (Photo: J. Danvers)

Executive summary

Context

This report details the findings of the road kill surveys undertaken from July 27 2016 to July 28 2017, 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 fauna mitigation measures on the OH2K Pacific Highway Upgrade (the Project).

Methods

Surveys were conducted weekly for the period July 27 2016 to July 28 2017. Surveys involved 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. Geographic coordinates and species, where possible, were recorded. Where a threatened species was identified, additional information was recorded.

Key results

A total of 134 road kill animals were recorded over 53 weeks of monitoring, in comparison to 100 records for 12 weeks of baseline surveys. The 2016/2017 monitoring period recorded a lower average weekly road kill than baseline surveys for all seasons when considering the entire monitoring period, and when considering only the same four week period of construction surveys as the baseline surveys. One threatened species, the Koala, was recorded on two occasions (one beyond the northern boundary of the OH2K project) as road kill during the current monitoring period. Fauna fencing, underpasses and culverts are in the vicinity of the Koala road kill locations, as well as additional retrofitted boundary fencing to direct fauna towards the underpass.

Conclusions

Current trends indicate an overall reduction in road kill incidence during construction activities. The surveys for 2016/2017 show a reduced road kill rate compared to the baseline surveys in spring, summer and autumn, as such the performance indicator relating to reduced road kill incidence has been met. Other performance indicators relating to mitigation measures (rope bridges, fauna fencing and underpasses) are not yet relevant as structures are still under construction.

Management implications

There are no current recommendations based on the outcomes of the 2016/2017 monitoring period. Continued monitoring of road kill upon completion of mitigation measures will provide further information as to the effectiveness of these measures.

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1. Introduction

1.1 Context

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

1.1.1 Monitoring Framework

Road kill monitoring is to be performed in accordance with the EMP. The monitoring framework provided within the EMP and the reporting status is shown in Table 1.

Table 1: Road kill monitoring

Project Phase	Monitoring event: report	Timing of survey	Location
Baseline	*spring 2013, summer 2014, autumn 2014:* Niche 2015	Weekly during October (spring), January (summer) and April (autumn) prior to commencement of construction (12 weeks)	Entire length of existing highway in Project area
During clearing operations	*November 2014- July 2015*: Niche 2015	Daily	Portion of existing highway adjacent to clearing operations
One month following clearing operations			
For the duration of construction	*8 August 2015 – 22 July 2016*: Niche 2016 *27 July 2016 – 28 July 2017*: current report	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

1.1.2 Baseline Data

Baseline surveys were undertaken prior to the commencement of construction over 12 weeks in spring 2013, summer 2014 and autumn 2014. Monitoring took place weekly for four weeks in each of the seasons as required by the EMP. Baseline surveys recorded 100 animals as road kill during the three monitoring events, representing 33 species and an average weekly road kill for spring, summer and autumn of 9.5, 12.0 and 3.3 respectively.

1.1.3 Purpose of this report

This report complies with the monitoring requirements described within the EMP and details the findings obtained from the construction phase of monitoring from July 27 2016 – July 28 2017. The aim of this report is to summarise the methods and results of the 2016/2017 road kill monitoring and determine if performance measures have been met, as per the EMP.

1.2 Performance Measures

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

- *"Lower rates of road kill in proximity (i.e. areas of the main carriageways within areas adjacent to installed fauna fencing, and within 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."*

1.3 Monitoring Timing

The 2016/2017 monitoring period involved weekly monitoring of the entire length of the existing highway.

1.4 Reporting

Annual reporting of monitoring results are required to include:

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

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

1.5 Limitations

Due to safety concerns associated with slowing down or stopping on the highway, and prescribed data collection methods, data collection was limited to the following:

- Some road kill fauna were identified to the "vertebrate group" level only.
- Some road kill fauna could not be identified as a result of extensive collision damage. These records were classified as 'unknown'.
- It was not always possible to remove road kill fauna from the road side, potentially resulting in double counts.
- Small-sized road kill fauna have the potential to be partially or wholly removed by scavenger animals, resulting in impossible identification from the vehicle. As a result, it is possible that small fauna such as frogs, snakes, small mammals and birds have been under counted.
- Road kill surveys undertaken during and after clearing operations concerned only those sections of the highway adjacent to the areas being cleared. As such, these surveys cannot be compared with baseline and construction surveys where the entire length of the highway was surveyed.

2. Survey Methods

The survey method described within the EMP was employed for all surveys and is provided 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 safely 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.

The EMP also notes that: "*If the animal is identified as a TSC Act or EPBC Act threatened species, the following information will also be 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, for TSC Act or EPBC Act threatened species, local habitat attributes will be 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."*

3. Results

The results summarise the 2016/2017 weekly monitoring undertaken from July 27 2016 to July 28 2017, a total of 53 monitoring events. Figure 1 shows the seasonal distribution of all road kill for the baseline and 2016/2017 monitoring period. The data was collected by Road and Maritime Services and is summarised below. The raw data is provided in Annex 1.

3.1 2016/2017 weekly monitoring

Fauna results

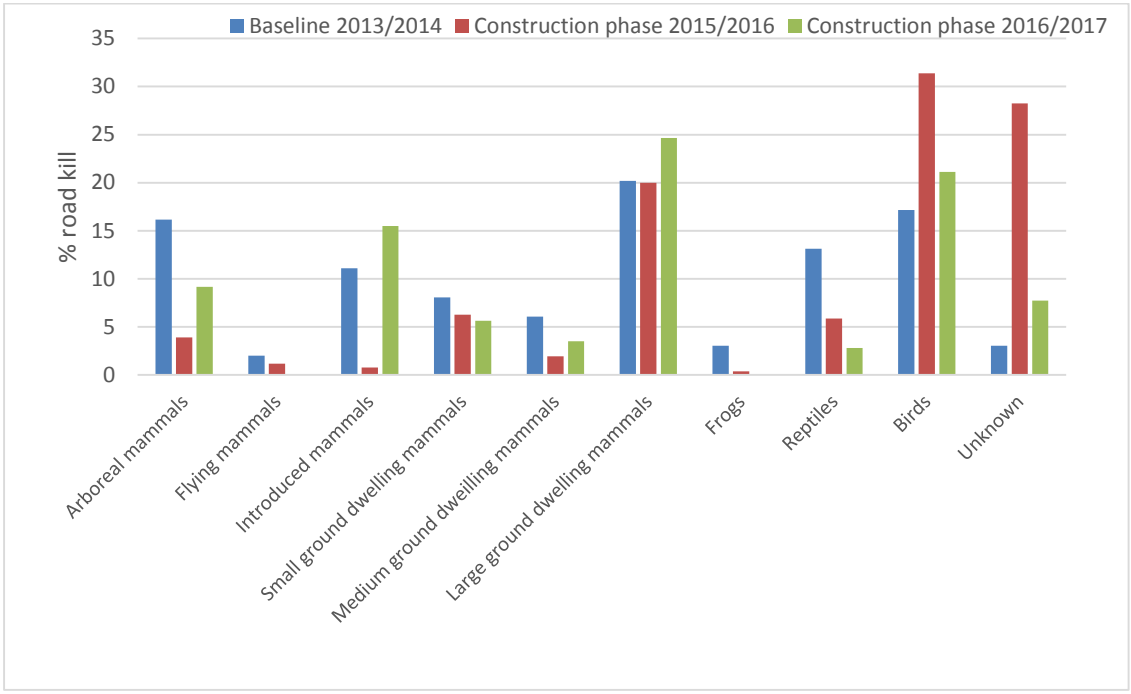
There were a total of 134 road kill records during the 2016/2017 monitoring period: 23% occurred in winter (late winter 2016, n = 14, and early winter 2017, n = 17), 32% in spring (n = 43), 25% in summer (n = 34) and 19% in autumn (n = 26).

The baseline report (Lewis 2014) defined fauna categories for analysis as follows:

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

As stated in Section 1.5 Limitations, an 'unknown' category was included to account for those species that could not be identified. The percentage of road kill records for each category are presented in Graph 1. Large ground dwelling mammals (Kangaroo and Wallaby) (26% of road kill, n = 35), birds (22.4% of road kill, n = 34), and introduced mammals (15.5%, n = 22) were the most commonly recorded fauna groups.

Graph 1: Comparison of road kill fauna categories for each monitoring period



Threatened fauna

Two dead Koalas were recorded in spring 2016. These were located at the northern end of the Project area within 3 km of each other (Figure 2), with ID32 occurring beyond the northern boundary of the OH2K project. As per the EMP, additional details regarding the sex, age class and pouch young were recorded (Table 2). The sex of the individuals was unknown but they were considered to be adolescent animals. A number of habitat attributes were also recorded, these are provided in Table 3. Locations of both animals were adjacent to wet sclerophyll forest.

- ID32 – approximately 350 m north of the Stumpy Creek bridge underpass and beyond the northern boundary of the OH2K project. Approximately 100 m of boundary fence was retrofitted at this location (after the road kill event) to assist in directing fauna to the Ku2K Stumpy Creek bridge underpass. The existing fauna fence for the Ku2K section finishes at Stumpy Creek, however fauna fencing continues for approximately 400 m, erected in association with the Kempsey Bypass construction. The additional 100 m of retrofitted boundary fence continues north from this point.
- ID37 – approximately 100 m north of a 3 m x 3 m combined box culvert. There is also a 3 m x 3 m combined culvert approximately 600 m to the north of this location and a dedicated 3m x 3m culvert approximately 1100 m to the south. There is fauna fencing throughout this area (on the new alignment).

Table 2: Threatened species road kill

ID	Season	Date	Species detected	Sex	Age	Pouch young	Location	Easting	Northing
32*	Spring	5 October 2016	Koala	Unknown	Adolescent	n/a	North of Gate 20	483413	6555959
37	Spring	12 October 2016	Koala	Unknown	Adolescent	n/a	North of Gate 17	482815	6553852

n/a – not applicable; * = recorded beyond the northern limit of the OH2K project

Table 3: Local habitat attributes for threatened species road kill

ID	Structure and floristics					Hydrological features	Rocky features	Logs	Hollow-bearing trees	Foraging resources
	Broad habitat type	Overstorey	Mid stratum	Shrub layer	Ground cover					
32*	Wet sclerophyll forest	Absent	Absent	Acacia	Exotic grasses and some native grasses	none	none	none	none	Suitable foraging forest habitat approx. 1km to the south
37	Wet sclerophyll forest	Eucalypt and Casuarina	Casuarina	Acacia and Lantana		Gully with semi-permanent standing water within 100m	none	none	none	Suitable Koala habitat

* = recorded beyond the northern limit of the OH2K project

3.2 Road kill and mitigation measures

The majority of the traffic remains on the existing Pacific Highway, and fauna mitigation measures associated with the new carriageway are still under construction. The full benefit of these structures will not be realised until the new carriageway is operational and these structures are completed. As such, an assessment of road kill with regards to mitigation measures has not been undertaken for the 2016/2017 monitoring period.

3.3 2016/2017 road kill incidence comparison with previous construction surveys

Road kill incidence

Figure 1 shows the seasonal distribution of all road kill for the baseline and 2016/2017 monitoring period. These construction monitoring results cannot yet consider the relationship between mitigation measures (still under construction) and road kill distribution. Distribution of road kill will be considered in relation to mitigation measures once they are operational. The difference in survey effort between baseline and construction monitoring (12 weeks *vs.* 53 weeks) also makes visual comparison difficult. Instead, to examine changes in road kill rates, the average weekly road kill was calculated. The average weekly road kill for the baseline surveys and the 2015/2016 and 2016/2017 monitoring periods for all survey events is presented in Table 4.

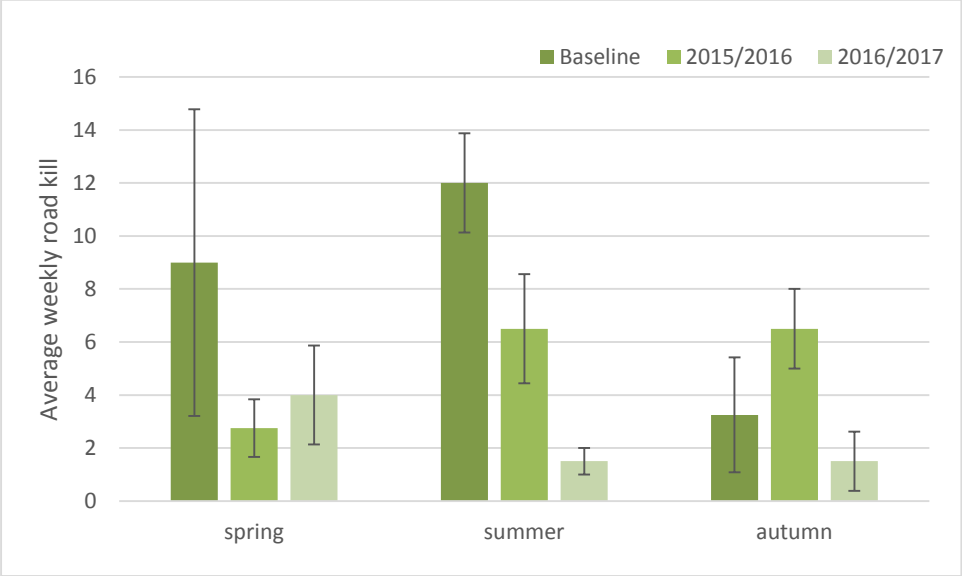
In order to directly compare the results of the baseline surveys with that of the later monitoring periods, the average weekly road kill for the four survey weeks undertaken in each season of the baseline surveys (spring (October), summer (January), autumn (May)), was compared to the same four weeks of each subsequent monitoring event. No road kill surveys were undertaken in winter during the baseline monitoring. Graph 2 shows the average weekly road kill over same four week period in baseline and construction monitoring periods.

The 2016/2017 monitoring period recorded a lower average weekly road kill than baseline surveys for all seasons when considering the entire monitoring period, and also when considering only the four week spring, summer and autumn periods. The 2016/2017 monitoring period also recorded a lower average weekly road kill in winter than the 2015/2016 monitoring period.

Table 4: Comparison of baseline and construction monitoring

Monitoring period		Spring (n)	Summer (n)	Autumn (n)	Winter (n)
Baseline	**2013/2014**	9.5 (4)	12.0 (4)	3.3 (4)	No surveys
Construction phase	**2015/2016 (all surveys)**	4.2 (13)	5.8 (13)	6.7 (13)	4.1 (12)
	2015/2016 (4 weeks)	2.75 (4)	6.5 (4)	6.5 (4)	No surveys
	2016/2017 (all surveys)	3.3 (13)	2.6 (13)	2.0 (13)	2.2 (14)
	2016/2017 (4 weeks)	4.0 (4)	1.5 (4)	1.5 (4)	n/a

Graph 2: Average (±SD, n = 4) weekly road kill per season, for baseline and construction monitoring



3.3.1 Fauna categories

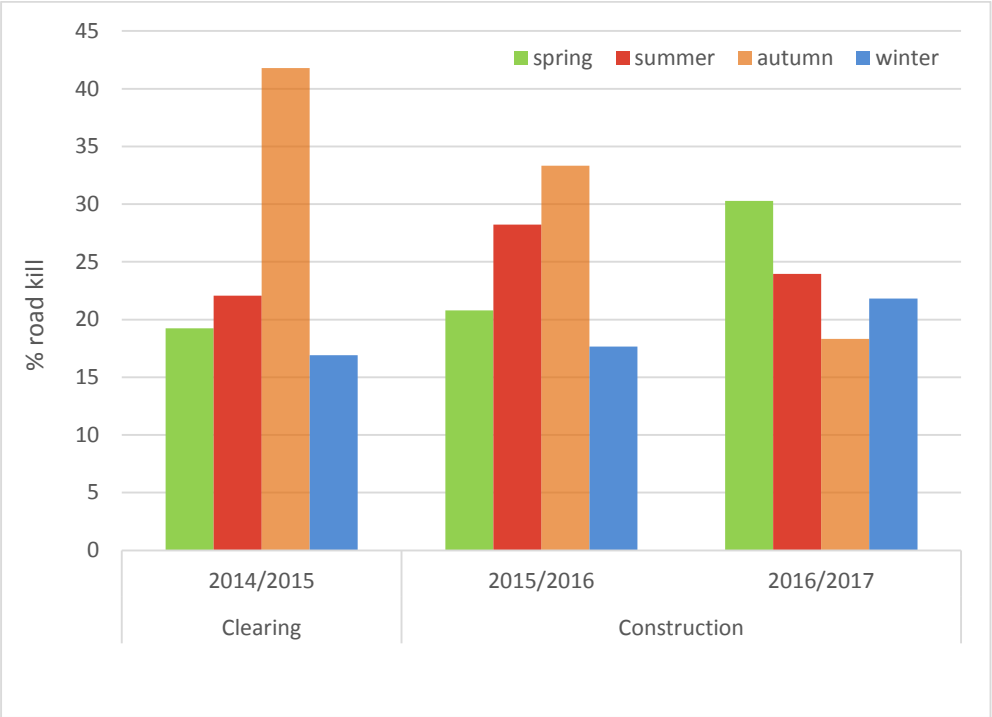
The percentage of road kill represented by each fauna category has been used to identify changes in road kill patterns. These categories and the percentage of road kill records are presented in Graph 1.

Terrestrial mammals and birds have been consistently the most commonly represented category during all monitoring periods. It is noted that small-sized road kill fauna have the potential to be partially or wholly removed by scavenger animals and not observed from the vehicle due to their size. Therefore there may be an under representation of smaller fauna, however this should be consistent across all surveys.

3.3.2 Seasonal differences

Seasonal differences in road kill rates were analysed using data obtained during the clearing (2014/2015) and also construction phases (2015/2016 and 2016/2017) as these monitoring periods include data from all four seasons. Baseline data was excluded from the comparison as winter surveys were not undertaken. Graph 3 shows the seasonal trend in road kill for each of the monitoring periods. A similar trend was observed between the 2014/2015 and the 2015/2016 monitoring periods with autumn recording the highest percentage of road kill. This trend was not observed in the 2016/2017 monitoring period where the highest number of road kill was recorded in spring. Further monitoring is required to establish any seasonal trends in road kill.

Graph 3: Percentage of road kill records per season



4. Discussion

A summary of the 2016/2017 survey results in relation to the performance measures is provided in Table 5.

Table 5: Performance measures

Performance Measures	Discussion
Lower rates of road kill in proximity (i.e. areas of the main carriageways within areas adjacent to installed fauna fencing, and within 100m of rope bridges and fauna underpasses) to fauna fencing, rope bridges and fauna underpasses than in sections of the upgrade not near wildlife crossing structures or fauna fences in Year 1 – 6 & 8 monitoring events.	**This performance measure was not assessed for the 2016/2017 monitoring period.** The majority of the traffic remains on the existing Pacific Highway, and fauna mitigation measures associated with the new carriageway are still under construction. As such, an assessment of road kill with regards to mitigation measures has not been undertaken.
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 for the 2016/2017 construction phase.** Overall there has been a decline in the recorded road kill between baseline and the subsequent two construction monitoring events. One threatened species (two individual Koalas, one beyond the northern boundary of the OH2K project) was recorded during the 2016/2017 monitoring period, while two threatened species (one Koala and two Grey-headed Flying-fox) were recorded as road kill during the baseline surveys (see Figure 2 for locations). Boundary fencing was retrofitted at the northern end of the Project to direct fauna to the Stumpy Creek bridge underpass. Culverts exist in the vicinity of both road kill locations.
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 (2018).**

5. Recommendations

5.1 Contingency measures

The EMP lists potential problems and contingency measures for various components of the monitoring program, however specific contingency measures for road kill have not been provided within the EMP. Road kill results will however be considered in relation to future underpass and fauna fence monitoring, as per the EMP.

5.2 Recommendations

Current trends indicate an overall reduction in road kill incidence during construction activities, as such there are no current recommendations based on the outcomes of the 2016/2017 monitoring period. These results represent construction monitoring and therefore cannot yet consider the relationship between mitigation measures (still under construction) and road kill rates or patterns. Continued monitoring of road kill upon completion of mitigation measures will provide further information as to the effectiveness of these measures.

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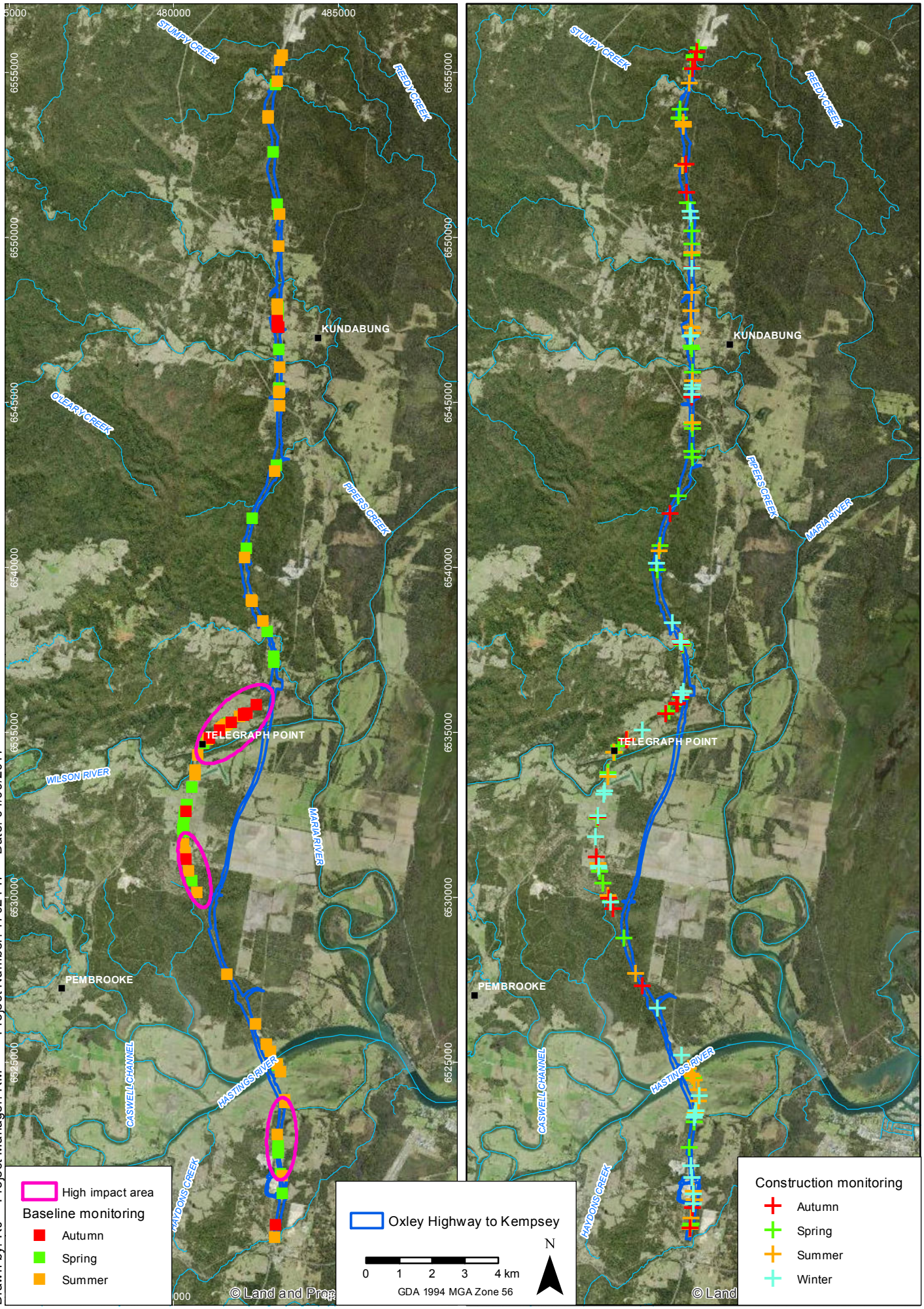

Seasonal distribution of road kill along the OH2K project (baseline monitoring vs. construction phase 2016-2017)

Pacific Highway Upgrade – Oxley Highway to Kempsey

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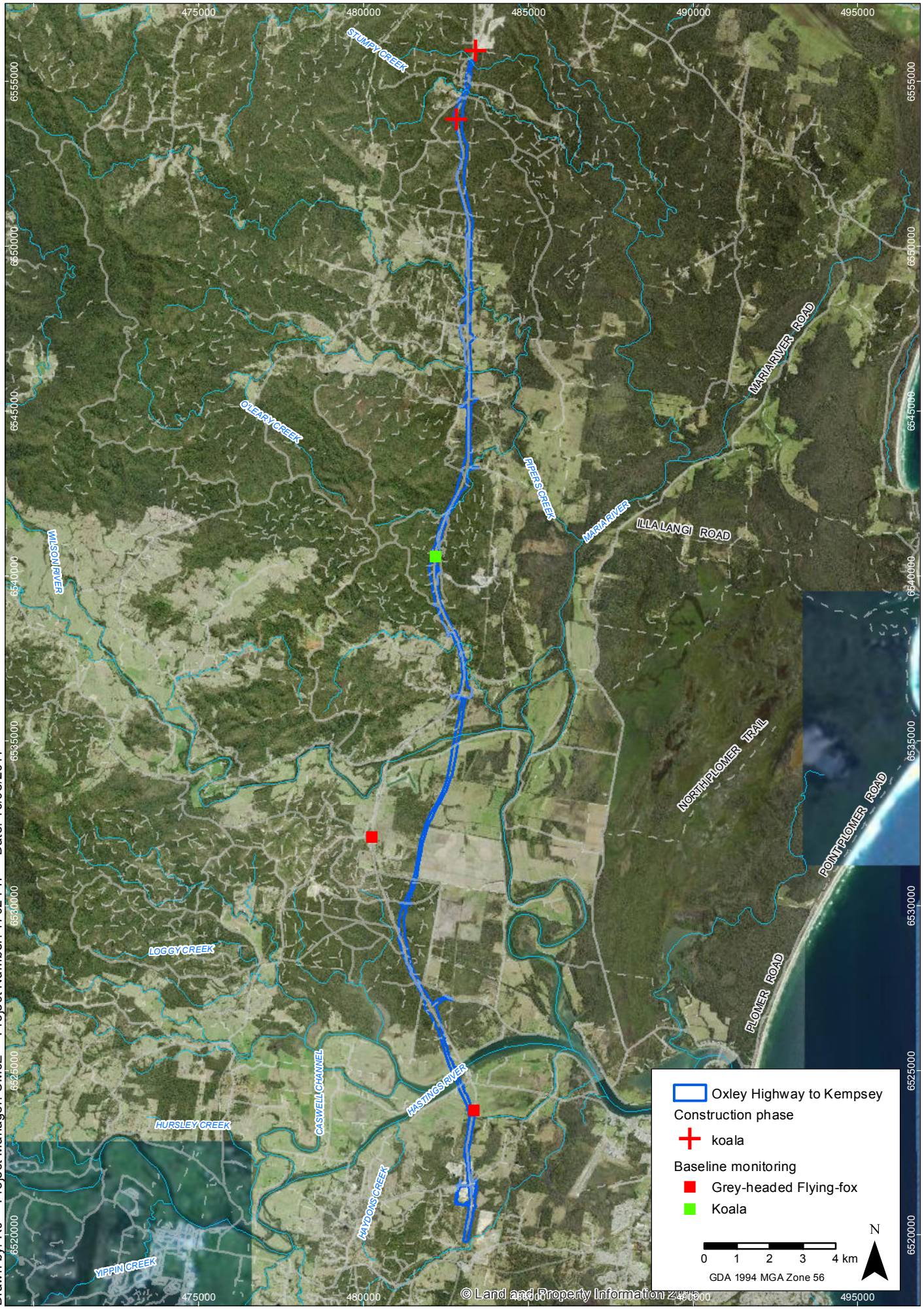
FIGURE 1

Imagery: (c) LPI 2014-10-06



Drawn by: RJ Project Manager: CMcE Project Number: 1702 PI7 Date: 10/08/2017

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

Pacific Highway Upgrade - Oxley Highway

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FIGURE 2

Imagery: (c) LPI 2014-10-06

Annex 1. Road Kill Data

Data presented as provided by Roads and Maritime Services. Table 6 provides location and fauna details. Table 7 presents additional habitat details where recorded. Note that additional data, including habitat and individual details, were not recorded for all road kill as the update to the EMP during the 2016/2017 season no longer required these details for all records, only for threatened species. An "ID" column has been added to the original data to link records between tables.

Table 6. Road kill locations and animal details

ID	Week number	Date	Start time	Finish time	Location description	Easting	Northing	Species	Assigned vertebrate group	Sex	Age	Pouch young
1	Week 51	27/07/2016	8:30am	9:50am	northbound, south of Cooperabung Creek	31°17'34.8"	152°49'12.8"	kookaburra	bird	unknown	adult	na
2					northbound, adjacent Cassegrain buildings	31°26'10.1"	152°49'22.9"	bird	bird	unknown	unknown	unknown
3					northbound, south of Fernbank Creek	31°25'20.0"	152°49'27.1"	kangaroo	mammal	unknown	unknown	unknown
4					northbound, north of McInerney's driveway	31°24'21.6"	152°49'11.7"	cat	mammal	unknown	adult	na
5	Week 52	02/08/2016	7:30	8:30	northbound, 2.3km south of Wilson River bridge	480273.61	6532036.5	unidentifiable	mammal	unknown	unknown	unknown
6					northbound, 0.9km south of Wilson River bridge	480567.27	6533420.63	unidentifiable	bird	unknown	unknown	unknown
7					southbound, 0.55km south Smiths Creek	483211.43	6545723.03	unidentifiable	bird	unknown	unknown	unknown
8	Week 53	11-Aug	7:30	8:30	southbound, 50m north of Cairncross State Forest	480375.262	6531089.268	echidna	mammal	unknown	unknown	unknown
9					within 60km/hr. section of Hastings River interchange	481972.026	6586925.854	unidentifiable	mammal	unknown	unknown	unknown
10					northbound, 600m south of Wilson River Bridge	480645.463	6533910.471	unidentifiable	bird	unknown	unknown	na
11	Week 54	19/08/2016	7:30	8:30	South of Kundabung interchange	483161.118	6546912.466	eastern grey kangaroo	mammal	unknown	unknown	unknown
12					Northern end of Ravenswood Road	483182.311	6550789.294	fox	mammal	unknown	adult	unknown
13	Week 55	26/08/2016	7:30	8:30	South of Wharf Rd Kundabung	483207.103	6544534.324	Yellow Tail Black Cockatoo	bird	unknown	adult	na
14						483207.103	6544585.759	Unknown	bird	unknown	adult	na

ID	Week number	Date	Start time	Finish time	Location description	Easting	Northing	Species	Assigned ver-tebrate group	Sex	Age	Pouch young
15	Week 56	01/09/2016	7:30	8:30	Northern end of Ravenswood Road	483189.853	6550007.144	Unknown	bird	unknown	adult	na
16	Week 57	07/09/2016	7:30	8:30		482797.01	6542362.23	eastern grey kangaroo	mammal	unknown	unknown	unknown
17						483208.07	6544544.486	eastern grey kangaroo	mammal	unknown	unknown	unknown
18	Week 58	15/09/2016	7:30	8:30		483130.027	6522614.902	unidentifiable	mammal	unknown	unknown	unknown
19						480331.435	6532588.126	unidentifiable	mammal	unknown	unknown	unknown
20						483164.97	6555314.874	Possum	mammal	unknown	unknown	unknown
21	Week 59	23/09/2016	7:30	8:30		483211.43	6544432.57	eastern grey kangaroo	mammal	unknown	unknown	unknown
22	Week 60	30/09/2016	15:30	16:30		483213.984	6543530.971	echidna	mammal	unknown	unknown	unknown
23						483165.267	6546907.521	eastern grey kangaroo	mammal	unknown	unknown	unknown
24						483201.81	6550424.03	kookaburra	bird	unknown	unknown	unknown
25						483072.429	6551245.034	goanna	reptile	unknown	unknown	unknown
26						482873.197	6537984.62	unidentifiable	bird	unknown	unknown	unknown
27						483242.512	6524730.821	unidentifiable	bird	unknown	unknown	unknown
28	Week 61	05/10/2016	7:30	8:30	South of Hastings River	483262.356	6523395.422	Possum	mammal			
29					Cooperabung Creek Bridge	482873.197	6537984.62	unidentifiable	bird			
30					South of Hastings River	483242.512	6524730.821	unidentifiable	bird			
31					South Wilsons River bridge	480648.186	6533986.621	grey goshawk	bird			
32					**north gate 20**	**483412.664**	**6555958.966**	**koala**	**mammal**	**unknown**	**adolescent**	**na**
33	week 62	12/10/2016	7:30	8:30	South of Hastings River	483246.835	6524726.877	small mammal	mammal			
34					North of OH2K interchange	481147.217	6528947.073	eastern grey kangaroo	mammal			
35					North wilmarra rd	482839.099	6536207.188	fox	mammal			
36					South Cooperabung creek	482909.213	6537883.327	small mammal	mammal			
37					**North gate 17**	**482815.923**	**6553852.401**	**koala**	**mammal**	**unknown**	**adolescent**	**na**

ID	Week number	Date	Start time	Finish time	Location description	Easting	Northing	Species	Assigned vertebrate group	Sex	Age	Pouch young
38					southern end of OH2K	483170.893	6520286.046	eastern grey kangaroo	mammal			
39	week 63	20/10/2016	7:30	8:30	North Wilson River bridge	480843.634	6534580.821	swamp wallaby	mammal			
40					Northern end of Cairncross SF	480405.13	6530997.481	feral dog	mammal			
41					Mobbs Dr	483207.902	6543711.444	Tawny Frog Mouth	bird			
42					Near old gate 8	483191.895	6546843.479	Unknown	bird			
43	Week 64	28/10/2016	7:30	8:30	South Smiths Creek Bridge	483212.03	6546110.998	Magpie	bird			
44	Week 65	04/11/2016	7:30	8:30	North Gate 17 K2K	482815.648	6553819.477	Possum	mammal			
45					southern end of OH2K	483154.027	6520204.737	rabbit	mammal			
46					ch 31700	483200.649	6549673.999	wood duck	bird			
47					North Tele Point Bridge	480989.521	6534790.628	rabbit	mammal			
48					North Tele Point Bridge	480848.233	6534581.871	red bellied black snake	reptile			
49					North Yarrabee Quarry	482143.707	6540128.3	swamp wallaby	mammal			
50	Week 66	11/11/2016	7:30	8:30	Nth end of overtaking lanes	480728.3	6530064.4	swamp wallaby	mammal			
51					South of Cooperabung Creek	482920.539	6537843.844	eastern grey kangaroo	mammal			
52					Between Yarrabee and Barries Creek	482228.784	6540851.964	echidna	mammal			
53	Week 67	18/11/2016	7:30	8:30	Nth Stumpy Creek	483285.887	6555711.157	kangaroo	mammal			
54					Nth gate 17 (K2K)	482838.212	6554097.301	Possum	mammal			
55					Cairncross SF	480498.219	6530641.607	echidna	mammal			
56	Week 68	25/11/2016	7:30	8:30	end of 2nd overtaking lane	482520.295	6535836.004	unidentifiable	bird			
57					Nth Stumpy Creek	483262.556	6555635.607	swamp wallaby	mammal			
58	Week 69	02/12/2016	7:30	8:30	Nth side of Sancrox Bridge	483257.55	6521286.05	goanna	reptile			
59					Sth of Hastings River Bridge	483278.42	6524658.93	white ibis	bird			
60					Telegraph Point turnoff	481231.92	6535003.65	swamp wallaby	mammal			

ID	Week number	Date	Start time	Finish time	Location description	Easting	Northing	Species	Assigned ver-tebrate group	Sex	Age	Pouch young
61					Scrubby Creek Rd turnoff	483126.03	6554871.56	swamp wallaby	mammal			
62		09/12/2016	7:30	8:30	Nth Bloodwood Rest Area	482913.01	6552398.24	wild dog	mammal			
63					South of Hastings River Bridge	483221.54	6524759.47	white ibis	bird			
64		16/12/2016	7:30	8:30	South Smiths Creek	483214.307	6545872.518	unknown	mammal			
65					South Smiths Creek	483214.307	6545872.518	unknown	mammal			
66					Kundabung SB off ramp	483235.04	6547326.66	kookaburra	bird			
67		21/12/2016	7:30	8:30	Entry into Carlye Rd	483205.387	6549750.825	swamp wallaby	mammal			
68					Under Sancrox bridge	483255.724	6520910.654	rabbit	mammal			
69					south Sancrox bridge	483176.348	6520477.398	dog	mammal			
70		29/12/2016	10:00	11:00	Nth Sancrox bridge	483275.307	6521022.81	magpie	bird			
71					South Hastings River Drive	483400.596	6524362.811	dog	mammal			
72					Kundabung Interchange	483189.613	6547455.735	magpie (x2)	bird			
73					near basin B30.00	483169.637	6547983.58	swamp wallaby	mammal			
74					near C35.80	482941.169	6553610.158	eastern grey kangaroo	mammal			
75					gate 5	483221.01	6544601.889	Unknown	unknown			
76	Week 70	06/01/2017	7:30	8:30	None noted							
77	Week 71	13/01/2017	7:30	8:30	Frog culvert OH2K	481492.842	6527884.527	black snake	reptile			
78					North Tele Point Bridge	480841.124	6534584.822	bandicoot	mammal			
79					Kundabung Interchange	483182.118	6547492.017	wood duck	bird			
80					South Pipers Creek	483198.429	6548546.092	swamp wallaby	mammal			
81	Week 72	20/01/2017	7:30	8:30	Near Cairncross waste facility turnoff	480668.682	6530236.138	eastern grey kangaroo	mammal			
82	Week 73	25/01/2017	7:30	8:30	Cairncross SF	480340.879	6531220.225	fox	mammal			
83					Hastings River Bridge	483092.86	6525005.238	Unknown	mammal			
84	Week 74	01/02/2017	7:30	8:30	Southern end of OH2K	483138.478	6520131.55	Unknown	bird			
85					South of Hastings River	483389.304	6524020.104	eastern grey kangaroo	mammal			

ID	Week number	Date	Start time	Finish time	Location description	Easting	Northing	Species	Assigned ver-tebrate group	Sex	Age	Pouch young
86	Week 75	08/02/2017	7:30	8:30	South of Hastings River	483176.203	6524840.535	Possum	mammal			
87	Week 76	16/02/2017	7:30	8:30	ch35700 - near rope crossing	482941.156	6553593.508	wallaby	mammal			
88	week 77	24/02/2017	7:30	8:30	South Wilsons River bridge	480648.476	6533863.22	Possum	mammal			
89					Between Yarrabee and Barries Creek	482204.361	6540711.726	dog	mammal			
90					Fernbank Creek Bridge	483305.394	6523640.883	cat	mammal			
91					ch35800	482931.132	6553688.264	magpie	bird			
92	Week 78	02/03/2017	7:30	8:30	PCAR - south	483202.892	6549296.211	eastern grey kangaroo	mammal			
93	Week 79	10/03/2017	7:30	8:30	None noted							
94	Week 80	16/03/2017	7:30	8:30	Cairncross waste facility turnoff	480686.345	6530163.75	fox	mammal			
95					South Cooperabung creek	482859.729	6536256.258	wallaby	mammal			
96					North Wilson River bridge	481205.498	6534974.745	Possum	mammal			
97					south Stumpy Creek	483295.369	6555597.886	bandicoot	mammal			
98	Week 81	21/03/2017	7:30	8:30	Cairncross SF	480804.68	6529835.468	eastern grey kangaroo	mammal			
99					South Cooperabung creek	482415.184	6535749.993	eastern grey kangaroo	mammal			
100	Week 82	31/03/2017	7:30	8:30	None noted							
101	Week 83	07/04/2017	7:30	8:30	Cooperabung Creek Bridge	482853.759	6537995.358	fox	mammal			
102					Southern end of OH2K	483140.673	6520165.96	unknown small mammal	mammal			
103	Week 84	13/04/2017	7:30	8:30	North Stumpy Creek	483346.256	6555839.009	wallaby	mammal			
104					South end of southern NB overtaking lanes	480307.351	6531413.5	eastern grey kangaroo	mammal			
105					South Barries Creek	482543.676	6541833.099	cat	mammal			
106					Northern Wauchope turnoff	480342.868	6532635.679	wallaby	mammal			
107					cut 18 K2K	483039.273	6551592.261	kookaburra	bird			
108	week 85	21/04/2017	7:30	8:30	2nd overtaking lanes NB	482753.888	6536084.287	eastern grey kangaroo	mammal			

ID	Week number	Date	Start time	Finish time	Location description	Easting	Northing	Species	Assigned vertebrate group	Sex	Age	Pouch young
109					Upper Smiths Creek Rd	483207.187	6545354.485	eastern grey kangaroo	mammal			
110	Week 86	28/04/2017	7:30	8:30	None noted							
111	Week 87	04/05/2017	7:30	8:30	South Sancrox bridge	483225.16	6520777.048	Possum	mammal			
112					south Cooperabung Creek	482883.053	6537890.994	antechinus	mammal			
113					fill 20	483031.802	6552420.987	swamp wallaby	mammal			
114	Week 88	12/05/2017	7:30	8:30	South stumpy creek	483214.959	6555312.267	Possum	mammal			
115					Blackmans Point turnoff	481694.581	6527507.982	cat	mammal			
116	Week 89	19/05/2017	7:30	8:30	south Cooperabung Creek	482743.947	6536071.953	Possum	mammal			
117	Week 90	26/05/2017	7:30	8:30	None noted							
118	Week 91	01/06/2017	7:30	8:30	South sports club	480531.946	6533320.964	cat	mammal			
119					under Kundabung bridge	483172.365	6547236.038	Unknown	mammal			
120					Sancrox bridge	483247.715	6520895.643	cat	mammal			
121	week 92	07/06/2017	7:30	8:30	Sancrox on ramp	483193.106	6521678.155	cat	mammal			
122					OH2K interchange	482152.23	6526852.357	swamp wallaby	mammal			
123	week 93	16/06/2017	7:30	8:30	Cairncross SF	480724.891	6530057.129	Possum	mammal			
124					South Hastings river	483265.602	6523519.527	Unknown	bird			
125	week 94	23/06/2017	7:30	8:30	None noted							
126	week 95	30/06/2017	7:30	8:30	None noted							
127	week 96	07/07/2017	7:30	8:30	Wharf Rd	483208.768	6545425.588	rabbit	mammal			
128	week 97	13/07/2017	7:30	8:30	Fernbank Creek Bridge	483319.855	6523722.023	Unknown	mammal			
129					Nth Fernbank Creek	483416.758	6524178.364	fox	mammal			
130	week 98	21/07/2017	7:30	8:30	South Cooperabung creek	482863.058	6536341.855	Possum	mammal			
131					Yarabee Rd	482119.288	6540336.234	eastern grey kangaroo	mammal			
132					PCAR - south	483192.732	6549259.933	Possum	mammal			
133	week 99	28/07/2017	7:30	8:30	Kundabung Interchange	483150.182	6547226.271	magpie	bird			

ID	Week number	Date	Start time	Finish time	Location description	Easting	Northing	Species	Assigned vertebrate group	Sex	Age	Pouch young
134					Cooperabung Creek Bridge	482845.637	6537967.018	Unknown	mammal			

Table 7: Road kill habitat details

ID	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	cleared	cleared	cleared	cleared	cleared	Cooperabung Ck	none	none	none	food/water source	unknown	
2	cleared	cleared	cleared	cleared	cleared	none	none	none	none	no	unknown	
3	cleared	cleared	cleared	cleared	cleared	Fernbank Ck within 50m	none	none	none	no	unknown	
4	cleared	absent	absent	absent	pasture grass	none	none	none	none	no	unknown	not directly adjacent works
5	cleared	absent	absent	absent	pasture / residential area	none	none	none	none	none	unknown	possible a cat
6	cleared	absent	absent	a	pasture / residential area	none	none	none	none	none	unknown	
7	wet sclerophyll forest	red gum	casuarina	grass	grass	Smiths Creek 550m away	none	none	none	eucalypts and grass	unknown	
8	dry sclerophyll forest	Blackbutt	cleared	grass	grass	adjacent farm dams	none	none	none	adjacent to state forest	unknown	
9	wet sclerophyll forest											
10	cleared											
11	wet sclerophyll forest	casuarina, eucalypts	casuarina	grass	grass	north of Smiths Creek	none	none	scattered	grasses	unknown	
12	wet sclerophyll forest		casuarina	grass	grass	scattered drainage lines and swampy areas	none	none	scattered	adjacent to state forest	unknown	
13	wet sclerophyll forest	casuarina, eucalypts	casuarina	grass	grass	scattered drainage lines and swampy areas	none	none	scattered	adjacent bushland	unknown	
14	wet sclerophyll forest	casuarina, eucalypts	casuarina	grass	grass	scattered drainage lines and swampy areas	none	none	scattered	adjacent bushland	unknown	

ID	Broad habitat type	Overstorey	Mid stratum	Shrub layer	Groundcover	Hydrological features	Rock	Log	Hollow-bearing Trees	Foraging resources associated with fauna	Likely attractant	Comments
15	wet sclerophyll forest	casuarina, eucalypts	casuarina	grass	grass	scattered drainage lines	none	none	scattered	adjacent bushland and farm pasture	unknown	
16	wet sclerophyll forest											
17	dry sclerophyll forest											
18	wet sclerophyll forest											
19	cleared											
20	wet sclerophyll forest											
21	dry sclerophyll forest											
22	wet sclerophyll forest											
23	wet sclerophyll forest											
24	wet sclerophyll forest											
25	dry sclerophyll forest											
26	wet sclerophyll forest											
27	wet sclerophyll forest											
28	wet sclerophyll forest											
29	wet sclerophyll forest											
30	wet sclerophyll forest											
31	wet sclerophyll forest											
32	**wet sclerophyll forest**	**absent**	**absent**	**acacia**	**exotic grass, some native grass**	**none**	**none**	**none**	**none**	**suitable foraging forest approx. 1km to the south**	**forest approx. 1km to the south**	
33	wet sclerophyll forest											
34	wet sclerophyll forest											
35	dry sclerophyll forest											
36	wet sclerophyll forest											

ID	Broad habitat type	Overstorey	Mid stratum	Shrub layer	Groundcover	Hydrological features	Rock	Log	Hollow-bearing Trees	Foraging resources associated with fauna	Likely attractant	Comments
37	**wet sclerophyll forest**	**Eucalypt and casuarina**	**casuarina**	**acacia and lantana**		**gully line with semi-permanent standing water within 100m**	**none**	**none**	**none**	**suitable koala habitat**	**surrounding suitable koala habitat**	
38	wet sclerophyll forest											
39	wet sclerophyll forest											
40	dry sclerophyll forest											
41	wet sclerophyll forest											
42	cleared											
43	wet sclerophyll forest											
44	wet sclerophyll forest											
45	wet sclerophyll forest											
46	Dry sclerophyll forest and cleared areas.											
47	wet sclerophyll forest											
48	wet sclerophyll forest											
49	wet sclerophyll forest											

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Annex 4. Pre-clearing and clearing monitoring OH2Ku 2016/2017 (Sandpiper 2017a and 2017b)

Field data is provided within the reports.

Pacific Highway Upgrade: Oxley Highway to Kundabung

Clearing Report

Sandpiper Ecological

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Final Report – Version 5

8 August 2017

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Cover Photo: Female koala (*Phascolarctos cinereus*) shortly after being release in Rawdon Creek Nature Reserve.

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1. Introduction

Sandpiper Ecological Surveys was contracted by Lend Lease Engineering to provide ecological services during construction of the Oxley Highway to Kundabung (OH2K) section of the Pacific Highway Upgrade. The following report discusses the procedures and results of ecological tasks undertaken during the clearing phase of the project. Clearing for the OH2K project commenced on 3 November 2014 and substantive clearing was completed by 25 August 2015. A small section in the north of the project corridor will be cleared in 2016. The results of that clearing will be detailed in a supplementary report with any additional clearing for ancillary work. This report has been prepared in accordance with the specifications of the Oxley Highway to Kempsey Ecological Monitoring Program (EMP) (RMS 2016). Section 7 of the EMP specifies, "A report on the clearing procedures will be prepared upon the completion of clearing operations and will include:

1. Details of methods used during pre-clearing surveys and clearing operations.
2. Fauna species displaced by clearing, species captured, species released and any wildlife mortalities resulting either directly or indirectly from the clearing operations.
3. Location of fauna within clearing footprint (recorded with GPS) and release locations.
4. Hollow-bearing tree register, and comparison of this data to nest box plan (assess the adequacy of nest boxes installed and how they are mitigating the loss of tree hollows).
5. Discussion of the effectiveness of those methods employed.
6. Recommendations for future pre-clearing and/or clearing procedures."

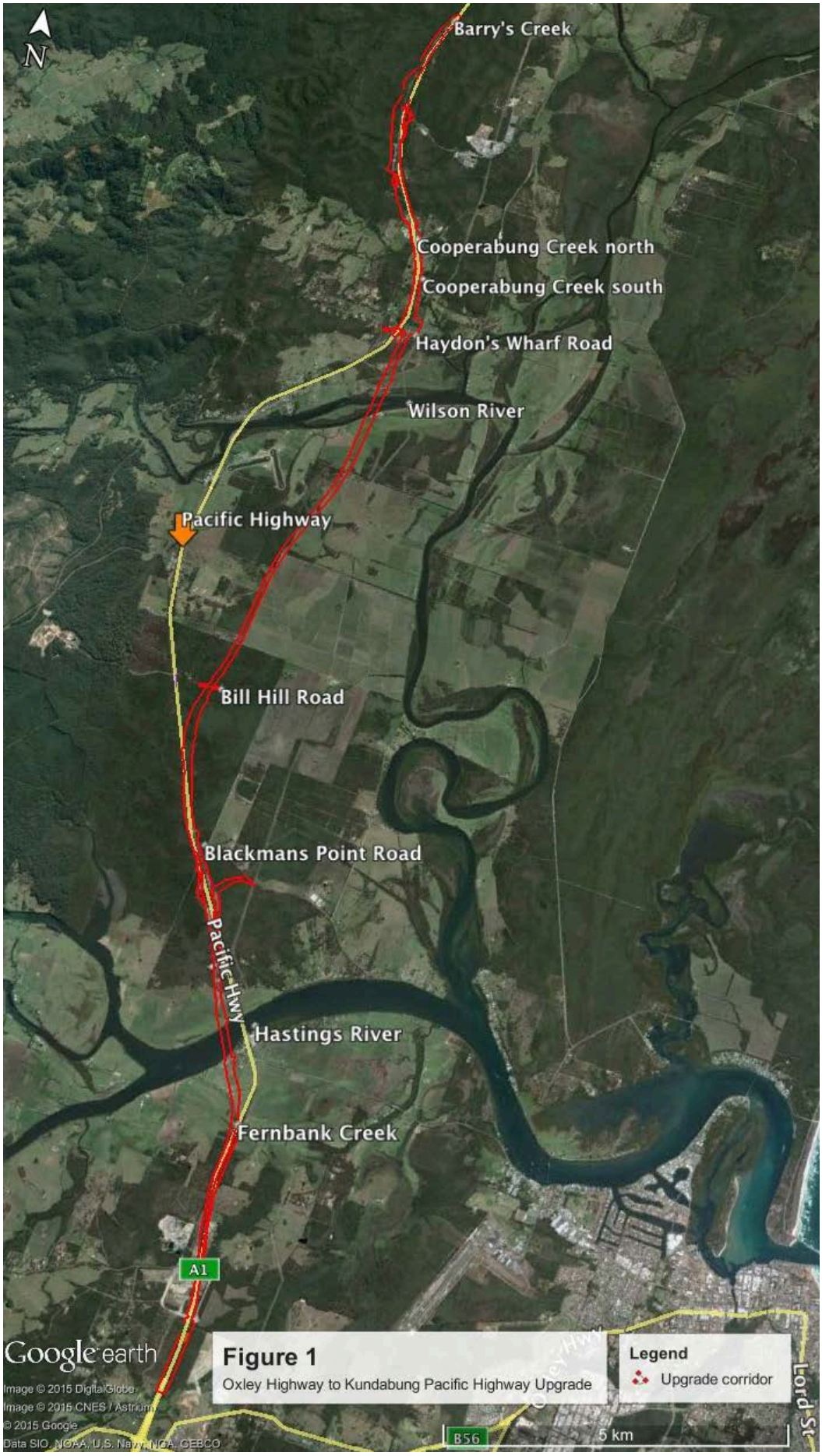
The above points form the scope of this report.

1.1 Background

The EMP (RMS 2016) summarises the pre-clearing and clearing procedures required and includes details on the type of data to collect for target species and activities (Section 4.1 of EMP). Further specification on survey requirements is provided in the various threatened species management strategies, namely giant barred frog (Mixophyes iteratus), green-thighed frog (Litoria brevipalmata) and microbats (see Lewis 2013a, b, c). There are some discrepancies between management strategies and the EMP although, in the event of inconsistencies, the EMP will take precedence (refer Section 1.2 of EMP). For example, the green-thighed frog management strategy specifies (section 3.3, pg 16) "The project ecologist will conduct frog surveys consisting of active searches set at 15 minutes per hectare of suitable microhabitats immediately prior (<2hrs) to commencing clearing operations… The requirement for nocturnal surveys is to be made at the discretion of the project ecologist performing the pre-clearing surveys." In contrast, the EMP states (Table 9, pg 30) "Targeted searches for green-thighed frog (Litoria brevipalmata) and giant barred frog (Mixophyes iteratus) will be undertaken where known or potential habitat for the species occurs within the clearing limits. Surveys to last 1 person hour per hectare of habitat to be disturbed/removed and involve the use of call broadcast, spotlighting and active searches of litter, debris and logs."

1.2 Study area

The OH2K Pacific Highway Upgrade extends from the Pacific Highway/Oxley Highway intersection in the south to immediately north of Barry's Creek in the north, a distance of approximately 24km (Figure 1). The study area abuts the southern end of the Kundabung to Kempsey (K2K) Pacific Highway Upgrade. The OH2K alignment follows the existing Pacific Highway for much of its length with deviations across the Hastings and Wilson river floodplains.


N
Barry's Creek
Cooperabung Creek north
Cooperabung Creek south
Haydon's Wharf Road
Wilson River
Pacific Highway
Bill Hill Road
Blackmans Point Road
Pacific Hwy
Hastings River
Fernbank Creek
A1
B56
Oxley Hwy
Lord St
Google earth
Image © 2015 DigitalGlobe
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Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Figure 1
Oxley Highway to Kundabung Pacific Highway Upgrade
Legend
Upgrade corridor
5 km

2. Methods

2.1 Terrestrial fauna

2.1.1 Vegetation and pre-construction surveys

Retaining vegetation within the project corridor was dependent on detailed design of the upgrade. Where necessary, ecologists provided advice to the design team on Endangered Ecological Communities (EEC) and other sensitive habitats that should be protected. Vegetation mapping provided by RMS was used as a baseline for the distribution of EEC. Verification of EEC, project and retained vegetation boundaries was conducted from 18-22 August 2014. Verification involved a targeted foot-based traverse of the alignment to verify vegetation community boundaries. Previously unmapped areas of EEC were also inspected. These areas were typically cleared land where regrowth had occurred since RMS purchased the land. During clearing, vegetation to be retained within the project boundary was delineated by orange bunting or helicopter tape. All staff involved in clearing operations were tool-boxed on the marking system used. Targeted surveys and habitat assessment for giant-barred frog (Mixophyes iteratus), koala (Phascolarctos cinereus), spotted-tailed quoll (Dasyurus maculatus), grey-headed flying-fox (Pteropus poliocephalus), threatened flora and noxious weeds were conducted at the same time as EEC verification. RMS conducted pre-construction surveys for threatened fauna prior to construction.

2.1.2 Habitat resource surveys

Prior to commencement of clearing in a specific area the alignment was traversed to mark fauna habitat resources, including hollow-bearing trees (HBT), nest trees, trees with hollow arboreal termitaria, dreys, large hollow logs, bush rock and glider sap trees. The HBT survey included remarking of trees identified by Lewis (2013, NBPoM) and marking additional trees. HBT's were marked with red and white danger tape and four large "H" were painted on the trunk at head height (Plate 1). The tree number was written on the flagging tape and, in some cases, sprayed on the trunk. Data collected on each tree included: tree number, species, location (GDA 94), diameter at breast height (DBH), proportion of crown remaining, and hollow size (small 10-50mm, medium 51-150mm, large 151-300mm and very large >300mm), type (e.g. branch, trunk, spout, fissure, decorticating bark), and evidence of use (i.e. chew marks or wear around entrance, white-wash, pellets, scats, or scratches). Habitat resource surveys began one week prior to the commencement of clearing and were undertaken progressively during the clearing phase. Not all previously marked HBT's were remarked if no evidence of fauna habitat was recorded.

Trees in flower were not marked during the clearing phase. The EMP suggests that such trees should be treated the same as habitat trees and be retained during stage one clearing. However, such an approach is contrary to standard practice and would reduce the likelihood that arboreal fauna would move away from the clearing area thereby reducing the effectiveness of two-stage clearing. Large flowering trees may actually attract fauna into the clearing area, which is contrary to the intent of the two-stage process.

Plate 1: HBT's marking protocol – red and white danger tape and painted orange "H".

2.1.3 Frog surveys

Frogs were targeted during all nocturnal spotlight surveys (refer section 2.1.4), and diurnal pre-clear surveys (refer section 2.1.5), as part of targeted surveys in areas of potential habitat and targeted surveys in areas of mapped threatened frog habitat. Two species of threatened frog have been recorded in the OH2K alignment, giant barred frog and green-thighed frog (Lewis 2013b & c). Giant barred frog habitat was mapped at two sites on Cooperabung Creek and green-thighed frog habitat was identified north of Blackmans Point Road (chainage 9000 to 9350) and south of Barry's Creek (chainage 23900). The frog hygiene protocol included in the Fauna and Flora Management plan was applied during all frog surveys. Lewis (2013b) identified potential giant barred frog habitat on Barry's Creek, several hundred meters downstream of the alignment, but no potential or known habitat was mapped within the section of creek traversed by the upgrade.

Giant barred frog

Surveys for giant barred frog were conducted on two non-consecutive nights within 5 days of clearing, and during the day, immediately prior to clearing. Nocturnal surveys were conducted by 2-3 personnel and involved a foot-based meandering traverse of potential habitat with hand held (200 lumen) spotlights. Survey effort was focused on the riparian zone and vegetation within 50m of the creek channel as this represents primary habitat. The total area of potential giant barred frog habitat within 50m of the creek was 0.42ha. During each nocturnal survey calls of giant barred frog were periodically broadcast through a 5watt megaphone for a period of five minutes. Each broadcast was followed by a brief (1-2 minute) listening period before active searching recommenced. Calls were broadcast at approximate 15-minute intervals. During some surveys observers imitated giant barred frog calls throughout the sample period. Call imitation is an effective means of detecting giant barred frogs. In all cases greater survey effort was expended to maximise frog capture and relocation. The sporadic nature of clearing at Cooperabung Creek meant that giant barred frog habitat was sampled on multiple occasions.

Diurnal surveys involved active searching of leaf litter, splitting and rolling logs, and searching beneath and around *Lomandra longifolia* clumps. These surveys occurred prior to each scheduled clearing event and an ecologist was present to supervise all clearing. An ecologist supervised all clearing in giant barred frog habitat, and during clearing, periodically inspect the clearing front and clumps of vegetation removed (Plate 2). The procedure for clearing inspections was discussed with operators at the start of work. In areas of dense ground cover, particularly featuring *Lantana camara*, operators were asked to remove small patches of ground cover to enable systematic inspection of area to be cleared as clearing progressed.

Captured frogs were housed individually in clip-seal plastic bags or plastic aquaria, with a small amount of leaf litter and water. Data collected on each captured frog included: sex, snout-vent length and breeding condition. Adult frogs (>40mm in length) were taken to Ben Lewis to be pit-tagged. Individuals were housed temporarily before being released outside but within 150m of the project boundary. All frogs were released on the same section of creek on which they were captured. The intent was to keep individuals for one night only, however, the recapture of a male frog within the LoC four nights after it was initially released resulted in two individuals being housed for 2 to 3 nights until clearing was completed. The decision to house frogs for longer was based on concern about potential movement into the clearing zone and subsequent mortality. Prior to the construction of a temporary crossing over Cooperabung Creek the affected pool was dip-netted for tadpoles. Dip netting was conducted in three sessions for a combined period of 75 person minutes. All dewatering activities were performed in accordance with Environmental Work Method Statement 17.

Plate 2: Stripping of vegetation in degraded giant barred frog habitat north of Cooperabung Creek on 24 November 2014.

Green-thighed frog

Targeted surveys for green-thighed frogs occurred during, and immediately after, major rainfall events. Otherwise this species was targeted during general spotlight and preclear surveys. Activity of green-thighed frogs is closely associated with rainfall and rain events of 50-75mm over a period of 1-3 days is required to stimulate breeding activity, although frogs may remain active after such events. Three major rainfall events occurred during the summer/autumn breeding season, 20 to 28 January 2015 (400mm), 18 to 24 February (124mm) and 21 to 23 March (95mm) (Bureau of Meteorology 2015).

Green-thighed frog habitat at Blackmans Point Road (chainage 9000 and 9350) was cleared prior to the January rain event and potential habitat north of Bill Hill Road was cleared between the January and February events. Both nocturnal and diurnal targeted surveys for green-thighed frogs were undertaken in the Blackmans Point and Bill Hill Road areas during the January 2015 rain event. As part of the pre clear requirements, in known green thighed frog habitat, active searches involved the use of a rake and wrecking bar to search vegetation and debris. Active searches were carried out for a minimum of 15 minutes per hectare of habitat as per (Lewis 2013b). As habitat was cleared outside of suitable survey conditions the two non-consecutive nights survey five days prior to clearing specified in the EMP was not strictly applied. Importantly, Lewis (2013b) did not specify this requirement. Targeted nocturnal surveys during favorable conditions were undertaken by 2-3 staff and involved a meandering traverse of the upgrade corridor and adjacent habitat using 200 lumen spotlights. Green-thighed frog calls were broadcast through a 5-watt megaphone for periods of 2-5 minutes, with a brief (1-2 minute) listening period after each broadcast. An iPhone was used to broadcast calls on one night due to equipment failure. Frogs recorded were captured, sexed and housed temporarily in clip-seal plastic bags with a small amount of water. Captured frogs were released within suitable habitat outside the limit of clearing. Green-thighed frogs were also targeted during nightly spotlight surveys (refer Section 2.1.4). These surveys involved repeated sampling of the same habitat and act as surrogate non-consecutive night surveys prior to clearing.

2.1.4 Spotlighting and nocturnal preclear surveys

Nocturnal surveys included spotlighting for arboreal mammals, including koalas, and frogs. Call broadcast and stag watching were regarded as additional measures to be used as required. Call broadcast is an effective means of detecting arboreal fauna, however, fauna can be drawn to the playback site, which, in this case, was considered counter-productive. Stag watching can, in some cases, be an effective means of determining if a tree is occupied by fauna. Experience on the Sapphire to Woolgoolga and Nambucca Heads to Urunga Pacific Highway Upgrades indicated that stag watching was time consuming and of less value than targeted spotlight surveys.

Spotlight surveys targeted the clearing front (i.e. area to be cleared the next day) the night before clearing was to occur. The area spotlighted was based on daily advice from Lend Lease site engineers who provided an annotated map of the alignment with clearing areas marked. Spotlighting was undertaken from Sunday through to Thursday each week. The spotlight surveys targeted all fauna, with specific emphasis on arboreal mammals (particularly koala, squirrel glider and yellow-bellied glider), and threatened frogs (particularly green-thighed frog). Spotlighting involved a slow meandering foot-traverse of the clearing front by two staff using hand-held spotlights and binoculars. Observed fauna were identified to species level.

Most of the alignment was spotlighted on multiple occasions due to the three-stage clearing process (i.e. stage 1 - drains & basins, stage 2 – mainline, stage 3 – habitat trees) and the standard approach of spotlighting a greater area than was cleared the following day was implemented. Frogs were recorded during all spotlight surveys, although greater effort was focused on frogs in priority habitats such as, wetlands, dams, creeks and potential green-thighed frog habitat.

Data collected during spotlight surveys included: personnel, area sampled (chainage or location description), start and end time, date, weather conditions (rain, cloud cover, wind speed, air temperature, relative humidity), habitat type, species, number of individuals and behaviour (foraging, calling, roosting, transit). The location of threatened species was recorded using a hand held GPS (datum GDA 94). Species observed and heard calling were recorded. When possible fauna were captured and released immediately in a predetermined location outside the limit of clearing and adjacent to the point of capture (in accordance with the Flora and Fauna Management Plan).

2.1.5 Diurnal pre-clearing surveys

Diurnal pre-clearing surveys were conducted immediately prior to clearing a section of the alignment and the section inspected was the same as that spotlighted the previous evening. Spotlighting was generally not conducted in areas cleared of trees due to the absence of arboreal fauna habitat. Surveys typically commenced prior to the start of clearing each morning but some sections of habitat were inspected at other times, as required by the clearing schedule. In many cases habitat was inspected several times as the area inspected always exceeding that cleared within a day.

Pre-clearing inspections involved a meandering foot-based traverse of the clearing footprint by one or (sometimes) two observers. During the traverse all accessible fauna habitats were inspected. This included use of a wrecking bar to roll and split logs and visual searching of the shrub and canopy layers for koalas, bird nests, possum dreys and unmarked HBT. A rake was used to search leaf litter in potential green-thighed frog habitat. Captured fauna were released immediately into adjoining habitat or, if adjacent habitat was unsuitable, housed temporarily in cotton or plastic bags (frogs only).

2.1.6 Trapping

Large (B-type) Elliott traps were used in areas with high potential for small ground mammals, such as the riparian zone of Cooperabung Creek. Traps were baited with peanut butter, honey and oats and were set in the late afternoon and checked at first light. Captured fauna were processed and released into surrounding habitat at least 100m from the Limit of Clearing (LoC) boundary. Two trap lines were set during the clearing phase. On 21 January 2015, a total of 10 Elliot traps (small mammal traps) were set at approximate even intervals in moist closed forest north of Bill Hill Rd, chainage 11000, for a period of one night. On 17 February 2015 a trap line was set south of Cooperabung Creek. A total of ten Elliot traps were set at random throughout habitat for a period of one night.

A koala trap was used as required. The koala trap was based on Phillips (2011) and included a corflute pen positioned around the occupied tree with a large cage trap fitted into a hole in the fence (Plate 3). A protocol was developed to deal with koalas recorded in the clearing area (Appendix A). The adopted protocol differs slightly to the method proposed in the EMP. The main difference was that a pen trap was installed immediately upon identifying a koala during spotlighting rather than leaving the individual to move, potentially to another tree in the clearing limit. This approach was preferred due to concern about relocating the koala the following day. There is a high likelihood that a koala identified at night would move prior to the morning pre-clear survey and relocating that individual in tall forest with a dense shrub layer during daylight would be difficult. Due to concern about an increased risk of mortality if an identified individual was left to move elsewhere within the clearing limit it was decided to control the situation and minimise the risk of mortality. The method proposed in the EMP relies on relocating a koala during the morning preclear and installing a 50m buffer around the occupied tree. A pen trap would then be installed if the koala does not vacate the area. The EMP does not specify the time between the initial observation and installation of the pen trap.

Plate 3: Koala trap installed around a tallowwood occupied by a female koala on 19 January 2015.

2.1.7 Microchiropteran bats

Structures identified in the Microbat Management Strategy (Lewis 2013dc) were inspected in September 2014. The methods used to inspect culverts and exclude roosting microbats are summarised in a letter report submitted to Lend Lease Engineering in November 2014 (Appendix B). Periodic inspection of exclusion devices in accessible culverts, such as at Barry's Creek, was undertaken throughout the clearing phase. Pipe culverts along the Cooperabung Range were inspected daily whilst clearing was occurring nearby. Several of these culverts were occupied intermittently by between 1 and 3 eastern horseshoe bat (Rhinolophus megaphyllus). Exclusion of horseshoe bats was ineffective due to their habit of hanging on imperfections in the concrete pipe. As a consequence, an inspect and observe method was adopted whereby pipes were inspected for roosting or dead bats during morning preclear surveys. No sites required seasonal limitation of clearing and grubbing as per the Microbat Management Strategy (Lewis 2013c).

2.1.8 Habitat tree inspections

Habitat trees were left in-situ for a minimum of 48 hours (2 nights) after surrounding vegetation had been cleared. In some instances the retention period was longer due to weather, equipment breakdown or clearing logistics. In some cases trees containing dreys and nests were removed immediately or after one night. Retention of these trees for longer periods either has no benefit as animals cannot leave (i.e. nests) or increases the risk of injury (i.e. dreys). Common ringtail possums (*Pseudocheirus peregrinus*) will often leave dreys during the first stage of clearing, moving into vegetation to be cleared where they are at risk of injury. In addition, dreys are often situated in the shrub-layer and can be difficult for operators to see and clear around. Removing dreys at the start of clearing, particularly early in the morning, reduces the risk of injuring fauna.

The majority of HBTs were felled carefully using a harvester, although a small number of trees, mainly in creek lines, close to the existing highway, on the boundary, or within narrow service corridors were felled by chainsaw. Immediately prior to felling each HBT was inspected visually and the preferred fall direction discussed with the machine operator.

During the initial inspection the location of major hollows was noted to enable quicker detection once the tree was felled. HBT's were felled in a careful manner with specific attention given to the direction of fall in relation to visible hollows, topography and ground debris. Where possible, trees were felled on the side without hollows, upslope, away from windrows and uneven ground.

The clearing method varied between contractors depending on operator skill and equipment capability. In most cases small and medium sized trees were cut near the base and placed on the ground, or the tree was pushed with the root bole intact and lowered to the ground. Large trees were felled with the root bole intact.

Once felled, two ecologists carefully inspected each HBT. All trunk and branch hollows and broken hollow limbs were inspected using a hand-held LED torch and/or a bore scope. Trees were rolled over to expose buried hollows, and branches were cut off to enable closer inspection or set aside for further trimming with a hand-held chainsaw. Inspection time varied depending on tree size and hollow number and ranged from 5-20 minutes. Information collected on each HBT included:

- Date and personnel;
- Tree number and species;
- Number, type (branch, trunk, spout, fissures) and size (small 2-5cm; medium 5-15cm, large 15-30cm; very large >30cm) of hollows;
- Species and number of individuals present;
- Evidence of previous use; and
- If fauna were detected the fate of captured individuals.

Evidence of previous use by fauna was based on the presence of:

- Leaf nest;
- Feathers, scats, fur, eggs or egg shell;
- Wear or chew marks at the hollow entrance.

The shape and size of nesting material, the size of the entrance hole, type of tree and animal signs (i.e. fur, feathers, scats) were used to determine which species might have used the hollow.

Fauna were either left in hollows (by temporarily sealing openings or captured and placed in cotton bags or a cat cage). Frogs were housed individually in plastic clip-seal bags with a small amount of water and leaf litter. Hollows containing fauna were plugged with a cotton bag and placed between the LoC and project boundary (Plate 4). Fauna were only left in-situ if they were uninjured, if the tree could be left undisturbed and if there was minimal activity nearby. Hollows were unplugged at dusk and re-inspected the following morning. In cases

where there was no adjoining forest to place hollows in or animal/s were suspected of being injured a hand-held chainsaw was used to trim retained sections of tree to enable extraction of fauna. Captured fauna and occupied hollows were placed into the adjoining forest, or the closest area of suitable forest (i.e. appropriate area and habitat type for the subject species) within 100m of the LoC boundary. All gliders were transferred to nest boxes, which were installed temporarily in habitat to the point of capture (Plate 5). Nest boxes were inspected the following day and removed if there was no sign of continued use. Reptiles were placed on trees with decorticating bark and hollows or in piles of logs where there was good refuge habitat. Insectivorous bats were released at dusk near their point of capture and frogs were released on drainage lines or at dams. The maximum distance between point of capture and point of release was 150m and most individuals were released immediately adjacent to their point of capture.

Plate 4: Section of tree with a hollow occupied by two sugar gliders being moved outside the LoC. The hollow (centre of log) is plugged with a cotton bag.

Plate 5: Sugar gliders settled into nest boxes after being after being removed from habitat trees.

2.2 Aquatic fauna

2.2.1 Locations

To the authors knowledge fish translocations occurred at all locations along the OH2K upgrade where existing water bodies had to be dewatered completely to facilitate construction activities such as creek diversions, culvert and bridge construction and infilling of farm dams. There were nine such locations; they are listed in Table 1 along with the dates of fish translocation.

Table 1: Locations of the capture and release points for fish translocation along the OH2K upgrade.

Date	Waterway	Chainage	Capture Location (GDA94)	Release Location (GDA94)
10/12/2015	Compound Dam	6950	56J482412, UTM6525860	56J483064, UTM6525648
11/12/2015	Compound Dam	6950	56J482412, UTM6525860	56J483064, UTM6525648
6/02/2015	Gate L26 Dam	20150	56J482572, UTM6538386	56J482273, UTM6538707
6/03/2015	Haydon's Wharf Rd Unnamed Creek	18250	56J483079, UTM6536595	56J482961, UTM65366174
6/03/2015	Haydon's Wharf Rd Southern Dam	17900	56J483037, UTM6536225	56J482961, UTM65366174
9/03/2015	Haydon's Wharf Rd Unnamed Creek	18250	56J483079, UTM6536595	56J482961, UTM65366174
18/03/2015	Wakeboard Dam	18200	56J483111, UTM6536501	56J482961, UTM65366174
22/04/2015	Salvinia Dam	17100	56J482830, UTM6535478	56J482799, UTM6535450
29/04/2015	Haydon's Wharf Rd Northern Dam	18100	56J4831217, UTM6536400	56J482961, UTM65366174
7/07/2015	4400 Dam	4400	56J483233, UTM6523454	56J483296, UTM6523678

2.2.2 Capture

Fish and other aquatic fauna were captured using a mixture of backpack electrofishing, seine net deployment and/or dip netting. The specific methods employed at each site are listed in Table 2.

Table 2: Capture methods employed at each of the fish translocation locations.

Date	Waterway	Chainage	Methods	Comments
10/12/2015	Compound Dam	6950	Seine Net	Large quantities of sediment disturbed during seine net deployment.
11/12/2015	Compound Dam	6950	Seine Net	
6/02/2015	Gate L26 Dam	20150	Dip Net	Captures occurred as water level receded and then subsequently as water was released from the dam into a constructed channel
6/03/2015	Haydon's Wharf Rd Unnamed Creek	18250	Electrofisher (125V, 40Hz) and Dipnet	Numerous deep holes requiring continued pumping to facilitate capture.
6/03/2015	Haydon's Wharf Rd Southern Dam	17900	Seine Net	Very smooth, even benthic surface.
9/03/2015	Haydon's Wharf Rd Unnamed Creek	18250	Electrofisher (125V, 40Hz) and Dipnet	Numerous deep holes requiring continued pumping to facilitate capture.
18/03/2015	Wakeboard Dam	18200	Dipnet and Seine Net	Seine net deployed with difficulty in the upstream sections, then changed to the dipnet for the remainder.
22/04/2015	Salvinia Dam	17100	Electrofisher (250 V, 30 – 50 Hz) and Dipnet	Capture and release points both full of Salvinia (Salvinia molesta),
29/04/2015	Haydon's Wharf Rd Northern Dam	18100	Dipnet and Seine Net	
7/07/2015	4400 Dam	4400	Electrofisher (350 V, 30 – 50 Hz) and Dipnet	Lots of debris, high TSS and algal concentrations, seine net deployment not possible.

Fish capture was generally delayed until the dewatering had progressed to the point where fish capture was judged to be most effective without causing undue distress to aquatic fauna. This approach allows an increased efficiency of fish capture while minimising the amount of dirty water created; fish capture activities tend to significantly increase the suspended sediment concentrations in the water as benthic material is disturbed by almost all of the fishing methods employed. An aquatic ecologist was usually present once dewatering had progressed to the point where the maximum water depth was approximately 1 m and supervised pumping from that point on. When fish capture commenced every effort was made to complete them in the minimum time to avoid long periods where aquatic fauna were exposed to low water levels, which increase their susceptibility to temperature fluctuations, increased suspended sediment concentrations, decreased dissolved oxygen concentrations, reduced habitat availability, increased fauna densities and resulting increases in predator/prey interactions.

2.2.3 Backpack Electrofishing

The backpack electrofisher was employed as the chief method of capture where debris in the water column and the benthic surface excluded the use of other nets. In general the settings were adjusted to utilise the lowest possible voltage to effectively stun fish and the most appropriate frequency to effectively stun the

majority of fish present in any particular waterway. This tends to mean lower voltages in smaller volumes of water or higher salinities and lower frequencies when targeting larger bodied fish such as eels. The voltage settings of the backpack electrofisher utilised were between 150 V and 350 V and the frequency setting were adjusted between 30 and 50 Hz. During backpack electrofishing the fish are stunned by the electrofishing operator and collected by a second member of the ecology team using a dipnet (5 mm woven mesh). The backpack electrofisher cannot be used in circumstances where the maximum water depth exceeds 1m due to safety concerns. Captured fish were held temporarily in a half filled 20 L bucket and transferred intermittently into 50 L nelly bins, filled with water from the immediate site and aerated with battery powered pumps.

2.2.4 Seine Netting

The seine net was utilised in broad areas of shallow water where the water column and benthic surface where relatively free of debris, and the benthic surface was firm and smooth. Seine netting is an effective way of collecting large numbers of fish quickly but can lead to larger numbers of fish perishing as a result of capture. The seine net used was 10 m long, 2 m deep and constructed of 5 mm woven mesh. In general it was deployed repeatedly until the ratio of capture to effort became very low or zero. In waterbodies with high numbers of visible mosquito fish (*Gambusia holbrooki*) an effort was made to deploy the seine net through the top 10 - 20 cm of the water column to capture the majority of the mosquito fish prior to disturbing the benthic material and further targeting native fish. This was done to minimise the amount of time spent sorting Mosquitofish from native fish, a process which can be time consuming and cause undue stress to all captured organisms as they need to be held in captivity for longer periods. The aims of this approach were achieved with varying levels of success, usually depending upon the depth of water at the time of fish capture, the numbers of firetail gudgeons (*Hypseleotris galii*) present and/or the terrain surrounding the waterbody in question. After each deployment of the seine net the captured fish were transferred into 50 L nelly bins, filled with water from the immediate site and aerated with battery powered pumps.

2.2.5 Dip Netting

The dip net was utilised in situations where very little water remained after pumping, where it was not safe to employ the backpack electrofisher and not possible to use the seine net, where water was running through a channel carrying aquatic fauna and/or during backpack electrofishing. The dipnets used were constructed of 5 mm woven mesh with and opening approximately 60 cm x 50 cm. Captured fish were held temporarily in a half filled 20 L bucket and transferred intermittently into 50 L nelly bins, filled with water from the immediate site and aerated with battery powered pumps.

2.2.6 Holding, Transport and Release

Captured aquatic fauna were held in 50 L nelly bins, filled with water from the immediate site and aerated with battery powered pumps. The nelly bins were stocked at a density of less than 5% (kg fish/L water). Fish were separated by size to avoid predation of smaller fish by larger fish. Holding times were generally less than 1 hour. Fish were transported by hand or light vehicle from the place of capture to the release point at regular intervals to avoid overcrowding of holding tanks and long holding periods.

Release points that best resembled the capture point in terms of water quality and habitat were chosen within the immediate catchment area. Where water quality did not closely resemble the measurements collected at the release point in terms of temperature, pH and conductivity water from the release point was gradually mixed in to the holding tanks to avoid shock. Non-native fish were separated out and euthanased in an ice slurry during the process of releasing native fish. At the release point all native fauna were identified, counted and observed as they swam away. Perished native fish and euthanased non-native fish were buried on-site.

2.3 Stage 2 nest box assessment

The NBPoM specifies (Section 7.1, page 23) that "The contractor will install 60% of the nominated nest boxes prior to or during the clearing works with the objective of providing temporal refuge habitat for those hollow dependent fauna displaced during clearing operations. The remaining 40% of nest boxes will be installed by the contractor once a final tally of functional tree hollows has been compiled and reviewed as a result of the data collected during the clearing supervision. Occupancy rates of tree hollows during the clearing supervision will also facilitate the final number and types of nest boxes being installed."

The NBPoM specifies (section 4, page 12) that "The final (i.e. second stage) will be an appraisal once the clearing works have been completed and a final tally of the actual numbers of hollow bearing trees and tree hollows has been tallied based on the detailed design (numerical data substituted back into the formulas provided below). At this point in time the nest box plan will be updated to reflect the final number of nest boxes required and re submitted to the EPA for approval."

The formula referred to above is:

Density of HBT/ha * Mean number of functional hollows/HBT * correction factor (20% or 1.2).

To obtain the necessary data for input into the nest box equation the number of Hollow Bearing Trees (HBT)/hectare (ha) and the number of functional hollows/HBT for each nest box zone was calculated. Data were combined for nest box zones that occurred on opposite sides of the alignment such as zones A and B, C and D and O and P. It was necessary to combine adjacent zones as the recording of HBT data did not distinguish between east and west sides of the alignment. Data were sourced for each nest box zone from clearing records and Lend Lease Engineering calculated the area cleared/zone. A 200m buffer was added to each zone to account for any inaccuracies in recording the location of HBT during clearing. This means that the calculated HBT/ha overestimates the actual number of HBT in each zone and the calculation of nest boxes required is therefore conservative. Other data relevant to the assessment were also calculated, including: total number of habitat trees inspected, number of HBT, area cleared (ha), number of functional hollows, other types of hollows and the number of hollows with evidence of use.

3. Results

3.1 Threatened Fauna

Twelve threatened species were recorded during the clearing phase (Table 3). All 12 species are listed on the NSW *Threatened Species Conservation (TSC) Act 1995* and three are also listed on the Commonwealth *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* (Table 1). Koala (or evidence of) was recorded on five occasions during clearing. Three records were of road-killed individuals, two near Yarrabee Road and one near Sancrox Road. One individual was recorded in the clearing zone north of Bill Hill Road and scats were recorded beneath a Swamp Mahogany south of Bill Hill Road (refer 3.2.1).

Grey-headed flying-fox were recorded throughout the alignment with consistent records during the clearing phase. No grey-headed flying-foxes were recorded roosting in the alignment. A camp of black flying-fox (Pteropus alecto) was recorded on Dalhunty Island west of the upgrade corridor on 8 December 2014. The camp was surveyed on several occasions between 8 December 2014 and 15 January 2015 to determine if grey-headed flying-foxes were present. The peak count was 238 black flying-fox on 15 January 2015. No grey-headed flying-fox were recorded at the camp.

Glossy black cockatoo were recorded at three sites, Sancrox Road, Cooperabung Creek and Barry's Creek. A (probable) little eagle was observed roosting within the alignment south of the Blackmans Point interchange on 25 November 2015 and individuals were recorded flying over the highway between Blackmans Point Road and Bill Hill Road in December 2014 and January 2015. An arborist removed the little eagle nest at chainage 10875 on 24 July 2014 (Appendix C). Masked owls were recorded on five occasions. Owls were heard calling north of Mahogany Road (6/1/15) and north of Bill Hill Road (9 & 11/3/15) and two road-killed individuals were recorded on the existing highway south of the Wilson River bridge on 4 and 11 May 2015. A flock of 10 varied sitella was recorded foraging in mixed eucalypt forest west of Yarrabee Road on 14 January 2015.

Table 3: Threatened species recorded during and immediately after the clearing phase. V = vulnerable, E = endangered.

Species Name	Common Name	Status		No. Ind; No. Sites; Comments
		NSW	C'Wealth	
Litoria brevipalmata	Green-thighed Frog	V		2 ind; Males calling at East Rd 150m north of Blackmans Point Rd.
Mixophyes iteratus	Giant Barred Frog	E	E	8 ind; 2 on alignment Cooperabung Ck, 6 east of alignment Cooperabung Ck.
Hieraaetus morphnoides	Little Eagle	V		1 ind; Roosting in *E. pilularis* south of Wharf Rd; recorded in November and December 2014 flying over highway in Blackmans Point Road area.
Pandion cristatus	Eastern Osprey	V		2 individuals recorded foraging in Dalhunty Channel (Wilson River) west of alignment.
Tyto novaehollandiae	Masked Owl	V		4 ind; Two road killed 100m and 200m south of Wilson River; one calling near Mahogany Road and one calling north Bill Hill Road.
Calyptorhynchus lathami	Glossy-black Cockatoo	V		8 ind; 2 feeding in Allocasuarina sp. Sancrox Rd; 5 flying over Cooperabung Ck; 1 flying over Barry's Ck.
Daphoenositta chrysoptera	Varied Sitella	V		~10 individuals in feeding flock north of Cooperabung Range.
Phascolarctos cinereus	Koala	V	V	5 ind; 2 road kill sites; 1 scat recorded under swamp mahogany sth Bill Hill Road, 1 Bill Hill Rd spotlighting.
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	Recorded throughout the alignment during entire clearing phase.
Maundia triglochinoides	Maundia	V		>100 ind; 1 site with newly emergent plants approx. 0.05ha (ch 3750); Abundant at Fernbank Creek.
Petaurus norfolcensis	Squirrel Glider	V		Recorded during spotlight surveys foraging north of Haydon's Wharf Rd. Ch 17550.
Dasyurus maculatus	Spotted-tailed Quoll	V		Roadkill individual recorded on date 5.7.15, Cooperbung Creek.

3.1.1 Threatened frog surveys

Threatened frog surveys were conducted at five locations within the OH2K alignment (Tables 4 and 5). Giant barred frogs were targeted at two sites on Cooperabung Creek and green-thighed frogs at three sites, north of Blackmans Point Road, north of Bill Hill Road and Barry's Creek.

Giant barred frogs were recorded at both sites on Cooperabung Creek (Plate 6). Up to six male frogs were recorded over a 50m section of creek at Cooperabung Creek south (chainage 18950 E 483087; N 6537284) and two individuals, one male and one female, were recorded at Cooperabung Creek north (chainage 19660 E 0482781; N 6537974). The project boundary fence and location of temporary frog fence at Cooperabung Creek

south was moved outside the riparian zone to avoid impacts on giant barred frog habitat and all individuals recorded at that site were outside the (adjusted) project boundary fence and therefore were not captured or processed. Two giant barred frogs were captured within the LoC at Cooperabung Creek north, one adult male and one adult female. Both individuals had been previously PIT (Passive Integrated Transponder) tagged. The adult male was initially captured on 11 February 2015, released on 12 February 2015 and recaptured within the LoC on 15 February 2015. A (probable) adult female was observed outside the temporary frog fence on 13 February 15 and left insitu. An adult female was captured within the LoC on 16 February 2015. The adult male and female captured on 15 and 16 February 2015 were held in separate aquaria for two and three nights respectively until substantive clearing of riparian habitat had been completed. Both individuals were released alive and in good health on 18 February 2015. No giant barred frog tadpoles were captured during targeted dip-netting at Cooperabung Creek north.

Plate 6: Male giant barred frog (Mixophyes iteratus) recorded outside the alignment at Cooperabung Creek.

Table 4: Timing and results of giant barred frog surveys conducted during the clearing phase of the OH2K upgrade. M = male; F = female; J = juvenile.

Site	Survey Date	Duration (minutes)	Personnel	No. Individuals & (Sex)	Comment
Cooperabung Creek sth (Ch 18900)	5/2/15	NR	2	3 (M)	Outside boundary – not captured
	7/2/15	45	2	3 (M)	Outside boundary – not captured
	9/2/15	80	1	6 (M)	Outside boundary – not captured
	5/3/15	50	2	3 (2M; 1J)	Outside boundary – not captured
Cooperabung Creek nth (Ch 19660)	19/11/14	50	2	0	Temporary fence on north side
	20/11/14	28	3	0	
	23/11/14	30	2	0	North of creek
	8/12/14	40	3	0	
	14/12/14	25	3	0	
	15/12/14	60	2	0	
	16/12/14	20	2	0	North of creek
	29/1/15	60	2	0	
	11/2/15	70	3	1 (M)	SV- 74mm; 55gr; adult; released 100m upstream boundary
	13/2/15	60	2	1 (F)	Outside frog fence - not captured
	15/2/15	60	3	1 (M)	Recapture; same frog as 11/2/15; held for three nights until site cleared; released 150m upstream of boundary.
	16/2/15	65	3	1 (F)	SV – 95mm; 120gr; held for two nights until site cleared; released 150m upstream of boundary
	17/2/15	30	2	0	
	26/2/15	60	2	0	
	27/2/15	45	2	0	
	4/3/15	30	2	0	
	9/3/15	24	2	0	
	10/3/15	15	2	0	

Clearing, at Cooperabung Creek north, in late February and early March 2015 was limited to minor excavation and rock placement for a drill rig and installation of temporary exclusion fence on the eastern side of the existing highway.

Twenty-two targeted surveys for giant barred frogs were conducted at the two sample sites between 19 November 2014 and 10 March 2015, including 18 at Cooperabung Creek north. Clearing was undertaken in stages, mid-November and December 2014, mid and late February 2015 and late March 2015. Despite Barrys Creek being described as unsuitable for giant barred frogs (Section 2.2.2, OH2K Giant Barred Frog Strategy, Lewis 2013), targeted surveys were carried out on two occasions and during nocturnal pre-clear surveys.

Green-thighed frogs were recorded at one site following the January 2015 rainfall event. Targeted (nocturnal) green thighed frog surveys were conducted on three non-consecutive nights at Blackmans Point Road and Bill Hill Road in mid-late January 2015 (Table 5). On 22 January 2015 two male frogs were recorded at an ephemeral pond outside the project boundary near East Road (approx. chainage 9000), north of Blackmans Point Road (E: 481840 N: 6527853) (Plate 7). Other frog species present in the area were *Litoria dentata, Limnodynastes peronii, Litoria gracilenta* and *Crinia signifera*.

Plate 7: Adult male green-thighed frog (Litoria brevipalmata) recorded near east Road, north of Blackmans Point Road on 22 January 2015.

Table 5: Timing and results of green-thighed frog surveys conducted during the clearing phase of the OH2K upgrade.

Site	Survey Date	Duration (minutes)	Personnel	No. Individuals & (Sex)	Comment
Blackmans Point Rd/East Rd area	22/1/15	75	2	2 (M)	Survey occurred during heavy rain.
	27/1/15	60	2	0	Survey followed a week of consistent rain
	28/1/15	60	2	0	Survey followed a week of consistent rain
Bill Hill Road area	19/1/15	Nr	2	0	Survey occurred during heavy rain.
	21/1/15	135	2	0	Survey occurred during heavy rain.
	27/1/15	90	2	0	Survey followed a week of consistent rain
	9/3/15	25	1	0	
Barry's Creek	9/12/14	20	1	0	
	29/1/15	60	2	0	Survey followed a week of consistent rain

3.2 Spotlighting

A total of 186 spotlight surveys were conducted between 2nd November 2014 and 21 August 2015 (Table D1, Appendix D). During spotlight surveys 309 records of 51 species were made, including 18 species of frog, five reptiles, 19 mammals and seven birds (Table 6). One introduced species; black rat (Rattus rattus) was recorded. Threatened species recorded during spotlight surveys included; Koala, Grey-headed Flying-Fox, Masked Owl, Giant-barred Frog, Green-thighed Frog and Little Eagle. During spotlighting, 29 vertebrates from 17 species were captured and relocated from the clearing front. Of these, 19 individuals were frogs removed from dams, sedge swamps and drainage lines (Table 6).

Table 6: Species of vertebrate captured during pre-clearing and spotlighting surveys for the Oxley Highway to Kundabung Pacific Highway upgrade. ^{V} = Listed as vulnerable by the NSW *Threatened species Conservation Act 1995*. Note: does not include deceased or euthanized; ** introduced species.

Species Name	Common Name	Preclearing & Trapping (No. relocated)	Spotlighting (No. relocated)	Giant Barred Frog Surveys	Targeted Frog Surveys	Incidental
Adelotus brevis	Tusked Frog		x(1)			
Crinia spp.			x			
Limnodynastes peronii	Stripped Marsh Frog		x(4)	x(1)		
Litoria brevipalmata	Green-thighed Frog^{V}		x			
Litoria caerulea	Common green tree frog		x			
Litoria dentata	Bleating Tree Frog		x(1)			
Litoria dentata tadpoles		x(170)				
Litoria fallax	Easter Dwarf Tree Frog	x(1)	x(5)			
Litoria gracilenta	Dainty Green Tree Frog		x		x(1)	
Litoria latopalmata	Broad-palmed Frog		x			
Litoria nasuta	Striped Rocket Frog		x(2)	x(1)		
Litoria peronii	Peron's Tree Frog		x(2)			
Litoria revelata	Whirring Tree Frog					x(1)
Litoria tyleri	Tyler's Tree Frog		x(2)			
Mixophyes iteratus	Giant Barred Frog ^{V}		x	x(8)		
Pseudophryne coriacea	Red-backed Toadlet		x(1)			
Pseudophryne spp.		x(1)	x			
Uperoleia fusca	Dusky Toadlet		x			
Uperoleia laevigata	Smooth Toadlet		x			
Uperoleia spp.			x(1)			
Hemiaspis signata	Black bellied Swamp Snake	x(2)		x(1)		x(1)
Lampropholis delicata	Garden Skink	x(8)		x(5)		x(1)
Amphibolurus muricatus	Jacky Lizard		x(1)			
Cacophis krefftii	Southern Dwarf Crowned	x(2)	x(1)			
Dendrelaphis punctulata	Common Tree Snake					
Egernia mcpheei	Eastern Crevice Skink	x(1)				
Fossorial Skink spp.		x(3)				
Hemisphaeriodon gerrardii	Pink Tongue Lizard		x(1)			
Lampropholis amicula	Friendly Sun Skink			x(1)		
Ramphotyphlops nigrescens	Blackish Blind Snake	x(5)				x(15)
Rhinoplocephalus nigrescens	Eastern Small-eyed Snake	x(3)	x(1)			
Saiphos equalis	Yellow-bellied Three-toed skink	x(1)				
Saproscincus oriarus	Heath Shadeskink			x(1)		

Tiliqua scincoides	Blue Tongue Lizard						x(2)
Vermicella annulata	Bandy Bandy		x(1)				
Demansia psammophis	Yellow Faced Whip Snake	x(1)					
Acrobates spp.	Feathertail glider		x				
Antechinus spp.		x(3)	x				
Antechinus stuartii	Brown Antechinus	x	x				
Macropus giganteus	Eastern Grey Kangaroo		x				
Macropus rufogriseus	Red-necked Wallaby		x				
Macropod spp.			x				
Micro-bat spp.			x				
Perameles nasuta	Long-nosed Bandicoot		x				
Petaurus breviceps	Sugar Glider		x				x(1)
Petaurus spp.			x				
Phascolarctos cinereus	Koala[V]		x(1)				
Pseudocheirus peregrinus	Common Ringtail Possum		x				x(1)
Pteropus poliocephalus	Grey-headed Flying Fox		x				
Pteropus spp.	Flying Fox		x				
Rattus fuscipes	Bush Rat	x(4)					
Rodentia spp.	Rodent		x				
Tachyglossus aculeatus	Echidna	x(1)	x(1)				x(1)
Trichosurus caninus	Short-eared Brushtail Possum		x				
Trichosurus vulpecula	Common Brushtail Possum		x				
Wallabia bicolor	Swamp Wallaby		x				
Aegotheles cristatus	Owlet-nightjar		x				
Cacomantis variolosus	Brush Cuckoo		x				
Dacelo novaeguiineae	Kookaburra						x(1)
Eurostopodus mystacalis	White-throated Nightjar						
Hieraaetus morphnoides	Little Eagle (po)[V]		x				
Philemon corniculatus	Noisy Friarbird		x				
Podargus strigoides	Tawny Frogmouth		x				x(1)
Tyto alba	Barn Owl		x				
Tyto novaehollandiae	Masked Owl[V]		x				
	Freshwater Crayfish spp.		x(3)				
Rattus rattus	Black Rat **	x	x				

3.2.1 Koala Capture and Relocation

One Koala was detected during nightly spotlight surveys on 19 January 2015. The individual was located in a large tallowwood at chainage 11850 (E: 481423 N: 6530439), approximately 300m north of Bill Hill Rd in Cairncross State Forest. The OH2K Koala Protocol was implemented and the individual was trapped at approximately 4.30am the following morning.

After an initial inspection, by the project ecology team, it was noted the right eye had partial clouding. This was sufficient to warrant transferring the animal to the Port Macquarie Koala Hospital for further assessment. The animal was a 7-8 year old female carrying no joeys but with evidence of previous breeding. After consultation with vets at the hospital the clouding of the right eye was deemed to be corneal scarring from a previous injury. Other than the aforementioned injury, vets thought the animal was of healthy weight and condition.

The koala was held for an extra week due to a small injury sustained whilst in care. Following discussions within the project team and senior management at the Koala Hospital and reconnaissance for a suitable release site it was agreed that Rawdon Creek Nature Reserve, on the western side of the existing highway, was the most suitable release site. This was deemed to be within the animals home range and safer from the impacts of logging, ongoing clearing and vehicle movement than forest adjoining the upgrade. The release occurred at approximately 11am on 3 February 2015. The animal was released onto a Tallowwood tree, which is a primary feed tree species and the same species occupied when the individual was captured (Plate 8). The GPS coordinates for the release site were: E: 480226 N: 6529946.

Plate 8: Female koala being released onto a tallowwood (Eucalyptus microcorys) after treatment at the Port Macquarie Koala hospital.

3.3 Pre-clearing surveys and trapping

A total of 376 pre-clearing surveys were undertaken between 3 November 2014 and 7 September 2015 (Table D2, Appendix D). Pre-clearing surveys prior to the commencement of spotlighting were for minor clearing work. Sixteen species were recorded during the surveys, including three frog, nine reptile and four mammal species (Table 4). Seventeen species and 206 individuals, including 170 *Litoria dentata* tadpoles, were captured and relocated. A further 180 Litoria peroni and 405 striped marsh frog tadopoles were relocated during aquatic fauna surveys. Trapping results included: one bush rat (Rattus fuscipes) captured north of Bill Hill Road; and two bush rats, two black rats (Rattus rattus) and one brown antechinus (Antechinus stuartii) at Cooperabung Creek. The bush rats and brown antechinus' were relocated outside clearing area and two Black Rats were euthanised in accordance with Sandpiper's DPI AC&E licence.

3.2 Habitat tree removal

3.2.1 Habitat resource survey

A total of 468 Hollow-bearing Trees (HBT) were marked during the habitat resource surveys. This included trees marked during the initial survey (Lewis 2013d) and additional trees marked during the habitat resource survey and pre-clear surveys.

3.2.2 Hollow characteristics and species recorded

During clearing of the OH2K alignment, 443 habitat trees were inspected, of which 310 (70%) contained 738 hollows (Table 7). Small branch hollows were most abundant (243) followed by medium branch (229), medium trunk (60), small trunk (56), large trunk (46), large branch (45), large spout (25), medium spout (22), very large spout (4) very large trunk (4), very large branch (3), and small spout (1) (Table 5). Inspected trees also contained 11 nests (6 stick nests, 5 cup nests), 64 termitaria (with hollows) and 19 dreys. Fifteen (15) trees had native beehives and five (5) had European beehives. A further six trees contained fissures and one (1) had decorticating bark. A total of 62 trees were occupied by vertebrate fauna and a further 91 trees displayed evidence of use. Of the 310 trees with hollows 153 (49.3%) were occupied or showed evidence of use by vertebrate fauna. The higher quality hollows removed from HBTs were placed into low conservation value retained vegetation to act as habitat for small ground dwelling and scansorial fauna.

A total of 125 individuals and 28 species were captured during HBT removal (Table 7, Plates 9-20). Species richness was comprised of seven mammal (25% of total species), 10 reptile (36%), four bird (14%) and seven frog (25%) species. The most commonly captured fauna were tree skinks (43 individuals, 3 species), tree frogs (19 individuals, 7 species), sacred kingfisher (13 individuals + 12 eggs), sugar gliders (13 individuals), feathertail glider (13 individuals), brown antechinus (7 individuals) as well as four tree snakes of two species (coastal carpet python and common green tree snake), and four large possums of two species (common brushtail possum and common ringtail possum). None hollow dependent species recorded during HBT inspections were small-eyed snake (Cryptophis nigrescens; 1 ind), blackish blind snake (Ramphotyphlops nigrescens; 5 ind) and *Lampropholis* spp. (1 ind). *R. nigrescens* was often recorded in the root-ball of trees, particularly stags.

The largest number of individuals was removed from stags (34 individuals), followed by tallowwood (24 individuals + 11 eggs), coastal blackbutt (29), small-fruited grey gum (14) and red mahogany (9). The tree species with the highest proportion of active hollows was small-fruited grey gum (57%), followed by white stringybark (47%), pink bloodwood (45%), coastal blackbutt (40%) and stag (35%). *Acacia longifolia, Melaleuca styphelioides,* and *Callistemon spp.* had an activity rating of 100%. This is attributed to the confirmed presence of dreys prior to tree felling.

Table 7: Results of Hollow Bearing Tree inspections conducted during the clearing phase of the Oxley to Kundabung Pacific Highway upgrade. *A hollow was considered viable if it was >1cm in diameter and 10cm deep; S = small; M = medium; L = large; VL = very large; Term = termitaria; Fis = fissure; E = epiphyte, CN = cup nest; SN = stick nest; PN = passerine nest; NB = native bee hive; EB = European bee hive; D = drey; De = decorticating bark; Basal = basal.

Tree Type	No. Inspected	No. trees with hollows (%)	Hollow Type								Spout	Other	No. Active HBT	No. HBT with evidence	No. Individuals & Species
			Branch				Trunk								
			S	M	L	VL	S	M	L	VL					
Blackbutt	72	55(76)	52	53	8		3	3	10		1m, 2l	D1, NB3, Fis2, EB2, Term1, SN1	19	10	lace monitor (2), *Eulamprus spp.* (5), sugar glider (9), tawny frogmouth (2), sacred kingfisher nestlings (4)*Litoria peronii* (4), green tree snake (1), small-eyed snake
Pink Bloodwood	11	7(64)	10	6	4				1			Term2, D1,	3	2	*Eulamprus tenuis* (1), microbat sp. (1),
Red Bloodwood	8	5(62)	5	1				3				NB1, Term1		1	
Bloodwood spp.	12	10(83)	10	14	8		1	2				PN1, Term2	2	3	Unid. Bird chicks(2)
White stringybark	32	27(84)	19	17	3		1	5	1		1vl, 4l, 1m	Term4, D2, EB 1, NB1, Basal 1, Fis 2	6	9	Feathertail glider (1), sugar glider (3), *Eulamprus tenuis* (1*), Litoria dentata*, pink tongue lizard (1)
Tallowwood	55	37 (67)	30	38	5	2	3	2	5		3m, 1l	Term 34, CN 1, NB 2	4	13	Sacred kingfisher chick (5), feathertail glider (2), sacred kingfisher eggs (4), *Litoria peronii* (1), sacred kingfisher nestlings (4), lace monitor eggs (7), sugar glider (1), *Litoria tyleri* (1), *Litoria dentata* (1), *Eulamprus tenuis* (3), common brushtail possum (1), blackish blind snake (1)
Melaleuca nodosa	6	5(83)	4	1			2	3					2		*Litoria fallax* (1), *Litoria dentata* (1)
Melaleuca quinquenervia	9	6(67)	2	1			5	4	2			D1,		1	
Melaleuca styphelioides	1											D1		1	

Melaleuca spp.	7	4(57)	2				1					SN1, D1, Term2		2	*Litoria peronii* (1)
Stag	117	92(79)	48	65	11	1	31	17	11	3	1vl, 18l, 17m, 1s	Fis2, NB1, Basal2, Term4, NB5, EB1, E1	10	31	*Eulamprus spp*.(9), antechinus spp. (7) - pinkies (5), blackish blind snake (2), *Lampropholis sp*. (1), feathertail glider spp. (5), brushtail possum (1), green tree snake (2), *Litoria tyleri* (1), *Egernia mcpheei* (1), microbat sp. (1), carpet python (1), *Litoria caerulea* (1), pink tongue lizard (2)
Eucalyptus spp.	5	2(40)	1	2				2	3			Term4	2		Bird eggs poss. king fisher sp. (4), *Eulamprus tenuis* (2)
White mahogany	6	5(83)	13	1	1			4	3			CN1	1		Noisy friarbird
Norfolk Island Pine	1											CN2	1		Figbird eggs (3)
Camphor laurel	1											D1			
Euc. stringybark spp.	15	7	10	2			1	4				D2, Term6, CN1, NB1	2	2	Feathertail glider spp. (2), noisy friarbird
Swamp she-oak	9	6(67)	3	2				1	3			De1	1		*Litoria gracilenta* (1)
Black she-oak	5											D4, CN1			Common ringtail possum (1), noisy friarbird (1)
Euc. Ironbark	2	2(100)	2									Term1	1	1	*Litoria spp*. (1)
Small fruited grey gum	7	5(71)	3	2				2	2		1vl	NB1	1	3	*Litoria peronii* (1), feathertail glider (2), *Eulamprus tenuis* (11)
Acacia spp.	1											D1			
Red Mahogany	32	16(50)	16	9	2		5	6	4	1		Term2	4	5	*Eulampris spp*. (4), blackish blind snake (1), feathertail glider den (1), *Litoria caerulea* (2), *Litoria gracilenta* (1)
Forest red gum	6	5(83)	1	6	2		2				1vl	EB1, Term1	1	2	
Flooded gum	5	3(60)	2	4	1							SN2		1	
Spotted Gum	3	1(33)	1												

Swamp mahogany	2	2(100)	5	2								EB1	1	1	*Eulamprus tenuis* (3)
Turpentine	4	3(75)	3	1								D1		1	
Brush box	1											D1		1	
Callistemon spp.	1											D1		1	
Acacia longifolia	1											D1	1		Common ringtail possum (1)
Water gum	2	2(100)	1	2			1	2							
Lophostemon sp.	1	1(100)							1						
Forest oak	1											SN1			
Tallowwood with nest boxes	2	2(100)													
Totals	443	310	243	229	45	3	56	60	46	4	53	64 term,19 Drey,15 NB,5 SN,5 EB,6 CN,3 Basal,6 Fis, 1 E.	62	91	

Plate 9: Feathertail glider captured from HBT.

Plate 10: Common ringtail possum relocated from drey in forest oak.

Plate 11: Juvenile (puggle) short-beaked echidna.

Plate 12: Juvenile sugar glider.

Plate 13: *Egernia mcpheii* relocated during preclear survey.

Plate 14: Bandy bandy relocated during spotlight surveys.

Plate 15: Pink tongue lizard relocated during spotlight surveys.

Plate 16: Southern dwarf crown snake relocated during spotlight surveys.

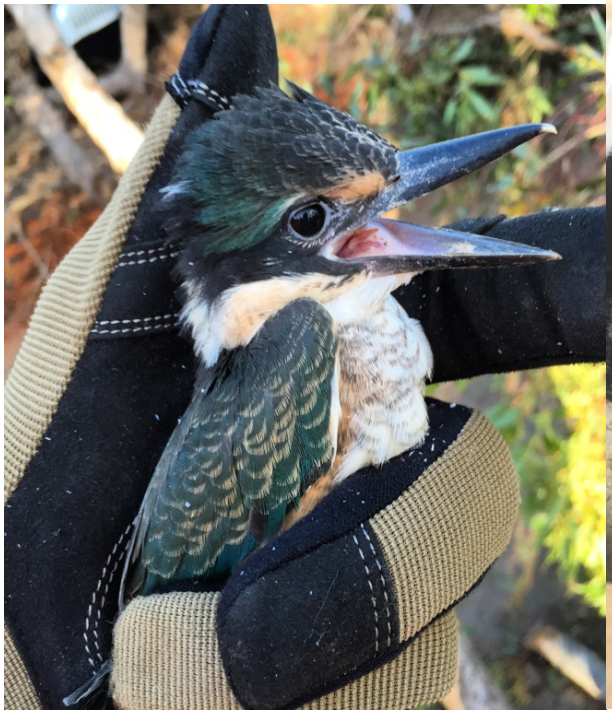

Plate 17: Sacred kingfisher fledgling.

Plate 18: Juvenile tawny frogmouth.

Plate 19: Brown Gerygone nest in clearing zone (chicks fledged).

Plate 20: Australian Figbird nest and eggs. Nest retained & chicks fledged.

3.2.2 Mortality

Twenty (20) individuals comprising 7 species died from 10 separate incidents during mainline clearing (Table 8, Appendix D). Eleven eggs of two species (sacred kingfisher and Australian figbird) were also euthanised. Five individuals, comprised of four species (list species), died during habitat tree removal and seven individuals, comprised of four species (list species) were found dead during general clearing. All deaths attributed to general clearing were of reptiles and frogs.

The number of individuals killed during HBT removal (5 individuals) was 4% of fauna relocated from HBT and made up 25% of total mortalities. The number of individuals found dead in either the previous days clearing area or on light vehicle access tracks (7 individuals) was 5.6% of fauna captured and 35% of total mortalities. The number of individuals euthanised (8) made up 6.4% of total fauna captured and 40% of the total mortalities. The total number of individuals killed or euthanised during the clearing phase (20 individuals out of 359 total) represents 5.5% of the fauna captured and relocated during all activities.

Table 8: Fauna mortality during the clearing phase of the OH2K Pacific Highway Upgrade.

Species & No.	Chainage	Location description	Injuries	Cause of death
Litoria nasuta x1	Ch 9600	On vehicle track	Crushed	Run over by light vehicle on access track
Figbird Eggs x3	Ch 5500	Cracked during tree removal	Cracked open	Euthanised
Sacred kingfisher eggs x 4	7200 W	Termitaria in HBT	N/A	Destroyed during HBT removal
Sacred kingfisher eggs x 4	7850 E	Termitaria in HBT	N/A	Destroyed during HBT removal
Brown Antechinus x 1	Ch 10000	Stump clearing, crushed by dozer	Crushed	Bulldozer
Brown Antechinus x 5	8500 E	South Blackmans Point Rd	Nil but very young	Separation from mother, died in care. HBT removal
Sacred Kingfisher Chicks x 2	8000 W	South Wharf Rd	Crushed	HBT removal. Crushed, Euthanised
Sacred Kingfisher Chicks x 3	8000 W	South Wharf Rd	Nil, very young	Taken into care, euthanised
Blind Snake x 1	24500	Barrie's Creek	Crushed	Crushed during stage 1 clearing
Green Tree Snake x 1(prob)	202000	North Cooperabung Dr	Crushed	Crushed during stage 1 clearing
Sugar Glider x 1	19000	North Haydon's Wharf, HBT removal	Crushed/paralysed	Euthanised by Vet
Lit. caerulea x 1	6000	Glen Ewan Rd	Crushed	Crushed by light vehicle on access track
Blackish Blind Snake x 1	18300	Wyndell Close	Crushed	HBT removal crushed
Blackish Blind Snake (3)	24500	Barry's Creek	Crushed/severed	Severed by excavator

3.3 Aquatic fauna

A total of 17589 (this number includes some block counting and estimates where counting individual fish was thought to be counter-productive) fish and other aquatic fauna were captured and successfully released during fish translocation efforts. A total of 8431 mosquitofish (*Gambusia holbrooki*) were captured and euthanased (also includes some block counting). The total number of individual taxa captured, translocated (TR), dead in transit (DT) or euthanased (EE) are displayed in Table 9. The most common fish encountered were firetail gudgeons (*Hypseleotris galii*) and mosquitofish. A relatively large proportion of firetail gudgeons (approximately 30%) perished during fish translocations. Lower numbers of striped gudgeons (12%) and empire gudgeons (7%) also perished. Other species captured included; long-finned eel (88 individuals; Plate 21), short-finned eel (75 individuals; Plate 21), silver perch (14 individuals; Plate 22), goldfish (2 individuals; Plate 22), and eastern long-necked turtle (2 individuals; Plate 23).

Table 9: Combined numbers of fish captured, translocated (TR), dead in transit (DT) and euthanased (EE) for all fish translocation activities along the OH2K upgrade.

Common Name	Species Name	Fish Captured	TR	DT	EE
Invasive Fish					
Goldfish	*Carassius auratus*	2	0	0	2
Mosquitofish	*Gambusia holbrooki*	8431	0	0	8431
Silver Perch	*Bidyanus bidyanus*	14	0	0	14
Amphibian					
Peron's Tree Frog (tadpole)	*Litoria peronii*	180	180	0	0
Striped Marsh Frog (tadpole)	*Limnodynastes peronii*	405	375	30	0
Crayfish					
Yabby	*Cherax species*	12	12	0	0
Fish					
Empire Gudgeon	*Hypseleotris compressa*	5119	4759	360	0
Firetail Gudgeon	*Hypseleotris galii*	13479	9501	3978	0
Long-finned Eel	*Anguilla reinhardtii*	88	85	3	0
Short-finned Eel	*Anguilla australis*	75	75	0	0
Striped Gudgeon	*Gobiomorphus australis*	2922	2564	358	0
Shrimp					
Glass Shrimp	*Paratya australiensis*	36	36	0	0
Turtle					
Eastern Snake-necked Turtle	*Chelodina longicollis*	2	2	0	0
Grand Total		30765	17589	4729	8447

Plate 21: Shortfin Eel (*Anguilla australis*) (left side) and Longfin Eel (*Anguilla reinhardtii*) (right side) were captured during aquatic fauna surveys.

Plate 22: Silver perch (Bidyanus bidyanus) (left side) and goldfish (Carassius auratus) (right side).

Plate 23: Eastern Snake-necked Turtle (*Chelodina longicollis*)

3.4 Stage 2 nest box assessment

The stage 2 calculation of nest box numbers, using data gathered during the clearing phase, is presented in Table 10. The results are substantially different to those presented in the NBPoM, with a total of 114 boxes calculated in stage 2 compared with 469 during stage 1 (Table 11). Based on stage 2 calculation only 24.3% of the initial estimate of boxes are required.

Large discrepancies were recorded in zones A/B, C/D, L, N, O/P and R. After stage 2 calculations zone A/B had an actual nest box requirement of 10, 11.3% of the original stage 1 calculation. Zone C/D requires 15 nest boxes, 20.8% of the initial calculation. Zones L and N require 1 (7.1% of initial calculation) and 4 (16.6% of initial calculation) nest boxes respectively. Zone O/P had the largest discrepancy where only 6.6% of the initial 30 nest boxes from stage 1 calculations were required. Zones F and K are the only zones where the initial calculation was under-representative of the actual abundance of hollows. Stage 2 calculations require the installation of 1 box in zone F and 3 in zone K.

Table 10: Habitat tree and hollow data gathered from each nest box zone during the clearing phase of the Oxley to Kundabung project. SoC = side of carriageway; T = termitaria; Dr = drey; DB decorticating bark; F = fissures, Ba = basal.

NB Zone	Zone chainage	SoC	No. Habitat Trees Inspected/Zone	No. HBT with Hollows (incl term):Drey	Area cleared (ha)	HBT/ha	No. functional hollows	Hollows/ tree	Other	Used hollows/ha	Used hollows (incl term):Drey
A & B	900 - 1700	Both	37	25:8	7.95	3.14	66	2.64	8xDr, 1xT, 1xBa, 2xF	0.62	5:2
C & D	3500 - 4250	Both	43	12:0	7.16	1.67	88	7.33	4xT	0.41	3:0
E	7000 - 8000	West	32	29:0	13.13	2.20	57	2	7xT, 1xF	0.68	9:0
F	8050 - 8650	East	54	38:4	12.78	2.97	79	2.1	4xDr, 11xT	1.09	14:1
G	9000 - 9600	East	22	13:3	4.16	3.12	30	2.31	3xDr, 2xT, 1xBa	0.24	1:0
H	10000 - 10800	Both	29	21:0	7.07	2.97	66	3.14	7xT, 2xF	0.56	4:0
I	10800 -11450	Both	37	24:1	4.77	5.03	62	2.58	1xDr, 1xT	3.14	15:0
J	11650 - 12350	Both	38	28:1	4.41	6.34	53	1.89	1xDr, 3xT	2.72	12:0
K	12550 - 13150	West	12	12:1	3.61	3.32	25	2.08	1xDr, 2xT	0.54	3:0
L	13600 - 14200	West	5	3:0	5.53	0.54	5	1.67	1xDB	0.18	1:0
M	17400 - 17950	West	9	7:0	4.99	1.40	21	3	7xT	0.20	1:0
N	18000 - 18550	Both	16	13:1	13.69	0.94	50	3.85	1xDr, 4xT	0.51	7:0
O & P	20550 - 21550	West	10	8:0	9.85	0.81	17	2.13	1xDB	0.20	2:0
Q	22000 - 22700	West	10	9:0	9.62	0.93	21	2.33	2xT	0.31	3:0
R	23000 - 24000	West	21	15:0	8.39	1.78	31	2.07	1xT	0.35	3:0

Table 11: Stage 2 nest box calculation for the OH2K Pacific Highway Upgrade.

NB Zone	Number of NB	Equation	Number of NB - Stage 2	Number of NB installed - Stage 1	No. of extra NB required - Stage 2
A & B	88	3.14*2.64*1.2	10	40	0
C & D	72	1.67*7.33*1.2	15	39	0
E	14	2.20*2*1.2	5	9	0
F	10	2.97*2.1*1.2	7	6	1
G	24	3.12*2.31*1.2	9	15	0
H	19	2.97*3.14*1.2	11	12	0
I	60	5.03*2.58*1.2	16	36	0
J	41	6.34*1.89*1.2	14	25	0
K	8	3.32*2.08*1.2	8	5	3
L	14	0.54*1.67*1.2	1	8	0
M	11	1.40*3*1.2	5	7	0
N	24	0.94*3.85*1.2	4	12	0
O&P	30	0.81*2.13*1.2	2	16	0
Q	9	0.93*2.33*1.2	3	6	0
R	45	1.78*2.07*1.2	4	27	0
Total	469		114	263	4

4. Discussion

4.1 Coverage of scope items

The scope of this report included:

1. Details of methods used during pre-clearing surveys and clearing operations.
2. Fauna species displaced by clearing, species captured, species released and any wildlife mortalities resulting either directly or indirectly from the clearing operations.
3. Location of fauna within clearing footprint (recorded with GPS) and release locations.
4. Hollow-bearing tree register, and comparison of this data to nest box plan (assess the adequacy of nest boxes installed and how they are mitigating the loss of tree hollows).
5. Discussion of the effectiveness of those methods employed.
6. Recommendations for future pre-clearing and/or clearing procedures."

Scope items are addressed in the following sections:

- Section 2 covers methods used during preclear surveys and clearing operations. That section also covers methods employed during spotlight surveys, targeted threatened species surveys and pre-construction requirements.
- Section 3 outlines the results of ecological work carried out during the clearing phase. This includes records of any threatened fauna, fauna relocated or displaced, and any mortalities during the clearing phase. The location of fauna captured and released is presented as chainages in relevant tables in Appendix D. As all fauna were released adjacent to their point of capture the chainage listed for HBT or pre-clear surveys also relate to release locations. AMG coordinates are presented for threatened fauna. The hollow bearing tree register is presented in Appendix D and data summarised in Section 3. A comparison of HBT data collected during clearing and that presented in the NBPoM is presented in section 3 and discussed in section 4.
- Section 4 of the report discusses the results and interprets the effectiveness or otherwise of methods implemented to minimise impacts on wildlife throughout the clearing phase. Recommendations for future projects are also presented in this section. The hollow bearing tree register is presented in the appendix (Appendix D, Table D3).

4.2 Success of clearing phase fauna mitigation

4.2.1 Clearing method

The clearing method was successful in reducing impacts on local fauna. The low mortality rate (i.e. <4% from HBT removal) and the number of individuals relocated from HBT (125 individuals), pre-clear surveys (205 individuals) and spotlight surveys (29 individuals) supports this notion. The implementation of a staged clearing process whereby HBTs were retained for at least two nights after surrounding vegetation was removed may be a key factor to the successful minimisation of mortalities of local fauna. The two stage clearing process whereby HBT are retained for at least two nights enables fauna to escape the clearing area. Whilst engaged in spotlighting activities on the Nambucca to Urunga Highway Upgrade sugar gliders were observed, on two occasions, inhabiting retained HBTs on the night following stage one clearing but were not present in the tree once felled after 48 hours (N. Priest pers obs). The two-night retention time for potential HBT provides a reasonable balance between animal welfare and clearing progress.

The utilisation of harvesters and bulldozers in the felling of HBTs had varied success. Whilst the inclusion of harvesters in clearing operations has obvious benefits for careful removal of small and medium sized trees the ability to lower trees is influenced by machine and operator capability. Standard 30 - 40 tonne harvesters cannot lower large trees. We noted a substantial difference in equipment and operator capability between clearing contractors. When harvesters were not available, or trees were too large to be handled, and after consultation with RMS and Lend Lease staff, bulldozers were employed to fell HBTs. In some cases both a bulldozer and harvester were used. In some instances larger trees that a harvester would not have been able to lower gently were felled better with the bulldozer provided the operator managed to slow the fall of the tree by placing the blade of the machine on the root ball as it was levered out of the ground. Using a bulldozer to remove HBT's is preferable to the cutting and pushing method preferred at times by harvester operators for large trees.

One notable benefit of harvesters is a reduction in use of hand-held chainsaws to remove vegetation from drainage lines and the ability to easily cut and sections of tree containing fauna. Falling trees with hand-held saws increases the risk of mortality, as the impact tends to be greater than if a tree is pushed with the root ball attached. Harvesters are also able to cut and carry sections of tree with occupied hollows, which reduces stress (& risk of mortality) associated with extracting animals out of hollows. Cutting and relocating vacant hollows to nearby adjacent habitat also creates refuge for small ground dwelling mammals and reptiles. With the assistance of a harvester this was done with ease and precision reducing any impacts on the receiving environment.

The results show that the first stage of clearing (i.e. all non-HBT) is insufficient to force all animals away from the clearing zone. This is not surprising given the influence of competition for resources and the importance of viable hollows for hollow dependent fauna (Gibbons & Lindenmayer 2002). Competition for space in adjoining vegetation that already contains occupied home ranges will influence the ability of fauna to relocate. Generally, total canopy separation between HBT's is regarded as essential to encourage movement and reduce clearing impacts on hollow dependent fauna. An appropriately designed scientific study is required to resolve the issue of one verse two nights retention time. Such a study should be conducted in similar habitats using the same clearing methods and with sufficient replication.

4.2.2 Impacts on fauna

During this stage of the clearing phase, 113.6 ha of native vegetation was removed including 310 HBT containing 738 functional hollows. At OH2K the proportion of HBT with evidence of use by fauna (49.3%) was substantially lower than that reported for the Nambucca to Urunga (74%), Glenugie (65%) and Sapphire to Woolgoolga (57%) Pacific Highway Upgrades (Sandpiper Ecological 2015 & 2010; Benchmark Environmental management 2013). It was similar to the Coopernook to Herons Creek (44%) and Hunter Expressway (KK2B) (48%) project and greater than the Karuah to Bulahdelah (31%) upgrade (see Benchmark Environmental Management 2007; Sandpiper Ecological Surveys 2009, 2012). The proportion of occupied HBT recorded at OH2K (14%) was substantially lower than Nambucca to Urunga (35%), Sapphire to Woolgoolga (35%), Glenugie (38%), Hunter Expressway KK2B (22%) and Karuah to Bulahdelah (20%) (Sandpiper 2015, 2010,2012; BEM 2007, 2013).

Differences in rates of occupancy and evidence of use between projects is due, in part, to different habitat type and quality, survey effort and clearing method. Importantly the results from OH2K are similar to the nearby Coopernook to Herons Creek project. Much of the OH2K alignment was situated within State Forest that has been logged repeatedly for almost 100 years. It takes over 100 years for most Eucalypt species to start forming viable hollows (OEH, 1999) and successive logging rotations can remove most of the available hollows within a forest.

Fauna recorded in HBTs was biased toward the Reptilian Class, with 36% of animals captured being reptiles. In comparison to mammals and Amphibians (frogs) with 25% each. Birds (Aves) made up the remaining 14%. Small animals, such as feathertail glider and many lizards, snakes and frogs, can remain in large isolated trees for several days and in some cases weeks, as they are still able to forage within the tree canopy (D. Rohweder pers obs). The degree of isolation of HBT following the initial clearing phase contributes to the likelihood of occupancy by small mammals and reptiles after two nights. Animals, including petaurid gliders, are more likely to continue using trees situated within gliding distance of the forest edge than those that are fully isolated, particularly if these trees support (or occur near) blossom. Some species, such as the common brushtail possum seem to be more tolerant of disturbance than others and may stay within retained HBTs. Site fidelity may depend on the availability of alternate hollow resources.

Squirrel, yellow-bellied and greater gliders are rarely detected during HBT inspections. It is unclear why this is the case but may be due to a greater sensitivity to disturbance. Although squirrel gliders have been removed from hollows at K2B, S2W at HEX they were uncommon in HBT's but at HEX were the most common petaurid glider in nest boxes (SES 2012 & 2013). The 28 species recorded during HBT inspections at OH2K is slightly lower than S2W (30 species) and Coopernook to Herons Creek (37 species) projects.

The mortality rate during clearing at OH2K (4%) was comparable to several other studies, including NH2U (3.3%), HEX (4%), Karuah to Bulahdelah (4%), Glenugie (4%), Sapphire to Woolgoolga (3%) and Coopernook to Herons Creek (3%) (BEM 2007, 2013; SES 2009, 2010, 2012, 2015). The similarity in mortality rates between OH2K and other similar clearing programs is interesting because, of the studies cited, OH2K and NH2U are the only projects in which harvesters were consistently used to fell HBT's. The result for Coopernook to Herons Creek is biased by the exclusion of mortality whilst animals were in care. Nonetheless, the finding indicates that harvesters do not substantially reduce mortality.

4.2.3 Adequacy of survey methods

Survey methods applied during this project included, pre-clear inspections (active search), spotlight surveys, targeted frog surveys, trapping (small mammal & koala), and inspection of HBT. These methods resulted in the capture and relocation of 359 individuals from 28 species. Survey effort was substantial with a total of 443 habitat trees inspected, 376 pre-clear surveys and 186 spotlight surveys completed. The difference in spotlight and preclear surveys can be explained through workload expectations. All areas that were deemed viable habitat for arboreal mammals and threatened frogs was spotlighted the night before clearing operations commenced. The reason for the discrepancy between the number of spotlight and preclear surveys can be explained by the following:

1. Spotlight surveys typically covered a large area of habitat.
2. Preclears were conducted progressively during the day and two preclears were sometimes conducted in an area covered by a single spotlight survey.
3. Grassland, cleared land with scattered shrubs, young regrowth or weed infestations were not spotlighted (as these were deemed unlikely to support arboreal mammals or any threatened frog species) but were precleared.
4. Unless covered as part of mainline spotlight surveys fence lines were not spotlighted separately due to the limited extent of vegetation removal and ability to conduct thorough pre-clear inspections.

Six ecological staff were involved in the project and 3-4 personnel were onsite most days between mid-October 2014 and mid-June 2015.

Twelve threatened species (11 animal, 1 plant) were recorded during the clearing phase (Table 6). Of these species, two (giant barred frog and koala) were considered in direct threat of clearing operations and

therefore captured and relocated. A road-killed spotted-tailed quoll was recorded on the existing highway at Cooperabung Creek 5 July 2015 (pers comm B. Lewis). On 3 December 2014, a squirrel glider was recorded foraging in vegetation north of Haydon's Wharf Road during spotlight surveys. No squirrel gliders were captured during clearing in that area.

The result of fauna rescue during clearing is positive and has satisfied the intent of the various conditions of approval that relate to minimising the impact of clearing on fauna, and the Ecological Monitoring Program. All but three of the species relocated are common and abundant in northern New South Wales and the conservation benefit associated with the rescue and relocation of common species is questionable. Capture and relocation of fauna from cleared areas as a conservation measure is flawed as it ignores the effect of competition, home range use, social interactions and distribution of key habitat resources on the distribution of fauna (Krebs 1994). The premise that removing (occupied) habitat and relocating resident fauna to adjacent habitat where they will continue to survive ignores the ecological factors that influence species distribution. Many translocation programs have been successful but these involve detailed planning and typically, the movement of fauna into habitat that no longer supports the species being translocated.

Relocating threatened species may be beneficial, although, positive outcomes are not guaranteed for the reasons listed above. Whilst there have been numerous successful translocations of threatened species from one area to another (see Serena 1994) there is less information on the results of small-scale movement. Research on the behaviour of relocated fauna is required before it is regarded as a positive conservation measure. One record to mention here is the observed return of a relocated giant barred frog at Cooperabung Creek. The male frog was captured within the alignment during targeted surveys on 11 February 2015, it was processed (measured, weighed and PIT tag number recorded) and then released 100m upstream from the capture site on 12 February 2015. This animal was subsequently recaptured within the clearing limit three days later on 15 February 2015. Recapture was confirmed by comparing the PIT tag number. Temporary giant barred frog fence was in place, suggesting the animal swam downstream to access the construction site. Whilst such behaviour seems atypical the male frog was captured at the same section of creek bank on both occasions, suggesting that this was a favoured calling location.

The clearing phase of the OH2K project extended from spring 2014 to mid-winter 2015. This period includes the primary stages of breeding for several species of bird and the primary breeding season for frogs (Hoskin *et al* 2015). The high incidence of certain bird species, such as sacred kingfisher, can be explained by season. Sacred kingfishers are a common species that predominately nest in arboreal termite mounds (termitaria) and tree hollows from September to January. They can often have two clutches in this time (Morcombe 2014). Eight of the eleven eggs that were euthanised were sacred kingfisher and five sacred kingfisher chicks were killed in the process of clearing or were euthanised, this accounted for 25% of the total mortality rate for the clearing phase. The high occurrence of sacred kingfisher nesting activity was most pronounced in late 2014. Some mitigating actions to reduce mortality of the species were discussed on site and implemented accordingly. These actions included retaining active nest trees for as long as possible or until nestlings had fledged. This was successfully adopted on three occasions. The occurrences where nest trees were felled after two nights were in areas of critical works.

Three rainfall events occurred during the summer/autumn frog breeding season. These events occurred 20 to 28 January 2015 (400mm), 18 to 24 February (124mm) and 21 to 23 March (95mm) (Bureau of Meteorology 2015). Dry conditions persisted prior to 20 January 2015. Weather had a strong influence on threatened frog species detections. Green-thighed frogs were recorded outside the project boundary during the January rainfall event, which occurred after the area of known habitat north of Blackmans Point Road was cleared. Green-thighed frog activity is closely linked to rainfall. Although frogs can be detected for some time after rain events have triggered breeding the species is rarely detected during dry conditions prior to rainfall. The below average rainfall experienced in spring 2014 and early summer 2014/15 meant that targeted surveys were

unnecessary. Nonetheless, green-thighed frogs were targeted during all spotlight and pre-clear surveys in areas of identified habitat.

A total of 19 giant barred frog observations were recorded, three of which were within the project boundary and one immediately outside temporary frog fencing on the western boundary at Cooperabung Creek north. All of these records occurred after at least one of the significant rainfall events. This is consistent with findings and previous research suggesting significant rainfall events trigger frog activity.

The survey methods applied during the clearing phase of the OH2K project follow standard procedures applied during several other highway upgrades. Some methods proposed in the EMP were considered impractical or inappropriate given the weather conditions and were therefore not applied. Examples include:

1. Arboreal mammal surveys did not include stag watching or call playback. Stag watching is a time consuming method and results are often inconclusive. The method was used on the S2W and NH2U projects where it was found to be less effective than spotlight surveys. Call broadcast is useful in detecting yellow-bellied glider and koala, however, the method relies on prompting a territorial response and may draw fauna into the clearing area from a substantial distance away. Once again spotlight was deemed to be the preferred method as it would not draw fauna into the clearing area from adjacent habitat.

2. Flowering trees were not marked as Habitat Trees. Whilst blossom is a critical food resource for fauna, including arboreal mammals, the retention of such trees would only encourage fauna to remain within the clearing area and compromise the two stage clearing process.

4.2.4 Habitat tree retention and clearing times/recommendations for future preclearing and/or clearing procedures.

Retention times for HBT's and other habitat trees warrant further assessment. Habitat tree is a broad term that includes all trees with fauna habitat, whilst HBT includes trees with hollows only. Trees containing dreys and bird nests, that is, habitat trees, can be removed immediately, or one night after initial clearing. Possum dreys should be removed immediately to reduce the likelihood of possums exiting the drey during the initial clearing phase when they are subject to an increased risk of mortality. Retaining bird nests may only serve a positive conservation outcome if the nest tree can be retained long enough for chicks to hatch and fledge, as occurred with sacred kingfisher nests during this project.

Further consideration of the HBT removal process is warranted as harvesters are often unable to gently fell large HBT's. In some cases a bulldozer can fell large HBT's more gently or a bulldozer and harvester can be used together. Greater flexibility must be included in clearing methods to acknowledge that harvesters have limitations and bulldozers have a role to play in HBT removal. Operator experience and machine capability have a strong influence on HBT removal. Small harvesters or machines with a high centre of gravity are not capable of gently lowering even small to medium sized trees and stricter controls are required to exclude some equipment.

The timing (season) of clearing has a substantial influence on outcomes, particularly mortality. Clearing during the breeding season for native birds (i.e. October – January) can cause considerable mortality of chicks and eggs, as occurred during this project. In contrast, clearing during autumn and winter reduces the likelihood of impacts on breeding individuals and also provides time for animals of all classes to adjust breeding territories before the onset of the new breeding season. Removal of habitat within the territory of a breeding pair of animals during the breeding season is likely to affect breeding success even if individuals are not directly impacted. Numerous active bird nests were removed during this project, although few nestlings were affected.

4.2.5 Aquatic fauna

The fish translocation effort along the OH2K upgrade was relatively successful. Large numbers of aquatic fauna were captured and translocated successfully using a variety of methods. The authors are confident that the vast majority of aquatic fauna present in the waterways that were dewatered were captured and translocated prior to dewatering.

There were significant losses of firetail gudgeons (30% of this species captured) and, to a lesser extent, empire gudgeons and striped gudgeons. The majority of these losses occurred at two of the waterways; the Compound Dam and the Wakeboard Dam. There are a number of factors that contributed to these losses, including:

- The sensitivity of firetail gudgeons to capture and handling;
- High temperatures at the time of capture, and the subsequent effects on fish metabolism and dissolved oxygen concentrations in the water;
- High suspended sediment and algal concentrations in the water at the time of capture, possibly stressing fish prior to capture;
- Large numbers of fish captured leading to increased processing times; and
- Use of the seine net, leading to disturbance of bottom sediments;

There are also a number of mitigating strategies that were applied at other sites to avoid these losses, including;

- Reduced use of the seine net where other methods could be successfully employed;
- Attempts to drag the seine net through the surface 10 - 20 cm for the first few shots to capture the majority of mosquitofish and firetail gudgeons prior to disturbing the bottom sediments;
- Gradual deployment of the seine net through increasing areas of the water present to reduce the number of fish captured per shot and reduce processing times; and
- Returning fish to the water for later capture when numbers captured were thought to be too large.

4.3 Stage 2 nest box assessment

The large difference between the stage one and two nest box calculations is consistent with the NH2U project where the number of required boxes was reduced from 303 (stage one) to 164 (stage two). At OH2K the number was reduced from 469 (stage one) to 114 (stage two). There are several likely reasons for the large discrepancy between the stage one and two calculations, including:

1. Overestimate of hollow number and occurrence from ground inspections – It is difficult to accurately count the number of hollows from the ground. Gibbons and Lindenmayer (2002) list issues that may cause both over and underestimates of hollow number, such as obstruction by foliage, inclusion of blind hollows and tree type. During clearing inspections at OH2K no hollows were recorded in 30% of the trees identified as containing hollows from the initial ground-based assessment. Although this rate is high it is not unusual for some HBT identified from ground observations to not contain hollows. Comparison of hollows in a random sample of trees identified from ground observations by Lewis (2013) with the results of clearing surveys found that the number of hollows recorded from the ground was higher for each tree and the total number of hollows recorded from ground observations (145 hollows) was more than 3 times greater than the number recorded during clearing (44 hollows; Table 9). During preclearing HBT markup a number of original HBTs did not appear to exhibit any hollows and therefore were not classified as HBT. It

seems that a very conservative approach was adopted to counting hollows during the initial HBT survey, which resulted in an overestimate of nest boxes required.

2. Inclusion of a 20% error factor - The inclusion of a 20% error factor, in the nest box equation, assumes that ground counts are underestimates only, yet this is not the case. Whilst foliage may obscure hollows causing an underestimate the inclusion of 'blind' hollows will cause an overestimate. These confounding factors may cancel each other out and the application of an error factor results in an overestimate.
3. Application of minimum specification for hollow to be considered viable – Sandpiper Ecological does not record hollows <10mm diameter or less than 100mm deep as these are not considered viable.
4. Destruction of hollows during felling – Tree hollows often break apart following impact with the ground. Care is taken to piece hollows back together and obtain an accurate count, however, undercounting of hollows is likely when trees hit the ground with great impact (i.e. operator unable to slow the descent). On the OH2K project many HBT's were felled in a controlled and gradual manner and as a consequence many hollows remained intact, which enabled accurate counts. The error associated with counts of hollows in felled trees is predicted to be approximately 10%.
5. Rationalisation of hollow numbers – Inspection of hollows after felling involves some (minor) rationalisation of hollows. For example, a forked branch with short hollows entering the same chamber may be counted as a single hollow. Hollow counts from the ground usually only count evident hollow entrances.
6. Initial HBT surveys consider the entire project corridor and therefore include some HBT that are not cleared once the clearing limits are refined. This would have some effect on numbers of hollows registered during clearing.

Table 12: Twenty-five randomly chosen HBTs showing original survey hollow counts and Sandpipers on-ground hollow count.

HBT number	Tree Species	NBPoM hollow count	Sandpiper on-ground count
H01	Corymbia intermedia	3	0
H05	Corymbia intermedia	7	2
H108	Melaleuca spp.	5	1
H121	Corymbia intermedia	3	1
H125	Stag	13	9
H130	Mahogany spp.	5	1
H139	Eucalyptus pilularis	6	0
H144	Eucalyptus pilularis	3	2
H155	Stag	7	3
H167	Eucalyptus pilularis	7	2
H189	Eucalyptus pilularis	2	1
H204	Mahogany spp.	5	3
H211	Eucalyptus pilularis	3	1
H216	Eucalyptus pilularis	2	0
H222	Eucalyptus resinifera	5	0
H235	Eucalyptus robusta	3	2
H244	Stag	7	4
H256	Eucalyptus resinifera	4	1
H268	Stag	5	0
H283	Eucalyptus robusta	4	1
H299	Eucalyptus tereticornis	14	2
H305	Eucalyptus tereticornis	6	4
H318	Eucalyptus resinifera	11	1

H325	Eucalyptus microcorys	7	3
H345	Eucalyptus resinifera	8	0
Total		145	44

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Appendix A – Koala Protocol

Oxley Highway to Kundabung (OH2K) Pacific Hwy Upgrade

Protocol for Managing Koalas during Clearing and Construction Operations – *Draft (v1)*

The koala *(Phascolarctos cinereus*) is listed as threatened (vulnerable) under NSW (*Threatened Species Conservation Act* 1995) and Commonwealth (*Environmental Protection and Biodiversity Conservation Act* 1999) legislation. The following protocol has been prepared to minimise impacts on koalas during the clearing and construction phase of the Oxley Highway to Kundabung (OH2K) Pacific Highway Upgrade and to satisfy standard pre-clearing procedures. The protocol provides procedural guidelines to be followed if koalas are encountered during clearing and construction activities, including their capture and relocation if required.

During Clearing Operations:

1. Surveys for koalas during clearing and grubbing operations:
    - In areas containing potential koala habitat, foot-based, observational surveys for koalas ('Koala Surveys') will be conducted the night before (using spotlights) and in the morning immediately prior to clearing. *'Potential koala habitat'* is defined as areas where scats have been collected, where koalas have been sighted, which satisfy the definition of "habitat critical to the survival of koalas" (as per DotE 2013) or delineated in project approvals.
    - Koala Surveys will cover the area scheduled for clearing that day ('Day Clearing Zone') and habitat immediately adjacent.
    - Koala Surveys may extend beyond the Day Clearing Zone to establish the presence or otherwise of koalas ahead of the clearing front.
    - Clearing contractors and site staff will be asked to provide any sightings of koalas to the Environment Team.

2. Koala identified in tree within Day Clearing Zone in area of contiguous habitat:
    a. Immediately enforce a 50m-radius Exclusion Zone (refer Point 6) around occupied tree.
    b. Install koala pen trap, unless:
        i. Sighting occurs on a Friday when individuals would be left to move unassisted.
        ii. Female with joey on back would not be trapped and left to move unassisted.
    c. Capture koala and assess health status.
    d. Sick and/or injured koalas transported to Port Macquarie koala hospital.
    e. Healthy and un-injured koalas relocated (refer Point 5).
    f. Koalas would only be removed from site if they require treatment or hospitalisation.
    g. In some instances it may take several days to capture a koala, and capture time may be influenced by stress. Pen traps would be installed for 72 hours before alternate methods are applied. Standard alternate procedure would involve the use of flags to encourage koalas to descend the tree where they are hand captured. A tree climber may be required in some instances.

3. Koala identified in tree within Day Clearing Zone in isolated remnant (no suitable release habitat within 200m of site):

a. Clearing of remnant would cease and koala allowed to move unassisted – no trapping would occur.
b. Periodic daytime observation and spotlighting would occur to track koala movement within remnant.
c. If koala is sighted within an area of high risk (e.g. remnant beside highway), rescue options would be discussed with Port Macquarie Koala Hospital.

4. Koala identified in tree up to 50m outside the LoC and adjacent Day Clearing Zone:
   a. Immediately enforce a 50m-radius Exclusion Zone (refer Point 6) around occupied tree.
   b. Assess the site and Project Ecologist to determine an appropriate course of action. Options include:
      i. Retain Exclusion Zone and avoid clearing the buffer until koala has relocated;
      ii. Implement trapping protocol (Point 2);
      iii. Continue clearing whilst spotter observes koala.

5. Retention and relocation:
   a. Captured individuals shall be relocated to suitable habitat within their predicted home range, and:
      i. Behind the clearing front;
      ii. Outside LoC;
      iii. In close proximity to point of capture;
      iv. Away from high risk areas (i.e. roads); and
      v. Within habitat identified as suitable by the Project Ecologist.
   b. Captured individuals will be released at time of capture or later as determined by the Project Ecologist.

6. Exclusion (Buffer) Zone restrictions:
   a. No clearing or grubbing operations within Exclusion Zone apart from the following exceptions:
   b. Hand felling of small shrubs around occupied tree (i.e. shrubs with interlocking canopy or within 2m of trunk) is permissible to improve effectiveness of pen trap.
   c. Plant and equipment may be 'walked' through Exclusion Zone under supervision of Project Ecologist. Machinery must be walked as far from the occupied tree as possible and pathway clearing would be limited to vegetation <150mm diameter.
   d. Clearing outside the buffer must be done in such a manner to ensure that felled timber does not enter the buffer zone.

7. Incidental observations of koalas during clearing operations:
   - All site personnel to be instructed (weekly tool box, staff notifications) to report koala sightings to the Project Ecologist or Environment Manager and to immediately enforce a 50m Exclusion Zone around sighted individual(s).
   - Environmental staff and plant and machinery operators conducting clearing operations shall be tool boxed on key aspects of the Protocol for Managing Koalas During Clearing and Construction Operations, particularly Exclusion Zone restrictions and areas of known or predicted high koala activity.
   - All contractors and staff must be aware of koala presence when moving around the site at dawn or dusk (periods of increased koala activity) particularly during the winter months when site work overlaps these periods.

During Construction Operations:

1. Koala sighted in habitat near construction operations:
    a. Koala sighting to be reported immediately to Environment Manager or Project Ecologist.
    b. All site personnel and staff working within the area of the sighting to be made aware of koala presence and encouraged to be vigilant.
    c. Plant/vehicle speed shall be reduced within 200m of sighting.
2. Koala sighted within construction area:
    a. Koala sighting to be reported immediately to Environment Manager or Project Ecologist.
    b. Operations within 50m of koala must cease immediately until such time as the koala exits the construction area.
    c. Vehicle speed must be reduced to 40kph within 200m of koala.
    d. Signs must be erected on all vehicle movement paths identifying the presence of koala and specifying restrictions.

Data Management and Review:

1. Project Ecologist to maintain record of koala sightings, captures, relocations and transfers to koala hospital.
2. Protocol to be reviewed by Project Ecologist prior to 2015 koala breeding season (Jul-Dec).

References

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Appendix B – Culvert inspection and exclusion

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Biodiversity Survey

Project Management

Impact Assessment

Ecological Monitoring

Specialist Surveys

Grant Fletcher
Environmental Manager
Oxley Highway to Kundabung
Lend Lease Engineering
grant.fletcher@lendlease.com

4 December 2014

Cc. Nathan Russell, Hari Corliss

Dear Grant,

RE: Microchiropteran bat roost exclusion from pipe and culvert structures for the Oxley Highway to Kundabung (OH2K) Pacific Highway upgrade.

1. Introduction

The Oxley Highway to Kempsey Microbat Management Strategy ((MMS) LES 2013) details a number of management strategies to mitigate impacts on microbats and identified roost sites. One of these strategies (Strategy C) is planned roost exclusion. According to the MMS, roost exclusion will be necessary at those structures requiring removal or substantial modification. At a minimum, this will apply to those structures identified in Table 5-2 (of the MMS).

The MMS states that the timing of roost exclusion will occur during autumn (mid April-May) and the start of spring (September). Importantly, these two periods fall outside the breeding season for the southern myotis (*Myotis macropus*) and over-wintering times for southern myotis, little bent-wing (*Miniopterus australis*) and eastern horseshoe bat (*Rhinolophus megaphyllus*). For the current reporting period, roost exclusion was conducted during September 2014.

2. Roost exclusion

As required by the MMS, roost boxes were installed in adjacent habitat >6 months prior to the planned roost exclusion (RPS 2013). The process for roost exclusion was then followed in accordance with the MMS. Beginning from 16 September 2014, pre-exclusion surveys were conducted on all structures identified in Table 5-2 within the Oxley Highway to Kundabung (OH2K) section (refer Table 1) to assess roost activity. For roosts determined as inactive, all potential roost points (i.e. expansion joins, grab holes, pipe joins, drainage holes) were filled with variably sized styrofoam rod and steel mesh was used for high-flow drain holes (Plate 1). For roosts containing microbats, the species and number of individuals present was identified to determine the importance of the roost. No roosts were assessed to be of high conservation value (refer to MMS).

Plate 1. Vacant drain holes (L) and expansion joins (M) were filled with styrofoam rod and steel mesh was used at high-flow drain holes (R).

To exclude microbats from occupied roosts the following steps were followed:

1. During the day all unoccupied roost points were filled except for two minor (sub-optimal) roost points (e.g. hold points);
2. Occupied roost points were re-inspected ~90 minutes after dark and if vacant were filled;
3. Minor (sub-optimal) roost points were re-inspected the following day and if vacant were filled. If minor roost point was occupied then step 2 was repeated until all roost points were decommissioned.

Details of roost exclusion and inspection history are provided in Table 1. Microbats were observed in 9 of the 13 culverts inspected. Little bentwing bats were recorded in three culverts and eastern horseshoe bats in six culverts. The twin galvanised pipe culverts at 22200 are suspected of being used as a flyway. Results indicate that horseshoe bats do not always roost in the same culverts and the number and presence of bats at several culverts changed during the September surveys. This means that repeat surveys will be required to confirm bats are absent.

Table 1. Details of roost exclusion conducted on structures identified in Table 5-2 of the MMS within the OH2K upgrade section. EH = eastern horseshoe bat; LB = little bent-wing bat.

Culvert (chainage)	Cells	Conserv Rating	Inspection History	Exclusion	Management
510067 (1000)	750 RCP	low	17/9: nil, Anabat: EH calls @ E end, not roosting - excluded; 19/9 & 23/9 & 25/9: no bats in pipe or on curtains.	EXCLUDED (18/9/14 - curtain over entrance & exit)	No inspection required
599011 (18250)	1300x4 RCP	high	16/9: LB x5; 18/9: LB x14 in hold pts – partially excluded >dark; 19/9: bats in 1 hold pt - left; 22/9: no bats in hold pt – excluded, 10 bats hanging from scuff in ceiling; 23/9: LB x3 hanging from scuff in ceiling.	EXCLUDED (22/9/14, Styrofoam rod in roost pts)	Inspect prior to decommission
599012 (18720)	1800 RCP	mod	18/9: LB x1 – partially excluded >dark; 19/9: no bats - excluded; 23/9: nil.	EXCLUDED (19/9/14, Styrofoam rod in roost pts)	Inspect prior to decommission
599016 (20250)	1800 RCP	low	17/9: nil - excluded; 23/9: LB? x1 on side wall.	EXCLUDED (17/9/14, Styrofoam rod in roost pts)	Inspect prior to decommission
599017 (20500)	750 RCP	low	17/9 & 18/9: nil, Anabat; EH calls b/t 1800-1900, prob flying through not roosting; 19/9: EH x3 on ceiling. Likely only small no's of EH but likely used as flyway so not appropriate to curtain due to risk of entanglement.	NOT EXCLUDED.	Inspect prior to decommission
599019 (21290)	900 RCP	low	16/9: EH x3 on ceiling; 23/9: EH x1 on ceiling; 23/9: nil - partially excluded; 24/9: nil – excluded.	EXCLUDED (24/9/14, Styrofoam rod in roost pts)	Inspect prior to decommission
599020 (21500)	1200 RCP	low	16/9: EH x3 on ceiling; 18/9: scats below most hold pts - partially excluded; 23/9: nil >dark – excluded; 24/9: EH x1 on ceiling.	EXCLUDED (23/9/14, Styrofoam rod in roost pts)	Inspect prior to decommission
599021 (21790)	900 RCP	low	16/9: nil – excluded; 23/9: EH x1 on ceiling.	EXCLUDED (16/9/14, Styrofoam rod in joins)	Inspect prior to decommission
599021DS (21790)	900 RCP	low	16/9: nil – excluded; 23/9: nil	EXCLUDED (16/9/14, Styrofoam rod in roost pts)	Inspect prior to decommission
599022 (22200)	3000x2 Galv Pipe	low	16/9: nil; 23/9: nil. Likely a major flyway; no cracks/joins; ltd roost potential; not appropriate to curtain due to risk of bat entanglement.	NOT EXCLUDED.	Inspect prior to decommission

599023 (22350)	750 RCP	low	16/9: nil, Anabat; 18/9: EH x3 on ceiling; 19/9: EH x3 on ceiling; 23/9: EH x1 on ceiling. Likely only small no's of EH but probably used as flyway so not appropriate to curtain.	NOT EXCLUDED.	Inspect prior to decommission
599026 (23140)	900 RCP	low	16/9: EH x1 on ceiling; 17/9: nil - excluded; 23/9: EH x1 on ceiling.	EXCLUDED (17/9/14, styrofoam rod in roost pts)	Inspect prior to decommission
599028 (23990)	3000x5 RCC	mod	22/9: LB x5 in drain holes – partial exclusion; 23/9: LB x1 in drain hole & LB x2 in corner of ceiling; 24/9: nil - excluded; 25/9: nil.	EXCLUDED (24/9/14, steel mesh over drain holes)	Inspect prior to decommission

The roosting habit of eastern horseshoe bat, that is, there preference for hanging from an imperfection (i.e. chip or lump) in culvert, means they are difficult to exclude. Consequently ongoing inspection of culverts and exclusion immediately prior to work on structures is required to minimise impacts on this species. The removal of adjoining vegetation may be sufficient to deter use of culverts by horsehoe bats (and other species) and observation during clearing and earthworks will be important to guide the need for exclusion.

3. Roost management during clearing

In accordance with Strategy B (MMS), the project ecologist will perform pre-clearing surveys of all structures described in Table 1 with the exception of culverts at chainages 1000, 22200 and 21790. Surveys will involve visual inspection from structure entry/exit and will be performed daily during clearing operations within 100m of the structure. Inspections will occur as part of daily pre-clear surveys.

4. Roost management during construction

Two measures will be adopted during construction - monthly inspection during the first six-months of construction activity (i.e. earthworks, construction of new culvert etc) occurring within 100m of structure and inspection and exclusion immediately prior to decommissioning (i.e. removal of structure or work immediately abutting structure). Excluded and non-excluded structures will require different management approaches prior to decommission. Information gathered during the clearing and earthworks phases should be used to guide the application of measures specified in sections 4.1 and 4.2. For example, if, following clearing, bats are not detected using a culvert during successive inspections the frequency or need for ongoing inspection and exclusion shall be reviewed.

According to MMS roost exclusion should occur:

- Outside of the breeding season for southern myotis and any other species detected breeding (during the pre-clearing survey) by the Project Ecologist in the structure; and
- Outside over wintering times for the little bent-wing bat, eastern horseshoe bat and southern myotis.

To date no species have been recorded breeding within the structures, although several structures could be used during the overwinter period (June-August). Exclusion work discussed below would need to occur before or after that period. The roost at 18250 is classified as a High Conservation Value roost and therefore seasonal limitation of construction work will apply unless a noise and vibration plan is prepared. In this case the site is used as an overwinter roost by little bentwing bats and restrictions would apply from mid-June to mid-August.

4.1 Excluded structures

Excluded structures occur at chainages 1000, 18250, 18720, 20250, 21290 x 2, 21500, 21790, 23140 and 23990. Post-exclusion inspections of the 10 structures excluded revealed four with eastern horseshoe bats and one with little bentwing bats hanging from imperfections in the ceiling and one structure with a little bentwing bat attached to the wall (Plate 2; Table 1). Because all expansion joins, grab holes, pipe joins, drainage holes within these structures were filled during the exclusion process, it is reasonable to assume that bats roosting within these structures will be visible during inspections conducted from the structure entry/exit. As such,

decommission of already excluded structures, with the exception of chainage 1000, should proceed in accordance with the following steps:

1. 48-72 hours prior to decommission (i.e. removal of structure or work on/adjoining structure) inspect interior of structure from entry/exit area during daylight. Inspections should involve careful observation of ceiling and wall surfaces with spotlight/binoculars to determine the presence/absence of roosting bats.
2. If bats are absent, install a curtain across the entry/exit leaving a 100mm gap at the base.
3. If bats are present, re-inspect structure ~90 minutes after dark and later in the evening if necessary. If bats are absent, install a curtain across the entry/exit leaving a 100mm gap at the base (Plate 3).
4. If bats are still present after two evening inspections, repeat step 1-3 the following day.
5. Internal and external sides of entry/exit curtains should be inspected for bats each morning prior to decommission.
6. Curtains will only be installed after written confirmation from Lend Lease Engineering that the procedure will not have a detrimental effect on drainage.

The entry/exit to structure RCP 510067 at chainage 1000 was curtained during the September 2014 exclusion process (Plate 3) and further inspection of that site is not required.

Plate 2. Eastern horsehoe bats (L) were observed hanging from the edge of expansion joins (chainage 22350) and little bent-wing bats (R) were observed hanging from imperfections in the concrete ceiling (chainage 18250) several days after roost cavities were filled.

Plate 3. RCP 511067 (chainage 1000) was excluded with a nylon curtain after determining microbats were not roosting within the structure. The curtain features a 100mm gap at the base.

4.2 Non-excluded structures

Non-excluded structures occur at chainages 20500, 22200 and 22350 (Table 1). These structures will require a similar approach to that recommended for excluded structures. For the 750mm RCP structures (i.e. chainage 20500 and chainage 22350), Anabat detectors will be used to assist in determining the presence/absence of microbats that may be roosting within cavities in the structure. Exclusion of these structures should proceed as follows:

1. At dusk, 48-72 hours prior to decommission, Anabat detectors will be positioned at structure entry/exit and a visual inspection (using spotlight and binoculars) of the structure interior will be conducted from entry/exit area. Anabat detectors should remain in place for at least 60 minutes during which time the entry/exit is visually monitored for bats exiting the structure.
2. If by ~90 minutes after dark visual inspection and Anabat detectors demonstrate that no bats are present, install a curtain across the entry/exit leaving a 100mm gap at the base.
3. If bats are present, re-inspect structure later in evening and if absent, install a curtain across the entry/exit leaving a 100mm gap at the base.
4. If bats are still present after two inspections, repeat step 1-3 the following day.
5. Internal and external sides of entry/exit curtains should be inspected for bats each morning prior to decommission.
6. Curtains will only be installed after written confirmation from Lend Lease Engineering that the procedure will not have a detrimental effect on drainage.

Alternate measures such as positioning floodlights in selected culverts after bats have departed should be considered as an alternative to curtaining.

For the twin 3000mm galvanized pipes (chainage 22200 – Plate 4), initial inspections revealed no viable egress roost points and limited roost points on the wall/ceiling surface. However, the pipes are probably used as a microbat flyway and would present an entanglement hazard if curtained. We recommend that this structure, which can be effectively inspected visually, be monitored during clearing (as per item 3) and inspected 48-72 hours prior to decommission, including each morning up to decommission.

Plate 3. C599022 (chainage 22200) features 2x 3000mm galvanised pipes. The structure is likely a major microbat flyway and would present an entanglement hazard if curtained.

5. Cassegrain Winery access road

The RCP (3 x 1300mm) structure on the side road leading to Cassegrain Winery (chainage 2600) was inspected on 17 September 2014. The structure features numerous gaps and cracks 25-100mm wide and >300mm deep. No microbats were evident during the inspection although the structure features numerous deep cavities that could not be visually inspected. The site is regarded as potential microbat roosting habitat. Exclusion of this structure, if required, would need to be done in accordance with the MMS.

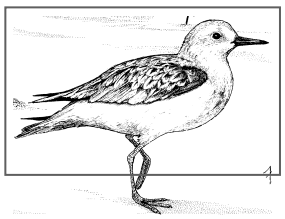
Please contact me on 0429 460 338 if you have any questions regarding the information provided.

Yours faithfully,

Dr Brendan Taylor

Senior Ecologist

Appendix C – Little Eagle nest removal



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Biodiversity Survey

Project Management

Impact Assessment

Ecological Monitoring

Specialist Surveys

Nathan Russell
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30 July 2014

Cc Grant Fletcher

Dear Nathan,

RE: Removal of Little Eagle nest.

Between 22 and 24 July 2014 Mr Tom Welch (Sandpiper ecologist) inspected the little eagle nest located near chainage 10875. The aim of the inspection was to determine if the nest could be removed prior to the onset of breeding, as recommended by the "*Assessment of Impact: Little Eagle (Hieraaetus morphnoides) in the Pacific Highway Upgrade – Oxley Highway to Kempsey Project area*" report (SMEC/Hyder 2013). Inspections were undertaken at the following times:

- 22 July 2014 – 1115-1215hrs and 1530 – 1630hrs;
- 23 July 2014 – 0630-0745hrs and 1630-1740hrs; and
- ➢ 24 July 2014 – 0615-0730hrs and 1230-1300hrs.

The nest was observed from a point 45m northwest that had an unobstructed view of the nest and surrounding sky. On 22 July the proposed construction footprint 500m north and south of the nest was searched for additional stick nests.

During the morning inspection on 23 July a bird was briefly observed occupying the nest before flying away with a second bird, which was roosting nearby. These birds were observed whilst approaching the observation point and positive identification was impossible due to low light and an obstructed view. No further bird activity was recorded during the other observation periods and no additional stick nests were recorded.

The nest was removed at 1pm on 24 July by an arborist. The nest was then inspected on the ground for any evidence of recent activity. No eggs or chicks were present, although the nest was in good condition. The nest consisted of a deep bowl of sticks lined with bark and synthetic material and measuring approximately 600mm in diameter and 300mm deep.

The observation of a possible little eagle and the good condition of the nest suggests that birds may have been preparing to use it during the 2014 breeding season. Whilst removing the nest reduces the likelihood that little eagles will nest in that location in 2014 it is possible that the pair will nest nearby. Work was undertaken in accordance the SMEC/Hyder (2014) assessment.

If you have any questions regarding the above information please contact me on 0401 195 480.

Yours Faithfully

Dr David Rohweder
Managing Director/Senior Ecologist

Appendix D – Field data

Table D1: Spotlight surveys conducted for the Oxley Highway to Kundabung Pacific Highway Upgrade. Ind = individuals; Beh = Behaviour; NR = Not recorded. C = calling; F = flying; T = transit; F = foraging. Chainage locations are provided for all fauna captures in addition to GPS location of threatened fauna.

Date	Observers	General Location	Location (chainage)	Start Time	End Time	Weather (cloud, wind, rain, temp, rh)	Visibility	Species	No. Ind	Behaviour	Comments & GPS location (Thr spp)
3/11/14	DR, NP	Compound south to Hastings river (private)	7000-7700	1945	2115	100%, rl, ls, t20.5, 80%	M	Litoria fallax	>5	C	
2/11/14	NP, JE		6900-6700	1930	2030	30%, rl, nil, 19.5, 65%	M	Litoria fallax	>5	C	
								Brush Cuckoo	1	C	
								Flying Fox spp.	5	T/C	
5/11/14	TW, JE	Cairncross SF	7600 - 8250	1930	2100	100%, rl, mod, 19.2, 92%	DK	Pseudophryne coriacea	1	C	
6/11/14	NP/TW		7600-8300	1940	2100	60%, nil, nil, 19.3, 81%	BR	Pseudophryne coriacea	1	C	
								Fan-tailed Cuckoo	1	C	
								Microbat spp.	1	T	
								Flying Fox spp.	1	T	
9/11/14	NP/TW		7600-8300	1950	21:10	20%, msb, nil, 25.3, 63%	DT	Sugar Glider	1	F	
								Macropod spp.	>1	F/T	
								Microbat spp.	2	F/T	
								Limnodynastes peronii	1	F	
10/11/14	NP/JE		7600-8300	2020	2130	80%, rl, ls, 24.7, 74.6%	DT	Nil			
11/11/14	NP/TW		8288-8900 E of existing HWY	2000	2105	100%, rl, ls, 19.7, 76%	DK	Nil			
12/11/14	NP/TW		7700-8700	2009	2116	80%, nil, nil, 20.4, 75%	DK	Nil			
13/11/14	NP/TW		7700-8700	2005	2105	75%, msb, nil, 23, 83%	DT	Jacky Lizard	1	R	Relocated outside LoC
16/11/14	NP/JE		7686-8103	2005	2050	20%, nil, nil, 25.3, 71%	DT	Feathertail Glider spp.	1	F	In road reserve.
19/11/14	NP/BT		9200-9500	2005	2043	20%, nil, nil, 23.4, 77%	DT	Litoria gracilenta	1	C	
								Microbat spp.	1	T/F	
19/11/14	NP/BT	Tea Tree area	13350-14050	2100	2200	30%, nil, nil, 21.7, 76.5%	DT	Owlet Nightjar	1	C	
								Red-necked Wallaby	1	T	
								Pseudophryne coriacea	2	C	
								Litoria fallax	1	C	
								Limnodynastes peronii	2	T	Relocated outside LoC
								Litoria gracilenta	1	C	
19/11/14	NP/BT	Cooperabung	19700-20200	2210	2300	10%, nil, nil, 19.5, 76%	DK	Grey-headed flying fox	>5	C	
								Litoria fallax	>10	C	
								Litoria peroni	>5	C	
20/11/14	BT/JE/TW	Cooperabung Ck sth	19650-19700	2037	2105	0%;mSb; nil; 21.2; 78.2%	DK	Adelotus brevis	>5	C	
20/11/14	BT/JE/TW	Cooperabung	19700-20200	2107	2120	0%;mSb; nil; 21.2; 78.2%	DK	Nil			
20/11/14	BT/JE/TW	Haydons wharf rd	18050-18200	2128	2140	0%;mSb; nil; 21.2; 78.2%	DK	Nil			
20/11/14	BT/JE	Tea tree farm	13350-14050	2218	2245	0%;mSb; nil; 24.2, 78.6%	DK	Grey-headed flying fox	1	F	
								Litoria dentata	1	C	
								Litoria fallax	1	C	
20/11/	BT/JE	Black mans pt	9400-9650	2300	2331	0%;mSb; nil; 20.2,	DK	Grey-headed flying	1	F	

14						77.9%		fox			
23/11/14	NP/TW	Compound sth	6000-6900	2007	2042	100%, mlb, nil, 27.8, 60.2%	DK	Litoria nasuta	1	T	
								Eastern grey kangaroo	2	F	
23/11/14	NP/TW	Mahogany rd	9400-9800	2055	2130	100%,mlb, 29.6, 50.5%	DK	Nil			
24/11/14	NP/TW	Compound north	6900-7600	2012	2100	100%, rl, nil, 27.5, 67%	DK	Nil			
24/11/14	NP/TW	Mahogany Rd	9850-10400	21:10	2200	100%, rl, nil, 26.5, 67%	DK	Owlet-nightjar	1	C	
								Feather tail glider	1	T	
								Macrapod spp.	1	T	
26/11/14	NP/TW	Nth compound	7200-8200	2007	2054	100%, nil, nil, 22.6, 82%	DK	Feathertail glider	1	F	
								Tawny frogmouth	1	T/F	Flew directly into tree trunk. Was ok
	NP/TW	Mahogany rd	9150-9950	2104	2135	100%, nil, nil, 23.2, 77.6%	DK	Swamp wallaby	1	T/F	
27/11/14	NP/TW	Nth compound	7600-8200	2010	2100	80%, nil, msb, 20.9, 80%	DK	Small Eyed Snake	1	T/F	
30/11/14	BT/TW	Haydons wharf sth	17400-17800	2025	2143	0%, mSb, nil, 21.3, 71%	Mod	Litoria nasuta , Litoria fallax, Pseudophryne coriacea, Litoria tyleri, Litoria peronii;	>30	C	
								Grey-headed flying fox	6	F	
30/11/14	NP/JE	Wharf rd	7200-8200	2010	2055	10%, MLB! nil, 24.3, 74%	Mod	Nil			
1/12/14	NP/JE	Mahog rd north	10000-10500	2015	2050	90%, msb, lr, 22.1, 81.8%	Dk	Microbat spp.	1	F/T	
1/12/14	NP/JE	Wharf rd	8300-8600	2100	2135	90%, rl, lr, 20.2,88.4%	DK	Flying fox spp.	1	T	
								Litoria nasuta	1	T	Relocated
3/12/14	NP/BT	Haydons wharf nth	18000-18660	2026	2135	90%;MLB;nil;23.3; 82.6%	Mod	Squirrel Glider	1	F	
								Grey-headed flying fox	>5	F/T	
								Litoria Fallax	>10	C	
								Limnodynastes peroni	3	C	
3/12/14	NP/BT	Wyndell Close		21:40	2155	90%, mc, nil, 23.3, 84%	Mod	Limnodynastes peroni	5	C	
								Grey-headed flying fox	3	T/C	
4/12/14	NP/JE	Wharf rd north	18300-18805	20:39	2136	90%, MLB, nil, 21.3, 86.3%	Mod	Grey-headed flying fox	>10	C/F/T	
								Limnodynastes peronii	<5	C	
								Litoria fallax	>5	C	
								Crinia spp.	1	C	
								Pseudophryne spp.	1	C	
7/12/14	NP/JE	Mahogany Rd	10000-10450	21:00	21:30	70%, msb, nil, 22.6, 91%	Mod	Nil			
7/12/14	NP/JE	Wharf Rd north		2000	2045	75%, msb, nil, 23, 88%	Mod	Grey-headed flying fox	>5	C	
								Litoria fallax	<5	C	
8/12/14	NP/TW	Barrie's Ck		2115	2200	100%, msb, HS, 23.1, 87%	Dk	Short Eared Brushtail Possum	1	F	
								Pseudophryne coriacea	>30	C	1 individual relocated
15/12/14	NP/GM	Cooperabung Ck	19600	2030	2130	50%, rl, nil, 20.9, 70%	DK	Pseudophryne coriacea	1	C	
								Echidna	1	F	Relocated upstream
								Flying fox spp.	5	C	
16/12/14	NP/GM	Cooperabung	19600-20200	2020	2140	100%, msb, ls, 22.5, 88%	DK	Flying fox spp.	5	C/F	
								Litoria dentata	>10	C	1 individual relocated
								Litoria fallax	>20	C	

								Limnodynastes peronii	>10	C	
								Pseudophryne coriacea	>10	C	
								Litoria tyleri	<5	C	
								Litoria peronii	<5	C	
17/12/14	NP/GM	North Haydons wharf		2030	2130	95%, rl, ls, 20.2, 88%	DK	Litoria fallax	13	C (1 pair observed mating)	13 Relocated
17/12/14	NP/GM	South Haydons wharf		2130	2200	100%, rl, ls, 19.8, 90%	DK	Litoria fallax	3	P	3 Relocated
5/1/14	NP/GM	Blackmans point rd	8900-9200	2025	2103	10%, nil! nil, 24.2, 74%	BR	Litoria dentata	1	C	
								Owlet Nightjar	1	C	
								Bandy Bandy	1	F	Relocated
5/1/15	NP/GM	Mahogany Rd	99500-10500	2112	2155	10%, nil, nil, 22.8, 82%	BR	Owlet Nightjar	1	C	
6/1/15	NP/GM	Range rd	20700-21000	2035	2141	0%, nil, nil, 28.3, 69.7%	BR	Litoria peronii	5	C	1 relocated
								Flying Fox spp	>50	T	
								Adelotus brevis	1	-	Relocated
								Litoria tyleri	>10	C	2 relocated
								Pseudophryne coriacea	>5	C	
								Limnodynastes peronii	<5	C	
6/1/15	NP/GM	Mahog rd	10500-11100	2200	2310	0%, nil, nil, 26.9, 76.4%	BR	Litoria dentata	1	C	
								Limnodynastes peronii	1	T	Relocated
								Owlet Nightjar	1	C	
								Possible Masked Owl	1	C	
								Macrapod spp	2	T	
6/1/15	NP/GM	Blackmans south	8650-8900	2335	0000	0%, nil, nil, 25.3, 78.1%	BR	Nil			
7/1/15	NP/JE	Mahog north	10500-11100	2040	2115	10%, nil, nil, 26, 63.8%	DT	Owlet Nightjar	1	C	
								Macrapod spp.	3	T/F	Probable Swamp Wallaby
								Microbat spp.	1	T/F	
7/1/15	BT/GM		21000-21500	2035	2115	10%, nil, nil, 26, 63.8%	DT	Nil			
8/1/15	NP/JE	Bill Hill South	11100-11400	2040	2140	0%, msb, nil, 24, 84%	DT	Feathertail Glider spp.	1	F/T	
								Tawny Frogmouth	2	T/C	
								Owlet Nightjar	1	C	
8/1/15	NP/JE	Median NB	10500-10900	2150	2240	0%, msb, nil, 26.7, 70%	DT	Owlet Nightjar	1	C	
8/1/15	BT/GM		21000-21500	2035	2110	0%, msb, nil, 24, 84%	DT	Nil			
8/1/15	BT/GM		8900	2130	2140	0%, msb, nil, 26.7, 70%	DT	Nil			
11/1/15	NP/JE	Range rd	20600-21500	2035	2050	100%, nil, mod, 24.9, 92%	DK	Nil			
11/1/15	NP/JE	Bill Hill South	10700-11450	2105	2205	100%, nil, mod, 22.8, 89.2%	DK	Green Tree Snake	1	T	Climbing stag HBT Hs48
								Microbat spp.	4	T/F	
								Crinia signifera	5	C	
13/1/15	NP/TW	North coop	21500-21800	2050		80%, mlb, nil, 25, 81%	DT	Pseudophryne coriacea	>100	C	
								Adelotus brevis	1	C	
								Microbat spp.			
18/1/15	NP/JE	North Bill Hill	11500-12350	2133	1109	30%, nil, nil, 25.5, 75%	DK	Owlet Nightjar	3	C	

								Feathertail Glider spp.	2	F/T	
								Small Eyed Snake	1	T	Relocated
								Limnodynastes peroni	2	T	1 relocated
								Macrapod spp.	2	T	
								Microbat spp.	3	T/F	
18/1/15	NP/JE	North cut 19	21700-22000	2033	2115	20%, nil, nil, 26.1, 74.4%	DT	Pseudophryne coriacea	1	C	
								Litoria tyleri	1	C	
19/1/15	NP/TW	Haydons wharf South	17200-17500	2049	2115	90%, lr, mlb, 23.8, 77.4%	DK	Litoria peronii	1	C	
								Pseudophryne spp.	1	C	
								Litoria fallax	3	C	
								Litoria nasuta	>5	C	
								Litoria dentata	3	C	
19/1/15	NP/TW	Bill Hill rd North	11500-12350	2130		90%, lr, mlb, 25.6, 75.3%	DK	Owlet Nightjar	3	C	
								Common Brushtail Possum	2	F/T	1 individual sitting in Turpentine
								Koala	1	F	Sitting in large Tallowwood at ch11850; E: 481423 N:6530439
								Swamp Wallaby	1	T/F	
								Litoria dentata	>3	C	
								Litoria tyleri	2	C/T	1 relocated
								Limnodynastes peronii	1	T	Relocated
21/1/15	NP/JE	Bill Hill North, East Rd	11500-12350	2030	2245	90%, lr, rl, 23.9, 95%	DK	Limnodynastes peronii	>100	C/T	3 relocated
								Litoria peronii	<5	C	
								Litoria gracilenta	>100	C/M	
								Litoria dentata	>10	C	Heavy rain in preceding nights (190mm)
								Crinia signifera	>50	C/M	
								Adelotus brevis	>10	C	
								Litoria nasuta	>10	C	
								Pseudophryne coriacea	>10	C	
								Litoria fallax	>5	C	
								Freshwater Crayfish	>10	F	3 relocated
22/1/15	NP/JE	East Rd frogging		2000	2115	100%, hr, rl, 22.8, 94%	DK	Litoria brevipalmata	2	C	Initially heard calling in response to playback. Responded every time call played. Photos, video and GPS coordinates recorded; E: 481840 N: 6527853
								Litoria dentata	>10	C	
								Crinia signifera	>50	C	
								Litoria gracilenta	>100	C/T	
								Limnodynastes peronii	>30	C	
								Pseudophryne coriacea	2	C	
								Litoria nasuta	<10	C	
								Litoria fallax	<10	C	
								Freshwater Crayfish	3	F	

								Tawny Frogmouth	1	C	
27/1/15	NP/GM	Bill Hill Rd	11500-12350	2030	2200	100%, rl, lr, 20.5, 90%	DK	Crinia signifera	>50	C	
								Litoria dentata	>40	C	
								Limnodynastes peronii	>30	C	
								Litoria fallax	<10	C	
								Pseudophryne coriacea	<5	C	
								Owlet Nightjar	1	C	
27/1/15	NP/GM	East Rd Frogging		2200	2300	100%, rl, lr, 19.6, 90.5%	DK	Crinia signifera	>20	C	
								Limnodynastes peronii	>10	C	
								Litoria dentata	<15	C	
								Uperoleia laevigata	<5	C	
28/1/15	NP/GM	Frogging South of Blackmans pt rd		2030	2130	80%, msb, nil, 21.4, 79.5	DT	Litoria tyleri	>20	C	
								Litoria fallax	<10	C	
								Limnodynastes peronii	>10	T/C	
								Crinia signifera	>10	C	
								Psued. coriacea	>10	C	
								Uperoleia laevigata	<5	C	
29/1/15	NP/GM	Frogging Cooperabung		2030	2130	5%, msb, nil, 20.3, 73.9%	DT	Litoria tyleri	<10	C	
								Litoria dentata	<10	C	
								Uperoleia fusca	>10	C	
								Limnodynastes peronii	<5	C	
								Litoria fallax	<10	C	
29/1/15	NP/GM	Frogging Barrie's Creek		2135	2235	5%, rl, nil, 20, 84.9%	DT	Pseudophryne coriacea	>200	C	
								Litoria fallax	1	C	
								Pink Tongue Lizard	1	T	
1/2/15	NP/JE	Cooperabung range	21600-22000	2020	2105	90%, rl, mod, 23.2, 82.8%	DT	Pseudophryne coriacea	>50	C	
1/2/15	NP/JE	Cooperabung drive corner		2110	2130	90%, rl, ls, 22.9, 90%	DT	Feathertail Glider spp.	1	F	
								Tawny Frogmouth	2	P	Juveniles.
1/2/15	NP/JE	Haydons Wharf Rd South	17600-18050	2130	2220	90%, rl, mod, 22.1, 99.5%	DK	Limnodynastes peronii	<5	C	
								Litoria fallax	<5	C	
								Litoria nasuta	<5	C	
								Litoria tyleri	>5	C	
								Litoria dentata	>10	C	
								Litoria peronii	>5	C	
								Uperoleia spp.	1	C	
1/2/15	NP/JE	Bill Hill North	11500-12350	2230	2315	60%, rl, nil, 22.6, 100%	DT	Feathertail Glider spp.	1	F	
								Litoria dentata	>10	C	
								Litoria gracilenta	<5	C	
2/2/15	NP/JE	Haydons Wharf Rd South	17600-18050	2035	2140	40%, nil, nil, 24.7, 75.2%	DT	Common Ringtail Possum	1	F	
								Litoria nasuta	<5	C	
								Litoria peronii	>5	C	
								Limnodynastes peronii	>10	C	
								Litoria tyleri	>10	C	

								Uperoleia spp.	2	C	
								Litoria fallax	<5	C	
								Litoria dentata	<5	C	
3/2/15	NP/TW	Haydons wharf	17600-18050	2030	2120	0%, nil, nil, 20.8, 78%	BR	Litoria nasuta	<5	C	
								Litoria peronii	<5	C	
								Limnodynastes peronii	<10	C	
								Litoria tyleri	<10	c	
								Uperoleia spp.	<10	C	
								Litoria fallax	<10	C	
								Pseudophryne coriacea	<15	C	
3/2/15	NP/TW	Bill Hill North	11500-12350	2125	2230	0%, nil, nil, 19.9, 74%	BR	Owlet Nightjar	1	C	
								Crinia signifera	>20	C	
								Limnodynastes peronii	<10	C	
								Litoria fallax	<5	C	
								Litoria nasuta	<5	C	
4/2/15	TW/JE	Haydons wharf rd sth	17200 - 17700	2032	2105	20%, nil, nil, 21.4, 68%	BR	Litoria nasuta	>5	C	
								Litoria peronii	<5	C	
								Limnodynastes peronii	<5	C	
								Litoria tyleri	<5	C	
								Litoria fallax	>5	C	
								Pseudophryne coriacea	>5	C	
								Grey-headed flying fox	1	F	
4/2/15	TW/JE	Haydons wharf rd nth	18200 - 18551	2115	2153	10%, nil, nil, 20.8, 69%	BR	Litoria fallax	>10	C	
5/2/15	NP/TW	North Sancrox	3400-3575	2040	2120	50%, rl, nil, 23.6, 67%	BR	Pseudophryne coriacea	<20	C	
5/2/15	NP/TW	North Haydons wharf	18200 - 18551	2130		75%, rl, nil, 22.3, 70%	BR	Rodent spp.	1	F	
								Litoria revelata	<10	C	
								Litoria fallax	<10	C	
								M. ITERATUS	3	C	
								Limnodynastes Peronii	<20	C	
								Uperoleia spp.	3	C	
7/2/15	NP/JE	North Haydons Wharf/Coop Ck frogging	18200 - 18551	2015	2200	20%, nil, nil, 23.3, 78.6%	BR	Mixophyes iteratus	4	C	At least 3 calling. All within 3m from stream.
8/2/15	NP/JE	South Fernbank	3600-4100	2020	2130	0%, nil, nil, 27.5, 71.8%	DK	Pseudophryne coriacea	>20	C	
8/2/15	NP/JE	North Haydons - Coop close	18200-19500	2145	2245	0%, nil, nil, 24.2, 80.7%	DK	GH FF	1	F	
								Tawny Frogmouth	1	F	
								Litoria dentata	1	C	
9/2/15	NP/JE	Cooperabung range	21900-22100	2050	2125	75%, rl, lr, 22.8, 96.7%	DK	Pseudophryne coriacea	>20	C	
10/2/15	NP/JE	Cooperabung range	21900-22400	2045	2130	60%, nil, nil, 22.9, 82.4%	DK	Pseudophryne coriacea	>50	C	
								Feathertail Glider spp.	1	F	
								GH FF	3	F	
10/2/15	NP/JE	Fernbank South	4100-4470	2210	2245	80%, nil, lr, 22.8, 78.6%	DK	Pseudophryne coriacea	>30	C	
								Uperoleia spp.	2	C	
								Litoria fallax	<5	C	
11/2/15	NP/JE/DR	Coop Ck literatus survey		2030	2140	20%, nil, nil, 24, 79.1%	DK	Mixophyes iteratus	1	C	Animal captured for pit tagging and

											relocation
11/2/15	NP/DR	Coop range	21900-22500	2210	2330	10%, nil, nil, 22.2, 79.5%	DK	Feathertail Glider spp.	1	T	
								Pink tongue lizard	1	F	Relocated
								Pseudophryne coriacea	>50	C	
15/2/15	NP/JE/TW	Coop Ck iteratus survey		2025	2125	80%, nil, nil, 24.4, 73.9%	DT	Mixophyes iteratus	1	C	Animal captured for pit tagging and relocation
15/2/15	NP/TW	Haydons Wharf to Coop Close		2135	2210	80%, nil, nil, 23.2, 82%	DK	small mammal spp. (Rodent? Ante?)	2	F/T	
15/2/15	NP/TW	Sancrox North	2800-3600	2230	2320	20%, rl, nil, 22.9, 98.2%	DT	Sugar Glider	1	F	
								Tawny Frogmouth	1	F	
16/2/15	NP/JE/TW	Coop Ck iteratus survey		2020	2125	10%, nil, nil, 24.5, 76%	DT	Mixophyes iteratus	1	F	Animal captured for pit tagging and relocation (large individual, prob. female.
	NP	Elliot trap line set									
16/2/15	NP/TW	Sancrox Rd North W	2800-3500	2145	2215	10%, nil, nil, 25.6, 76%	DT	GH FF	1	C	
17/2/15	NP/JE	Coop Ck iteratus survey		2030	2100	Nil, nil, nil, 25, 71.3%	DT	Antechinus spp.	1	F	Climbing tree. Noticed animal didn't want to climb higher than bark on F.Gum, just circled tree, hiding under decort. Bark.
17/2/15	NP/JE	Compound E Bdy		2120	2130	30%, nil, nil, 24.5, 75%	DT	Nil			
18/2/15	NP/JE	Coop Range	21900-22700	2125	2200	80%, nil, lr, 23.9, 84.4%	DK	Pseudo. coriacea	>10	C	
26/2/15	NP/GM	Coop Ck and Compound		0500	0600	60%, nil, nil,	DK	Uperoleia spp.	1	C	
								Litoria fallax	1	C	
27/2/15	NP/GM	Coop Ck		0500	0545	50%, nil, nil, 20, 92%	DK	Nil			
5/3/15	NP/BT	Coop Ck, sth fence line		0510	0600	0%, nil, nil, 23.7, 81%	DT	M iteratus 40m+ upstream	5	2c	1x juv(55mm); 2 males C
6/3/15	NP/JE	New Blackmans point rd		0445	0550	10%, nil, nil, 20.8, 76.2%	BR	Feathertail Glider spp	1	F	
2/3/15	NP/TW	Yarrabee Rd		0500	0555	85%, rl, ls, 23, 85.7	DK	Brown Antechinus	1	F	
2/3/15	NP/TW	Coop Range						Pseudophryne coriacea	>5	C	
3/3/15	NP/TW	Coop Range	22450-22620	0500	0545	0%, nil, nil, 18.4, 85.9%	DK	Microbat spp.	1	F	
3/3/15	NP/TW	Yarrabee Rd		0545	0600	0%, nil, nil, 18.2, 78%	DT	Nil			
4/3/15	NP/TW	Yarrabee rd East		0540	0600	0%, nil, nil, 21.9, 80%	DT	Nil			
4/3/15	NP/TW	Coop Creek fence line East		0500	0530	0%, nil, nil, 22.3, 79.7%	DT	Nil			
5/3/15	TW/JE	Coop range nth	22585-22900	532	610	0%, nil, nil, 22.3, 79.7%	DT	Nil			
5/3/15	TW/JE	Yarrabee nth	22000-22200	500	520	0%, nil, nil, 20.4, 82.1%	DT	Nil			
6/3/15	TW/BT	Coop range nth	22585-22900	525	600	0%, nil, nil, 23.1, 80%	DT	Nil			
6/3/15	TW/BT	Nth/sth Yarrabee rd E		500	515	0%, nil, nil, 21.7, 82.6%	DT	Nil			
9/3/15	TW/JE	Coop Ck ITERATUS survey		500	524	0%, nil, nil, 19.4, 76.6%	DT	Nil			
9/3/15	TW/JE	Yarrabee rd nth	Yarrabee nth	532	554	0%, nil, nil, 20.1, 79.7%	DT	Nil			
10/3/15	TW/JE	Cooperabung Ck		500	515	0%, nil, nil, 19.7, 94.2%	DT	Nil			
10/3/15	TW/JE	Nth Cooperabung range	22500-22900	530	550	0%, nil, nil, 22.3, 79.7%	DT	Nil			
11/3/15	TW/JE	Nth Cooperabung	22850-22200	515	615	90%, nil,nil, 22.4, 88.7%	DT	Nil			

		range									
12/3/15	TW/JE	Nth Cooperabung	21700-22100	518	605	0%, nil, nil, 19.4, 94.2%	BR	Pseudophryne coriacea	1	C	
								Tawny frogmouth	2	R	
13/3/15	TW/JE	Nth Cooperabung		517	523	100%, msb, heavy, 22.1, 92.8	DK	Nil			Rained out, had to leave site
16/3/15	TW/JE	Nth Cooperabung	21500-22400	516	613	0%, msb, nil, 18, 82%	DK	Pseudophryne Coriacea	5	C	
16/3/15	BT	Bill hill rd	13100-14200	502	615	0%, msb, nil, 18, 82%	DK	Nil			
17/3/15	BT	Bill hill rd	13100-14850	455	608	0%, mSb, nil, 14.8, 88%	DK	ONj	1	C	
18/3/15	BT/JE	Nth Cooperabung	22100-22400	505	527	50%;mSb;nil;	DK				
18/3/15	BT/JE	Nth Cooperabung	22850-22900	530	545	50%;mSb;nil;	DK				
19/3/15	BT	Bill hill rd	11600-11700	459	554	0%, nil, nil, 22.2;81%	DK				
19/3/15	BT	Bill hill rd	11900-12250	459	554	0%, nil, nil, 22.2;81%	DK	ONj	1	C	
30/3/15	NP/TW	North Cooperabung range	22900-23300	0530	0630	60%, nil, nil, 19, 82%	DK	Southern Dwarf Crown Snake	1	T	Relocated
8/4/15	NP	South	1100-1600	0440		0%, msb, nil, 15.5, 58.8%	DT	Sugar Glider	1	T	Juvenile
								Macropod spp.	2	T	
								Crinia signifera	>10	C	
								Pseudophryne coriacea	>5	C	
8/4/15	TW/GM	Sth Barries Ck	22900-23350	437	530	0%, nil, nil, 12.1, 82%	DT	Nil			
8/4/15	TW/GM	Sth Barries Ck	22900-23350	1840	1950	0%, nil, nil, 19.1, 70%	DT	Nil			
8/4/15	TW/GM	Sth Sancrox	750-1050	2020	2045	0%, nil, nil, 17.2, 71%,	DT	Ln bandicoot	1	F	
9/4/15	TW/GM	Sth Sancrox	750-1050	1850	1920	0%, msb, nil, 19.1,72.5%	DT	Nil			
	TW/GM	Sth Barries	22900-23300	1956	2030	0%, msb, nil, 18.2, 76%	DT	Crinia signifera	2	C	
13/4/15	NP/TW	Sth Barries Ck	22900-23400	1845	1925	10%, rl, nil, 20.7, 75.3%	DT	Litoria peronii	1	F	Relocated to stream
14/4/15	NP/TW	Sth Barries Ck	22900-23400	1905	1925	20%, nil, nil, 21.4, 75%	DK	Nil			
14/4/15	NP/TW	Blackmans South	7900-8650	1950	2040	20%, nil, nil, 22.5. 73.2%	DK	Nil			
15/4/15	NP/TW	South Barries	23200-23400	1905	1936	0%, nil, nil, 22.2, 82%	DK	Nil			
16/4/15	NP/TW	South Barries East	23350-23750	1855	2000	20%, nil, nil, 23.8, 82%	DK	Nil			
20/4/15	NP/JE	South Barries East	22900-23750	1850	1930	100%, nil, mlb, 19.7, 85%	DK	Nil			
21/4/15	NP/JE	South Barries Creek East	22500-23000	1850	1945	20%, nil, msgb, 17.6, 77%	DK	Nil			
7/5/15	NP/JE	South of Cooperabung close West	18300-18800	1840	1930	0%, nil, rl, 13.1, 97%	DK	Long Nose bandicoot	1	C	
								Crinia signifera	>10	C	
14/5/15	NP/JE	South East sancrox	700-1000	1830	1920	10%, nil, msb, 17.8, 59.3%	DK	Nil			
3/11/14	DR, NP		7000-7700	1945	2115	NR	M	Nil			
4/11/14	DR, JE		7300-8000	1945	2130	cc 60%, rl, nil, 23.3, 61.8	Bright	White-throated nightjar	1	C	
								Brush cuckoo	1	C	
17/11/14	DR, TW		7700-7800	2004	2024	Cc80%, rl, nil, 22.2, 64.4	Dark	Nil			
17/11/14	DR,TW		8900-9300	2035	2120	Cc80%, rl, nil, 22.2, 64.4	Dark	Nil			Green-thighed frog survey along track
17/11/14	DR, TW		21000-21500	2145	2235	Cc90%, nil, nil, 23.6, 62.7	Dark	GHFF	1	F	
18/11/14	DR, NP		9150-9650	2040	2125	100%, nil! light, 22.3, 86.5	Dark	Nil			
18/11/14	DR, NP		13600-14050	2150	2230	100%, nil! nil, 23.4, 76.2	Dark	Lim peronii, Lit nasuta, Uperoleia spp	2,1,1	T	All relocated outside alignment

18/11/14	DR, NP		21300-21500	2300	2135	100%, nil! nil, 22, 80%	Dark	GHFF	1	F	
18/11/14	DR, NP		20700-21000	2340	2400	100%, nil! nil, 22, 80%	Dark	GHFF	2	F	
23/11/14	DR, GM		Nth side coop Ck	2020	2050	95%; MLB, nil, 32.3; 33.4%	Dark	GHFF, Tawny Frog	1, 1	F	GBF survey nth side coop ck.; very poor conditions
23/11/14	DR, GM		19050-19350	2105	2135	95%, MLB, nil, 31.3, 38.3%	Dark	Noisy friar bird	1	R	
24/11/14	DR, GM		19050-19600	2020	2140	100%, nil! nil, 27.4, 63.2	Dark	GHFF	3	F	GBF survey sth side coop Ck, moderate cond - stormy; playback & active search (20min x 2 person)
								Limnodynastes peronii	1	T	
25/11/14	DR, GM		17850-18050	2025	2110	100%, rl, prev24hr, 23.1, 74.5	Dark	GHFF, L. fallax, L. peronii, L. caerulea.	5	F	
								L. fallax	5	C	
								L. peronii	1	C	
								L. caerulea	2	C	
25/11/14	DR, GM		10000-10600	2130	2230	100%, rl, <24hr, 22.8, 78.9	Dark	Nil			
25/11/14	TW, JE		7200-7650	2023	2130	100%, rl, <24hr, 27.7, 86%	Dark	GHFF, Eastern Grey kangaroo, Little Eagle (pr)	1, 1, 1	C, T, R	482293E, 6526355N
25/11/14	TW, JE		9150-9650	2140	2220	100%, nil, <24hr, 26.2, 82%	Dark	Nil			
26/11/14	DR, GM		17300-17800	2020	2220	100%, nil, v light, 22.7, 79.4	Dark	GHFF, Litoria nasuta	10, 1	F	
27/11/14	DR, GM		17300-17800	2020	2145	70%; rl, prev 24hr, 23.4, 65.4	Dark	GHFF, tawny frogmouth, L. fallax, L. tyleri, Ps. coriacea	6, 2, 5, 1, 10	F, R, C	Fallax & tyleri relocated into adj dam.
8/12/14	DR, TW, NP		19700	2030	2110	80%, nil, prev 24hr, 26.7, 71	Detail seen	Litoria gracilenta, L. latopalmata	2, 10+	C, C	GBF survey, 5m call broadcast at 3 sites; 3 person search of riparian zone; Ck dry
9/12/14	DR, TW, JE		23850-24100	2000	2030	80%, nil, prev24hr, nr, nr	Detail seen	Ps. coriacea, grey-headed flying-fox	50+	C	
10/12/14	DR, JE		20050-20700	2000	2125	100%, nil, nil, 24, 75	Detail seen	Petaurus spp., Feathertail glider, Ps. coriacea, L. fallax, Ad. brevis, Limnodynastes peroni	1,1,20,10, 5,5	F, C	Gliders at 20700; near HBT's
14/12/14	DR, GM, NP		Coop Ck	2020	2045	20%, rl! nil, 24.7, 83	Detail seen	Tawny frog; red-backed toadlet; tusked frog	1,2,1	C	
14/12/14	DR, GM, NP		20250-20700	2100	2130	20%, nil! nil, 23, 89	Detail seen	Red-backed Toadlet, tusked frog, antechinus spp	5, 5, 1	C, C, F	
12/1/15	DR, TW		10500-bill Hill	2040	2140	10%, rl! prev 24hr, 27, 73	Detail seen	Owlet nightjar, brown antechinus, Crinia signifera, L. dentata	1, 1, 1	C, T, c	
12/1/15	DR, TW		9025-9075& 9325-9275	2200	2254	5%, rl, prev24hr, 24.3, 76	Detail seen	Lim. peroni, Litoria dentata, Litoria tyleri, Ps. coriacea	5, 1, 1	C, C, C	
14/1/15	DR, NP		21500-22000	2045	2125	50; rl; nil; 29.3; 74	Detail seen	Feathertail spp; Ps coriacea; est small-eyed	1,1,1	F, F, T	Small-eyed & Toadlet relocated
14/1/15	DR, NP		11500-11600	2205	2230	nil; rl; nil; 27.7; 79	Detail seen	Lim peronii; owlet nightjar	2, 1	T, C	
15/1/15	DR, JE		11500-11600	2040	2100	100; nil; nil; 27.4; 73.9	Dark	Owlet nightjar, Litoria gracilenta	1, 1	C, C	
15/1/15	DR, JE		21500-22000	2125	2200	10; rl; nil; 27.9; 77.7	Dark	Ps. coriacea; L. tyleri; L. peronii	Several	C, C, C	Tyleri & peronii both in basin
9/2/15	DR		Coop Ck sth	2015	2135	40; rl; LS	Dark	M. iteratus; Lim. peroni; Litoria revelata; U. fusca, Lit tyleri; Litoria latopalmata	6 (os), 1, 3, 2, 1, 2	C	6 M. iteratus over 59m of creek bank - outside LoC
10/2/15	DR		18200-19200	2000	2100	15; rl; nil; 23	Dark	M. iteratus; tawny frogmouth; Litoria dentata; Litoria latopalmata	2; 1; 3; 3	C	2 iteratus on east side of Ck, outside LoC

13/2/15	DR, JE		Cooperabung Ck	2045	2145	15; nil; shower; 22	Dark	M. Iteratus; Limnodynastes peroni	1; 1	F	1 female tetanus just outside frog fence
13/2/15	DR, JE		21900-22400	2200		75; nil; shower; 22	Dark				
9/3/15	DR		11650-11700	0500	0530	0; nil; nil; 18; 77.2	DS	Barn owl; owlet nightjar	1, 2	C	
9/3/15	DR		Blackmans Pt Rd	0535	0615	0; nil; nil; 18; 77.2	DS	Nil			
10/3/15	DR		11700-12200	0500	0600	10; nil; nil; 21; 87	DS	Tawny frogmouth; owlet n'jar; ft cuckoo	1, 2, 2	C	
11/3/15	DR		11900-12350	0500	0600	90; nil; nil; 23; 85.6	DS	Owlet n'jar; barn owl	1, 1	C	
12/3/15	DR		11900-13150	0500	0615	0; nil; nil; 20; 81.	DS	Tawny F'mouth	1	C	
13/3/15	DR		11900-13100	0500	0615	100; rl; light; 21; 86	D	Nil			
26/3/15	DR, NP		900-1400	0530	0630	100; rl; nil; 21.7; 85	D	Nil			
27/3/15	DR, NP		1100-1600	0545	0630	Nil; rl; nil; 19.1; 62	D				
19/5/15	NP/JE	South East sancrox	800-1600	1800	1900	50%, nil, msb, 18.4, 85.6%	DK	Feather tail Glider	1	T	
								Microbat spp	2	F	Bat boxes in location
								Crinia signifera	<10	C	
								CRTP	1	F	
20/5/15	NP/GM	South East sancrox	800-1600	1815	1920	30%, nil, rl, 19.9, 85%	DK	Petaurid spp (SuG or SqL)	1	T	
								CRTP	1	F	
								Crinia signifera	<10	C	
NR	TW/JE	South East sancrox	750-1700	1810	1920	80%, nil, nil, 18.7, 95%	DS	Black rat	1	T	
								Tawny frog mouth	1	R	
NR	TW/JE	South East sancrox	750-1700	2028	2120	0%, nil, nil, 16.3, 83.7%	DS	Nil			
NR	TW/JE	South East sancrox	750-1700	1805	1900	0%, nil, nil, 18.8, 93.6%	DS	Nil			
20/07/15	GM/JE	Sancrox	1850-2450	1900	2030	50%, light, 16.2, 84.1%	nr	Eastern grey kangaroo, flying-fox spp.	1, 1	F	
21/07/15	GM/JE	Sancrox	1850-2450	1800	1900	5%, nil, 15.2, 87.3%	DS	nil			
22/07/15	GM/JE	Sancrox	1850-2450	1800	1900	100%, nil, 14.1, 93.6%	Dark	nil			
23/07/15	GM/JE	Sancrox	1850-2450	1800	1845	nr, nr, 17.9, 87.9%	nr	flying-fox spp	2	f	
18/08/15	GM	South SB Fernbank Creek	3600 - 4500	530	600	0%, nil, nil, 11, 81	Good	nil			
20/08/15	GM	RMS depot to Sancrox bridge SB	1800 - 2300	530	600	40%, light, nil, 11, 88	Good	nil			
21/08/15	GM	RMS depot to Sancrox bridge SB	1800 - 2300	530	600	0%, nil, nil, 11.8, 89	Good	nil			

Table D2: Pre-clearing surveys conducted for the Oxley Highway to Kundabung Pacific Highway Upgrade.

Date	Observer	Chainage Sampled	Purpose of clearing	Start Time	Finish Time	Species Captured (1 row for each individual)	Fate	Release Location
3/11/14	NP	6900-6700	Stage 1	0630	0800	1x Hemiaspis signata; 1x Lamp. delicata. 1x HBT marked up; active N.Friarbird? nest present.	Relocated outside LoC	W. Of BDY @ ch6800
4/11/14	DR	6800-7000	Stage 1	0720	0730	Nil		
4/11/14	DR	7000-7800	Stage 1	0600	0715	2x HBT marked (termitaria)		
5/11/14	DR/JE	7000-7700	Stage 1	0600	0730	3x HBT marked up		
6/11/14	TW/JE	7600-8250	Stage 1	0600	0720	Nil		
7/11/14	NP/TW	7000-7700	Stage 1	0550	0730	1x Lampropholis delicata relocated; 1x HBT marked up.	Relocated outside LoC	W. Of BDY @ ch7300
7/11/14	NP	19700	Stage 1	1000	1130	Nil		
10/11/14	NP/JE	7000-7700	Stage 1	0600	0710	2x HBT marked up (active S.Kingfisher in termitaria)		
11/11/14	NP/DR	7000-7700	Stage 1	0600	0700	Nil		
12/11/14	TW/NP	8288-8900	Stage 1	0600	0655	1x HBT marked		
12/11/14	TW	8200-8250	Stage 1	0710	0720	Nil		
13/11/14	NP/TW	7700-8700	Stage 1	0600	0710	1x Drey removed		
14/11/14	NP/TW	7700-8500	Stage 1	0600	0710	1x Hemiaspis signata; 2x Lampropholis delicata relocated	Relocated outside LoC	E of BDY @ ch8200
17/11/14	NP/JE	7686-8103	Stage 1	0600	0715	1x HBT log for relocation; 1x small mammal nest		
17/11/14	NP/JE	nr	Bund	0730	0800	Nil		
17/11/14	NP	19675	Frog fence	1200	1300	Nil		
18/11/14	NP/JE	8900-9500	Stage 1	0620	0730	1x Blind Snake; 1x HBT log	Relocated outside LoC	E of BDY @ ch 9100
18/11/14	NP/JE	7400	Stage 1	0600	0615	Nil		
19/11/14	NP/BT	8900-9500	Stage 1	0600	0710	1x Blind Snake; 3x HBTs marked up	Relocated outside LoC	E of BDY @ ch 9300
19/11/14	TW	21250-21500	Stage 1	0600	0650	1x log marked for relocation		
20/11/14	TW	21450-21500	Stage 1	0600	0620	Nil		
20/11/14	BT	20775-20700	Stage 1	0600	0630	Nil		
20/11/14	TW/BT	20180-19700	Stage 1	0635	0715	Nil		
21/11/14	TW	20700-20750	Stage 1	0600	0615	Nil		
21/11/14	TW	20100-19700	Stage 1	0625	705	Nil		
21/11/14	TW	18050-18200	Stage 1	0715	0730	Nil		
20/11/14	NP/JE	9200-9600	Stage 1	0600	0635	Nil		
20/11/14	NP/JE	13300-14300	Stage 1	0640	0800	1x HBT marked up		
21/11/14	NP/JE	13300-14300	Stage 1	0600	0645	1x HBT marked up		
21/11/14	NP/JE	9400-9600	Stage 1	0650	0745	Crows seen using stick nest; 1 deceased Litoria nasuta on track (squashed)		
24/11/14	NP/TW	9400-9800	Stage 1	0600	0700	Nil		
25/11/14	NP/TW	9800-10350	Stage 1	0600	0700	Nil		
26/11/14	NP/GM	9150-10600	Stage 1	0600	0900	2x HBT logs marked; 4x HBT marked		
26/11/14	TW	7200-8200	Stage 2	0600	0700	3x HBT marked		
27/11/14	NP/GM	9150-9950	Stage 2	0600	0730	1x drey removed; 1x HBT marked up; 1x Egernia major in log just outside LoC		
27/11/14	TW	7200-8200	Stage 2	0600	0650	Nil		
28/11/14	TW/GM	7800-8200	Stage 2	0600	0710	Nil		
28/11/14	NP	9150-9950	Stage 2	0610	0710	Nil		
4/11/14	DR	7000-7800	Stage 1	0600	0715	2x HBT marked (termitaria)		
4/11/14	DR	6800-7000	Stage 1	0720	0730	N/A		
18/11/14	DR/TW	21000-21350	Stage 1	0600	0655	1x fossorial skink		
24/11/14	DR	19050-19350	Stage 2	0600	0630	1x drey		
24/11/14	DR	21500	10x50m	0640	0700	2x horseshoe bats in pipe culvert; outside clearing zone - monitor.		
24/11/14	DR	19700	Basin in GBF	0800	0930	Strip basin; 1x Hemiaspis signata; 1x Saproscincus oriarus; 1x Lampropholis delicata; 1x Lampropholis amicula	Relocated into adjacent riparian habitat	
25/11/14	DR/GM	19050-19550	Stage 2	0600	0700	Nil		
26/11/14	DR	19350-19600	Stage 2	0600	0630	Nil; discussed clearing in GBF habitat		

26/11/14	TW	7200-7650	Stage 2	0600	0645	Nil		
27/11/14	DR	17400-17900	Stage 1	0600	0830	1x eastern small-eyed snake; 1x old antechinus den; 2x HBT marked	Relocated outside alignment	
27/11/14	DR	18300-18500	Services	0715	0745	1x passerine nest with dead chick		
27/11/14	DR	17400-17900	Stage 1	0600	0700	1x HBT marked		
1/12/14	NP	91500-9950	Stage 2	0600	0700	Nil		
1/12/14	TW/BT	17400-17900	Stage 1	0600	0700	3x HBT & drey marked up		
1/12/14	TW/BT	7500-7800	Stage 1	0720	0735	Nil		
2/12/14	NP	9159-10500	Stage 2	0600	0740	1x HBT marked up		
2/12/14	TW/BT	17250-17900	Stage 1	0600	0650	Nil		
2/12/14	TW/BT	18300-18870	Boundary fence	0730	0800	Nil		
3/12/14	TW	17250-17900	Stage 1	0600	0650	1x HBT with termitaria marked for retention		
3/12/14	TW	Wyndell Close	Access	1500	1510	Nil		
3/12/14	NP	9400-10450	Stage 2	0600	0710	1 x HBT marked up		
4/12/14	NP	9400-10000	Roadside	0600	0635	1x small cup nest removed		
4/12/14	TW/BT	18000-18660	Stage 1	0600	0650	3x HBT marked up		
4/12/14	TW/BT	Wyndell Close	Stage 1	0710	0730	Nil		
4/12/14	TW/BT	C599011(bat culvert)	Stage 1	0750	0755	Nil bats		
4/12/14	TW/BT	C599012(bat culvert)	Stage 1	0800	0805	Nil bats		
4/12/14	TW/BT	C599019(bat culvert)	Stage 1	0815	0820	Nil bats		
5/12/14	NP	7900-9000	Stage 2	0600	0715	1 x HBT marked up; active Sacred Kingfisher nest		
5/12/14	TW/BT	18000-18660	Stage 1	0600	0650	Nil		
5/12/14	TW/BT	Wyndell Close	Stage 1	0710	0725	Nil		
5/12/14	TW/BT	C599011(bat culvert)	Stage 1	0620	0623	Nil bats		
5/12/14	TW/BT	C599012(bat culvert)	Stage 1	0640	0645	Nil bats		
8/12/14	NP	10000-10450	Stage 2	0600	0700	Nil		
9/12/14	TW	18000-18700	Stage 1	0600	0700	Marked 28 FF trees.		
9/12/14	TW	Wyndell close	Stage 1	0715	0735	1x nest tree change to outside LoC		
12/12/14	NP/JE	Cooperabung Dr - Range rd.	Stage 2	0610	0700	1x Drey marked up		
24/11/14	JE	6119 - Hasting river	Stage 2	0525	0800	2 x HBT marked up		
25/11/14	JE	6800 - 7600	Stage 2	0520	0835	5x HBT marked up; 1 x Demansia psammophis relocated	Adjacent habitat	
3/12/14	JE	6561 - 8594	Stage 2	0525	1115	Nil		
4/12/14	JE	6561-8594	Stage 2	0545	0620	Nil		
8/12/14	DR	18050-18700	Stage 2	0600	0700	1 x HBT marked		
8/12/14	TW	17900-18250	Stage 1	0600	0630	Nil		
8/12/14	DR	Dalhunty Is, south bank	General observation	1200	1239	Flying fox camp, mostly black, 201 individuals		
9/12/14	DR	23730-24110	Stage 1	0730	1100	GTF search (20 mins); 14 FF (4 ironbark, 8 tallowwood); 4 nest boxes, several HBTs		
10/12/14	DR	23730-24110	Stage 1	0600	0645	Discussed HBT for removal; 2 hazardous trees, 1 nest tree removed after 24hrs		
10/1/14	DR	Wyndell Close	Stage 1	0720	0800	Discussed removal of trees on fence line; no significant habitat		
10/12/13	DR	Nth Cooperabung Drive	Stage 2	1200	1300	3 new HBT's,		
10/12/14	DR	Dalhunty Is, south bank	General observation	1330	1345	Flying fox camp, 201 individuals, all black FF		
11/12/14	DR/NP	20050-20700	Stage 2	0600	0710	1 x drey, numerous FF trees		

8/12/14	DR	18050-18700	Stage 1 & 2	0600	0700	1 x HBT		
15/12/14	NP/GM	20000-20700	Stage 2	0600	0700	Nil		
16/12/14	NP/GM	19600-20700	Stage 2/creek clearing	0600	0800	1 x HBT marked up, 1HBT destroyed		
17/12/14	NP/GM	19600-20700	Stage 2/ creek clearing	0600	0800	1 dead Snake found		
6/1/15	NP	8900-9200	Stage 2	0610	0640	Nil		
6/1/15	BT/GM	9500-10500	Stage 2	0610	0640	Stick nest@10500 (corvid?)		
7/1/15	NP	8650-9200	Stage 2	0600	0645	2 x HBT marked up		
7/1/15	NP/JE	10500-11000	Stage 2	0600	0825	1x Blue tongue lizard escaped capture		
7/1/15	BT/GM	20600-21100	Stage 2	0610	0650	Nil		
8/1/15	NP/JE	10000-11100	Stage 2	0600	0700	1x Echidna relocated		
8/1/15	BT/GM	20900-21500	Stage 2	0610	0655	Nil		
9/1/15	NP/JE	10000-11400	Stage 2	0610	0810	6x HBTs marked up; 3 logs marked up		
9/1/15	NP/JE	8910	Roundabout	0815	0840	1x HBT marked up		
9/1/15	BT/GM	20600-21100	Stage 2	0610	0640	Nil		
12/1/15	NP/TW	11200-11400	Stage 2	0600	0715	1 x HBT marked up		
13/1/15	NP/TW	11200-11400	Stage 2	0600	0720	1 x Lampropholis delicata relocated		
14/1/15	NP	11200-11400	Stage 2	0600	0700	1 x HBT marked up		
14/1/15	NP	7400-8900	Service corridor	0700	0800	Nil		
15/1/15	NP	11400-11600	Stage 2	0600	0700	3 x HBT marked up		
15/1/15	NP	7400-8900	Service corridor	0700	0800	1 x HBT stump marked up.		
14/1/14	TW	18600-18900	Fence line	0630	0700	Nil		
15/1/14	TW	18000-17600	Fence line	0630	0700	Nil		
16/1/15	NP	11400-11600	Stage 2	0600	0700	1 x HBT log marked up		
16/1/15	NP	7400-8900	Service corridor	0700	0800	1 x Lampropholis delicata relocated		
16/1/15	TW	18050-17225	Fence line	0630	0700	1x nest marked		
19/1/15	NP/TW	11600-12350	Stage 1	0600	0745	3 x HBT marked up		
19/1/15	NP/TW	Wilson River South	Grass slashing	0800	0900	Nil		
19/1/15	BT	21500-21950	Stage 1	0600	0655	Nil		
19/1/15	BT	7600-8870	Service corridor	0805	0840	Nil		
20/1/15	NP	7600-8870	Service corridor	0700	0735	Nil		
22/1/15	NP/JE	7600-8870	Service corridor	0700	0710	Nil		
28/1/15	NP/GM	Trapping line		0600	0640	1 x Bush Rat	relocated into adjacent habitat	
3/2/15	NP	7600-8870	Service corridor	0730	0815	Nil		
3/2/15	NP	11500-12350	Stage 1	0600	0720	1 x HBT marked up		
4/2/15	TW/JE	17200-17700	Stage 2	0600	0640	Nil		
4/2/15	NP	11500-12350	Stage 1	0600	0700	Nil		
5/2/15	TW	17200-17700	Stage 2	0610	0640	Nil		
5/2/15	TW	21600-22100	Stage 1	0655	0730	Nil		
5/2/15	NP	11500-12350	Stage 1	0600	0700	Nil		
5/2/15	NP/TW	Haydons wharf rd-18540	Stage 2	0900	1000	1x Saiphos equalis relocated; 1x Drey marked up; 3x HBT marked up		
6/2/15	NP	Sancrox	Stage 1	0700	0800	3 x HBT marked up		
9/2/15	NP	Haydons wharf rd-18540	Stage 2	0600	0730	Nil		

9/2/15	NP	Cooperabung Range	Stage 1	0740	0815	FF trees marked up		
10/2/15	NP	Fernbank South	Stage 1	0600	0720	Nil		
11/2/15	NP	Fernbank South	Stage 1	0630	0740	3 x HBT marked up		
12/2/15	NP	Fernbank South	Stage 1	0615	0715	Nil		
13/2/15	NP	Fernbank South	Stage 1	0615	0700	1 x Wedge-tail Eagle observed hunting		
16/2/15	TW/JE	Fernbank South	Stage 1	0615	0710	Nil		
16/2/15	NP	18000-19300	Stage 2	0615	0700	Nil		
16/2/15	NP	22300-22445	Stage 1	0715	0815	1 x HBT; 1 x HBT log; Fauna furniture trees marked		
17/2/15	NP	18800-19300	Stage 2	0615	0700	Nil		
17/2/15	NP	22300-22445	Stage 1	0700	0800	Brown Gerygone Nest marked up		
17/2/15	JE/TW	19600	Creek clearing	0900	1000	1 x HBT marked up		
18/2/15	NP	Haydons wharf south fence line	Fence line	0630	0700	Nil		
18/2/15	TW	4000-4500	Fence line	0630	0650	Nil		
18/2/15	TW	Nth bank Hastings river	Stage 2	0700	0710	Nil		
18/2/15	TW	6800-6850	Stage 2	0715	0725	Nil		
18/2/15	TW	7577-7336	Fence line	0730	0745	Nil		
18/2/15	NP	22300-22445	Stage 1	0730	0800	Nil		
19/2/15	TW	7577-7336	Fence line	0630	0640	Nil		
19/2/15	TW	7000	Stage 2	0645	0645	Nil		
19/2/15	NP	22300-22445	Stage 1	0630	0715	Nil		
25/2/15	NP/GM	Cooperabung Creek	Stage 2	0630	0715	Nil		
26/2/15	NP/GM	Cooperabung Creek	Stage 2	0630	0715	Nil		
27/2/15	NP/GM	Cooperabung Creek	Stage 2	0620	0700	1 x small HBT relocated by hand over LoC		
27/2/15	NP/GM	Crushing yard, Cooperabung Compound	Stage 2	0710	0800	4 x Tawny Frogmouths just outside LoC, mentioned to operators		
2/3/15	NP/TW	22100-22400	Stage 1	0630	0710	Culvert clear of Bats, Gerygone chicks fledged.		
2/3/15	NP/TW	South Wilson River	Stage 2	0730	0800	Nil		
3/3/15	NP	22600-22700	Stage 1	0700	07300	Nil		
3/3/15	TW	South Wilsons river	Stage 2	0730	0800	1x HBT taken down		
3/3/15	TW/NP	Nth Yarrabee rd. E	Side road	0630	0710	2x Microbats (probable horseshoe) in culvert N of Yarrabee		
4/3/15	NP/TW	Nth Yarrabee rd.	Side road	0630	0715	Nil		
4/3/15	NP	22600-22700	Stage 1	0730	0815	Nil		
5/3/15	BT/NP	Nth Yarrabee rd. E	Side road	0610	0700	Nil		
5/3/15	TW/JE	22585-22900	Stage 1	0630	0700	Nil		
5/3/15	TW/JE	Yarrabee nth	Side road	0710	730	Nil		
6/3/15	TW/BT	22585-22900	Stage 1	0630	0700	Nil		
6/3/15	TW/BT	Nth/south Yarrabee rd. E	Side road	0715	0745	Nil		
6/3/15	TW	Wyndell close	Side road	0815	0825	Nil		
9/3/15	TW/JE	Yarrabee nth	Side road	0715	0730	Nil		

9/3/15	TW/JE	22600-22900	Stage 1	0630	0700	Nil		
10/3/15	TW	22400-22900	Stage 1	0630	0700	Nil		
10/3/15	TW	18800-19400	Stage 2	0720	0755	Nil		
11/3/15	TW/JE	22800-22900	Stage 1	0630	0640	Nil		
11/3/15	TW/JE	Yarrabee south	Stage 1	0700	0720	Nil		
11/3/15	TW/JE	Tinkers south	Fence line	0740	0805	Nil		
11/3/15	TW/JE	21800-22150	Stage 2	0820	0900	1x HBT marked; 3x logs marked		
12/3/15	TW/JE	22400-21650	Stage 2	0630	0720	Nil		
12/3/15	TW/JE	Yarrabee rd. South	Side road	0735	0750	Nil		
12/3/15	TW/JE	Cut 19B	Stage 2	0800	0805	Nil		
13/3/15	TW	22100-21660	Stage 2	0715	0755	FF marked up		
13/3/15	TW/JE	South Yarrabee rd.	Side road	0635	0655	Nil		
13/3/15	TW	20700 cut 19A	Fauna fence	0810	0820	Nil		
16/3/15	TW/JE	21500-22400	Stage 2	0640	0750	Nil		
16/3/15	TW/JE	Cut 19a West 20700	Fauna fence	0800	0805	Nil		
16/3/15	BT	13100-14200	Stage 2	0640	0725	Nil		
16/3/15	BT	Wharf rd.- Blackmans pt. rd.	Stage 2	0740	0755	Nil		
17/3/15	BT	13100-14900	Stage 2	0640	0756	Mark up Stick nest (inactive?) @14850		
18/3/15	BT/JE	22100-22400	Stage 2	0630	0650	Nil		
18/3/15	BT/JE	22850-22900	Stage 2	0652	0659	Nil		
19/3/15	BT	11600-11700	Stage 2	0920	0930	Nil		
19/3/15	BT	11900-12250	Stage 2	0830	0920	3x HBT marked up		
19/3/15	BT	13850-15550	Stage 2	0640	0725	Nil		
24/3/15	JE	22180	Culvert	nr	nr	Nil		
24/3/15	JE	Wyndell close	Stage 2	nr	nr	Nil		
24/3/15	JE	Wilmaria rd.	Stage 2	nr	nr	Nil		
25/3/15	JE	Wyndell close	Stage 2	nr	nr	Nil		
25/3/15	JE	Wilmaria rd.	Stage 2	nr	nr	Nil		
26/3/15	JE	22180	Culvert	nr	nr	Nil		
26/3/15	JE	Wilmaria rd.	Stage 2	nr	nr	Nil		
26/3/15	JE	Wyndell close	Stage 2	nr	nr	Nil		
26/03/15	DR, NP	0900-1400	Stage 2	0615	0700	Nil		
27/3/15	JE	22180	Culvert	nr	nr	Nil		
27/3/15	JE	Wilmaria rd.	Stage 2	nr	nr	Nil		
27/03/15	DR, NP	1100-1600	Stage 2	0615	0700	Nil		
30/3/15	NP	Blackmans point rd.	Interchange	0645	0715	Egernia mcpheei located but escaped capture		
6/3/15	NP	Blackmans point blackbutt	Stage 2	nr	nr	Nil		
6/3/15	NP/JE	Median 1100	Stage 1	nr	nr	2 x HBT marked up		
6/3/15	NP	Dalhunty Island	Large tree clearing	nr	nr	Fox observed.		
30/3/15	NP/JE	Fernbank Creek	Haul rd.	nr	nr	2x Antechinus spp. fled hollow log into grass		
8/4/15	NP	1100-1600	Stage 2	0620	0720	3 x HBT marked up; 2 x dreys marked up		
8/4/15	NP	Fernbank Ck	Stage 2	0830	0900	Nil		
9/4/15	NP	750-1600	Stage 2	0600	0700	Nil		
8/4/15	TW/GM	22900-22300	Stage 2	0605	0710	Nil		
8/4/15	TW/GM	Nth Haydons wharf rd.	Stage 2/Side road	0815	0815	1x nest checked		

9/4/15	TW/GM	22000-23350	Stage 2	0610	0720	1x horseshoe bat in 700mm culvert adj to cleared area. Was not in culvert prior to clearing		
9/4/15	TW	18000-18300	Stage 2/side road	0820	0840	Nil		
9/4/15	TW	Railway-Wilsons	Stage 2	0855	0925	Nil		
9/4/15	TW	Barries Ck heritage bridge	Stage 2	0945	1000	Nil		
10/4/15	TW/GM	22900-23300	Stage 2	0610	0700	Nil		
10/4/15	TW/GM	18000-18300	Side road	0730	0800	Nil		
10/4/15	TW/GM	18700	Stage 2	0810	0815	Nil		
10/4/15	NP	750-1100	Stage 2	0600	0700	1x drey removed		
10/4/15	NP	Fernbank Ck	Stage 2	0700	0730	Nil		
14/4/15	NP/TW	22900-23400	Stage 2	0600	0700	FF trees marked up		
15/4/15	NP	7900-8650	Stage 2	0600	0700	Nil		
13/4/15	TW	22900-23350	Stage 2	0610	0700	Nil		
15/4/51	TW	22900-23400	Stage 2	0610	0650	Nil		
16/4/15	NP	7900-8650	Stage 2	0600	0715	2 x FF trees marked up		
16/4/15	TW	23000-23400	Stage 2	0600	0625	Nil		
16/4/15	TW	23550-23750	Stage 2	0640	0740	FF marked up, HBTs remarked. Core Koala habitat		
16/4/15	TW	Barries Ck bridge	Stage 2	0750	0800	Nil		
16/4/15	TW/NP	23550-23750	Stage 2	0800	0830	Core Koala habitat		
17/4/15	NP	7900-8650	Stage 2	0600	0715	Nil		
17/4/15	TW	23255-23750	Stage 2	0610	0710	FF marked, HBTs remarked		
20/4/15	NP/JE	22900-23500 E	Stage 2	0610	0720	1x HBT marked up; Glossy Black Cockatoo flew overhead		
20/4/15	NP/JE	7900-8650	Stage 2	0730	0815	Nil		
21/4/15	NP	7900-8650	Stage 2	0600	0700	Nil		
21/4/15	JE	22900-23750	Stage 2	0600	0630	Nil		
21/4/15	JE	22890-23390	Stage 2	0630	0700	Nil		
21/4/15	JE	Hayden's wharf area	Extension	0730	0800	Nil		
22/4/15	NP/JE	22700-23500	Stage 2	0600	0700	Nil		
22/4/15	NP/JE	Cooperabung close fence line East	Fence line	0710	0730	Nil		
23/4/15	NP	Cooperabung close - Cooperabung creek East	Positrack	0700	0730	Nil; 3x Wood ducks stuck behind concrete barrier on highway.		
23/4/15	NP	Yarrabee rd. culvert extension	Culvert access	0740	0815	Nil		
23/4/15	NP	South railway	Stage 2	0830	0900	Nil		
23/4/15	NP/JE	Fernbank creek	Stage 2	1100	1115	Nil		
23/4/15	NP/JE	Barries creek batter	Stage 2	1200	1300	Nil		
24/4/15	NP	Blackmans bus stop	Stage 2	0600	0700	Nil		
28/4/15	NP	Barries Ck batter and wings at Cooperabung hill climb	Small trees	0700	0740	Nil		
28/4/15	TW	7450-8750	Stage 2	0615	0645	FF marked up		
28/4/15	TW	Blackmans bus stop	Stage 2	0645	0705	FF marked up		

28/4/15	TW	Hayden's wharf rd.	12 trees	730	0750	Nil		
28/4/15	TW/NP	South railway	Stage 2	815	0850	Coral trees marked for disposal		
29/4/15	NP	South Railway, Wilson north bank	Stage 2	0700	0745	Nil		
29/4/15	NP	Cooperabung hill climb barriers	Two offshoots	0800	0810			
29/4/15	NP	Culvert South East Yarrabee	Culvert access	0820	0840	Nil. Nil bats in culvert		
29/4/15	TW	7450-7750	Remaining trees	0630	0700	Nil		
29/4/15	TW	Blackmans bus stop	Remaining trees	0700	0710	Nil		
30/4/15	TW	7450-7550	Remaining trees	0620	0645	Nil		
30/4/15	NP	18800	Access track	0700	0715	Nil		
30/4/15	NP/TW	Fence line Wyndell close	Fence line	0730	0830	Nil		
4/5/15	JE	Dalhunty Island	Stage 2	0800	0900	Nil		
6/5/15	NP	7450-7550	Remaining trees	0600	0645	Nil		
6/5/15	NP	9200-9300	Stage 1	0650	0730	Nil, mentioned to Hari - sediment in GTF habitat		
6/5/15	GM	18700-18800	Crossing	0700	0720	Empty bird nest taken out		
6/5/15	GM	Wyndell Close	Fence line	0730	0745	Nil		
7/5/15	NP	9200-9300	Basin	0600	0630	Nil		
7/5/15	NP	7350-7650	Drain	0640	0700	1 x HBT marked up; 3 logs marked for relocation		
8/5/15	JE	19750-20250	Slashing	0730	0815	Nil		
8/5/15	JE	Cut 19A	Widening	1300	1330	Nil		
8/5/15	JE	750-100	Median	0900	1000	Nil		
8/5/15	JE	18300-18700	Stage 2	0630	0800	Nil		
11/5/15	NP	10400-11300	Drain	0600	0645	Nil		
11/5/15	NP	18440-18800	Stage 2	0700	0800	1 x HBT marked up; FF marked up		
11/5/15	NP	19750-20250	Slashing	0810	0830	Nil		
12/5/15	NP	4450-4800	Stage 2	0700	0800	Nil		
12/5/15	JE	19750-20250	Stage 2	0700	0800	Nil		
12/5/15	JE	18100-18300	Stage 2	0810	0900	Nil		
13/5/15	NP	4450-4800	Stage 2	0600	0630	Nil		
13/5/15	NP	18440-18800	Stage 2	0640	0715	2 x FF trees marked up; no bats in culvert		
13/5/15	NP	19750-20250	Slashing	0725	0800	Nil		
14/5/15	NP	8500-8900	Stage 2	0830	0900	Nil		
14/5/15	NP	19750-20250	Remaining trees	0730	0815	1 X FF tree marked		
14/5/15	NP	18440-18800	Fence line	0700	0730	1 x Small Eyed Snake relocated		
15/5/15	NP	18440-18800	Fence line	0700	0730	Nil		
15/5/15	JE	19750-20250	Remaining trees	0720	0745	Nil		
15/5/15	NP/JE	700-1000 E	Stockpile	0800	0930	10 x FF trees marked		
18/5/15	NP	700-1000	Stockpile and fence	0620	0715	Nil bats in boxes		
19/5/15	JE	18100-18700	Fence line	0700	0730	Nil		
11/12/14	DR/NP	20050-20700	Stage 2	0600	0710	1 x drey; numerous FF trees		

15/12/14	DR	South compound	Fence line	0700	0730	Nil		
15/12/14	DR/NP/GM	Dalhunty Island South bank	General observation	1200	1220	Flying-fox camp, 189 individuals, all black, dependent juv present		
16/12/14	DR	6600	Stockpile	0630	0700	Nil		
12/1/15	DR	21000	Stage 2	0600		Clearing cancelled		
13/1/15	DR	20800-21200	Stage 2	0600	0700	Nil		
14/1/15	DR	21500-22000	Stage1	0600	0800	1x Egernia mcpheei; 1x Calyptotis spp; 1x small cup nest (poss YFH); 10x varied sitella	Skinks released immediately over boundary & cup nest inspected	
15/1/15	DR	21500-21900	Stage 1	0600	0730	Nil - searched for sitella		
15/1/15	DR	Dalhunty Is South bank	General observation	0900	0920	238 black flying-fox; 2 x osprey		
16/1/15	DR/TW	21600-22000	Stage 1	0600	0720	Nil		
10/2/15	DR	18200-18600	Stage2	0600	0700	Nil - good stack of fauna furniture (mostly ironbark) sheared.		
11/2/15	DR	18200-18900	Stage 2	0600	0700	Nil - marked some extra fauna furniture		
12/2/15	DR	18200-18300	Stage2	0700	0730	Nil		
9/3/15	DR	Blackmans Pt. Rd	Stage 2	0800	0930	1 x drey; 1 x HBT		
9/3/15	DR	11650-11700	Stage 2	0725	0750	Nil; raked litter & searched for GTF		
10/3/15	DR	11650-12250	Stage 1	0600	0715	Nil		
11/3/15	DR	11900-13100	Stage 1 & fence line	0615	0715	Nil		
10/3/15	DR/TW/JE	Cooperabung Ck	Crossing	0930	1530	75 person minutes dip netting		
12/3/15	DR	12150-13150	Stage 2	0615	0715	Nil		
12/3/15	DR	10600-11400	Nth bound west edge	0730	0800	Nil		
12/3/15	DR	~10800	South bound median	0810	0830	1x hazardous tree, which will damage a tree outside the median. No significant habitat value.		
26/3/15	DR/NP	900-1400	Stage 2	0645	0730	15x fauna furniture trees marked		
27/3/15	DR/NP	1100-1600						
20/5/15	NP/GM	700-1800	Fence line and mainline	0630	0800	2 x HBTs marked u; 2 x Hlogs marked up		
25/05/15	TW/JE	750-1700	Stage 2	0630	0730	Bat boxes in area inspected		
26/05/15	TW	18600-18700	Fence line	0700	0800	2 fauna furniture trees marked		
27/05/15	TW	18600-18700	Fence line	0700	0730	nil		
28/05/15	TW	750-1700	Stage 2	0640	0710	Bat boxes in area inspected		
26/05/15	JE	750-1700	Stage 2	0615	0800	Bat boxes in area inspected		
27/05/15	JE	750-1700	Stage 2	0615	0710	Bat boxes in area inspected		
3/06/15	JE	Southern side of Hastings River	Install rock platform	0700	0730	Nil		
4/06/15	JE	16860	Crush mangroves and infill	0800	0830	Nil		
4/06/15	JE	16650	Crush mangroves and infill	0845	0900	Nil		
5/06/15	JE	16650	Crush mangroves and infill	08454	0900	Nil		
10/06/15	JE	16860	Crush mangroves and infill			Nil		

10/06/15		10500 to 10782	Clear west side Nth bound carriageway			Nil		
11/06/15	JE	13600 to 14300	clear fence line	0800	0845	Nil		
12/06/15	JE	11700 to 11800	Stock pile	0630	0730	Nil		
12/06/15	JE	16700	Dalhunty island	0730	0745	Nil		
15/06/15	DO	20070-20700	Fenceline	0830	0930	Nil		
16/06/15	TW	20080-20700	fenceline	0650	0715	Nil		
16/06/15	TW	9750-10000	stockpile	0730	0750	Nil		
16/06/15	TW	4500-4900	full width	0830	0900	Water Dragon in tree - tree to be retained		
17/06/15	TW	4500-4900	full width	0730	0800	Nil		
19/06/15	DR	16700	Dalhunty island	0730	0800	Agreed to retain 1 small stag near LoC & 1 mature swamp oak		
22/06/15	DO	20070-20700	Fenceline	0800	0830	Nil		
22/06/15	DO	20150-20500	Extension of LoC	0900	0930	Nil		
22/06/15	DO	16450-16550	Mainline clearing	1000	1030	1 cockspur coral tree within LoC		
23/06/15	BL	20070-20700	Fence line	0900	1000	Nil		
23/06/15	BL	15500	Mainline	800	830	1 HBT (BLP with 1sb)		
24/06/15	JE	20080 to 20800	Fence line, additional clearing along drainage line	700		Nil		
	JE	Cut 17/16	Clearing of batter Nth and South bound	840		Nil		
	JE	4700 to 4900	Filling in swampy habitat at Fernbank Ck			Nil		
25/06/15	JE	20080 to 20800	Fence line and additional clearing along drainage line			Nil		
		4500 to 4800	Fill in habitat at Fernbank Ck			Nil		
21/07/15	GM/JE	1850-2450	South Sancrox Rd	645	745	Nil		
21/07/15	GM	18000	Powerline easement Wyndell Close	745	800	Nil		
22/07/15	GM/JE	1850-2450	Stage 2	645	745	Nil		
23/07/15	GM	1850-2450	Stage 2	700	800	Nil		
24/07/15	GM	1850-2450	Stage 2	630	730	Nil		
25/07/15	JE	1850 to 2450	Stage 2	730	815	Nil		

27/07/15	JE	1620 to 2300	Stage 2	630	800	marked up Casuarina with active drey (see HBT removal)		
28/07/15	JE	1900 to 2450	Stage 2	645	720	Nil		
29/07/15	JE	2350 to 2800	Stage 2	645	740	Nil		
29/07/15	JE	750 to 1700	East side water main	1030	1145	Nil		
30/07/15	JE	750 to 1700	East side water main	645	715	Nil		
31/07/15	JE	750 to 1700	East side water main					
3/08/15	JE	750 to 1700	East side water main					
3/08/15	JE	2350 to 2800	Stage 2					
4/08/15	JE	2350 to 2800	Stage 2	900	930	Nil		
5/08/15	BDL	2800-3600	Stage 2	545	630	Nil		
6/08/15	BDL	2800-3850	Stage 2	530	715	Nil		
7/08/15	BDL	2800-4100	Stage 2	530	730	Grey headed Flying fox; 3 x Rusa Deer		
8/08/15	BDL	2150-2450	Stage 2	730	800	Nil		
10/08/15	BDL	2150-4100	Stage 2	515	730	Nil		
11/08/15	BDL	2150-4100	Stage 2	515	745	1 x Sugar Glider; 1 x Deceased Long-nosed Bandicoot		
12/08/15	BDL	1900-4300	Stage 2	515	800	1 x Common Ringtail Possum		
13/08/15	BDL	1000-4300	Stage 2	515	945	1 x Barn Owl; 1 x Common Ringtail Possum		
14/08/15	BDL	3600-4300	Stage 2	515	715	1 x Common Ringtail Possum		
18/08/15	GM	4000 - 4650	Stage 2	630	800	Nil; Fairy Martins nesting in box culvert		
18/08/15	GM	Mooney St (Sports club) to 200m north along highway	Grass slashing	900	915	Nil		
18/08/15	GM	21030 - 20240	Stage 2	930	1100	Active burrow found (ch20590) and excavated, nothing found		
19/08/15	GM	2300 - 2500	Stage 2	600	630	Nil		
20/08/15	GM	1800 - 2300	Stage 2	615	715	Nil		
21/08/15	GM	1800 - 2300	Stage 2	615	715	Nil		
24/08/15	JE	1800 to 2500	Cancelled due to rain	645	710			
25/08/15	JE	1800 to 2500	East side	640	715	nil		
26/08/15	JE	Lend Lease Compound				nil		
7/09/15	JE	Corner Bill Hill and Pacific Hwy	East side	700	730	nil		

Table D3: Habitat tree data collected during clearing for the Oxley Highway to Kundabung Pacific Highway Upgrade. NR = not recorded

HBT #	Date	Observers	Location	Tree species	Hollows	Fauna signs	Fauna present	Comment
H123	5/11/14	NP	South compound ch6500	E. pilularis	1sb	Nil	Nil	
H122	5/11/14	NP	South compound ch6500	E. pilularis	2sb, 1mb	Old leaf material in sb. Some wear	Nil	Possible Petaurid
H121	5/11/14	NP	South compound ch6500	Corymbia intermedia	1sb	Some leaf material, very wet	Nil	
HS5	5/11/14	NP	South compound ch6500	E. globoidea	1m term Large chamber (30x30cm, old)	Wear in chamber	Nil	
HAdd	5/11/14	NP	South compound ch6500	E. microcorys	3s term	Foraging holes	Nil	S. Kingfishers observed scouting termitaria
HAdd	5/11/14	NP	South compound ch6500	Melaleuca spp.	S stick nest	N/A	Nil	Possible White-headed pigeon
H125	6/11/14	TW/JE	7100	Stag	1lt, 1mt, 3st, 2sb, 2mb	Fresh leaf nest, large nest constructed of small clumps of fresh euc leaves.	Nil	Possible BT Phascogale
H157	6/11/14	TW/JE	7100	Eucalyptus spp.	1s term		Nil	
HAdd	6/11/14	TW/JE	7100	Eucalyptus spp.	1s term 300mm deep hole	4 small white eggs (25mm)	Nil	Possible Kingfisher spp. eggs
H131	6/11/14		Ch7900 W of existing hwy	E. pilularis	1mb	Nil	Nil	
H13#	6/11/14		Ch7900 W of existing hwy	E. pilularis	Nil	Nil	Nil	
HAdd	10/11/14	NP/JE	7600 - 7900	E. acmenoides	Nil	Noisy Friarbird Nest	Adult bird flying about, alarmed	Very fresh nest, about to lay?
H148	10/11/14	NP/JE	7600 - 7900	E. pilularis	2sb	Nil	Nil	
H146	10/11/14	NP/JE	7600 - 7900	E. pilularis	Nil	Nil	Nil	
HAdd	10/11/14	NP/JE	7600 - 7900	E. acmenoides	1sb	Nil	Nil	
HAdd	10/11/14	NP/JE	7600 - 7900	Corymbia gummifera	Nil	Nil	Nil	
HS24	10/11/14	NP/JE	Ch 8500 W of existing hwy	E. pilularis	1lt, 1sb	Drey material, wear.	Lace Monitor	LM escaped capture into windrow
HAdd	10/11/14	NP/JE	Ch 8500 W of existing hwy	Eucalyptus spp.	1sb, 1s term	Nil	Nil	
H139	10/11/14	NP/JE	Ch 8500 W of existing hwy	E. pilularis	Nil	Nil	Nil	
HAdd	10/11/14	NP/JE	Ch 8500 W of existing hwy	E. acmenoides	Nil	Nil	Nil	
HS14	12/11/14	TW/NP	7600 - 7900	E. globoidea	1vl sp	Nil	Nil	
HAdd	12/11/14	TW/NP	7600 - 7900	E. microcorys	1sb, 1s term	Wear in sb	Nil	
HAdd	12/11/14	TW/NP	7600 - 7900	E. microcorys	1m term	Fresh leaf nest in term chamber	Nil	Possible Petaurid/FTG
H149	12/11/14	TW/NP	7600 - 7900	E. pilularis	1lt	Nil	Nil	
HAdd	12/11/14	TW/NP	7600 - 7900	E. pilularis	1sb, 1mb, 1lt	Nil	Nil	
H167	17/11/14	NP/JE	8200 - 8300	E. pilularis	1mb, 1sb	Nil	Nil	
H166	17/11/14	NP/JE	8200 - 8300	E. resinifera	Nil	Nil	Nil	

HAdd	17/11/14	NP/JE	8200 - 8300	E. pilularis	1sb	Nil	Nil	
H162	18/11/14	nr	Ch7500	Stag	1vlb, 1vl sp, 1lt, 3lb	Old leaf nest	2 x Eulamprus tenuis, 1 x Adult Brown Antechinus, 5 pinkies	Adult escaped into windrow, pinkies died in care, 1 x Eulamprus escaped
HAdd	19/11/14	nr	18600	Stag	Nil	Nil	Nil	
HAdd	24/11/14	TW/NP	Ch13900	Melaleuca quinquenervia	1sb, 1mt	Wear in m hollow	Nil	
HAdd	24/11/14	TW/NP	Ch13900	nr	Nil	Nil	Nil	
HAdd	24/11/14	TW/NP	Ch13900	nr	1mt	Nil	Nil	
HAdd	25/11/14	NP/GM	South Hastings river floodplain	Araucaria heterophylla	Nil	2 cup nests	3 x Figbird eggs	Well developed embryo, euthanased
HAdd	25/11/14	TW/NP	Ch13900	nr	1sb, 1st	Nil	1 x Lit. den tats	Relocated E of LoC
H?	26/11/14	nr	8900 Blackmans Pt Rd	Corymbia gummifera	2mt, 1sb	Nil	1 x native beehive	Relocated
HAdd	26/11/14	nr	8900 Blackmans Pt Rd	Camphor laurel	Nil	Drey	Nil	
HAdd	26/11/14	nr	Ch9300	Eucalyptus spp.(Mahogany)	Nil	Nil	Nil	Term. had poss. hollows
HAdd	26/11/14	nr	Ch9301	Eucalyptus spp.(Mahogany)	Nil	Drey	Nil	
HAdd	26/11/14	TW/NP	Ch13900	Casuarina glauca	Dec. bark	Nil	Nil	Felled onto windrow
HAdd	27/11/14	TW/NP		Allocasuarina littoralis	Nil	Drey	Nil	
H137	27/11/14	TW/NP	Ch7100, north of compound	E. pilularis	1sb	Leaf material	Nil	
HAdd	27/11/14	TW/NP	Ch7100, north of compound	E. microcorys	1sb	Leaf nest	Nil	Probable FTG
HAdd	27/11/14	TW/NP	Ch7100, north of compound	E. pilularis	2mb, 1sb	Nil	Nil	
HAdd	27/11/14	TW/NP	Ch7100, north of compound	Eucalyptus spp. (Ironbark)	1sb	Old leaf.	Nil	
HAdd	27/11/14	TW/NP	Ch7100, north of compound	E. propinqua	1mt	Wear, claw marks	1 x Lit. peronii	Hollow relocated
H127	1/12/14	TW/BT	Ch7500	Stag	1m sp	Nil	Nil	
H128	1/12/14	TW/BT	Ch7500	Stag	Nil	Nil	Nil	
H129	1/12/14	TW/BT	Ch7500	E. pilularis	1m sp	Nil	Nil	
H134	1/12/14	TW/BT	Ch7500	E. pilularis	5mb	Nil	1 Eulamprus spp.	Hollow cut and relocated
H132	1/12/14	TW/BT	Ch7500	Stag	1sb, 1m sp	Old leaf nest	Nil	
HAdd	1/12/14	TW/BT	Ch7500		1sb, 1st, 1m sp	Extensive leaf nest, Petaurid	Nil	
H130	1/12/14	TW/BT	Ch7500	Eucalyptus spp.(Mahogany)	1sb	Nil	Nil	
HAdd	1/12/14	TW/BT	Ch7500	E. microcorys	1m term	M chamber	5 x S.Kingfisher chicks	3 deceased, 2 euthanased
HAdd	1/12/14	TW/BT	Ch7500		1s term	Old chambers	Nil	
HAdd	2/12/14	NR	Blackmans point	Stag	1st	Nil	Nil	
H172	2/12/14	NR	Blackmans point	E. pilularis	1sb	Nil	Nil	
HAdd	2/12/14	NR	Blackmans point		2 x Stick nests	Nil	Nil	1 nest lost in windrow
HAdd	2/12/14	NR	Blackmans point	E. microcorys	1s term	Nil	Nil	
HAdd	2/12/14	NR	Blackmans point	E. pilularis	Nil	Nil	Nil	
HAdd	3/12/14	NP	Wharf Rd south	E. microcorys	1 term	Nil	1 x FTG	
HAdd	3/12/14	NP	Wharf Rd south	E. propinqua	1mt	Nil	Nil	
HAdd	3/12/14	NP	Wharf Rd south	E. microcorys	1l term, 1m term		4 s. kingfisher eggs	

HAdd	3/12/14	NP	Wharf Rd south	Stag	1m	Leaf nests	Antechinus	Relocated insitu
HAdd	3/12/14	NP	Wharf Rd south	Eucalyptus spp.(Mahogany)	1s term	Leaf nest	1 x FTG	
HAdd	3/12/14	NP	Wharf Rd south	Stag	1ms	Old leaf nest	Nil	Possible Antechinus nests
HAdd	3/12/14	NP	Wharf Rd south	Acacia spp.	1 Drey	Drey	Nil	
H143	4/12/14	NR	Wharf Rd	Stag	3st, 2mb	2 old leaf nests	1 x Blind Snake	
HAdd	4/12/14	NR	Wharf Rd	E. globoidea	Nil	Nil	Nil	
HAdd	4/12/14	NR	Wharf Rd	Eucalyptus spp.(Mahogany)	1l term	Nil	Nil	Possible Kookaburra
HAdd	4/12/14	NR	Wharf Rd	Eucalyptus spp.(Mahogany)	Nil	Cup nest	Nil	N. Friarbird
HAdd	4/12/14	NR	Wharf Rd	E. resinifera	3sb	Leaf nest	Nil	Probable FTG
HAdd	4/12/14	NR	Wharf Rd	E. microcorys	1sb	Nil	Nil	
HAdd	4/12/14	NR	Wharf Rd	E. microcorys	1mt	Very old leaf nest	Nil	
HAdd	4/12/14	NR	Wharf Rd	E. microcorys	Nil	Nil	Nil	
HAdd	4/12/14	NR	Wharf Rd	E. pilularis	1sb	Nil	Nil	
HAdd	4/12/14	NR	Wharf Rd	E. microcorys	Nil	Nil	Nil	
HAdd	4/12/14	NR	Wharf Rd	E. pilularis	1mt	Nil	Nil	Native beehive relocated
HAdd	4/12/14	NR	Wharf Rd	Stag	Nil	Nil	Nil	
H142	4/12/14	NR	Wharf Rd	E. pilularis	4mb, 2sb	Leaf nest	Sugar Glider x 7	4 juveniles
HS12	5/12/14	NR	8000 - 8500	E. microcorys	1s term	Nil	Nil	
H157	5/12/14	NR	8450	E. resinifera	1st	Nil	Nil	
HAdd	5/12/14	NR	8000 - 8500	Eucalyptus spp.	1l term	Nil	Nil	
HAdd	5/12/14	NR	8000 - 8500	Allocasuarina littoralis	Drey	Nil	CRTP x 1	Tree was not marked up
HAdd	5/12/14	NR	8000 - 8500	E. pilularis	Nil	Nil	Tawny Frogmouths x 2	Flew from tree
HAdd	5/12/14	NR	8000 - 8500	E. microcorys	4mb, 3sb	Nil	Nil	
H144	5/12/14	NR	8000	E. pilularis	2mb	Leaf nests	Sugar Glider x 2	
HAdd	5/12/14	NR	8000 - 8500	E. microcorys	1mb, 1sb	Nil	Litoria peronii x 1	
HAdd	5/12/14	NR	8000 - 8500	E. microcorys	1m term, 1s	Nil	Nil	
H140	5/12/14	NR	8100	E. pilularis	Trunk fissure	Nil	Euro bees	
H141	5/12/14	NR	8100	E. pilularis	1s term, 2sb	Nil	4 fresh S. Kingfisher eggs	Native beehive relocated
H302	8/12/14	NR	North Haydons Wharf	Stag	1l sp	Nil	Nil	
HAdd	8/12/14	NR	North Haydons Wharf	Stag	3mb, 2sb, 1l sp	Leaf nest	Nil	Possible Petaurid
H299	8/12/14	NR	North Haydons Wharf	E. tereticornis	2mb	Nil	Nil	Euro Bees
HAdd	10/12/14	DR	Barrie's Ck	Stag	Nil	Nil	Nil	
HAdd	10/12/14	DR	Barrie's Ck	Stag	1mb, 2sb	Leaf, Glider fur, Snake skin	Nil	
HAdd	10/12/14	DR	Barrie's Ck	E. grandis	Stick nest	Leaf material, artificial material, pillow stuffing	Nil	Possible crow
HS11	10/12/14	DR	Barrie's Ck	Stag	1m sp	Leaf nest	Nil	
HAdd	7/1/15	NR	Blackmans point	Allocasuarina littoralis	1 Nest	Noisy Friarbird	Nil	
HAdd	7/1/15	NR	Blackmans point	Stag	Nil	Nil	Nil	Felled accidently
HAdd	8/1/15	NP/JE	Mahogany north	E. microcorys	1sb, 2s term	S.Kingfisher nest	4x S. Kingfisher nestlings	Flew away once released (approx. 1 week from fledging)
H183	8/1/15	NP/GM	Mahogany north	E. pilularis	1lb, 5mb, 4sb	Some leaf material	2 x Eulamprus spp.	Hollow relocated east of LoC
HAdd	8/1/15	NP/GM	Mahogany north	E. microcorys	Nil holes in term	Nil	Nil	
H186	8/1/15	NP/GM	Mahogany north	E. pilularis	1mb,	Nil	Euro bees	Euro bees prevented thorough search

H204	8/1/15	NP/GM	Mahogany north	Eucalyptus spp.(Mahogany)	2sb, 1mb	Nil	Native bees	Hive relocated
HAdd	8/1/15	NP/GM	Mahogany north	E. microcorys	Nil	Nil	Nil	
H187	8/1/15	NP/GM	Mahogany north	Stag	1sb, 1mb, trunk fissure	Nil	Nil	
HAdd	8/1/15	NP/GM	Mahogany north	E. microcorys	2s term	Nil	Nil	
H?	8/1/15	NP/GM	Mahogany north	Eucalyptus spp.(Mahogany)	3mt	Wear	Nil	Trunk relocated
HAdd	8/1/15	NP/GM	Mahogany north	E. pilularis	1l sp	Nil	Nil	
H189	8/1/15	NP/GM	Mahogany north	E. pilularis	Fissure	Old blind snake skin	Native bees	
H?	8/1/15	NP/GM	Mahogany north	E. pilularis	1l sp	Nil	1 x Eulamprus spp.	Escaped capture
HAdd	8/1/15	NP/GM	Mahogany north	E. pilularis	Stick nest	Nil	Nil	Possible old crow nest
HAdd	8/1/15	NP/GM	Mahogany north	Eucalyptus spp.(Mahogany)	1s term	Nil	Nil	
HAdd	8/1/15	NP/GM	Mahogany north	E. microcorys	Nil	Nil	Nil	
HAdd	8/1/15	NP/GM	Mahogany north	Corymbia spp.(Bloodwood)	Passerine nest	Dead chicks	2 x dead chicks	Olive feathers present, OBO?
HAdd	8/1/15	NP/GM	Mahogany north	E. microcorys	Nil in term	Nil	Nil	
HAdd	7/1/15	BT	20700	Stag	1sb	Nil	Lampropholis sp	Escaped
HAdd	9/1/15	BT	21350	Stag	1s sp	Old euc leaf nest	Nil	Felled accidently
HAdd	9/1/15	BT	20900	E. propinqua	3sb 1mb	Euc Leaf nest(FTG?)	Nil	
HAdd	9/1/15	BT	20750	Stag	1sb,1st	Nil	Nil	
H314	9/1/15	BT	20700	E. acmenoides	2sb 1mb	Nil	1 x Eulamprus sp	Escaped
HAdd	9/1/15	BT	20690	Corymbia spp. (Spotted Gum)	1sB	Nil	Nil	
HAdd	9/1/15	BT	Blackmans point rd.	E. pilularis	2sb	Nil	Nil	
HAdd	9/1/15	NP/JE	Blackmans Point	E. microcorys	1sb	Nil	Nil	
HAdd	9/1/15	NP/JE	Blackmans Point	E. pilularis	Nil	Nil	Nil	
HAdd	9/1/15	NP/JE	Blackmans Point	E. microcorys	Nil	Cup Nest	Nil	
HAdd	9/1/15	NP/JE	Blackmans Point	E. globoidea	1mb	Nil	Nil	
HAdd	9/1/15	NP/JE	Blackmans Point	E. pilularis	1mb	Nil	1 x Litoria peronii	Relocated
HAdd	9/1/15	NP/JE	Blackmans Point	E. microcorys	1s term	Nil	Nil	
HAdd	9/1/15	NP/JE	Blackmans Point	Stag	3mb	Nil	Nil	
HAdd	13/1/15	NP/TW	Median SB	Stag	1m sp	Old Antechinus nest	Nil	
HAdd	13/1/15	NP/TW	Median SB	Stag	1m sp	Nil	Nil	
HAdd	13/1/15	NP/TW	Median SB	Stag	1l sp	Nil	Nil	
HAdd	13/1/15	NP/TW	Median SB	Melaleuca spp.	Nil	Nil	Nil	Orchids
HAdd	13/1/15	NP/TW	Median SB	Stag	1m sp	Very old leaf nest	Nil	
HS51	13/1/15	NP/TW	Median SB	E. resinifera	2mb, 1sb, 1lt	Wear in hollows	Nil	
H237	13/1/15	NP/TW	Median SB	Stag	2l sp	Nil	Native beehive	
H194	13/1/15	NP/TW	Median SB	Corymbia spp.(Bloodwood)	4lb, 5mb	Old leaf nest	Nil	
HAdd	13/1/15	NP/TW	Median SB	Corymbia spp.(Bloodwood)	4mb, 2sb	Nil	Nil	
HAdd	13/1/15	NP/TW	Median SB	Eucalyptus spp. (Mahogany)	2mb, 2sb, 1st	Wear	Euro beehive	
H196	13/1/15	NP/TW	Median SB	Corymbia spp.(Bloodwood)	4lb, 3mb, 2sb	Nil	Nil	
H309	13/1/15	NP/TW	Cooperabung Range	E. microcorys	1m sp	Nil	Nil	
H308	13/1/15	NP/TW	Cooperabung Range	Corymbia spp. (Spotted Gum)	Nil	Nil	Nil	
HAdd	13/1/15	NP/TW	Cooperabung Range	Stag	Nil, Dec bark	Nil	Nil	Most of Dec bark knocked off in stage 1 clearing
HAdd	13/1/15	NP/TW	Blackmans Point Rd	E. pilularis	1sb	Nil	Nil	

HAdd	13/1/15	NP/TW	Blackmans Point Rd	Stag	2mb, 1s basal	Old drey material, old Antechinus nest	Nil	Termitaria and best hollow knocked off during stage 1 clearing
HAdd	14/1/15	NP/TW	Median SB	E. resinifera	Nil	Nil		
HAdd	14/1/15	NP/TW	Median SB	E. resinifera	1mb	Nil	1 Eulamprus spp. Escaped capture	Prob Eul. tenuis
H235	14/1/15	NP/TW	Median SB	E. robusta	2mb	Nil	Eulamprus tenuis x 3, Euro bees	2 x Eul. tenuis relocated, tree left as is overnight due to bees.
H228	14/1/15	NP/TW	Median SB	E. resinifera	Nil	Nil		
HAdd	15/1/15	NP/TW	Median Bill Hill	Stag	1mb	Nil	Nil	
H208	15/1/15	NP/TW	Median Bill Hill	Stag	1mb, 3sb	3 leaf nests, feathers present in mb	2 x Feathertail Gliders	Feathers possible Owlet Nightjar.
H207	15/1/15	NP/TW	Median Bill Hill	Stag	Nil	Nil	Nil	
H206	15/1/15	NP/TW	Median Bill Hill	Stag	1mb	Nil	Nil	
H241	15/1/15	NP/TW	Median Bill Hill	Stag	3mb, 1lb, 2sb	Extensive leaf material, twigs with leaves in one nest, very worn	Nil	Possible Phascogale, Rat, Possum
H209	15/1/15	NP/TW	Median Bill Hill	Stag	1lb, 4mb, 2sb	Stripped bark/twigs/feather nest, bird flew from tree	Poss. ONJ flew from tree	
HS47	15/1/15	NP/TW	Median Bill Hill	Stag	1sb	Nil	Nil	
HS48	15/1/15	NP/TW	Median Bill Hill	Stag	Nil	Nil	Nil	
HAdd	15/1/15	NP/TW	Median Bill Hill	Stag stump	Nil	Nil	Nil	
H211	15/1/15	NP/TW	Median Bill Hill	E. pilularis	1mb	Nil	Nil	
H212	15/1/15	NP/TW	Median Bill Hill	Stag	1mt, 3sb	Nil	Nil	
H238	15/1/15	NP/TW	Median Bill Hill	Stag	Nil	Nil	Nil	
H551	15/1/15	NP/TW	Median Bill Hill	Stag	1lt, 2mb	Leaf nest, poss. Petaurid	1 x Brushtail Possum spp, 2 x Eulamprus tenuis, Native beehive	Possum escaped to bush E of LoC, 2 x Eul. tenuis relocated
HAdd	15/1/15	NP/TW	Median Bill Hill	Stag	1mb	Nil	Native beehive	
HAdd	15/1/15	NP/TW	Median Bill Hill	Stag	Nil	Nil	Nil	
H239	15/1/15	NP/TW	Median Bill Hill	E. pilularis	3mb, 1sb	Nil	1x Eulamprus tenuis	
HAdd	15/1/15	NP/TW	Median Bill Hill	E. pilularis	3sb	Nil	Nil	
H215	15/1/15	NP/TW	Median Bill Hill	Stag	1l sp	3 leaf nests, prob Antechinus	1 x Antechinus, escaped capture, 2 x Eulamprus tenuis, Native beehive	
H214	15/1/15	NP/TW	Median Bill Hill	Stag	1m sp, 1mb	Leaf/feathers	Nil	Possible Rat or ONJ
HAdd	15/1/15	NP/TW	Median Bill Hill	Stag	Nil	Nil	Nil	
H213	15/1/15	NP/TW	Median Bill Hill	Stag	1mb, 2sb, 1m sp	Leaf nest	3 x Feathertail Glider spp., 1 Green Tree Snake	
HAdd	15/1/15	NP/TW	Median Bill Hill	Eucalyptus spp.(Mahogany)	Nil	Drey material in fork	Nil	
H220	15/1/15	NP/TW	Median Bill Hill	Stag	Nil	Nil	Nil	
HAdd	15/1/15	NP/TW	Median Bill Hill	Stag	Nil	Nil	Native beehive	
H225	15/1/15	NP/TW	Median Bill Hill	Stag	1mb, 1lt	2 leaf nests, prob Antechinus	1 x Antechinus escaped capture	
H221	15/1/15	NP/TW	Median Bill Hill	E. pilularis	1lt, 2sb	Nil	Nil	
H222	15/1/15	NP/TW	Median Bill Hill	E. resinifera	Nil	Nil	1 x Eulamprus spp. escaped	
H216	15/1/15	NP/TW	Median Bill Hill	E. pilularis	Nil	Nil	Nil	
H217	15/1/15	NP/TW	Median Bill Hill	E. resinifera	3mb	Nil	Native beehive	
H218	15/1/15	NP/TW	Median Bill Hill	E. resinifera	Nil	Nil	Nil	

HAdd	15/1/15	NP/TW	Cut 19, Cooperabung Range	E. acmenoides	4sb	Nil	Nil	
HAdd	16/1/15	NP	Bill Hill rd.	Corymbia intermedia	1s term	Nil	Nil	
HAdd	2/2/15	TW/NP	11450 - 12200 Bill Hill North	E. pilularis	1lb	Nil	Nil	
HAdd	2/2/15	TW/NP	11450 - 12200 Bill Hill North	Eucalyptus spp. (Ironbark)	1sb, 1s term	Nil	1 x Litoria spp.	
HAdd	3/2/15	TW/NP	11450 - 12200 Bill Hill North	Stag	1st	Nil	Nil	
HAdd	4/2/15	TW/NP	23800 - 24000 Barrie's Creek	E. microcorys	1s term	Old bird scat	Nil	
H222	4/2/15	TW/NP	11450 - 12200 Bill Hill North	Stag	1m term	Nil	Nil	
HS152	4/2/15	TW/NP	11450 - 12200 Bill Hill North	Syncarpia glomulifera	1mb	Nil	Nil	
H250	4/2/15	TW/NP	11450 - 12200 Bill Hill North	Stag	1mt, 1mb	Nil	Nil	
HS153	4/2/15	TW/NP	11450 - 12200 Bill Hill North	Stag	1sb	Nil	Nil	
H245	4/2/15	TW/NP	11450 - 12200 Bill Hill North	Stag	1mb, 2sb	Nil	1 x Eulamprus tenuis(escaped), 1 x Litoria tyleri, 1 x Egernia mcpheei	
H244	4/2/15	TW/NP	11450 - 12200 Bill Hill North	Stag	2mb, 2mt	Nil	Nil	
HS141	4/2/15	TW/NP	11450 - 12200 Bill Hill North	E. globoidea	1m sp	Nil	Nil	
HAdd	5/2/15	TW/NP	11450 - 12200 Bill Hill North	Stag	1lb	Nil	Nil	
HAdd	5/2/15	NP/TW	Haydons wharf South	E. microcorys	1m term	7 Goanna eggs (old)	Nil	
H291	5/2/15	NP/TW	Haydons wharf South	Stag	10mb, 2vlt	Nil	Nil	
H29	5/2/15	NP/TW	Haydons wharf South	Stag	nr	nr	nr	European bees (aggressive)
HAdd	5/2/15	NP/TW	Haydons wharf South	E. microcorys	1sb	Nil	Nil	
HAdd	5/2/15	NP/TW	Haydons wharf South	E. microcorys	1s term	1 wire nest	Nil	Nest made almost entirely of wire
HAdd	5/2/15	NP/TW	Haydons wharf South	E. microcorys	4s term	Nil	Nil	
HAdd	6/2/15	NP	11450 - 12200 Bill Hill North	Stag	5mb, 3sb	Nil	Nil	
HAdd	6/2/15	NP	11450 - 12200 Bill Hill North	Stag	2sb	Nil	Nil	
H89	9/2/15	NP/JE	Ch3200-3600	Stag	1mt, 4sb	Nil	Nil	
HAdd	9/2/15	NP/JE	Ch3200-3600	Stag	1sb, 1st	Nil	Nil	
H88	9/2/15	NP/JE	Ch3200-3600	E. acmenoides	1lt, 1sb	Nil	Nil	
H108	9/2/15	NP/JE	Ch3200-3600	Melaleuca spp.	1sb	Nil	Nil	
HAdd	9/2/15	NP/JE	Ch3200-3600	E. pilularis	Nil	Nil	Nil	
HAdd	9/2/15	NP/JE	Ch3200-3600	Corymbia spp.(Bloodwood)	1st, 1sb	Nil	Nil	
HAdd	10/2/15	NP/DR	Fernbank Ck South	Stag	3 st, 1lbasal	Antechinus nest	At least 3 x Antechinus spp., 1 x Microbat spp.	Felled during initial clearing, no 48hr wait. MBat took flight before ID possible
H285	10/2/15	DR, JE	17500	Stag	1lsp	Nil	Nil	
HAdd	10/2/15	DR, JE	17700	Stag	Nil	Nil		
HAdd	10/2/15	DR, JE	18300	E. microcorys	1m term	Recent sacred kingfisher nest		
HAdd	10/2/15	DR, JE	18500	E. microcorys	1m term	Nil		
HAdd	10/2/15	DR, JE	18500	Lophostemon confertus	drey	Drey removed during clearing		

HAdd	10/2/15	DR, JE	18600	Callistemon spp.	drey	Drey - nil		
H93	11/2/15	NP/JE	Ch3200-3600	nr	1st, 3sb	Nil	Nil	
H92	11/2/15	NP/JE	Ch3200-3600	Corymbia spp.(Bloodwood)	1mb, 1sb	Nil	Nil	
H95	11/2/15	NP/JE	Ch3200-3600	Stag	1lt	Nil	Nil	
H96	11/2/15	NP/JE	Ch3200-3600	E. pilularis	1mb	Nil	Nil	
H94	11/2/15	NP/JE	Ch3200-3600	E. pilularis	1mb, 2sb	Nil	Nil	
HAdd	11/2/15	NP/JE	Ch3200-3600	Eucalyptus spp.(Mahogany)	1sb	Nil	Nil	
HAdd	11/2/15	NP/JE	Ch3200-3600	Eucalyptus spp.(Mahogany)	1mt, 1mb, 4sb	Nesting material in trunk hollow	Nil	
HAdd	11/2/15	NP/JE	Ch3200-3600	Eucalyptus spp.(Mahogany)	1st, 2sb	Nil	Nil	
H99	11/2/15	NP/JE	Ch3200-3600	E. pilularis	1sb	Nil	Nil	
HAdd	11/2/15	NP/JE	Ch3200-3600	Stag	1lt	Fresh nesting material, Antechinus?	Nil	
HAdd	11/2/15	DR, NP	17900	E. microcorys	1m term	Old kookaburra nest (probable)		
H300	12/2/15	DR	18250	Stag	1l sp	Nil	1x carpet python (juvenile)	
HAdd	12/2/15	NP/DR	Fernbank Ck South	Stag	1m sp, 1st	Possible RTP drey material	Nil	Mistakenly felled by operator during initial clearing
H322	12/2/15	NP/JE	23000, Cooperabung range	nr	Nil	Nil	Nil	
HAdd	12/2/15	NP/JE	23000, Cooperabung range	E. propinqua	Nil	Nil	Nil	
HAdd	12/2/15	NP/JE	23000, Cooperabung range	Eucalyptus spp.(Ironbark)	1mt	Nil	Nil	
HAdd	12/2/15	NP/JE	23000, Cooperabung range	Corymbia spp.(Bloodwood)	1sb	Nil	Nil	
HS165	12/2/15	NP/JE	23000, Cooperabung range	E. acmenoides	2lt, 4mt, 1lb, 5sb	Nil	Nil	
HAdd	13/2/15	NP/JE	Haydons Wharf North	E. microcorys	1m term	Kookaburra sized chamber?	Nil	
HAdd	13/2/15	NP/JE	Haydons Wharf North	E. microcorys	1sb, 1m term	Kookaburra hollow?	Sugar Glider	Euthanased by vet, broken back.
HAdd	13/2/15	NP/JE	Haydons Wharf North	E. propinqua	1mb	Nil	Feathertail Glider spp. X 2	
HAdd	13/2/15	NP/JE	Haydons Wharf North	E. propinqua	1lt	Claw marks up trunk to hollow. Hollow smoothed out	Nil	
H319	13/2/15	NP/JE	Haydons Wharf North	Eucalyptus spp.	3lt, 2mt, 2mb	Nil	Eulamprus tenuis	
HAdd	13/2/15	NP	Fernbank South	E. tereticornis	1st	Nil	Nil	Sugar Glider emerged from non marked HBT
HAdd	16/2/15	TW/JE	Fernbank Ck South	Melaleuca quinquenervia	Drey	Drey	Nil	
HAdd	16/2/15	TW/JE	Fernbank Ck South	Stag	Nil	Nil	Nil	
HAdd	16/2/15	TW/JE	Fernbank Ck South	Melaleuca quinquenervia	Nil	Nil	Nil	Dropped into dam
HAdd	16/2/15	TW/JE	Fernbank Ck South	E. resinifera	1vlt, 2lt, 4mt, 2st	Old leaf nest	Nil	One central chamber
HAdd	16/2/15	TW/JE	Fernbank Ck South	E. resinifera	1lt, 2mt, 1st, 1sb	Old leaf nest	Nil	One central chamber
H80	17/2/15	NP	Sancrox North	Stag	2mb	Nil	Nil	
HAdd	17/2/15	NP	Sancrox North	E. globoidea	1l sp, 1mb	Nil	Nil	
HAdd	17/2/15	NP	Sancrox North	E. resinifera	1mb	Nil	Nil	
H87	18/2/15	NP/TW	Sancrox North	E. resinifera	1lb, 1sb	Nil	Nil	
H85	18/2/15	NP/TW	Sancrox North	E. pilularis	2mb, 1lb	Nil	Nil	
H84	18/2/15	NP/TW	Sancrox North	Stag	1st, 1sb	Nil	Nil	
HAdd	18/2/15	NP/TW	Sancrox North	E. resinifera	Nil in term	Nil	Nil	

HAdd	18/2/15	NP/TW	Sancrox North	E. globoidea	2sb	Nil	1x Feathertail Glider (Narrow toed)	
H82	18/2/15	NP/TW	Sancrox North	S. glomulifera & stag hanger	2sb, 1mt	Wear on mt	Cryptoblephar us spp.	
HAdd	18/2/15	NP/TW	Sancrox North	Corymbia intermedia	Nil	Nil	Nil	
H83	18/2/15	NP/TW	Sancrox North	Corymbia spp.(Bloodwood)	1mt, 1mb, 1sb	Extensive leaf nest	Nil	Nest soaked due to recent rain
H118	25/2/15	NP/GM	Compound	E. pilularis	1sb	Old leaf nest	Nil	
HAdd	27/2/15		Cooperabung Ck	Stag	2st	Old leaf nest (prob Ante)	Nil	Relocated outside LoC
HAdd	27/2/15		Cooperabung Ck	Melaleuca spp.	Drey	Drey	Nil	
HAdd	2/3/15		Wilsons south	E. grandis	Stick nest	Nest	Nil	
	3/3/15	TW	Wilsons south floodplain	E. microcorys	1mb, 2sb	Old leaf nest (prob ante)	1 Litoria tyleri, 1 Litoria dentata	Relocated into tree E of LoC. Tree very isolated in paddock
H303	4/3/15	NP	Cooperabung Close South	E. grandis	1lb, 3mb, 1sb	Scratches, wear at hollow entrances	Nil	Prob bird sign as pretty isolated tree
HAdd	5/3/15	NP	New Yarrabee Rd	Stag	Nil	Nil	Nil	
H321		TW/JE	Fill 22	E. microcorys	1lt, 1mb, 3sb	Nil	Nil	
H318	9/3/15	TW/JE	Fill 22	E. resinifera	1mb	Nil	Blackish blind snake	
HAdd	9/3/15	TW/JE	Fill 22	Corymbia intermedia	1mb, 1m term	Nil	Nil	
HAdd	9/3/15	TW/JE	Fill 22	E. microcorys	1m term, 1sb	Nil	1xfeathertail glider, 1x Eulamprus tenuis	
H224	10/3/15	DR	11250	Stag	1mt	Nil	1x Eul. tenuis	Released on west side carriageway
HAdd	10/3/15	DR	11250	Syncarpia glomulifera	2s	Nil		
H336	10/3/15	TW/JE	Cut 23	Stag	1ls, 1ms, 1lt, 1st	Old leaf nest	Nil	
HAdd	10/3/15	TW/JE	Cut 23	Eucalyptus spp.(Ironbark)	1mb	Nil	Nil	
H325	10/3/15	TW/JE	Cut 23	E. microcorys	1lt, 1st, 1mt	Wear in hollows	Nil	Euro bees in st
H306	11/3/15	TW	South of Cooperabung Ck	E. tereticornis	1st	Nil	Nil	Nil
HAdd	13/3/15	JE	South bank Hastings River	Acacia longifolia	1 drey	1x drey	1x ringtail possum	Escaped capture
HAdd	13/3/15	DR/JE	12100-12600	E. resinifera	1sb	feathertail glider den		
HAdd	13/3/15	DR/JE	12100-12600	E. resinifera	nil	Nil		
H276	13/3/15	DR/JE	12250	E. resinifera	nil	Nil	green tree frog	
H262	13/3/15	DR/JE	12200	E. resinifera	3sb	Nil		
H256	13/3/15	DR/JE	12100-12300	E. resinifera	1mb	old owlet nightjar nest		
H267	13/3/15	DR/JE	12150	E. resinifera	nil		graceful tree frog	
HAdd	13/3/15	DR/JE	12100-12600	E. resinifera	Nil	Nil		
H268	13/3/15	DR/JE	12100	Stag	Nil		Green tree frog	
HAdd	13/3/15	DR/JE	12100-12600	Melaleuca styphelioides	Nil	1 x drey		
H26#	13/3/15	DR/JE	12100-12300	E. resinifera	1sb	Nil		
H257	13/3/15	DR/JE	12150	E. resinifera	1mb		Eulamprus tenuis	
H251	13/3/15	DR/JE	12200	E. resinifera	1lb, 1sb	Nil		
H252	13/3/15	DR/JE	12200	E. resinifera	Nil		green tree frog, E. tenuis	
HAdd	16/3/15	TW/JE	Cut 22	Eucalyptus spp.(Ironbark)	1m term	M chamber	Nil	
HAdd	16/3/15	TW/JE	Cut 22	Stag	1mt	Nil	Nil	
HAdd	16/3/15	TW/JE	Cut 22	Stag	1sb	Nil	Nil	
Hs163	16/3/15	TW/JE	Cut 22	Stag	1lsp, 1lb	Nil	Nil	
Hs162	16/3/15	TW/JE	Cut 22	Stag	1lsp	Nil	Nil	
HS159	18/3/15	BT/JE	21000	Stag	1l sp, 2mb	Nil	Pink-tongue skink; blackish Blind snake	released in adjacent habitat
HAdd	18/3/15	BT/JE	12400 - 13150	Melaleuca nodosa	1mt	Nil	Nil	

HAdd	18/3/15	BT/JE	12400 - 13150	Melaleuca nodosa	1st	Nil	Lit. fallax x1	released in adjacent habitat
HAdd	18/3/15	BT/JE	12400 - 13150	Melaleuca nodosa	1sb, 1mb	Nil	Lit. dentata x1	released in adjacent habitat
HAdd	18/3/15	BT/JE	12400 - 13150	Melaleuca nodosa	2mt, 1sb	Nil	Nil	
HAdd	18/3/15	BT/JE	12400 - 13150	Stag	1mt, 1sb, 1m sp	Nil	Nil	
HAdd	18/3/15	BT/JE	12400 - 13150	Stag	1st, 1mt, 1m term	Nil	Nil	
HAdd	18/3/15	BT/JE	12400 - 13150	Stag	1m sp	Nil	Nil	
H281	18/3/15	BT/JE	12400 - 13150	Eucalyptus robusta	1l sp	Drey material	Nil	Probable Common Ringtail poss
H282	18/3/15	BT/JE	12400 - 13150	Stag	1l sp	Nil	Nil	
H283	18/3/15	BT/JE	12400 - 13150	Eucalyptus robusta	1m term	Nil	Nil	
HAdd	18/3/15	BT/JE	12400 - 13150	Eucalyptus robusta	1st, 1mt, 1mb, 3sb	Worn hollow entrance	Lit fallax x2, Lit peronii x2	
HS169	19/3/15	JE/TW	Cooperabung	Tristaniopsis spp.	1sm, 1st	Nil	Nil	
H320	19/3/15	JE/TW	Cooperabung	Tristaniopsis spp.	2mb, 2mt	Nil	Nil	
HAdd	19/3/15	JE/TW	Cooperabung	E. microcorys	Nil	Nil	Nil	
HAdd	19/3/15	JE/TW	Cooperabung	Lophostemon	1lt	Nil	Nil	
HAdd	19/3/15	JE/TW	T Tree farm	Allocasuarina torulosa	Crows nest	Nil	Nil	
HAdd	19/3/15	JE/TW	T Tree farm	Melaleuca quinquenervia	1mt, 1sb	Nil	Nil	
HAdd	19/3/15	JE/TW	T Tree farm	Melaleuca quinquenervia	1lt, 1mt, 1st	Nil	Nil	
HAdd	19/3/15	JE/TW	T Tree farm	Melaleuca quinquenervia	1lt, 1mb	Nil	Nil	
HAdd	19/3/15	JE/TW	T Tree farm	Melaleuca quinquenervia	Nil	Nil	Nil	
HAdd	19/3/15	BT	12400 - 13150	Melaleuca quinquenervia	1st, 1mt	Nil	Nil	
HAdd	25/3/15	JE	Blackmans point road	Stag	Nil	Nil	Nil	
HAdd	25/3/15	JE	Blackmans point road	Stump stag	1vlt	Nil	Nil	
HAdd	25/3/15	JE	Blackmans point road	Stag	3lb, 2mb, 1lt	Nil	Nil	
HAdd	25/3/15	JE	Blackmans point road	Casuarina spp.	Drey	Nil	Nil	
HAdd	25/3/15	JE	Blackmans point road	E. globoidea	2mb, 2sb	Nil	Nil	
HAdd	25/3/15	JE	Blackmans point road	E. globoidea	2mb, 1sb	Nil	Nil	
HAdd	25/3/15	JE	11900 - 12200	Melaleuca nodosa	Nil	Nil	Nil	
HS149	25/3/15	JE	11900 - 12200	Melaleuca nodosa	1st, 2sb	Nil	Nil	
HS147	25/3/15	JE	11900 - 12200	Casuarina glauca	1mt	Nil	Nil	
HS148	25/3/15	JE	11900 - 12200	Casuarina glauca	1mb	Nil	Nil	
HS144	25/3/15	JE	11900 - 12200	Casuarina glauca	1lt, 1mb, 1sb	Nil	Nil	
HS146	25/3/15	JE	11900 - 12200	Casuarina glauca	Nil	Nil	Nil	
HS145	25/3/15	JE	11900 - 12200	Casuarina glauca	1lt	Nil	1 x Litoria gracilenta	Relocated
H269	25/3/15	JE	12100	Casuarina glauca	1lt, 1sb	Nil	Nil	
HAdd	25/3/15	JE	11900 - 12200	Casuarina glauca	1sb	Nil	Nil	
HAdd	25/3/15	JE	11900 - 12200	Casuarina glauca	Nil	Nil	Nil	
HAdd	30/3/15	NP	22000	Eucalyptus spp.(Ironbark)	Nil	Nil	Nil	
HAdd	30/3/15	NP	22000	Eucalyptus spp.(Ironbark)	1mb, 1lb	Nil	Native bees	
HAdd	30/3/15	NP	22000	E. microcorys	1sb	Old leaf nest	Nil	
H304	26/3/15	NP/DR	Wyndell close	E. microcorys	2vlb, 4lb, 13mb, 3sb, 3lt	Wear, 2x old leaf nest	1 x common Brushtail possum, 2 x Eulamprus tenuis, 1x blackish Blind snake, native beehive	Brushtail escaped capture, blind snake dead
HAdd	9/4/15	NP	South Sancrox	E. globoidea	1l sp	Fresh Drey material, wear.	Nil	Stripped bark
H04	9/4/15	NP	South Sancrox	Stag	1m sp	Old leaf nest	Nil	
H64	9/4/15	NP	South Sancrox	E. resinifera	Nil	Nil	Nil	
HAdd	9/4/15	NP	South Sancrox	E. globoidea	1l sp, 1mt	Wear on both entrances	Nil	Old Euro Beehive
HAdd	9/4/15	NP	South Sancrox	E. globoidea	1l sp, 1mt	Old Drey material, old leaf nest	Nil	

HAdd	9/4/15	NP	South Sancrox	E. globoidea	1mb	Old leaf nest	Nil	Hanger in tree
H60	9/4/15	NP/GM	South Sancrox	E. globoidea	2lb, 1mb	Fresh Leaf Nest	3 x Sugar Gliders (M, F, F(juv))	Native beehive
H58	9/4/15	NP/GM	South Sancrox	Stag	1vl sp, 1lb	Nil	Native bees	
H57	9/4/15	NP/GM	South Sancrox	Corymbia intermedia	1sb	Nil	Nil	
HAdd	9/4/15	NP/GM	South Sancrox	E. globoidea	Nil	Nil	Nil	Sugar glider observed climbing tree late morning
H59	9/4/15	NP/GM	South Sancrox	Corymbia intermedia	1lt, 2sb	Ringtail Drey material in t	Nil	
HAdd	9/4/15	NP/GM	South Sancrox	Allocasuarina littoralis	Drey	Old Drey	Nil	
H61	9/4/15	NP/GM	South Sancrox	E. globoidea	1basal	Nil	Nil	
HAdd	9/4/15	NP/GM	South Sancrox	Corymbia intermedia	2lb, 1sb	Nil	1 x Eulamprus tenuis	
H63	9/4/15	NP/GM	South Sancrox	Syncarpia glomulifera	1sb	Nil	Nil	
HAdd	9/4/15	NP/GM	South Sancrox	Syncarpia glomulifera	Drey	Old Drey	Nil	
H01	9/4/15	NP/GM	South Sancrox	Corymbia intermedia	Nil	Nil	Nil	
H03	9/4/15	NP/GM	South Sancrox	E. microcorys	Nil	Nil	Nil	
H05	9/4/15	NP/GM	South Sancrox	E. globoidea	2mb, 1sb	Nil	1 x Eulamprus tenuis	
HAdd	9/4/15	NP/GM	South Sancrox	Allocasuarina littoralis	Drey	Old Drey	Nil	
Hnestbox1	10/4/15	NP	Barries Creek	E. microcorys	2 boxes	Nil	Nil	
Hnestbox2	10/4/15	NP	Barries Creek	E. microcorys	2 boxes	Nil	Nil	
H352	10/4/15	NP	Barries Creek	E. grandis	1sb	Nil	Nil	
HAdd	10/4/15	NP	Barries Creek	Corymbia spp.(Bloodwood)	1sb	Nil	Nil	
H351	10/4/15	NP	Barries Creek	E. grandis	1mb	Nil	Nil	
H05	10/4/15	NP	South Sancrox	Corymbia intermedia	1mb, 1sb	Nil	1 x Microbat spp	Took flight before ID possible
Hs41	10/4/15	NP/TW	Haydons Wharf	E. microcorys	Nil	Nil	Nil	
H294	10/4/15	NP/TW	Haydons Wharf	E. tereticornis	1sb	Nil	Nil	
H333	14/4/15	NP	South Barries Creek	Stag	1mt, 1m sp	Leaf nest	1 x Pink Tongue Lizard	Nil
H414	15/4/15	NP/TW	South Barries Creek	E. propinqua	1lt, 1vl sp	Nil	Eulamprus tennis X11	Native beehive relocated
HAdd	20/4/15	NP/JE	South Barries East	Eucalyptus spp.(Ironbark)	1lt, 1mb	Extensive leaf nest	Nil	Possible Antechinus
HS158	20/4/15	NP/JE	South Barries East	E. resinifera	1st	Nil	Nil	
H349	20/4/15	NP/JE	South Barries East	Stag	1l sp	Nil	1 x Eulamprus tennis	Relocated
HAdd	20/4/15	NP/JE	South Barries East	E. resinifera	1m term	Nil	Nil	
HAdd	20/4/15	NP/JE	Fernbank creek	Melaleuca spp.	1l term, 1s term	Old bark nest	Nil	
H344	21/4/15	DR/JE	South Barries Creek	E. globoidea	1sb, 2mb	Nil	Nil	
H345	21/4/15	DR/JE	South Barries Creek	E. resinifera	Nil	Nil	Nil	
HAdd	21/4/15	DR/JE	South Barries Creek	Corymbia spp. (Spotted Gum)	Nil	Nil	Nil	
H342	21/4/15	DR/JE	South Barries Creek	Stag	1mb	Nil	Nil	
HSStump	23/4/15	NP	Blackmans interchange	Stag	2st	Old nesting den	Nil	
HAdd	23/4/15	NP/JE	Blackmans interchange	E. pilularis	Nil	Nil	Nil	
H153	23/4/15	NP/JE	Blackmans interchange	E. pilularis	Nil	Nil	Nil	
HsStump	23/4/15	NP/JE	Blackmans interchange	Stag	1st	Old leaf nest	Nil	
HAdd	23/4/15	NP/JE	Blackmans interchange	Eucalyptus spp.(Mahogany)	Nil in term	Nil	Nil	
H55#	23/4/15	NP/JE	Blackmans interchange	Stag	1mb, 1sb	Old drey material	Nil	
HAdd	23/4/15	NP/JE	Blackmans interchange	Stag	Nil	Nil	Nil	
HAdd	23/4/15	NP/JE	Blackmans interchange	Eucalyptus spp.(Mahogany)	1s term	Nil	Nil	
HAdd	23/4/15	NP/JE	Blackmans	E. pilularis	2sb	Nil	1 x Lit. peronii	Relocated

			interchange					
HAdd	23/4/15	NP/JE	Blackmans interchange	E. globoidea	Nil	Nil	Nil?	
HAdd	23/4/15	NP/JE	Blackmans interchange	E. microcorys	Nil	Nil	Nil	
HAdd	23/4/15	NP/JE	Blackmans interchange	E. pilularis	1lt, 1st, 3mb, 2sb	Nil	1 x Green Tree Snake	Relocated in situ
HSStump	24/4/15	NP	Blackmans interchange	Stag	3st	Old leaf nest, old den	Nil	
HAdd	24/4/15	JE	New Blackmans rd.	E. pilularis	3mb	Nil	Nil	
HAdd	24/4/15	JE	New Blackmans rd.	E. globoidea	1mt	Nil	1 x Lit. dentata	Relocated
HAdd	24/4/15	JE	New Blackmans rd.	Corymbia gummifera	Nil	Nil	Nil	
HAdd	24/4/15	JE	New Blackmans rd.	E. globoidea	1mb, 1sb	V. Old leaf material	Nil	
HAdd	29/4/15	TW	New Blackmans rd.	E. globoidea	1m term	M chamber	Nil	
H155	29/4/15	TW	South railway	Stag	2mb, 1sb	Nil	1 x gr tree snake	Relocated
HS20	7//5/15	NP/GM	North of compound	E. pilularis	2st	Possible antechinus markings	Nil	
HAdd	11/5/15	NP	Cooperabung culvert	E. tereticornis	1vl sp, 2lb, 1mb	Possible old leaf nest	Nil	
H305	13/5/15	NP	South Tinkers Driveway	E. tereticornis	3mb, 1m term	Old Lorikeet feathers in mb	Nil	
HAdd	13/5/15	NP	North Wyndell close	E. globoidea	Nil	Nil	Nil	
H19	nr	TW	17000	Stag	2mt	1 old leaf nest		
HAdd	nr	TW	17000	E. globoidea	1lt, 2mb, 1st	nil		
H20	2/06/15	JE	1500	E. globoidea	Large fissure in trunk	Old leaf material about 2m above ground	Nil	
HAdd	2/06/15	JE		E. pilularis	1sb	Nil	Nil	
HS132	2/06/15	JE		E. globoidea	2mt, 3sb	Nil	Nil	
HAdd	2/06/15	JE		E. globoidea	1lb, 1sb		Nil	
HAdd	2/06/15	JE		E. globoidea	1sb, t fissure		pink tongue	
H10	2/06/15	JE	1250	E. globoidea	3mb, 5sb		Nil	
HAdd	2/06/15	JE	11670	Stag	1l sp	very old leaf nest	Nil	
HAdd	20/07/15	JE	1600 - 1800	Corymbia spp. (Bloodwood)	1sb	Old nest in termitaria	Nil	
HAdd	20/07/15	JE	1600 - 1800	E. globoidea (senescing)	Nil	Nil	Nil	
HAdd	20/07/15	JE	1600 - 1800	Stag	1sb	Nil	Nil	
HAdd	20/07/15	JE	1600 - 1800	Corymbia spp. (Bloodwood)	1mt	Nil	Nil	
HAdd	20/07/15	JE	1600 - 1800	Melaleuca	Nil	small old nest	Nil	
HAdd	20/07/15	JE	1600 - 1800	E. pilularis	3lt, 2mt, 3lb, 1mb	old nests (2) in trunk and branch	Nil	
HAdd	20/07/15	JE	1600 - 1800	Casuarina spp.	Nil	Active Drey	Female ringtail and baby (furred)	Relocated in nest box, within 80 metres. Mother & baby gone next morning
HAdd	25/07/15	JE	1850 - 2450	Stag	1l sp, 1st, 1mt	2 nests, probably antechinus, good condition	Nil	
HAdd	25/07/15	JE	1850 - 2450	Corymbia spp. (Bloodwood)	Nil	Termitaria		
HAdd	25/07/15	JE	1850 - 2450	Stag	1st, t fissure	Nil		
HAdd	27/07/15	JE	1860	Stag	3st	old nest material	Nil	
	27/07/15	JE	1860	E. microcorys	1m sp	old nest material	Nil	
	27/07/15	JE	1750	Casuarina	Nil	Active new drey	Female ringtail and baby (furred)	Relocated in nest box, within 120 metres.
H44	28/07/15	JE	1900 - 2100	E. pilularis	Nil	Nil		
H46	28/07/15	JE	Ch1900 - 2100	E. pilularis	2sb	Nil		
H47	28/07/15	JE	Ch1900 - 2100	E. pilularis	1mb	Nil		
H48	28/07/15	JE	Ch1900 - 2100	E. microcorys	1mb	Nil		
H49	28/07/15	JE	Ch1900 - 2100	Corymbia gummifera	Nil	Nil		
H50	28/07/15	JE	Ch1900 - 2100	Corymbia gummifera	1mb, 1sb	Nil		

HAdd	28/07/15	JE	Ch1900 - 2100	E. microcorys	1m sp, 2st	Nil		
HAdd	28/07/15	JE	Ch1900 - 2100	E. microcorys	1mb, 1sb	Nil		
HAdd	28/07/15	JE	Ch1900 - 2100	E.globoidea	1 term	Nil		
HAdd	28/07/15	JE	Ch1900 - 2100	E. microcorys	1l sp, 1mb, 1sb	Nil		
HAdd	28/07/15	JE	Ch1900 - 2100	E. microcorys	3mb	old leaf nest material, bee hive	Trigonia	Relocated onto retained veg
HAdd	30/07/15	JE	Ch 750 to 1900	E. microcorys	1lb, 3mb, 1sb	Nil		
		JE						
HAdd	4/08/15	JE	Ch 2450 to 2800	E.globoidea	1sb			
H79	4/08/15	JE	Ch 2450 to 2800	E. pilularis	6mb, 4sb	Nil		
HAdd	4/08/15	JE	2450 - 2800	Stag (E.globoidea)	1lt, 1mb, 1sb	Old leaf nest material		
HAdd	4/08/15	JE	2450 - 2800	Corymbia gummifera	1 term	Nil		
HAdd	4/08/15	JE	2450 - 2800	Stag	2mt, 2sb	Nil		
HAdd	4/08/15	JE	2450 - 2800	Stag	Nil	Nil		
H65	4/08/15	JE	2450 - 2800	E. pilularis	Nil	Nil		
HAdd	7/08/15	BDL	Cassegrains to Fernbank Creek east of hwy	Corymbia intermedia	Nil	Nil	Nil	
HAdd	7/08/15	BDL	Cassegrains to Fernbank Creek east of hwy	Stag	1m sp	Old glider nest	Nil	
HAdd	7/08/15	BDL	Cassegrains to Fernbank Creek east of hwy	E. pilularis	1sb	Nil	Nil	
HAdd	7/08/15	BDL	Cassegrains to Fernbank Creek east of hwy	E. pilularis	Blind	Nil	Nil	
HAdd	7/08/15	BDL	Cassegrains to Fernbank Creek east of hwy	E. pilularis	2lb, 1sb	Nil	Small-eyed Snake around base of tree	Captured and relocated 100 m to north east
HAdd	7/08/15	BDL	Cassegrains to Fernbank Creek east of hwy	Stag	1m sp	Nil	Nil	
HAdd	7/08/15	BDL	Cassegrains to Fernbank Creek east of hwy	E. pilularis	Blind	Nil	Nil	
HAdd	7/08/15	BDL	Cassegrains to Fernbank Creek east of hwy	E. globoidea	2sb, 1 term	Nil	Nil	
HAdd	7/08/15	BDL	Cassegrains to Fernbank Creek east of hwy	E. pilularis	1sb	Nil	Nil	
HAdd	11/08/15	BDL	Cassegrains to Fernbank Creek east of hwy	Melaleuca quinquenervia	3st	Nil	Nil	
HAdd	13/08/15	BDL	West of driver reviver at Sancrox	Blackbutt Stag	Nil	Nil	Nil	
HAdd	19/08/15	GM	1600	E. microcorys (senescent)	5mb, 3sb	termitaria	nil	
HAdd	19/08/15	GM	3350 - 4400	E. pilularis	1mb	Old leaf nest material	2 x Litoria peronii	Released in adjacent habitat
HAdd	19/08/15	GM	3350 - 4400	E. pilularis	Nil	Nil	Nil	
HAdd	19/08/15	GM	3350 - 4400	Stag	1lt (spout), 1mb	Nil	Nil	
HAdd	19/08/15	GM	3350 - 4400	Eucalyptus sp.	Nil	Nil	Nil	
HAdd	19/08/15	GM	3350 - 4400	E. robusta	5sb	Old leaf nest material	Nil	
H114	19/08/15	GM	3350 - 4400	Eucalyptus sp.	2sb	Nil	Nil	
HAdd	19/08/15	GM	3350 - 4400	Eucalyptus sp.	Nil	2 x termitaria	Nil	Trunk painted "BEES", none present
H111	19/08/15	GM	3350 - 4400	E. resinifera	4sb	Nil	Nil	

HAdd	19/08/15	GM	3350 - 4400	Melaleuca sp.	2st	Nil	1 x Litoria peronii	Relocated insitu
H112	19/08/15	GM	3350 - 4400	Eucalyptus sp.	3sb	Nil	Nil	
H 107	19/08/15	GM	3350 - 4400	E. pilularis	2mb	Leaf & bark in lace monitor hollow	Lace monitor	Escaped into windrow
H122a	19/08/15	GM	3350 - 4400	Allocasuarina spp.	1st	Nil	Nil	Large Elkhorn
H102	19/08/15	GM	3350 - 4400	E. microcorys	6sb	Nil	Nil	
H103	19/08/15	GM	3350 - 4400	Eucalyptus sp.	4sb	Fresh leaf nest	Nil	Possible feathertail glider nest, cut section relocated into adjacent habitat
H106	19/08/15	GM	3350 - 4400	Eucalyptus sp.	5sb	Nil	Nil	
HAdd	19/08/15	GM	3350 - 4400	Melaleuca sp.	1sb	Nil	Nil	
H122b	19/08/15	GM	3350 - 4400	Stag	1sb	Termitaria	Nil	Large Elkhorn
H42	19/08/15	GM	2350	Stag	1mb, 1st, 1sb	Nil	Nil	
H43	19/08/15	GM	2350	Stag	2mb, 1sb	Old leaf material in 2mb	Nil	
H56	20/08/15	GM	1300	Corymbia intermedia	2lb, 5mb, 4sb	1lb with old leaf	Nil	
HAdd	25/08/15	JE	Ch 1800 to 2500 East side	Corymbia gummifera	1mt	old nest material	Nil	
HAdd	25/08/15	JE	Ch 1800 to 2500 East side	E. pilularis	2sb		Nil	
H37	25/08/15	JE	Ch 1800 to 2500 East side	E. pilularis	Nil	Nil	Nil	
H38	25/08/15	JE	Ch 1800 to 2500 East side	E. pilularis	1sb	Nil	Nil	
HAdd	25/08/15	JE	Ch 1800 to 2500 East side	E. pilularis	2sb	Nil	Nil	
H35	25/08/15	JE	Ch 1800 to 2500 East side	Stag	Nil	Nil	Nil	
HS125	25/08/15	JE	Ch 1800 to 2500 East side	Corymbia gummifera	2sb	Nil	Nil	

Table D4: Register of terrestrial fauna captured during the clearing phase of the Oxley Highway to Kundabung Pacific Highway Upgrade.

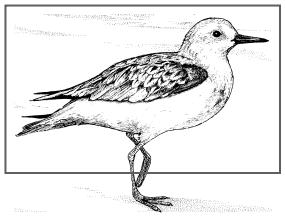
Capture situation/HBT no.	Fauna Retrieved					Immediate Fate	Final Fate (for individuals retained)	Release Site (Location)
	Species	Sex	Age	Breeding Status	Evidence of Injury			
Preclear	Black bellied Swamp Snake		Juv		Nil	Released immediately	Released alive	W of BDY @ch6800
Preclear	Lampropholis delicata				Nil	Held for ID	Released alive	W of BDY @ch6800
Preclear	Lampropholis delicata				Nil	Held for ID	Released alive	W. Of BDY @7300
HS24	Lace Monitor				Nil	Escaped capture into windrow	Observed alive and uninjured	Ch8200
FF mark-up	Egernia mcpheei				2 missing toes (old injury)	Held for ID	Released alive	W of BDY @ ch7350
Spotlight	Jacky Lizard				Nil	Held for ID	Released alive	E of BDY @ ch8100
Preclear	Black bellied Swamp Snake		Juv		Nil	Held for ID	Released alive	E of BDY @ ch8300
Preclear	Lampropholis delicata x 2				Nil	Held for ID	Released alive	E of BDY @ ch8200
Drillers	Black bellied Swamp Snake		Juv		Nil	Held for relocation	Released alive	W of BDY at Fernbank Ck
Preclear	Blackish Blind Snake				Nil	Held for ID	Released alive	E of BDY @ ch9100
Pre clear	Blackish Blind Snake				Nil	Held for ID	Released alive	E of BDY @ ch9400
HBT removal	3 x Figbird eggs				Cracked shell	Euthanased	Euthanased	N/A
Iteratus habitat	Limnodynastes peronii				Nil	Released immediately	Released alive	W of BDY at Cooperabung ck
HBT removal	Litoria peronii				Nil	Hollow cut and placed over LoC	Released alive	E of LoC @ch7200
GBF clearing	Black bellied Swamp Snake				Nil	Held for ID	Released alive	W of LoC @ Ch19700
GBF clearing	Saproscincus oriarus				Lost tip of tail	Held for ID	Released alive	W of LoC @ Ch19700
GBF clearing	Lampropholis delicata x 4				Nil	Held for ID	Released alive	W of LoC @ Ch19700
GBF clearing	Lampropholis amicula				Nil	Held for ID	Released alive	W of LoC @ Ch19700
Preclear	Small Eyed Snake				Nil	Relocated immediately	Released alive	Ch 17500
Preclear	Fossorial Skink spp.				Nil	Relocated immediately	Relocated immediately	Ch 21000
Spotlighting	Litoria peronii x 2				Nil	Held for ID	Released alive	In drainage E of LoC @ ch14000
Spotlighting	Litoria nasuta				Nil	Held for ID	Released alive	In drainage E of LoC @ ch14000
Spotlighting	Uperoleia spp.				Nil	Held for ID	Released alive	In drainage E of LoC @ ch14000
Spotlighting	Litoria fallax x 5				Nil	Held for ID	Released alive	Ch17500
Spotlighting	Litoria tyleri				Nil	Held for ID	Released alive	Ch17500
HBT134	Eulamprus spp.				Nil	Left in situ	Hollow place over LoC	E of LoC at ch7450
HAdd	S.Kingfisher chicks x 2		Pinkies		Nil	Held in calico bag	Euthanased	N/A
HAdd	S. Kingfisher chicks x 3		Pinkies		Yes, crush injuries	Deceased	Placed over LoC	W of LoC @ ch7450
Spotlight	Lit. nasuta				Nil	Held for ID in zip lock bag	Released alive	W of Loc @ ch8500
Stump clearing	Lampropholis delicata x 2				Nil	Relocated immediately	Released alive	W of LoC @ Ch10000
Stump clearing	Brown Antechinus x 2	M	Sub Adult		Nil	Held in aquarium	Released at dusk	E of LoC @ Ch10000
H162	Brown Antechinus pinkies x 5		Pinkies		Nil	Held in calico bag	Died in care	N/A
Stump Clearing	Brown Antechinus		Sub Adult		Yes, crushed	Deceased	Deceased	N/A
Spotlight	Pseudophryne coriacea		Adult		Nil	Held in zip lock bag	Released alive	W of existing highway, Barries Ck
HBT removal	S. Kingfisher eggs (1)				Old	Placed outside LoC	N/A	N/A
Frog fence	Lampropholis delicata				Nil	Held for ID	Released alive	W of LoC at Cooperabung Ck
H143	Blind Snake				Nil	Held for ID	Released alive	W of LoC at ch 8700
HAdd	Narrow Toed Feathertail Glider x 2	M, M	Adult		Nil	Held for ID, settling	Released at dusk	W of LoC @ ch17500

HAdd	Common Ringtail Possum	F	Adult		Nil	Held in calico bag and Nestbox	Released in Nestbox at dusk	W of LoC @ ch 8500
H142	Sugar Glider x 7	1M, 2F, 4unknown	Adult x 3, juv x 4	Breeding	Nil (orange fungus on ears)	Held together in calico bag and nestbox	5 Gliders released at dusk, 2juv stolen next day.	W of LoC @ch 8500
H144	Sugar Glider x 2	M, F	Adult		Nil (orange fungus on ears)	Held in calico bag and nestbox with Euc. leaves	Released in nestbox at dusk	W of LoC at ch 8500
HAdd	Antechinus (At least 1)		Adult		Nil	Left insitu	Log placed over LoC	W of LoC @ ch 17500
HAdd	Litoria peronii		Adult		Nil	Held in plastic zip lock bag	Released outside LoC	W of LoC @ ch 8500
HAdd	S.Kingfisher Eggs (4)				Nil	Euthanased	N/A	N/A
HAdd	S.Kingfisher Eggs (4)				Yes, crushed	Deceased	N/A	N/A
Preclear	Yellow Faced Whip Snake				Nil	Held for relocation	Released alive in hollow log	W of LoC @ ch7100
Spotlighting	Echidna	M	Adult		Nil	Held for relocation	Released alive in riparian veg	W of LoC @ ch19600
Spotlight	Lit. dentata				Nil	Held in plastic ziplock bag for ID	Released alive	W of LoC @ ch19700
Frogging	Lit. fallax x13				Nil	Held in plastic gloves	Released immediately	W of LoC @ ch???
Frogging	Lit. fallax x 3				Nil	Held in plastic gloves	Released immediately	W of LoC @ ch???
Workers find	Echidna	M	Juv		Leech sore/wobbly walk	Held in cotton bag in cat cage	Taken to vet, held in care for 24hrs	Cooperabung Nature Reserve
Spotlight	Bandy Bandy		Sub-adult		Nil	Held for relocation	Released outside LoC	E of LoC at Blackmans Point Rd
Spotlight	Lim. peronii				Nil	Held in plastic bag for ID	Released outside LoC	E of LoC @ 10700
Spotlight	Lit. peronii				Nil	Held in plastic bag for ID	Released outside LoC	W of LoC @ 20800
Spotlight	Adelotus brevis				Nil	Held in plastic bag for ID	Released outside LoC	W of LoC @ 20800
Spotlight	Lit. tyleri x 2				Nil	Held in plastic bag for ID	Released outside LoC	W of LoC @ 20800
Preclear	Echidna	F	Adult		Nil	Held for relocation	Released outside LoC	E of LoC @10700
HBT Add	S. Kingfisher nestlings x 4		Sub adult		Nil	Released alive	Flew to neighbouring trees	Outside LoC @ ch10000
H183	Eulamprus spp. x 2				Nil	Left insitu	Hollow relocated outside LoC	E of LoC @ ch10200
HBT Add	Eulamprus sp.				Nil	Left insitu	Relocated outside LOC	W of LOC @20700
Preclear	Lamp. delicata				Nil	Held for relocation	Released outside LoC	E of LoC @ Bill Hill Rd
Spotlight	Bandy Bandy				Nil	Held for relocation	Released outside LoC	E of LoC @ Blackmans Point Rd
Workers find	Blue tongue Lizard		Adult		Dazed, missing toes-old injury	Taken to vet	???	???
Preclear	Lamp. delicata				Nil	Held for ID	Released outside LoC	E of alignment @ 7700
H235	Eulamprus tenuis x 2				Nil	Held for ID	Released outside LoC	E of LoC @ ch11200
H208	Feathertail Glider spp. X 2				Nil	Left insitu	Log relocated outside LoC	E of LoC @ ch 11300
H551	Brushtail Possum spp.		Adult		Nil	Fled from tree	Escaped to bush outside LoC	E of LoC @ ch11200
H551	Eulamprus tenuis x 2				Nil	Held for ID	Released outside LoC	E of LoC @ ch11200
H239	Eulamprus tenuis				Nil	Held for ID	Released outside LoC	E of LoC @ ch11200
H215	Eulamprus tenuis x 2				Nil	Held for ID	Released outside LoC	E of LoC @ ch11200
H213	Narrow-toed Feathertail Glider	Female	Adult	Parous	Nil	Held in calico bag	Released outside LoC in Nestbox at dusk	W of LoC @ ch 11200
H213	Narrow-toed Feathertail Glider x 2	Female	Sub adult		Nil	Held in calico bag	Released outside LoC in Nestbox at dusk	W of LoC @ ch 11200

H213	Common Tree Snake (Green)				Nil	Left insitu	Log relocated outside LoC	W of LoC @ ch 11200
HAdd	Litoria peronii				Nil	Held for ID	Released outside LoC	E of LoC @ ch8900
Spotlighting	Lim. peronii				Nil	Held for relocation	Released outside LoC	W of LoC @ ch12200
Spotlighting	Small Eyed Snake				Nil	Relocated immediately	Released outside LoC	W of LoC @ ch11900
Preclear	Litoria dentata tadpoles x170		Tadpoles		Nil	Held for ID	Released outside LoC	W of LoC @ ch12200
Spotlighting	Limnodynastes peronii		Adult		Nil	Held for relocation	Released outside LoC	W of LoC @ ch12100
Spotlighting	Lit. tyleri		Adult		Nil	Held for relocation	Released outside LoC	W of LoC @ ch11800
Spotlighting	KOALA	Female	Adult	Evidence of breeding	Partial clouding in right eye	Held in trap	Taken to Koala hospital	Rawdon Creek Nature Reserve E: 480226, N:6529946
Trapping	Bush Rat		Adult		Nil	Held in trap for ID	Released outside LoC	W of LoC @ ch11890
Spotlighting	Lit. dentata				Nil	Relocated immediately	Released outside LoC	W of LoC @ ch 12000
Workers Find	Tawny Frogmouth		Juv		Nil	Held in cardboard box until evening	Released back in nest tree with family group	Northern compound, Cooperabung Dr
Spotlighting	Pink Tongue Lizard				Nil	Held for ID	Released outside LoC	W of LoC at Barrie's Creek
Preclear	Saiphos equalis				Nil	Held for ID	Released outside LoC	E of LoC @ ch18400
H245	Eulamprus tenuis				Nil	Escaped capture	Na	Na
H245	Lit. Tyleri				Minor toe laceration	Relocated immediately	Released outside of LoC	E of LoC @ 11800
H245	Egernia mcpheei				Nil	Relocated immediately	Released outside of LoC	E of LoC @ 11800
HAdd	Antechinus x 3				Nil	2 x Escaped capture, 1 x left insitu	Stag placed outside LoC	W of LoC @ ch4000
HAdd	Microbat spp.				Nil	Took flight before capture	N/A	N/A
Spotlighting	Pink Tongue Lizard				Nil	Held for photo	Released outside LoC	W of LoC @ ch22300
Frogging	Lit. gracilenta				Poss. chytrid fungus	Held in aquarium for 3 weeks	Released outside alignment (nil chytrid)	E of LoC on Bill Hill rd
HAdd	Feathertail Glider spp. X 2	F, M	Adult		Nil	Held until dusk	Released in Nestbox	E of Loc @
HAdd	Sugar Glider	M	Adult		Yes, paralysed	Taken to vet	Euthanased	N/A
Workers find	Sugar Glider	M	Sub Adult		Nil	Held for 2 nights until clearing complete	Released in Nestbox near find location	W of LoC @ ch 4000
Trapping	Bush Rat x 3		Adult		Nil	Released immediately	Released outside LoC	W of LoC @ ch19600 (Coop Ck)
Trapping	Antechinus spp.		Adult		Nil	Held in aquarium until clearing finished	Released outside LoC	W of LoC @ ch19600
Trapping	Black Rat x 2		Adult		Tail laceration	Released in clearing area		
HAdd	Narrow toed Feathertail Glider	F	Adult		Nil	Held in calico bag	Released in Nestbox	W of LoC @ ch3500
H82	Cryptoblepharus spp.				Nil	Held in plastic zip lock bag for ID	Released outside LoC	W of LoC @ ch 3400
H319	Eulamprus tenuis				Nil	Held in calico bag	Released outside LoC	W of LoC @ Coop Creek
Cooperabung Ck	MIXOPHYES ITERATUS X2	F, M	Adult		F gravid.	Held in plastic aquariums for tagging and measurements	Released upstream 200m	W. of LoC @ Coop Ck
HAdd	Litoria tylerii				Nil	Released immediately	Released into tree outside LoC	E of LoC
HAdd	Litoria dentata				Nil	Released immediately	Released into tree outside LoC	E of LoC
Workers find	Lit. revelata				Nil	Held for ID	Released near dam outside LoC	E of LoC at ch21000

On site	Blue tongue lizard				End of tail missing	Held and assessed injury	Released E of LoC	E of LoC Sth tinkers driveway
HAdd	Feathertail glider	M	Adult		Nil	Held in calico bag and put in nestbox	Released E of LoC	E of LoC 21800
HAdd	Eulamprus tenuis				Nil	Released immediately	Released E of LoC	E of LoC 21800
H318	Blackish blind snake				Nil	Released immediately	Released E of LoC	E of LoC at 21800
HS159	Blackish blind snake				No	Released immediately	Released W of LoC	W of LoC at 21000
HS159	Pink-tongue skink				No	Released immediately	Released W of LoC	W of LoC at 21000
HAdd	Lit. fallax x1				No	Released immediately	Released E of LoC	Released E of LoC ~14000
HAdd	Lit. dentata x1				No	Released immediately	Released E of LoC	Released E of LoC ~14000
HAdd	Lit fallax x2				No	Released immediately	Released E of LoC	Released E of LoC ~14000
HAdd	Lit peroni x2				No	Released immediately	Released E of LoC	Released E of LoC ~14000
Spotlighting	Southern Dwarf Crowned Snake		Juv		Nil	Held for ID	Released W of LoC	Released W of LoC @ ch 22100
H304	Common Brushtail Possum		Adult		Nil	Escaped capture	In neighbours shed @ Wyndell close	Wyndell close
H304	Eulamprus tenuis x 2				Nil	1 escaped, 1 relocated	Relocated South of LoC	Wyndell Close
H304	Blackish Blind Snake				Yes, deceased	Na	Na	Na
H60	Sugar Glider x 3	M, F, F	A, A, J		Juv F was dazed upon capture, held for observation, was ok.	Held in calico bag	Released in Nestbox	W of LoC @ ch1500
H?	Eulamprus tenuis				Tail missing (old injury)	Released immediately	Released outside LoC	W of LoC @ chainage 1100
H05	Eulamprus tenuis				Nil	Released immediately	Released outside LoC	W of LoC @ chainage 1100
Workers find	Common Ringtail Possum	M	A		Nil	Held for observation and until clearing finished	Released in nestbox in retained veg	Retained veg @ ch850
Workers find	Blackish Blind Snake x15		Juv		Nil	Relocated outside LoC	Released outside LoC	W of LoC @ 1550
H333	Pink Tongue Lizard		Juv		Nil	Held for ID	Released outside LoC	W of LoC @ ch22800
Spotlighting	Lit. peronii		Juv		Nil	Relocated	Released in nearby stream	Ch 22900
H349	Eulamprus tennis				Nil	Held for ID	Released in log	East of LoC at 23500
Found on ground	Lampropholis delicata				Nil	Held for ID	Released outside LOC	East of LoC @ 10000
HAdd	Lit. peronii				Nil	Held for relocation	Released outside LoC	East of LoC at ch9000
HAdd	Common Green Tree Snake		Juv		Nil	Left insitu	Plugged, branch cut and relocated	East of LoC @ ch 8000
HAdd	Lit. dentata				Nil	Held for relocation	Released outside LoC	North of LoC @ back and point rd
Old Barries creek bridge	3 x Blackish Blind Snakes				1 x tail section missing	Held for relocation	Released outside LoC	East of LoC @ Barries creek
Old Barries creek bridge	2 x Southern Dwarf Crowned Snake				Abrasions and slow moving	Held for relocation	Released outside LoC	East of LoC @ Barries Creek
Old Barries creek bridge	1 x Pseudophryne spp.				Nil	Held for relocation	Released outside LoC	East of LoC @ Barries creek.
HS145	Lit. gracilenta				Nil	Released immediately	Released outside LoC	T Tree Farm
H155	Green tree snake				Nil	Left insitu	Section relocated outside LOC	SE of LOC in bush
Fern bank creek	Litoria fallax				Nil	Released immediately	Released outside LoC	Fernbank creek
Workers find	Kookaburra				Wing broken	Taken to vet	Euthanased	N/A
Preclear	Small Eyed Snake				Nil	Held for ID	Released outside LoC	W of LoC @ ch 18200
H276	green tree frog				Nil	Held for relocation	Released outside LoC	west of 12500
H267	graceful tree frog				Nil	Held for relocation	Released outside LoC	west of 12500
H268	Green tree frog				Nil	Held for relocation	Released outside LoC	west of 12500

H257	Eulamprus tenuis				Nil	Held for relocation	Released outside LoC	west of 12500
H252	green tree frog, E. tenuis				Nil	Held for relocation	Released outside LoC	west of 12500
H300	Carpet python		juvenile		Nil	Held for relocation	Release outside LoC	Cooperabung Creek - Haydons Wharf Road
H224	Eulamprus tenuis				Nil	Held for relocation	Release outside LoC	Release on west side carriageway
Preclear	Eastern Small-eyed Snake	na	Adult	na	Nil	kept in calico bag for 1 hour	released into nest box area @ 3650	nest box zone at 3650
HAdd	Ringtail possum	F	Adult		Nil	Relocated in nest box	Released	E:0483144; N 65207319
HAdd	Joey Ringtail possum	Unknown	Furred	Nil	Nil	Relocated in nest box	Released	E:0483144; N 65207319
HAdd	Ringtail possum (same as above)	F	Adult		Nil	Relocated in nest box	Released	E:0483144; N 65207319
HAdd	Joey Ringtail possum (same as above)	Unknown	Furred	Nil	Nil	Relocated in nest box	Released	E:0483144; N 65207319



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Biodiversity Survey

Project Management

Impact Assessment

Ecological Monitoring

Specialist Surveys

Kieran Metcalfe
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8 August 2017

cc. Grant Fletcher

Dear Kieran,

RE: OH2K phase 2 clearing report – September 2015 to June 2017.

Introduction

Sandpiper Ecological Surveys was contracted by Lend Lease Engineering (LLE) to provide ecological services during construction of the Oxley Highway to Kundabung (OH2K) section of the Pacific Highway Upgrade. Part of the provision of ecological services includes reporting on clearing operations and associated ecological tasks. The following report provides results from ecological tasks undertaken during phase 2 clearing in the north of the project area for the period September 2015 and June 2017. It should be read as an addendum to the substantive report submitted at completion of Phase 1 clearing which occurred between 3 November 2014 and 25 August 2015 (Sandpiper 2015).

Methods

Clearing operations during phase 2 largely focused on a small amount of habitat clearing in the north of the project area, fence-line clearing and clearing associated with decommissioning bridges at Cooperabung Creek and Barrys Creek. Pre-clearing procedures followed those described in the Phase 1 report (Sandpiper 2015) and included:

- Diurnal pre-clear surveys – conducted immediately prior to clearing a section of the alignment. Involved a meandering foot traverse by one to two ecologists. During traverses, all accessible fauna habitats were inspected. This included use of a wrecking bar to roll and split logs and visual searching of the shrub and canopy layers for koalas, bird nests, possum dreys and unmarked hollow bearing trees (HBT). A rake was used to search leaf litter in potential green-thighed frog habitat. Captured fauna were released immediately into adjoining habitat or, if adjacent habitat was unsuitable, housed temporarily in cotton or plastic bags (frogs only), and later released into nearby suitable habitat.
- Habitat tree inspections - Habitat trees were left in-situ for a minimum of 48 hours (2 nights) after surrounding vegetation had been cleared. In some instances, trees containing dreys and nests were removed immediately if they were accessible from the ground and deemed vulnerable to damage/disturbance during the under-scrubbing. Once felled, all hollows were inspected using a hand-held LED torch and/or a bore scope. Captured fauna were released into surrounding habitat.

- Frog surveys - frogs were targeted during all nocturnal spotlight surveys and diurnal pre-clear surveys and threatened frog targeted surveys were conducted in areas of potential habitat or areas mapped as supporting either giant barred frog (*Mixophyes iteratus)* or green-thighed frog (*Litoria brevipalmata*). Stage 2 clearing areas affected by threatened frog habitat included Cooperabung Creek and south of Barry's Creek (chainage 23900) (giant barred frog) and north of Blackmans Point Road (chainage 9000 to 9350) (green-thighed frog). The frog hygiene protocol included in the Fauna and Flora Management plan was applied during all frog surveys. Frog survey protocols were as per those described in Stage 1 clearing report (Sandpiper 2015).

Results

No fauna deaths were reported during phase 2 clearing operations and no fauna were recovered during pre-clearing surveys conducted prior to general and fence-line clearing operations (Table 1). Targeted nocturnal surveys at Cooperabung Creek prior to bridge decommissioning resulted in capture of two giant barred frogs (Plate 1; Table 1 and 2). In both instances, individuals were relocated 120 - 190m upstream.

Plate 1. Giant barred frogs captured on 10 January 2017 (left) and 23 March 2017 (right) at Cooperbung creek during targeted nocturnal survey (L). Individuals were released 120m and 190m upstream, respectively.

Only one hollow bearing tree was removed during phase 2 clearing operations (Table 3). The tree featured a native beehive in a small trunk hollow. The hive was relocated in adjoining habitat. Road mortality surveys were conducted on two occasions during clearing operations adjacent Barrys Creek (Table 4). No road-killed fauna were observed on the road surface during these surveys.

Discussion

Phase 2 pre-clearing and clearing procedures during the reporting period may be regarded as successful due to the absence of fauna deaths and the detection and relocation of targeted threatened species. Few fauna were detected during phase 2 pre-clearing surveys which likely reflects the relatively small clearing footprint and mostly low quality habitat removed. The exception to this was Cooperabung Creek and Barrys Creek areas, where a small amount of riparian habitat was removed.

Targeted pre-clearing frog surveys at Cooperabung Creek resulted in capture of two threatened giant barred frogs. Such captures highlight the importance of the pre-clearing survey protocols for this target species. Repeat surveys

are a critical feature of this protocol especially during times of the year when the species may be difficult to detect.

Please contact me if you have any questions regarding the information provided.

Yours faithfully,

Dr Brendan Taylor
Senior Ecologist
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Table 1: Results of the pre-clear inspections conducted during Stage 2 clearing operations August 2016 to June 2017. (GBF = giant barred frog; Hbt = hollow-bearing tree). Inspections were generally carried out in favourable weather conditions.

Date	Observer	Chainage/Area Sampled	Purpose	Start Time	Finish Time	Species Captured	Release Location
8/8/2016	JE	NR	Preclear for frog fence	0700	1200	Nil	
9/8/2016	JE	NR	Preclear for frog fence	0630	0900	Nil	
9/8/2016	NP & JE	Barrys Ck	GBF pre-clear survey - spotlight	1730	2000	Nil	
10/8/2016	NP & JE	Barrys Ck west	Spotlight survey for clearing	1730	2000	Nil	
11/8/2016	NP	Barrys creek West	1 x Hbt marked up	0600	0700	Nil	
11/8/2016	NP & JE	Barrys creek West	GBF pre-clear survey - spotlight	1715	2000	Nil	
12/8/2016	NP	Barrys creek West	pre-clear	0630	0900	Nil	
15/8/2016	JE	Barrys Ck west	pre-clear	545	800	Nil	
15/8/2016	NP & JE	Barrys Ck	Phase 2 microbat exclusion in Barrys Creek culvert	1730	1945	ni	
31/10/2016	ST	sw of rail line	fence line clearing	1035	1050	nil	
31/10/2016	ST	ne of rail line	fence line clearing	1015	1030	nil	
31/10/2016	ST	ne of Haydons Wharf Rd	fence line clearing	0950	1010	nil	
7/2/2017	JE & K	Cnr Cooperabung Drv and C Range Rd	Preclearing inspection	0620	0835	nil	
	JE & K	Hacks ferry Rd and exit from Wilson Rvr bridge	Preclearing inspection	0620	0835	nil	
15/3/2017	JE	Cooperabung Drv to Yarranbee Rd	Stage 2: Habitat mark up	0700	1045	nil	
16/3/2017	JE	top of Cooperabung Range to Yarranbee Rd	Stage 2: Koala search, 100m in from temp fence	0945	1245	nil	
20/3/2017	JE	20080 to 21500	Stage 2: Preclearing inspection with LL staff.	0630	1045	nil	
21/3/2017	JE	20080 to end of stage 2.	Spotlight, koala search.	0400	0715	nil	
21/3/2017	JE	20080 to 21100	Stage 2: Preclearing inspection	0730	1115	nil	
22/3/2017	JE	Yarrabee to end Stage 2	Stage 2: Spotlight, koala search	0430	0700	nil	
22/3/2017	JE	20080 and 22800	Pre-clearing inspection	0700	0915	nil	
22/3/2017	JE	20650 to 21100	Additional preclearing inspection	0945	1215	nil	
23/3/2017	JE	Cooperabung Ck	GBF pre-clear survey - spotlight	1900	2145	GBF x1; [E:482864 N:6537992]	released 120m upstream
29/3/2017	JE	Cooperabung Ck	Seal scuppers in bridge to exclude microbats	1600	1815	nil	
24/5/2017	JE, Sam (LL)	Cassegrain to Fernbank Ck	Preclearing inspection along fence line.	0845	1115	nil	

Table 2: Results of the pre-clear threatened frog spotlight surveys conducted during Stage 2 clearing operations August 2016 to June 2017 (GBF = giant barred frog; GtF = green-thighed frog).

Date	Observers	General Location	Location (chainage)	Start Time	End Time	Weather (cloud, wind, rain, temp, rh)	Visibility	Species	No. Individuals	Comments
10/8/16	NP/JE	Barrys Creek	23800-24500	1800	1930	0%, nil, nil, 20.3, 82%	Dark	Nil		
11/8/16	NP/JE	Barrys Creek	23800-24500	1800	1930	0%, nil, nil, 19.3, 87%	Dark	Nil		
15/8/16	NP/JE	Barrys Creek culvert	24300	1830	1930	bat exclusion in scupper	Dark	nil		
10/1/17	NP/JE	GBF survey, Cooperabung Crk		2030	2215	50%, msb,nil, 27.5, 75.6%	Dark	GBF	1F; [E: 482870, N: 6538014]	94mm. New. PIT tag number: 991001000620127. Released 190m upstream.
12/1/17	NP/JE	GBF survey, Cooperabung Crk		2020	2130	100%, nil, nil, 25.1, 83.2%	Dark	L. fallax	17	Relocated south of frog fence
19/1/17	NP/JE	GBF survey, Cooperabung Crk		2030	2110	100%, nil, very light drizzle, 22.7, 72%	Dark	L. fallax	4	Relocated south of Frog fence
13/3/17	NP	GTF survey, Blackmans Point Rd		1940	2045	100%, nil, nil, 23.1, 75%	Dark	Lit. peronii tads, Lim. peronii	30+, 2.	

Table 3: Results of hollow-bearing tree removal (Hbt) during Stage 2 clearing operations August 2016 to June 2017.

Hbt Number	Date	Observer	Location	Tree species	Hollows	Fauna signs	Fauna present	Comment
HSAdd	15/8/16	JE	23800- 24500	Tallow wood	Trunk: 1x small	nil	old native beehive	relocated over LoC

Table 4: Results of the road mortality surveys during Stage 2 clearing operations August 2016 to June 2017.

Date of Survey	Observers	Start location/ Area inspected	Carriageway (NB, SB)	Distance of kill from start	Species /group	Accuracy	Adj clearing <48hrs	Adj Clearing	Location (approx)
12/8/16	NP	23800-24500	Nil						
15/8/16	JE	23800-24500	Nil						

Annex 5. Nest box monitoring 2016/2017

Event 1 – OH2Ku (Sandpiper 2017e)

Field data is provided within the report.

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Kieran Metcalfe
Environmental Manager
Lend Lease Engineering
OH2Ku Pacific Highway Upgrade
Kieran.Metcalfe@lendlease.com.au

08 August 2017

Dear Kieran,

RE: Nest box monitoring winter 2016.

Sandpiper Ecological was contracted by Lend Lease Engineering to conduct bi-annual, construction phase, nest box monitoring as per the Oxley Highway to Kempsey Nest Box Plan of Management (Lewis 2013). Following is a brief overview of the winter 2016 inspection, which was the first of four scheduled construction phase surveys.

Nest boxes were inspected between 20 and 23 June and on 8 and 9 August 2016. Inspections between 20 and 23 June were conducted using a customised gopro camera mounted on a 9m extendable pole. The 8 and 9 August inspection was conducted by tree climbers and targeted higher boxes (i.e. large forest owl and cockatoo). Weather variables during the survey are included in Table 1.

A total of 263 boxes were inspected (Table 2). Of which, 32 (12.1%) were occupied and 115 (43.7%) had evidence of use by vertebrate fauna. A total of 147 (55.8%) nest boxes were either occupied or showed evidence of use. This result parallels the Nambucca to Urunga Pacific Highway Upgrade, which recorded occupation and evidence of use rates of 56% in winter 2015 to 59% in summer 2016 and 65% in winter 2016 (Sandpiper 2016).

The most commonly recorded fauna were sugar gliders (*Petaurus breviceps*) with 36 individuals occupying 14 boxes, followed by common brush-tailed possum (*Trichosurus vulpecula*) with 11 individuals occupying 11 boxes. Other notable records included two common ring-tailed possums (*Pseudocheirus peregrinus*) both with juveniles, suggesting successful breeding events have taken place. Owlet nightjar, lace monitor and brown antechinus are among other species that were recorded.

Overall, boxes were in good condition. Exceptions were one microbat box (no.280) which had severe termite damage and two small owl boxes (no.255 & no.362) which had severe termite damage but were still functional. The microbat box was replaced during phase two nest box installation on 9 August 2016. The small owl boxes will be reassessed during the summer 2016 inspection and required action taken in due course.

A small number of boxes (8.7%) showed evidence of European bee occupation, however, all but one were abandoned hives. European bees generally abandon smaller volume nest boxes when the hive outgrows space available.

If you have any questions regarding the Winter 2016 nest box inspection, feel free to give me a call.

Yours sincerely,

Nick Priest,
Ecologist.

Table 1: Weather conditions during the winter 2016 nest box inspection. Source: BOM, Port Macquarie Airport Weather Station (station 060139).

Date	Rainfall	Cloud cover	Wind	Ambient Temperature (^{0}C)	Time
20/06/2017	20.4mm	8/8	NNE 41km/hr	17.2	13:00-16:30
21/06/2016	0	0/8	NNE 24km/hr	18.9	07:00-16:30
22/06/2016	0	0/8	W 28km/hr	21	07:00-16:00
23/06/2016	0	7/8	N 13km/hr	17.6	08:00-15:00
8/08/2016	0	0/8	SW 26km/hr	19.8	10:00-16:00
9/08/2016	0	0/8	ENE 28km/hr	20.6	11:00-15:30

Table 2: Summary of findings from the winter 2016 nest box inspection for the Oxley Highway top Kundabung Pacific Highway Upgrade.

No. of boxes inspected	No. of boxes occupied	No. of boxes with evidence of use	Total occupied & evidence of use	No. of boxes with Euro bees or evidence	No. of boxes requiring repair/replacement
263	32 (12.1%)	115 (43.7%)	147 (55.8%)	1 active, 22 old (8.7%)	3 (1%)

Table 3: Data collected during the winter 2016 nest box inspection for the OH2Ku Pacific Highway Upgrade. CBTP = common brush-tailed possum, FTG = feather-tail glider, Ante = antechinus, CRTP = common ring-tail possum, ONJ = owlet nightjar, YBG = yellow-bellied glider, Petaurid = Small Petauridae glider (sugar/squirrel glider), Euro = European beehive, poss = possum, prob = probable, BTPhas = Brush-tailed Phascogale, cnr = corner, nil? = possible occupation by fauna but leaf obscures view

Box number	Box type	Check Date	Fauna	Signs	Box condition
201	SG	21/6/16	Nil	Fresh leaf nest, petaurid	Good
200	SO	21/6/16	CBTP x 1	CBTP	Good
199	Poss	21/6/16	Nil	Nil	Good
198	Parr	21/6/16	Nil	Nil	Good
196	Scan	21/6/16	Nil	Some scats, no leaf	Good
195	Poss add	21/6/16	CBTP x 1	Nil	Good
274	Cock	8/8/16	Nil	Possible chewing at entrance	Good
193	SG	21/6/16	Nil	Partial leaf nest, no real structure	Good
194	MB	21/6/16	Nil	Nil	Good
202	MB	21/6/16	Nil	Nil	Good
206	SG	21/6/16	Nil	Scrappy nest, massive latrine cnr	Good
203	Poss	21/6/16	Nil	Nil	Good
204	Scan	21/6/16	Nil	Old leaf nest, prob petaurid/FTG	Good
197	LG	8/8/16	Nil	Few scattered leaves, old euro beehive	Good
213	Parr	22/6/16	Nil	Scattered fresh leaf nest, poss scansorial	Good
211	LG	22/6/16	Nil	Old euro beehive	Good
212	Poss	22/6/16	Nil	Nil	Good
215	Scan	22/6/16	Nil	Old bowled leaf nest, petaurid/FTG	Good
214	SG	22/6/16	Nil	Old scattered leaf nest, prob old petaurid	Good
206	Poss	22/6/16	Nil	Nil	Good
208	LG	22/6/16	Nil	Old euro beehive	Good
210	SO	8/8/16	Nil	Nil	Good
207	SG	22/6/16	Sugar Glider x 2	Leaf nest	Good
209	Scan	22/6/16	Nil	Extensive messy leaf nest, messy scats, poss rodent	Good
166	Scan	21/6/16	Nil	Abandoned fresh euro beehive (still honey)	Good
161	Poss	21/6/16	Nil	Nil	Good
160	SO	21/6/16	Nil	Old euro beehive	Good
162	LFO	8/6/16	Nil	Scattered leaves, prob CBTP	

164	SG	21/6/16	Sugar Glider x 4	Leaf nest.	Good
163	Poss	21/6/16	Lace Monitor x 1	Extensive leaf nest.	Good
165	Scan	21/6/16	Nil	Nil	Good
180	SG	21/6/16	Nil	Fresh leaf nest, petaurid	Good
380	LG	21/6/16	Nil	Nil	Good
181	Poss	21/6/16	Nil	Nil	Good
182	Poss	21/6/16	Nil	Nil	Good
172	Scan	21/6/16	Nil	Nil	Good
173	SG	21/6/16	Nil	Old petaurid leaf nest	Good
174	LG	21/6/16	Nil	Old euro beehive	Good
186	Poss	21/6/16	Nil	Nil	Good
176	Parr	21/6/16	Nil	Very old leaf nest, poss Ante.	Good
178	SO	21/6/16	Nil	Scattered leaves, poss ONJ	Good
380	Scan	21/6/16	Nil	Possible latrine cnr	Good
381	SG	21/6/16	Nil	Nil	Good
382	Parrot	21/6/16	Nil	Extensive chewing inside and outside entrance	Good
383	Poss	21/6/16	Nil	Nil	Good
384	Cockatoo	8/8/16	Nil	Nil	Good
179	Scan	21/6/16	Nil	Fresh leaf lest (globular), poss FTG	Good
183	Scan	21/6/16	Nil	Nil	Good
184	SG	21/6/16	Nil	Nil	Good
185	Poss	21/6/16	Nil	Nil	Good
186	LG	21/6/16	Nil	Nil	Good
187	Parr	21/6/16	Sugar Glider (m) x 1	Fresh leaf nest	Good
188	Scan	21/6/16	Nil	Old leaf nest, latrine cnr, poss ante.	Good
189	SG	21/6/16	Nil	Fresh leaf nest, prob petaurid	Good
168	LG	21/6/16	Nil	Old euro beehive	Good
191	Poss	21/6/16	Owlet Nightjar x 1	Nil sign, prob roost box	Good
171	Small owl	8/8/16	Nil	ONJ took flight from possum box to this box on 21/6/16. Some scattered leaf on 8/8/16	Good
223	Poss	22/6/16	Nil	Old flattened CRTP drey, possibly CBTP sat on it.	Good
222	SG	22/6/16	Nil	Messy leaf nest/neat latrine cnr, ante?	Good
226	Parr	22/6/16	CRTP x 2	Drey material, minimal chew at entrance, tight squeeze	Good
225	LG	22/6/16	Nil	Active Euro Beehive	Good
224	Scan	22/6/16	Nil	Fresh leave nest with melaleuca leaf, prob FTG	Good
218	Poss	22/6/16	CRTP x 2	Ringtail drey	Good
221	LG	22/6/16	Nil	Nil	Good
220	Scan	22/6/16	Nil	Nil	Good
217	Parr	22/6/16	Nil	Old messy leaf nest, petaurid prob	Good
219	SG	22/6/16	Nil	Old flattened leaf nest	Good
216	LG	22/6/16	Nil	Few scrappy leaves, egg shell, reptile or spider	Good
227	Poss	22/6/16	Nil	CRTP drey	Good
228	SG	22/6/16	Sugar glider x 3	Extensive globular leaf nest	Good
229	Scan	22/6/16	Nil	Scrappy leaf/twig nest, rodent?	Good
230	SG	23/6/16	Nil	Nil	Good
231	LG	23/6/16	Nil	CBTP evidence	Good
232	SG	23/6/16	Nil	Fresh scattered leaf, old euro beehive	Good
233	Poss	23/6/16	Nil	Lots of euc leaf, flouncy nest. Scratch marks on lid.	Good
234	Scan	23/6/16	Nil	Nil	Good
235	Poss	20/6/16	Nil	Nil	Good

236	Parr	20/6/16	Nil	Nil	Good
237	SG	20/6/16	2 x Sugar Glider	Leaf nest	Good
238	Scan	20/6/16	Nil	Old leaf nest, petaurid	Good
239	LG	23/6/16	Nil	Lots of leaf, old euro beehive	Good
240	SG	23/6/16	Nil	Petaurid nest	Good
243	Scan	23/6/16	Nil	Few scattered leaves	Good
242	Parr	23/6/16	Nil	Fresh scattered leaves, bark mixed into it.	Good
241	Scan	23/6/16	Nil	Nil	Good
244	Poss	23/6/16	Nil	CBTP evidence	Good
245	Scan	23/6/16	Nil	Fresh scattered leaf.	Good
246	LG	23/6/16	Nil	Nil	Good
251	Poss	23/6/16	Nil	Nil	Good
248	Scan	23/6/16	Nil	Petaurid leaf nest, old euro beehive	Good
249	SG	23/6/16	Nil	Scrappy leaf nest, no scat, old euro beehive	Good
250	Poss	23/6/16	Nil	Nil	Good
252	MB	23/6/16	Nil	Nil	Good
247	SG	23/6/16	Nil	Reasonably fresh, flouncy leaf nest, no scats, old euro beehive.	Good
305	Poss	23/6/16	Nil	Nil	Good
303	Scan	23/6/16	Nil	Large scat. Prob reptile	Good
302	SG	23/6/16	Nil	Nil	Good
304	Scan	23/6/16	Nil	Nil	Good
306	SG	23/6/16	Nil	Nil	Water in box
255	SO	23/6/16	Nil	Nil	Severe termite damage
253	Poss add	23/6/16	Nil	Nil	Good
254	Mb	23/6/16	Nil	Nil	Good
256	LG	23/6/16	Nil	CBTP evidence	Good
257	Scan	23/6/16	Nil?	Packed with fresh leaf, branchlets, FTG?	Good
258	Poss	23/6/16	Nil	CBTP evidence	Good
259	LG	23/6/16	Lace Monitor x 1	Nil	Good
260	Poss	23/6/16	Nil	Possible CBTP evidence	Good
261	Scan	23/6/16	Sugar Glider x 5	Older leaf nest	Good
262	SG	23/6/16	Nil	Very fresh makings of a new petaurid nest	Good
263	Parr	23/6/16	Nil	Outside chewing evidence at entrance, nil inside	Good
264	LG	23/6/16	Nil	Nil	Good
266	SG	23/6/16	Nil	Old petaurid nest	Good
265	SG	23/6/16	Nil	Scrappy old leaf nest, latrine cnr, ante?	Good
267	Scan	23/6/16	Sugar Glider x 3	Leaf nest	Good
268	Poss	23/6/16	Nil	Nil	Good
269	LG	23/6/16	Nil	Possible YBG, big flouncy fresh nest.	Good
270	Poss	23/6/16	Nil	CBTP evidence	Good
273	Scan	8/8/16	Sugar Glider x 3	Leaf nest	Good
272	SG	23/6/16	Nil	Few leaves, start of a nest?	Good
271	Parr	23/6/16	Nil	Old petaurid nest, scattered though.	Good
275	LG	8/8/16	CBTP x 1	CBTP den	Good
277	Scan	23/6/16	Nil?	Box packed to capacity with fresh leaf, prob FTG.	Good
276	LG	23/6/16	Nil	Nil	Good
276	MB	23/6/16	Microbat sp x 1	Nil	Good
292	SG	22/6/16	Nil	Messy leaf nest, scats, poss BTphas	Good

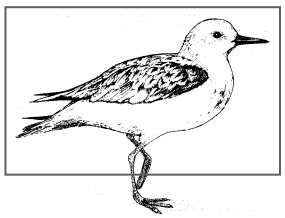
290	SG	22/6/16	Nil	Old Euro beehive	Good
294	Poss	22/6/16	Nil	CBTP evidence	Good
293	Scan	22/6/16	Nil	Nil	Good
288	LG	22/6/16	Nil	Nil	Good
295	SG	22/6/16	Petaurid sp x 1	Leaf nest	Good
291	MB	22/6/16	Nil	Nil	Good
296	Scan	22/6/16	Nil	Nil	Good
289	Parr	22/6/16	Nil	Nil	Good
285	LG	22/6/16	Nil	Flat scattered leaves,	Good
287	Scan	22/6/16	Nil	Old petaurid leaf nest	Good
284	Poss	22/6/16	Nil	Nil	Good
286	SG	22/6/16	Nil	Few scattered leaves, fresh	Good
283	SO	8/8/16	Nil	Nil, old euro beehive	Good
279	LG	8/8/16	Nil	CBTP evidence, old bark	Good
282	Poss	8/8/16	Nil	CBTP evidence	Good
280	MB	22/6/16	Nil	Nil	Disintegrated, replaced 8/8/16
281	Parr	8/8/16	Nil	Few fresh leaves	Good
297	SG	22/6/16	Nil	Nil	Good
298	Poss	22/6/16	Nil	CBTP evidence	Good
299	Add. Poss	22/6/16	Nil	Possible CBTP evidence	Good
300	SO	22/6/16	Nil	Fresh leaves, branchlets	Good
301	LG	22/6/16	Nil	Nil	Good
307	Poss	22/6/16	CBTP x 1	Fresh leaf, extensive.	Good
308	SG	22/6/16	Nil	Old euro beehive	Good
309	Parr	22/6/16	Nil	Nil	Good
310	Scan	22/6/16	Nil	Nil	Good
311	LG	22/6/16	Nil	Nil	Good
312	Parr	22/6/16	Nil	Messy leaf nest. Prob Ante	Good
313	LG	22/6/16	Nil	Nil	Good
314	LG	8/8/16	Nil	Nil	Good
315	MB	22/6/16	Nil	Nil	Good
316	LG	22/6/16	Nil	Nil	Good
317	Poss	22/6/16	Nil	Nil	Good
318	Parr	22/6/16	Nil	Old euro beehive	Good
319	Cockatoo	8/8/16	Nil	Nil	Good
320	Poss	20/6/16	Nil	Nil	Good
321	MB	20/6/16	Nil	Nil	Good
322	LFO	20/6/16	Nil	Nil	Good
323	Add poss	20/6/16	Nil	Nil, possible CBTP evidence	Good
324	Scan	20/6/16	Nil	Old leaf, prob Antechinus	Good
325	SG	20/6/16	Nil	Nil	Good
326	SF	20/6/16	Nil	Nil	Good
327	MB	20/6/16	Nil	Nil	Good
328	Parr	20/6/16	Nil	Old leaf, poss Ante	Good
329	Poss	20/6/16	Nil	Few old leaves, poss Ante	Good
330	LG	20/6/16	Nil	Few scattered leaves, compressed	Good
331	Poss	20/6/16	Nil	Few scats, poss rodent	Good
332	Co	20/6/16	Nil	CBTP evidence	Good
333	add Poss	20/6/16	Nil	Nil	Good
334	LG	20/6/16	Nil	Few compressed, scattered leaves. RE box	Good
335	Scan	20/6/16	Nil	Old leaves, latrine cnr, poss Ante.	Good
336	SG	20/6/16	Nil	Old euro beehive, few leaves	Good
337	P/L	20/6/16	Nil	Nil	Good

338	LG	20/6/16	Nil	Nil	Good
339	Poss	20/6/16	Nil	Nil	Good
340	LG	20/6/16	Nil	Nil	Good
341	Poss	20/6/16	Nil	Nil	Good
342	Parr	20/6/16	Nil	Old euro beehive	Good
343	MB	20/6/16	Nil	Nil	Good
344	SG	20/6/16	Nil	Old leaf, lots of messy scat in corner, possible Ante	Good
345	Scan	20/6/16	Nil	Nil	Good
346	LG	20/6/16	Nil	Nil	Good
347	SG			Taken down during clearing Re-installed 8/8/16	Good
348	MB	23/6/16	Nil	Nil	Good
349	Poss	23/6/16	Nil	CBTP evidence	Good
350	Scan	23/6/16	Nil	Nil	Good
351	LG	23/6/16	CBTP x 1	Sitting on old CRTP drey material, old euro beehive.	Good
352	Parr	23/6/16	Nil	Old leaf, extensive chewing outside entrance	Good
353	SG	23/6/16	Sugar Glider x 5	Leaf nest	Good
354	Poss	23/6/16	Nil	Down, old egg shell, prob Wood Duck	Good
355	LG	8/8/16	CBTP x 1	Old euro beehive	Good
356	Poss	21/6/16	Nil	CBTP evidence	Good
357	SG	21/6/16	Sugar Glider x 1 (m)	Extensive leaf nest	Good
358	Parr	21/6/16	Nil	Nil	Good
359	Scan	21/6/16	Nil	Old leaf nest	Good
360	SG	21/6/16	Nil	Extensive bowled leaf nest, petaurid.	Good
361	Poss	21/6/16	CBTP x 1	CBTP evidence	Good
362	Scan	21/6/16	Nil	Old leaf nest, prob petaurid	Good
363	MB	21/6/16	Nil	Nil	Good
364	SG	21/6/16	Nil	Branchlet leaf nest, no structure, fresh	Good
365	SG	21/6/16	Sugar Glider x 1	Extensive leaf nest (old)	Good
366	Scan	21/6/16	Nil	Nil	Good
367	Parr	21/6/16	Nil	1 scat, extensive chewing at entrance, nil leaves	Good
368	Poss	21/6/16	Nil	Nil	Good
378	SG	21/6/16	Nil	Nil	Good
369	Parr	21/6/16	Nil	Extensive chewing at entrance	Good
376	SG	21/6/16	Brown Antechinus x 3 (min)	Classic ante nest, latrine cnr	Good
371	Scan	21/6/16	Nil	Fresh leaf nest, prob petaurid	Good
372	LG	21/6/16	Nil	Old euro beehive, poss BTPoss evidence	Good
373	Poss	21/6/16	CBTP x 1	Extensive leaf nest	Good
374	Poss	21/6/16	Nil	CBTP evidence	Good
375	Scan	21/6/16	Nil	Very old petaurid nest	Good
378	MB	21/6/16	Nil	Nil	Good
377	LG	21/6/16	CBTP x 1	Classic CBTP evidence/sitting position	Good
379	Parr	21/6/16	Nil	Old petaurid leaf nest, chewing at entrance	Good
385	LG	22/6/16	Nil	Nil	Good
386	SG	22/6/16	Nil	Messy leaf nest, some messy scat, prob rodent	Good
387	Parr	22/6/16	Nil	Old scattered leaf nest	Good
388	Poss	22/6/16	Nil	Nil	Good
389	MB	22/6/16	Nil	Nil	Good
390	SG	22/6/16	Nil	Old petaurid nest	Good
391	LG	22/6/16	Nil	Nil	Good
392	SG	22/6/16	Sugar Glider x 1	Extensive leaf nest	Good

393	Cock	8/8/16	Nil	Nil	Good
394	Poss	22/6/16	Nil	Nil	Good
395	SG	22/6/16	Nil	Nil	Good
396	LG	8/8/16	Nil	Nil	Good
397	SG	21/6/16	Nil	Nil	Good
398	Poss	21/6/16	Nil	CBTP evidence	Good
399	Scan	21/6/16	Nil	Nil	Good
400	Parr	21/6/16	Nil	Chewing on outside of entrance	Good
401	Scan	21/6/16	Nil	Fresh Leaves (branchlet), prob FTG	Good
402	Poss	21/6/16	Nil	Possible CBTP. Debris spread in circle (no leaves though)	Good
403	MB	21/6/16	Nil	Nil	Good
404	SG	21/6/16	Nil	Nil	Good
405	Scan	21/6/16	Sugar Glider x 4	Leaf nest	Good
406	LG	21/6/16	Nil	BTP evidence - few leaves	Good
167	SG	8/8/16	Nil	Chewing on outside entrance, old petaurid nest	Good
407	Cock	8/8/16	CBTP x 1	Nil	Good
408	Poss add	21/6/16	CBTP x 1	Nil	Good
355	Scan	23/6/16	Nil	Messy Antechinus/poss rodent nest. Old euro beehive	Good
356	Poss	23/6/16	Nil?	Packed full of CRTP drey material	Good
357	Parr	23/6/16	Nil	Extensive chewing at entrance. Nesting material built up in cnr, ante?	Good
362	SO	23/6/16	Nil	Termite damage, still intact, will need replacing soon	Severe termite damage
361	Poss add	23/6/16	Nil	Nil	Good
358	SG	23/6/16	Nil	Old petaurid nest	Good
359	Scan	23/6/16	Nil	Old leaf nest, chewing at entrance, prob Antechinus nest	Good
360	LG	23/6/16	Nil	CRTP drey, old euro beehive	Good
363	Scan	23/6/16	Nil	Very messy nest, lots of scat, poss rodent	Good
364	Poss	23/6/16	Nil	Few old scattered leaves, ante	Good
365	LG	23/6/16	Nil	Fresh CRTP drey	Good
366	SG	23/6/16	Nil	Messy leaf nest, massive latrine cnr	Good
367	LG	20/6/16	Nil	Nil	Good
368	Scan	20/6/16	Nil	Nil	Good
371	Poss	20/6/16	Nil	Nil	Good
370	LFO	8/8/16	Nil	Nil	Good
369	P	20/6/16	Nil	Nil	Good
372	LG	20/6/16	Nil	Nil	Good

Event 2 – OH2Ku (Sandpiper 2017d)

Field data is provided within the report.



Sandpiper Ecological Surveys

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Kieran Metcalfe
Environmental Manager
Lend Lease Engineering
OH2Ku Pacific Highway Upgrade
Kieran.Metcalfe@lendlease.com.au

08 August 2017

Dear Kieran,

RE: Nest box monitoring summer 2017.

Sandpiper Ecological was contracted by Lend Lease Engineering to conduct bi-annual, construction phase, nest box monitoring as per the Oxley Highway to Kempsey Nest Box Plan of Management (Lewis 2013). Following is a brief overview of the summer 2017 inspection, which was the second of four scheduled construction phase surveys.

Nest boxes were inspected between 16 and 20 January and on 13 and 14 March 2017. Inspections between 16 and 20 January were conducted using a customised gopro camera mounted on a 9m extendable pole. The 13 and 14 March inspection was conducted by tree climbers and targeted higher boxes (i.e. large forest owl and cockatoo). Inspection of boxes by climbers occurred outside the summer period due to a combination of weather and logistical delays. Weather variables during the survey are included in Table 1.

A total of 269 boxes were inspected (Table 2). Of which, 22 (8.1%) were occupied and 125 (46.4%) had evidence of use by vertebrate fauna. A total of 147 (54.6%) nest boxes were either occupied or showed evidence of use. The most commonly recorded fauna were sugar gliders (*Petaurus breviceps*) with 24 individuals occupying seven boxes, followed by common brush-tail possum (*Trichosurus vulpecula*) with 10 individuals occupying seven boxes (Table 3). Other notable records included a Greater Glider (*Petauroides volans*) occupying a large forest owl box. Greater Gliders are listed as vulnerable by the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999.*

Overall, boxes were in good condition. Exceptions were two small owl boxes (no.255 & no.362) which had severe termite damage but were still functional and one parrot box (no. 342) and one possum box (no. 383) which had severe termite damage and had fallen down. It is recommended that replacement boxes (two small owl, one parrot and one possum) are purchased and reinstalled during the next inspection in winter 2017.

Twenty-five boxes (9.2%) showed evidence of European bee occupation, however, all but two were abandoned hives. European bees generally abandon smaller volume nest boxes when hives outgrow space available.

If you have any questions regarding the Winter 2016 nest box inspection, please call me on the number below.

Yours sincerely,

Nick Priest,
Ecologist.

Table 1: Weather conditions during the summer 2017 nest box inspection. Source: BOM, Port Macquarie Airport Weather Station (station 060139).

Date	Rainfall	Cloud cover	Wind (max gust)	Ambient Temperature @ 9am ($^{degrees\ celcius0}$C)
16/1/17	0	6/8	44	18.9
17/1/17	11.2	1/8	35	21.4
18/1/17	0	8/8	30	23.7
19/1/17	0	0/8	31	26.3
13/3/17	0	1/8	63	31.4
14/3/17	0.2	8/8	33	21.0

Table 2: Summary of findings from the summer 2017 nest box inspection for the Oxley Highway top Kundabung Pacific Highway Upgrade.

No. of boxes inspected	No. of boxes occupied	No. of boxes with evidence of use	Total occupied & evidence of use	No. of boxes with Euro bees or evidence	No. of boxes requiring repair/replacement
269	22 (8.1%)	125 (46.4%)	147 (54.6%)	2 active, 25 old (9.2%)	4 (1.4%)

Table 3: Data collected during the summer 2017 nest box inspection for the OH2Ku Pacific Highway Upgrade. CBtP = common brush-tailed possum, FtG = feather-tail glider, Ante = antechinus, CRtP = common ring-tail possum, ONJ = owlet nightjar, YBG = yellow-bellied glider, Petaurid = Small Petauridae glider (sugar/squirrel glider), Euro = European beehive, poss = possum, prob = probable, BTPhas = Brush-tailed Phascogale, cnr = corner, nil? = possible occupation by fauna but leaf obscures view

Box number	Box type	Check Date	Fauna	Signs	Box condition
201	SG	17/1/17	Nil	Old leaf nest, prob SuG/SqG	Good
200	SO	17/1/17	Nil	CBTP marks	Good
199	Poss	17/1/17	Nil	Nil	Good
198	Parr	17/1/17	Nil	Nil	Good
196	Scan	17/1/17	Nil	Old scrappy leaf nest	Good
195	Poss add	17/1/17	Nil	CBtP marks	Good
274	Cockatoo	14/3/17	Nil	Nil	Good
193	SG	17/1/17	Nil	Small downy feathers, prob ONJ	Good
194	MB	17/1/17	Nil	Nil	Good
202	MB	17/1/17	Nil	Nil	Good, mud wasps
206	SG	17/1/17	Nil	Ante nest, latrine Cnr	Good
203	Poss	17/1/17	Nil	Nil	Cam dropped into box.
204	Scan	17/1/17	Nil	Old bowled leaf nest, SuG/SqG	Good
197	LG	17/1/17	Nil	Old Euro beehive	Good
213	Parr	17/1/17	Nil	Scattered leaf nest, poss ONJ	Good
211	LG	17/1/17	Nil	Old Euro beehive	Good
212	Poss	17/1/17	Nil	Nil	Good
215	Scan	17/1/17	Nil	Old leaf nest, Prob SuG/SqG	Good
214	SG	17/1/17	Nil	Old scrappy leaf nest, prob SuG/SqG	Good
206	Poss	17/1/17	Nil	Nil	Good
208	LG	17/1/17	Nil	Nil, old euro beehive	Good

Box number	Box type	Check Date	Fauna	Signs	Box condition
210	SO	17/1/17	Nil	Nil	Good
207	SG	17/1/17	Nil	Scrappy old leaf nest, prob Ante	Good
209	Scan	17/1/17	Sugar Glider x 3	Old leaf nest	Good
166	Scan	17/1/17	Nil	Old Euro beehive	Good
161	Poss	17/1/17	Nil	Nil	Good
160	SO	17/1/17	Nil	Nil, old euro beehive	Good
162	LFO	14/3/17	Nil	Old Euro beehive, scattered leaves.	Good
504	SG	17/1/17	Nil	Nil	Good
164	SG	17/1/17	Sugar Glider x 3	Leaf nest	Good
163	Poss	17/1/17	Nil	Old CBtP nest, ants	Good
165	Scan	16/1/17	Nil	Nil	Good
180	SG	16/1/17	Native beehive	N/A	Good
380	LG	16/1/17	Nil	Nil	Good
181	Poss	16/1/17	Nil	Nil	Good
182	Poss	16/1/17	Nil	Possible bones/skull?	Good
172	Scan	16/1/17	Nil	Few old leaves	Good, ants
173	SG	16/1/17	Nil	Possible old latrine Cnr, old euro beehive	Good
174	LG	16/1/17	Nil	Nil	Good
186	Poss	16/1/17	Nil	CBtP marks	Good
176	Parr	16/1/17	Nil	Nil	Good, Ants
178	SO	16/1/17	EURO BEES	N/A	N/A
380	Scan	16/1/17	Sugar Glider x 2	Leaf nest	Good
381	SG	16/1/17	Nil	Nil	Good
382	Parrot	16/1/17	Nil	Chewing around entrance	Good
383	Poss	16/1/17	Nil		Fallen down, infested with termites, replace.
384	Cockatoo	13/3/17	Nil	Nil	Good, evidence of 300mm water inundation
179	Scan	16/1/17	Nil	Old leaf nest, prob SuG/SqG	Good
183	Scan	16/1/17	Nil	Nil	Good
184	SG	16/1/17	Nil	Fresh leaf nest, prob SuG/SqG	Good
185	Poss	16/1/17	Nil	Nil	Good
?	LG	16/1/17	Nil	Nil	Good
187	Parr	16/1/17	Nil	Old leaf nest, prob SuG/SqG	Good
188	Scan	16/1/17	Nil	Old leaf nest, prob SuG/SqG	Good
189	SG	16/1/17	Nil	Old leaf nest, prob SuG/SqG	Good
168	LG	16/1/17	Nil	Nil	Good
191	Poss	16/1/17	Nil	Nil	Good
171	Small owl	13/3/17	Brown Antechinus x 4 (min)	100mm leaf litter, old Euro beehive	Good

Box number	Box type	Check Date	Fauna	Signs	Box condition
223	Poss	17/1/17	Nil	CRtP drey	Good
222	SG	17/1/17	Nil	Used by SuG/SqG and Ante.	Good
226	Parr	17/1/17	Nil	Flattened CRtP drey (CRtP present last week)	Good
225	LG	17/1/17	Nil	Old Euro beehive	Good
224	Scan	17/1/17	Nil	Old SuG/SqG leaf nest	Good
218	Poss	17/1/17	Nil	CRtP drey	Good
221	LG	17/1/17	Nil	Bark strips, leaves, CRtP?	Good
220	Scan	17/1/17	Nil	Nil	Good
217	Parr	17/1/17	Sugar Glider x 2	Skint leaf nest	Good
219	SG	17/1/17	Nil	Old Ante nest	Good
216	LG	17/1/17	Nil	Old Euro beehive	Good
227	Poss	17/1/17	CRtP x 1	Extensive drey	Good
228	SG	17/1/17	Sugar Glider x 4	Old leaf nest	Good
229	Scan	17/1/17	Nil	Scrappy leaf nest, prob Ante	Good
230	SG	19/1/17	Nil	Fresh leaf, FtG? Old Euro beehive	Good
231	LG	19/1/17	Nil	CBtP marks	Good
232	SG	19/1/17	Nil	Nil	Good
233	Poss	19/1/17	Nil	Old scrappy leaf nest (no change from last survey)	Good
234	Scan	19/1/17	Nil	Nil, ants	Good
235	Poss	20/1/17	Nil	Nil	Good
236	Parr	20/1/17	Nil	Old SuG/SqG leaf nest	Good
237	SG	20/1/17	Nil	Old SuG/SqG leaf nest	Good
238	Scan	20/1/17	Nil	Bark strips and leaves, BTPhas?	Good
239	LG	20/1/17	Nil	Extensive old leaf nest, old Euro beehive	Good
240	SG	20/1/17	Sugar Glider x 3	Leaf nest	Good
243	Scan	20/1/17	Nil	Nil	Good
242	Parr	20/1/17	Nil	Nil	Good
241	Scan	20/1/17	Nil	Nil, ants	Good
244	Poss	20/1/17	Nil	Nil	Good
245	Scan	20/1/17	Nil	Partial leaf nest	Good
246	LG	19/1/17	Nil	Nil	Good
251	Poss	19/1/17	Nil	Possible latrine cnr. Termites?	Good
248	Scan	19/1/17	Nil	Old leaf nest, prob Ante, old Euro beehive	Good
249	SG	19/1/17	Nil	Old leaf nest, FtG?	Good
250	Poss	19/1/17	Nil	Nil	Good
252	MB	19/1/17	Nil	Nil	Good
247	SG	19/1/17	Nil	Old SuG/SqG leaf nest	Good
305	Poss	19/1/17	Nil	Possible CBtP wear	Good
303	Scan	19/1/17	Nil	Reptile scat	Good

Box number	Box type	Check Date	Fauna	Signs	Box condition
302	SG	19/1/17	Nil	Nil	Good
304	Scan	19/1/17	Nil	Nil	Good
306	SG	19/1/17	Nil	Nil	Good
503	Scan	19/1/17	Nil	Nil	Good
502	Scan	13/3/17	Nil	Nil	Good
505	Poss	19/1/17	CBtP x 1	NA	Good
255	SO	19/1/17	Nil	Nil	Severe termite damage, Old Euro beehive
253	Poss add	19/1/17	Nil	Nil	Good
254	Mb	19/1/17	Nil	Nil	Good
256	LG	19/1/17	Nil	Nil, old Euro beehive	Good
257	Scan	19/1/17	Nil	Packed with old leaf, latrine cnr. Old FtG taken over by Ante.	Good
258	Poss	19/1/17	Nil	CBtP marks	Good
259	LG	19/1/17	Nil	Nil	Good
260	Poss	19/1/17	Nil	CBtP marks	Good
261	Scan	19/1/17	Nil	Partial leaf nest	Good
262	SG	19/1/17	Nil	Old leaf nest, prob SuG/SqG	Good
263	Parr	19/1/17	Nil	Nil	Good
264	LG	19/1/17	Nil	CBtP marks	Good
266	SG	19/1/17	Nil	Old scrappy leaf nest, Ante?	Good
265	SG	19/1/17	Nil	Old leaf nest, prob SuG/SqG	Good
267	Scan	19/1/17	Nil	Nil, SuG/SqG nest	Good
268	Poss	19/1/17	Nil	Nil	Good
269	LG	19/1/17	Nil	Decay, skeleton, old leaf. Sent for analysis	Good
270	Poss	19/1/17	Nil	CBtP marks	Good
273	Scan	14/3/17	Nil	Old SuG leaf nest	Good, lowered 5m
272	SG	19/1/17	Nil	Partial leaf nest, prob SuG/SqG	Good
271	Parr	19/1/17	Nil	Nil, Euro bee hive	Good
275	LG	14/3/17	Nil	Old scattered leaf, old Euro beehive, prob CBTP.	Good, pic on nicks phone. Box lowered 3m
277	Scan	19/1/17	Nil	Extensive leaf nest, prob FtG	Good
276	LG	19/1/17	Nil	CBtP marks	Good
276B	MB	19/1/17	Nil	Nil	Good
292	SG	19/1/17	Nil	Old Euro beehive	Good
290	Scan	18/1/17	Nil	Old leaf nest, prob SuG/SqG	Good
294	Poss	19/1/17	Nil	CBtP marks	Good
293	SG	19/1/17	Nil	Ante nest, latrine cnr, messy.	Good
288	LG	14/3/17	Nil	Nil	Good, lowered 2m
295	SG	18/1/17	Nil	Bowled SuG/SqG leaf nest	Good

Box number	Box type	Check Date	Fauna	Signs	Box condition
291	MB	18/1/17	Nil	Nil	Good
296	Scan	18/1/17	Nil	Partial SuG/SqG leaf nest	Good
289	Parr	18/1/17	Nil	Old SuG/SqG leaf nest	Good
285	LG	19/1/17	Nil	Old Leaf nest, prob CBtP	Good
287	Scan	19/1/17	Nil	Old leaf nest, prob SuG/SqG	Good
284	Poss	19/1/17	Nil	Nil	Good
286	SG	19/1/17	Nil	Old leaf nest, prob SuG/SqG	Good
283	SO	19/1/17	Nil	CBtP marks, old Euro beehive	Good
279	LG	19/1/17	Nil	Strips of bark, poss scat, BTPhas?	Good
282	Poss	19/1/17	Nil	Few leaves, CBtP marks	Good
280	MB	19/1/17	Nil	Nil	Good
281	Parr	19/1/17	Nil	Few leaves, old Euro beehive	Good
297	SG	19/1/17	Nil	Nil	Good
298	Poss	19/1/17	Nil	CBtP marks	Good
299	Add. Poss	19/1/17	SEBtP x 1	SEBtP marks	Good
300	SO	14/3/17	Nil	CBtP marks	Good
301	LG	19/1/17	Nil	CBtP marks	Good
307	Poss	19/1/17	Nil	Nil	Good
308	SG	19/1/17	Euro BEES	Euro BEES	Good
309	Parr	19/1/17	Nil	Nil	Good
310	Scan	19/1/17	Nil	Nil	Good
311	LG	19/1/17	Nil	Nil	Good
312	Parr	18/1/17	Nil	Nil	Good
313	LG	18/1/17	Nil	Nil, ants	Good
314	LG	18/1/17	Nil	Nil	Good
315	MB	18/1/17	Nil	Nil	Good
316	LG	19/1/17	Nil	Nil, ants	Good
317	Poss	19/1/17	Nil	Possible latrine cnr, Ante? no leaf	Good
318	Parr	19/1/17	Nil	Nil, old Euro beehive	Good
319	Cockatoo	14/3/17	Nil	Some old leaf, poss ONJ	Good
320	Poss	20/1/17	Nil	Nil	Good
321	MB	20/1/17	Nil	Nil	Good
322	LFO	20/1/17	Greater Glider x 1	Nil	Good.
323	Add poss	20/1/17	Nil	CBtP marks	Good
324	Scan	20/1/17	Nil	Very old leaf litter, prob Ante	Good
325	SG	20/1/17	Nil	Few scattered old leaves, partial nest	Good
326	SF	20/1/17	Nil	Very old leaf litter, prob Ante	Good
327	MB	20/1/17	Nil	Nil	Good
328	P/L	20/1/17	Nil	Few scattered old leaves, partial leaf nest	Good

Box number	Box type	Check Date	Fauna	Signs	Box condition
329	Poss	20/1/17	Nil	Nil	Good
330	LG	20/1/17	Nil	Nil, old Euro beehive	Good
331	Poss	20/1/17	Nil	Nil	Good
332	Co	13/3/17	Nil	Nil	Good
333	add Poss	13/3/17	Nil	Nil	Good
334	LG	13/3/17	Greater Glider x 1	Nil, scattered bark.	Good. Probably same individual as LFO box 322.
335	Scan	20/1/17	Nil	Old leaf litter, prob Glider sp. nest	Good
336	SG	20/1/17	Nil	Nil, old Euro beehive	Good
337	P/L	20/1/17	Nil	Nil, ants	Good
338	LG	20/1/17	Nil	Nil	Good
339	Poss	20/1/17	Nil	Nil	Good
340	LG	20/1/17	Nil	Nil	Good, minor water damage
341	Poss	20/1/17	Nil	Nil	Good
342	P/L	20/1/17	Nil	Nil, severe termite damage	Replace
343	MB	20/1/17	Nil	Nil	Delaminating on top, but ok
344	SG	20/1/17	Nil	Old Ante nest, latrine cnr	Good
345	Scan	20/1/17	Nil	Few old scattered leaves, poss Ante	Good
346	LG	20/1/17	Nil	Nil	Good, some water stains
347	SG	19/1/17	Nil	Few scattered leaves	Good
348	MB	19/1/17	Nil	Nil	Good
349	Poss	19/1/17	Nil	CBtP marks	Good
350	Scan	19/1/17	Nil	Nil	Good
351	LG	19/1/17	Owlet Nightjar x 1	Bark strips, prob old RtP drey	Good
352	Parr	19/1/17	Nil	Leaves, twigs, skull?	Good
353	SG	19/1/17	Juv Sugar Glider x 1?	Extensive bowed leaf nest	Good
354	Poss	19/1/17	Nil	Wood Duck nest, down, egg shells	Good
500	LFO	13/3/17	Owlet Nightjar x 1	Latrine cnr	Good
501	Poss	13/3/17	Nil	Few scattered leaves	Good
355	LG	13/3/17	Nil	Old CBtP use. Old Euro beehive	Good
356	Poss	18/1/17	Nil	CBtP marks	Good
357	SG	18/1/17	Nil	Old leaf nest, prob SuG/SqG	Good
358	PARR	18/1/17	Nil	Nil	Good
359	Scan	18/1/17	Nil	Old leaf nest, SuG/SqG	Good
360	SG	18/1/17	Nil	Old leaf nest, SuG/SqG	Good
361	Poss	18/1/17	CBtP x 1	CBtP marks and scat	Good
362	Scan	18/1/17	Nil	Old leaf nest, SuG/SqG	Good
363	MB	18/1/17	Nil	Nil	Good

Box number	Box type	Check Date	Fauna	Signs	Box condition
364	SG	18/1/17	Nil	Old leaf nest, FtG?	Good
365	SG	17/1/17	Nil	Old SuG/SqG nest	Good
366	Scan	17/1/17	Nil	Nil	Good
367	Parr	17/1/17	Nil	Stripped bark with depression in Cnr, WtTC?	Good
368	Pos	17/1/17	Nil	CBTP marks	Good
378	SG	17/1/17	Nil	Nil	Good
369	Parr	17/1/17	Nil	CBTP marks	Good
376	SG	17/1/17	Nil	Antechinus nest	Good
371	Scan	17/1/17	Nil	Old SuG/SqL leaf nest	Good
372	LG	17/1/17	CBtP x 2	Nil	Good
373	Poss	17/1/17	Nil	Extensive CBtP wear	Good
374	Poss	17/1/17	Nil	CBtP marks	Good
375	Scan	17/1/17	Nil	Ante nest	Good
378	MB	17/1/17	Nil	Possible wear	Good
377	LG	17/1/17	CBtP x 1	Small leaf nest	Good
379	Parr	17/1/17	Nil	Old leaf nest, SuG/SqG	Good
385	LG	18/1/17	Nil	Nil	Good
386	SG	18/1/17	Nil	Old leaf nest, prob SuG/SqG	Good
387	Parr	18/1/17	Nil	Nil	Good
388	Poss	18/1/17	Nil	Few scattered leaves, ants	Good
389	MB	18/1/17	Nil	Nil	Good
390	SG	18/1/17	Nil	Old leaf nest, SuG/SqG	Good
391	LG	18/1/17	Nil	Nil	Good
392	SG	18/1/17	Nil	Old leaf nest, SuG/SqG	Good
393	Cock	14/3/17	Nil	Some leaf litter	Good
394	Poss	18/1/17	Nil	Nil	Good
395	SG	18/1/17	Nil	Nil	Good
396	LG	18/1/17	Nil	Nil, Old Euro beehive	Good
397	SG	16/1/17	Nil	Couple of leaves	Good
398	Poss	16/1/17	Nil	CBtP marks	Good
399	Scan	16/1/17	Nil	Few old leaves/half nest	Good
400	Parr	16/1/17	Nil	Chewing at entrance	Good
401	Scan	16/1/17	Nil	Old leaf nest, SuG/SqG	Good
402	Poss	16/1/17	Nil	Nil	Good
403	MB	16/1/17	Nil	Nil	Good
404	SG	16/1/17	Nil	Old leaf nest, SuG/SqG	Good
405	Scan	16/1/17	Sugar Glider x 6	Leaf nest	Good
406	LG	16/1/17	Nil	CBtP marks	Good
167	SG	16/1/17	Nil	Old leaf nest, chewing around entrance	Good

Box number	Box type	Check Date	Fauna	Signs	Box condition
407	Cock	16/1/17, 13/3/17	CBtP (head at entrance), CBtP x 2	CBtP marks, one individual fled box.	Good
408	Poss Add	15/1/17	Nil	Nil	Good. CBtP in box 13/3/17
355	Scan	19/1/17	Nil	Strips of bark etc, Ante?	Good
356	Poss	19/1/17	Nil	Extensive drey material, CRtP	Good
357	Parr	19/1/17	Nil	Very old leaf nest, prob SuG/SqG. Chewing at entrance	Good
362	SO	19/1/17	Nil	Some scattered leaves, severe termite damage	Extensive termite damage, replace
361	Poss ad	19/1/17	Nil	Nil	Good
358	SG	19/1/17	Nil	Old leaf nest, SuG/SqG	Good
359	Scan	19/1/17	Nil	Very old leaf nest, prob SuG/SqG	Good
360	LG	19/1/17	CBtP x 2	Sitting on CRtP drey	Good
363	Scan	19/1/17	C. Carpet Python x 1	Sitting on old Ante nest	Good
364	Poss	19/1/17	Nil	Few leaves, latrine cnr, Ante	Good
365	Lg	19/1/17	Nil	Old CRtP drey with massive latrine cnr	Good
366	Sg	19/1/17	Nil	Twigs, leaves, latrine cnr, Ante	Good
367	Lg	20/1/17	Nil	Few scats, leaves, prob BtPoss	Good
368	SF	20/1/17	Nil	Nil, ants	Good
371	PO	20/1/17	Nil	Nil	Good
370	LFO	13/3/17	Nil	Nil	Good
369	Po	20/1/17	Nil	Nil	Good
372	LG	20/1/17	Nil	Nil, old Euro beehive	Good

Event 1 and Event 2 – Ku2K (Lewis 2017b)

Field data is provided within the report.

KUNDABUNG TO KEMPSEY: NEST BOX MONITORING

YEAR 1

JULY 2017

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Disclaimer

The client (K2K Joint Venture) may only use this document for the purposes for which it was commissioned. This report relies upon data, surveys, measurements and results based on a short-term objective study in response to a brief issued to Lewis Ecological Surveys from the K2K Joint Venture. Although conclusions have been based on the available data at that time, some professional judgement has been applied in reaching these conclusions due to the temporal limitations arising from the dynamic nature of available information, legislation, schedules, individual species and associated habitats. Every attempt has been made to ensure the accuracy and objectivity of the report's findings, conclusions and recommendations. Lewis Ecological Surveys does not accept responsibility for its use beyond the scope of works.

……..
Ben Lewis
(B. Applied Science Hons)

…4th July 2017……

Date

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Photography - Lewis Ecological Surveys © else stated

Title Page – Yellow-bellied Glider recorded from Maria River (Management Zone AA).

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1.0 INTRODUCTION

1.1 Project Overview and Background to this Monitoring

The Kundabung to Kempsey Joint Venture (K2K JV) is currently upgrading the Pacific Highway to provide 14 kilometres of four-lane divided road from south of Kundabung, where it will connect to the Oxley Highway to Kundabung project that is also currently under construction, to the Kempsey Bypass. The project is being built to Class-A (Arterial) standard, and includes a new grade separated interchange in the vicinity of Kundabung Road and Rodeo Drive, two new rest areas, and a new heavy vehicle inspection facility.

As part of accommodating the works described above, the Environmental Assessment identified a loss of tree hollows to a range of native fauna (GHD 2010). As a consequence, the Roads and Maritime (the proponent) were conditioned with MCoA B7 "*prior to the commencement of any construction work that would result in the disturbance of any native vegetation (or as otherwise agreed to by the Director General), the Proponent shall in consultation with OEH prepare and submit for the approval of the Director General a Nest Box Plan to provide replacement hollows for displaced fauna consistent with the requirements of SoC F15. The plan shall detail the number and type of nest boxes to be installed which must be justified based on the number and type of hollows removed (based on detailed pre-construction surveys), the density of hollows in the area to be cleared and adjacent forest, and the availability of adjacent food resources. The plan shall also provide details of maintenance protocols for the nest boxes installed including responsibilities, timing and duration".*

To address the above, Lewis Ecological Surveys was contracted to prepare a Nest Box Plan of Management prior to tenders being awarded for the construction of either the Oxley Highway to Kundabung or the Kundabung to Kempsey Upgrades (Lewis 2013). This plan identified 254 nest boxes were required for the Kundabung to Kempsey stage of the Upgrade and that 60% of these nest boxes must be installed prior to clearing in either of the nine management zones. In October 2014, approximately 4 weeks prior to the commencement of clearing works, 156 (61%) nest boxes were installed by Lewis Ecological Surveys as part of Project Ecologist works for the K2K Joint Venture.

With clearing works continuing from November 2014 through to September 2016, a decision was made to commence the monitoring of the previously installed nest boxes (n=156). Lewis Ecological Surveys was subsequently contracted on the 15th August 2016 (Variation Claim 12) to implement the Year 1 winter monitoring survey in a manner compliant with the approved NBPoM (Lewis 2013). A second variation order (Variation Claim 17) was approved and processed on the 22nd February 2017 to implement the summer nest box monitoring. The following report documents the findings of both surveys which form Year 1 and provides some indication of nest box performance in accordance with the approved Nest Box Plan of Management.

2.0 STUDY AREA AND SURVEY METHODS

2.1 Nest Boxes Monitored

All 156 nest boxes were accessed using the 'goto' function on Garmin Montana 650t hand held GPS (Figure 2-1). Nest boxes were inspected in accordance with Lewis Ecological Surveys (version 4) approved safe work method statement. Winter monitoring commenced on the 20th August and was completed on the 25th September 2016 whilst the summer surveys were performed 9th through to the 14th March 2017. The sampling of boxes slightly outside the seasonal calendar of winter and summer was by a matter of weeks, yet importantly, the period between the monitoring was kept at approximately 6 months.

2.2 Data Recorded

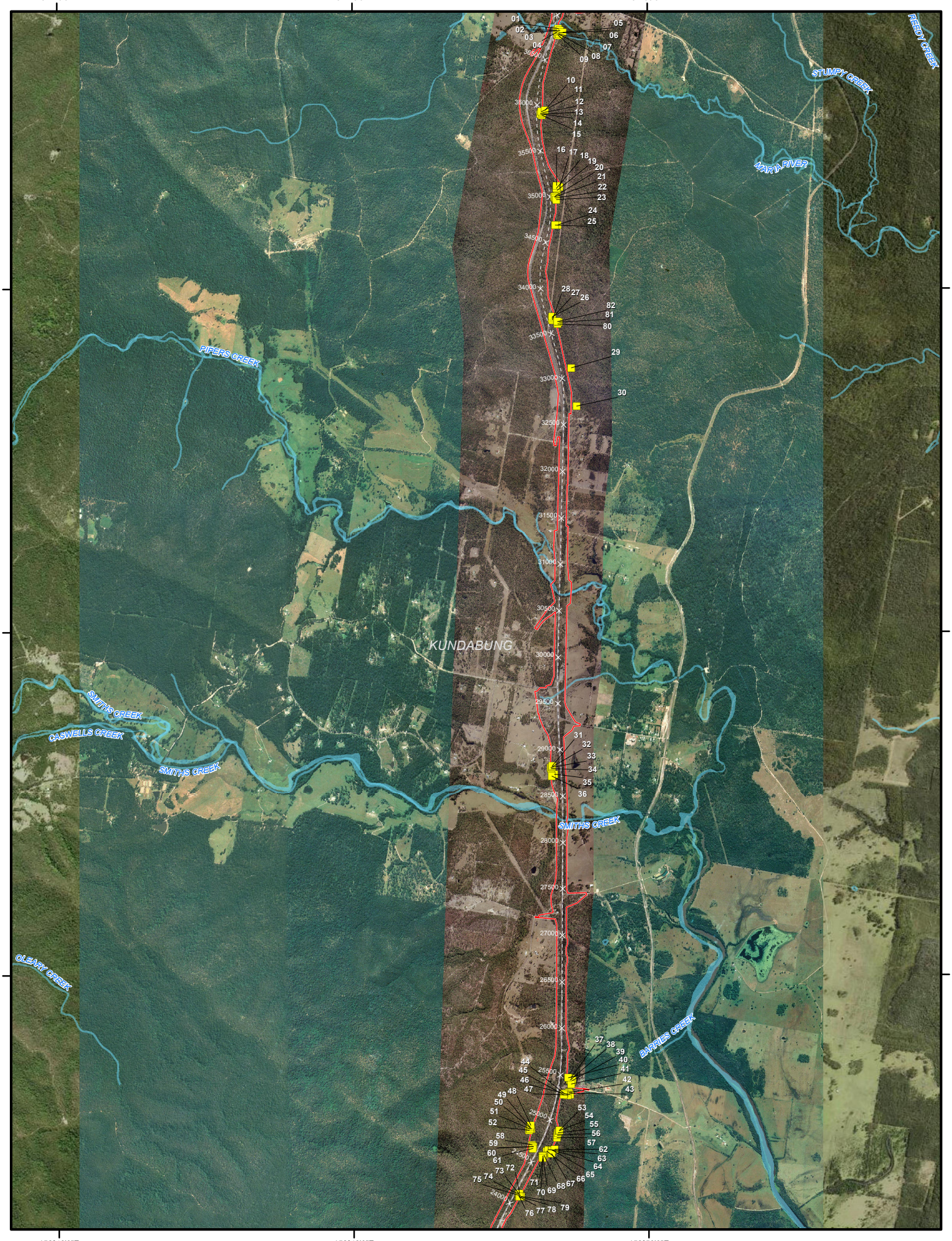
During the inspection of each nest box, the following information was transcribed onto a field proforma:

- Weather conditions and time/date that each nest box was checked;
- Whether there was any sign of use or occupancy by fauna (Yes/No);
- The type of evidence present (Hair, Scat, Leaves, Nest, Feathers etc);
- Could the species be identified and if so, what was it or what group of fauna (glider, possum) was it likely to belong to;
- Any evidence of pest species such as ants, termites, European Bees (*Apis mellifera*), spiders, wasps;
- Any sign of damage to the box;
- Whether an maintenance action was performed; and
- Whether any maintenance is required in the future.

Any handling procedures were undertaken in accordance with Lewis Ecological Surveys NSW Animal Care and Ethics Approval (Trim14/3786).

2.3 Data Analysis

Data were summarised into percentage use statistics to present occupancy rates across the K2K project and for each of the nest box management zones. This was applied to nest box use by fauna, non-target pest species and for nest boxes requiring maintenance or some rectification works. In some instances, these percentages were displayed using frequency histograms. A seasonal comparison between the two monitoring periods was also performed.



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Source:	Cadastre: Roads and Traffic Authority 2007 Project Boundaries: Roads and Traffic Authority 2012 Watercourses: Geoscience Australia 2009 Aerial Photogaraphy: Main - Roads and Traffic Authority (date unknown) - surrounds © Land and Property Information 2015 Nest Box Monitoring:Lewis Ecological Surveys April 2017
Disclaimer:	This plan is based on or contains data provided by others. Lewis Ecological Surveys. gives no warranty in relation to the data (including accuracy, reliability, completness, currency or suiability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to and use of the data. Data must not be used for direct marketing or be used in breach of privacy laws.
File:	K2KNestBoxMonitoring01-Year1Winter160407

N W E S

0 500 1,000 1,500

Meters

A4 Scale 1:50,000

Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator

Project Boundary

Nest Box Tree Name

Watercourse

K2K Nest Box Monitoring Year 1 Winter

3.0 MONITORING RESULTS

3.1 Year 1 Nest Box Occupancy Rates

Ninety-seven (62%) of the 156 installed nest boxes showed signs of current or past use by native fauna in Year 1. Not all of the 97 boxes were occupied by fauna at the time of the inspection, but rather showed clear signs of past use (i.e. scats, fur and/or feathers). The reporting rates for direct fauna observations during this monitoring episode was 19 nest boxes (12%) occupied by at least 49 individuals. This equated to fauna being recorded at a rate of one in every eight nest boxes during the survey. Most observations were of 1-2 individuals, although on one occasion, 12 Feather-tail Gliders (*Acrobates pygmaeus*) were recorded communally denning in a nest box adjacent to the south bound rest area (i.e. nest box management zone T; Plate 3-1).

Plate 3-1. Feather-tail Gliders communal den site in a scansorial fauna box from management zone T adjacent to the southbound rest area.

Nest box occupancy varied from 39% in Zone T through to 100% in Zone V (Figure 3-1). No boxes had been installed in Zone W due to some uncertainty about the future extent of retained vegetation. Generally, occupancy rates varied between 47-70%.

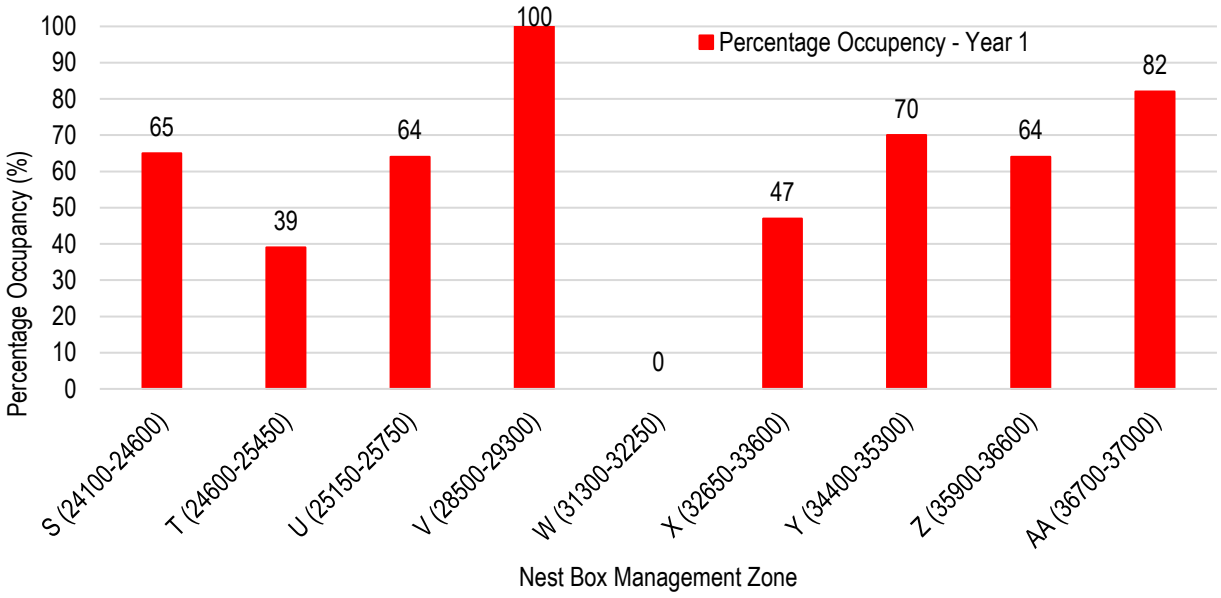

Figure 3-1. Year 1 occupancy rates at each of the nest box zones.

3.2 Seasonal Occupancy Rates across the Project

3.2.1 Winter Sampling

Sixty-nine (44%) of the 156 installed nest boxes showed signs of current or past use by native fauna. Not all of the 69 boxes were actually occupied by fauna at the time of the inspection but showed clear signs of past use (i.e. scats, fur, feathers). The reporting rates for direct fauna observations during this monitoring episode was 11 nest boxes (7%) occupied by at least 17 individuals. This equated to fauna being recorded at a rate of one in every nine nest boxes during the winter survey.

3.2.2 Summer Sampling

Forty-eight (31%) of the 156 installed nest boxes showed signs of current or past use by native fauna. Like the winter survey, not all of the 48 boxes were actually occupied by fauna at the time of the inspection but showed clear signs of past use (i.e. scats, fur, feathers). The reporting rates for direct fauna observations during this monitoring episode was eight nest boxes (5%) occupied by at least 32 individuals. This equated to fauna being recorded at a rate of one in every 19 nest boxes during the summer survey.

3.3 Seasonal Variability in Occupancy Rates within Each Management Zone

Occupancy rates were higher in winter than summer in Zones T, X, Y, Z and AA (Figure 3-2). There was a general trend of occupancy being greater in summer in the southern zones than the northern zones where a wildfire event had occurred in early November 2016.

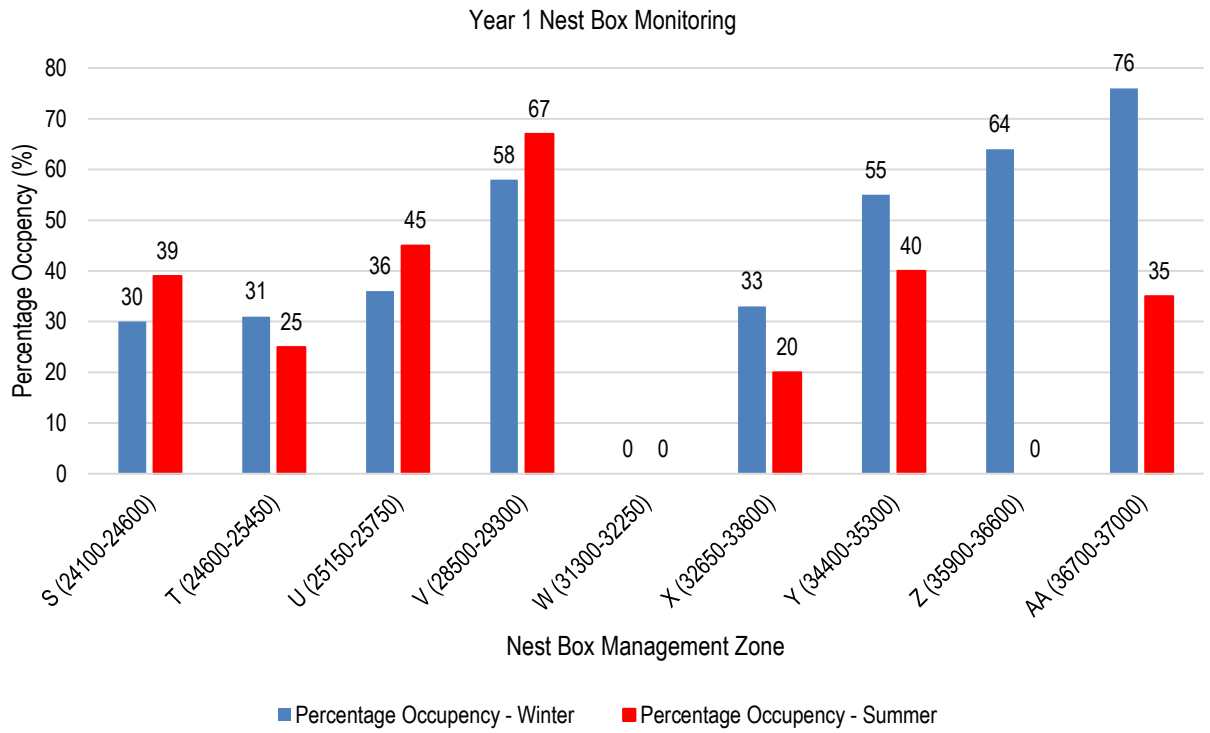

Figure 3-2. Occupancy rates at each of the nest box zones.

3.4 Native Species Composition

Year 1 monitoring recorded mammals, birds and reptiles summarised as follows:

- Mammals divided into three groups:
    - Arboreal mammals including the Short-eared Possum (*Trichosurus caninus*), Common Brushtail Possum (*Trichosurus vulpecula*), Yellow-bellied Glider (*Petaurus australis*), Sugar Glider (*Petaurus breviceps*) and Feather-tail Glider (*Acrobates pygmaeus*);
    - Scansorial mammals: Brown Antechinus (*Antechinus stuartii*);
    - Flying mammals: Gould's Long-eared Bat (*Nyctophilus gouldi*) and Chocolate Wattled Bat (*Chalinolobus morio;* Plate 3-2);
- Birds: Australian Owlet Nightjar (*Aegotheles chrisoptus*) and Scaly-breasted Lorikeet (*Trichoglossus chlorolepidotus*); and
- Reptiles: Lace Monitor (*Varanus varius*).

Commonly encountered species included the Brown Antechinus, Sugar Glider and evidence of possum use with more than five occurrences each. In contrast, the Yellow-bellied Glider and Australian Owlet Nightjar were recorded on less than two occasions.

Only the Short-eared Possum, Yellow-bellied Glider and Chocolate Wattled Bat were recorded during the summer monitoring. In contrast, no direct observations were made of Sugar Glider during this monitoring period but rather indirect signs such as their leaf nests. More Lace Monitor were also recorded during the summer sampling.

Plate 3-2. Chocolate Wattled Bat (*Chalinolobus morio*) remains from a wedge shaped bat box in Management Zone V.

3.5 Use of Nest Boxes by Threatened Fauna

The threatened Yellow-bellied Glider (*Petaurus australis*) was recorded from Nest Box Zone AA where two individuals were observed in a rear entry glider box (Design Type 4; NBT08 in Figure 2-1). This box had been installed on a mature Coastal Blackbutt (*Eucalyptus pilularis*) approximately 16 m above the ground in an area with little to no shrub or mid stratum. A possum design nest box installed in a nearby Tallowwood (10 m above ground) also contained a conspicuous leaf nest which is likely to have been constructed by Yellow-bellied Glider.

Plate 3-3. Yellow-bellied Glider (*Petaurus australis*) recorded using a rear entry glider box (NBT-08) near Maria River (Management Zone AA).

There was no sign of use by large forest owls (i.e. Powerful Owl, *Ninox strenua*) or large cockatoos (Glossy Black Cockatoo, *Calyptorhynchus lathami*) despite these species being known from the area. Similarly, there is no sign of past or current use of any nest box by the threatened Brush-tailed Phascogale (*Phascogale tapoatafa*).

3.6 Use of Nest Boxes by Pests and Non-Target Species During

Seventy-seven (77) or 49% of the 156 boxes recorded non target or pest species during Year 1 monitoring with all eight zones affected. Most observations (i.e. 51 boxes or 66%) were attributed to ants (4 species) and mud wasps, both of which are commonly encountered during the tree hollow inspections in the clearing operations. Twenty (24%) nest boxes were occupied at some stage by the European Bee, however, almost all hives had been impacted by the Small Hive Beetle (*Aethina tumida*) rendering them destroyed. The remaining six nest boxes were occupied by Huntsman Spider (*Sparassidae spp*) and on one occasion, Termites.

One concern at the commencement of the nest box program was the occurrence of both the Common Myna (*Acridotheres tristis*) and Common Starlings (*Sturnus vulgaris*) in the study area. Neither were recorded during this monitoring event.

3.6.1 Winter Sampling

Fifty-eight (58) or 37% of the 156 boxes recorded non target or pest species during the winter monitoring with all eight zones affected. Most of these occurrences (i.e. 39 boxes or 67%) were attributed to ants (4 species) and mud wasps, both of which are commonly encountered during the tree hollow inspections in the clearing operations. The remaining 14 (24%) nest boxes were occupied at some stage by the European Bee, however, almost all hives had been impacted by the Small Hive Beetle (*Aethina tumida*) rendering them destroyed.

3.6.1 Summer Sampling

Fifty-three (53) or 34% of the 156 boxes recorded non target or pest species during the summer monitoring with all eight zones affected. Most of these occurrences (i.e. 38 boxes or 72%) were again attributed to ants (4 species) and mud wasps. The remaining 15 (28%) nest boxes were occupied at some stage by the European Bee, and similar to the winter monitoring, all had been impacted by the Small Hive Beetle (*Aethina tumida*) rendering them destroyed.

4.0 DISCUSSION

Monitoring during Year 1 has identified that almost two thirds of the nest boxes installed in spring 2014 have been utilised by native fauna. Whilst the earlier winter sampling period had concluded that uptake or occupancy was a little lower than expected, the summer sampling had contributed a further 18% to an overall measure of 62% for Year 1. This is marginally higher than the neighbouring Kempsey Bypass where 52% uptake from its 173 nest boxes installed 6-12 months prior to monitoring (Lewis 2013).

The decline in occupancy between the winter and summer period was largely attributed to the loss of nest boxes during a wildfire event in November 2016 which destroyed 31 boxes and contributed to some forced displacement of boxes which previously housed wildlife. In some cases, this marked decline resulted in zero occupancy during the summer period for Zone Z (ch.35900-36600). Replacement nest boxes are required at this and any other location where boxes have been destroyed or no longer remain functional. Continued monitoring will prove useful in gaining an understanding on the role of nest boxes during post fire recovery of wildlife populations.

Summer monitoring was able to confirm the presence of several large leaf nests recorded in nest boxes from the road reserve bordering Maria River State Forest belong to the threatened Yellow-bellied Glider. This is perhaps the first documented evidence of Yellow-bellied Glider using nest boxes on the Pacific Highway Upgrade program. The box itself was a rear entry glider design placed 16 m above ground where little mid storey exists and is estimated 50% height of the surrounding overstorey canopy. The required height outlined for this nest box design in the Nest Box Plan of Management was generally 8-10 m (Lewis 2013). One neighbouring nest box positioned at 10 m above ground also had what is thought to be a Yellow-bellied Glider nest indicating this species may require boxes installed quite high into the canopy.

Other threatened fauna including the Squirrel Glider and Stephens Banded Snake (*Hoplocephalus stephensii*) remain as potential inhabitants of nest boxes. Whilst every effort has been given to installing the large owl and cockatoo boxes in sufficiently high enough locations (>10 m above ground), none show sign of use by target species. The uptake of nest boxes by large forest owls and large cockatoos remains elusive and there does not appear to be any reported uptake as part of the overall Pacific Highway Upgrade program stretching between Newcastle and the Queensland border.

The discovery of deceased micro bats from a nest box specifically designed for bats raises some discussion. At the time of monitoring (i.e. 11th March), leaves had been constructed at the egress of the box and this would not enable bats to move freely from their roost. The fact that a number of smaller skeletal remains were present in the box indicates that the deaths occurred around the time of breeding (Plate 3-2). With this in mind, it is thought that the hot conditions which regularly exceeded 40°C in January/February may have contributed to this finding. The exposure of nest boxes and how fauna respond requires additional attention as individuals may be subject to greater levels of exposure.

Monitoring almost two years after the first round of nest boxes were installed has revealed a number of useful management insights. Firstly, similar types of fauna recorded during the clearing operations have also been recorded inhabiting the nest boxes. This would suggest that nest boxes do provide a useful management tool in ensuring there are at least some unoccupied roosting, denning and nesting resources around the time of the clearing operations. Interestingly, no tree frogs (hylids) were recorded in the nest boxes whilst the clearing operations commonly encountered Peron's Tree Frog (*Litoria peronii*), Tylers Tree Frog (*Litoria tyleri*) and Graceful Tree Frog (*Litoria gracilenta*). Typically, these would be recorded in exposed tree hollows that would receive rainfall or in the case of Graceful Tree Frog it was almost always recorded from dense vegetation or under exfoliating bark as opposed to tree hollows themselves.

Around a third of the nest boxes showed evidence of use by non-target or pest species. Most of these were in fact native species of ant and wasps which are thought to deter the uptake of boxes by target species over the short term. Further monitoring will assist our understanding of this process. Although European Bees had constructed hives in almost one out of every 10 boxes the Small Hive Beetle had destroyed all 14 hives. Therefore, active management in accordance with the approved NBPoM doesn't seem necessary at this point in time.

The following section assesses the performance of the monitoring in accordance with the approved Oxley Highway to Kempsey NBPoM (Lewis 2013).

5.0 PERFORMANCE OF THE NEST BOXES

The NBPoM developed for the Project required the performance of the nest boxes to be measured against the following

- Use of nest boxes by a wide range of native fauna;
- Use of nest boxes designed for specific species by those species (i.e. Brush-tailed Phascogale nest box being used by this species);
- Low rates of exotic fauna using nest boxes; and
- Reduced maintenance requirements (Lewis 2013).

5.1 Use of Nest Boxes by Wide Range of Native Fauna

Eleven (11) species of native vertebrate fauna were recorded during Year 1 monitoring. There were some notable absentees, particularly tree frogs (Family Hylidae) and the large nest boxes which show no sign of use by target species such as large forest owl and large cockatoos. Monitoring during the next few years will prove useful in determining whether this was simply a short term anomaly or a short fall of nest box designs or their installation.

5.2 Use of Nest Box Design for Specific Species

The NBPoM proposed the use of eight nest box designs to compensate for the forecast loss of tree hollows to accommodate the Upgrade (Lewis 2013). Specific designs such as the bat shaped wedge box were used exclusively by this group of fauna. This was the only box which has a vertical entrance and consequently this design feature appears important to micro bats.

The large nest boxes which have been designed for cockatoo, large parrots and forest owls remain uninhabited by either of these fauna groups. This is consistent with much of the nest box monitoring in eastern Australia and suggests its use as a management tool may require additional review.

Nest boxes referred to as scansorial boxes were used by the scansorial Brown Antechinus whilst the rear entry boxes designed for gliders were found to contain glider nests and two species of Petaurid glider. Together, they are deemed successful at this point in time.

5.3 Low Rates of Nest Box Use by Exotic Fauna

Twenty (20) of the 156 (24%) nest boxes showed evidence of use by the exotic European Bee. This uptake had occurred over the 22-30 months since their installation in October 2014. During this time, hives had been established but subsequently destroyed by the Small Hive Beetle indicating hive treatment may not be necessary during these initial phases of monitoring.

5.4 Reduced Maintenance Requirements

Thirty-nine maintenance actions were undertaken during Year 1 monitoring with three maintenance events (two re-wiring works and one lid adjustment) during winter and 36 events during summer. The majority of the summer maintenance related to replacing the 31 nest boxes lost during the November 2016 wildlife. The five other maintenance actions included the tightening of wires and unblocking of drainage holes on two occasions each, whilst the fifth was a top lid re-alignment and re-screw into place.

Termites, delaminating and some minor rot were recorded in four additional boxes and these have been identified for further inspection during Year 2 monitoring. Currently, they provide suitable nesting/roosting opportunities, and therefore remain functional.

5.5 Performance Summary

The performance summary is shown in Table 5.1 and complies with the requirements of the Nest Box Plan of Management (Lewis 2013).

Table 5-1. Summary of performance measures part way through Year 1 of Nest Box monitoring.

Problem	Contingency/Correction Action	Comment
Poor use of nest box materials resulting in increased maintenance.	Review and change nest box supplier. Investigate the use of alternative materials.	• Number of repairs were performed during installation in October 2014. • One of the 156 nest boxes starting to laminate and another rotting as a result of material use (ply)
Nest box being used by non-target species.	Review the selection and number of nest box designs.	• Nest boxes being used by a range of fauna including those designs which targeted faunal groups (i.e. bats, gliders).
Nest boxes become occupied by exotic or invasive fauna (i.e. European Bees, Termites).	Review/modify nest box design to exclude undesirable species, treat if applicable (i.e. Buffalo Fly ear tags for bees) or relocate those nest boxes to another location.	• Twenty (24%) show use, however, hive beetle has resulted in most being destroyed. Hive material considered an attractant for gliders and other nectivourous fauna. • Termite activity at only one nest box. • No nest boxes used by Black Rat, Common Myna or Starlings
Poor uptake/usage rate by native fauna.	Review the types and numbers of nest box designs, their location or positioning (i.e. aspect) within the tree.	• 62% uptake during Year 1. Equate to fauna using 2 out of every three boxes.
Nest boxes deteriorating rapidly and requiring maintenance.	Identify causes of nest box failure, modify design and construct accordingly.	• Four boxes so signs of wood rot, termite damage and delaminating 22-30 months after their installation.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Year 1 monitoring has revealed two out of every three nest boxes have been utilised by wildlife some 22-30 months after their installation. Fauna from most of the target groups including gliders, possums, reptiles, scansorial mammals and birds were recorded either directly or as indirect signs (scats, fur, nests and feathers). As these nest boxes were placed immediately adjacent to the clearing works to accommodate the Upgrade, they are considered an effective tool in accommodating the loss of tree hollows in the short term.

With the above in mind, the following recommendations are proposed:

1. Assess with input from the RMS where nest boxes might be best located in zone W to comply with the NBPoM;
2. Conduct winter monitoring in late July or early August and have the summer survey completed in January so that they accord with the seasonal requirements of the NBPoM.

7.0 REFERENCES

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8.0 APPENDIX A – NEST BOX MONITORING: YEAR 1 RAW DATA

Table A-1. Winter Year 1 raw data.

Nest Box Tree Name	Tree Species	Nest Box Design Types	Chainage	Nest Box PoM Zone	Side of Carriageway	Lat	Long	Date of Survey	Time	Weather	Sign of Fauna	Type of Evidence	Species Identification	Pest Species	Damage to Box	Maintenance Action Performed	Maintenance Action Required
K2K-NBT-01	Turpentine	3	36700-37000	AA	Eastern	-31.1414	152.8233	20.08.2016	830	unsettled, cloudy light drizzle, no wind	Yes	Antechinus stuartii using leaf nest	Antechinus stuartii				
K2K-NBT-01	Turpentine	4	36700-37000	AA	Eastern	-31.1414	152.8233	20.08.2016	830	unsettled, cloudy light drizzle, no wind	Yes	Leave nest	Glider				
K2K-NBT-02	Tallowwood	3	36700-37000	AA	Eastern	-31.1416	152.8231	20.08.2016	910	unsettled, cloudy light drizzle, no wind	No			Lots of ants			
K2K-NBT-02	Tallowwood	4	36700-37000	AA	Eastern	-31.1416	152.8231	20.08.2016	910	unsettled, cloudy light drizzle, no wind	Yes	Leave nest	Glider				
K2K-NBT-03	Coastal Blackbutt	5	36700-37000	AA	Eastern	-31.1416	152.8235	20.08.2016	935	unsettled, cloudy light wind	No						
K2K-NBT-03	Coastal Blackbutt	6	36700-37000	AA	Eastern	-31.1416	152.8235	20.08.2016	935	unsettled, cloudy light wind	Yes	Scats	Brushtail Possum	European Bee Hive			
K2K-NBT-04	Brush Box	1	36700-37000	AA	Eastern	-31.1417	152.8232	20.08.2016	1010	unsettled, cloudy light wind	Yes	Leave nest loose	Probably Antechinus				
K2K-NBT-04	Brush Box	5	36700-37000	AA	Eastern	-31.1417	152.8232	20.08.2016	1010	unsettled, cloudy light wind	Yes	Scats	Antechinus stuartii				
K2K-NBT-05	Coastal Blackbutt	5	36700-37000	AA	Eastern	-31.1418	152.8238	20.08.2016	1035	unsettled, cloudy light wind	Yes	Scats	Antechinus stuartii				
K2K-NBT-05	Coastal Blackbutt	9	36700-37000	AA	Eastern	-31.1418	152.8238	20.08.2016	1035	unsettled, cloudy light wind	Nil			Termite damage to rear of box, however, nest opened up and damaged			
K2K-NBT-06	Brush Box	2	36700-37000	AA	Eastern	-31.1418	152.8233	20.08.2016	1115	unsettled, cloudy light wind	Yes	Antechinus scats	Antechinus stuartii				
K2K-NBT-06	Brush Box	8	36700-37000	AA	Eastern	-31.1418	152.8233	20.08.2016	1115	unsettled, cloudy light wind	Yes	Leave nest	Glider				
K2K-NBT-07	Tallowwood	2	36700-37000	AA	Eastern	-31.1419	152.8232	20.08.2016	1130	fine, cloudy, light wind	Yes	Leave nest	Probably Feathertail glider				
K2K-NBT-07	Tallowwood	5	36700-37000	AA	Eastern	-31.1419	152.8232	20.08.2016	1130	fine, cloudy, light wind	Yes	Leave nest	Glider				
K2K-NBT-08	Coastal Blackbutt	4	36700-37000	AA	Eastern	-31.1419	152.8234	20.08.2016	1150	fine, cloudy, light wind	Yes	Leave nest	Glider	Old European Bee Hive		Hive Beetle Destroyed Hive	
K2K-NBT-09	Turpentine	1	36700-37000	AA	Eastern	-31.1421	152.8233	20.08.2016	1215	fine, cloudy, light wind	No						

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K2K-NBT-09	Turpentine	3	36700-37000	AA	Eastern	-31.1421	152.8233	20.08.2016	1215	fine, cloudy, light wind	Yes	Scats	Antechinus stuartii				
K2K-NBT-10	Coastal Blackbutt	3	35900-36600	Z	Eastern	-31.1493	152.8218	21.08.2016	1330	fine, no rain, light wind	No						
K2K-NBT-10	Coastal Blackbutt	4	35900-36600	Z	Eastern	-31.1493	152.8218	21.08.2016	1330	fine, no rain, light wind	Yes	Leave nest	Glider				
K2K-NBT-11	White Stringybark	2	35900-36600	Z	Eastern	-31.1495	152.8214	21.08.2016	1350	fine, no rain, light wind	Yes	Leave nest	Probably Feathertail glider				
K2K-NBT-11	White Stringybark	8	35900-36600	Z	Eastern	-31.1495	152.8214	21.08.2016	1350	fine, no rain, light wind	Yes	few leaves	Possible glider				
K2K-NBT-12	Pink Bloodwood	1	35900-36600	Z	Eastern	-31.1496	152.8215	21.08.2016	1425	fine, no rain, light wind	No						
K2K-NBT-12	Pink Bloodwood	5	35900-36600	Z	Eastern	-31.1496	152.8215	21.08.2016	1425	fine, no rain, light wind	Yes	hair	Brushtail Possum				
K2K-NBT-13	White Mahogany	2	35900-36600	Z	Eastern	-31.1497	152.8213	21.08.2016	1540	fine, no rain, light wind	Yes	Few leaves	Glider or Antechinus nest				
K2K-NBT-14	Pink Bloodwood	1	35900-36600	Z	Eastern	-31.1497	152.8213	21.08.2016	1450	fine, no rain, light wind	No						
K2K-NBT-14	Pink Bloodwood	4	35900-36600	Z	Eastern	-31.1497	152.8213	21.08.2016	1510	fine, no rain, light wind	Yes	Leave nest	Glider	Mud wasps			
K2K-NBT-15	Pink Bloodwood	3	35900-36600	Z	Eastern	-31.1498	152.8214	21.08.2016	1510	fine, no rain, light wind	Yes	Sugar Glider x 2 - leaf nest	Sugar Glider x 2				
K2K-NBT-15	Pink Bloodwood	5	35900-36600	Z	Eastern	-31.1498	152.8214	21.08.2016	1515	fine, no rain, light wind	No			European Bee Hive		Hive Beetle Destroyed Hive	
K2K-NBT-16	Coastal Blackbutt	1	32650-33600	Y	Eastern	-31.1566	152.8231	22.08.2016	810	fine, no rain, no wind	No						
K2K-NBT-16	Coastal Blackbutt	8	32650-33600	Y	Eastern	-31.1566	152.8231	22.08.2016	810	fine, no rain, no wind	Yes	Glider nest - Sugar Glider x 2	Sugar Glider x 2				
K2K-NBT-17	Grey Ironbark	2	32650-33600	Y	Eastern	-31.1568	152.8234	22.08.2016	840	fine, no rain, no wind	No						
K2K-NBT-17	Grey Ironbark	6	32650-33600	Y	Eastern	-31.1568	152.8234	22.08.2016	840	fine, no rain, no wind	Yes	Feathers + Australian Owlet Nightjar	Australian Owlet Nightjar				
K2K-NBT-18	Tallowwood	1	32650-33600	Y	Eastern	-31.1569	152.8231	22.08.2016	915	fine, no rain, no wind	Yes	Leave nest + scats	Antechinus stuartii				
K2K-NBT-18	Tallowwood	4	32650-33600	Y	Eastern	-31.1569	152.8231	22.08.2016	915	fine, no rain, no wind	No						
K2K-NBT-19	Pink Bloodwood	5	32650-33600	Y	Eastern	-31.1571	152.8231	22.08.2016	940	fine, no rain, no wind	No						
K2K-NBT-19	Pink Bloodwood	6	32650-33600	Y	Eastern	-31.1571	152.8231	22.08.2016	940	fine, no rain, no wind	Yes	Hair/fur	Brushtail Possum				
K2K-NBT-20	White Mahogany	3	32650-33600	Y	Eastern	-31.1577	152.8229	22.08.2016	1030	fine, no rain, no wind	Yes	Scats n leaves	Antechinus stuartii	Old mud wasp nests			

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K2K-NBT-20	White Mahogany	5	32650-33600	Y	Eastern	-31.1577	152.8229	22.08.2016	1030	fine, no rain, no wind	No						
K2K-NBT-21	White Mahogany	3	32650-33600	Y	Eastern	-31.1578	152.8228	22.08.2016	1055	fine, no rain, no wind	Yes	Scats	Antechinus stuartii	Ants			
K2K-NBT-21	White Mahogany	5	32650-33600	Y	Eastern	-31.1578	152.8228	22.08.2016	1055	fine, no rain, no wind	Yes	Old leaves	Possum				
K2K-NBT-22	Grey Ironbark	2	32650-33600	Y	Eastern	-31.1579	152.8229	22.08.2016	1125	fine, no rain, no wind	Yes	Leaves + Antechinus	Antechinus stuartii				
K2K-NBT-22	Grey Ironbark	8	32650-33600	Y	Eastern	-31.1579	152.8229	22.08.2016	1125	fine, no rain, no wind	No	No	No				
K2K-NBT-23	White Mahogany	4	32650-33600	Y	Eastern	-31.158	152.8231	22.08.2016	1150	fine, no rain, no wind	Yes	Leave nest	Glider				
K2K-NBT-23	White Mahogany	5	32650-33600	Y	Eastern	-31.158	152.8231	22.08.2016	1150	fine, no rain, no wind	No			Ants and Huntsman Spider			
K2K-NBT-24	Coastal Blackbutt	5	32650-33600	Y	Eastern	-31.1605	152.8232	22.08.2016	1205	fine, no rain, no wind	Yes	Hair/fir possum	Brushtail Possum	Ants			
K2K-NBT-24	Coastal Blackbutt	7	32650-33600	Y	Eastern	-31.1605	152.8232	22.08.2016	1205	fine, no rain, no wind	No			Ants			
K2K-NBT-25	Scribbly Gum	5	32650-33600	Y	Eastern	-31.1605	152.8229	22.08.2016	1225	fine, no rain, no wind	Yes	Scats	Antechinus stuartii				
K2K-NBT-25	Scribbly Gum	9	32650-33600	Y	Eastern	-31.1605	152.8229	22.08.2016	1225	fine, no rain, no wind	No						
K2K-NBT-26	White Mahogany	3	32650-33600	X	Eastern	-31.1694	152.8226	22.08.2016	1315	fine, no rain, no wind	No					Loose wire so tightened up again	
K2K-NBT-26	White Mahogany	8	32650-33600	X	Eastern	-31.1694	152.8226	22.08.2016	1315	fine, no rain, no wind	No						
K2K-NBT-27	Pink Bloodwood	1	32650-33600	X	Eastern	-31.1695	152.8225	22.08.2016	1340	fine, no rain, no wind	No						
K2K-NBT-27	Pink Bloodwood	8	32650-33600	X	Eastern	-31.1695	152.8225	22.08.2016	1340	fine, no rain, no wind	Yes	leave nest	Glider				
K2K-NBT-28	White Stringybark	2	32650-33600	X	Eastern	-31.1697	152.8226	22.08.2016	1400	fine, no rain, no wind	No						
K2K-NBT-28	White Stringybark	5	32650-33600	X	Eastern	-31.1697	152.8226	22.08.2016	1400	fine, no rain, no wind	No			Huntsman Spider			
K2K-NBT-29	Coastal Blackbutt	7	32650-33600	X	Eastern	-31.1744	152.8247	22.08.2016	1430	fine, no rain, no wind	No			Ants			
K2K-NBT-30	Small-fruited Grey Gum	5	32650-33600	X	Eastern	-31.1781	152.8253	22.08.2016	1500	fine, no rain, no wind	Yes	Hair/fur	Brushtail Possum				
K2K-NBT-30	Small-fruited Grey Gum	9	32650-33600	X	Eastern	-31.1781	152.8253	22.08.2016	1500	fine, no rain, no wind	No			Ants			
K2K-NBT-31	Tallowwood	1	28500-29300	V	Western	-31.213	152.8225	28.08.2016	840	unsettled, recent heavy	No						

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										rain, light wind, cloudy							
K2K-NBT-31	Tallowwood	3	28500-29300	V	Western	-31.213	152.8225	28.08.2016	840	unsettled, recent heavy rain, light wind, cloudy	Yes	Leaf nest + Sugar Glider	Sugar Glider x 2				
K2K-NBT-32	Small-fruited Grey Gum	3	28500-29300	V	Western	-31.2131	152.8225	28.08.2016	910	unsettled, recent heavy rain, light wind, cloudy	No			Ants			
K2K-NBT-32	Small-fruited Grey Gum	8	28500-29300	V	Western	-31.2131	152.8225	28.08.2016	910	unsettled, recent heavy rain, light wind, cloudy	Yes	Few leaves and hair/fur	Common Ringtail Possum				
K2K-NBT-33	Grey Ironbark	1	28500-29300	V	Western	-31.2132	152.8223	28.08.2016	935	unsettled, recent heavy rain, light wind, cloudy	No			Spider webs			
K2K-NBT-33	Grey Ironbark	2	28500-29300	V	Western	-31.2132	152.8223	28.08.2016	935	unsettled, recent heavy rain, light wind, cloudy	Yes	Bat scat	Micro bat				
K2K-NBT-34	Tallowwood	3	28500-29300	V	Western	-31.2133	152.8224	28.08.2016	1010	unsettled, recent heavy rain, light wind, cloudy	No	Native Bee hive					
K2K-NBT-34	Tallowwood	5	28500-29300	V	Western	-31.2133	152.8224	28.08.2016	1010	unsettled, recent heavy rain, light wind, cloudy	Yes	Hair	Brushtail Possum				
K2K-NBT-35	Scribbly Gum	2	28500-29300	V	Western	-31.2138	152.8227	28.08.2016	1035	unsettled, recent heavy rain, light wind, cloudy	Yes	Bat scat	Micro bats				
K2K-NBT-35	Scribbly Gum	8	28500-29300	V	Western	-31.2138	152.8227	28.08.2016	1035	unsettled, recent heavy rain, light wind, cloudy	Yes	Few leaves	Probably glider				
K2K-NBT-36	Pink Bloodwood	1	28500-29300	V	Western	-31.214	152.8224	28.08.2016	1100	unsettled, recent heavy rain, light wind, cloudy	No			Ants			

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K2K-NBT-36	Pink Bloodwood	5	28500-29300	V	Western	-31.214	152.8224	28.08.2016	1100	unsettled, recent heavy rain, light wind, cloudy	Yes	Scats	Brushtail Possum				
K2K-NBT-37	Flooded Gum	5	25150-25750	U	Eastern	-31.2434	152.8245	28.08.2016	1230	unsettled, recent heavy rain, light wind, cloudy	No			Lots of ants			
K2K-NBT-37	Flooded Gum	9	25150-25750	U	Eastern	-31.2434	152.8245	28.08.2016	1230	unsettled, recent heavy rain, light wind, cloudy	Yes	Scats	Brushtail Possum				
K2K-NBT-38	Grey Ironbark	1	25150-25750	U	Eastern	-31.2436	152.8245	28.08.2016	1255	unsettled, recent heavy rain, light wind, cloudy	Yes	Leaf nest	Glider				
K2K-NBT-38	Grey Ironbark	3	25150-25750	U	Eastern	-31.2436	152.8245	28.08.2016	1255	unsettled, recent heavy rain, light wind, cloudy	Yes	Leaf nest	Glider				
K2K-NBT-39	Tallowwood	4	25150-25750	U	Eastern	-31.2436	152.8247	28.08.2016	1315	unsettled, recent heavy rain, light wind, cloudy	No			Old European Bee Hive		Hive beetle destroyed hive	
K2K-NBT-39	Tallowwood	5	25150-25750	U	Eastern	-31.2436	152.8247	28.08.2016	1315	unsettled, recent heavy rain, light wind, cloudy	No						
K2K-NBT-40	Grey Ironbark	3	25150-25750	U	Eastern	-31.2433	152.8242	28.08.2016	1335	unsettled, recent heavy rain, light wind, cloudy	No						
K2K-NBT-40	Grey Ironbark	8	25150-25750	U	Eastern	-31.2433	152.8242	28.08.2016	1335	unsettled, recent heavy rain, light wind, cloudy	Yes	Loose old dead leaves	Likely Brushtail Possum				
K2K-NBT-41	Brush Box	2	25150-25750	U	Eastern	-31.2439	152.8246	28.08.2016	1405	unsettled, recent heavy rain, light wind, cloudy	Yes	bat scat	micro bat				
K2K-NBT-41	Brush Box	5	25150-25750	U	Eastern	-31.2439	152.8246	28.08.2016	1405	unsettled, recent heavy rain, light	Yes	Scratches from Possum	Probably Brushtail Possum				

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										wind, cloudy							
K2K-NBT-42	White Mahogany	2	25150-25750	U	Eastern	-31.2448	152.8243	28.08.2016	1425	unsettled, recent heavy rain, light wind, cloudy	No						
K2K-NBT-42	White Mahogany	6	25150-25750	U	Eastern	-31.2448	152.8243	28.08.2016	1425	unsettled, recent heavy rain, light wind, cloudy	Yes	Feathers	Australian Owlet Nightjar				
K2K-NBT-43	Grey Ironbark	2	25150-25750	U	Eastern	-31.2448	152.8243	28.08.2016	1500	unsettled, recent heavy rain, light wind, cloudy	No				Top lid delaminating		Continue to monitor
K2K-NBT-43	Grey Ironbark	8	25150-25750	U	Eastern	-31.2448	152.8243	28.08.2016	1500	unsettled, recent heavy rain, light wind, cloudy	No			Old European Bee Hive		Hive beetle destroyed hive	
K2K-NBT-44	White Mahogany	1	25150-25750	U	Eastern	-31.2449	152.8238	03.09.2016	1435	sunny, clear, light wind	No			Ants			
K2K-NBT-44	White Mahogany	3	25150-25750	U	Eastern	-31.2449	152.8238	03.09.2016	1435	sunny, clear, light wind	No			Ants and old European Bee Hive		Hive beetle destroyed hive	
K2K-NBT-45	Pink Bloodwood	3	25150-25750	U	Eastern	-31.245	152.8237	03.09.2016	1510	sunny, clear, light wind	No			Ants			
K2K-NBT-45	Pink Bloodwood	4	25150-25750	U	Eastern	-31.245	152.8237	03.09.2016	1510	sunny, clear, light wind	No			Old European Bee Hive		Hive beetle destroyed hive	
K2K-NBT-46	White Mahogany	1	25150-25750	U	Eastern	-31.245	152.8245	03.09.2016	1545	sunny, clear, light wind	Yes	Glider nest + Sugar Glider	Sugar Glider x 2				
K2K-NBT-46	White Mahogany	4	25150-25750	U	Eastern	-31.245	152.8245	03.09.2016	1545	sunny, clear, light wind	No			Old European Bee Hive		Hive beetle destroyed hive	
K2K-NBT-47	White Mahogany	3	25150-25750	U	Eastern	-31.245	152.8242	03.09.2016	1600	sunny, clear, light wind	No			Few Ants			
K2K-NBT-47	White Mahogany	5	25150-25750	U	Eastern	-31.245	152.8242	03.09.2016	1600	sunny, clear, light wind	No						
K2K-NBT-48	White Mahogany	2	24600-25450	T	Western	-31.2479	152.82	03.09.2016	1635	sunny, clear, light wind	No						
K2K-NBT-48	White Mahogany	5	24600-25450	T	Western	-31.2479	152.82	03.09.2016	1635	sunny, clear, light wind	No			Old Ant Nest			
K2K-NBT-49	Pink Bloodwood	2	24600-25450	T	Western	-31.2481	152.8199	03.09.2016	1655	sunny, clear, light wind	No						
K2K-NBT-49	Pink Bloodwood	4	24600-25450	T	Western	-31.2481	152.8199	03.09.2016	1655	sunny, clear, light wind	No					Lid re-aligned as it was slightly open by 30 mm	

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K2K-NBT-50	Tallowwood	1	24600-25450	T	Western	-31.2483	152.8201	03.09.2016	1710	sunny, clear, light wind	No			Ant nest			
K2K-NBT-50	Tallowwood	5	24600-25450	T	Western	-31.2483	152.8201	03.09.2016	1710	sunny, clear, light wind	No			Ant nest			
K2K-NBT-51	Tallowwood	4	24600-25450	T	Western	-31.2483	152.8199	03.09.2016	1730	sunny, clear, light wind	No			Old European Bee Hive		Hive beetle destroyed	
K2K-NBT-51	Tallowwood	5	24600-25450	T	Western	-31.2483	152.8199	03.09.2016	1730	sunny, clear, light wind	No			Ant nest			
K2K-NBT-52	White Stringybark	3	24600-25450	T	Western	-31.2484	152.8198	04.09.2016	750	sunny, clear, light wind	Yes	Few leaves	Possible Antechinus or glider				
K2K-NBT-52	White Stringybark	8	24600-25450	T	Western	-31.2484	152.8198	04.09.2016	750	sunny, clear, light wind	No						
K2K-NBT-53	Tallowwood	1	24600-25450	T	Eastern	-31.2484	152.8233	04.09.2016	825	sunny, clear, light wind	Yes	Fresh leaves + Antechinus	Antechinus stuartii	Ants			
K2K-NBT-53	Tallowwood	3	24600-25450	T	Eastern	-31.2484	152.8233	04.09.2016	825	sunny, clear, light wind	Yes	Leaf nest	Gliders				
K2K-NBT-54	Red Mahogany	3	24600-25450	T	Eastern	-31.2485	152.8232	04.09.2016	900	sunny, clear, light wind	Yes	Messy leaf nest	Possible Antechinus	Old European Bee Hive		Hive beetle destroyed hive	
K2K-NBT-54	Red Mahogany	4	24600-25450	T	Eastern	-31.2485	152.8232	04.09.2016	900	sunny, clear, light wind	No			Ants			
K2K-NBT-55	Pink Bloodwood	1	24600-25450	T	Eastern	-31.2487	152.8231	04.09.2016	930	sunny, clear, light wind	Yes	Leaf nest + Sugar Glider x 1	Sugar Glider x 1				
K2K-NBT-55	Pink Bloodwood	8	24600-25450	T	Eastern	-31.2487	152.8231	04.09.2016	930	sunny, clear, light wind	No			Ants			
K2K-NBT-56	Brush Box	1	24600-25450	T	Eastern	-31.2489	152.823	04.09.2016	950	sunny, clear, light wind	No			Ants			
K2K-NBT-56	Brush Box	3	24600-25450	T	Eastern	-31.2489	152.823	04.09.2016	950	sunny, clear, light wind	No			Ants			
K2K-NBT-57	Brush Box	2	24600-25450	T	Eastern	-31.2492	152.8229	04.09.2016	1015	sunny, clear, light wind	Yes	scats	micro bat				
K2K-NBT-57	Brush Box	4	24600-25450	T	Eastern	-31.2492	152.8229	04.09.2016	1015	sunny, clear, light wind	No			Ants			
K2K-NBT-58	Brush Box	1	24100-24600	S	Western	-31.2498	152.8202	04.09.2016	1120	sunny, clear, light wind	No			Ants			
K2K-NBT-58	Brush Box	4	24100-24600	S	Western	-31.2498	152.8202	04.09.2016	1120	sunny, clear, light wind	No						
K2K-NBT-59	Tallowwood	3	24100-24600	S	Western	-31.25	152.8203	04.09.2016	1140	sunny, clear, light wind	No						
K2K-NBT-59	Tallowwood	5	24100-24600	S	Western	-31.25	152.8203	04.09.2016	1140	sunny, clear, light wind	No			Huntsman Spiders			
K2K-NBT-60	White Mahogany	4	24100-24600	S	Western	-31.25	152.8203	04.09.2016	1155	sunny, clear, light wind	No			Ants and Old European Bee Hive		Hive Beatle Destroyed Hive	

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K2K-NBT-60	White Mahogany	5	24100-24600	S	Western	-31.25	152.8203	04.09.2016	1155	sunny, clear, light wind	No						
K2K-NBT-61	Pink Bloodwood	5	24100-24600	S	Western	-31.2502	152.8202	04.09.2016	1220	sunny, clear, light wind	No			Ants			
K2K-NBT-61	Pink Bloodwood	6	24100-24600	S	Western	-31.2502	152.8202	04.09.2016	1220	sunny, clear, light wind	No			Ants			
K2K-NBT-62	Tallowwood	7	24600-25450	T	Eastern	-31.2503	152.8227	04.09.2016	1255	sunny, clear, light wind	No						
K2K-NBT-63	Small-fruited Grey Gum	3	24600-25450	T	Eastern	-31.2503	152.822	04.09.2016	1310	sunny, clear, light wind	Yes	Leaf nest	Glider				
K2K-NBT-63	Small-fruited Grey Gum	4	24600-25450	T	Eastern	-31.2503	152.822	04.09.2016	1310	sunny, clear, light wind	Yes	Old dead leaves	Glider	Old European Bee Hive		Hive beetle destroyed hive	
K2K-NBT-64	Grey Ironbark	3	24600-25450	T	Eastern	-31.2504	152.8224	04.09.2016	1335	sunny, clear, light wind	no			Ants			Monitoring the extent of rot
K2K-NBT-64	Grey Ironbark	4	24600-25450	T	Eastern	-31.2504	152.8224	04.09.2016	1335	sunny, clear, light wind	no			Ants			
K2K-NBT-65	Tallowwood	6	24600-25450	T	Eastern	-31.2504	152.8224	04.09.2016	1355	sunny, clear, light wind	Yes	Leaves - fresh	Possum	Old European Bee Hive		Hive beetle destroyed hive	
K2K-NBT-66	Small-fruited Grey Gum	3	24600-25450	T	Eastern	-31.2505	152.8218	04.09.2016	1420	sunny, clear, light wind	no			Ants			
K2K-NBT-66	Small-fruited Grey Gum	8	24600-25450	T	Eastern	-31.2505	152.8218	04.09.2016	1420	sunny, clear, light wind	no			Ants			
K2K-NBT-67	Tallowwood	5	24600-25450	T	Eastern	-31.2507	152.8224	04.09.2016	1455	sunny, clear, light wind	No						
K2K-NBT-67	Tallowwood	9	24600-25450	T	Eastern	-31.2507	152.8224	04.09.2016	1455	sunny, clear, light wind	No						
K2K-NBT-68	Tallowwood	3	24600-25450	T	Eastern	-31.2508	152.8215	04.09.2016	1520	sunny, clear, light wind	No			Ants and Huntsman Spider			
K2K-NBT-68	Tallowwood	4	24600-25450	T	Eastern	-31.2508	152.8215	04.09.2016	1520	sunny, clear, light wind	No			Ants			
K2K-NBT-69	Pink Bloodwood	2	24600-25450	T	Eastern	-31.2509	152.8213	04.09.2016	1535	sunny, clear, light wind	Yes	Glider nest + Feathertails x 2	Feathertail Gliders x 2				
K2K-NBT-70	Tallowwood	6	24600-25450	T	Eastern	-31.2509	152.8214	04.09.2016	1605	sunny, clear, light wind	Yes	Hair/fur	Brushtail Possum				
K2K-NBT-71	Flooded Gum	2	24600-25450	T	Eastern	-31.2511	152.8213	04.09.2016	1625	sunny, clear, light wind	No						
K2K-NBT-71	Flooded Gum	4	24600-25450	T	Eastern	-31.2511	152.8213	04.09.2016	1625	sunny, clear, light wind	No						
K2K-NBT-72	Turpentine	4	24100-24600	S	Eastern	-31.2546	152.8187	25.09.2016	1000	unsettled, light wind, partly cloudy	No			Ants			

Nest Box Tree Name	Tree Species	Nest Box Design Types	Chainage	Nest Box PoM Zone	Side of Carriageway	Lat	Long	Date of Survey	Time	Weather	Sign of Fauna	Type of Evidence	Species Identification	Pest Species	Damage to Box	Maintenance Action Performed	Maintenance Action Required
K2K-NBT-72	Turpentine	5	24100-24600	S	Eastern	-31.2546	152.8187	25.09.2016	1000	unsettled, light wind, partly cloudy	Yes	Leaf nest with some age/old	Glider				
K2K-NBT-73	Pink Bloodwood	4	24100-24600	S	Eastern	-31.2546	152.8187	25.09.2016	1035	fine, light wind, no rain	No			Old European Bee Hive		Hive Beetle Destroyed Hive	
K2K-NBT-73	Pink Bloodwood	5	24100-24600	S	Eastern	-31.2546	152.8187	25.09.2016	1035	fine, light wind, no rain	Yes	Scratches	Brushtail Possum				
K2K-NBT-74	Grey Ironbark	7	24100-24600	S	Eastern	-31.2547	152.8188	25.09.2016	1100	fine, light wind, no rain	No			Ants			
K2K-NBT-75	Pink Bloodwood	1	24100-24600	S	Eastern	-31.2548	152.8188	25.09.2016	1120	fine, light wind, no rain	Yes	Leaf nest	Glider				
K2K-NBT-75	Pink Bloodwood	8	24100-24600	S	Eastern	-31.2548	152.8188	25.09.2016	1120	fine, light wind, no rain	No						
K2K-NBT-76	Brush Box	1	24100-24600	S	Eastern	-31.2548	152.8186	25.09.2016	1155	fine, light wind, no rain	No						
K2K-NBT-76	Brush Box	5	24100-24600	S	Eastern	-31.2548	152.8186	25.09.2016	1155	fine, light wind, no rain	Yes	Leaf nest	Glider				
K2K-NBT-77	Grey Ironbark	5	24100-24600	S	Eastern	-31.2549	152.8186	25.09.2016	1230	fine, light wind, no rain	yes	Scats	Antechinus stuartii			Rewired as too loose	
K2K-NBT-77	Grey Ironbark	9	24100-24600	S	Eastern	-31.2549	152.8186	25.09.2016	1230	fine, light wind, no rain	no			ants			
K2K-NBT-78	Brush Box	3	24100-24600	S	Eastern	-31.2549	152.8189	25.09.2016	1255	fine, light wind, no rain	No			Ants and Huntsman Spider			
K2K-NBT-78	Brush Box	8	24100-24600	S	Eastern	-31.2549	152.8189	25.09.2016	1255	fine, light wind, no rain	Yes	Leaf nest	Glider				
K2K-NBT-79	Turpentine	1	24100-24600	S	Eastern	-31.2549	152.8187	25.09.2016	1330	fine, light wind, no rain	Yes	Old leaf nest and some scats	Antechinus stuartii				
K2K-NBT-79	Turpentine	3	24100-24600	S	Eastern	-31.2549	152.8187	25.09.2016	1330	fine, light wind, no rain	No			Ants			
K2K-NBT-80	Coastal Blackbutt	1	32650-33600	X	Eastern	-31.1701	152.8232	22.08.2016	1625	fine, no rain, no wind	No						
K2K-NBT-80	Coastal Blackbutt	2	32650-33600	X	Eastern	-31.1701	152.8232	22.08.2016	1625	fine, no rain, no wind	No						
K2K-NBT-81	Pink Bloodwood	1	32650-33600	X	Eastern	-31.1699	152.8233	22.08.2016	1655	fine, no rain, no wind	Yes	Scats	Antechinus stuartii				
K2K-NBT-81	Pink Bloodwood	8	32650-33600	X	Eastern	-31.1699	152.8233	22.08.2016	1655	fine, no rain, no wind	Yes	Leaf nest + Sugar Glider x 1	Sugar Glider x 1				
K2K-NBT-82	Turpentine	1	32650-33600	X	Eastern	-31.1699	152.8231	22.08.2016	1720	fine, no rain, no wind	No			Ants			
K2K-NBT-82	Turpentine	5	32650-33600	X	Eastern	-31.1699	152.8231	22.08.2016	1720	fine, no rain, no wind	Yes	Lace Monitor - young one - yearling					

Table A-2. Summer Year 1 raw data.

Nest Box Tree Name	Tree Species	Nest Box Design Types	Chainage	Nest Box PoM Zone	Side of Carriageway	Lat	Long	Date of Survey	Time	Weather	Sign of Fauna	Type of Evidence	Species Identification	Pest Species	Damage to Box	Maintenance Action Performed	Maintenance Action Required
K2K-NBT-01	Turpentine	3	36700-37000	AA	Eastern	-31.1414	152.8233	11.03.2017	1150	fine, 27 deg, light wind	no				Lost in November Fire	Replaced with Design 2 (Bat Wedge)	
K2K-NBT-01	Turpentine	4	36700-37000	AA	Eastern	-31.1414	152.8233	11.03.2017	1150	fine, 27 deg, light wind	no				Lost in November Fire	Replaced with Design 1 (Scansorial)	
K2K-NBT-02	Tallowwood	3	36700-37000	AA	Eastern	-31.1416	152.8231	11.03.2017	1225	fine, 27 deg, light wind	no			Lots of ants	Nil		
K2K-NBT-02	Tallowwood	4	36700-37000	AA	Eastern	-31.1416	152.8231	11.03.2017	1225	fine, 27 deg, light wind	no				Lost in November Fire	Replaced with Design 8 (Parrot)	
K2K-NBT-03	Coastal Blackbutt	5	36700-37000	AA	Eastern	-31.1416	152.8235	11.03.2017	1255	fine, 27 deg, light wind	no						
K2K-NBT-03	Coastal Blackbutt	6	36700-37000	AA	Eastern	-31.1416	152.8235	11.03.2017	1255	fine, 27 deg, light wind	no			European Bee Hive			Probably just monitor given hive beetle will eventually destroy the hive
K2K-NBT-04	Brush Box	1	36700-37000	AA	Eastern	-31.1417	152.8232	11.03.2017	1315	fine, 27 deg, light wind	Yes	Old leave nest and scats in corner probably Antechinus	Antechinus stuartii				
K2K-NBT-04	Brush Box	5	36700-37000	AA	Eastern	-31.1417	152.8232	11.03.2017	1315	fine, 27 deg, light wind	Yes	Lace monitor sheath and scats from likely Antechinus	Lace Monitor and Antechinus				
K2K-NBT-05	Coastal Blackbutt	5	36700-37000	AA	Eastern	-31.1418	152.8238	11.03.2017	1335	fine, 27 deg, light wind	no			Termite damage to rear of box, however, nest opened up and damaged			
K2K-NBT-05	Coastal Blackbutt	9	36700-37000	AA	Eastern	-31.1418	152.8238	11.03.2017	1335	fine, 27 deg, light wind	Yes	Antechinus scats and shredded coakcroaches					
K2K-NBT-06	Brush Box	2	36700-37000	AA	Eastern	-31.1418	152.8233	11.03.2017	1405	fine, 27 deg, light wind	no				Burnt out bottom from November 2016 fire	Replaced with Design 8 but slightly higher above the expected flame zone	
K2K-NBT-06	Brush Box	8	36700-37000	AA	Eastern	-31.1418	152.8233	11.03.2017	1405	fine, 27 deg, light wind	Yes	Antechinus scats					
K2K-NBT-07	Tallowwood	2	36700-37000	AA	Eastern	-31.1419	152.8232	11.03.2017	1425	fine, 27 deg, light wind	no				Lost in November 2016 fire	Replaced with Design 3	
K2K-NBT-07	Tallowwood	5	36700-37000	AA	Eastern	-31.1419	152.8232	11.03.2017	1440	fine, 27 deg, light wind	Yes	Large glider leaf nest	Possibly Yellow-bellied Glider				
K2K-NBT-08	Coastal Blackbutt	4	36700-37000	AA	Eastern	-31.1419	152.8234	11.03.2017	1440	fine, 27 deg, light wind	Yes	Yellow-bellied Glider x 2	Yellow-bellied Glider	Old European Bee Hive			
K2K-NBT-09	Turpentine	1	36700-37000	AA	Eastern	-31.1421	152.8233	11.03.2017	1510	fine, 27 deg, light wind	no				Lost in November 2016 fire	Replaced with Design 1 (Scansorial)	
K2K-NBT-09	Turpentine	3	36700-37000	AA	Eastern	-31.1421	152.8233	11.03.2017	1510	fine, 27 deg, light wind	no				Lost in November 2016 fire	Replaced with Design 3 (Scansorial)	

Nest Box Tree Name	Tree Species	Nest Box Design Types	Chainage	Nest Box PoM Zone	Side of Carriageway	Lat	Long	Date of Survey	Time	Weather	Sign of Fauna	Type of Evidence	Species Identification	Pest Species	Damage to Box	Maintenance Action Performed	Maintenance Action Required
K2K-NBT-10	Coastal Blackbutt	3	35900-36600	Z	Eastern	-31.1493	152.8218	11.03.2017	1520	fine, 27 deg, light wind	no				Lost in November 2016 fire	Replaced with Design 4 (Rear Entry Glider)	
K2K-NBT-10	Coastal Blackbutt	4	35900-36600	Z	Eastern	-31.1493	152.8218	11.03.2017	1520	fine, 27 deg, light wind	no				Lost in November 2016 fire	Replaced with Design 3 (Scansorial)	
K2K-NBT-11	White Stringybark	2	35900-36600	Z	Eastern	-31.1495	152.8214	11.03.2017	1545	fine, 27 deg, light wind	no				Lost in November 2016 fire	Replaced with Design 2 (Bat Wedge)	
K2K-NBT-11	White Stringybark	8	35900-36600	Z	Eastern	-31.1495	152.8214	11.03.2017	1545	fine, 27 deg, light wind	no				Lost in November 2016 fire	Replaced with Design 5 (Possum)	
K2K-NBT-12	Pink Bloodwood	1	35900-36600	Z	Eastern	-31.1496	152.8215	11.03.2017	1600	fine, 27 deg, light wind	no				Lost in November 2016 fire	Replaced with Design 1 (Scansorial)	Update the GIS layer as new location in White Stringybark around 30 m south
K2K-NBT-12	Pink Bloodwood	5	35900-36600	Z	Eastern	-31.1496	152.8215	11.03.2017	1615	fine, 27 deg, light wind	no				Lost in November 2016 fire	Replaced with Design 8 (Parrot)	Update the GIS layer as new location in White Stringybark around 30 m south
K2K-NBT-13	White Mahogany	2	35900-36600	Z	Eastern	-31.1497	152.8213	11.03.2017	1615	fine, 27 deg, light wind	no				Lost in November 2016 fire	Replaced with Design 3 (Scansorial)	Update the GIS layer as new location in White Mahogany around 30 m south
K2K-NBT-14	Pink Bloodwood	1	35900-36600	Z	Eastern	-31.1497	152.8213	11.03.2017	1640	fine, 27 deg, light wind	no				Lost in November 2016 fire	Replaced with Design 2 (Bat Wedge)	
K2K-NBT-14	Pink Bloodwood	4	35900-36600	Z	Eastern	-31.1497	152.8213	11.03.2017	1640	fine, 27 deg, light wind	no			Mud wasps			
K2K-NBT-15	Pink Bloodwood	3	35900-36600	Z	Eastern	-31.1498	152.8214	12.03.2017	800	fine, 23 deg, nil wind	no				Lost in November 2016 fire	Replaced with Design 1 (Scansorial)	
K2K-NBT-15	Pink Bloodwood	5	35900-36600	Z	Eastern	-31.1498	152.8214	12.03.2017	800	fine, 23 deg, nil wind	no				Lost in November 2016 fire	Replaced with Design 8 (Parrot)	
K2K-NBT-16	Coastal Blackbutt	1	32650-33600	Y	Eastern	-31.1566	152.8231	12.03.2017	830	fine, 23 deg, nil wind	no				Lost in November 2016 fire	Replaced with Design 2 (Bat Wedge)	
K2K-NBT-16	Coastal Blackbutt	8	32650-33600	Y	Eastern	-31.1566	152.8231	12.03.2017	830	fine, 23 deg, nil wind	Yes	Older glider nest	Sugar Gliders			Box straightened up on the tree	
K2K-NBT-17	Grey Ironbark	2	32650-33600	Y	Eastern	-31.1568	152.8234	12.03.2017	900	fine, 23 deg, nil wind	no				Lost in November 2016 fire	Replaced with Design 1 (Scansorial)	Update the GIS layer as new location 20 m south as recipient tree had burnt out
K2K-NBT-17	Grey Ironbark	6	32650-33600	Y	Eastern	-31.1568	152.8234	12.03.2017	900	fine, 23 deg, nil wind	no				Lost in November 2016 fire	Replaced with Design 8 (Parrot)	Update the GIS layer as new location 20 m south as recipient tree had burnt out
K2K-NBT-18	Tallowwood	1	32650-33600	Y	Eastern	-31.1569	152.8231	12.03.2017	920	fine, 23 deg, nil wind	no						
K2K-NBT-18	Tallowwood	4	32650-33600	Y	Eastern	-31.1569	152.8231	12.03.2017	920	fine, 23 deg, nil wind	Yes	Leave nest + scats	Antechinus stuartii				

Nest Box Tree Name	Tree Species	Nest Box Design Types	Chainage	Nest Box PoM Zone	Side of Carriageway	Lat	Long	Date of Survey	Time	Weather	Sign of Fauna	Type of Evidence	Species Identification	Pest Species	Damage to Box	Maintenance Action Performed	Maintenance Action Required
K2K-NBT-19	Pink Bloodwood	5	32650-33600	Y	Eastern	-31.1571	152.8231	12.03.2017	1005	fine, 23 deg, nil wind	no						
K2K-NBT-19	Pink Bloodwood	6	32650-33600	Y	Eastern	-31.1571	152.8231	12.03.2017	1005	fine, 23 deg, nil wind	no				Lost in November 2016 fire	Replaced with Design 1 (Scansorial)	
K2K-NBT-20	White Mahogany	3	32650-33600	Y	Eastern	-31.1577	152.8229	12.03.2017	1030	fine, 23 deg, nil wind	no			Old mud wasp nests			
K2K-NBT-20	White Mahogany	5	32650-33600	Y	Eastern	-31.1577	152.8229	12.03.2017	1030	fine, 23 deg, nil wind	no				Lost in November 2016 fire	Replaced with Design 1 (Scansorial)	
K2K-NBT-21	White Mahogany	3	32650-33600	Y	Eastern	-31.1578	152.8228	12.03.2017	1055	fine, 23 deg, nil wind	no				Lost in November 2016 fire	Discontinued and new tree located as NBT 86	Update GIS layer with new information
K2K-NBT-21	White Mahogany	5	32650-33600	Y	Eastern	-31.1578	152.8228	12.03.2017	1055	fine, 23 deg, nil wind	no				Lost in November 2016 fire	Discontinued and new tree located as NBT 86	Update GIS layer with new information
K2K-NBT-22	Grey Ironbark	2	32650-33600	Y	Eastern	-31.1579	152.8229	12.03.2017	1120	fine, 23 deg, nil wind	no				Lost in November 2016 fire	Replaced with Design 1 (Scansorial)	
K2K-NBT-22	Grey Ironbark	8	32650-33600	Y	Eastern	-31.1579	152.8229	12.03.2017	1120	fine, 23 deg, nil wind	Yes	Dry green leaves of glider nest	Probably Sugar Glider				
K2K-NBT-23	White Mahogany	4	32650-33600	Y	Eastern	-31.158	152.8231	12.03.2017	1150	fine, 23 deg, nil wind	no				Lost in November 2016 fire	Replaced with NBT 89 downslope with Design types 4 (Rear Entry Glider and Possum)	Update GIS layer with new information
K2K-NBT-23	White Mahogany	5	32650-33600	Y	Eastern	-31.158	152.8231	12.03.2017	1150	fine, 23 deg, nil wind	no				Lost in November 2016 fire	Replaced with NBT 89 downslope with Design types 4 (Rear Entry Glider and Possum)	Update GIS layer with new information
K2K-NBT-24	Coastal Blackbutt	5	32650-33600	Y	Eastern	-31.1605	152.8232	12.03.2017	1220	fine, 23 deg, nil wind	no			Old ant nest but no ants			
K2K-NBT-24	Coastal Blackbutt	7	32650-33600	Y	Eastern	-31.1605	152.8232	12.03.2017	1220	fine, 23 deg, nil wind	no			Huntsmen Spiders x 2 and old ant nest			
K2K-NBT-25	Scribbly Gum	5	32650-33600	Y	Eastern	-31.1605	152.8229	12.03.2017	1335	fine, 23 deg, nil wind	no				Bottom of box burnt out	Replaced with another D5 possum but left damaged box out as has potential as a bat roost	
K2K-NBT-25	Scribbly Gum	9	32650-33600	Y	Eastern	-31.1605	152.8229	12.03.2017	1335	fine, 23 deg, nil wind	no						
K2K-NBT-26	White Mahogany	3	32650-33600	X	Eastern	-31.1694	152.8226	12.03.2017	1400	fine, 23 deg, nil wind	no					Loose wire so tightened up again	
K2K-NBT-26	White Mahogany	8	32650-33600	X	Eastern	-31.1694	152.8226	12.03.2017	1400	fine, 23 deg, nil wind	no						

Nest Box Tree Name	Tree Species	Nest Box Design Types	Chainage	Nest Box PoM Zone	Side of Carriageway	Lat	Long	Date of Survey	Time	Weather	Sign of Fauna	Type of Evidence	Species Identification	Pest Species	Damage to Box	Maintenance Action Performed	Maintenance Action Required
K2K-NBT-27	Pink Bloodwood	1	32650-33600	X	Eastern	-31.1695	152.8225	12.03.2017	1430	fine, 23 deg, nil wind	no						
K2K-NBT-27	Pink Bloodwood	8	32650-33600	X	Eastern	-31.1695	152.8225	12.03.2017	1430	fine, 23 deg, nil wind	Yes	Glider nest with green leaves					
K2K-NBT-28	White Stringybark	2	32650-33600	X	Eastern	-31.1697	152.8226	12.03.2017	1450	fine, 23 deg, nil wind	No			Huntsman Spider			
K2K-NBT-28	White Stringybark	5	32650-33600	X	Eastern	-31.1697	152.8226	12.03.2017	1510	fine, 23 deg, nil wind	Yes	Recent feathertail glider nest	Feathertail Glider				
K2K-NBT-29	Coastal Blackbutt	7	32650-33600	X	Eastern	-31.1744	152.8247	12.03.2017	1510	fine, 23 deg, nil wind	No				Lost in November 2016 fire	Relocate in nearby suitable tree with new box.	Update GIS layer with new information
K2K-NBT-30	Small-fruited Grey Gum	5	32650-33600	X	Eastern	-31.1781	152.8253	11.03.2017	800	fine, 24 deg, light wind	No				Lost in November 2016 fire	Relocate in nearby suitable tree with new box.	Update GIS layer with new information
K2K-NBT-30	Small-fruited Grey Gum	9	32650-33600	X	Eastern	-31.1781	152.8253	11.03.2017	800	fine, 24 deg, light wind	No				Lost in November 2016 fire	Relocate in nearby suitable tree with new box.	Update GIS layer with new information
K2K-NBT-31	Tallowwood	1	28500-29300	V	Western	-31.213	152.8225	11.03.2017	825	fine, 24 deg, light wind	No						
K2K-NBT-31	Tallowwood	3	28500-29300	V	Western	-31.213	152.8225	11.03.2017	825	fine, 24 deg, light wind	Yes	Old well-constructed leave nest (gliders)	Probably Sugar or Squirrel Glider				
K2K-NBT-32	Small-fruited Grey Gum	3	28500-29300	V	Western	-31.2131	152.8225	11.03.2017	900	fine, 24 deg, light wind	Yes	Feathers from nest	Scaly-breasted Lorikeet				
K2K-NBT-32	Small-fruited Grey Gum	8	28500-29300	V	Western	-31.2131	152.8225	11.03.2017	900	fine, 24 deg, light wind	Yes	Loose dry green leaves	Possibly Common Ringtail Possum				
K2K-NBT-33	Grey Ironbark	1	28500-29300	V	Western	-31.2132	152.8223	11.03.2017	920	fine, 24 deg, light wind	No			Spider webs			
K2K-NBT-33	Grey Ironbark	2	28500-29300	V	Western	-31.2132	152.8223	11.03.2017	920	fine, 24 deg, light wind	Yes	Roosting bat	Gould's Long-eared Bat (Nyctiphilus gouldi) x 1				
K2K-NBT-34	Tallowwood	3	28500-29300	V	Western	-31.2133	152.8224	11.03.2017	955	fine, 24 deg, light wind	No	Native Bee hive		Small hive beetle destroyed the hive			
K2K-NBT-34	Tallowwood	5	28500-29300	V	Western	-31.2133	152.8224	11.03.2017	955	fine, 24 deg, light wind	Yes	Common Brushtail Possum x 1	Common Brushtail Possum x 1				
K2K-NBT-35	Scribbly Gum	2	28500-29300	V	Western	-31.2138	152.8227	11.03.2017	1015	fine, 24 deg, light wind	Yes	Dead bats and glider leave nest	Chocolate Wattled Bat (Chalinolobus morio x 12) + Feathertail Leaf Nest			Cleaned box out so it can be returned to functional state	
K2K-NBT-35	Scribbly Gum	8	28500-29300	V	Western	-31.2138	152.8227	11.03.2017	1015	fine, 24 deg, light wind	Yes	Few leaves	Probably glider				
K2K-NBT-36	Pink Bloodwood	1	28500-29300	V	Western	-31.214	152.8224	09.03.2017	815	Fine, sunny 27deg, light wind, no rain	No			Few ants			
K2K-NBT-36	Pink Bloodwood	5	28500-29300	V	Western	-31.214	152.8224	09.03.2017	815	Fine, sunny	Yes	Scats, scratches and hair	Common Brushtail Possum				

Nest Box Tree Name	Tree Species	Nest Box Design Types	Chainage	Nest Box PoM Zone	Side of Carriageway	Lat	Long	Date of Survey	Time	Weather	Sign of Fauna	Type of Evidence	Species Identification	Pest Species	Damage to Box	Maintenance Action Performed	Maintenance Action Required
										27deg, light wind, no rain							
K2K-NBT-37	Flooded Gum	5	25150-25750	U	Eastern	-31.2434	152.8245	09.03.2017	840	Fine, sunny 27deg, light wind, no rain	No			Lots of ants			
K2K-NBT-37	Flooded Gum	9	25150-25750	U	Eastern	-31.2434	152.8245	09.03.2017	840	Fine, sunny 27deg, light wind, no rain	Yes	Short -eared Possum	Short-eared Possum x 2				
K2K-NBT-38	Grey Ironbark	1	25150-25750	U	Eastern	-31.2436	152.8245	09.03.2017	910	Fine, sunny 27deg, light wind, no rain	Yes	Leaf nest - well-formed + scats	Glider and Possible Phascogale Scats				
K2K-NBT-38	Grey Ironbark	3	25150-25750	U	Eastern	-31.2436	152.8245	09.03.2017	910	Fine, sunny 27deg, light wind, no rain	Yes	Old leaf nest	Glider				
K2K-NBT-39	Tallowwood	4	25150-25750	U	Eastern	-31.2436	152.8247	09.03.2017	950	Fine, sunny 27deg, light wind, no rain	No			Old European Bee Hive		Hive beetle destroyed hive	
K2K-NBT-39	Tallowwood	5	25150-25750	U	Eastern	-31.2436	152.8247	09.03.2017	950	Fine, sunny 27deg, light wind, no rain	Yes	Strong possum odour in box	Brushtail Possum				
K2K-NBT-40	Grey Ironbark	3	25150-25750	U	Eastern	-31.2433	152.8242	09.03.2017	1015	Fine, sunny 27deg, light wind, no rain	Yes	Chew marks at entrance	Typical parrot and likely to be Rosella				
K2K-NBT-40	Grey Ironbark	8	25150-25750	U	Eastern	-31.2433	152.8242	09.03.2017	1015	Fine, sunny 27deg, light wind, no rain	Yes	Loose old dead leaves	Probably Brushtail Possum				
K2K-NBT-41	Brush Box	2	25150-25750	U	Eastern	-31.2439	152.8246	09.03.2017	1040	Fine, sunny 27deg, light wind, no rain	No						
K2K-NBT-41	Brush Box	5	25150-25750	U	Eastern	-31.2439	152.8246	09.03.2017	1040	Fine, sunny 27deg, light wind, no rain	Yes	Scratches from Possum	Probably Brushtail Possum				
K2K-NBT-42	White Mahogany	2	25150-25750	U	Eastern	-31.2448	152.8243	09.03.2017	1105	Fine, sunny 27deg, light wind, no rain	No						
K2K-NBT-42	White Mahogany	6	25150-25750	U	Eastern	-31.2448	152.8243	09.03.2017	1105	Fine, sunny 27deg, light wind, no rain	Yes	Feathers from nest	Australian Owlet Nightjar				

Nest Box Tree Name	Tree Species	Nest Box Design Types	Chainage	Nest Box PoM Zone	Side of Carriageway	Lat	Long	Date of Survey	Time	Weather	Sign of Fauna	Type of Evidence	Species Identification	Pest Species	Damage to Box	Maintenance Action Performed	Maintenance Action Required
K2K-NBT-43	Grey Ironbark	2	25150-25750	U	Eastern	-31.2448	152.8243	09.03.2017	1130	Fine, sunny 27deg, light wind, no rain	No				Top lid delaminating		Insert or rig screw down assembly during next monitoring event
K2K-NBT-43	Grey Ironbark	8	25150-25750	U	Eastern	-31.2448	152.8243	09.03.2017	1130	Fine, sunny 27deg, light wind, no rain	No			Old European Bee Hive		Hive beetle destroyed hive	
K2K-NBT-44	White Mahogany	1	25150-25750	U	Eastern	-31.2449	152.8238	09.03.2017	1155	Fine, sunny 27deg, light wind, no rain	No						
K2K-NBT-44	White Mahogany	3	25150-25750	U	Eastern	-31.2449	152.8238	09.03.2017	1155	Fine, sunny 27deg, light wind, no rain	No			Ants and old European Bee Hive		Hive beetle destroyed hive	
K2K-NBT-45	Pink Bloodwood	3	25150-25750	U	Eastern	-31.245	152.8237	09.03.2017	1210	Fine, sunny 27deg, light wind, no rain	No			Ants			
K2K-NBT-45	Pink Bloodwood	4	25150-25750	U	Eastern	-31.245	152.8237	09.03.2017	1210	Fine, sunny 27deg, light wind, no rain	No			Old European Bee Hive		Hive beetle destroyed hive	
K2K-NBT-46	White Mahogany	1	25150-25750	U	Eastern	-31.245	152.8245	09.03.2017	1235	Fine, sunny 27deg, light wind, no rain	No			Old European Bee Hive		Hive beetle destroyed hive	
K2K-NBT-46	White Mahogany	4	25150-25750	U	Eastern	-31.245	152.8245	09.03.2017	1235	Fine, sunny 27deg, light wind, no rain	Yes	Old glider leave nest		Ants			
K2K-NBT-47	White Mahogany	3	25150-25750	U	Eastern	-31.245	152.8242	09.03.2017	1345	Fine, sunny 29deg, light wind, no rain	No			Few Ants			
K2K-NBT-47	White Mahogany	5	25150-25750	U	Eastern	-31.245	152.8242	09.03.2017	1345	Fine, sunny 29deg, light wind, no rain	Yes	Feathers	Australian Owlet Nightjar				
K2K-NBT-48	White Mahogany	2	24600-25450	T	Western	-31.2479	152.82	09.03.2017	1415	Fine, sunny 29deg, light wind, no rain	No						
K2K-NBT-48	White Mahogany	5	24600-25450	T	Western	-31.2479	152.82	09.03.2017	1415	Fine, sunny 29deg, light wind, no rain	No			Old Ant Nest			
K2K-NBT-49	Pink Bloodwood	2	24600-25450	T	Western	-31.2481	152.8199	09.03.2017	1440	Fine, sunny 29deg,	No						

Nest Box Tree Name	Tree Species	Nest Box Design Types	Chainage	Nest Box PoM Zone	Side of Carriageway	Lat	Long	Date of Survey	Time	Weather	Sign of Fauna	Type of Evidence	Species Identification	Pest Species	Damage to Box	Maintenance Action Performed	Maintenance Action Required
										light wind, no rain							
K2K-NBT-49	Pink Bloodwood	4	24600-25450	T	Western	-31.2481	152.8199	09.03.2017	1440	Fine, sunny 29deg, light wind, no rain	No					Lid re-aligned as it was slightly open by 30 mm	
K2K-NBT-50	Tallowwood	1	24600-25450	T	Western	-31.2483	152.8201	09.03.2017	1500	Fine, sunny 29deg, light wind, no rain	No			Ant nest			
K2K-NBT-50	Tallowwood	5	24600-25450	T	Western	-31.2483	152.8201	09.03.2017	1500	Fine, sunny 29deg, light wind, no rain	No			Ant nest			
K2K-NBT-51	Tallowwood	4	24600-25450	T	Western	-31.2483	152.8199	09.03.2017	1525	Fine, sunny 29deg, light wind, no rain	No			Old European Bee Hive	Half full of water	Drain holes reopened to drain water from box	Drill larger holes
K2K-NBT-51	Tallowwood	5	24600-25450	T	Western	-31.2483	152.8199	09.03.2017	1525	Fine, sunny 29deg, light wind, no rain	No			Ant nest			
K2K-NBT-52	White Stringybark	3	24600-25450	T	Western	-31.2484	152.8198	09.03.2017	1550	Fine, sunny 29deg, light wind, no rain	No			Ants			
K2K-NBT-52	White Stringybark	8	24600-25450	T	Western	-31.2484	152.8198	09.03.2017	1550	Fine, sunny 29deg, light wind, no rain	Yes	Leave nest - recent in past couple of months	Gliders				
K2K-NBT-53	Tallowwood	1	24600-25450	T	Eastern	-31.2484	152.8233	09.03.2017	1615	Fine, sunny 29deg, light wind, no rain	Yes	Dead leaves	Possible Antechinus	Ants			
K2K-NBT-53	Tallowwood	3	24600-25450	T	Eastern	-31.2484	152.8233	09.03.2017	1615	Fine, sunny 29deg, light wind, no rain	Yes	Large dead/old leave nest	Gliders				
K2K-NBT-54	Red Mahogany	3	24600-25450	T	Eastern	-31.2485	152.8232	09.03.2017	1630	Fine, sunny 29deg, light wind, no rain	No			Ants			
K2K-NBT-54	Red Mahogany	4	24600-25450	T	Eastern	-31.2485	152.8232	09.03.2017	1630	Fine, sunny 29deg, light wind, no rain	Yes	Dead leaves	Possible Antechinus	Old European Bee Hive		Hive beetle destroyed hive	
K2K-NBT-55	Pink Bloodwood	1	24600-25450	T	Eastern	-31.2487	152.8231	09.03.2017	1655	Fine, sunny 29deg, light wind, no rain	Yes	old leaf nest	Probably a glider				

Nest Box Tree Name	Tree Species	Nest Box Design Types	Chainage	Nest Box PoM Zone	Side of Carriageway	Lat	Long	Date of Survey	Time	Weather	Sign of Fauna	Type of Evidence	Species Identification	Pest Species	Damage to Box	Maintenance Action Performed	Maintenance Action Required
K2K-NBT-55	Pink Bloodwood	8	24600-25450	T	Eastern	-31.2487	152.8231	09.03.2017	1655	Fine, sunny 29deg, light wind, no rain	Yes	scats	Antechinus stuartii			Re-wired the box to tree as loose	
K2K-NBT-56	Brush Box	1	24600-25450	T	Eastern	-31.2489	152.823	09.03.2017	1715	Fine, sunny 29deg, light wind, no rain	No			Ants			
K2K-NBT-56	Brush Box	3	24600-25450	T	Eastern	-31.2489	152.823	09.03.2017	1715	Fine, sunny 29deg, light wind, no rain	No			Ants			
K2K-NBT-57	Brush Box	2	24600-25450	T	Eastern	-31.2492	152.8229	10.03.2017	740	Unsettled, 25deg, light wind	No						
K2K-NBT-57	Brush Box	4	24600-25450	T	Eastern	-31.2492	152.8229	10.03.2017	740	Unsettled, 25deg, light wind	No			Ants			
K2K-NBT-58	Brush Box	1	24100-24600	S	Western	-31.2498	152.8202	10.03.2017	820	Unsettled, 25deg, light wind	No			Ants			
K2K-NBT-58	Brush Box	4	24100-24600	S	Western	-31.2498	152.8202	10.03.2017	820	Unsettled, 25deg, light wind	No			Ants			
K2K-NBT-59	Tallowwood	3	24100-24600	S	Western	-31.25	152.8203	10.03.2017	840	Unsettled, 25deg, light wind	No			Ants			
K2K-NBT-59	Tallowwood	5	24100-24600	S	Western	-31.25	152.8203	10.03.2017	840	Unsettled, 25deg, light wind	No			Huntsman Spiders			
K2K-NBT-60	White Mahogany	4	24100-24600	S	Western	-31.25	152.8203	10.03.2017	905	Unsettled, 25deg, light wind	No			Ants and Old European Bee Hive		Hive Beatle Destroyed Hive	
K2K-NBT-60	White Mahogany	5	24100-24600	S	Western	-31.25	152.8203	10.03.2017	905	Unsettled, 25deg, light wind	No						
K2K-NBT-61	Pink Bloodwood	5	24100-24600	S	Western	-31.2502	152.8202	10.03.2017	1340	Fine, 28deg, light wind, no rain	No			Ants			
K2K-NBT-61	Pink Bloodwood	6	24100-24600	S	Western	-31.2502	152.8202	10.03.2017	1400	Fine, 28deg, light wind, no rain	Yes	Lace Monitor (yearling) x 1	Lace Monitor (yearling) x 1				
K2K-NBT-62	Tallowwood	7	24600-25450	T	Eastern	-31.2503	152.8227	10.03.2017	1400	Fine, 28deg, light wind, no rain	No						
K2K-NBT-63	Small-fruited Grey Gum	3	24600-25450	T	Eastern	-31.2503	152.822	10.03.2017	1430	Fine, 28deg, light wind, no rain	No						
K2K-NBT-63	Small-fruited Grey Gum	4	24600-25450	T	Eastern	-31.2503	152.822	10.03.2017	1430	Fine, 28deg, light wind, no rain	Yes	Old dead leaves	Glider	Old European Bee Hive		Hive beetle destroyed hive	
K2K-NBT-64	Grey Ironbark	3	24600-25450	T	Eastern	-31.2504	152.8224	10.03.2017	1455	Fine, 28deg, light wind, no rain	no			Ants	Minor rot to box		Monitoring the extent of rot

Nest Box Tree Name	Tree Species	Nest Box Design Types	Chainage	Nest Box PoM Zone	Side of Carriageway	Lat	Long	Date of Survey	Time	Weather	Sign of Fauna	Type of Evidence	Species Identification	Pest Species	Damage to Box	Maintenance Action Performed	Maintenance Action Required
K2K-NBT-64	Grey Ironbark	4	24600-25450	T	Eastern	-31.2504	152.8224	10.03.2017	1515	Fine, 28deg, light wind, no rain	no			Ants			
K2K-NBT-65	Tallowwood	6	24600-25450	T	Eastern	-31.2504	152.8224	10.03.2017	1515	Fine, 28deg, light wind, no rain	Yes	Old leave nest	Possum	Old European Bee Hive		Hive beetle destroyed hive	
K2K-NBT-66	Small-fruited Grey Gum	3	24600-25450	T	Eastern	-31.2505	152.8218	10.03.2017	1540	Fine, 28deg, light wind, no rain	no			Ants			
K2K-NBT-66	Small-fruited Grey Gum	8	24600-25450	T	Eastern	-31.2505	152.8218	10.03.2017	1540	Fine, 28deg, light wind, no rain	no			Ants			
K2K-NBT-67	Tallowwood	5	24600-25450	T	Eastern	-31.2507	152.8224	10.03.2017	1605	Fine, 28deg, light wind, no rain	No						
K2K-NBT-67	Tallowwood	9	24600-25450	T	Eastern	-31.2507	152.8224	10.03.2017	1605	Fine, 28deg, light wind, no rain	No						
K2K-NBT-68	Tallowwood	3	24600-25450	T	Eastern	-31.2508	152.8215	10.03.2017	1615	Fine, 28deg, light wind, no rain	No			Ants and Huntsman Spider			
K2K-NBT-68	Tallowwood	4	24600-25450	T	Eastern	-31.2508	152.8215	10.03.2017	1645	Fine, 28deg, light wind, no rain	No			Ants			
K2K-NBT-69	Pink Bloodwood	2	24600-25450	T	Eastern	-31.2509	152.8213	10.03.2017	1700	Fine, 28deg, light wind, no rain	Yes	Glider nest and Feathertail	Feathertail Gliders x 12				
K2K-NBT-70	Tallowwood	6	24600-25450	T	Eastern	-31.2509	152.8214	10.03.2017	1700	Fine, 28deg, light wind, no rain	No						
K2K-NBT-71	Flooded Gum	2	24600-25450	T	Eastern	-31.2511	152.8213	10.03.2017	1000	Fine, 26deg, light wind, no rain	No						
K2K-NBT-71	Flooded Gum	4	24600-25450	T	Eastern	-31.2511	152.8213	10.03.2017	1000	Fine, 26deg, light wind, no rain	No				Half full of water	Drain holes unclogged	Reinspect next monitoring and drill out if necessary
K2K-NBT-72	Turpentine	4	24100-24600	S	Eastern	-31.2546	152.8187	10.03.2017	1020	Fine, 26deg, light wind, no rain	Yes	Scats	Antechinus stuartii	Ants			
K2K-NBT-72	Turpentine	5	24100-24600	S	Eastern	-31.2546	152.8187	10.03.2017	1020	Fine, 26deg, light wind, no rain	Yes	Old leaf nest	Glider				
K2K-NBT-73	Pink Bloodwood	4	24100-24600	S	Eastern	-31.2546	152.8187	10.03.2017	1035	Fine, 26deg, light wind, no rain	No			Old European Bee Hive		Hive Beetle Destroyed Hive	
K2K-NBT-73	Pink Bloodwood	5	24100-24600	S	Eastern	-31.2546	152.8187	10.03.2017	1100	Fine, 26deg,	Yes	Bark, possum scratches	Brushtail Possum				

Nest Box Tree Name	Tree Species	Nest Box Design Types	Chainage	Nest Box PoM Zone	Side of Carriageway	Lat	Long	Date of Survey	Time	Weather	Sign of Fauna	Type of Evidence	Species Identification	Pest Species	Damage to Box	Maintenance Action Performed	Maintenance Action Required
										light wind, no rain							
K2K-NBT-74	Grey Ironbark	7	24100-24600	S	Eastern	-31.2547	152.8188	10.03.2017	1100	Fine, 26deg, light wind, no rain	No			Ants			
K2K-NBT-75	Pink Bloodwood	1	24100-24600	S	Eastern	-31.2548	152.8188	10.03.2017	1120	Fine, 26deg, light wind, no rain	No			Ants			
K2K-NBT-75	Pink Bloodwood	8	24100-24600	S	Eastern	-31.2548	152.8188	10.03.2017	1120	Fine, 26deg, light wind, no rain	Yes	Glider nest ball of leaves	Gliders				
K2K-NBT-76	Brush Box	1	24100-24600	S	Eastern	-31.2548	152.8186	10.03.2017	1145	Fine, 26deg, light wind, no rain	No						
K2K-NBT-76	Brush Box	5	24100-24600	S	Eastern	-31.2548	152.8186	10.03.2017	1145	Fine, 26deg, light wind, no rain	Yes	Glider nest and Owlet Nightjar Feathers	Gliders and Australian Owlet Nightjar				
K2K-NBT-77	Grey Ironbark	5	24100-24600	S	Eastern	-31.2549	152.8186	10.03.2017	1210	Fine, 26deg, light wind, no rain	no			ants			
K2K-NBT-77	Grey Ironbark	9	24100-24600	S	Eastern	-31.2549	152.8186	10.03.2017	1210	Fine, 26deg, light wind, no rain	yes	Scats	Antechinus stuartii			Rewired as too loose	
K2K-NBT-78	Brush Box	3	24100-24600	S	Eastern	-31.2549	152.8189	10.03.2017	1225	Fine, 26deg, light wind, no rain	No			Ants and Huntsman Spider			
K2K-NBT-78	Brush Box	8	24100-24600	S	Eastern	-31.2549	152.8189	10.03.2017	1225	Fine, 26deg, light wind, no rain	Yes	Glider nest very old	Gliders				
K2K-NBT-79	Turpentine	1	24100-24600	S	Eastern	-31.2549	152.8187	13.03.2017	1115	Cloudy, 24 deg, light wind	No			Ants			
K2K-NBT-79	Turpentine	3	24100-24600	S	Eastern	-31.2549	152.8187	13.03.2017	1115	Cloudy, 24 deg, light wind	Yes	Old leaf nest and some scats	Antechinus stuartii				
K2K-NBT-80	Coastal Blackbutt	1	32650-33600	X	Eastern	-31.1701	152.8232	13.03.2017	1140	Cloudy, 24 deg, light wind	No				Lost in November 2016 fire	Replaced with Design 3 (Scansorial)	
K2K-NBT-80	Coastal Blackbutt	2	32650-33600	X	Eastern	-31.1701	152.8232	13.03.2017	1140	Cloudy, 24 deg, light wind	No				Lost in November 2016 fire	Replaced with Design 4 (Rear Entry Glider)	
K2K-NBT-81	Pink Bloodwood	1	32650-33600	X	Eastern	-31.1699	152.8233	13.03.2017	1215	Cloudy, 24 deg, light wind	No				Lost in November 2016 fire	Replaced with Design 2 (Bat Wedge)	
K2K-NBT-81	Pink Bloodwood	8	32650-33600	X	Eastern	-31.1699	152.8233	13.03.2017	1215	Cloudy, 24 deg, light wind	Yes	Lace Monitor - 2 year old animal	Lace Monitor				
K2K-NBT-82	Turpentine	1	32650-33600	X	Eastern	-31.1699	152.8231	11.03.2017	1150	fine, 27 deg, light wind	No				Lost in November 2016 fire	Replaced with Design 3 (Scansorial)	
K2K-NBT-82	Turpentine	5	32650-33600	X	Eastern	-31.1699	152.8231	11.03.2017	1150	fine, 27 deg, light wind	No				Lost in November 2016 fire	Replaced with Design 5 (Possum)	

Annex 6. Microbat roost box monitoring 2016/2017

Event 9 – Ku2K winter 2016 (Lewis 2016)

Field data provided by Ben Lewis and presented in Table 22.

Ref: 2431617d:BatBoxMonitoringWinter2016

24th August 2016

Kundabung to Kempsey Joint Venture
Kundabung Road
Kundabung, NSW 2441
Attention: Servaes van der Meulen

Re: Kundabung to Kempsey Bat Box Monitoring – Episode 9 (Winter 2016)

Please find within, a summary of the Kundabung to Kempsey Bat Box Monitoring – Episode 9 as a registered output for your records in delivering the construction related component of the Ecological Monitoring Plan (SMEC-Hyder Joint Venture 2014) and associated Micro Bat Management Strategy (Lewis 2013). Monitoring for Episode 9 was performed between the 4th and 22nd August and represents the sixth monitoring episode to have taken place since the clearing and grubbing program commenced in November 2014.

Micro Bat Use of Boxes

All 75 of the Roads and Maritime installed bat boxes were located and inspected for signs of micro bats or any other fauna inhabiting them. No micro bats were recorded in any of the bat boxes and this finding accords to that of the last round of monitoring in autumn 2016 (Niche 2016). This trend, whilst consistent to some of the earlier monitoring episodes would suggest the installation of bat boxes have not been overly effective at providing alternative roosting habitat following the decommissioning of roost sites at bridges and culverts on the Kundabung to Kempsey project.

To gauge this potential impact on local micro bat populations, six of the newly installed culverts comprising both concrete box and round concrete pipe configurations were inspected along with the twin bridges at Pipers Creek. The observations revealed an encouraging result with all six structures recording micro bats, predominantly Little Bent-wing Bat (*Miniopetrus australis*) which is currently a threatened species pursuant to the *Threatened Species Conservation* Act (1995) and was one of the main species recorded during the development of the Micro Bat Management Strategy itself (*see* Lewis 2013; Plate 1-1). Furthermore, some inspections of existing bat habitat has revealed micro bats continue to inhabit these structures and careful planning of works is required to ensure compliance with the Micro Bat Management Strategy. For example, hundreds of Bent-wing Bats under the Maria River Bridges where wash down works had been planned, and micro bats suspected as being Southern Myotis (*Myotis macropus*) using newly constructed Swallow nests under Pipers Creek bridge (Plate 1-2). Consequently, I have outlined a number of recommendations below.

Recommendation 1 – Assess each of the installed or partly installed structures with apertures of >1 m for evidence of micro bats and their suitability as bat roost habitat.

Recommendation 2 – Following adoption of Recommendation 1, instances where bat habitat was previously identified in the micro bat management strategy and now no longer exists, consider repositioning some but not all of the RMS bat boxes into the culvert or bridge structure ensuring their installation occurs over water or in the case of culverts, areas with reduced light levels. Give due consideration to placing bat boxes in structure which have been designed to enhance fauna connectivity.

Recommendation 3 – Ensure all of the construction works activities are being carried out in accordance with the requirements of the Micro Bat Management Strategy.

Plate 1-1. One of the four main clusters of roosting Little Bent-wing Bat (*Miniopterus australis*) recorded in Culvert 599038.

Plate 1-2. Micro bat suspected as Southern Myotis (*Myotis macropus*) inhabiting newly constructed swallow nests under the existing Pipers Creek Bridge.

Other Fauna Using Bat Boxes

Monitoring during Episode 9 recorded a continuation in the use of the bat boxes by other types of native fauna referred to here as non-target species. On this occasion, 18 (24%) of the bat boxes contained leaf nests constructed by either the Brown Antechinus (*Antechinus stuartii*), a small scansorial dasyurid, or the Feather-tail Glider (*Acrobates pygmaeus*) which is the world's smallest gliding marsupial. It should be noted that no direct observations of these two species were made but rather their constructed nests of leaves. Box 50 recorded Peron's Tree Frog (*Litoria peronii*) which is the first record of frogs using the boxes. Since the monitoring began in August 2014, there has generally been a continuing upwards trend on the use of boxes by non-target species with:

- Episode 1 reporting 10.6%;
- Episode 2 increased to 17.3%;
- Episode 3 to 20%;
- Episode 4 with 17.3%;
- Episode 5 with 22.6%; and
- Episode 8 with 28% (Lewis 2014 a,b; Lewis 2015 a,b,c; Niche 2016).

This confirms that bat boxes themselves provide an alternative den/roost resource and therefore contribute to the required quantities of nest boxes outlined in the Nest Box Plan of Management for the Oxley Highway to Kempsey Upgrade (Lewis 2013).

Bat Box Maintenance

With regard to the maintenance of the bat boxes, termites on both box number 54, 56, 68 remain dormant and at present the box shows no obvious structural damage that would limit its functionality. Continual evaluation of this will be required to ensure the boxes remain in a functional state during the remainder of the construction program. At Bat Box 35, vegetation growth was trimmed back to make this box more suitable to micro bats (Plate 1-3). At Bat Box 8, the Monkeys Rope (*Parsonsia straminea*) vines are starting to encapsulate the boxes entrance. Clearing was also reported Boxes 139 and 140 (Plate 1-4).

Plate 1-3. Bat Box 35 showing vegetation requiring removal (left) to improve its suitability for micro bats (right).

Plate 1-4. Clearing of vegetation around Bat Boxes 139 and 140 adjacent to Mobbs Drive.

Please also find an attached excel spreadsheet as an addendum file to this letter report which detailed the specifics of each box. Should you have any questions or queries please contact me at your convenience.

Kind Regards

Ben Lewis (Principal Ecologist)
Lewis Ecological Surveys

References

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

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Table 22: Bat roost box Event 9 Ku2K

Box	Roost Box Type	Height of Roost Box (m)	Aspect	Tenure	APO (MRS Identifier)	Easting (GDA1994 MGA 56)	Northing (GDA1994 MGA 56)	Lewis Record Number	Date	Bats Recorded	Species Name	Common Name	Number	Comments
2	Dark green wedge box	3.3	North-east	Private property (Tipping)	72	483308.2507	6546220.627	55	04.08.2016	No	-	-	-	
3	Light green box	3.2	North	Private property (Tipping)	72	483303.8392	6546224.456	56	04.08.2016	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
4	Black slot box	3.1	North	Private property (Tipping)	72	483300.1451	6546233.754	57	04.08.2016	No	-	-	-	
5	Light green wedge box	3.3	North-east	Private property (Tipping)	72	483303.765	6546264.738	52	04.08.2016	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
6	Light green box	3.3	North-east	Private property (Tipping)	72	483290.786	6546260.629	51	04.08.2016	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
7	Hollow home standard box	3.8	North	Private property (Tipping)	72	483285.4427	6546262.768	50	04.08.2016	No	-	-	-	
8	Hollow home standard box	3.6	North-west	Private property (Tipping)	72	483364.6935	6546214.528	53	04.08.2016	No	-	-	-	
9	Black wedge box	3.6	North	Private property (Tipping)	72	483362.8052	6546214.258	54	04.08.2016	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
10	Dark green slot box	3.6	North-east	RMS. Within project boundary	-	483088.8618	6546635.822	8	04.08.2016	No	-	-	-	
11	Light green wedge box	3	North	RMS. Within project boundary	-	483103.5806	6546630.993	7	04.08.2016	No	-	-	-	
12	Hollow home standard box	3.6	North	RMS. Within project boundary	-	483099.2928	6546659.418	5	04.08.2016	No	-	-	-	
13	Hollow home standard box	3.6	North	RMS. Within project boundary	-	483108.4539	6546628.604	6	04.08.2016	No	-	-	-	
14	Black wedge box	3.6	North-west	RMS. Within project boundary	-	483094.3948	6546658.888	4	04.08.2016	No	-	-	-	

Box	Roost Box Type	Height of Roost Box (m)	Aspect	Tenure	APO (MRS Identifier)	Easting (GDA1994 MGA 56)	Northing (GDA1994 MGA 56)	Lewis Record Number	Date	Bats Recorded	Species Name	Common Name	Number	Comments
15	Dark green box	3.4	North-west	RMS. Within project boundary	-	483090.2553	6546663.497	3	04.08.2016	No	-	-	-	
16	Light green slot box	2.9	North	Private property (Toepfer)	63	483297.4404	6544838.048	10	08.08.2016	No	-	-	-	
17	Black wedge box	3.1	North	Private property (Toepfer)	63	483293.8617	6544837.358	11	08.08.2016	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
18	Dark green box	3.5	North-west	Private property (Toepfer)	63	483266.3041	6544791.538	14	08.08.2016	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
19	Hollow home narrow box	3.5	North-west	Private property (Toepfer)	63	483272.6204	6544814.953	13	08.08.2016	No	-	-	-	
20	Light green wedge box	3.1	North-west	Private property (Toepfer)	63	483268.7779	6544829.45	12	08.08.2016	No	-	-	-	
21	Hollow home slot box	3.3	North-west	Private property (Toepfer)	63	483295.3048	6544846.946	9	08.08.2016	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
22	Black slot box	3	North-west	Private property (Hambly)	81	483299.9719	6548665.049	41	09.08.2016	No	-	-	-	
23	Hollow home narrow box	3.8	North-west	Private property (Hambly)	81	483308.9929	6548656.581	43	09.08.2016	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
24	Light green wedge box	3.5	North-west	Private property (Hambly)	81	483331.133	6548673.088	44	09.08.2016	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
25	Light green wedge box	3.7	North	RMS. Within project boundary	-	483256.4091	6548645.343	46	09.08.2016	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
26	Black box	3	North	RMS. Within project boundary	-	483246.9841	6548641.664	45	09.08.2016	No	-	-	-	
27	Hollow home slot box	3	North	RMS. Within project boundary	-	483293.4989	6548662.37	42	09.08.2016	No	-	-	-	
28	Hollow home narrow box	3.7	North-west	RMS. Within project boundary	-	483127.9306	6548695.633	49	09.08.2016	No	-	-	-	
29	Dark green slot box	3	North	RMS. Within project boundary	-	483135.6817	6548673.658	47	09.08.2016	No	-	-	-	

Box	Roost Box Type	Height of Roost Box (m)	Aspect	Tenure	APO (MRS Identifier)	Easting (GDA1994 MGA 56)	Northing (GDA1994 MGA 56)	Lewis Record Number	Date	Bats Recorded	Species Name	Common Name	Number	Comments
30	Hollow home standard box	3.6	North	Private property (Brayley)	70	483118.7695	6546265.858	59	10.08.2016	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
31	Dark green wedge box	3.4	North-east	RMS. Within project boundary	-	482880.8439	6542409.253	69	10.08.2016	No	-	-	-	
32	Hollow home narrow box	3.3	North-west	Private property (Brayley)	70	483112.849	6546281.694	58	10.08.2016	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
35	Light green slot box	3	North	Private property (Brayley)	70	483059.9271	6546309.169	60	10.08.2016	No	-	-	-	
36	Hollow home slot box	3.1	North-west	RMS. Within project boundary	-	482870.7922	6542405.373	68	10.08.2016	No	-	-	-	
37	Hollow home narrow box	3.5	North	RMS. Within project boundary	-	482873.3237	6542400.274	67	10.08.2016	No	-	-	-	
38	Light green box	3.6	North-west	RMS. Within project boundary	-	482861.1116	6542374.4	66	10.08.2016	No	-	-	-	
46	Light green box	4	North-west	RMS. Within project boundary	-	483133.3234	6554724.566	32	10.08.2016	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
47	Hollow home narrow box	3.8	North-west	State Forest	87	483146.3766	6554719.227	33	10.08.2016	No	-	-	-	
49	Dark green wedge box	3.5	North-west	RMS. Within project boundary	-	483141.3054	6554709.099	34	10.08.2016	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
50	Dark green slot box	3.4	North	RMS. Within project boundary	-	483030.3988	6554308.511	38	10.08.2016	No	-	-	-	Litoria peronii (Hylid Tree Frog) using box
51	Hollow home standard box	4	North	State Forest	87	483151.5879	6554744.552	31	10.08.2016	No	-	-	-	
52	Hollow home narrow box	3.6	North-west	State Forest	87	483073.8214	6554383.555	39	10.08.2016	No	-	-	-	
53	Dark green box	3.3	North	State Forest	87	483081.6879	6554377.806	40	10.08.2016	No	-	-	-	
54	Hollow home standard box	3.7	North	RMS. Within project boundary	-	483040.0134	6554316.769	37	10.08.2016	No	-	-	-	

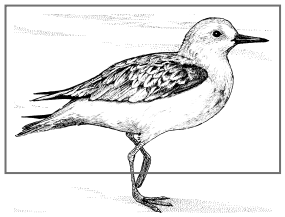
Box	Roost Box Type	Height of Roost Box (m)	Aspect	Tenure	APO (MRS Identifier)	Easting (GDA1994 MGA 56)	Northing (GDA1994 MGA 56)	Lewis Record Number	Date	Bats Recorded	Species Name	Common Name	Number	Comments
55	Hollow home narrow box	3.6	North	State Forest	87	483051.2937	6554332.976	36	10.08.2016	No	-	-	-	
56	Black wedge box	3.7	North-west	State Forest	87	483051.0629	6554342.454	35	10.08.2016	No	-	-	-	
57	Dark green wedge box	3.5	North	State Forest	57	482769.6848	6542094.168	73	10.08.2016	No	-	-	-	
58	Black slot box	3.1	North	State Forest	57	482779.166	6542118.566	74	10.08.2016	No	-	-	-	
59	Hollow home standard box	3.8	North-west	State Forest	57	482729.6069	6542081.099	71	10.08.2016	No	-	-	-	
61	Hollow home narrow box	3.3	North-west	State Forest	57	482733.5319	6542073.671	70	10.08.2016	No	-	-	-	
62	Light green wedge box	3.2	North	State Forest	57	482726.5147	6542070.142	75	10.08.2016	No	-	-	-	
63	Black box	3.1	North	RMS. Within project boundary	-	482721.5836	6542109.474	72	18.08.2016	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
64	Hollow home slot box	3.3	North-west	State Forest	57	482859.0254	6542360.363	65	18.08.2016	No	-	-	-	
65	Hollow home standard box	3.5	North	State Forest	57	482834.4693	6542316.172	64	18.08.2016	No	-	-	-	
66	Dark green box	3.2	North	RMS. Within project boundary	-	482836.976	6542340.487	63	18.08.2016	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
67	Black box	3.3	North-east	RMS. Within project boundary	-	482839.0375	6542332.138	62	18.08.2016	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
68	Black wedge box	3.5	North	State Forest	57	482828.6889	6542290.127	61	18.08.2016	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider + Termite Activity
95	Hollow home slot box	3.8	North-west	State Forest	57	483195.2662	6543189.204	29	18.08.2016	No	-	-	-	

Box	Roost Box Type	Height of Roost Box (m)	Aspect	Tenure	APO (MRS Identifier)	Easting (GDA1994 MGA 56)	Northing (GDA1994 MGA 56)	Lewis Record Number	Date	Bats Recorded	Species Name	Common Name	Number	Comments
96	Hollow home slot box	3.8	North	State Forest	57	483201.0218	6543172.447	28	18.08.2016	No	-	-	-	
97	Hollow home standard box	3.7	North	State Forest	57	483179.8464	6543172.387	27	18.08.2016	No	-	-	-	
98	Dark green wedge box	4	North-west	RMS. Within project boundary	0	483172.4912	6543194.823	24	18.08.2016	No	-	-	-	
99	Black box	3.1	North-east	State Forest	57	483175.1875	6543170.218	25	18.08.2016	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
100	Light green slot box	3.4	North-east	State Forest	57	483189.189	6543197.612	30	18.08.2016	No	-	-	-	
101	Black slot box	3.5	North	State Forest	57	483179.5661	6543166.269	26	18.08.2016	No	-	-	-	
130	Hollow home narrow box	3.6	North	Private property (Parkin property)	58	483338.8593	6543361.719	22	22.08.2016	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
131	Dark green slot box	3.6	North-west	Private property (Parkin property)	58	483322.1945	6543388.723	17	22.08.2016	No	-	-	-	
132	Hollow home slot box	3.7	North	Private property (Parkin property)	58	483280.0747	6543367.618	21	22.08.2016	No	-	-	-	
133	Hollow home slot box	3.6	North-east	Private property (Parkin property)	58	483287.5372	6543386.294	18	22.08.2016	No	-	-	-	
134	Hollow home slot box	3.1	North-east	Private property (Parkin property)	58	483302.0499	6543360.639	19	22.08.2016	No	-	-	-	
135	Black slot box	3.2	North	Private property (Parkin property)	58	483303.1878	6543387.404	16	22.08.2016	No	-	-	-	
136	Hollow home slot box	3.8	North	Private property (Parkin property)	58	483297.8032	6543381.775	15	22.08.2016	No	-	-	-	
137	Hollow home slot box	3.3	North-west	Private property (Parkin property)	58	483343.1059	6543367.418	23	22.08.2016	No	-	-	-	
138	Hollow home standard box	3.7	North	Private property (Parkin property)	58	483305.6698	6543364.228	20	22.08.2016	No	-	-	-	

Box	Roost Box Type	Height of Roost Box (m)	Aspect	Tenure	APO (MRS Identifier)	Easting (GDA1994 MGA 56)	Northing (GDA1994 MGA 56)	Lewis Record Number	Date	Bats Recorded	Species Name	Common Name	Number	Comments
139	Hollow homes standard box	3.9	North	Private property (Mobbs)	60	483279.2996	6543729.284	1	22.08.2016	No	-	-	-	Clearing of vegetation near boxes - picture in report
140	Hollow home slot box	3.6	North-west	Private property (Mobbs)	60	483287.9247	6543727.064	2	22.08.2016	No	-	-	-	Clearing of vegetation near boxes - picture in report
28B	Black wedge box	3.4	North	RMS. Within project boundary	-	483126.8009	6548693.244	48	22.08.2016	No	-	-	-	

Event 9– OH2Ku spring 2016 (Sandpiper 2016)

Field data is provided within the report.



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Biodiversity Survey

Project Management

Impact Assessment

Ecological Monitoring

Specialist Surveys

Clive Wightwick
Environment Coordinator
OH2K Pacific Highway Upgrade
Grant.fletcher@lendlease.com.au

12 October 2016

cc. Grant Fletcher

Dear Clive,

RE: OH2K bat box inspection and corrective action assessment – spring 2016.

Sandpiper Ecological Surveys recently completed a supplementary spring 2016 microbat box inspection to compensate for the absence of a winter 2016 survey as required by the Microbat Management Plan. The winter 2016 survey was not undertaken due to uncertainty regarding implementation of alternate surveys, as proposed in the autumn 2016 bat box inspection and corrective action letter, dated 22 July 2016.

As part of the impact mitigation package for the Oxley Highway to Kundabung Pacific Highway Upgrade 83 microbat boxes were installed in early 2014. This survey represents the 9th inspection and the first biannual inspection and was undertaken in accordance with the *Pacific Highway Upgrade Oxley Highway to Kempsey Microbat Management Strategy* (Lewis 2013). The bat box program currently totals 83 boxes installed across eight sites within the Oxley Highway to Kundabung section of the Oxley Highway to Kempsey Pacific Highway upgrade.

Methods

Two ecologists inspected 83 boxes on 26 and 27 September 2016. A combination of spotlight and binoculars was used to inspect boxes. To avoid disturbing roosting bats, individuals were not removed from boxes unless there was concern about identification or breeding status. As a consequence, long-eared bats (*Nyctophilus* spp.) were identified to genus only. Genus and species, along with box condition and any change in habitat were recorded on a spreadsheet (Table 1). Weather data were obtained from the Port Macquarie Airport weather station (Table 2).

Results

Of the 83 boxes inspected, one box (no. 48) contained long-eared bats (*Nyctophilus* spp, probably *N. gouldii)* totaling seven individuals (Table 1). No evidence of breeding was recorded in any of the box designs. No significant scat deposits or signs of wear suggesting continuous use were recorded. Feathertail glider (leaf) nests were recorded in three boxes. A possible *Antechinus* spp. nest was recorded in two boxes at Cooperabung Creek. Scats consistent with *Antechinus* sp. were recorded in box 129. All boxes were in good condition at the time of inspection with the exception of box 122 where the back panel had been pushed in slightly, however the box was functional and did not require urgent repair at the time of inspection. Evidence of recent ground fire and understory clearing was observed around boxes in the south western section of the alignment (chainages 1000-1700). No damage to any boxes was recorded and flyways were not disrupted.

Review of bat box program

According to the Microbat Management Strategy (MMS) quarterly monitoring should occur for two years before corrective actions are taken (refer G1, p14 of MMS). The MMS does not define corrective action, although we interpret that to mean identification of actions to better compensate species displaced by culvert exclusion. No obligate cave roosting species have been recorded using nest boxes. Long-eared bats (*Nyctophilus* sp) have been recorded using several bat boxes throughout the two years of monitoring. Long-eared bats are mostly associated with tree hollows and would not have been displaced by culvert exclusion. Use of bat boxes by this species is most likely an opportunistic response to the presence of additional roosting habitat.

During exclusion, two species of microbat; little bent-wing bat (*Miniopterus australis*) and eastern horseshoe bat (*Rhinolophus megaphyllus*), were recorded using culverts within the OH2K project corridor (Sandpiper Ecological 2014). Southern Myotis (*Myotis macropus*) was also recorded in culverts 599012 and 599028 during field surveys for the MMS and eastern bent-wing bat was recorded in culvert 599011 (Lewis, 2013). All three of these species are obligate cave roosting species that regularly utilise artificial structures, such as culverts, bridges, mines and tunnels (Van Dyck *et al.* 2013).

The absence of target species in nest boxes means that corrective action is warranted to more adequately provide supplementary (cave dwelling) microbat roosting habitat.

There are several possible reasons for the apparent absence of target species, including:

1. Presence of other suitable roosts close to excluded culverts – there may be natural caves/overhangs or other culverts nearby.
2. Cave dwelling species of microbat may select roosts via the identification of large cavernous structures (with appropriate small crevices within) through echo-location. This may help to explain part of the reason why target species of bats are not roosting in small bat boxes attached to trees (Churchill, 2008).
3. The distance that boxes have been installed from excluded culverts - bat boxes were moved to greater than 50m from the subject culverts to negate the risk associated with the seasonal limitation of work provision included the MMS. This distance may be too great for uptake by displaced bats.
4. The design and material of installed boxes – bent-wing bats (*Miniopterus spp*) have not been recorded using artificial bat boxes and we are not aware of microbats using masonry boxes in Australia. Two species (*Nyctophilus gouldii* and *Myotis macropus*) have been recorded using wedge and rectangular shaped timber boxes at the Nambucca to Urunga Pacific Highway upgrade (NH2U) and timber boxes have been successful elsewhere (Rhodes & Jones 2011; Bender 2011; Marshall 2011). Bat boxes installed in trees may be less suitable for *Myotis* spp. than boxes installed beneath bridges.
5. Height and orientation of boxes – variation in the height and orientation of boxes with a single cluster[1] can influence use (Rhodes & Jones 2011). At present, orientation varies within a cluster but there is limited variation in height.

[1] A cluster is defined as a group of bat boxes installed in a specific area of variable size, but often less than 50 x 50m.

Limitations with the existing bat box program may be overcome by:

- Providing supplementary roosting habitat consistent with that removed by exclusion; and
- Removing temporary exclusion material installed in September 2014 from selected culverts that are not scheduled for demolition.

The effect of distance from culverts, and height and orientation of boxes on use may be overcome by moving boxes closer (i.e. within 50m) to the alignment and excluded culverts and reinstalling boxes at variable heights and orientations. Irrespective, timber boxes installed on trees do not provide compensatory roosts for the target species and alternate measures are required.

Removing temporary exclusion material from culverts would restore previously available habitat known to be used by little bent-wing and eastern horseshoe bats. This may not be feasible at OH2K due to the planned demolition and/or alteration (slip-lining, grouting etc.) of all the existing, old culvert and drainage structures (pers. comms. H. Corliss, 10 June 2016).

Recently constructed culverts and bridges could provide a substantially larger area of roosting habitat for the target cave-dwelling species than the original culverts. An inspection revealed evidence of roosting bats in several recently constructed culverts and bridges on the Nambucca Heads to Urunga (NH2U) upgrade (Sandpiper Ecological 2016). The presence of a large colony of little and eastern bent-wing bats in a recently constructed box culvert on the NH2U project, whilst construction continued above, provides some evidence that microbats will tolerate some construction activity. This observation is consistent with records of microbats roosting in bridges and culverts beneath busy roads (pers obs). Based on our findings at NH2U, and observations on the Kundabung to Kempsey upgrade where bats have begun roosting in newly constructed bridges (pers. comms B. Tolhurst, August 2016) there is a high likelihood that new culverts and bridges on the OH2K project would provide viable roost options for microbats. Inspection of completed and partially completed structures would provide useful information on the potential roosting resource created by the upgrade.

If no suitable habitat is identified following such an inspection, there may be a case for enhancement of habitat within these structures via installation of roost features, such as shot-crete (to roughen up certain surfaces) or installation of Hebel boxes beneath new structures.

Implications of bat roosts in newly constructed structures

If microbats begin to use new culverts and bridges, the management restrictions imposed by the MMS may apply. Management Strategy D – Seasonal limitation of construction work – poses the greatest risk to construction. Strategy D applies to High Conservation Value (HCV) sites only, and only to 'high risk' activities, such as clearing and grubbing, dumping of oversize rock, piling, and any activity deemed high risk by the project ecologist. Lewis (2013) defined a HCV roost as: breeding colonies of microbats; colonies exceeding 50 individuals; overwintering colonies exceeding 20 individuals; and one or more individuals of (the nationally listed) large-eared pied bat (*Chalinolobus dwyeri*). No HCV roosts were recorded on the OH2K section of the OH2Ke upgrade during pre-construction or exclusion surveys (Lewis 2013; Sandpiper Ecological 2014). There is the possibility of newly constructed bridges and culverts becoming HCV sites if the above criteria are met. This may have implications for construction in areas where construction is staged, i.e. Barries Creek and, south of Sancrox Road. Ultimately the risk of disturbance and possible abandonment of the roost of any proposed activity is up to the discretion of the Project Ecologist.

Recommendations

A combination of corrective actions, that reflects the stage of construction, quality of excluded habitat and likelihood of satisfying the bat box program objectives, are recommended.

Recommended actions include:

- Inspect completed and partially completed box culverts and bridges within the OH2K alignment to determine the type and quality of roosting habitat within each structure, and if any microbats are currently inhabiting them. Only structures that can be safely accessed should be inspected. During the inspection the quality of insitu roosting habitat would be assessed using a standard set of criteria (see Sandpiper Ecological 2016). The culvert inspection would be undertaken in spring/summer 2016. Data collected would include: Presence/absence (P/A) of microbats (i.e. individuals, scats or stains); species present and number of individuals; type of feature/s used; If evidence only area used; P/A of water within or at entrance; type of structure; surrounding habitat type; location (GDA94); Type and extent of roost features present (i.e. scuppers, cavities around planks and headstocks, joins, lift holes, rough concrete, bird nests etc.); Microclimate at point of roost or in centre of structure (airflow, temperature (at ceiling), humidity & light).
- Inspect original culverts and drains that have been slip-lined or altered for potential bat habitat, provided it is safe to do so.
- Culverts and bridges with high value roosting habitat would be subject to biannual monitoring for a period of one year.
- If microbats are found to be occupying unfinished structures, more robust monitoring may be required whilst work continues. The need for such monitoring would depend on the species present, permanency of roost, likelihood of impact, duration and type of work required.
- Existing bat boxes should remain in place.
- Quarterly monitoring of bat boxes should cease and be replaced by an annual maintenance inspection to Year 6 as per the MMS (G1, p14). This should be coordinated with the biannual inspection of any new high value bridge and culvert roosts.

Please contact me if you have any questions regarding the spring 2016 bat box survey or any of the recommendations.

Yours sincerely,

Dr David Rohweder
Senior Ecologist (0401 195 480).

Table 1: Results of the 2016 spring inspection of bat boxes installed for the Oxley Highway to Kundabung Pacific Highway Upgrade. Nsp = *Nyctophilus* spp.; Pr = probable; Ftg = feathertail glider.

RPS ID no.	Chainage	Box no.	Species	Box condition	Comments/Signs
46	1000	150	Nil	Good	
46	1000	151	Nil	Good	
46	1000	152	Nil	Good	
46	1000	89	Nil	Good	
46	1000	90	Nil	Good	
46	1000	94	Nil	Good	
46	1000	93	Nil	Good	
46	1000	92	Nil	Good	
46	1000	91	Nil	Good	
49	1000	112	Nil	Good	Vegetation (understory) cleared around box trees
49	1000	113	Nil	Good	Vegetation (understory) cleared around box trees
49	1000	114	Nil	Good	Vegetation (understory) cleared around box trees
45	1300	149	Nil	Good	
45	1300	146	Nil	Good	
45	1300	148	Nil	Good	
45	1300	147	Nil	Good	
50	1300	111	Nil	Good	
50	1300	109	Nil	Good	
50	1300	110	Nil	Good	
44	1550	86	Nil	Good	
44	1550	85	Nil	Good	
44	1550	84	Nil	Good	
44	1550	88	Nil	Good	
44	1550	87	Nil	Good	
51	1700	102	Nil	Good	Wasp nest
51	1700	107	Nil	Good	
51	1700	106	Nil	Good	
51	1700	108	Nil	Good	
51	1700	103	Nil	Good	
51	1700	104	Nil	Good	Evidence of recent fire
47	3600	115	Nil	Good	
47	3600	120	Nil	Good	Tree has died. Vegetation encroaching on box
47	3600	118	Nil	Good	
47	3600	117	Nil	Good	
47	3600	116	Nil	Good	Packed with leaf – FtG nest (prb)
47	3600	119	Nil	Good	Box a bit wobbly, loose on tree – still

					functional.
48	3800	39	Nil	Good	
48	3800	40	Nil	Good	Wasp nest
48	3800	41	Nil	Good	
48	3800	42	Nil	Good	Fresh green leaf
48	3800	43	Nil	Good	
48	3800	44	Nil	Good	
48	3800	45	Nil	Good	Wasp nests
48	3800	48	7 x Nyctophilus sp.	Good	In large NB Aus box type
48	3800	156	Nil	Good	
48	3800	33	Nil	Good	Leaf material (prb Antechinus)
31	18200	78	Nil	Good	
31	18200	79	Nil	Good	
31	18200	80	Nil	Good	
31	18200	81	Nil	Good	
31	18200	82	Nil	Good	
31	18200	83	Nil	Good	
33	19650	122	Nil	Back panel pushed forward	Still functional
33	19650	121	Nil	Good	
33	19650	127	Nil	Good	
33	19650	129	Nil	Good	Antechinus (prob) scat
33	19650	124	Nil	Good	
33	19650	125	Nil	Good	
33	19650	126	Nil	Good	Full with old leaf (Prb FtG)
33	19650	128	Nil	Good	Full with old leaf (Prb FtG)
57	21550	142	Nil	Minor deterioration	
57	21550	123	Nil	Minor deterioration	
57	21550	141	Nil	Good	
57	21550	144	Nil	Good	
57	21550	145	Nil	Good	Wasp nest
57	21550	143	Nil	Good	Wasp nest
57	21550	1	Nil	Good	
15	23700	153	Nil	Good	Wasp nest
15	23700	154	Nil	Good	Wasp nest and spider nest
15	23700	155	Nil	Good	
15	23700	157	Nil	Good	
15	23700	158	Nil	Good	Leaf material. Box has slid down tree to approx. 3m

15	23700	159	Nil	Wire tightening on tree	Leaf material prob FtG
15	23700	73B	Nil	Good	
15	23700	69	Nil	Good	
15	23700	70	Nil	Good	
15	23700	72	Nil	Good	
13	23700	71	Nil	Good	
13	23900	73A	Nil	Good	
13	23900	74	Nil	Wire tightening on tree	
13	23900	76	Nil	Wire tightening on tree	Wasp nest, old leaf material.
13	23900	77	Nil	Good	
13	23900	75	Nil	Good	

Table 2: Weather conditions for bat box inspection carried out spring 2016. Source: Bureau of Meteorology, Port Macquarie Airport, station number: 60139.

Survey Date	Rain (mm)	Wind (max gust, km/h)	Cloud Cover (8^{th})	Ambient temperature (max. C)
26 September 2016	0	33km/hr	0	21
27 September 2016	0	41km/hr	0	24.4

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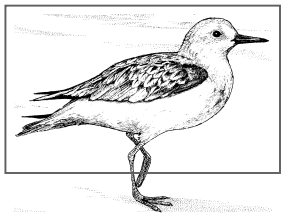
Event 10 – OH2Ku summer 2017 (Sandpiper 2017c)

Field data is provided within the report.



Sandpiper Ecological Surveys
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Biodiversity Survey

Project Management

Impact Assessment

Ecological Monitoring

Specialist Surveys

Kieran Metcalfe
Environment Manager
OH2K Pacific Highway Upgrade
Kieran.Metcalfe@lendlease.com.au

8 August 2017

Dear Kieran,

RE: OH2K bat box inspection – summer 2016.

Sandpiper Ecological Surveys was contracted to conduct a summer 2017 inspection of microbat boxes located adjacent the Oxley Highway to Kundabung Pacific Highway Upgrade (OH2K) alignment. The microbat boxes were installed in early 2014 as part of the impact mitigation package for the OH2K. The current survey represents the 10th inspection and the second biannual inspection and was undertaken in accordance with the *Pacific Highway Upgrade Oxley Highway to Kempsey Microbat Management Strategy* (Lewis 2013). The microbat box program currently totals 83 boxes installed across eight sites within the upgrade alignment.

Methods

Two ecologists inspected 83 boxes on 11 January 2017. A combination of spotlight and binoculars was used to inspect boxes. To avoid disturbing roosting bats, individuals were not removed from boxes unless there was concern about identification or breeding status. Genus and species, along with box condition and any change in habitat were recorded on a spreadsheet (Table 1). Weather data were obtained from the Port Macquarie Airport weather station (Table 2).

Results

No bats were recorded roosting in any of the 83 boxes. No evidence of breeding was recorded in any of the box designs. No scat deposits or signs of wear suggesting continuous use were recorded. Probable feathertail glider (*Acrobates sp*.) leaf nests were recorded in five boxes. Probable antechinus (*Antechinus sp*.) nests were recorded in four boxes. Old mud wasp (*Sceliphron sp*.) nests were present in four boxes. All boxes were in good condition at the time of inspection except for box 122 where the back panel had been pushed in slightly, however the box was functional and did not require repair at the time of inspection.

Discussion

The summer 2017 survey represents the 10th inspection (including box relocations February 2015) of microbat boxes installed on the OH2K project. A total of 20 microbats have been recorded over these surveys of which none were the target species (*Miniopterus sp.* & *Myotis macropus*). All bats recorded were long-eared bats (*Nyctophilus sp.*). Recommendations arising from the review of the bat box program conducted in 2016 (Sandpiper 2016) still apply.

Yours sincerely,

Nick Priest,
Ecologist.

Table 1: Results of the 2017 summer inspection of bat boxes installed along the OH2K Pacific Highway Upgrade. Pr = probable; Ftg = feathertail glider sp., Ante = Antechinus sp.

RPS ID no.	Chainage	Box no.	Species	Box condition	Comments/Signs
46	1000	150	Nil	Good	
46	1000	151	Nil	Good	
46	1000	152	Nil	Good	
46	1000	89	Nil	Good	
46	1000	90	Nil	Good	
46	1000	94	Nil	Good	
46	1000	93	Nil	Good	
46	1000	92	Nil	Good	
46	1000	91	Nil	Good	
49	1000	112	Nil	Good	
49	1000	113	Nil	Good	
49	1000	114	Nil	Good	
45	1300	149	Nil	Good	
45	1300	146	Nil	Good	
45	1300	148	Nil	Good	
45	1300	147	Nil	Good	
50	1300	111	Nil	Good	
50	1300	109	Nil	Good	
50	1300	110	Nil	Good	
44	1550	86	Nil	Good	
44	1550	85	Nil	Good	
44	1550	84	Nil	Good	
44	1550	88	Nil	Good	
44	1550	87	Nil	Good	
51	1700	102	Nil	Good	
51	1700	107	Nil	Good	Leaf/bark nest, pr Ante
51	1700	106	Nil	Good	
51	1700	108	Nil	Good	Mud wasp nest
51	1700	103	Nil	Good	
51	1700	104	Nil	Good	
47	3600	115	Nil	Good	
47	3600	120	Nil	Good	Tree has died. Vegetation encroaching on box
47	3600	118	Nil	Good	
47	3600	117	Nil	Good	
47	3600	116	Nil	Good	Leaf nest – pr Ante
47	3600	119	Nil	Good	
48	3800	39	Nil	Good	
48	3800	40	Nil	Good	
48	3800	41	Nil	Good	
48	3800	42	Nil	Good	Leaf litter – pr Ante
48	3800	43	Nil	Good	Leaf nest – pr FtG
48	3800	44	Nil	Good	

48	3800	45	Nil	Good	Mud wasp nest
48	3800	48	Nil	Good	
48	3800	156	Nil	Good	
48	3800	33	Nil	Good	Leaf material – pr Ante
31	18200	78	Nil	Good	
31	18200	79	Nil	Good	
31	18200	80	Nil	Good	
31	18200	81	Nil	Good	Mud wasp nest
31	18200	82	Nil	Good	
31	18200	83	Nil	Good	
33	19650	122	Nil	Back panel pushed forward	Still functional
33	19650	121	Nil	Good	
33	19650	127	Nil	Good	
33	19650	129	Nil	Good	
33	19650	124	Nil	Good	
33	19650	125	Nil	Good	
33	19650	126	Nil	Good	Old leaf nest – pr FtG
33	19650	128	Nil	Good	Old leaf nest - pr FtG
57	21550	142	Nil	Good	
57	21550	123	Nil	Good	
57	21550	141	Nil	Good	
57	21550	144	Nil	Good	
57	21550	145	Nil	Good	
57	21550	143	Nil	Good	
57	21550	1	Nil	Good	
15	23700	153	Nil	Good	Mud wasp nest
15	23700	154	Nil	Good	Mud wasp nest
15	23700	155	Nil	Good	
15	23700	157	Nil	Good	
15	23700	158	Nil	Good	
15	23700	159	Nil	Good	Old leaf nest – pr FtG
15	23700	73B	Nil	Good	
15	23700	69	Nil	Good	
15	23700	70	Nil	Good	
15	23700	72	Nil	Good	
13	23700	71	Nil	Good	
13	23900	73A	Nil	Good	
13	23900	74	Nil	Good	
13	23900	76	Nil	Good	Leaf nest – pr FtG
13	23900	77	Nil	Good	
13	23900	75	Nil	Good	

Table 2: Weather conditions for bat box inspection carried out summer 2017. Source: Bureau of Meteorology, Port Macquarie Airport, station number: 60139.

Survey Date	Rain (mm)	Wind (max gust, km/h)	Cloud Cover (8^{th})	Ambient temperature (max. C)
11 January 2017	0	30km/hr	2/8	32.6

Event 10 – Ku2K summer 2017 (Lewis 2017a)

Field data provided by Ben Lewis and presented in Table 23 and Table 24.

Ref: 2431617d:BatBoxMonitoringSummer2017

17th March 2017

Kundabung to Kempsey Joint Venture
Kundabung Road
Kundabung, NSW 2441
Attention: Servaes van der Meulen

Re: Kundabung to Kempsey Bat Box Monitoring – Episode 10 (Summer 2017)

Please find within, a summary of the Kundabung to Kempsey Bat Box Monitoring – Episode 10 as a registered output for your records in delivering the construction related component of the Ecological Monitoring Plan (SMEC-Hyder Joint Venture 2014) and associated Micro Bat Management Strategy (Lewis 2013). Monitoring for Episode 10 was performed between the 27th and 28th February and represents the seventh monitoring episode to have taken place since the clearing and grubbing program commenced in November 2014.

Micro Bat Use of Boxes

Seventy-one (71) of the 75 Roads and Maritime installed bat boxes were located and inspected for signs of micro bats or any other fauna inhabiting them. The remaining four had been burnt in the November 2016 fire.

Of the 71 inspected boxes, five (7%) were inhabited by micro bats comprising two species, Gould's Long-eared Bat (*Nyctophilus gouldi*) and Lesser Long-eared Bat (*Nyctophilus geoffroyi*). Roosts were located in the Barrys Creek, Smiths Creek and the southern end of Rodeo Drive with roost sizes ranging from 1-4 individuals (Plate 1-1).

Plate 1-1. Long-eared Bats recorded from Barrys Creek area.

This is the first time bats have been recorded using the boxes since Monitoring Episode 5 in July 2015 (Lewis 2015). Interestingly, this round of monitoring has produced the highest occupancy rate over the ten monitoring episodes to date. The prevailing weather may have assisted in this result as the wet conditions would reduce the suitability of exfoliating bark often used by Long-eared Bats.

Other Fauna Using Bat Boxes

Monitoring during Episode 10 recorded a continuation in the use of the bat boxes by other types of native fauna referred to here as non-target species. On this occasion, 16 (22.5%) of the bat boxes contained leaf nests constructed by either the Brown Antechinus (*Antechinus stuartii*), a small scansorial dasyurid, or the Feather-tail Glider (*Acrobates pygmaeus*). It should be noted that no direct observations of these two species were made but rather their constructed nests of leaves.

Since the monitoring began in August 2014, there has generally been a continuing upwards trend on the use of boxes by non-target species which now appears to have plateaued:

- Episode 1 reporting 10.6%;
- Episode 2 increased to 17.3%;
- Episode 3 to 20%;
- Episode 4 with 17.3%;
- Episode 5 with 22.6%;
- Episode 8 with 28%
- Episode 9 with 24%; and
- Episode 10 with 22.5% (Lewis 2014 a,b; Lewis 2015 a,b,c; Lewis 2016; Niche 2016).

This confirms that bat boxes themselves provide an alternative den/roost resource and therefore contribute to the required quantities of nest boxes outlined in the Nest Box Plan of Management for the Oxley Highway to Kempsey Upgrade (Lewis 2013).

Bat Box Maintenance

Fire has destroyed four of the bat boxes catalogued as 49, 52, 54 and 56 as a result of the November 2016 fire (Plate 1-2). Two of these boxes had been previously reported as containing some termite damage (54, 56). Bat Box 3 (Tipping property) was laying on the ground and has subsequently been relocated around 10 m to the north where it now overhangs a back channel of Smiths Creek (Plate 1-3).

Termite activity remains largely static and at present the box shows no obvious structural damage that would limit its functionality. Continual evaluation of this will be required to ensure the boxes remain in a functional state during the

remainder of the construction program. At Bat Box 8, the Monkeys Rope (*Parsonsia straminea*) vines have been removed to maintain a clear passage.

Plate 1-2. Remnants of Bat Box 49 from the southern side of Maria River.

Plate 1-3. Bat Box 3 as located during Episode 10 monitoring (left) which has been subsequently relocated to an over water position 10 m to the north (right).

Recommendations

1. Replace the lost bat boxes by fixing to some specific underpass structures identified after the completion of the newly constructed culvert and bridge monitoring. The completion date for these works is winter 2017.

We have also attached an excel spreadsheet as an addendum file to this letter report which details the specifics of each box. Should you have any questions or queries please contact me at your convenience.

Kind Regards

Ben Lewis (Principal Ecologist)
Lewis Ecological Surveys

References

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

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Table 23: Bat roost box Event 10 Ku2K

Box	Roost Box Type	Height of Roost Box (m)	Aspect	Tenure	APO (MRS Identifier)	Easting (GDA1994 MGA 56)	Northing (GDA1994 MGA 56)	Lewis Record Number	Date	Bats Recorded	Species Name	Common Name	Number	Comments
2	Dark green wedge box	3.3	North-east	Private property (Tipping)	72	483308.2507	6546220.627	55	27.02.2017	No	-	-	-	
3	Light green box	3.2	North	Private property (Tipping)	72	483303.8392	6546224.456	56	27.02.2017	No	-	-	-	Laying on ground. Refitted to more appropriate location 10 m to north over water
4	Black slot box	3.1	North	Private property (Tipping)	72	483300.1451	6546233.754	57	27.02.2017	No	-	-	-	
5	Light green wedge box	3.3	North-east	Private property (Tipping)	72	483303.765	6546264.738	52	27.02.2017	No	-	-	-	Old leaf nest still present
6	Light green box	3.3	North-east	Private property (Tipping)	72	483290.786	6546260.629	51	27.02.2017	No	-	-	-	Old leaf nest still present
7	Hollow home standard box	3.8	North	Private property (Tipping)	72	483285.4427	6546262.768	50	27.02.2017	No	-	-	-	
8	Hollow home standard box	3.6	North-west	Private property (Tipping)	72	483364.6935	6546214.528	53	27.02.2017	No	-	-	-	vine maintenance enacted
9	Black wedge box	3.6	North	Private property (Tipping)	72	483362.8052	6546214.258	54	27.02.2017	No	-	-	-	Old leaf nest still present
10	Dark green slot box	3.6	North-east	RMS. Within project boundary	-	483088.8618	6546635.822	8	27.02.2017	Yes	*Nyctophilus gouldi*	Gould's Wattled Bat	1	
11	Light green wedge box	3	North	RMS. Within project boundary	-	483103.5806	6546630.993	7	27.02.2017	No	-	-	-	recent leaf nest
12	Hollow home standard box	3.6	North	RMS. Within project boundary	-	483099.2928	6546659.418	5	27.02.2017	Yes	*Nyctophilus gouldi*	Gould's Wattled Bat	1	
13	Hollow home standard box	3.6	North	RMS. Within project boundary	-	483108.4539	6546628.604	6	27.02.2017	No	-	-	-	
14	Black wedge box	3.6	North-west	RMS. Within project boundary	-	483094.3948	6546658.888	4	27.02.2017	No	-	-	-	

Box	Roost Box Type	Height of Roost Box (m)	Aspect	Tenure	APO (MRS Identifier)	Easting (GDA1994 MGA 56)	Northing (GDA1994 MGA 56)	Lewis Record Number	Date	Bats Recorded	Species Name	Common Name	Number	Comments
15	Dark green box	3.4	North-west	RMS. Within project boundary	-	483090.2553	6546663.497	3	27.02.2017	No	-	-	-	
16	Light green slot box	2.9	North	Private property (Toepfer)	63	483297.4404	6544838.048	10	27.02.2017	No	-	-	-	
17	Black wedge box	3.1	North	Private property (Toepfer)	63	483293.8617	6544837.358	11	27.02.2017	No	-	-	-	
18	Dark green box	3.5	North-west	Private property (Toepfer)	63	483266.3041	6544791.538	14	27.02.2017	No	-	-	-	
19	Hollow home narrow box	3.5	North-west	Private property (Toepfer)	63	483272.6204	6544814.953	13	27.02.2017	No	-	-	-	
20	Light green wedge box	3.1	North-west	Private property (Toepfer)	63	483268.7779	6544829.45	12	27.02.2017	No	-	-	-	
21	Hollow home slot box	3.3	North-west	Private property (Toepfer)	63	483295.3048	6544846.946	9	27.02.2017	No	-	-	-	
22	Black slot box	3	North-west	Private property (Hambly)	81	483299.9719	6548665.049	41	27.02.2017	No	-	-	-	recent glider/antechinus nest
23	Hollow home narrow box	3.8	North-west	Private property (Hambly)	81	483308.9929	6548656.581	43	27.02.2017	No	-	-	-	
24	Light green wedge box	3.5	North-west	Private property (Hambly)	81	483331.133	6548673.088	44	27.02.2017	No	-	-	-	Older leaf nest still present
25	Light green wedge box	3.7	North	RMS. Within project boundary	-	483256.4091	6548645.343	46	27.02.2017	No	-	-	-	
26	Black box	3	North	RMS. Within project boundary	-	483246.9841	6548641.664	45	27.02.2017	No	-	-	-	Older leaf nest still present
27	Hollow home slot box	3	North	RMS. Within project boundary	-	483293.4989	6548662.37	42	27.02.2017	No	-	-	-	mud wasp in rear chamber
28	Hollow home narrow box	3.7	North-west	RMS. Within project boundary	-	483127.9306	6548695.633	49	27.02.2017	No	-	-	-	
29	Dark green slot box	3	North	RMS. Within project boundary	-	483135.6817	6548673.658	47	27.02.2017	No	-	-	-	

Box	Roost Box Type	Height of Roost Box (m)	Aspect	Tenure	APO (MRS Identifier)	Easting (GDA1994 MGA 56)	Northing (GDA1994 MGA 56)	Lewis Record Number	Date	Bats Recorded	Species Name	Common Name	Number	Comments
30	Hollow home standard box	3.6	North	Private property (Brayley)	70	483118.7695	6546265.858	59	27.02.2017	No	-	-	-	
31	Dark green wedge box	3.4	North-east	RMS. Within project boundary	-	482880.8439	6542409.253	69	27.02.2017	No	-	-	-	Old leaf nest still present
32	Hollow home narrow box	3.3	North-west	Private property (Brayley)	70	483112.849	6546281.694	58	27.02.2017	Yes	*Nyctophilus geoffroyi*	Lesser Long-eared Bat	1	
35	Light green slot box	3	North	Private property (Brayley)	70	483059.9271	6546309.169	60	27.02.2017	No	-	-	-	leaf nest recent
36	Hollow home slot box	3.1	North-west	RMS. Within project boundary	-	482870.7922	6542405.373	68	27.02.2017	No	-	-	-	
37	Hollow home narrow box	3.5	North	RMS. Within project boundary	-	482873.3237	6542400.274	67	27.02.2017	No	-	-	-	
38	Light green box	3.6	North-west	RMS. Within project boundary	-	482861.1116	6542374.4	66	27.02.2017	No	-	-	-	
46	Light green box	4	North-west	RMS. Within project boundary	-	483133.3234	6554724.566	32	27.02.2017	No	-	-	-	
47	Hollow home narrow box	3.8	North-west	State Forest	87	483146.3766	6554719.227	33	27.02.2017	No	-	-	-	
49	Dark green wedge box	3.5	North-west	RMS. Within project boundary	-	483141.3054	6554709.099	34	27.02.2017	No	-	-	-	Destroyed by fire
50	Dark green slot box	3.4	North	RMS. Within project boundary	-	483030.3988	6554308.511	38	27.02.2017	No	-	-	-	
51	Hollow home standard box	4	North	State Forest	87	483151.5879	6554744.552	31	27.02.2017	No	-	-	-	
52	Hollow home narrow box	3.6	North-west	State Forest	87	483073.8214	6554383.555	39	27.02.2017	No	-	-	-	Destroyed by fire
53	Dark green box	3.3	North	State Forest	87	483081.6879	6554377.806	40	27.02.2017	No	-	-	-	
54	Hollow home standard box	3.7	North	RMS. Within project boundary	-	483040.0134	6554316.769	37	27.02.2017	No	-	-	-	Destroyed by fire

Box	Roost Box Type	Height of Roost Box (m)	Aspect	Tenure	APO (MRS Identifier)	Easting (GDA1994 MGA 56)	Northing (GDA1994 MGA 56)	Lewis Record Number	Date	Bats Recorded	Species Name	Common Name	Number	Comments
55	Hollow home narrow box	3.6	North	State Forest	87	483051.2937	6554332.976	36	27.02.2017	No	-	-	-	
56	Black wedge box	3.7	North-west	State Forest	87	483051.0629	6554342.454	35	27.02.2017	No	-	-	-	Destroyed by fire
57	Dark green wedge box	3.5	North	State Forest	57	482769.6848	6542094.168	73	27.02.2017	No	-	-	-	
58	Black slot box	3.1	North	State Forest	57	482779.166	6542118.566	74	27.02.2017	No	-	-	-	
59	Hollow home standard box	3.8	North-west	State Forest	57	482729.6069	6542081.099	71	27.02.2017	No	-	-	-	Old leaf nest still present
61	Hollow home narrow box	3.3	North-west	State Forest	57	482733.5319	6542073.671	70	27.02.2017	No	-	-	-	
62	Light green wedge box	3.2	North	State Forest	57	482726.5147	6542070.142	75	27.02.2017	No	-	-	-	
63	Black box	3.1	North	RMS. Within project boundary	-	482721.5836	6542109.474	72	28.02.2017	No	-	-	-	Old leaf nest still present
64	Hollow home slot box	3.3	North-west	State Forest	57	482859.0254	6542360.363	65	28.02.2017	No	-	-	-	
65	Hollow home standard box	3.5	North	State Forest	57	482834.4693	6542316.172	64	28.02.2017	No	-	-	-	
66	Dark green box	3.2	North	RMS. Within project boundary	-	482836.976	6542340.487	63	28.02.2017	No	-	-	-	Old leaf nest still present
67	Black box	3.3	North-east	RMS. Within project boundary	-	482839.0375	6542332.138	62	28.02.2017	No	-	-	-	Old leaf nest still present
68	Black wedge box	3.5	North	State Forest	57	482828.6889	6542290.127	61	28.02.2017	No	-	-	-	Old leaf nest still present
95	Hollow home slot box	3.8	North-west	State Forest	57	483195.2662	6543189.204	29	28.02.2017	No	-	-	-	
96	Hollow home slot box	3.8	North	State Forest	57	483201.0218	6543172.447	28	28.02.2017	No	-	-	-	

Box	Roost Box Type	Height of Roost Box (m)	Aspect	Tenure	APO (MRS Identifier)	Easting (GDA1994 MGA 56)	Northing (GDA1994 MGA 56)	Lewis Record Number	Date	Bats Recorded	Species Name	Common Name	Number	Comments
97	Hollow home standard box	3.7	North	State Forest	57	483179.8464	6543172.387	27	28.02.2017	No	-	-	-	
98	Dark green wedge box	4	North-west	RMS. Within project boundary	0	483172.4912	6543194.823	24	28.02.2017	No	-	-	-	
99	Black box	3.1	North-east	State Forest	57	483175.1875	6543170.218	25	28.02.2017	No	-	-	-	
100	Light green slot box	3.4	North-east	State Forest	57	483189.189	6543197.612	30	28.02.2017	No	-	-	-	
101	Black slot box	3.5	North	State Forest	57	483179.5661	6543166.269	26	28.02.2017	No	-	-	-	
130	Hollow home narrow box	3.6	North	Private property (Parkin property)	58	483338.8593	6543361.719	22	28.02.2017	No	-	-	-	Old leaf nest still present
131	Dark green slot box	3.6	North-west	Private property (Parkin property)	58	483322.1945	6543388.723	17	28.02.2017	No	-	-	-	
132	Hollow home slot box	3.7	North	Private property (Parkin property)	58	483280.0747	6543367.618	21	28.02.2017	No	-	-	-	
133	Hollow home slot box	3.6	North-east	Private property (Parkin property)	58	483287.5372	6543386.294	18	28.02.2017	Yes	*Nyctophilus geoffroyi*	Lesser Long-eared Bat	4	Using third chamber
134	Hollow home slot box	3.1	North-east	Private property (Parkin property)	58	483302.0499	6543360.639	19	28.02.2017	No	-	-	-	
135	Black slot box	3.2	North	Private property (Parkin property)	58	483303.1878	6543387.404	16	28.02.2017	No	-	-	-	
136	Hollow home slot box	3.8	North	Private property (Parkin property)	58	483297.8032	6543381.775	15	28.02.2017	Yes	*Nyctophilus geoffroyi*	Lesser Long-eared Bat	1	Using inner chamber closest to tree
137	Hollow home slot box	3.3	North-west	Private property (Parkin property)	58	483343.1059	6543367.418	23	28.02.2017	No	-	-	-	Old leaf nest still present
138	Hollow home standard box	3.7	North	Private property (Parkin property)	58	483305.6698	6543364.228	20	28.02.2017	No	-	-	-	
139	Hollow homes standard box	3.9	North	Private property (Mobbs)	60	483279.2996	6543729.284	1	28.02.2017	No	-	-	-	

Box	Roost Box Type	Height of Roost Box (m)	Aspect	Tenure	APO (MRS Identifier)	Easting (GDA1994 MGA56)	Northing (GDA1994 MGA56)	Lewis Record Number	Date	Bats Recorded	Species Name	Common Name	Number	Comments
140	Hollow home slot box	3.6	North-west	Private property (Mobbs)	60	483287.9247	6543727.064	2	28.02.2017	No	-	-	-	
28B	Black wedge box	3.4	North	RMS. Within project boundary	-	483126.8009	6548693.244	48	28.02.2017	No	-	-	-	

Additional structures (Lewis Ecological Surveys)

Table 24: Bat roost additional structures monitoring

Old Culvert Identifier	Summer Survey Date	Winter Survey Date	Structure Type	Culvert/Bridge Configuration (~mm height x width)	No of Cells/ Spans	Constructed Material	Expansion Gaps	Drainage	Water in culvert	Martin/ Swallow Nests	Winter Bat Observation	Summer Bat Observation	Comments
599031	03.02.2017	Proposed for July 2017	Box	1500 x 3000	1	Concrete	Three cells with 20-30 mm gaps	Nil	Nil	No	To be completed	Nil	Potential for use during winter from Bent-wing Bats. Summer survey shortly after culvert works were completed.
599032 + 599033	03.02.2017	Proposed for July 2017	Box	3000 x 3000	1	Concrete	Several cells with 20-40 mm gaps	Combined	Nil	No	To be completed	Nil	Likely to provide habitat during winter months. Culvert recently completed which probably detracted from use during 2016/17 summer
599032 + 599033	03.02.2017	Proposed for July 2017	RCP	900	1	Concrete	<20 mm	Suitable at lifting lugs - 50 x 100 mm deep	No	No	To be completed	Nil	Likely to provide temporal habitat for bent-wing bats. This will be confirmed during winter survey when bent wing bat numbers build up in the project area
Mingaletta Bridge	03.02.2017	Proposed for July 2017	Box	2400 x 2400	5	Concrete	20-35 mm gaps present in each of 5 cells	Combined	Nil	No	To be completed	Southern Myotis x 1 (Cell C)	Confirmed as habitat for threatened bats. Bent-wing bats previously recorded using this structure.
599033	03.02.2017	Proposed for July 2017	Box	1500 x 3000	1	Concrete	<20 mm gaps only	Nil	Nil	No	To be completed	Nil	Not considered suitable bat habitat. Adjacent culverts provides increased suitability as roost habitat.
599035	03.02.2017	Proposed for July 2017	Box	2400 x 2400	1	Concrete	20-40 mm gaps present	Dedicated with overflow drainage design	Nil	Nil	To be completed	Nil	Newly installed culvert so it has only provide habitat for a matter of weeks. Likely to contain bats during the winter 2017 survey, particularly bent-wing bats.

Old Culvert Identifier	Summer Survey Date	Winter Survey Date	Structure Type	Culvert/Bridge Configuration (~mm height x width)	No of Cells/ Spans	Constructed Material	Expansion Gaps	Drainage	Water in culvert	Martin/ Swallow Nests	Winter Bat Observation	Summer Bat Observation	Comments
599035 + Private Access Driveway	03.02.2017	Proposed for July 2017	Pipe	1800	2	Concrete	20-35 mm gaps present in each cell	50 x 50 mm deep	Nil	Nil	To be completed	Nil	Newly installed culvert so it has only provide habitat for a matter of weeks. Likely to contain bats during the winter 2017 survey, particularly bent-wing bats. Moreover, bats were discouraged from this roost to enable the western culvert works to be completed in summer 2017.
599036	03.02.2017	Proposed for July 2017	Pipe	1100	1	Concrete	20-40 mm x 75 mm deep	50 x 50 mm deep	Nil	No	To be completed	Recent bat scats	Likely to be used by Bent-wing Bats during winter 2017 survey
599038	03.02.2017	Proposed for July 2017	Pipe	~1100	1	Concrete	To be completed when install finished	To be completed when install finished	To be completed when install finished		To be completed	Nil	As the culvert is contained with deep fill zone, micro bats are likely to select as roost site in winter 2017
599039	03.02.2017	Proposed for July 2017	Box	3000 high x 3000 wide	1	Concrete	20-30 mm gaps in two joins	Combined	Combined with upwards of 150 mm	No	To be completed	Nil	Likely to be used during forthcoming winter 2017 as works had recently been completed in this structure
599041	03.02.2017	Proposed for July 2017	Box	3000 high x 3000 wide	1	Concrete	20-40 mm gaps in four joins	Nil	Combined with upwards of 150	No	To be completed	Southern Myotis x 1	Confirmed as habitat for threatened bats. The combined nature of this culvert represents an increase from the previous 1100 RCP believed to provide more temporal roost habitat

Old Culvert Identifier	Summer Survey Date	Winter Survey Date	Structure Type	Culvert/Bridge Configuration (~mm height x width)	No of Cells/ Spans	Constructed Material	Expansion Gaps	Drainage	Water in culvert	Martin/ Swallow Nests	Winter Bat Observation	Summer Bat Observation	Comments
599043 Smiths Creek Overflow - Nth Side + Smiths Creek Bridge	03.02.2017	Proposed for July 2017	Bridge	3 spans slightly higher than original bridge	3	Concrete	In outer box girders and with the paraphats	Nil	Main pool below of Smiths Creek	No	To be completed	Nil	Likely to be used by both Southern Myotis and Bent-wing Bats in the near future.
599043 Smiths Creek Overflow - Nth Side + Smiths Creek Bridge	03.02.2017	Proposed for July 2017	Bridge	not constructed at time of survey	not constructed at time of survey	not constructed at time of survey	not constructed at time of survey	not constructed at time of survey	not constructed at time of survey	not constructed at time of survey	not constructed at time of survey	not constructed at time of survey	Will be available for the winter 2017 survey
599044	01.02.2017	Proposed for July 2017	Box	2400 x 2400	1	Concrete	20-30 mm gaps in four joins	Combined	Laminar flow	No	To be completed	Nil	Bats more likely to utilise neighbouring Smiths Creek bridges
599045	23.01.2017	Proposed for July 2017	Box	1300	4	Concrete	25-40 mm gaps in third and fourth cell sections	40 mm x 200 mm deep but plastic conduit		No	To be completed	Nil	Plastic conduit probably makes the vertical drainage too smooth as a roost site. Therefore probably not bat habitat
599046	25.01.2017	Proposed for July 2017	Box	3000 x 3000	1	Concrete	4 cells with 25-40 mm gaps	Combined	No	No	To be completed	Nil	No signs of bats but potential habitat

Old Culvert Identifier	Summer Survey Date	Winter Survey Date	Structure Type	Culvert/Bridge Configuration (~mm height x width)	No of Cells/ Spans	Constructed Material	Expansion Gaps	Drainage	Water in culvert	Martin/ Swallow Nests	Winter Bat Observation	Summer Bat Observation	Comments
Pipers Creek Bridge	23.01.2017	Proposed for July 2017	Bridge	3 separate bridges - local road is retained original	3	Concrete	New bridges paraphets provide extensive gaps in wedge configuration	Scupper blocked on old bridge, new ones are piped back to basins	Pools beneath bridge	Yes on old bridge	To be completed	Micro bat observed using Swallow nests on local road bridge but couldn't be identified. Presume Southern Myotis	Improvement in suitability of bat habitat with additional two new bridges, each provide extensive bat roost habitat. Layflat used on local road bridge scuppers should be now removed as part of finishing /bridge washing works
599050	23.01.2017	Proposed for July 2017	Box	3000 x 3000	1	Concrete	Generally <20 mm	Combined	No	No	To be completed	Nil	No signs of bats but potential habitat not too dissimilar to pre-construction surveys of smaller RCPs
599051	23.01.2017	Proposed for July 2017	Box	3000 x 3000	1	Concrete	5 cells with 25-40 mm gaps	Combined	No	No	To be completed	Nil	No signs of bats but potential habitat not too dissimilar to pre-construction surveys of smaller RCPs
599052	09.01.2017	Proposed for July 2017	Box	3000 x 3000	1	Concrete	<20 mm	Combined	No	Yes	To be completed	Nil	Rodent scats observed
599053	09.01.2017	Proposed for July 2017	Box	3000 x 3000	1	Concrete	<20 mm	Combined	No	No	To be completed	Nil	No signs of bats but potential habitat not too dissimilar to pre-construction surveys of smaller RCPs
599057	09.01.2017	Proposed for July 2017	Box	3000 x 3000	1	Concrete	20-40 mm gaps at three joins	Dedicated	Dry	No	To be completed	Nil	Most likely used by Bent-wing Bats during cooler months of the year

Old Culvert Identifier	Summer Survey Date	Winter Survey Date	Structure Type	Culvert/Bridge Configuration (~mm height x width)	No of Cells/ Spans	Constructed Material	Expansion Gaps	Drainage	Water in culvert	Martin/ Swallow Nests	Winter Bat Observation	Summer Bat Observation	Comments
599057	09.01.2017	Proposed for July 2017	Box	3000 x 3000	1	Concrete	20-40 mm gaps at two joins	Combined	Dry	No	To be completed	Nil	Most likely used by Bent-wing Bats during cooler months of the year
599058	09.01.2017	Proposed for July 2017	Box	3000 x 3000	1	Concrete	20-40 mm gaps at five joins	Combined	Dry	No	To be completed	Miniopterus australis x 3	Bats roosting singularly
599058	25.01.2017	Proposed for July 2017	Box	3000 x 3000	1	Concrete	Marginal gaps of around 20-25 mm in a few joins	Dedicated	Dry	No	To be completed	Nil	Likely for Bent-wing Bats to utilise this site during winter. Adjacent 3 cell box culvert no surveyed due to water depth and confined spaces. The culverts does look to provide ideal habitat for Southern Myotis
599062 + 599063	25.01.2017	Proposed for July 2017	Box	3000 x 3000	1	Concrete	Marginal gaps generally <25 mm	Combined	Small amount in low flow section	No	To be completed	Nil	Suitable location to re-distribute some of the bat boxes over water within the culvert to improve functionality for fauna. Note - culvert dimensions likely well beyond hydraulic capacity of the catchment
599064	09.01.2017	Proposed for July 2017	Box	3000 x 3000	1	Concrete	20-35 mm gaps in two joins	Combined	Dry	No	To be completed	Nil	Likely to be taken up by Bent-wing Bats during cooler winter months
Maria River - Historic Doolan Design Bridge	25.01.2017	Proposed for July 2017	Bridge	6000 high	3	Timber	<10-60 mm and up to 250 mm deep	No	1000 mm under centre span but shallow in summer	No	To be completed	Nil	Bats are likely to occasionally roost in this structure. This will be retained during the upgrade.

Old Culvert Identifier	Summer Survey Date	Winter Survey Date	Structure Type	Culvert/Bridge Configuration (~mm height x width)	No of Cells/ Spans	Constructed Material	Expansion Gaps	Drainage	Water in culvert	Martin/ Swallow Nests	Winter Bat Observation	Summer Bat Observation	Comments
Maria River North Bound	25.01.2017	Proposed for July 2017	Bridge	9000 high	1	Concrete Super T	40-100 mm and up to 150 deep	No	1000 mm under centre span but shallow in summer	No	To be completed	Miniopterus australis x 17	Bats are periodically using this structure with numbers likely to increase again during cooler months
Maria River South Bound	25.01.2017	Proposed for July 2017	Bridge	9000 high	3	Concrete	10-40 mm and up to 125 deep	No	1000 mm under centre span but almost dry in summer	No	To be completed	Miniopterus australis x 5	Bats are periodically using this structure with numbers likely to increase again during cooler months
Stumpy Creek Bridge North Bound	23.01.2017	Proposed for July 2017	Bridge	3 separate bridges	3	Concrete	New bridges paraphets provide extensive gaps in wedge configuration	Scupper blocked on old bridge, new ones are piped back to basins	Pools beneath bridge	No	To be completed	Nil	Improvement in suitability of bat habitat with additional two new bridges, each provide extensive bat roost habitat
Stumpy Creek Bridge South Bound	23.01.2017	Proposed for July 2017	Bridge	3 separate bridges	3	Concrete	New bridges paraphets provide extensive gaps in wedge configuration	Scupper blocked on old bridge, new ones are piped back to basins	Pools beneath bridge	No	To be completed	Nil	Improvement in suitability of bat habitat with additional two new bridges, each provide extensive bat roost habitat

Annex 7. Green-thighed Frog breeding pond monitoring 2016/2017 (Niche 2017b)

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Environment and Heritage

Green-thighed Frog Monitoring 2017

Breeding Ponds

Oxley Highway to Kempsey, Pacific Highway Upgrade

Prepared for Road and Maritime Services

9 August 2017

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Cover photograph: Green-thighed Frog located at Collombatti Reference Site (Photo: F. Lemckert)

Executive summary

Context

This report documents the 2017 monitoring period (summer 2017), the first of five monitoring events for the Green-thighed Frog breeding ponds, as required for the Oxley Highway to Kempsey (OH2K) Pacific Highway upgrade project (the Project).

Aims

The NSW Roads and Maritime Services (Roads and Maritime) is required to manage and monitor the effectiveness of the biodiversity mitigation measures implemented as part of the project. This includes the Green-thighed Frog, the monitoring of which is to be performed in accordance with the methodology presented in the Ecological Monitoring Program (EMP) (RMS 2016). The aim of the Green-thighed Frog breeding ponds monitoring is to determine if Green-thighed Frogs are using the purpose built compensatory breeding habitat and thus determine whether the Project is meeting the performance indicators for the species, and provide corrective actions where required.

Methods

Surveys were undertaken in accordance with the EMP. Stage 1 surveys were triggered by sufficient rainfall (EMP 2016) and involved a 30 minute nocturnal active search at the Collombatti reference site and at each of the constructed pond sites, as well as a peripheral habitat search. To consolidate monitoring surveys, Stage 2 surveys were undertaken 43 days after Stage 1 surveys. Stage 2 surveys involved a 20 minute active search of the ponds and adjacent vegetation and dip-netting of ponds. Pond depth was recorded, presence of fish and predatory larvae noted, and a photo was taken from a designated reference point.

Key results

Stage 1 surveys were undertaken on the 16th March 2017. Green-thighed Frogs were recorded at the Collombatti reference site and at two ponds at Site 3. All ponds at sites 1, 3 and 4E contained 10 – 40 cm of water, while ponds at site 4W were found to contain no water.

Stage 2 surveys were undertaken on the 28th April 2017, 43 days after Stage 1 surveys. No Green-thighed Frogs were recorded. All ponds at Sites 1 and 3 held water and all ponds at Site 4 were dry.

Gambusia (*Gambusia holbrooki*) was identified at the Collombatti reference site and Site 1.

Conclusions

Performance indicators of success have not been met for some or all of the constructed pond sites.

Performance indicators of unsuccessful mitigation have been been met for some or all of the ponds at each of the constructed pond sites.

Management implications

Contingency measures and corrective actions provided in the EMP and Green-thighed Frog Management Strategy, respectively, are considered relevant to a number or all ponds at all three monitoring sites. A number of recommendations to meet performance criteria should be considered and include:

- Laying a semi-permeable layer within the ponds to improve water retention, and
- Reviewing surrounding drainage.

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1. Introduction

1.1 Context

The Oxley Highway to Kempsey (OH2K) section of the Pacific Highway Upgrade Project (the Project) was approved in 2012, subject to various Ministers Conditions of Approval (MCoA) and a Statement of Commitments (SoC). A subsequent approval with additional conditions of consent (CoA) was granted in 2014 by the Commonwealth Department of Environment (DoE) for matters of national environmental significance (MNES) listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1995* (EPBC Act). The Ecological Monitoring Program (EMP) (RMS 2016) (hereafter referred to as the EMP) combines these approval conditions and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project. The Green-thighed Frog (*Litoria brevipalmata*) was identified as requiring mitigation and monitoring through the course of the Projects' construction and post construction period.

1.1.1 Legal Status

The Green-thighed Frog is listed as vulnerable under the NSW *Threatened Species Conservation Act 1995* (TSC Act). Monitoring of the species is required under the Project's approval.

1.1.2 Monitoring Framework

Green-thighed Frog monitoring is to be performed in accordance with the EMP and the Green-thighed Frog Management Strategy (Lewis 2013), with the EMP taking precedence where inconsistencies occur. Construction will involve direct and indirect impacts on known Green-thighed Frog habitat areas, which will prevent post-construction monitoring. Therefore monitoring will be of purpose-built constructed breeding ponds, as per the EMP .

The EMP states: "*Monitoring will be undertaken on five occasions commencing in Years 3-7 (construction and operation phase). Each monitoring event should be at least 10-12 months apart but ultimately dependant on rainfall events.",* and that *" The first round of monitoring (Year 3) is to commence once the vegetation on the edges of the constructed ponds is considered sufficient (>20% groundcover), to be determined by a suitably qualified Ecologist*."

The Green-thighed Frog Management Strategy requires a two-component approach to Green-thighed Frog monitoring:

- monitoring of breeding ponds, and
- monitoring the integrity of the frog fences.

The monitoring of frog fencing will be undertaken as part of the fauna fence monitoring (in conjuction with underpass monitoring periods). These results will be included in the reporting for the fauna fence monitoring component of the Project.

The summer 2017 monitoring represents the first of five monitoring events.

1.1.3 Baseline Data

Green-thighed Frogs were identified from eight locations during baseline surveys (Lewis 2013), however no tadpoles, metamorphs or juvenile Green-thighed Frogs were recorded at the breeding sites at 57 days. The Green-thighed Frog Management Strategy (Lewis 2013) states:

"*Frog breeding ponds will be constructed at four locations, two within the Oxley Highway to Kundabung Upgrade section and two within the Kundabung to Kempsey section.*"

The EMP provides a summary of the location of the proposed breeding ponds:

- Ch.9050-9350. Five ponds to be constructed on each side of the carriageway.
- Ch.11550. Five ponds to be constructed on each side of the carriageway (Project Ecologist to investigate the suitability of ponds in consultation with RMS and the EPA and be guided by the results of pre-clearing surveys).
- Ch.30660. Five ponds to be constructed on the western side of the carriageway.
- Ch.33650. Five ponds to be constructed on each side of the carriageway.

It was determined in consultation with the EPA that the construction of 10 ponds at Ch. 11550 was not warranted due to several surveys finding no record of Green-thighed Frogs in the area around Ch. 11550, and that breeding habitat remains available locally outside the project boundary. As such, monitoring has been undertaken of ponds constructed at the remaining three sites.

1.1.4 Purpose of this Report

This report complies with the monitoring requirements described within the approved EMP and the Green-thighed Frog Management Strategy (Lewis 2013), and details the findings obtained from the first monitoring period. It represents the first of five monitoring events.

The aims of this report are to summarise the methods and results of the summer 2017 monitoring, determine if performance measures are being met, and to comment on the need for contingency measures, as per the EMP.

1.2 Performance measures

The Green-thighed Frog Management Strategy and the EMP specify a number of performance indicators against which the success of the compensatory habitat will be measured . These are listed in Table 1 and their inclusion in the relevant document is shown.

Table 1: Performance indicators

	GThF MS	EMP
Performance indicators of success		
Continued presence of Green-thighed Frog at two/three or more of the three/four breeding pond sites.	✓	✓
Green-thighed Frogs calling from the edge of the constructed ponds.	✓	✓
The presence of tadpoles, juveniles or metamorphs at the frog breeding ponds during Stage 2 surveys.	✓	✓
Signs of the mitigation being unsuccessful		
Absence of Green-thighed Frogs from one or more of the four sites (GThF MS) Absence of Green-thighed Frogs from the area (EMP)	✓	✓
Ponds not holding water for a sufficient time to enable tadpoles to reach metamorphosis.	✓	✓
Ponds holding water for too long and representing unsuitable habitat (i.e. permanent versus ephemeral).	✓	✓
Exotic fish fauna recorded in breeding ponds.	✓	

GThF MS = Green-thighed Frog Management Strategy (Lewis 2013); EMP = Ecological Monitoring Program (RMS 2016).

1.3 Monitoring timing

The EMP specifies that:

"*Monitoring will be undertaken on five occasions commencing in Years 3-7 (construction and operation phase). Each monitoring event should be at least 10-12 months apart but ultimately dependant on rainfall events. On each occasion the site would be surveyed for 30 minutes during Stage 1 and for 20 minutes during stage 2 (see section 4.9.3). Four of the five monitoring events are to occur during the operational phase of the Project (Years 4-7). The first round of monitoring (Year 3) is to commence once the vegetation on the edges of the constructed ponds is considered sufficient (>20% groundcover), to be determined by a suitably qualified Ecologist. The timing would be staggered accordingly for either stage of the Upgrade.*"

1.4 Reporting

Annual reporting of monitoring results are required to include:

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

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

1.5 Limitiations

The following limitations to the monitoring procedure were encountered:

- A definitive statement as to the fulfilment of performance indicators relating to ponds drying too soon or holding water for too long cannot be made for some or all of the ponds respectively, due to surveys requiring Stage 2 surveys to be undertaken 30 – 40 days after Stage 1. As such, data concerning the presence of water in the ponds prior to or after Stage 2 surveys is not available.

2. Survey Methods

2.1 Monitoring sites

The monitoring site locations are shown in Figure 1. These sites correspond to the proposed pond locations as required by the EMP and are described in Table 2. The Collombatti site was used as the reference site.

Table 2: Survey sites

Site Name (map ID)	Proposed frog pond sites (EMP)
Collombatti Reference (Ref)	As required by Stage 1 surveys: "*Upon the study area receiving the required rainfall, a reference site would be visited to determine the extent of Green-thighed Frog activity*"
1W	Ch.9050-9350. Five ponds to be constructed on each side of the carriageway (10 in total)
1E	
3W	Ch.30660. Five ponds to be constructed on the western side of the carriageway
4W	Ch.33650. Five ponds to be constructed on each side of the carriageway (10 in total)
4E	

2.2 Survey method

The survey method described within the updated approved EMP (extracted from the Green-thighed Frog Management Strategy) was employed for all surveys and is provided below.

"*Monitoring of the constructed breeding ponds would ideally be undertaken on a rainfall event basis when 24-hour rainfall totals exceed 75 millilitres or a cumulative total of 150 millilitres over a 72-hour period. Such rainfall events would be monitored via the Bureau of Meteorology (BOM) website, specifically the Port Macquarie (Station No. 060183) and/or Kempsey (Station No. 059017) weather stations. Where sufficient rainfall is unlikely to occur during the monitoring period, the Project Ecologist will determine whether smaller rainfall events are suitable to conduct a monitoring event. The suitability of the rainfall trigger chosen would be subject to the reference site visit outlined in Stage 1 below. Surveys would be performed using a two-stage process outlined below.*

a) Stage 1 – Determining Presence and Breeding Activity

Upon the study area receiving the required rainfall, a reference site would be visited to determine the extent of Green-thighed Frog activity.

The survey would comprise a 30 minute nocturnal active search at each of the four breeding pond areas (sites) using a hand held spotlight. Peripheral habitats (i.e. <50 m) would also be surveyed at this time. Upon the completion of Stage 1 surveys the next stage would be implemented.

b) Stage 2 – Determining the Success of the Breeding Event

All sites would be subject to follow-up surveys between 30-40 days after the initial census to assess the outcome of the breeding event. This follow up survey will comprise:

- *A 20 minute active search for metamorphs and juvenile frogs around the pond edge and vegetation immediately adjacent to the pond (i.e. <10 m).*
- *Dip-netting of the constructed pond and subsequent tadpole identification. Specific attention will be given toward identifying the presence of fish (both native and exotic) along with predatory invertebrates such as dytiscid larvae.*

- *The depth of the ponds would be measured from the permanently installed water staff.*
- *Photo taken from a designated photo point (to be established during the first Stage 2 survey).”*

2.3 Analysis

Monitoring results are to be analysed in accordance with the performance indicators specified within the EMP. In the case of the Green-thighed Frog, performance measures are based on presence/absence results and pond habitat quality and do not require statistical comparison between survey events.

3. Results

3.1 Stage 1 and Stage 2 monitoring results

Field data from Stage 1 and Stage 2 monitoring for all sites are provided in Annex 1. Photo monitoring results are provided in Annex 2.

a) Stage 1 – Determining Presence and Breeding Activity

Suitable rainfall, as specified within the EMP, did not occur until March 2017. As such, Stage 1 surveys were undertaken on the 16th March 2017 when rainfall was deemed suitable by the Project Ecologist. Rainfall at the sites in the previous 24 hours ranged from 124 mm to 158 mm and air temperatures ranged from 19˚C to 25˚C.This rainfall was within the recommended range stated in the EMP of "*24-hour rainfall totals exceed 75 millilitres or a cumulative total of 150 millilitres over a 72-hour period".*

Nocturnal active searches

One Green-thighed Frog was identified at the Collombatti reference site within 10 m of the flooded depression. Three Green-thighed Frogs were heard calling and single individuals were observed at each of two ponds at Site 3 during Stage 1 surveys. One calling male was present on the border between a constructed pond and the flooded depression behind it. The other two calling males were heard calling within the roadside gutter and flooded swamplands to the west of the constructed ponds respectively.

A number of other frog species were heard calling at the Collombatti reference site, Site 1 and Site 3 and Site 4. Other species identified include the Great Barred Frog (*Mixophyes fasciolatus*), Striped Marsh Frog (*Limnodynastes peronii*), Common Froglet (*Crinia signifera*), Dusky Toadlet (*Uperoleia fusca*), Whirring Tree Frog (*Litoria revelata*), Rocket Frog (*Litoria nasuta*), Peron's Tree Frog (*Litoria peronii*), and Dainty Tree Frog (*Litoria gracilenta*).

Pond depth at Stage 1

All ponds at sites 1, 3 and 4E contained 10 – 40 cm of water. Ponds at site 4W contained no water during Stage 1 surveys.

b) Stage 2 – Determining the Success of the Breeding Event

Stage 2 surveys were undertaken on the 28th April 2017, 43 days after Stage 1 surveys. To consolidate monitoring efforts for Giant Barred Frog and Green-thighed Frog surveys from both the OH2K monitoring program and the Frederickton to Eungai Pacific Highway Upgrade (F2E) monitoring program all Stage 2 surveys were undertaken on the one day. For OH2K Green-thighed Frogs this falls outside the 30 - 40 day time frame for Stage 2 surveys. Efforts will be made in future monitoring events to ensure Stage 2 surveys are compliant with both OH2K and F2E requirements.

Active searches and dip-netting

A number of tadpoles were caught at the Collombatti reference site and Site 3 and were identified as either *Limnodynastes spp*. or Whirring Tree Frogs (*Litoria revelata*). None of these tadpoles were identified as Green-thighed Frog tadpoles.

Gambusia (*Gambusia holbrooki*) was identified at the Collombatti reference site and Site 1.

Pond depth at Stage 2

During the Stage 2 surveys water levels in the constructed ponds were as follows:

- site 1 - all constructed ponds held water (< 5 cm - 40 cm deep)
- site 3 - all constructed ponds held water (15 cm - 40 cm deep)
- site 4 – all constructed ponds were dry.

Photo monitoring

Photo points were established during Stage 2 surveys. It should be noted that photo points were not established at all Site 4 ponds as it was considered likely that the ponds would be re-worked due to their inability to hold water. The results of the first photo monitoring are provided in Annex 2.

4. Discussion

A discussion of the summer 2017 monitoring results in relation to the performance measures detailed in the EMP and the Green-thighed Frog management Strategy (Lewis 2013) is provided in Table 3 and Table 4.

Table 3: Performance indicators of success

Performance indicators of success	Discussion
Continued presence of Green-thighed Frog at two or more of the three breeding pond sites.	**This performance measure has not been met.** Green-thighed Frogs were heard calling and identified at only one (Site 3) of the three breeding pond sites.
Green-thighed Frogs calling from the edge of the constructed ponds.	**This performance measure has not been met for two of the three sites.** Green-thighed Frogs were heard calling at Site 3 only.
The presence of tadpoles, juveniles or metamorphs at the frog breeding ponds during Stage 2 surveys.	**This performance measure has not been met.** Green-thighed Frog tadpoles, juveniles or metamorphs were not observed or heard calling at any of the sites containing constructed ponds.

Table 4: Signs of the mitigation being unsuccessful

Performance indicators of unsuccessful mitigation	Discussion
Absence of Green-thighed Frogs from one or more of the three sites (GThF MS). Absence of Green-thighed Frogs from the area (EMP).	**This performance indicator of unsuccessful mitigation has been met.** Green-thighed Frogs were not recorded at two of the three breeding pond sites or within the broader area.
Ponds not holding water for a sufficient time to enable tadpoles to reach metamorphosis.	**This performance indicator of unsuccessful mitigation has been met for 10 of the 25 constructed ponds.** According to Lewis 2013, ponds should have a maximum depth of 400 mm and hold water for between 30-40 days at sunny exposed sites or 50-60 days at shaded locations. The surveyed ponds can be classed as sunny exposed sites due to the cleared nature of the area where ponds were constructed. Water should therefore be retained for at least 30 and up to 40 days in these ponds. Stage 2 surveys were undertaken 43 days after Stage 1. Site 1 and site 3 ponds (15 ponds) all contained water during Stage 1 and Stage 2 surveys, i.e. they held water long enough for breeding cycles to occur as per the EMP. **This performance indicator of unsuccessful mitigation has therefore not been met for these sites.** However, site 4W ponds were found to be dry during Stage 1 surveys and Stage 2 surveys. Site 4E ponds contained water during Stage 1 surveys but were dry during Stage 2 surveys. While survey timing precludes a definitive statement that ponds at site 4E were dry prior to the required 30 days, it is considered likely that these ponds did not hold water for the specified minimum period of 30 days. **This performance indicator of unsuccessful mitigation has therefore been met for these sites.**
Ponds holding water for too long and representing unsuitable habitat (i.e. permanent versus ephemeral).	**This performance indicator of unsuccessful mitigation has been met for 11 of the 25 constructed ponds.** The ponds can be classed as sunny exposed sites due to the cleared nature of the area where ponds were constructed. Water should therefore be retained for up to 40 days in these ponds. Surveys were undertaken 43 days after Stage 1. At this time all ponds at Site 1 and Site 3 still contained water (15 ponds). It is reasonable to assume that the four (of 15) ponds that had a maximum depth of 15 cm would have dried relatively soon after the survey-representing a suitable empemeral water source. However the other 11 ponds with a minimum 20 cm depth at Stage 2 surveys are likely to have retained water for longer periods of time beyond Stage 2 surveys at 43 days indicating an extended and potentially unsuitable hydroperiod for this species.

Exotic fish fauna recorded in breeding ponds (GThF MS).	**This performance indicator of unsuccessful mitigation has been met for one of the three sites.** Gambusia (*Gambusia holbrooki*) was identified in two ponds at Site 1.

GThF MS = Green-thighed Frog Management Strategy (Lewis 2013); EMP = Ecological Monitoring Program (RMS 2016).

5. Recommendations

5.1 Contingency Measures

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those that are considered to be relevant to the Green-thighed Frog monitoring program are listed and discussed in Table 5.

As potential problems listed in the EMP correspond with performance measures and corrective actions provided in the Green-thighed Frog Management Strategy, recommendations for both contingency measures and corrective actions are provided in Table 6.

Table 5: Contingency Measures

Potential Problem	Conitngency Measure proposed in EMP	Discussion of proposed measure
Ponds not used by Green-thighed frog.	Survey adjacent areas to confirm frogs remain in area. Review/modify ponds to improve potential site suitability problems.	Green-thighed Frogs were not recorded at Site 1 and Site 4 during any surveys. Surrounding areas (within 100 m) were assessed through aural surveys and visual transects to and from sites at the time of surveys. No additional Green-thighed Frog records were obtained. **This contingency measure is considered relevant.**
Ponds not holding water long enough to enable breeding to succeed.	Review/modify ponds either by placing a semi permeable layer or further excavation.	A number of ponds were dry at Stage 1 and Stage 2 surveys, as per Table 4. **This contingency measure is considered relevant.**
Ponds holding water for too long encouraging competition from non-target frog fauna.	Improve drainage.	A number of ponds contained water after 40 days, as per Table 4. **This contingency measure is considered relevant**.
Exotic fish species recorded in breeding ponds.	Modify pond to ensure it dries out.	Gambusia was identified in ponds at Site 1. **This contingency measure is considered relevant.**

5.2 Recommendations

As this report addresses the first monitoring event for Green-thighed Frog breeding ponds, the following recommendations/considerations are provided to address the proposed contingency measures as identified in the EMP, in an effort to maximise the likelihood that performance measures may be achieved in the future.

A number of recommendations have been made in Table 6 that relate directly to the contingency measures proposed within the EMP. Recommended actions listed below are based on the failure to detect Green-thighed Frogs at Site 1 and Site 4 during any of the survey periods; the lack of water retention for the minimum period in some of the ponds and the extended (and potentially unsuitable) hydroperiod in other ponds.

While specific recommendations have not been made, the following considerations should be taken into account in any interim discussions with the EPA and for the development of monitoring programs and compensatory habitat for this species.

Considerations

- Ponds not holding water for specified time or only filling to 50 % of their capacity:

- Consider increasing the size of these ponds to increase the volume and likely hydroperiod. Recommended dimensions: 10 m x 5 m, 50 – 100 cm deep. These recommended dimensions are based on the research of Dr David Ledlin (Ledlin 1997).
- Consider reviewing surrounding drainage in order to direct more surface runoff to the ponds.

Table 6: Signs of the mitigation being unsuccessful and corrective actions

Performance indicators of unsuccessful mitigation	Action described in GThF MS	Recommendation
Absence of Green-thighed Frogs from one or more of the four sites (GThF MS) Absence of Green-thighed Frogs from the area (EMP).	The corrective action for this would be to firstly, implement additional surveys of adjacent areas to confirm Green-thighed Frogs remain in that general area, and secondly, undertake a review and if deemed necessary modify the ponds to improve any site suitability problems.	Applies to: **Site 1 and Site 4** Consider additional surveys in habitat that is adjacent to monitoring sites and that is deemed suitable for Green-thighed Frogs by the project ecologist to assist in determining the continued presence and activity of the Green-thighed Frog in the general area. Consider necessary modifications to ponds as described below.
Ponds not holding water for a sufficient time to enable tadpoles to reach metamorphosis.	The corrective action for this would involve a review and if deemed necessary, modify the ponds by placing a semi permeable layer or further excavation.	Applies to: **all ponds at Site 4E and Site 4W** (dry at Stage 2) and **2 ponds Site 1E and 2 ponds Site 3** (these ponds did not fill to more than 50% of their capacity). Consider laying semi-permeable layer to improve water retention and/or extend semi-permeable layer up the walls. Ponds at Site 4W are isolated between two roadways. Connectivity for these ponds and surrounding habitat is limited to dispersal across Ravenswood Road. These ponds should provide breeding habitat for those animals in this isolated habitat. It is therefore recommended that consideration be given to additional revegetation in this area. Applies to: **All ponds at all sites** Install water staff with graduated water depth indicators.
Ponds holding water for too long and representing unsuitable habitat (i.e. permanent versus ephemeral).	The corrective action for this would be to improve drainage to ensure the pond dries out.	Applies to: **All ponds Site 1W, 3 ponds Site 1E and 3 ponds Site 3** Where ponds have a build up of clay material consider mixing a more permeable sediment, such as sand, with the natural substrate to improve drainage. Consider interim site visits to determine water presence in the constructed ponds. Extended hydroperiods may be acceptable, providing the pond dries at least once each year to prevent the build up of predators.
Exotic fish fauna recorded in breeding ponds (GThF MS).	The corrective action for this would be to improve drainage to ensure the pond dries out.	Applies to: **2 ponds Site 1E** Gambusia was recorded in two ponds at Site 1, however there is potential for this species to occur at all ponds holding water for too long and that at least occasionally connect to surrounding permanent water bodies. Consider applying recommendations provided above to improve drainage. Consider reviewing surrounding drainage and potential connections to other water bodies that may contain Gambusia. Landscaping should be undertaken to minimise the arrival of flood waters from such water bodies, i.e. directional drainage and barrier earth mounds.

GThF MS = Green-thighed Frog Management Strategy (Lewis 2013); EMP = Ecological Monitoring Program (RMS 2016)

References

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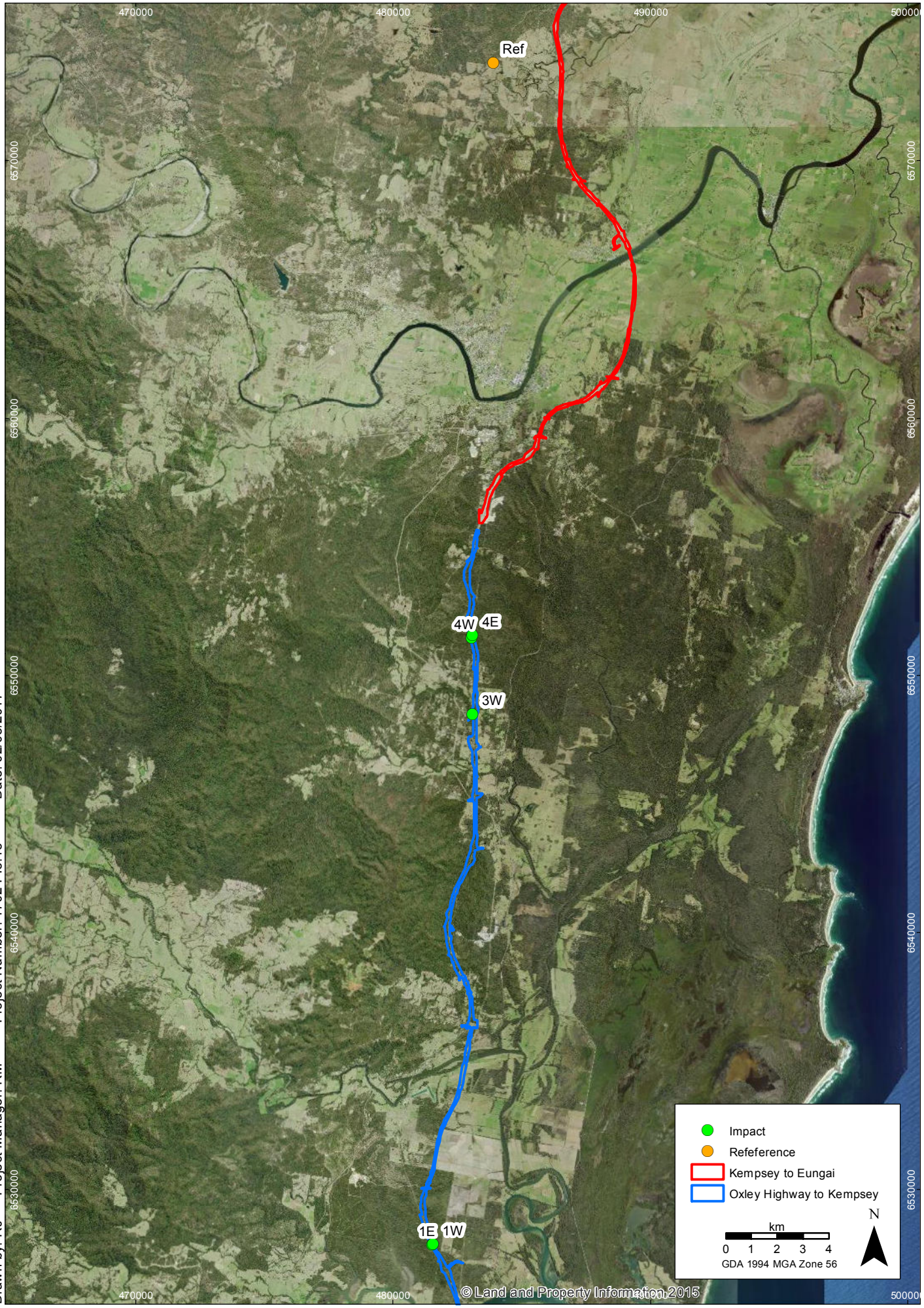

Drawn by: RJ Project Manager: RM Project Number: 1702 PI5.15 Date: 02/08/2017

Green-thighed Frog monitoring sites

Oxley Highway to Kempsey - PI 5.15 GTF Ponds

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Imagery: (c) LPI 2014-10-06

FIGURE 1

Path: T:\spatial\projects\a1700\a1702_OH2K_Ecology\Maps\PI_5_Ecology_OH2K\PI_515_GTF\report_20170801\1702_PI515_GTF_Figure_1.mxd

Annex 1. 2017 monitoring results

Stage 1 Results

Site Name	Date	Time	GTF Observed	GTF Calling	Other Species	Rainfall mm (24hrs)	Air Temp	Humidity	Wind	Cloud Cover %
Collombatti Reference	16/03/2017	0:40	1	0	Great Barred frog, Striped Marsh Frog, Common Froglets, Dusky Toadlets, Whirring Tree Frog.	124.2	21.3	82	0	10
1W	16/03/2017	19:40	0	0	Common Froglets, Striped Marsh Frog, Rocket Frog, Perons Tree Frog.	158.2	24.7	73	0	40
1E	16/03/2017	20:10	0	0						
3W P1-3	16/03/2017	20:50	0	0	Striped Marsh Frog, Common Froglets, Dusky Toadlets, Dainty Green Tree Frog.	141.4	24.2	84	0	30
3W P4	16/03/2017	20:50	1	1-2						
3W P5	16/03/2017	20:50	1	1						
4W	16/03/2017	21:38	0	0	None.	141.4	24.3	78	0	10
4E	16/03/2017	2:09	0	0	1 Striped Marsh Frog.	141.4	19	86	0	50

Stage 2 Results

Site	Date	Water Depth (cm)	No. GTF (juv)	No. of tadpoles caught	Tadpoles identified	Prescence of Fish	Predatory Invertebrates
Collombatti Reference	28/04/2017	30	0	22	*Limnodynastes sp*, likely *peronii*	Gambusia	
1E	28/04/2017	20	0	0		Gambusia	
		20	0	0		Gambusia	
		10	0	0			
		<5	0	0			
		20	0	0			
1W	28/04/2017	30	0	0			
		40	0	0			
		40	0	0			
		40	0	0			
		40	0	0			
3W	28/04/2017	40	0	>100	Striped Marsh Frog		
		40	0	0			
		10	0	0			
		40	0	0			
		15	0	0			
4W	28/04/2017	0	0	0			
		0	0	0			
		0	0	0			
		0	0	0			
		0	0	0			
4E	28/04/2017	0	0	0			
		0	0	0			
		0	0	0			
		0	0	0			
		0	0	0			

Annex 2. Photo monitoring

Site	Pond 1	Pond 2	Pond 3	Pond 4	Pond 5
CRef		NA	NA	NA	NA
1W					
1E					

Site	Pond 1	Pond 2	Pond 3	Pond 4	Pond 5
3W					
4E*					
4W*					

NA = not applicable, * individual pond photos not taken due to unsuccessful water rentention.

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Annex 8. *Maundia triglochinoides* monitoring 2016/2017 (Niche 2017d)

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Maundia triglochinoides monitoring 2016/2017

Oxley Highway to Kempsey, Pacific Highway Upgrade

Prepared for Roads and Maritime Services

25 July 2017

Document control

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Project client:	Roads and Maritime Services
Project office:	Port Macquarie
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Project Director:	Dr Rhidian Harrington
Project Manager:	Radika Michniewicz
Authors:	Radika Michniewicz
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Cover photograph: Maundia triglochinoides

Executive summary

Context

This report documents the 2016 -2017 monitoring period (spring 2016, summer 2017 and autumn 2017) for *Maundia triglochinoides* (Maundia) as required for the Oxley Highway to Kempsey (OH2K) Pacific Highway upgrade project (the Project).

Aim

The NSW Roads and Maritime Services (RMS) is required to manage and monitor the effectiveness of the biodiversity mitigation measures implemented as part of the project. This includes Maundia, the monitoring of which is to be performed in accordance with the methodology presented in the Ecological Monitoring Program (EMP) (RMS 2016). The aim of the Maundia monitoring program is to determine whether the Project is meeting the performance indicators for the species, and provide corrective actions where required.

Methods

The method used during the 2016/2017 monitoring period is consistent with previous monitoring events. Three paired 'impact - control' monitoring sites were identified to Niche by RMS staff in February 2015. Each monitoring location was surveyed in accordance with the monitoring method specified in the EMP (RMS 2016), with an additional more detailed cover abundance estimate (implemented in the 2015/2016 monitoring period) made in 5% increments to permit detection of a substantial difference (15% change) in cover abundance, as required by the EMP.

Key results

Maundia was recorded at two of the impact sites (MI01 and MI02) and only one control site (MC01) during the three monitoring events in 2016/2017.

At Site 1, Maundia was consistently present at the impact site, while only recorded during spring at the paired control site. In spring, a substantial difference (over 15%) in flowering was recorded between MC01 (about 90% of plants were flowering) and MI01 (10% of plants flowering).

Maundia was also found to be present at site 2 impact site and not at its paired control site.

Recruitment was observed at both the impact sites where it was recorded (MI01 and MI02). However, it should be noted that where water levels are above 5 cm, recruitment is difficult to determine as the juveniles can be hidden beneath the water's surface.

Flowering was recorded at MI01 and its paired control site MC01 during spring surveys. Flowering individuals were not recorded at MI02.

Conclusions

The Maundia performance measures have been mostly met for the 2016/2017 monitoring period. However to fulfil all required aspects of the performance measures, recommendations have been made to verify and replace exclusion fencing, sediment control measures and signage at relevant sites.

The substantial differences recorded between paired impact control sites cannot be directly attributed to the road impact only, but more likely are the result of environmental variables between paired control and impact sites.

Although comparison to pre-impact data is not possible, at the three sites where Maundia has been recorded by Niche, MI01, MC01, MC02, the percent cover abundance is relatively consistent across the monitoring periods (Niche 2015, Niche 2016, and current report).

Management implications

It is recommended that verification and replacement of exclusion fencing, sediment control and signage where relevant be undertaken.

It is also advised that on-going management of disturbance impacts be undertaken at the impact sites following recommended guidelines.

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1. Introduction

1.1 Context

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

Maundia triglochinoides (Maundia) is listed as vulnerable in the New South Wales *Threatened Species Conservation Act 1995* (TSC Act). Monitoring of the species is required under the Project's approval and design, methods and performance indicators for this monitoring are specified in the approved EMP for the Project (RMS 2016).

1.1.2 Monitoring framework

The EMP requires three monitoring cycles of summer, autumn and spring. To date, these monitoring events have been reported as follows:

- *Summer and autumn 2015*: Niche 2015.
- *Spring 2015, summer and autumn 2016*: Niche 2016.
- *Spring 2016, summer autumn 2017*: current report.

To complete the required three cycles of monitoring, a single spring survey remains. This survey will be undertaken in spring 2017 and be the subject of the final report for Maundia. This report therefore represents the third of four necessary reports for Maundia.

1.1.3 Baseline data

The EMP (RMS 2016) presents locations within the Project corridor where Maundia was recorded and details the potential impact area of these sub-populations. The EMP states the following:

"*Three distinct sub-populations of M. triglochinoides were recorded in the project area (Table 20).*" These populations are listed below in Table 1.

Table 1: *Maundia triglochinoides* in the project area (as per Table 20 in the EMP)

Location	*M. triglochinoides* potentially impacted by the project
Fernbank Creek (Ch.4450-5080)	0.75 ha
Wilson River Floodplain – wetlands (Ch.15,890)	0.03 ha
Wilson River Floodplain – canal (Ch.13,900-14,100)	0.09 ha
Barry's Creek	-
Total	**0.87 ha**

Three paired 'impact-control' sites were established within the vicinity of these recorded populations and form the basis of the ongoing monitoring in accordance with the EMP.

1.1.4 Purpose of this report

This report complies with the monitoring requirements described within the approved EMP (RMS 2016) and details the findings obtained from the third monitoring period following the baseline surveys. It represents the third monitoring report for the construction phase of the Project.

The aims of this report are to summarise the methods and results of the spring 2016, summer 2017 and autumn 2017 monitoring and determine if performance measures are being met, as per the EMP (RMS 2016).

1.2 Performance measures

The approved EMP specifies the following performance indicators for Maundia (RMS 2016).

Indicators of success will focus on the following:

- *Exclusion fencing with signage identifying these as 'no go' zones (during construction).*
- *Sediment control fencing in place (during construction).*
- *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 over subsequent monitoring events that cannot be attributed to environmental factors.*

1.3 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 in summer, autumn and spring until Year 4 (operation phase) of the Project.

1.4 Reporting

Annual reporting of monitoring results will outline:

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

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

1.5 Limitations

The following limitations to the monitoring procedure were encountered and have been noted previously (Niche 2016):

- Detection of Maundia was not possible or limited in areas where water depth was relatively high. The number and cover abundance of seedlings and recruiting individuals could not be recorded in such areas.
- The absence of Maundia from the control sites presented difficulties in site-pair 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.

2. Methods

2.1 Monitoring sites

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 **Error! Reference source not found.**.

Monitoring design is consistent with that specified in the EMP (RMS 2016). Three paired 'impact-control' monitoring sites were established for the monitoring of Maundia. 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. These sites correspond to the three original sub-populations identified in the EMP.

Table 2: Paired 'Impact –Control' monitoring sites

Site	Chainage (Location)	Description	Easting of Impact Plot (MI)	Northing of Impact Plot (MI)	Easting of Control Plot (MC)	Northing of Control Plot (MC)
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 were surveyed during the three monitoring events, however the assessment of MC01 was undertaken from the boundary fence as access to this property has not been granted.

2.2 Survey method

In accordance with the EMP, the following data was collected at each of the monitoring sites:

- Current extent of cover using the Braun-Blanquet scale (20 m X 20 m quadrat or 400 m^2).
- Average water depth, 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 from installed specific photo point.

As in 2015/2016, during the 2016/2017 monitoring period, cover abundance was also recorded as percent cover using 5% increments. This permits the assessment of a "substantial difference" (i.e. 15% allowance) in cover abundance between paired monitoring sites as specified in the EMP. 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.

In addition, to be able to address the performance indicators, the following information was recorded:

- Presence of exclusion fencing and "no go" zone signage and / or sensitive zone fencing.
- Presence of sediment control fencing.

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

2.3 Analysis

The majority of the performance indicators provided in the EMP are observation based, however the assessment of flowering/seeding and extent specifies:

"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."

The EMP 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. 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 a 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 and a *substantial difference (i.e. 15% allowance)* has been used as the basis for identifying changes.

3. Results

3.1 Maundia presence

Field data is provided in Annex 1 - 2016/ 2017 Monitoring resultsand a summary of the results has been provided in Table 4.

Maundia was recorded at two of the impact sites (MI01 and MI02) and only one control site (MC01) during the 2016/2017 monitoring period. These results are similar to those observed in the 2015/2016 monitoring period (Niche 2016).

Site 1

Maundia was recorded at MI01 during all seasons, as in 2015/2016. The Braun-Blanquet cover abundance score at MI01 was 2, 1 and 3 for spring, summer and autumn respectively, with an average coverage abundance (based of 5% estimate increments) of 7.5 ± 2.5% (compared to 10.0 ± 4% in 2015/2016, Niche 2016).

At paired control site MC01, Maundia was recorded in one season in 2016/2017 (spring 2016), with a Braun-Blanquet score of 3, representing a cover abundance estimate of 20%. This result is similar to the 2015/2016 results with Braun-Blanquet scores of 3, representing 15% cover abundance estimates in two seasons (spring 2015 and summer 2015, Niche 2016).

Site 2

Maundia was recorded at MI02 in spring 2016 and autumn 2017. It was first recorded at this site in autumn 2016 (Niche 2016). The Braun-Blanquet cover abundance score was 2 in both seasons, representing an average cover abundance estimate of 5 ± 0%. In 2015/2016, cover abundance was also low, with a Braun-Blanquet score of 1, representing a cover abundance estimate of <5% (Niche 2016).

Maundia was not recorded at MC02, the paired control site, during surveys in the current monitoring period. Similarly, Maundia has not been recorded at this site during any monitoring event by Niche (Niche 2015, Niche 2016).

Site 3

Maundia was not recorded at MI03 or MC03 during the current monitoring period, nor during the two previous monitoring periods (Niche 2015, Niche 2016). As in previous years, water depth at this site continued to be relatively high (100 – 200 cm) in spring and autumn and was dry in summer. According to the OEH species profile for Maundia, this species prefers water up to 60 cm deep (OEH 2016), as such the hydrology of this particular site (deep water varying to dry periods) may represent unfavourable habitat for this species.

3.2 Recruitment

Recruitment was recorded in spring 2016 at both MI01 and MI02. This is the first evidence of recruitment recorded over the three monitoring periods (Niche 2015, Niche 2016).

It should be noted that water depth at a monitoring site greatly impacts the ability to observe recruiting individuals of the species.

3.3 Flowering/Seeding

Flowering was recorded at MI01 and its paired control site MC01 during spring. No other impact or control sites contained flowering individuals. This is similar to 2015/2016 with flowering recorded at the same sites but in both spring 2015 and summer 2015 (Niche 2016).

In 2016/2017 flowering individuals made up 10% of those individuals recorded at MI01 and 90% of those recorded at MC01. These flowering rates at both sites are similar to the summer 2015 flowering rates (20% and 90% respectively, Niche 2016).

Table 4: Summary of Maundia presence, recruitment and flowering

Report	Niche 2015			Niche 2016					Current				
	Su		Aut	Sp		Su		Aut	Sp			Su	Aut
MI01	P	F	P	P	F	P	F	P	P	R	F	A	P
MC01	N		N	P	F	P	F	N	P		F	N	N
MI02	N		N	N		N		P	P		R	N	P
MC02	N		N	N		N		N	N			N	N
MI03	N		N	N		N		N	N			N	N
MC03	N		N	N		N		N	N			N	N

P = individuals present; F = flowering recorded; R = recruitment recorded; N = Maundia not recorded

3.4 Mitigation measures and disturbance monitoring

A summary of all mitigation measures in place at each location is presented in Annex 1 - 2016/ 2017 Monitoring results.

Site 1

Exclusion fencing and sediment control was not present during all surveys of MI01. The most recent survey, in autumn 2017, recorded barbed wire fencing and sediment control at this site.

Site 2

Specific exclusion fencing and sediment control were not recorded for MI02 during any surveys. It was however noted that this site now falls into an area that is protected by a fauna fence and is therefore distanced from any construction related direct impacts.

Site 3

It is noted that MC03, despite being a control site, is in close proximity (30 m) to construction works. For this reason information concerning protection measures was also recorded. Exclusion fencing and “no go” zones were in place in summer and autumn 2017 at MI03 and MC03. Sediment fencing was consistently present at MC03, MI03 however had no sediment control in autumn 2017.

Disturbance

There was substantial evidence of disturbance at most sites:

MC01: most notably, cattle trampling and grazing at MC01 was clearly evident given the site is located within a grazed paddock (Annex 2 photographs).

MI01: Evidence of die back of Maundia was observed at MI01 during the spring and summer season. This was likely attributed the off-spray associated with the chemical weed spraying of Salvinia. Dead patches of

vegetation can be seen in the spring (November 2016) monitoring photo (Annex 2). No evidence of any die back was observed during the autumn (May 2017) monitoring season, however Salvinia was recorded at the site.

MC02: spraying of vegetation along the fence is within close proximity to this control site (see summer (February 2017) photographs in Annex 2). Whilst no Maundia has been recorded at the site during the monitoring years, the spraying may impede on potential habitat for Maundia.

MI03: Evidence of construction, and earth movement which has resulted in erosion of the banks and habitat. This is clearly evident in the spring (November 2016) and summer (February 2017) photographs provided in Annex 2.

4. Discussion

A summary of the spring 2016, summer 2017 and autumn 2017 survey results in relation to the performance indicators are provided in Table 5 and Table 6.

Table 5: Performance indicators of success

Performance indicators of success	Discussion
Exclusion fencing with signage identifying these as 'no go' zones (during construction)	**This performance measure for 2016/2017 monitoring period has been partially met.** Exclusion fencing was present at two of the three impact sites and not during all survey periods at these sites. It is noted that a fauna fence is in place at MI02. Signage was present only at MI01.
Sediment control fencing in place (during construction)	**This performance measure for 2016/2017 has been partially met.** Sediment control was in place at MI01 and MI03 but not recorded during all surveys. However it should be noted that MI01 occurs within an active construction area, and sedimentation fencing was observed across the general construction area during the most recent (autumn 2017) monitoring event. Sediment control at MI02 is not required due to its distance from the road verge.
Flowering and/or seeding is consistent with paired control and/or nearest reference site.	**This performance measure for 2016/2017 was met for all monitoring periods for sites 2 and 3** (by considering absence of flowering individuals in both impact and control sites as consistency across paired sites). **This performance measure was not met in spring 2016 at sites MI01 and MC01** (the only recorded flowering/seeding). A substantial difference (over 15%) in flowering was recorded between MI01 (10% of flowering plants) and MC01 (about 90% of plants were flowering). 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 (discussed in Niche 2016), notably spraying at MI01 and cattle disturbance at MC01. It should be noted that this same large difference in flowering/ seeding percentages between these paired sites was recorded in the 2015/2016 monitoring period.

Table 6: Performance indicators of unsuccessful mitigation

Performance indicators of unsuccessful mitigation	Discussion
Breached exclusion fencing	**This performance indicator of unsuccessful mitigation has not been met.** No breaches in the exclusion fencing present were detected during the 2016/2017 monitoring period. Exclusion fencing was not present at MI02 however this site was behind a fauna fence.
No signage in place identifying the sensitive nature of the location as threatened species habitat	**This performance indicator of unsuccessful mitigation has been met.** Two of the three impact sites didn't have signage in place identifying the sensitive nature of the locations, and at times no impact sites had visible signage.
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 over subsequent monitoring events that cannot be attributed to environmental factors.	**This performance indicator of unsuccessful mitigation has not been met for Site 1.** Cover abundance and flowering/seeding records are not substantially different across monitoring events and recruitment was recorded for the first time at this site during the current monitoring. **This performance indicator of unsuccessful mitigation has not been met for Site 2.** Cover abundance is not substantially different across monitoring events and recruitment was recorded for the first time at this site during the current monitoring. Flowering / seeding has not been recorded at this site during any monitoring event **This performance indicator of unsuccessful mitigation has not been met for site 3.** Maundia has not been recorded at this site during any monitoring event. Although comparison to pre-impact data is not possible, at the three sites where Maundia has been recorded by Niche, MI01, MC01, MC02, the percent cover abundance is relatively consistent across the monitoring periods (Niche 2015, Niche 2016, and current report).

5. Recommendations

The absence of specific location and abundance data for the initial three populations listed in the EMP (RMS 2016) prevents pre- and post-impact comparisons. All comparisons made within the framework of this monitoring program can only be made within a post-impact timeframe.

5.1 Contingency Measures

The EMP lists potential problems and contingency measures for various components of the monitoring program, however specific contingency measures for Maundia have not been provided within the EMP. As such, it is suggested that consideration be given to corrective actions presented in Table 7 and Table 8 and recommendations to address disturbance impacts identified in Table 9.

5.2 Corrective actions to meet performance criteria

A summary of the performance indicators and recommended corrective actions are provided in Table 7 and Table 8.

Recommended actions listed below are contingent on the ongoing presence of construction activities at the specified sites.

Table 7: Performance indicators of success corrective actions

Performance indicators of success	Action
Exclusion fencing with signage identifying these as 'no go' zones	Fencing at MI01 and MI03 should be verified and replaced if necessary. Signage should be installed at MI02 and MI03.
Sediment control fencing in place	Sediment control should be verified and replaced if necessary at sites MI01 and MI03.
Flowering and/or seeding is consistent with paired control and/or nearest reference site.	No action is required as flowering, where recorded, has been consistent across the years at the same sites.

Table 8: Performance indicators of unsuccessful mitigation corrective actions

Performance indicators of unsuccessful mitigation	Result
Breached exclusion fencing	Fencing at MI01 and MI03 should be verified and replaced if necessary.
No signage in place identifying the sensitive nature of the location as threatened species habitat	Signage should be installed at MI02 and MI03.
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 over subsequent monitoring events that cannot be attributed to environmental factors.	Although comparison to pre-impact data is not possible, at the three sites where Maundia has been recorded by Niche, MI01, MC01, MC02, the percent cover abundance is relatively consistent across the monitoring periods (Niche 2015, Niche 2016, and current report). As such, no action is required as flowering, recruitment and extent, has been consistent across the years at the same sites.

5.3 Addressing disturbance impacts at monitoring sites

Disturbance issues and recommendations are provided below in Table 9.

Table 9: Disturbance and recommendations

Disturbance	Recommendation
Slashing and spraying along boundary fence lines.	Spraying at impact sites should be limited along fence lines where possible to avoid any impact in areas of potential habitat.
Cattle grazing.	If possible, prevent cattle from entering control monitoring sites.
Evidence of weed spraying within close proximity to sites.	Where possible, limit any weed management upstream or within close proximity (two metres) of 'no-go' zones to hand weeding and slashing.
Construction work and changes to drainage lines near Site 3 (control and impact sites).	Changing the hydrology of an area can substantially impact water dependant species. Construction/ earth moving should not be undertaken within three metres of 'no-go' zones where possible.
Changes to shading / sun levels.	Where possible, no cutting of over-hanging branches within or in immediate proximity to the monitoring sites.
Spreading abundance and cover of native water dependant species, such as *Persicaria* spp., *Eleocharis* spp. and *Baumea* spp.	Areas of potential Maundia habitat become fragmented and Maundia can be outcompeted. In areas where native or exotic water dependent species are obviously preventing Maundia from spreading, careful hand weeding of the flora immediately surrounding Maundia should be considered.

References

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OEH (2016). *Maundia triglochinoides* – online profile. http://www.environment.nsw.gov.au/threatenedSpeciesApp/profile.aspx?id=10511

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

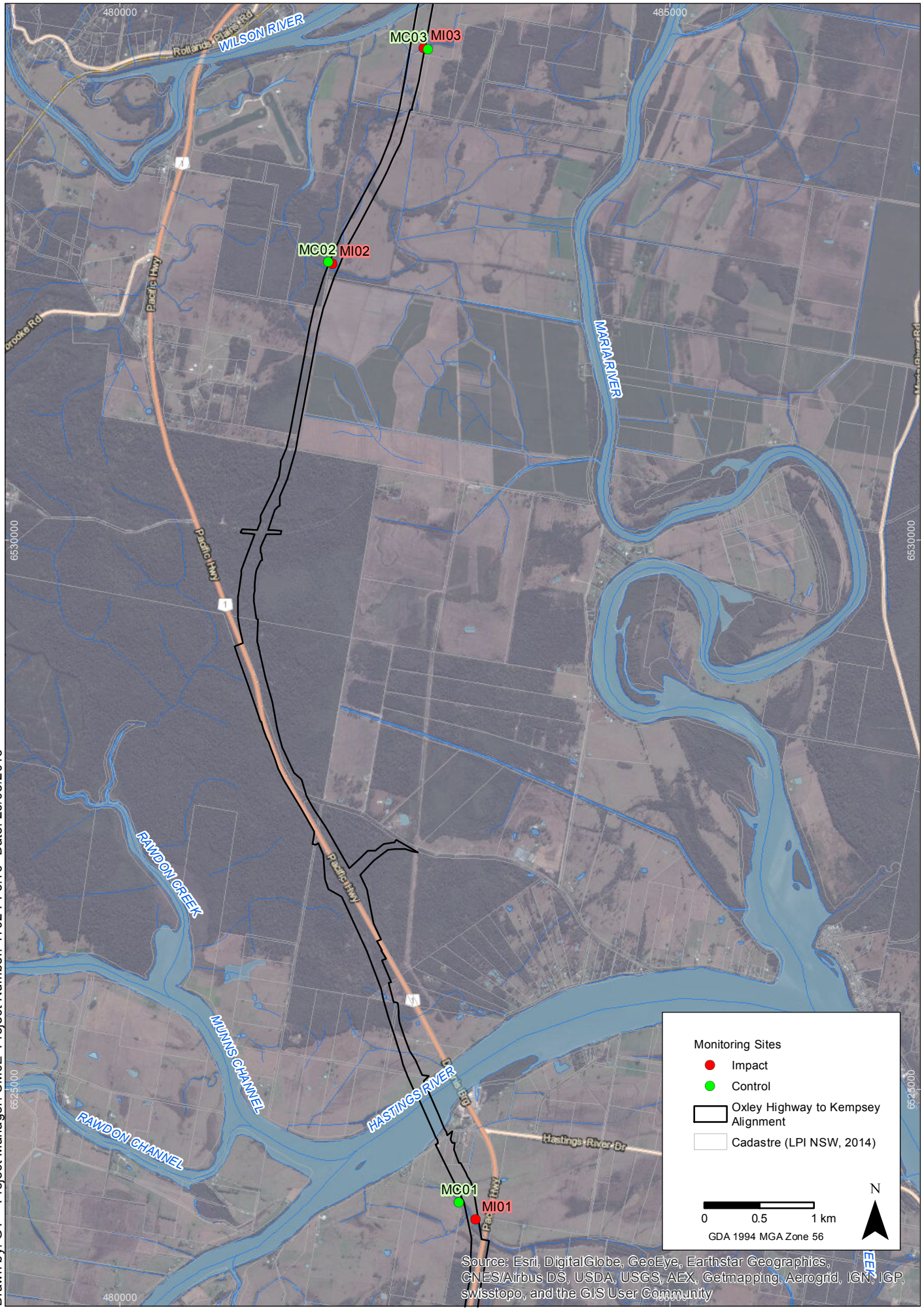
Drawn by: GT Project Manager: CMcE Project Number: 1702 PI 5.16 Date: 26/08/2015

Regional Location - OH2K Maundia Monitoring

Pacific Highway Upgrade - Oxley Highway to Kempsey & Frederickton to Eungai

FIGURE 1

Path: T:\spatial\projects\a1700\a1702_OH2K_Ecology\Maps\PI_5_Ecology_OH2K\PI_516_Maundia_Monitoring\1702_PI_516_Figure_1_StudyArea.mxd



Drawn by: GT Project Manager: CMcE Project Number: 1702 PI 5.16 Date: 26/08/2015

OH2K Maundia Monitoring Sites

Pacific Highway Upgrade - Oxley Highway to Kempsey & Frederickton to Eungai

FIGURE 2

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Annex 1 - 2016/ 2017 Monitoring results

Summary of *Maundia triglochinoides* results

Site N.	Site Name	Design	Inspection Date			Maundia present			Braun-Blanquet Score			% Cover (5% increment)			Water Depth (cm)			Flowering/ Seeding			Recruitment		
			Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut
1	MI01	impact	07/11/2016	16/02/2017	19/05/2017	Y	Y	Y	2	1	3	5	<5	10	0-50	0	10-40	10%	0	0	Y	0	0
1	MC01*	control	08/11/2016	16/02/2017	19/05/2017	Y	N	N	3	0	0	20	0	0	0-50	0	>30	90%	0	0	0	0	0
2	MI02	impact	09/11/2016	16/02/2017	19/05/2017	Y	N	Y	2	0	2	5	0	5	0-10	0	100	N	0	0	Y	0	0
2	MC02	control	10/11/2016	16/02/2017	19/05/2017	N	N	N	0	0	0	0	0	0	0	0	0	N	0	0	0	0	0
3	MI03	impact	11/11/2016	16/02/2017	19/05/2017	N	N	N	0	0	0	0	0	0	100-200	0	>30	N	0	0	0	0	0
3	MC03	control	12/11/2016	16/02/2017	19/05/2017	N	N	N	0	0	0	0	0	0	100-200	0	>30	N	0	0	0	0	0

UNK = unknown, Y = Yes, N = No, * = site survey undertaken from fence boundary due to access restrictions

Summary of Mitigation Measures and Disturbance

Site N.	Site Name	Design	Inspection Date			Signs of disturbance			Exclusion fencing "no go" zone in place			Sediment control fencing in place		
			Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut
1	MI01	impact	07/11/2016	16/02/2017	19/05/2017	Salvinia spraying and shade from the bridge	Previous Salvinia spraying knocked out Maundia		N	Y	Y (barbed wire fencing preventing access)	Y	N	Y
1	MC01	control	08/11/2016	16/02/2017	19/05/2017	Cattle trampling and eating Maundia	Heavily grazed paddock	Cattle	Fauna fence	Fauna fence	Fauna fence	NA	NA	NA
2	MI02	impact	09/11/2016	16/02/2017	19/05/2017	None observed	None observed		N	N	N	N	N	N
2	MC02	control	10/11/2016	16/02/2017	19/05/2017	NA	Weed spraying and slashing along fence		NA	NA	NA	NA	NA	NA
3	MI03	impact	11/11/2016	16/02/2017	19/05/2017	Construction work on drainage line - earth movement	Prone to grazing and slashing		N	Yes, around drain	Y	Y	Some sediment bags	N
3	MC03	control	12/11/2016	16/02/2017	19/05/2017	None observed	Erosion, new rocks, drainage channel has been moved since last monitoring. Sprayed and slashing.	This control site is very close to construction	N	Some flags	Y	Y	Matting and rocks	Fallen down

NA = not applicable to control sites that are removed from construction zones, excluding site MC03 which is within 30 m of construction.

Annex 2 - 2016/2017 Photo Monitoring

Site ID	Spring (November 2016)	Summer (February 2017)	Autumn (May 2017)
MI01			
MC01			

Site ID	Spring (November 2016)	Summer (February 2017)	Autumn (May 2017)
MI02			
MC02			

Site ID	Spring (November 2016)	Summer (February 2017)	Autumn (May 2017)
MI03			
MC03			

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Annex 9. Landscape and revegetation monitoring 2016/2017

Table 25: Landscape and revegetation data OH2Ku.

Refined data provided by Roads and Maritime (extracted by Roads and Maritime from data collected by Lendlease). Highlighted inspection dates occur within the July 2016 – June 2017 monitoring period. NB = northbound, SB = southbound, T = treatment, HW = Hydromulch Woodfibre, W = Weed cover, De = native plant every 6 m^2, H = average height >15 cm, Di = diversity, O = overall, NA = not applicable as monitoring to be restarted.

General Location	Specific Location	Vegetation Community Type	T	Date of Sowing	8 month	8 month inspection comments	12 month	12 month performance criteria					12 month inspection comments
								W	De	H	Di	O	
Cut 1	NB	Tall Shrubs	HW	Mar-2016	Nov-16	No native strike	Mar-17	N	N	N	N	N	No native strike & requires weed spraying
Fill 1	NB	Frangible Shrubs	HW	Mar-2016	Nov-16	No native strike	Mar-17	N	N	N	N	N	No native strike & requires weed spraying
Cut 2A	NB	Tall Shrubs	HW	Feb-2016	Oct-16	Low native strike	Feb-17	Y	Y	Y	Y	Y	Poor native strike but still meets 12 month criteria. Batter stable (mon. done Mar-17)
Cut 2B	NB	Tall Shrubs	HW	Feb-2016	Oct-16	Low native strike	Feb-17	Y	Y	Y	Y	Y	Poor native strike but still meets 12 month criteria. Batter stable (mon. done Mar-17)
Fill 2	NB	Tall Shrubs	HW	Feb-2016/spray extra patches May16 & Oct16	Jun-17	Poor native strike, cover crop has died off. Well aided with native planting	Oct-17						
Fill 2	SB	Tall Shrubs	HW	Apr-17 & May-17	Jan-18		May-18						
Cut 3	NB	Frangible Shrubs/Native Grasses	HW	Feb-2016/May16/Jul-2016/Oct-16/Jan-17	Sep-17		Jan-18						
Cut 3	SB	Frangible Shrubs/Native Grasses	HW	Apr-17 & May-17	Jan-18		May-18						
Fill 3	NB	Native Grasses	HW	Feb-2016/May16	Jan-17	Minimal strike of natives. Dry conditions limiting growth. Batters stable from cover crop mix. Possible re-work / re-spray required	May-17	Y	Y	Y	Y	Y	Minimal strike of natives however still meets 12 month criteria. Dry conditions limiting growth. Batters stable.

General Location	Specific Location	Vegetation Community Type	T	Date of Sowing	8 month	8 month inspection comments	12 month	12 month performance criteria					12 month inspection comments
								W	De	H	Di	O	
Cut 4	NB			Oct-16	Jun-17	Minimal native strike. Dryer conditions limiting growth. Batters stable. Re-spray / planting required	Oct-17						
Fill 4	NB	Native Grasses	HW	Jul-2016	Mar-17	Minimal strike of natives. Batters stable from cover crop mix. May require weed spraying	Jul-17						
Cut 5	NB	Tall shrubs/Frangible Shrubs	HW	Aug-15 and Sep-15. Following Rework	May-16		Sep-16	Y	Y	Y	Y	Y	Good, lots of diversity with average heights of natives between 30-60cm.
Fill 5	A	Frangible Shrubs/Native Grasses	HW	Jul-2016, Aug-2016, Oct-16	Jun-17	Minimal native strike. Batters stable from cover crop. Weed spraying required.	Oct-17						
Fill 5	B	Frangible Shrubs/Native Grasses	HW	Jul-2016	Mar-17	Finishing works to be completed before hydromulching to be re-sprayed. Cover crop keeping batters stable with minimal natives	Jul-17						
Fill 5	C	Pasture Grasses	HW	Oct-16/ Jan-17	Sep-17		Jan-18						
Fill 5	D	Pasture Grasses	HW	Aug-2016	Apr-17	Not monitored?	Aug-17						
Fill 5	E	Pasture Grasses	HW	Aug-2016	Apr-17	Not monitored?	Aug-17						
Cut 6	NB	Native Grasses	HW	Jul-2015	Mar-16		Jul-16	N	N	N	N	N	Poor - occasional native. Weed treatment, retopsoil and re spray following verge placement. Investigate substitution of native grasses with an alternative seed mix through RFI (mon. done Sept-16)
Cut 6	SB	Native Grasses	HW	Jul-2015	Mar-16		Jul-16	N	N	N	N	N	Poor - occasional native. Weed treatment, retopsoil and re spray following verge placement. Investigate substitution of

General Location	Specific Location	Vegetation Community Type	T	Date of Sowing	8 month	8 month inspection comments	12 month	12 month performance criteria					12 month inspection comments
								W	De	H	Di	O	
													native grasses with an alternative seed mix through RFI (mon. done Sept-16)
Fill 6	NB	Frangible Shrubs/Native Grasses	HW	Jul-2015	Mar-16		Jul-16					NA	Reworked Aug 16. No topsoil or respray as yet. Mon. to be restarted
Fill 6	SB	Native Grasses	HW	Jul-2015/Aug-2016	Apr-17	Some natives present. Weed treatment required.	Aug-17						
Cut 7	NB	Frangible Shrubs	HW	Jul-2015	Mar-16		Jul-16	Y	Y	Y	Y	Y	Good - height 60 - 70cm. Minimal weeds. Good diversity (mon. done Sept-16)
Cut 7	SB	Frangible Shrubs	HW	Jul-2015	Mar-16		Jul-16	Y	Y	Y	Y	Y	Good - height 60 - 70cm. Minimal weeds. Good diversity (mon. done Sept-16)
Fill 7	NB	Frangible Shrubs/Native Grasses	HW										
Fill 7	SB	Frangible Shrubs/Native Grasses	HW	Jul-2015	Mar-16		Jul-16	N	Y	N	Y	N	Some natives popping up. Top half re-sprayed after verge placement. Continued monitoring to determine whether this meets requirements (mon. done Sept-16).
Cut 8	NB	Tall shrubs/Frangible Shrubs	HW	Jul-2015	Mar-16		Jul-16	Y	Y	Y	Y	Y	Good native diversity (mon. done Sept-16).
Cut 8	SB	Tall shrubs/Frangible Shrubs	HW	Jul-2015	Mar-16		Jul-16	Y	Y	Y	Y	Y	Good native diversity, a few weeds but not too bad (mon. done Sept-16).
B0778L	NB	Tall Shrubs	HW	Sep-2015	May-16		Sep-16	Y	Y	Y	Y	Y	Good native diversity, a few weeds but not too bad.
Cut 9	NB	Frangible Shrubs	HW	Aug and Sep 2015	May-16		Sep-16	Y	Y	N	N	N	No natives but stable batter. Oversow with frangible shrub hydroseed.
Cut 9	SB	Frangible Shrubs	HW	Aug and Sep 2015	May-16		Sep-16	Y	Y	Y	Y	Y	Good native diversity with both grasses and shrubs. Oversow with hydroseed with northern end.

General Location	Specific Location	Vegetation Community Type	T	Date of Sowing	8 month	8 month inspection comments	12 month	12 month performance criteria					12 month inspection comments
								W	De	H	Di	O	
Blackmans Point Interchange	West	Tall Shrubs		Reworked. Restart monitoring once sprayed.									
Blackmans Point Interchange	East	Frangible Shrubs	HW	Sep-2015	May-16		Sep-16					NA	Most sections will require rework post verge etc. in finishing. Restart 8 months. Mon. to be restarted
Blackmans Point Road	Blackmans Point Road	Frangible Shrubs/Native Grasses	HW	Apr-16	Dec-16	Good cover crop strike	Apr-17	Y	Y	Y	Y	Y	Good strike and diversity of natives.
Fill 9	NB	Tall Shrubs	HW	Feb-17	Oct-17		Feb-18						
Fill 9	SB	Tall Shrubs	HW	April 2016/ Jan-17	Sep-17		Jan-18						
Cut 10	NB	Native Grasses	HW	Nov-2015	Jul-16	Cover crop strike poor (mon done in Sept-16)	Nov-16	Y	Y	Y	N	N	Poor cover (still one every 6m2), although difficult with native grasses
Fill 10	NB	Native Grasses	HW	Dec-2015, resprayed Apr-17	Dec-17		Apr-18						
Fill 10	SB	Tall shrubs/Native Grasses	HW	Dec-2015	Aug-16	Poor. To be reworked after verge placement (mon done Sept-16)	Dec-16	N	N	N	N	N	Poor cover, requires rework / respray
Cut 11	NB	Frangible Shrubs	HW	Nov-2015	Jul-16	Good native distribution, should achieve target (mon. done Sept-16)	Nov-16	Y	Y	Y	Y	Y	Good native distribution
Cut 11	SB	Tall shrubs/Frangible Shrubs	HW	Sep-2015	May-16		Sep-16	Y	Y/N	Y/N	Y/N	Y/N	Good diversity in top half of batter. Will get better over time. Patchy. Y - top half of batter, N - lower part of batter (hydromulched later
Cut 11	Centre	Tall shrubs/Frangible Shrubs	HW	sep-2015 (only eastern side, northern most corner)	May-16		Sep-16					NA	Good cover crop with some natives. Monitoring to be re-started as more material added which is yet to be re-sprayed.

General Location	Specific Location	Vegetation Community Type	T	Date of Sowing	8 month	8 month inspection comments	12 month	12 month performance criteria					12 month inspection comments
								W	De	H	Di	O	
Fill 11	NB	Native Grasses	HW	Nov-2015/ Jan-17/ Feb-17	Oct-17		Feb-18						
Fill 11	SB	Native Grasses	HW	Nov-2015/ Jan-17/ Feb-17	Oct-17		Feb-18						
Fill 11	SB	Native Grasses	HW	Nov-2015/ Jan-17/ Feb-17	Oct-17		Feb-18						
Cut 12	NB	Tall shrubs/Frangible Shrubs	HW	Nov-2015	Jul-16	Good cover crop strike. No natives. Has now been reworked (mon. done in Sept-16)	Nov-16					NA	Has been reworked. Restart monitoring following hydromulching. June-16 inspection indicates that this batter would meet criteria.
Cut 12	SB	Frangible Shrubs	HW	Sep-2015, resprayed Oct-16	Jun-17	Natives evident with good size	Oct-17						
Fill 12	NB	Frangible Shrubs	HW	Nov-2015	Jul-16	Patchy cover crop with strong native emergence. Good native strike early (mon. done in Sept-16)	Nov-16	Y	Y	Y	Y	Y	Good native strike early
Fill 12	SB	Frangible Shrubs	HW	Nov-2015	Jul-16	Good native strike in some areas. Batter chutes and stockpile still to be sprayed (mon. done in Sept-16)	Nov-16	Y	Y	Y	Y	Y	Good native strike in some areas.
Cut 13	NB	Frangible Shrubs	HW	Sep-2015	May-16		Sep-16	Y/ N	Y/N	Y/ N	Y/N	Y/N	Good at north end, respray south end. Y - north end,N - south end
Fill 13	A	Native Grasses	HW	Sep-2015/ Feb-17	Oct-17		Feb-18						
Fill 13	B	Native Grasses	HW	Dec-15/ Feb-17 (verge SB)	Aug-16	Pasture grass well established (mon. done in Sept-16)	Dec-16	Y	Y	Y	Y	Y	Grass well established.
Fill 13	C	Pasture Grasses	HW	Jul-2016	Mar-17	Pasture Grass strike is good.	Jul-17						
Fill 13	D	Pasture Grasses	HW	May-2016 (NB), Jul-2016 (SB)	Mar-17	Good strike. Weed treatment required	Jul-17						

General Location	Specific Location	Vegetation Community Type	T	Date of Sowing	8 month	8 month inspection comments	12 month	12 month performance criteria					12 month inspection comments
								W	De	H	Di	O	
Fill 13	E NB	Tall Shrubs	HW	Dec-15, Oct-16	Jun-17	Good cover crop. Poor native strike. Rework once permanent works completed.	Oct-17						
Fill 13	E SB	Tall Shrubs		Oct-16	Jun-17	Good cover crop, poor native strike. Stockpile placed on top of reveg. Restart monitoring once area has been reworked.	Oct-17						
Fill 13	F	Tall shrubs/Frangible Shrubs	HW	July-Aug 2015	Apr-16		Aug-16					NA	No native strike. Whole area has been reworked. Restart monitoring when resprayed (mon. done in Sept-16).
Cut 14	NB	Frangible Shrubs	HW	Sep-2015/ Jan-17	Sep-17		Jan-18						
Cut 14	SB	Frangible Shrubs	HW	Sep-2015/ Jan-17	Sep-17		Jan-18						
Fill 14	NB	Frangible Shrubs/Native Grasses	HW	Sep-2015/ Jan-17	Sep-17		Jan-18						
Fill 14	SB	Frangible Shrubs/Native Grasses	HW	Sep-2015	May-16		Sep-16	Y	N	N	N	N	Poor. Monitoring to restart after tyne / respray. Jun-17 monitoring indicates good cover crop strike.
Cut 15	NB	Frangible Shrubs	HW	Nov-2015/ Jan-17	Sep-17		Jan-18						
Cut 15	SB	Frangible Shrubs	HW	Nov-2015/ Jan-17	Sep-17		Jan-18						
Fill 15	NB												
Fill 15	SB												
Haydons Wharf Interchange	East Inside	Frangible Shrubs	HW	Nov-2015/ Jan-17	Sep-17		Jan-18						
Haydons Wharf Interchange	West												

General Location	Specific Location	Vegetation Community Type	T	Date of Sowing	8 month	8 month inspection comments	12 month	12 month performance criteria					12 month inspection comments
								W	De	H	Di	O	
Cut 16	NB	Frangible Shrubs	HW	Sep-2015/ Jan-17	Sep-17		Jan-18						
Fill 16	NB	Frangible Shrubs	HW	Sep-2015	May-16		Sep-16	Y	N	N	N	N	Dominated by pasture grasses, no native visible. Very stable batter. Consider changing requirement to pasture grass due to surrounding landscape being dominated by pasture grass.
Cut 17	NB	Frangible Shrubs	HW	Sep-2015/ Jan-17	Sep-17		Jan-18						
Fill 17	NB	Tall shrubs/Native Grasses	HW	July-2016/ Jan-17	Sep-17		Jan-18						
Cut 18	NB	Frangible Shrubs/Native Grasses	HW	Sep-15 (reworked March 2016), May-2016	Jan-17	Poor. Mainly grass cover. Limited growth due to dryer conditions. Possible rework/ spraying required.	May-17	N	N	N	N	N	Poor. Mainly grass cover. Limited growth due to dryer conditions. Weed treatment required.
Fill 18	NB	Tall Shrubs	HW	Nov-2015 (bottom 3/4s of fill)/Aug-2016 (top 1/4 of fill), resprayed Oct-16, Feb-17 (section b)	Jun-17	Poor. Mainly grass cover. Weed treatment required	Oct-17						
Cut 19A	NB	Frangible Shrubs	HW	Resprayed on 15 December 2015 following stockpiling against batter.	Aug-16	Good at top and poorer for resprayed area. Some weeds have been sprayed in rehydromulched section (mon. done in Sept-16)	Dec-16	N	Y	N	N	N	Good at top and poorer for resprayed area. Some weeds have been sprayed in rehydromulched section.
Cut19B	NB	Tall Shrubs	HW	Jun-2015, May-2016, resprayed Oct-16	Jun-17	Dominated by long grass, scattered natives on edges. Has improved since last inspection with more maturing natives.	Oct-17						
Fill 19	NB	Tall Shrubs	HW	May-2016/ Jan-17	Sep-17		Jan-18						

General Location	Specific Location	Vegetation Community Type	T	Date of Sowing	8 month	8 month inspection comments	12 month	12 month performance criteria					12 month inspection comments
								W	De	H	Di	O	
Cut 20	NB	Tall Shrubs	HW	Dec-2015	Aug-16	Good strike at top. Poor strike at bottom. No natives. Selectively re-scarify and hydromulch lower section where 100% bare. High weeds on bottom of batter but not noxious so no need for spraying (mon. done Sept-16)	Dec-16	N	N	N	N	N	Good strike at top but poor at bottom. 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	HW	March-2016/ Jan-17	Sep-17		Jan-18						
Cut 21	NB	Tall Shrubs	HW	Dec-2015	Aug-16	Good cover crop. No natives (mon. done Sept-16)	Dec-16	N	N	N	N	N	Top 2/3 of the batter to be worked upon the removal of topsoil stockpile. Bottom 1/3 to be sprayed if required.
Fill 21	NB	Tall Shrubs		Not yet sprayed.									
Cut 22	NB	Tall Shrubs	HW	Sep-2015, May-2016, Jan-17, Feb-17	Oct-17		Feb-18						
Fill 22	NB	Tall Shrubs	HW	May-2016/Aug-2016/Oct-16	Jun-17	Good native diversity, good density in some areas.	Oct-17						
Cut 23	NB	Tall Shrubs	HW	Top (Sep-2015)	May-16		Sep-16	Y	N	N	Y	N	Some native strike & more scattered natives emerging. Jun-17 inspection indicates that this now meets 12-month criteria.
Fill 23	NB	Frangible Shrubs	HW	June-2016	Feb-17	Poor/ minimal native growth. However cover crop providing stability (mon. done in Mar-17)	Jun-17	Y	Y	Y	Y	Y	Majority meets 12 month requirements. Minor weed spraying required
Cut 23	SB	Frangible Shrubs	HW	Sep-2015/ Feb-17 (south of cut)	Oct-17		Feb-18						
Fill 23	NB	Frangible Shrubs	HW	East (Sep-2015) Resprayed March 2016	Nov-16	Good cover crop. No natives.	Mar-17	N	Y	N	N	N	Poor/ minimal native growth. Cover crop providing stability.
Cut 24	SB	Tall shrubs/Fra	HW	Sep-2015	May-16		Sep-16	Y	Y	Y	Y	Y	Good native strike.

General Location	Specific Location	Vegetation Community Type	T	Date of Sowing	8 month	8 month inspection comments	12 month	12 month performance criteria					12 month inspection comments
								W	De	H	Di	O	
		ngible Shrubs											
Fill 24	SB	Frangible Shrubs	HW	Sep-2015	May-16		Sep-16	Y	Y	Y	Y	Y	Some native strike.

Table 26: Landscape and revegetation data Ku2K.

Refined data provided by Roads and Maritime (extracted by Roads and Maritime from data collected by Roads and Maritime). Highlighted inspection dates occur within the July 2016 – June 2017 monitoring period. NB = northbound, SB = southbound, T = treatment, HW = Hydromulch Woodfibre, W = Weed cover, De = native plant every 6 m^2, H = average height >15 cm, Di = diversity, O = overall, NA = not applicable as monitoring to be restarted.

Location			Hydroseed / Hydromulch Date	8 month	8 month inspection comments	12 month	12 month performance criteria					12 month inspection comments
Cut/Fill	C'way	Bench					W	De	H	Di	O	
Fill 1	SB		Aug-2015	Apr-16		Aug-16	Y	N	N	N	N	Large areas of native grass seed mix on batters not striking - continue to monitor
Fill 2	SB		Aug-2015	Apr-16		Aug-16	Y	N	N	N	N	Large areas of native grass seed mix on batters not striking - continue to monitor
Cut 2	NB		Dec-2016	Aug-17		Dec-17						
Cut 3	NB	Bottom	Sep-2015	May-16		Sep-16	Y	Y	N	Y	N	Progressing well with good variation of natives. Continue to monitor to ensure height of natives reaches standard.
Cut 3	NB	Top	Sep-2015	May-16		Sep-16	Y	N	N	N	N	Batter stripped and hydromulch reapplied (jun-17 inspection indicates all 12-month requirements except height have now been met)
Cut 3	SB		Sep-2016	May-17	Weed growth out pacing native regrowth in and around rest area. Manage weeds and monitor	Sep-17						
Cut 3	SB	rest area median	Jun-2016	Feb-17	Poor native growth and ground cover	Jun-17	N	N	N	N	N	Weed growth out pacing native regrowth in and around rest area. Weed management required (native grass seed mix)
Fill 4	SB		Jul-2015	Mar-16		Jul-16	Y	Y	N	N	N	High clay content in topsoil resulting in compact hard surface. Areas Resprayed July 2016 (Jul-17 inspection indicates that this area now meets all 12-month requirements)
Fill 4	SB	Nth Mingaletta	Sep-2015	May-16		Sep-16	Y	Y	Y	Y	Y	Good strike of natives on lower fill levels. Continue to monitor upper fill levels resprayed following verge works.
Fill 4	NB		Jul-2017	Mar-18		Jul-18						
Site 12	NB		May-2017	Jan-18		May-18						
Fill 5	SB	Drainage	Sep-2015	May-16		Sep-16	Y	Y	Y	Y	Y	Good strike of natives on lower fill levels. Continue to monitor upper fill levels resprayed following verge works.
Fill 5	SB		Sep-2015	May-16		Sep-16	Y	N	N	N	N	Continue to monitor following respray
Fill 5	NB		Mar-2017	Nov-17		Mar-18						

Location			Hydroseed / Hydromulch Date	8 month	8 month inspection comments	12 month	12 month performance criteria					12 month inspection comments
Cut/Fill	C'way	Bench					W	De	H	Di	O	
Cut 5	SB		Jul-2015	Mar-16		Jul-16	Y	Y	N	Y	Y (except height)	Progressing well with good variation of natives. Continue to monitor to ensure height of natives reaches standard (Jun-17 inspection indicates that height now meets req'ment)
Fill 6	SB		Sep-2015	May-16		Sep-16	Y	Y	N	N	N	Strike of natives could be better. Continue to monitor (Jun-17 inspection indicates all 12-month requirements have now been met)
Fill 6	NB		Mar-2017	Nov-17		Mar-18						
Cut 6	SB		Jul-2015	Mar-16		Jul-16	Y	Y	Y	Y	Y	Progressing well - meets specified standard for native height and species diversity.
Fill 7	SB		Oct-2015	Jun-16		Oct-16	Y	Y	N	N	N	Slightly down on coverage numbers. Continue to monitor (Jun-17 inspection indicates all 12-month requirements have now been met)
Fill 7	NB		Mar-2017	Nov-17		Mar-18						
Cut 7	SB		Sep-2015	May-16		Sep-16	N	Y	N	N	N	Coverage poor. Continue to monitor but respray may be required.
Fill 8	SB		Oct-2015	Jun-16		Oct-16	Y	Y	N	N	N	Bottom section of batter sprayed Oct15. Top Hydromulched July 2016. Continue to monitor following hydromulch of upper batters (Jun-17 inspection indicates all 12-month requirements have now been met)
Fill 8	NB		Jan-2017	Sep-17		Jan-18						
Cut 8	SB		Oct-2015	Jun-16		Oct-16	Y	Y	N	Y	Y (except height)	Progressing well with good variation of natives. Continue to monitor to ensure height of natives reaches standard (Jun-17 inspection indicates that height now meets req'ment)
Cut 8	NB	sth Upper Smiths	Dec-2016	Aug-17		Dec-17						
Site 26A+B	NB		Jul-2017	Mar-18		Jul-18						
Fill 9	SB	drainage	Aug-2015	Apr-16		Aug-16	N	N	N	N	N	Invasive grass species dominant, weed control unlikely to be effective given proximity of neighbouring paddock. Propose to leave 'as is'.
Fill 9	SB		Jan-2016	Sep-16	Limited growth on batter, requires rework and respray. Note, signs of invasive grasses likely to be issue on batter.	Jan-17	N	N	N	N	N	Invasive grass species dominant, weed control unlikely to be effective given proximity of neighbouring paddock. Propose to leave 'as is'.
Fill 9	NB		Nov-2016	Jul-17		Nov-17						

Location			Hydroseed / Hydromulch Date	8 month	8 month inspection comments	12 month	12 month performance criteria					12 month inspection comments
Cut/Fill	C'way	Bench					W	De	H	Di	O	
Fill 10	SB		Apr-2016	Dec-16	Good ground cover but poor native growth	Apr-17	N	Y	N	N	N	Invasive grass species dominant in patches, weed control unlikely to be effective given proximity of neighbouring paddock. Propose to leave 'as is'.
Fill 10	NB	Smiths Creek to C28.68	Jan-2016	Sep-16	Good ground cover but poor native growth	Jan-17	N	Y	N	N	N	Progressing - continue to monitor
Fill 10	NB	C28.68 to off ramp drain	Apr-2017	Dec-17		Apr-18						
Cut 10	SB		Feb-2016	Oct-16	High weeds and poor growth	Feb-17	N	N	N	N	N	Mulch ratio in topsoil to high. Resprayed Oct-16 with frangible mix (was pasture grass) following RMS landscape advice. Continue to monitor following re-spray
Cut 10	NB	Off ramp drain	Aug-2016	Apr-17	Quantity, variety and condition meets standard.	Aug-17						
Cut 10	NB		Feb-2016	Oct-16	Good ground cover but poor native growth. Resprayed Oct-16 with frangible mix following RMS landscape advice	Feb-17	N	N	N	N	N	Resprayed Oct-16 with frangible mix (was pasture grass) following RMS landscape advice. Continue to monitor following re-spray
Site 16	SB	Material Reuse Site No 16	Apr-2016	Dec-16	Good ground cover but poor native growth	Apr-17	Y	Y	Y	Y	Y	Majority of stockpile is good, some large bare patches to monitor.
Site 2	NB	Material Reuse Site No 2	Feb-2016	Oct-16	Poor ground cover and natives	Feb-17	N	N	N	N	N	Pasture grass mix.
Fill 11	SB		Nov-2015	Jul-16	Bottom of batter progressing well. Continue to monitor for top of batter and potential weeds / invasive grasses. High soil compaction issues.	Nov-16	N	Y	N	N	N	Bottom of batter progressing well. Continue to monitor for top of batter and potential weeds / invasive grasses.
Fill 11	NB		Nov-2015	Jul-16	Bottom of batter progressing well. Continue to monitor for top of batter and potential weeds / invasive grasses. High soil compaction issues.	Nov-16	N	Y	Y	N	N	Bottom of batter progressing well. Continue to monitor for top of batter and potential weeds / invasive grasses.

Location			Hydroseed / Hydromulch Date	8 month	8 month inspection comments	12 month	12 month performance criteria					12 month inspection comments
Cut/Fill	C'way	Bench					W	De	H	Di	O	
Site 10	SB		Oct-2016	Jun-17	Good ground cover and low weeds	Oct-17						
Cut 11	SB		Sep-2015	May-16		Sep-16	Y	Y	Y	Y	Y	Progressing well - meets specified standard for native height and species diversity.
Fill 12	SB		Oct-2015	Jun-16		Oct-16	Y	Y	N	Y	Y (except height)	Additional areas sprayed Oct-16. Progressing well - continue to monitor
Site 5B	SB		Oct-2016	Jun-17	Good ground cover and low weeds	Oct-17						
Cut 12	SB		Oct-2015	Jun-16		Oct-16	N	N	N	N	N	Topsoil application thin and compacted. Limited native strike - continue to monitor following herbicide application April 2016 to control weeds.
Fill 13	SB		Sep-2015	May-16		Sep-16	N	N	N	N	N	Area along drain sprayed Sept-15 remainder sprayed Dec-2015. Issues with topsoil compaction. Monitor weeds and invasive grasses.
Cut 13	SB		Oct-2015	Jun-16		Oct-16	Y	Y	N	N	N	Good ground cover. Continue to monitor following herbicide application to control weeds.
Fill 14	SB		Mar-2016	Nov-16	Good ground cover	Mar-17	Y	Y	Y	Y	Y	Good ground cover (pasture grass mix).
Fill 14	NB		May-2017	Jan-18		May-18						
Cut 14	SB		Mar-2016	Nov-16	Good ground cover	Mar-17	Y	Y	Y	Y	Y	Good ground cover (pasture grass mix).
Fill 15	SB		Mar-2016	Nov-16	Good ground cover	Mar-17	Y	Y	Y	Y	Y	Good ground cover (pasture grass mix).
Fill 15	NB		May-2017	Jan-18		May-18						
Cut 15	SB		Jan-2016	Sep-16	Good ground cover and low weeds	Jan-17	Y	Y	Y	Y	Y	Good ground cover & low weeds (pasture grass & native grass mix).
Fill 16	SB		Apr-2016	Dec-16	Good ground cover and low weeds	Apr-17	Y	N	N	N	N	Good ground cover & low weeds, however also low natives (native grass mix).
Fill 16	NB		May-2017	Jan-18		May-18						
Cut 16	SB		Mar-2016	Nov-16	Good ground cover and low weeds. Re-hydromulched Sept-16.	Mar-17	Y	N	N	N	N	Cut face had hydroseed (cover crop and natives +lime) applied Dec-16. Area above cut and around state forest access track only hydromulched Sept-16.
Fill 17	NB		May-2016	Jan-17	Good ground cover and low weeds	May-17	Y	N	N	N	N	Good ground cover, low natives.

Location			Hydroseed / Hydromulch Date	8 month	8 month inspection comments	12 month	12 month performance criteria					12 month inspection comments
Cut/Fill	C'way	Bench					W	De	H	Di	O	
Cut 17	SB		Dec-2015	Aug-16	Good ground cover. Topsoil high clay content	Dec-16	Y	N	N	N	N	Good ground cover, low natives. Topsoil high clay content that settled in cleat marks following rain.
Fill 18	NB		Nov-2015	Jul-16	Batter part sprayed Nov-15 and part sprayed Dec-15. Good progression with low weeds	Nov-16	Y	Y	N	N	N	Batter part sprayed Nov-15 and part sprayed Dec-15. Good progression - continue to monitor.
Fill 18	SB		Jun-2016	Feb-17	Poor cover crop strike	Jun-17	Y	N	N	N	N	Poor cover crop and native strike
Cut 18	SB		Sep-2015	May-16		Sep-16	N	N	N	N	N	Limited native strike - implement watering regime and continue to monitor. Hydromulch coverage not to standard. Southern end of cut hydromulched Mar-16 (resprayed again in Oct-16)
Cut 18	NB		Sep-2015	May-16		Sep-16	N	N	N	N	N	Limited native strike - implement watering regime and continue to monitor. Rilling repaired and catch drain installed at top of cut.
Fill 19	SB		Dec-2016	Aug-17		Dec-17						
Fill 19	NB		Dec-2016	Aug-17		Dec-17						
Cut 19	SB		Aug-2016	Apr-17		Aug-17						
Cut 19	NB		Sep-2016	May-17	Poor cover crop strike. Hydroseed application April 2017 with additional cover crop, natives and 25L/Ha liquid lime.	Sep-17						
Fill 20	SB		Sep-2015	May-16		Sep-16	N	N	N	N	N	Areas sprayed Oct 2015 progressing well. Area sprayed Sept 2015 requires further monitoring to ensure native strike. May have been weedy topsoil.
Fill 20	NB		Sep-2015	May-16		Sep-16	Y	Y	Y	Y	Y	Areas sprayed Oct 2015 progressing well. Area sprayed Sept and December 2015 requires further monitoring to ensure native strike (Jun-17 inspection indicates all 12-month requirements have now been met)
Cut 20	SB	Top	Sep-2015	May-16		Sep-16	Y	Y	N	N	N	Good ground cover & low weeds, however also low natives. Batter track rolled in wrong direction leaving vertical cleat marks
Cut 20	SB	Middle	Dec-2015	Aug-16	Batter track rolled in wrong direction leaving vertical cleat marks. Limited native strike but good cover crop	Dec-16	Y	N	N	N	N	Good ground cover & low weeds, however also low natives. Batter track rolled in wrong direction leaving vertical cleat marks
Cut 20	SB	Bottom	Aug-2016	Apr-17	Good ground cover and low weeds	Aug-17						

Location			Hydroseed / Hydromulch Date	8 month	8 month inspection comments	12 month	12 month performance criteria					12 month inspection comments
Cut/Fill	C'way	Bench					W	De	H	Di	O	
Cut 20	NB		Sep-2016	May-17	Section of batter topsoiled with weedy topsoil. Monitor and suppress weeds as required. Hydroseed application April 2017 with additional cover crop, natives and 25L/Ha liquid lime.	Sep-17						
Fill 21	SB		Mar-2016	Nov-16	Good ground cover. Additional areas sprayed Oct-16	Mar-17	Y	N	N	N	N	Additional areas sprayed Oct-16
Fill 21	NB		Apr-2016	Dec-16	Poor cover crop strike	Apr-17	Y	N	N	N	N	Hydroseed application April 2017 with additional cover crop, natives and 25L/Ha liquid lime.
Cut 21	NB		Dec-2015	Aug-16	Limited native strike, although good cover crop and low weeds	Dec-16	Y	N	N	N	N	Good cover crop, but limited native strike - continue to monitor (Jun-17 monitoring indicates that this batter meets all 12-month criteria except height).
Cut 21	SB		Dec-2015	Aug-16	Progressing well with good variation of natives. Continue to monitor to ensure height of natives reaches standard.	Dec-16	Y	Y	N	Y	Y (except height)	Progressing well with good variation of natives. Continue to monitor to ensure height of natives reaches standard.
Fill 22	SB		Apr-2016	Dec-16	Part spray April -16, Jan-16. Poor strike	Apr-17	N	N	N	N	N	Part spray April -16, Jan-16. Low cover crop and natives.
Fill 22	NB		Nov-2015	Jul-16	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.	Nov-16	N	N	N	N	N	Good cover crop. 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.
Cut 22A	NB		Apr-2017	Dec-17		Apr-18						
Cut 22B	NB		Mar-2017	Nov-17		Mar-18						
Fill 23	SB		Apr-2016	Dec-16	Good ground cover. Additional area sprayed Dec-16	Apr-17	N	N	N	N	N	Additional area sprayed Dec-16. Monitor again in Dec-17.
Cut 23	NB		Mar-2017	Nov-17		Mar-18						

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