Oxley Highway to Kempsey EPBC 2012/6518

Condition 8 Annual Report 2023

Transport for NSW (TfNSW) | October 2023

Document control

Report name	Oxley Highway to Kempsey EPBC 2012/6518 Condition 8 Annual Report 2023
Revision number	2
Publication Oct 2023	https://www.pacifichighway.nsw.gov.au/document-library/oxley-highway-to-kempsey-upgrade-epbc-compliance-reports

Revision history

Revision	Date	Description	Approval
1	September 2023	Draft v1	TfNSW
2	September 2023	Final	TfNSW

Contents

1 Introduction

1.1. Purpose of this document

The purpose of this report is to address EPBC (2012/6518) Approval Condition 8, which requires the preparation of a report addressing compliance with each of the conditions of approval, including implementation of the:

- Biodiversity Offset Management Plan (BOMP)
- Flora and Fauna Management Plans (FFMP)
- Ecological Monitoring Plan (EMP).

This report covers the seventh period from 22 July 2022 to 21 July 2023.

The timing for compliance with certain approval conditions is linked to specific dates as follows:

- Date of the approval decision under sections 130(1) and 133 of the *Environment Protection and Biodiversity Conservation Act 1999* – 24 January 2015
- Commencement of the action – 22 July 2014
- Expiry of Commonwealth approval – 31 December 2063

1.2. Project staging

The Oxley Highway to Kempsey Pacific Highway Upgrade project has been constructed in three main stages:

- Stage 1: The Sancrox Traffic Arrangement works located about two kilometers north of the Oxley Highway / Pacific Highway intersection. Note that the construction of Stage 1 was completed in November 2015
- Stage 2: Kundabung to Kempsey (K2K) consisting of about 14 kilometers of dual carriageway, commencing north of Barry's Creek near Kundabung (chainage 24,000) and connecting to the Kempsey Bypass at Stumpy Creek (Chainage 37,800). Note that construction of Stage 2 was completed in October 2017
- Stage 3: Oxley Highway to Kundabung (OH2Ku) consisting of about 24 kilometres of dual carriageway, commencing just north of the Oxley Highway / Pacific Highway intersection (chainage 700), and connecting with the Kundabung to Kempsey stage just north of Barry's Creek (chainage 24,000). Note construction of Stage 3 was completed in March 2018.

In addition, there is an ultimate upgrade to the four lane Class M (motorway) standard highway. Due to estimated traffic volumes and availability of funding some sections of the Project will initially be constructed and operated as a Class A (arterial) standard highway. Upgrade of those sections of the Project from Class A to Class M standard will occur when it is warranted by an increase in traffic volumes, and when funding becomes available.

1.3. Modifications to the Conditions of Approval

No modifications to the Conditions of Approval were approved during this reporting period.

2 Conditions of Approval

2.1. Condition 1

Condition 1

The person taking the action must not clear more than 211 hectares of Koala (*Phascolarctos cinerea)* habitat, 232 hectares of Grey-headed Flying-fox (*Pteropus poliocephalus*) habitat, 215 hectares of Spotted-tail Quoll (*Dasyurus maculatus*) habitat and 7.7 hectares of Giant-Barred Frog (*Mixophyes iteratus*) habitat within the project corridor of the proposed action.

Clearing for the three initial stages of the project (refer Section 1.2) is now complete. The clearing quantities for the first three stages against the limits outlined in Condition 1 are detailed in Table 1.

Table 1 Clearing quantities for the first three stages of the project

EPBC Species	Total estimated clearing	Total clearing	EPBC Limit Condition 1
Koala	196.8284	196.7656	211
Grey-headed flying fox	206.9144	206.8258	232
Spotted-tail Quoll	197.0330	196.2896	215
Giant-barred Frog	2.8512	2.8512	7.7

2.2. Condition 2

Condition 2

To assist in mitigating the impacts of the proposal on the Koala, Grey-headed Flying-fox, Spotted-tail Quoll and the Giant-Barred Frog during construction, the person taking the action must prepare and submit a Flora and Fauna Management Plan for each **stage** of the action, for the **Minister**'s written approval prior to **commencement** of each **stage** of the action. The Flora and Fauna Management Plan for each **stage** must be approved by the **Minister** in writing prior to **commencement** of the relevant **stage**. These plans must include:

a. Measures to be implemented to avoid, suppress and control the spread of weeds, plant pathogens and invasive species;
b. Measures to avoid and minimise other indirect impacts that may result from the proposal during and after construction, including erosion and sedimentation;
c. Measures to manage aquatic habitat on-site to at least maintain habitat values for the Giant Barred Frog;
d. A detailed description of the pre-clearance surveys to be undertaken by a **suitably qualified expert** within all areas proposed for disturbance, including: hollow bearing trees, logs, existing culverts and bridges, no earlier than 48 hours prior to the removal of vegetation occurring in that area to ensure that the area is free of the Koala, Giant-Barred Frog, Grey-headed Flying-fox and Spotted-tail Quoll.

Condition 2

e. Measures to relocate and/or ensure the **appropriate care of** individuals of the Koala, Giant-Barred Frog, Grey-headed Flying-fox and Spotted-tail Quoll that are identified during searches referred to in condition 2d; and

f. Clear key milestones, monitoring, performance indicators, corrective actions and timeframes for the completion of all actions outlined in the plan.

A Flora and Fauna Management Plan has been prepared for each stage of the project. As at 21 July 2021, these plans were approved by the Minister on the following dates:

- Stage 1: Sancrox Interchange — 24 June 2014
- Stage 2: Kundabung to Kempsey — 22 October 2014 (Revision 1); 15 November 2016 (Revision 2); 22 August 2019 (Revision 3)
- Stage 3: Oxley Highway to Kundabung — 10 October 2014 (Revision 1); 15 November 2016 (Revision 2); 22 August 2019 (Revision 3)

Construction of these three stages was completed during the 2017/18 reporting period, along with a majority of requirements of each Flora and Fauna Management Plan. The Ecological Monitoring Program (Appendix to the Flora and Fauna Management Plan) continues to be implemented and is reported on below in Condition 4.

2.3. Condition 3

Condition 3

To assist in mitigating the impacts of the proposal on the Koala, Spotted-tail Quoll and the Giant-Barred Frog, the person taking the action must construct and maintain **fauna crossings** and **fencing** in all **areas that are likely to benefit** these species for the duration of the impact of the action.

a. The **fauna crossings** must:
   - **i.** be **effective** for the Koala, Spotted-tail Quoll and/or Giant Barred Frog (the relevant species targeted to use the **fauna crossing**);
   - **ii.** provide dry passage up to a 1 in 100 year Average Recurrence Interval (ARI) event for **dedicated fauna crossings** and up to a one in 1 year 72 hour ARI event for **combined fauna crossings**;
   - **iii.** include a minimum of 11 **dedicated fauna crossings** and 30 **combined fauna crossings** for the project;
   - **iv.** not increase in length more than 10 per cent from the lengths provided in Schedule 2 of this notice, and not reduce in width and height from the values provided in Schedule 2 of this notice without the written consent of the **Minister**;
   - **v.** be bridges in **areas that are likely to benefit** the Giant-Barred Frog.

b. If a change to the **fauna crossing** design is proposed that does not meet the parameters described in Condition 3a), the person taking the action must:
   - **i.** provide evidence to the **Minister** that these will remain **effective** for the Koala, Spotted-tail Quoll or Giant-Barred Frog

Condition 3

(as relevant for the **fauna crossing**) for the **Minister's** written approval prior to **commencement** of the **stage** relevant to that fauna crossing; or

ii. provide written evidence to the **Minister** detailing how the resulting loss in connectivity will be compensated for with increased connectivity for the impacted species. This must be approved in writing by the **Minister,** prior to **commencement** of **stage 2** and **stage 3**.

c. **Fencing** must be constructed at a minimum the locations identified in Schedule 3 of this notice.

The requirements of this condition were completed during the 2017/2018 reporting period. Please refer to the 2017/18 report for further detail on compliance with this condition.

2.4. Condition 4

Condition 4

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

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

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

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

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

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

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

The Ecological Monitoring Program for the project was submitted to the Minister in a letter dated 29 April 2014 and approved by the Minister on 10 October 2014. Commencement dates for Stage 2 and Stage 3 were early to mid-November 2014.

An updated Ecological Monitoring Program for the project was submitted to the Minister on 3 May 2016 and approved by the Minister on 11 November 2016.

A third revision of the Ecological Monitoring Program for the project was submitted to the Minister on 3 April 2019 with a subsequent fourth revision submitted on 20 August 2019 and approved by the Minister on the 22 August 2019.

A fifth revision of the Ecological Monitoring Program was submitted to the Minister on 6 May 2022 and approved by the Minister on 30/05/2022.

The compliance status of the implementation of the Ecological Monitoring Program is detailed in Appendix A.

2.5. Condition 5

Condition 5

To compensate for the loss of 240 hectares of threatened species habitat the person taking the action must prepare and submit a Biodiversity Offset Management Plan (**BOMP**) for the **Minister's** written approval within 12 months of approval of the action. The BOMP must be approved in writing by the **Minister** within 12 months of approval of the action. The **BOMP** must include:

a. the identification of the portions of the lands described as the "Proposed Biodiversity Offset Areas" in the Map at Schedule 1 of this notice that are necessary to achieve the outcomes required by the *Environmental Offsets Policy 2012* (or subsequent published revisions). This must include **offset attributes**, **shapefiles**, textual descriptions and maps to clearly define the location and boundaries of the offset area(s);

b. the results of targeted field surveys within the offset sites (undertaken at any ecologically appropriate time of the year) to assess and describe habitat suitability and presence / absence of individuals in relation to the Koala, Grey-headed Flying-fox, Spotted-tail Quoll and Giant Barred frog;

c. an assessment of the baseline population for the Koala, Spotted-tail Quoll, Giant-Barred Frog, and Grey-headed Flying-fox which are detected within the offset area during field surveys;

d. a description of the current **quality** (prior to any management activities) of the offset area(s) identified in Condition 5a with reference to the Koala, Spotted-tail Quoll, Giant-Barred Frog, and Grey-headed Flying-fox;

e. an assessment demonstrating how the offset area(s) achieve the outcomes required by the *Environmental Offsets Policy 2012* (or subsequent published revisions) and user guide;

f. Should the offset sites identified in 5a not be sufficient to achieve the outcomes required by the *Environmental Offsets Policy 2012* (or subsequent published revisions) and user guide, as determined in writing by the **Minister**, the person taking the action must provide further suitable offset sites and include these as part of the **BOMP**;

g. information about the Koala, Grey-headed Flying-fox, Spotted-tail Quoll, Grey-headed Flying-fox, and Giant Barred frog (in relation to ecology, biology and conservation status) to inform appropriate management actions;

Condition 5

h. targeted management actions, regeneration and revegetation strategies to be undertaken on the offset area(s) to improve the ecological quality of these areas for the Koala, Grey-headed Flying-fox, Spotted-tail Quoll and Giant Barred frog

i. clear performance objectives for management actions that will enable maintenance and enhancement of habitat within the offset area, as well as contribute to the better protection of individuals and / or populations of Koala, Spotted-tail Quoll, Giant-Barred Frog, and Grey-headed Flying-fox onsite;

j. anticipated timeframes for achieving performance objectives.

k. performance and completion criteria for evaluating the management of the offset area, including contingency actions, criteria for triggering contingency actions and a commitment to the implementation of these actions in the event that performance objectives are not met;

l. a program to monitor and report on the effectiveness of these measures, and progress against the performance and completion criteria;

m. details of who would be responsible for monitoring, reviewing, and implementing the **BOMP**.

n. a description of funding arrangements or agreements including work programs and responsible entities;

The approved **BOMP** must be published on the NSW Roads and Maritime Services internet web site, within 1 month of the BOMP being approved.

The approved BOMP must be implemented.

The BOMP was first submitted to the Department of the Environment for the approval of the Minister in a letter dated 16 January 2015.

A revised version of the BOMP, taking into account comments received on the first version, was submitted on 14 April 2021 and again on 16 June 2021. The Department have advised TfNSW that they require the finalised management plan for the Paperbark Flora Reserve before they can approve the BOMP. TfNSW has received this from FCNSW and provided the plan to the Department on 27 June 2022. It was discussed and agreed that the Norton Site would be replaced by species credit for Giant Barred Frog from the Kalang Offset site. TfNSW has provided the final assessment report for Kalang Offset Site along with the EPBC Calculator for Giant Barred Frog.

TfNSW envisaged that the final BOMP with management plans as an appendix to be submitted to the Department by the end of October 2023.

Approval from the Minister remains outstanding.

2.6. Condition 6

Condition 6

If an offset site proposed as a part of Condition 5 is already required to be protected as a result of a separate EPBC Act approval, only the management actions which can be demonstrated to be additional to those required for the separate approval, can be considered as an offset for this project. The legal protection of the site and management measures required for a separate approval cannot be considered a part of the offset, in accordance with the *Environmental Offsets Policy 2012* (or subsequent published revisions).

This requirement has been noted as part of the preparation of the BOMP, required under Condition 5.

2.7. Condition 7

Condition 7

Within 12 months of approval of the Biodiversity Offset Management Plan (BOMP), the person taking the action must secure the offset area(s) identified in Condition 5a), under relevant conservation legislation. The legal instrument chosen must be registered on title, and must prevent any future development activities from occurring on the land protected, and ensure the active management of that land for the better protection of matters of national environmental significance for the duration of the impact of the action. Evidence of compliance with this condition must be provided to the **Department** within 30 days after the land(s) have been secured.

Approval from the Minister of the BOMP remains outstanding; as such compliance with this condition is not yet applicable.

2.8. Condition 8

Condition 8

Within three months of every 12 month anniversary of the **commencement** of the action, the person taking the action must publish a report on their website addressing compliance with each of the conditions of this approval, including implementation of the BOMP, Flora and Fauna Management Plans and Ecological Monitoring Plan as specified in the conditions. Documentary evidence providing proof of the date of publication must be provided to the **Department** at the same time as the compliance report is published. Noncompliance with any of the conditions of this approval must be reported to the **Department** within 2 business days of becoming aware of the non-compliance. At any time within the life of this approval the **Minister** may agree, in writing, that further reporting is not required if compliance with all requirements has been demonstrated to the **Minister's** satisfaction.

This report has been prepared to satisfy the requirements of this condition. Evidence of the date of publication will be provided to the Department when this report is published on the Transport for NSW project website.

The BOMP was first submitted to the Department of the Environment for the approval of the Minister in a letter dated 16 January 2015. The BOMP was re-submitted in April 2021 and June 2021. The Department advised TfNSW that they require the finalised management plan for the Paperbark Flora Reserve before they can approve the BOMP. TfNSW received this from FCNSW and provided the plan to the Department on 27 June 2022. It was discussed and agreed that the Norton Site would be replaced by species credit for Giant Barred Frog from the Kalang Offset site. TfNSW has provided the final assessment report for the Kalang Offset Site along with the EPBC Calculator for Giant Barred Frog.

Following recent consultation with the Department, TfNSW envisaged that the final BOMP to be submitted to the Department by the end of October 2023. Approval from the Minister remains outstanding.

A Flora and Fauna Management Plan has been prepared for each stage of the project. As at 21 July 2021, these plans were approved by the Minister on the following dates:

• Stage 1: Sancrox Interchange	24 June 2014
• Stage 2: Kundabung to Kempsey	22 October 2014 (Revision 1) 15 November 2016 (Revision 2) 22 August 2019 (Revision 3)
• Stage 3: Oxley Highway to Kundabung	10 October 2014 (Revision 1) 15 November 2016 (Revision 2) 22 August 2019 (Revision 3)

Construction of Stage 1 was completed in November 2015. Construction of Stage 2 and Stage 3 was completed in October 2017 and March 2018 respectively.

With the exception of the Ecological Monitoring Programs included as Appendices, the Flora and Fauna Management Plans are construction documents and were closed out in the Annual Report submitted to the July 2017 - July 2018 reporting period.

Details of the implementation of the Ecological Monitoring Plan is provided in Section 3.

All previous reports, and this report once published, can be found at the following link:

https://www.pacifichighway.nsw.gov.au/document-library/oxley-highway-to-kempsey-upgrade-epbc-compliance-reports

2.9. Condition 9

Condition 9

Within 30 days after the **commencement** of the action, the person taking the action must advise the **Department** in writing of the actual date of **commencement**.

In a letter to the Department, dated 19 August 2014, Transport for NSW advised the Department of the actual date of commencement, being 22 July 2014.

2.10. Condition 10

Condition 10

The person taking the action must maintain accurate records substantiating all activities associated with or relevant to these conditions of approval, including measures taken to implement the **BOMP,** Ecological Monitoring Plan and Flora and Fauna Management Plans, and make them available upon request to the **Department**. Such records may be subject to audit by the **Department** or an independent auditor in accordance with section 458 of the EPBC Act, or used to verify compliance with the conditions of approval. Summaries of audits will be posted on the **Department's** website. The results of audits may also be publicised through the general media.

TfNSW is maintaining accurate records for all activities relating to the conditions of approval, and the implementation of the BOMP, EMP and FFMPs. The potential audit by the Department is noted.

2.11. Condition 11

Condition 11

Upon the direction of the **Minister**, the person taking the action must ensure that an independent audit of compliance with the conditions of approval is conducted and a report submitted to the **Minister**. The independent auditor must be approved by the **Minister** prior to the **commencement** of the audit. Audit criteria must be approved by the **Minister** and the audit report must address the criteria to the satisfaction of the **Minister**.

The requirements of this condition are noted. A direction from the Minister under Condition 11 has not been received by Transport for NSW during this reporting period.

2.12. Condition 12

Condition 12

1. If the person taking the action wishes to carry out any activity otherwise than in accordance with the **BOMP**, Ecological Monitoring Plan and Flora and Fauna Management Plans as specified in the conditions, the person taking the action must submit to the **Department** for the **Minister's** written approval a revised version of that Plan. The varied activity shall not commence until the **Minister** has approved the varied Plan in writing. The **Minister** will not approve a varied Plan unless the revised Plan would result in an equivalent or improved environmental outcome over time. If the **Minister** approves the revised Plan, that Plan must be implemented in place of the Plan originally approved.

Transport for NSW submitted an update to the Ecological Monitoring Plan to the Department for approval on 3 May 2016. The updated Ecological Monitoring Plan was also an appendix of the approved Kundabung to Kempsey and Oxley Highway to Kundabung Flora and Fauna Management plans. The EMP and FFMP updates were approved by the Minister on 15 November 2016.

A third revision of the Ecological Monitoring Program for the project was submitted to the Minister on 3 April 2019 with a subsequent fourth revision submitted on 20 August 2019 and approved by the Minister on the 22 August 2019.

A fifth revision of the Ecological Monitoring Program was submitted to the Minister on 6 May 2022 and approved by the Minister on 30/05/2022.

The BOMP has not yet been approved by the Department, and therefore the requirements of this condition are not yet applicable to this plan.

2.13. Condition 13

Condition 13

1. If the **Minister** believes that it is necessary or convenient for the better protection of listed threatened species and ecological communities to do so, the **Minister** may request that the person taking the action make specified revisions to the **BOMP**, Ecological Monitoring Plan and Flora and Fauna Management Plans, as specified in the conditions and submit the revised **BOMP**, Ecological Monitoring Plan and Flora and Fauna Management Plans for the **Minister's** written approval. The person taking the action

Condition 13

must comply with any such request. The revised approved **BOMP**, Ecological Monitoring Plan and Flora and Fauna Management Plans must be implemented. Unless the **Minister** has approved the revised **BOMP**, Ecological Monitoring Plan and Flora and Fauna Management Plans then the person taking the action must continue to implement the **BOMP**, Ecological Monitoring Plan and Flora and Fauna Management Plans originally approved.

Noted.

No requests from the Minister under Condition 13 were received by Transport for NSW in this reporting period.

2.14. Condition 14

Condition 14

If, at any time after 5 years from the date of this approval, the person taking the action has not **substantially commenced** the action, then the person taking the action must not substantially commence the action without the written agreement of the **Minister**.

Commencement of the action occurred on 22 July 2014.

2.15. Condition 15

Condition 15

Unless otherwise agreed to in writing by the **Minister**, the person taking the action must publish all plans referred to in these conditions of approval on their website. Each plan must be published on the website within 1 month of being approved.

The Flora and Fauna Management Plans for each stage are published at

- https://www.pacifichighway.nsw.gov.au/document-library/sancrox-traffic-arrangement-flora-and-fauna-management-sub-plan
- https://www.pacifichighway.nsw.gov.au/document-library/oxley-highway-to-kundabung-upgrade-construction-environmental-management-plan-0
- https://www.pacifichighway.nsw.gov.au/document-library/kundabung-to-kempsey-upgrade-construction-environmental-management-plan

The Ecological Monitoring Program and Annual compliance reports are published at

- https://www.pacifichighway.nsw.gov.au/document-library/oxley-highway-to-kempsey-upgrade-ecological-monitoring-program-and-reports
- https://www.pacifichighway.nsw.gov.au/document-library/oxley-highway-to-kempsey-upgrade-epbc-compliance-reports

3 Ecological Monitoring Plan

Table 2 outlines the monitoring requirements from the Ecological Monitoring Plan, relevant to matters of National Environmental Significance that were required to be conducted during the last reporting period.

This monitoring was conducted in accordance with the timing requirements outlined in Table 2. The reports including the results of these monitoring events and evaluation of the project's compliance with the performance indicators, have been included in Appendix A.

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

Table 2 highlights monitoring completed to date, yet to be completed and the reports included as part of this Annual Compliance Report 2023.

Table 2 Ecological monitoring completed to date, yet to be completed and the reports included in Annual Compliance Report 2023.

Species monitored	Timing	Done/ yet to be done	Reporting
Koala	Spring/Summer	Year 3 monitoring (2017) completed. Year 4 monitoring (2018) completed. Year 5 monitoring spring 2019 and summer 2019/20 completed. Year 6 monitoring undertaken spring 2020 and summer 2020/21 completed. Year 8 monitoring scheduled for spring 2022 and summer 2022/2023 completed.	**Year 8 monitoring included in this report. Appendix A.** This is the final monitoring event and report as required by the Ecological Monitoring Program.
Spotted-tailed Quoll	Autumn/winter	Year 4 monitoring (2018) completed. Year 6 monitoring undertaken in autumn/winter 2020 completed. Year 8 monitoring scheduled for autumn/winter 2022 completed.	**Year 8 monitoring included in this report. Appendix A.** This is the final monitoring event and report as required by the Ecological Monitoring Program.
Giant Barred Frog	Spring, Summer and Autumn	Year 3 monitoring (2017/18) completed. Year 4 monitoring (2018/19) completed.	**Year 8 monitoring included in this report. Appendix A.** This is the final monitoring event and report as required by

Species monitored	Timing	Done/ yet to be done	Reporting
		Year 5 monitoring spring 2019, summer 2019/20 and autumn 2020 completed. Year 6 monitoring undertaken spring 2020, summer 2020/21and autumn 2021. Year 7 monitoring scheduled for spring 2021, summer 2021/22 and autumn 2022 completed. Year 8 monitoring scheduled for spring 2022, summer 2022/23 completed.	the Ecological Monitoring Program.
Road Kill	Weekly during October (spring), January (summer) and April (autumn) in Year 4, 5, 6 and 8	Construction / post opening – July 2017 – June 2018 completed. Year 4 monitoring (2018/19) completed. Year 5 monitoring October 2019, January 2020 and April 2020 completed. Year 6 monitoring undertaken October 2020, January 2021 and April 2021 completed. Year 8 monitoring scheduled for October 2022, January 2023 and April 2023 completed.	**Year 8 monitoring included in this report. Appendix A.** This is the final monitoring event and report as required by the Ecological Monitoring Program.
Fauna underpasses	Autumn and spring/summer year 4, 6 and 8	Year 4 monitoring (2018/19) completed. Year 6 monitoring undertaken late autumn 2020, late spring /early summer 2020 completed. Year 8 monitoring scheduled for late autumn 2022, late spring /early summer 2022 completed.	**Year 8 monitoring included in this report. Appendix A.** This is the final monitoring event and report as required by the Ecological Monitoring Program.
Fauna Fence		Year 4 monitoring autumn 2018 and spring/summer 2018/2019 completed. Year 6 monitoring undertaken autumn 2020 and spring/summer 2020/2021 completed. Year 8 monitoring - autumn 2022 and spring/summer 2022/2023 completed.	**Year 8 monitoring included in this report. Appendix A.** This is the final monitoring event and report as required by the Ecological Monitoring Program.

Table 3 lists the title of each of the monitoring reports where each of the EPBC reporting requirements in Table 2 have been included in this annual report. These reports are available in Appendix A.

Table 3 EPBC monitoring reports in Appendix A

Species / aspects monitored	Report title in Appendix A
Koala (Spring and Summer) Year 8 Monitoring	Koala Monitoring 2022
Spotted-tailed Quoll (Autumn and Winter) Year 8 Monitoring	Spotted-tailed Quoll Monitoring 2022
Giant Barred Frog (Spring, Summer and Autumn) Year 8 monitoring	Giant Barred Frog Monitoring 2022/2023
Road Kill (Spring, Summer and Autumn) Year 8 Monitoring	Fauna Fence and Road Kill Monitoring 2022/2023
Fauna Underpass (Autumn and Spring/Summer) Year 8 Monitoring	Fauna Underpass Monitoring 2022/2023
Fauna Fence (Spring, Summer and Autumn) Year 8 Monitoring	Fauna Fence and Road Kill Monitoring 2022/2023

All the Ecological Monitoring Program performance measures for the monitoring events listed in Table 3 were met for the 2022/2023 reporting period, with no further monitoring, mitigation or contingency measures required to be investigated and/or implemented, except for the following:

Koala: The performance measure relating to Koala Density for spotlighting records compared to the baseline records has only been met at two sites to date, the Cairncross State Forest impact site and Maria River State Forest control site.

While Koalas have not been detected during spotlighting surveys at the Maria River and Ballengarra impact sites, their presence has been previously demonstrated via SAT plot monitoring at the nearest SAT plot clusters to these spotlighting transects, therefore further monitoring is not recommended and no additional mitigation actions are considered necessary.

No significant change has been detected in the difference in Koala presence at control and impact sites between baseline and subsequent monitoring events.

Giant Barred Frog: The performance measure relating to continued presence of Giant Barred Frogs during each survey event where it was identified during baseline surveys was met for three of the six sites. Giant Barred Frogs were not recorded at Cooperabung reference sites during 2022/2023 surveys, where it was recorded during all three baseline surveys. Giant Barred Frogs were not recorded in summer or autumn at Smiths Creek impact site or spring at Maria River impact site.

The Project area experienced drought conditions in 2019 with below average rainfall followed by substantially higher than average rainfall during 2020/2021 and 2021/2022 resulting in waterway flooding and highly variable water levels. Frogs have since been recorded at all impact sites in at least one season during Year 8 monitoring, including at sites where they had not been recorded for a number of years, demonstrating continued presence at these sites. Recent records likely reflect natural population fluctuations associated with extreme climatic conditions experienced from Year 4 to Year 6 (2019 to 2022).

Given the number and location of Giant Barred Frogs recorded has varied between season and year at all sites and that trends are evident at both impact and reference sites, it is not possible to attribute these changes to the Project, therefore further monitoring is not recommended.

Giant Barred Frog: The performance measure relating to change to densities, distribution, habitat use and movement patterns compared to baseline data during monitoring in Year 1 – 8.

The number and location of Giant Barred Frogs recorded has varied between season and year at all sites. All sites show an overall decreasing trend in mean records and densities. However, as this decreasing trend is evident at both impact and reference sites, it is not possible to attribute these changes to the Project at this stage.

The high rainfall experience in 2020/2021 and 2021/2022 resulted in highly variable water levels, waterway flooding and expansive water flows across floodplains. The above-average rainfall conditions observed over the spring/summer periods of 2020/2021 and 2021/2022 follow the long-term drought conditions experienced across the Project area in 2019. It is possible that the population changes observed at all sites are in response to these changing conditions. Low capture rates may be a result of population impacts from drought conditions followed by waterway flooding, which is also likely to reduce capture and observation rates simply due to the likely dispersal of individuals across a broader wet area. A population response to improved waterway conditions after the 2020/2021 rainfall may be evidenced by the increased capture rates at some sites, but also hindered by difficult (flooding) survey conditions.

Within-year movement patterns that would permit comparison between baseline and subsequent monitoring events is not possible due to lack of data (surveys and captures are too infrequent), however, assessment of movement patterns of recaptured individuals over all surveys show that 25% of recaptured frogs have been found to traverse from one side of the carriageway to the other.

Given the number and location of Giant Barred Frogs recorded has varied between season and year at all sites and that trends are evident at both impact and reference sites, it is not possible to attribute these changes to the Project, therefore further monitoring is not recommended.

Appendix A: Ecological Monitoring Program Reports

Species / mitigation monitored	Report title
Koala	Koala Monitoring 2022
Spotted-tailed Quoll	Spotted-tailed Quoll Monitoring 2022
Giant Barred Frog	Giant Barred Frog Monitoring 2022/2023
Road Kill	Fauna Fence and Road Kill Monitoring 2022/2023
Fauna Underpass	Fauna Underpass Monitoring 2022/2023
Fauna Fence	Fauna Fence and Road Kill Monitoring 2022/2023

Koala Monitoring 2022

Year 8 Surveys – Oxley Highway to Kempsey, Pacific Highway Upgrade

Prepared for Transport for NSW

September 2023

Document control

Project no.:	1702
Project client:	Transport for NSW
Project office:	Port Macquarie
Document description:	Koala 2022 Monitoring Report
Project Director:	Radika Michniewicz
Project Manager:	Radika Michniewicz
Authors:	Jodie Danvers, Radika Michniewicz
Internal review:	Radika Michniewicz
Document status:	R1
Local Government Area:	Port Macquarie-Hastings and Kempsey

Author	Revision	Internal review	Date Issued
Jodie Danvers, Jai Green-Barber	D1	Radika Michniewicz	2/8/2023
Radika Michniewicz	R0		25/8/2023
Radika Michniewicz	R1		4/9/2023

Niche Environment and Heritage

A specialist environmental and heritage consultancy.

Head Office

Level 4, 460 Church Street
Parramatta NSW 2150
All mail correspondence to:
PO Box 2443
North Parramatta NSW 1750
Email: info@niche-eh.com

Sydney

0488 224 888

Central Coast

0488 224 999

Port Macquarie

0488 774 081

Brisbane

0488 224 036

Cairns

0488 284 743

Cover photograph: Koala recorded in Maria River State Forest during Spotted-tailed Quoll Monitoring in 2018 and Koala recorded in Underpass C32.35 during 2020 underpass monitoring.

Executive Summary

Context

This report documents findings from the spring-summer 2022 monitoring period for the Koala, as required for the Oxley Highway to Kempsey (OH2K) Pacific Highway Upgrade Project (the Project).

Aims

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

Methods

Each monitoring location was surveyed in accordance with the monitoring method and design specified in the Oxley Highway to Kempsey Pacific Highway Upgrade Ecological Monitoring Program (EMP, TfNSW 2022). Monitoring involved Spot Assessment Technique (SAT) plots and spotlighting. Surveys were undertaken in November 2022, December 2022, January 2023 and February 2023.

Key Results

- A total of 85 plots across 30 clusters were surveyed in spring-summer 2022. Koalas were found to be present within 10 of the 30 clusters (33%). This is lower than baseline, 2015, 2016, 2017, 2018, 2019 and 2020 surveys (83%, 45%, 37%, 52%, 52%, 74% and 57% respectively).
- The mean SAT activity level for all plots, measured as the percentage of trees at each plot with scats present, was 1.1% and ranged from 0 to 16.7%. This is similar to the mean activity recorded for plots during 2015, 2016, 2017 and 2020 surveys (2.0%, 0.7%, 1.8% and 1.9% respectively), but lower than the mean activity during baseline surveys (4.9%) and 2019 surveys (3.3%).
- Koalas were recorded more frequently at impact clusters (40%) than at control clusters (27%), which is consistent with results observed in the previous monitoring events.
- Koalas have been recorded using four of the 14 culverts (located within the vicinity of the monitoring sites) being monitored as part of the Fauna Underpass Monitoring for the Project.
- There was no significant change in the difference between Koala presence at control and impact clusters between 2022 and baseline surveys.
- There was no significant change in the difference between Koala presence at clusters with and without mitigation between 2022 and baseline surveys.
- Average plot activity levels for each treatment type have not decreased from the baseline surveys beyond the recommended 10% tolerance level.
- There were no Koala road kill records during 2022/2023 monitoring.
- There has not been a notable alteration in Koala record distribution pre and post construction.
- Grids traversed by the Project corridor have the lowest Koala density, and grids adjacent to the Project corridor have the highest Koala density in both the pre-construction and post-construction periods. Average record density has increased for each group of grids post construction.

Conclusions

All performance measures have been met.

Management Implications

As no significant changes in Koala presence, distribution, density and activity levels from baseline surveys have been detected to date, and as Koalas have been detected using four dedicated fauna underpasses within the Project area, additional mitigation actions are not considered necessary.

Table of Contents

List of Figures

List of Tables

List of Graphs

1. Introduction

1.1 Context

The Oxley Highway to Kempsey (OH2K) section of the Pacific Highway Upgrade Project (the Project) was approved in 2012 subject to various Ministers Conditions of Approval (MCoA) and a Statement of Commitments (SoC). A subsequent approval with additional conditions of consent (CoA) was granted in 2014 by the then Commonwealth Department of Environment (DoE) for Matters of National Environmental Significance (MNES) listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Ecological Monitoring Program (hereafter referred to as the EMP) (TfNSW 2022) combines these approval conditions and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project. The Koala was identified as requiring mitigation and monitoring during the Project's construction and operational periods.

1.1.1 Legal status

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

1.1.2 Monitoring framework

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

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

- Spring-summer 2015: *Koala Monitoring. Year 1 surveys - Oxley Highway to Kempsey Pacific Highway Upgrade* (Niche 2016)
- Spring- summer 2016: *Koala Monitoring 2016. Year 2 surveys - Oxley Highway to Kempsey Pacific Highway Upgrade* (Niche 2017)
- Spring-summer 2017: *Koala Monitoring 2017. Year 3 surveys - Oxley Highway to Kempsey Pacific Highway Upgrade* (Niche 2018a)
- Spring-summer 2018: *Koala Monitoring 2018. Year 4 surveys - Oxley Highway to Kempsey Pacific Highway Upgrade* (Niche 2019a)
- Spring-summer 2019: *Koala Monitoring 2019. Year 5 surveys - Oxley Highway to Kempsey Pacific Highway Upgrade* (Niche 2020a)
- Spring-summer 2020: *Koala Monitoring 2019. Year 6 surveys - Oxley Highway to Kempsey Pacific Highway Upgrade* (Niche 2021a)
- Spring-summer 2022: Current report.

Construction monitoring was completed in spring-summer 2017. This report represents the fourth (Year 8) and final of the required operational monitoring reports.

1.1.3 Baseline data

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

1.1.4 Purpose of this report

This report details the findings obtained from the 2022 monitoring period. As mentioned previously, it represents the third of four monitoring reports for the operational phase of the Project.

The aim of this report is to summarise the methods and results of the spring-summer 2022 monitoring, and to compare the results with the baseline surveys to determine whether performance measures are being met and comment on whether additional measures should be considered.

1.2 Performance Measures

The EMP specifies the following performance measures for the Koala:

- *Monitoring is undertaken during baseline surveys from Year 1 – Year 6 & Year 8, or until mitigation measures are demonstrated to be effective.*
- *Monitoring during Year 1 – Year 6 & Year 8 is undertaken at the Impact and Control sites where monitoring was undertaken during baseline surveys, subject to ongoing landowner agreement. Where landowner agreement cannot be obtained and the process in Section 3.1.2 of the EMP has been followed, this performance indicator will also be considered to have been met.*
- *Mitigation measures are demonstrated to be effective as defined in the EPBC approval when all monitoring events are considered at Year 8.*
- *Fauna fence is installed at a minimum in areas identified in Schedule 3 of the EPBC approval at Year 4.*
- *Density: Koala spotlighting records are compared to and discussed with reference to the baseline records, with the baseline detection frequency rate of 1 Koala per spotlight hour considered as the baseline density, as recommended in the baseline report. Compare the NSW BioNet wildlife Atlas density ranking of 5 km^2 grids, as per the baseline report, between pre and post-construction at Year 8.*
- *Movement: Reduction in Koala road kill compared to the baseline of 1 Koala road kill per 8 weeks for an average baseline plot activity level of 5%, whereby proportional changes in average plot activity level may be reflected in the acceptable level of Koala road kill.*
- *Distribution: Compare the number of records and clustering of records, as per the baseline report, between pre-construction and construction/post-construction at Year 8.*
- *Habitat Use: Koala SAT activity levels will be compared to the baseline activity levels data (below) with a 10% tolerance level, as recommended in the baseline report, to account for variability:*
  - *Broader study area set at 5% activity*
  - *The treatment classes of mitigation set at 8.05%, no mitigation set at 2.64% and control / reference set at 4.03%*
  - *Comparison of percent tree use with baseline tree use.*

1.3 Monitoring Timing

Spotlighting is to occur in spring and SAT plot monitoring is to occur during spring-summer.

1.4 Reporting

Annual reporting of monitoring results will include:

- A detailed description of the monitoring methodology
- Results of the monitoring surveys
- Discussion of the results, including how the results compare against performance measures and if contingency measures should be implemented.

All reports prepared under the EMP will be submitted to the NSW Department of Planning and Environment (DPE) and the NSW Environment Protection Authority (EPA) and the Australian Department of Climate Change, Energy, the Environment and Water (DCCEEW).

2. Survey Methodology

2.1 Koala Spot Assessment Technique (SAT)

2.1.1 Monitoring design

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

- Type A: Impact with mitigation. Mitigation plots are located within 500 metres (m) of sufficiently large culverts (>1.8 m, to allow Koalas to pass under the Highway) that are paired with floppy top fencing.
- Type B: Impact without mitigation. Plots where mitigation has not been proposed or only partial mitigation is proposed. Partial mitigation plots are where only floppy top fencing is present but with obvious openings at interchanges or entry/exit points.
- Type C: Control or reference. These are located in areas at least 3 km, and often 5-10 km from the Project.

Each treatment type (A, B or C) is represented by a cluster of three SAT plots within each of the eight areas, resulting in nine SAT plots per area giving a total of 72 baseline SAT plots, established by Lewis (2014) (with the exception of Cairncross State Forest (South), which had an additional type B cluster during baseline surveys and Mingaletta to Smiths Creek where no type B cluster was established during baseline surveys). Of these 72 plots, 24 were mitigation (type A), three part mitigation and 21 no mitigation (type B) and 24 were control sites (type C). To ensure a balanced monitoring design between impact plots (mitigated and not mitigated) and control plots, an additional 24 control plots (type C) were established during the first monitoring event in 2015 (Niche 2016). In accordance with the baseline monitoring design these additional 24 control plots were established at least 3 km from the Project and were grouped in clusters of three plots, one cluster for each of the eight broad areas.

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

Details of the 96 monitoring plots are presented in Table 1 and the location of the 93 accessible monitoring plots are shown in Figure 1. During the 2022 monitoring, eight of the 93 monitoring plots were not monitored due to: six plots (KUNDABUNG 6, MIN-SMITHS CK3, COOPERABUNG 1, LAKE INNES1-3) being inaccessible due inability to contact landholder and two plots (SAT ST1 and SAT ST2) being inaccessible due to track damage.

Table 1: SAT monitoring plots

Area	Type	Sub-category	Data source	Plot name	Easting	Northing
South Sancrox	Impact	No Mitigation	Baseline	1 Sancrox East - Cassegrains	483348	6521736
	Impact	No Mitigation	Baseline	2 Sancrox East - Cassegrains	483455	6521789
	Impact	No Mitigation	Baseline	3 Sancrox East - Cassegrains	483412	6521882

Area	Type	Sub-category	Data source	Plot name	Easting	Northing
	Impact	Mitigation	Baseline_Niche relocation	1 Sancrox South	483299	6520671
	Impact	Mitigation	Baseline_Niche relocation	2 Sancrox South	483254	6520383
	Impact	Mitigation	Baseline_Niche relocation	3 Sancrox South	483196	6520217
	Control	Control	Baseline	1 Cowarra State Forest	480608	6519056
	Control	Control	Baseline	2 Cowarra State Forest	480658	6519496
	Control	Control	Baseline	3 Cowarra State Forest	481305	6519136
	Control	New Control	Niche	COWARRA NC1	479706	6518522
	Control	New Control	Niche	COWARRA NC2	479788	6517922
	Control	New Control	Niche	SAT COWARRA NC3	479795	6518227
North Sancrox	Impact*	No Mitigation	Baseline	1 Sancrox North - Expressway Spares	483042	6521731
	Impact*	No Mitigation	Baseline	2 Sancrox North - Expressway Spares	482869	6521683
	Impact*	No Mitigation	Baseline	3 Sancrox North - Expressway Spares	482999	6521818
	Impact	Mitigation	Baseline	1 Fernbank Creek	483101	6523362
	Impact	Mitigation	Baseline	2 Fernbank Creek	483032	6523223
	Impact	Mitigation	Baseline	3 Fernbank Creek	483056	6523123
	Control+	Control	Baseline	1 Lake Innes	488124	6518469
	Control+	Control	Baseline	2 Lake Innes	488047	6518398
	Control+	Control	Baseline	3 Lake Innes	488228	6518390
	Control	New Control	Niche	COWARRA NC3 -SAT COW4	479674	6516436
	Control	New Control	Niche	SAT COW5	479704	6516174
	Control	New Control	Niche	SAT COW6	479667	6515913
Cairncross State Forest (South)	Impact	No Mitigation	Baseline	1 Cairncross State Forest (South)	482428	6526536
	Impact	No Mitigation	Baseline	2 Cairncross State Forest (South)	482385	6526644
	Impact	No Mitigation	Baseline	3 Cairncross State Forest (South)	482393	6526416
	Impact	No Mitigation	Baseline	16 Cairncross State Forest (south)	481655	6527256
	Impact	No Mitigation	Baseline	17 Cairncross State Forest (south)	481590	6527316
	Impact	No Mitigation	Baseline	18 Cairncross State Forest (south)	481637	6527175
	Impact	Mitigation	Baseline	4 Cairncross State Forest (South)	482249	6525930
	Impact	Mitigation	Baseline	5 Cairncross State Forest (South)	482125	6526077
	Impact	Mitigation	Baseline	6 Cairncross State Forest (South)	482488	6526226
	Control	Control	Baseline	1 Limeburners Creek ""The Hatch""	487011	6529909
	Control	Control	Baseline	2 Limeburners Creek ""The Hatch""	487014	6529455
	Control	Control	Baseline	3 Limeburners Creek ""The Hatch""	487035	6528694
	Control	New Control	Niche	SAT PEVI1	476817	6528422
	Control	New Control	Niche	SAT PEVI2	476730	6528225
	Control	New Control	Niche	Cairncross NC1	475996	6528211
Cairncross State Forest (north)	Impact	No Mitigation	Baseline_Niche relocation	7 Cairncross State Forest (North)	481346	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

Area	Type	Sub-category	Data source	Plot name	Easting	Northing
	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
	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

Area	Type	Sub-category	Data source	Plot name	Easting	Northing
	Control	New Control	Niche	SAT MAC3	476481	6552612
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

* not surveyed since baseline due to private landowner access restrictions; # not surveyed in 2022 due to track restrictions; + not surveyed in 2022 due to inability to contact landholder.

2.1.2 SAT Methodology

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

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

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

2.1.3 Analysis

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

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

2.2 Additional Surveys

Additional survey methods were adopted in 2019 as a result of the revision and adoption of an updated EMP (TfNSW 2022).

2.2.1 Spotlighting

Spotlighting surveys were undertaken as per baseline surveys at six sites across three locations: Cairncross State Forest, Ballengarra State Forest and Maria River National Park (Figure 1). Spotlighting locations have been set up in a paired Before After Control Impact (BACI) configuration comprising an impact site and a control site which exhibit similar vegetation/habitat type and landscape features. Field surveys involved a 10 minute listening period on arrival at site, followed by spotlighting performed by two observers using handheld variable beam ~100 watt spotlights whilst walking a 500 m transect over 30 minutes. These surveys are to be repeated on three separate occasions at least seven days apart.

2.2.2 NSW BioNet Wildlife Atlas

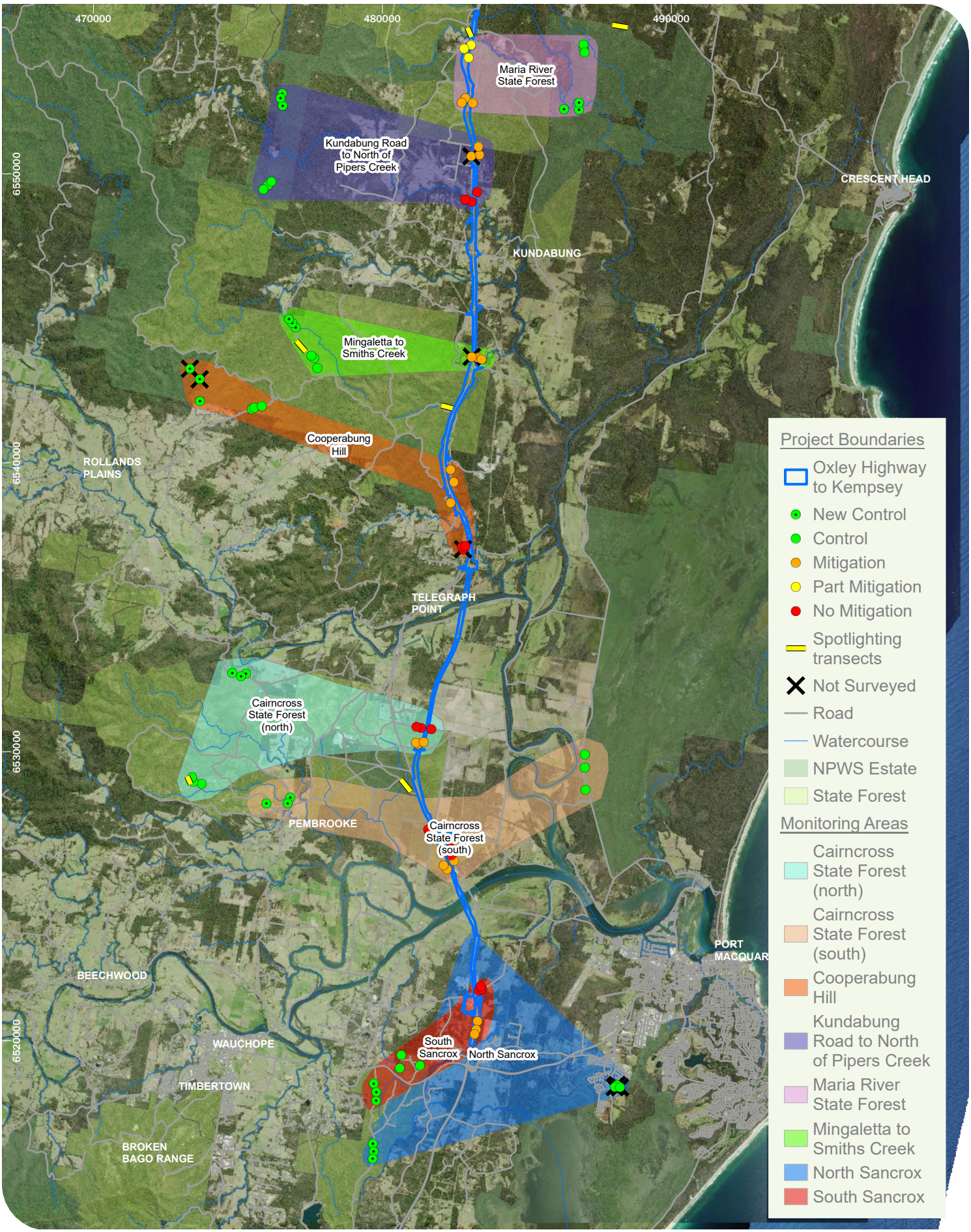
NSW BioNet wildlife Atlas records will be used to compare Koala distribution and density. A comparison of pre-construction records (i.e. 2004 - 2013 inclusive) to post-construction records at Year 8 (i.e. 2014 – 2022 inclusive) was undertaken, as per baseline methods.

Koala distribution: Koala distribution was measured using BioNet Wildlife Atlas records within 10 km of the study area so as to provide a comparison with the baseline monitoring distribution data. The Atlas data was divided into the following two chronological time scales:

- Pre-construction: 2004-2013 inclusive
- Post-construction: 2014-2022 inclusive

Differences in Koala records between 2004-2013, and 2014-2022 were discussed with reference to obviously clustering of records as focal points for Koala populations.

Koala density: Koala density was measured using historic records from the BioNet Wildlife Atlas to describe reporting rates using a standardised 5 km2 across the study area. The number of records within each grid was calculated for two time periods; pre-construction (2004-2013) as a baseline for comparison, and post-construction (2014-2022).



Drawn by: File: T:\spatial\projects\a1700\a1702_OH2K_EcologyMaps\PI_5_Ecology_OH2KPI_51_Koala_SAT\2022\a1702_PI51_Koala_SAT.aprx Last updated: 8/25/2023 5:09 PM

niche Environment and Heritage

0 4
km
GDA 1994 MGA Zone 56

SAT plot and spotlighting transect locations

Koala Monitoring: Pacific Highway Upgrade - Oxley Highway to Kempsey

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

Figure 1

v2.0

3. Results

3.1 SAT Plots

Surveys were undertaken between 9 December 2022 and 28 February 2023. Field data for each SAT plot is presented in Annex 1. The DBH (diameter at breast height) is provided for the SCT.

A total of 85 accessible SAT plots were surveyed across the eight monitoring areas (Figure 1).

3.1.1 Presence/absence

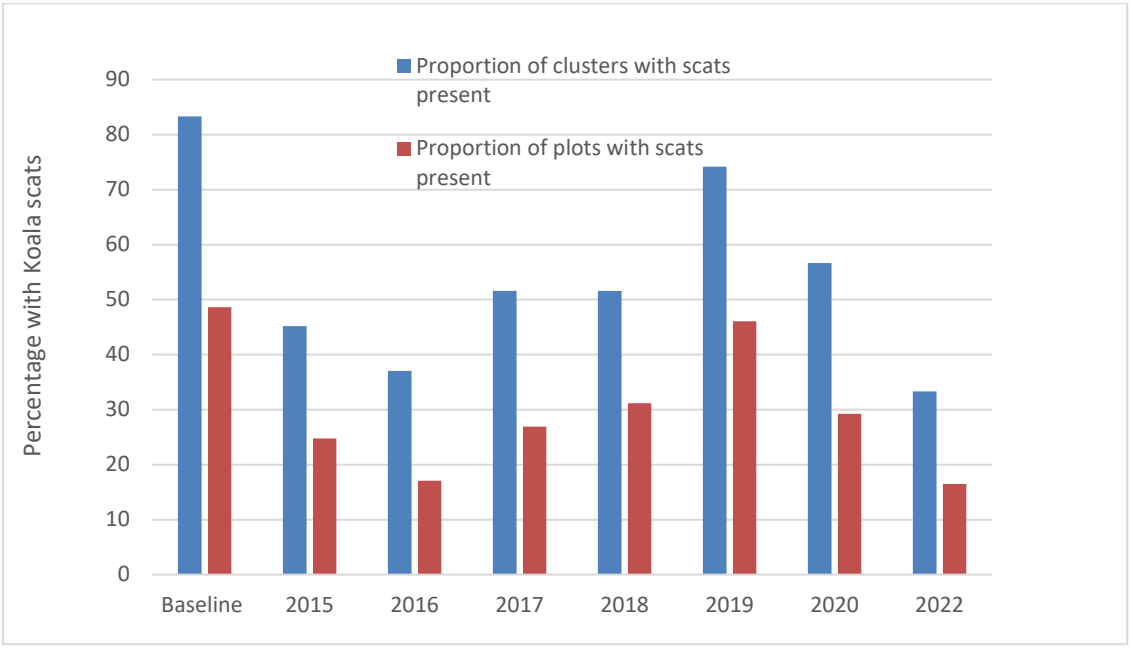
SAT plots

Table 2 provides a summary of presence/absence results for plots and clusters at each monitoring event. Graph 1 shows the percentage of plots and clusters with scats present for each monitoring period to date and Graph 2 shows the percentage of clusters within each area with scats present, for each monitoring period to date. Table 3 provides a detailed comparison of the activity level for each plot and presence/absence results of each cluster for each monitoring period to date and Figure 2 shows the SAT cluster presence/absence results for the 2022 monitoring (map reference ID for each cluster is listed in Table 3).

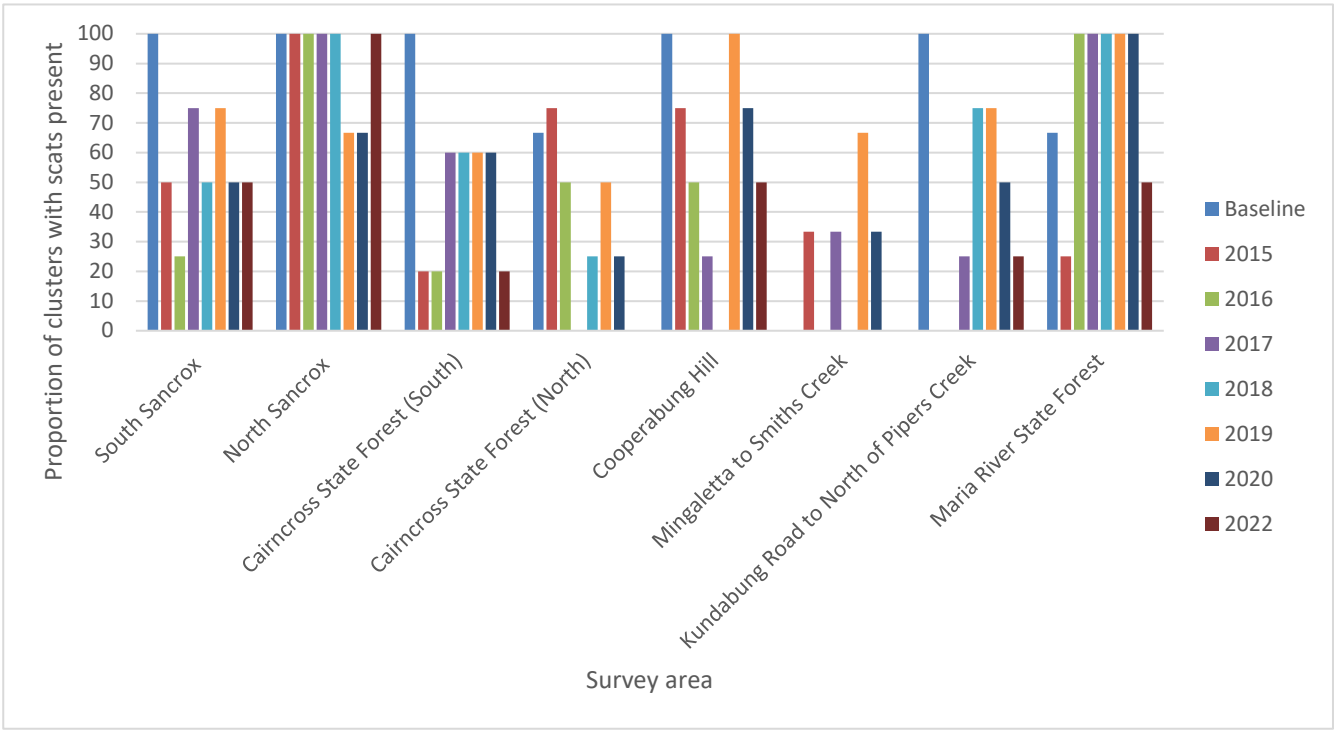
Of the 85 surveyed plots, Koala scats were recorded at 16.5% (14 of 85) of the individual plots. This is lower than previous surveys 2015, 2016, 2017, 2018, 2019 and 2020 surveys (25%, 17%, 27%, 31%, 46% and 29% respectively). This is also lower than the 49% recorded during baseline surveys. When grouped according to cluster, Koala scats were recorded at 33% of clusters (10 of 30). This is lower than baseline, 2015, 2016, 2017, 2018, 2019 and 2020 surveys (83%, 45%, 37%, 52%, 52%, 74% and 57% respectively).

Table 2: Presence/absence results

	Baseline	2015	2016	2017	2018	2019	2020	2022
Number of plots with scats present (n = plots surveyed)	35 (49%, n = 72)	23 (25%, n = 93)	14 (17%, n = 82)	25 (27%, n = 93)	29 (31%, n = 93)	41 (46%, n = 89)	26 (29%, n = 89)	14 (16.5%, n = 85)
Number of clusters with scats present (n = clusters surveyed)	20 (83%, n = 24)	14 (45%, n = 31)	10 (37%, n = 27)	16 (52%, n = 31)	16 (52%, n = 31)	23 (74%, n = 31)	17 (57%, n = 30)	10 (33%, n = 30)



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



Graph 2: Koala presence in areas across all monitoring events

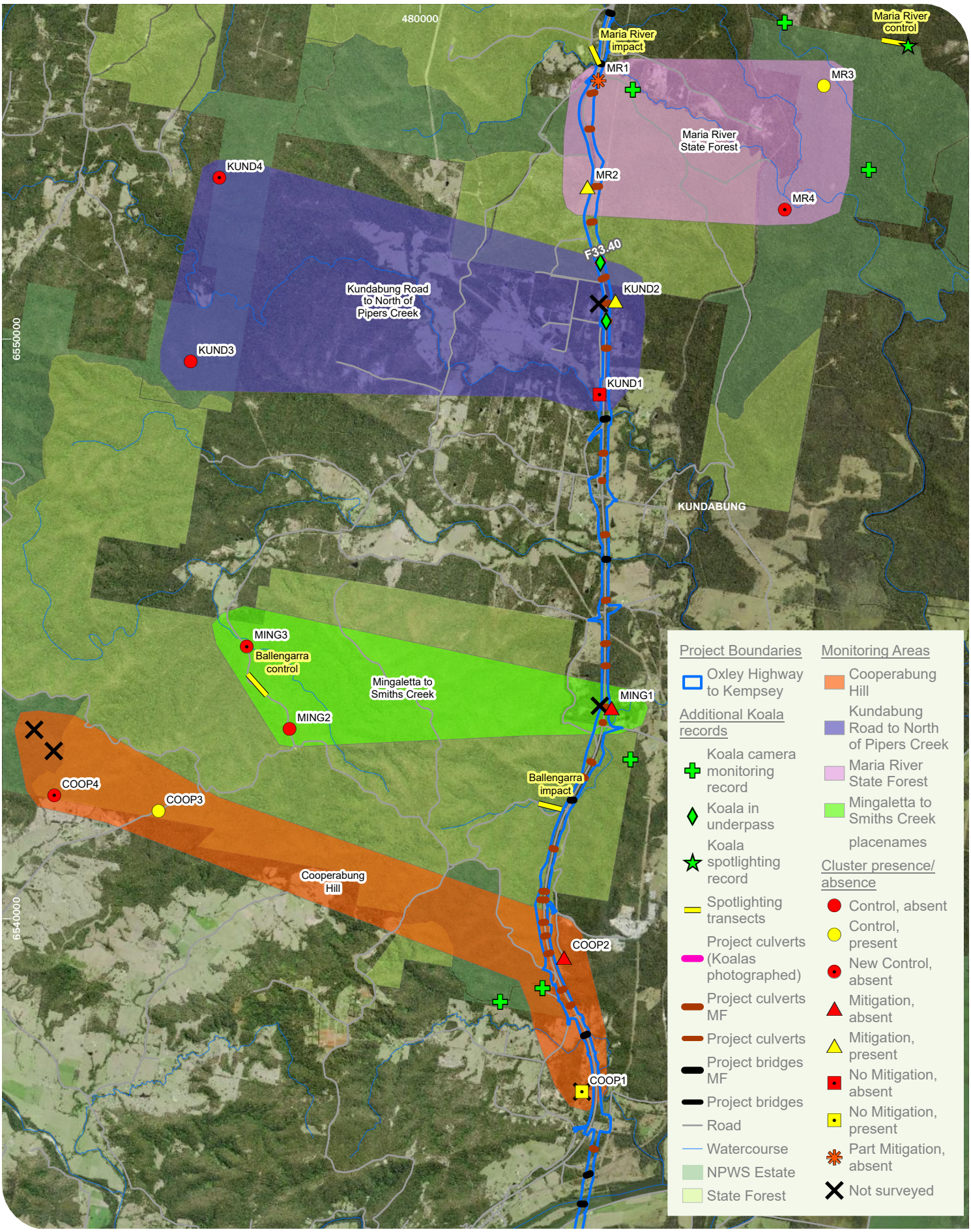
Table 3: SAT plot results baseline – 2022

Area	Type	Data source	Site ID	MapRef	Plot activity (%)								Scat presence (per cluster)							
					Base line	2015	2016	2017	2018	2019	2020	2022	Baseline	2015	2016	2017	2018	2019	2020	2022
South Sancrox	No Mitigation	Baseline	SANCROX E1	SSAN1	10.0	3.3	0.0	23.3	6.7	3.3	3.3	0.0	present	present	absent	present	present	present	present	absent
			SANCROX E2		0.0	0.0	0.0	0.0	0.0	fire	0.0	0.0								
			SANCROX E3		0.0	0.0	0.0	0.0	6.7	0.0	0.0	0.0								
	Mitigation	Baseline_Niche relocation	SANCROX S1	SSAN2	13.3	0.0	0.0	3.3	0.0	fire	3.3	0.0	present	absent	absent	present	present	present	present	present
			SANCROX S2		3.3	0.0	0.0	0.0	6.7	fire	0.0	10.0								
			SANCROX S3		10.0	0.0	0.0	0.0	3.3	3.3	0.0	0.0								
	Control	Baseline	COWARRA SF1	SSAN3	0.0	0.0	0.0	0.0	0.0	6.7	0.0	0.0	present	absent	present	absent	absent	present	absent	absent
			COWARRA SF2		3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0								
			COWARRA SF3		10.0	0.0	6.7	0.0	0.0	0.0	0.0	0.0								
	New Control	Niche	SAT COWARRA NC1	SSAN4	-	0.0	0.0	0.0	0.0	0.0	0.0	3.3	Not monitored	present	absent	present	absent	absent	absent	present
			SAT COWARRA NC2		-	3.3	0.0	6.7	0.0	0.0	0.0	0.0								
			SAT COWARRA NC3		-	0.0	0.0	3.3	0.0	0.0	0.0	0.0								
North Sancrox	No Mitigation	Baseline	SANCROX N1	-	3.3	-	-	-	-	-	-	-	present	No access	No access	No access	No access	No access	No access	No access
			SANCROX N2		0.0	-	-	-	-	-	-	-								
			SANCROX N3		0.0	-	-	-	-	-	-	-								
	Mitigation	Baseline	FERNBANK CK1	NSAN1	33.3	0.0	3.3	16.7	3.3	0.0	10.0	10.0	present	present	present	present	present	absent	present	present
			FERNBANK CK2		30.0	0.0	6.7	6.7	0.0	0.0	0.0	10.0								
			FERNBANK CK3		23.3	6.7	3.3	13.3	6.7	0.0	3.3	0.0								
	Control	Baseline	LAKE INNES1	NSAN2	26.7	13.3	0.0	3.3	6.7	3.3	3.3	-	present	present	present	present	present	present	present	No access
			LAKE INNES2		13.3	6.7	3.3	6.7	3.3	0.0	3.3	-								
			LAKE INNES3		3.3	6.7	0.0	0.0	3.3	10.0	10.0	-								
	New Control	Niche	SAT COW4	NSAN3	-	10.0	0.0	3.3	3.3	0.0	0.0	0.0	Not monitored	present	present	present	present	present	absent	present
			SAT COW5		-	0.0	0.0	0.0	0.0	3.3	0.0	0.0								
			SAT COW6		-	0.0	3.3	0.0	10.0	0.0	0.0	3.3								
		Baseline	CAINCROSS SF1	CCS1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	present	present	absent	absent	absent	present	present	absent

Area	Type	Data source	Site ID	MapRef	Plot activity (%)								Scat presence (per cluster)							
					Base line	2015	2016	2017	2018	2019	2020	2022	Baseline	2015	2016	2017	2018	2019	2020	2022
Cairncross State Forest (South)	No Mitigation		CAINCROSS SF2		3.3	6.7	0.0	0.0	0.0	3.3	0.0	0.0								
			CAINCROSS SF3		0.0	3.3	0.0	0.0	0.0	0.0	3.3	0.0								
	No Mitigation	Baseline	CAINCROSS SF16	CCS2	0.0	0.0	3.3	3.3	0.0	0.0	0.0	0.0	present	absent	present	present	present	absent	absent	absent
			CAINCROSS SF17		0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.0								
			CAINCROSS SF18		13.3	0.0	0.0	6.7	3.3	0.0	0.0	0.0								
	Mitigation	Baseline	CAINCROSS SF4	CCS3	3.3	0.0	0.0	3.3	6.7	13.3	3.3	3.3	present	absent	absent	present	present	present	present	present
			CAINCROSS SF5		3.3	0.0	0.0	0.0	0.0	13.3	0.0	0.0								
			CAINCROSS SF6		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0								
	Control	Baseline	LIMEBURNERS CK1	CCS4	0.0	0.0	0.0	3.3	0.0	0.0	-	0.0	present	absent	absent	present	absent	absent	absent	absent
			LIMEBURNERS CK2		3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0								
			LIMEBURNERS CK3		0.0	0.0	0.0	3.3	0.0	0.0	0.0	0.0								
	New Control	Niche	SAT PEVI1	CCS5	-	0.0	0.0	0.0	6.7	3.3	0.0	0.0	Not monitored	absent	absent	absent	present	present	present	absent
			SAT PEVI2		-	0.0	0.0	0.0	3.3	0.0	3.3	0.0								
			SAT PEVI3		-	0.0	0.0	0.0	0.0	0.0	0.0	0.0								
Cairncross State Forest (north)	No Mitigation	Baseline_Niche relocation	CAINCROSS SF7	CCN1	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	absent	present	absent	absent	absent	present	absent	absent
		Baseline	CAINCROSS SF8		0.0	20.0	0.0	0.0	0.0	3.3	0.0	0.0								
		Baseline	CAINCROSS SF9		0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0								
	Mitigation	Baseline	CAINCROSS SF10	CCN2	3.3	0.0	0.0	0.0	3.3	6.7	3.3	0.0	present	present	present	absent	present	present	present	absent
			CAINCROSS SF11		3.3	0.0	3.3	0.0	0.0	0.0	0.0	0.0								
			CAINCROSS SF12		6.7	3.3	0.0	0.0	0.0	3.3	0.0	0.0								
	Control	Baseline	CAINCROSS SF13	CCN3	6.7	3.3	3.3	0.0	0.0	0.0	0.0	0.0	present	present	present	absent	absent	absent	absent	absent
			CAINCROSS SF14		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0								
			CAINCROSS SF15		0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0								
	New Control	Niche	SAT RR1	CCN4	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Not monitored	absent	absent	absent	absent	absent	absent	absent
			SAT RR2		-	0.0	0.0	0.0	0.0	0.0	0.0	0.0								
			SAT RR3		-	0.0	0.0	0.0	0.0	0.0	0.0	0.0								

Area	Type	Data source	Site ID	MapRef	Plot activity (%)								Scat presence (per cluster)							
					Base line	2015	2016	2017	2018	2019	2020	2022	Baseline	2015	2016	2017	2018	2019	2020	2022
Cooperabung Hill	No Mitigation	Baseline	COOPERABUNG1	COOP1	3.3	3.3	0.0	0.0	0.0	0.0	0.0	-	present	present	present	absent	absent	present	present	present
			COOPERABUNG2		0.0	23.3	3.3	0.0	0.0	3.3	0.0	0.0								
			COOPERABUNG3		10.0	0.0	0.0	0.0	0.0	10.0	10.0	3.3								
	Mitigation	Baseline_Niche relocation	COOPERABUNG4	COOP2	0.0	3.3	6.7	0.0	0.0	10.0	6.7	0.0	present	present	present	present	absent	present	present	absent
		Baseline_Niche relocation	COOPERABUNG5		3.3	3.3	0.0	10.0	0.0	6.7	3.3	0.0								
		Baseline	COOPERABUNG6		0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0								
	Control	Baseline	COOP HILL1	COOP3	6.7	0.0	0.0	0.0	0.0	3.3	0.0	0.0	present	absent	absent	absent	absent	present	present	present
			COOP HILL2		0.0	0.0	0.0	0.0	0.0	6.7	3.3	3.3								
			COOP HILL3		0.0	0.0	0.0	0.0	0.0	10.0	13.3	3.3								
	New Control	Niche	SAT FL1	COOP4	-	16.7	0.0	0.0	0.0	logged	0.0	0.0	Not monitored	present	absent	absent	absent	present	absent	absent
			SAT ST1		-	0.0	0.0	0.0	0.0	10.0	0.0	-								
			SAT ST2		-	20.0	0.0	0.0	0.0	3.3	0.0	-								
Mingaletta to Smiths Creek	Mitigation	Baseline	MIN-SMITHS CK1	MING1	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0	absent	absent	absent	absent	absent	present	present	absent
			MIN-SMITHS CK2		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0								
			MIN-SMITHS CK3		0.0	0.0	0.0	0.0	0.0	6.7	0.0	-								
	Control	Baseline	BALLENGARA SF1	MING2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	absent	absent	absent	absent	absent	present	absent	absent
			BALLENGARA SF2		0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0								
			BALLENGARA SF3		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0								
	New Control	Niche	SAT BR1	MING3	-	6.7	0.0	0.0	0.0	0.0	0.0	0.0	Not monitored	present	absent	present	absent	absent	absent	absent
			SAT BR2		-	0.0	0.0	3.3	0.0	0.0	0.0	0.0								
			SAT BR3		-	0.0	0.0	0.0	0.0	0.0	0.0	0.0								
Kundabung Road to North of Pipers Creek	No Mitigation	Baseline	KUNDABUNG 1	KUND1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	present	absent	absent	absent	present	present	present	absent
			KUNDABUNG 2		10.0	0.0	0.0	0.0	6.7	3.3	3.3	0.0								
			KUNDABUNG 3		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0								
		Baseline	KUNDABUNG 4	KUND2	33.3	0.0	fire	0.0	13.3	10.0	0.0	16.7	present	absent	Fire	present	present	present	present	present

Area	Type	Data source	Site ID	MapRef	Plot activity (%)								Scat presence (per cluster)							
					Base line	2015	2016	2017	2018	2019	2020	2022	Baseline	2015	2016	2017	2018	2019	2020	2022
	Mitigation		KUNDABUNG 5		13.3	0.0	fire	3.3	16.7	13.3	6.7	3.3			Fire					
			KUNDABUNG 6		10.0	0.0	0.0	0.0	0.0	0.0	0.0	-			absent					
	Control	Baseline	KUMBATINE NP1	KUND3	3.3	0.0	0.0	0.0	0.0	3.3	0.0	0.0	present	absent	absent	absent	present	present	absent	absent
			KUMBATINE NP2		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0								
			KUMBATINE NP3		0.0	0.0	0.0	0.0	3.3	6.7	0.0	0.0								
	New Control	Niche	SAT MAC1	KUND4	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Not monitored	absent	absent	absent	absent	absent	absent	absent
			SAT MAC2		-	0.0	0.0	0.0	0.0	0.0	0.0	0.0								
			SAT MAC3		-	0.0	0.0	0.0	0.0	0.0	0.0	0.0								
Maria River State Forest	Part Mitigation	Baseline_Niche relocation	MARIA RIVER 1	MR1	0.0	0.0	fire	0.0	6.7	3.3	3.3	0.0	present	absent	No access - fire	present	present	present	present	absent
		Baseline	MARIA RIVER 2		3.3	0.0	fire	0.0	0.0	23.3	6.7	0.0								
		Baseline_Niche relocation	MARIA RIVER 3		6.7	0.0	fire	16.7	13.3	10.0	0.0	0.0								
	Mitigation	Baseline	MARIA RIVER 4	MR2	0.0	0.0	fire	6.7	6.7	10.0	6.7	0.0	absent	present	No access - fire	present	present	present	present	present
			MARIA RIVER 5		0.0	0.0	fire	0.0	0.0	3.3	6.7	3.3								
			MARIA RIVER 6		0.0	3.3	fire	0.0	3.3	0.0	0.0	0.0								
	Control	Baseline	MARIA NP1	MR3	0.0	0.0	0.0	3.3	20.0	10.0	10.0	0.0	present	absent	present	present	present	present	present	present
			MARIA NP2		10.0	0.0	3.3	0.0	10.0	10.0	33.3	3.3								
			MARIA NP3		10.0	0.0	3.3	3.3	36.7	13.3	3.3	16.7								
	New Control	Niche	SAT CO1	MR4	-	0.0	fire	6.7	10.0	13.3	-	0.0	Not monitored	absent	No access - fire	present	present	present	No access – roads blocked	absent
			SAT CO3		-	0.0	fire	3.3	0.0	3.3	-	0.0								
			SAT MAR 1		-	0.0	fire	6.7	3.3	6.7	-	0.0								



niche Environment and Heritage

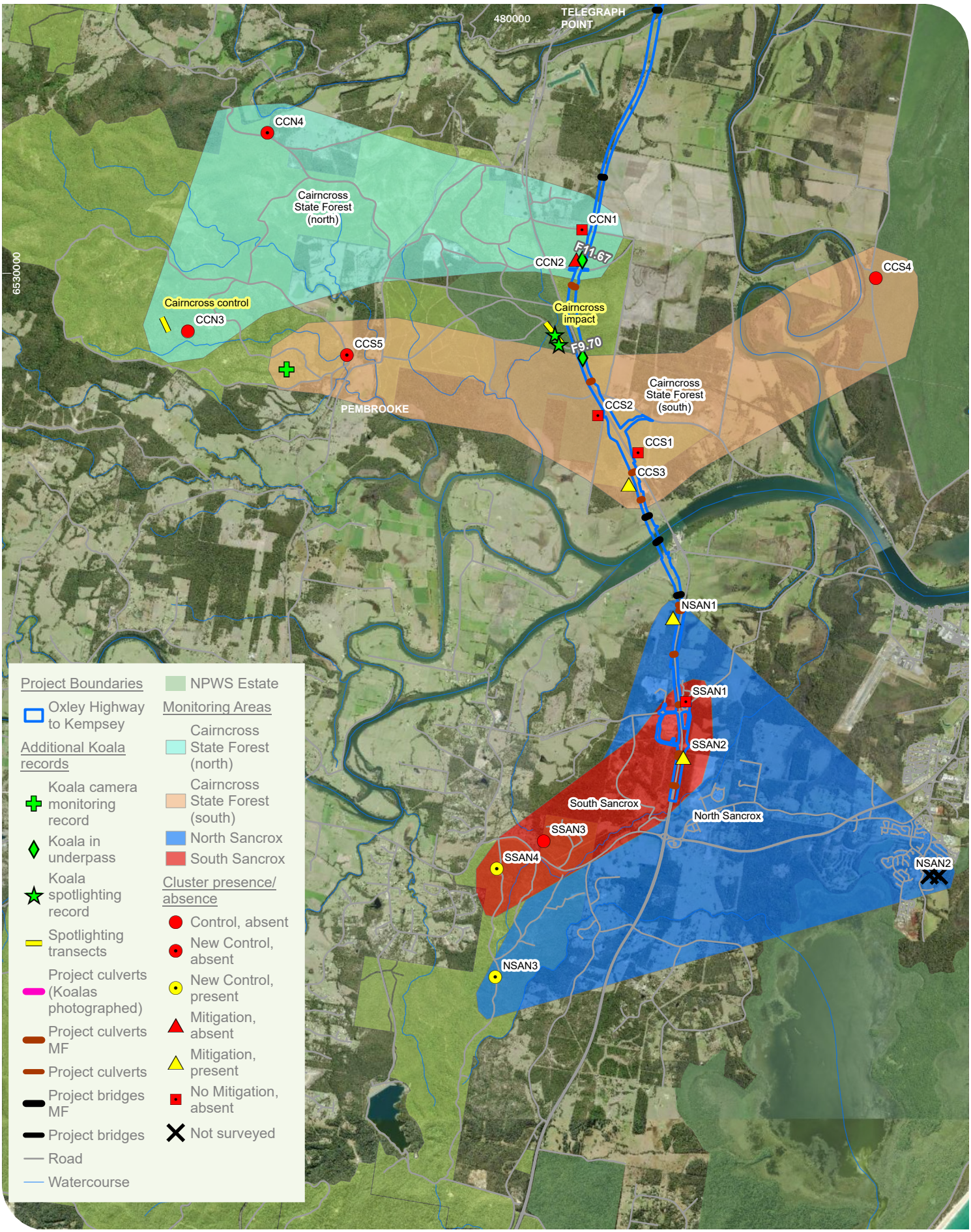
0 2
km
GDA 1994 MGA Zone 56

SAT cluster results and Koala records 2022 - North

Koala Monitoring: Pacific Highway Upgrade - Oxley Highway to Kempsey

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

Figure 2a



niche Environment and Heritage

N

0 2

km

GDA 1994 MGA Zone 56

SAT cluster results and Koala records 2022 - South

Koala Monitoring: Pacific Highway Upgrade - Oxley Highway to Kempsey

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

Figure 2b

3.1.2 Activity levels

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

Plot and cluster activity

The mean SAT activity level for all plots, measured as the percentage of trees at each plot with scats present, was 1.1% (standard deviation (SD) of 3.2) and ranged from 0 to 16.7%. This is similar to the mean activity recorded for plots during 2015, 2016, 2017 and 2020 surveys (2.0%, 0.7%, 1.8% and 1.9% respectively), but lower than the mean activity recorded during baseline surveys (4.9%), 2018 surveys (2.5%) and 2019 surveys (3.3%).

Considering the activity level within active plots only, i.e. plots where scats were found to be present, the average activity level was 6.7% (SD 5.1), which is higher than or similar to the mean activity recorded for active plots during 2016, 2017 and 2020 (4.0%, 6.8% and 6.5% respectively), but lower than the mean activity recorded for active plots during baseline surveys (10.1%) and 2015, 2018 and 2019 (8.0%, 8.0% and 7.2% respectively).

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

Table 4: Summary of SAT activity results

Average activity	Baseline	2015	2016	2017	2018	2019	2020	2022
Average activity per plot (n = plots surveyed)	4.9% (SD8.0, n = 72)	2.0% (SD4.6, n = 93)	0.7% (SD1.6, n = 82)	1.8% (SD4.1, n = 93)	2.5% (SD5.4, n = 93)	3.3% (SD4.7, n = 89)	1.9% (SD3.1, n = 89)	1.1% (SD3.2, n = 85)
Average activity per active plot (n = plots with activity)	10.1% (SD9.0, n = 35)	8.0% (SD6.3 n = 23)	4.0% (SD1.4, n = 14)	6.8% (SD5.3, n = 25)	8.0% (SD7.0, n = 29)	7.2% (SD5.8, n = 41)	6.5% (SD2.6, n = 26)	6.7% (SD5.1, n = 14)
Average activity per cluster (n = plots surveyed)	4.9% (SD6.9, n = 24)	2.0% (SD3.5, n = 31)	0.7% (SD1.1, n = 27)	1.8% (SD2.8, n = 31)	2.5% (SD4.5, n = 31)	3.3% (SD3.5, n = 31)	1.9% (SD3.1, n = 30)	1.2% (SD2.4, n = 30)
Average activity per active cluster (n = active clusters)	5.9% (SD7.1, n = 20)	4.4% (SD4.0, n = 14)	1.9% (SD1.1, n = 10)	3.5% (SD3.0, n = 16)	4.9% (SD5.5, n = 16)	4.5% (SD4.2, n = 23)	3.3% (SD4.0, n = 17)	3.5% (SD3.2, n = 10)
Average activity per area (n = 8)	4.8% (SD4.7)	2.1% (SD2.3)	0.9% (SD0.9)	1.9% (SD2.0)	2.6% (SD3.1)	3.4% (SD2.7)	2.1% (SD2.6)	1.3% (SD1.3)

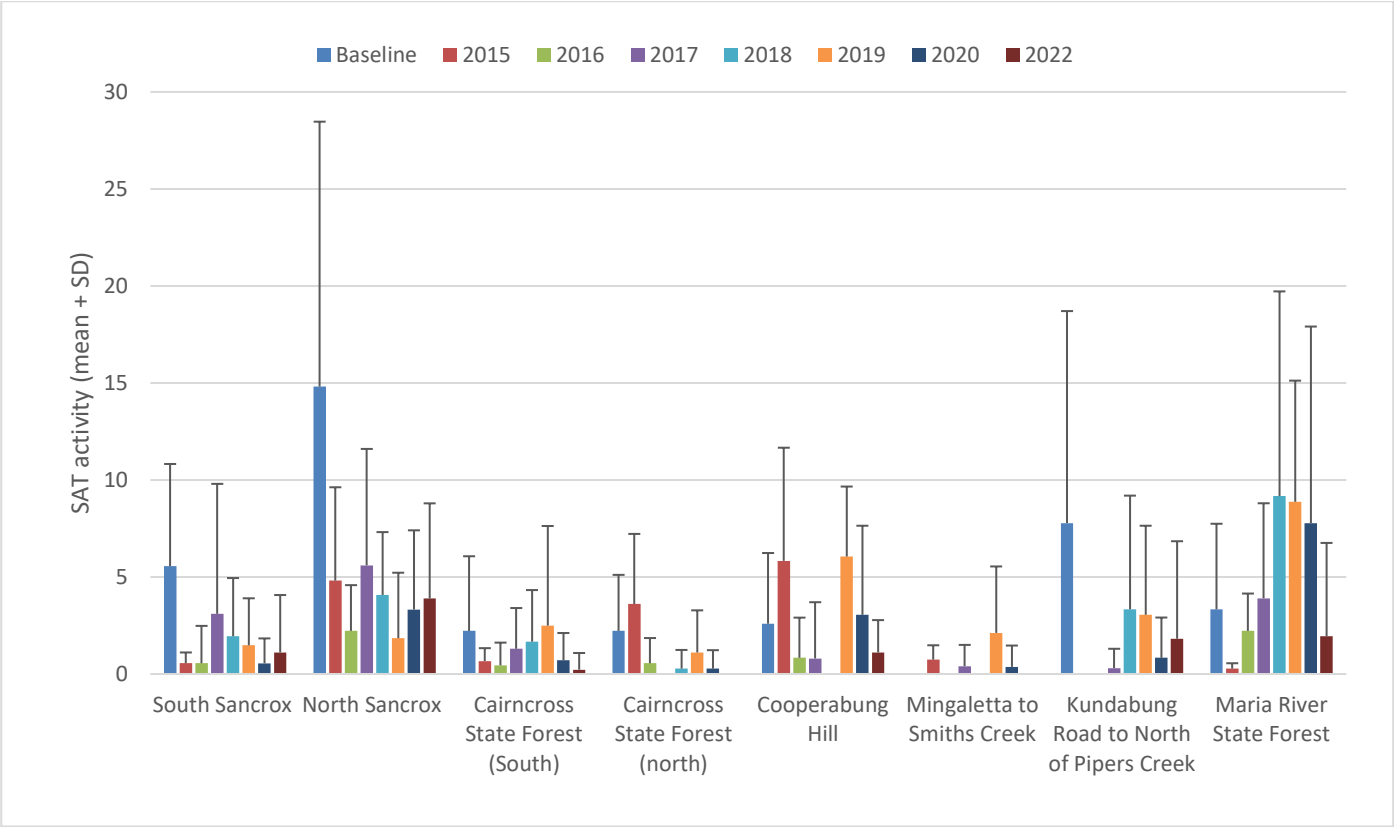
Area activity

Table 5 and Graph 3 show Koala activity at each of the eight monitoring areas. Area activity is the mean activity of all surveyed plots within the area. As for the 2018 and 2019 monitoring, SAT plot activity was highest at North Sancrox (3.9%), where scats were recorded at both of the two monitored clusters (two clusters were not monitored due to blocked access) and at three of the six SAT plots monitored.

To date, activity levels appear to fluctuate across the years within each monitoring area and a definitive increasing or decreasing activity trend within any one area is not apparent. Koala activity was recorded within six of the eight areas during the 2022 monitoring.

Table 5: Area activity levels

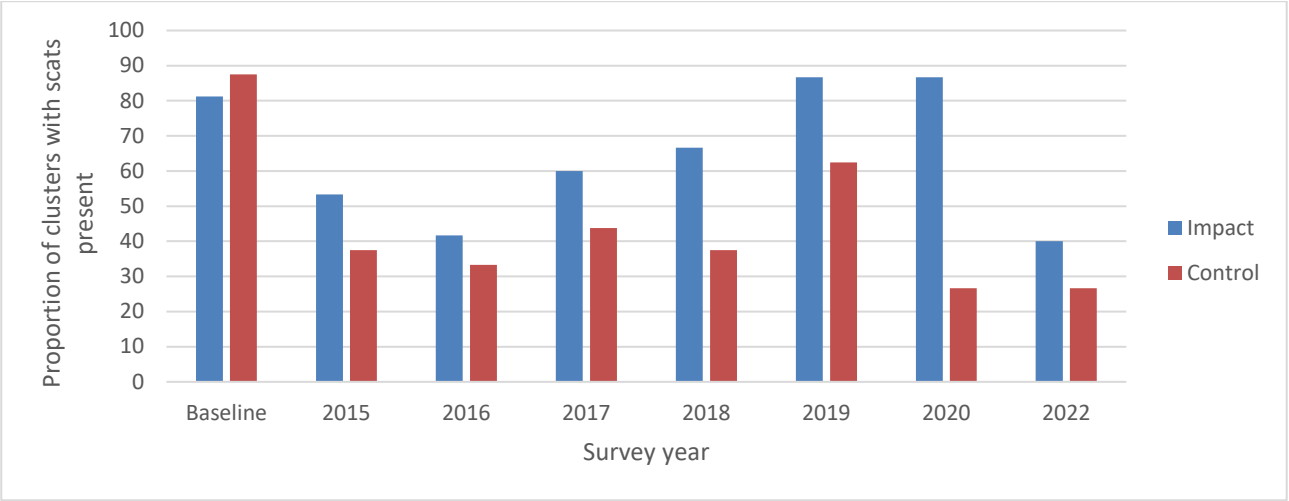
Monitoring area	Baseline	2015	2016	2017	2018	2019	2020	2022
South Sancrox	5.6% (SD5.3)	0.6% (SD1.3)	0.6% (SD1.9)	3.1% (SD6.7)	1.9% (SD3.0)	1.5% (SD2.4)	0.6% (SD1.3)	1.1% (SD3.0)
North Sancrox	14.8 (SD13.7)	4.8% (SD5.0)	2.2% (SD2.4)	5.6% (SD6.0)	4.1% (SD3.2)	1.8% (SD3.4)	3.3% (SD4.1)	3.9% (SD4.9)
Cairncross State Forest (South)	2.2% (SD3.8)	0.7% (SD1.9)	0.4% (SD1.2)	1.3% (SD2.1)	1.7% (SD2.7)	2.5% (SD5.1)	0.7% (SD1.4)	0.2% (SD0.9)
Cairncross State Forest (North)	2.2% (SD2.9)	3.6% (SD5.9)	0.6% (SD1.3)	0	0.3% (SD1.0)	1.1% (SD2.2)	0.3% (SD1.0)	0
Cooperabung Hill	2.6% (SD3.6)	5.8% (SD8.8)	0.8% (SD2.1)	0.8% (SD2.9)	0	6.1% (SD3.6)	3.1% (SD1.6)	1.1% (SD1.7)
Mingaletta to Smiths Creek	0	0.7% (SD2.2)	0	0.4% (SD1.1)	0	2.1% (3.4)	0.4% (SD1.1)	0
Kundabung Road to North of Pipers Creek	7.8% (SD10.9)	0	0	0.3% (SD1.0)	3.3% (SD5.9)	3.1% (SD4.6)	0.8% (SD2.1)	1.8% (SD5.0)
Maria River State Forest	3.3% (SD4.4)	0.3% (SD1.0)	2.2% (SD1.9)	3.9% (SD4.9)	9.2% (SD10.6)	8.9% (SD6.2)	7.8% (SD10.1)	1.9% (SD4.8)



Graph 3: Koala activity across the eight monitoring areas

3.2 Impact v Control Cluster Presence/Absence Analysis

A higher percentage of impact clusters had scats present than did control clusters during the 2022 monitoring period (40% *cf* 27%). This result is the same as that of the previous monitoring years (Graph 4). If we compare the Koala presence/absence results between control and impact clusters there **is no significant difference in Koala presence at impact and control clusters between the 2022 surveys and baseline, 2015, 2016, 2017, 2018, 2019 or 2020 surveys** ($X^2 = 0.112$, df = 1, $p > 0.05$; $X^2 = 0.854$, df = 1, $p > 0.003$; $X^2 = 0.656$, df = 1, $p > 0.05$; $X^2 = 0.795$, df = 1, $p > 0.05$; $X^2 = 0.588$, df = 1, $p > 0.05$; $X^2 = 0.814$, df = 1, $p > 0.05$; and $X^2 = 0.018$, df = 1, $p > 0.05$ respectively).

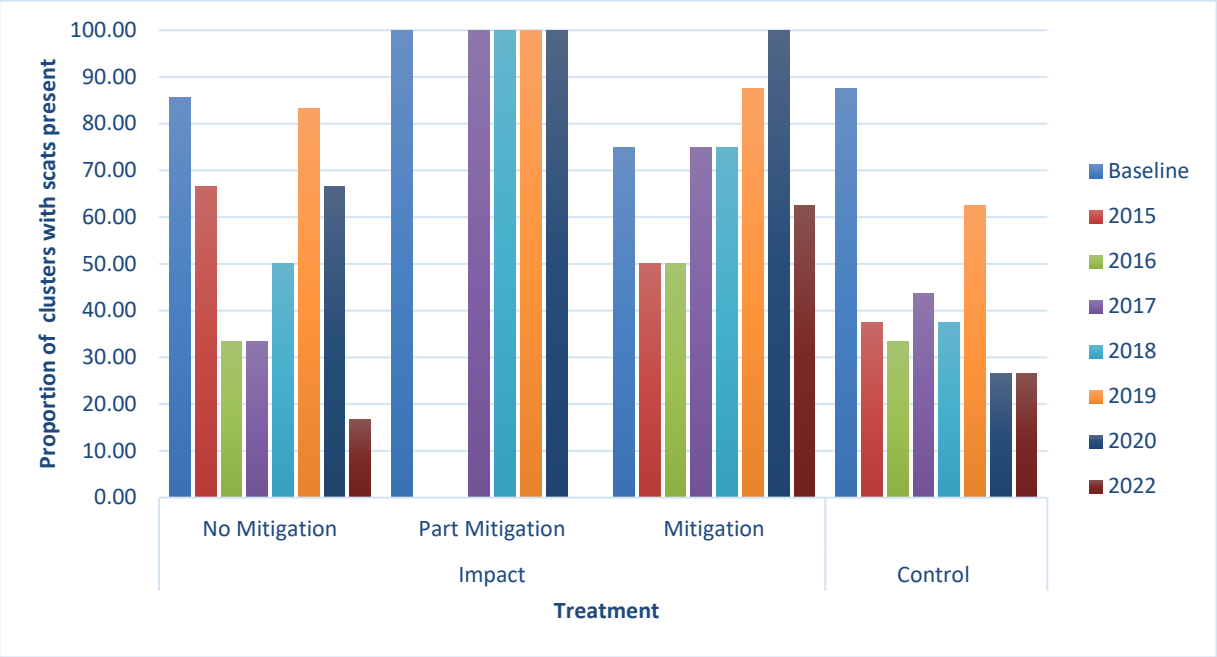


Graph 4: Koala presence at control and impact clusters

3.3 Mitigation v No Mitigation Analysis

3.3.1 Presence/absence analysis

Comparing Koala presence between mitigation and no-mitigation clusters shows **no significant difference between the 2022 surveys and baseline, 2015, 2016, 2017, 2018, 2019 or 2020 surveys** ($X^2 = 0.082$, df = 1, $p > 0.05$; $X^2 = 0.035$, df = 1, $p > 0.05$; $X^2 = 0.902$, df = 1, $p > 0.05$; $X^2 = 0.336$, df = 1, $p > 0.05$; $X^2 = 0.874$, df = 1, $p > 0.05$; $X^2 = 0.215$, df = 1, $p > 0.05$; and $X^2 = 0.858$, df = 1, $p > 0.05$, respectively). Graph 5 shows the percentage of clusters with scats present within different cluster types. There is no overall apparent trend between impact clusters with mitigation or without mitigation. While mitigation clusters appear to have a higher presence percentage in 2016, 2017, 2018, 2019, 2020 and 2022 than clusters with no mitigation, the presence percentage at clusters with no mitigation is similar to or greater than the presence percentage at control clusters during these years. This suggests that any difference is likely site specific and not necessarily related to construction activities.



Graph 5: Koala presence and cluster type

3.3.2 Treatment activity analysis

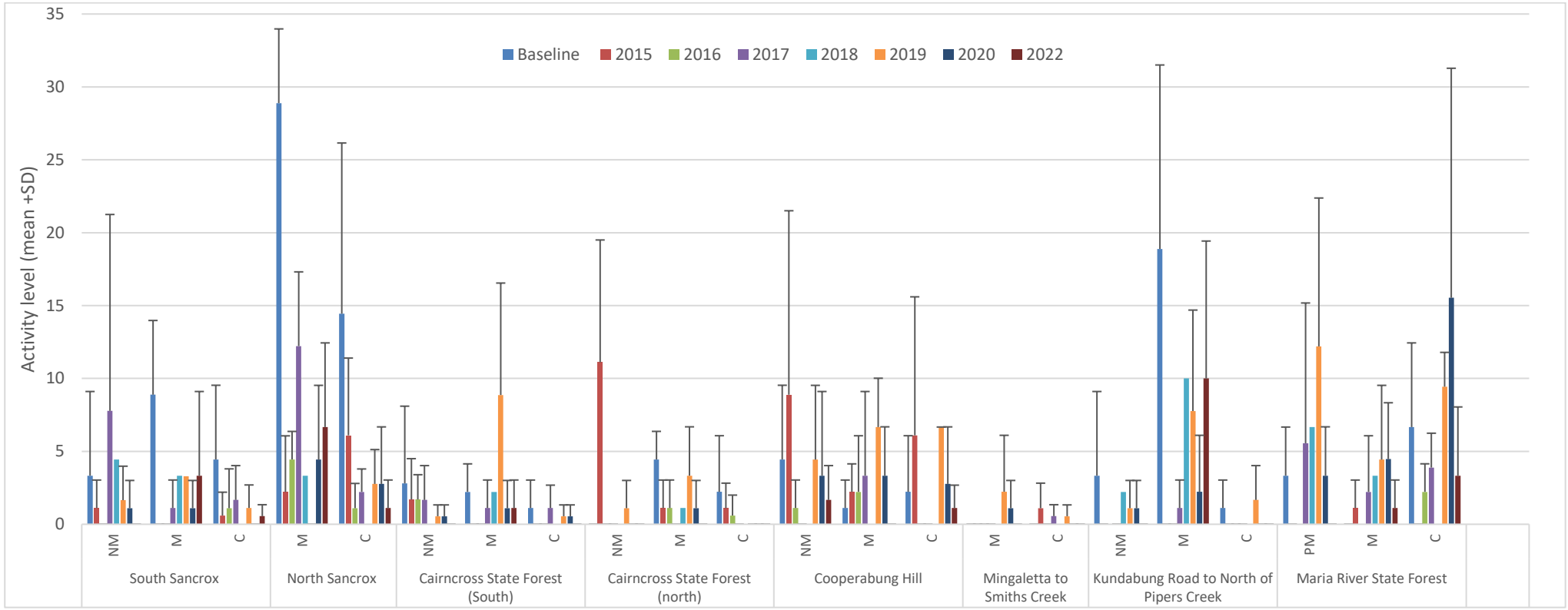
Koala activity (mean activity of plots) for the treatment types is provided in Table 6 and is shown for each area in Graph 6 (mean activity of all plots within each cluster type for each area). When considering all plots or active plots only (with scats present), average activity levels were lower than baseline levels for all treatment types. The 2022 monitoring plot activity levels were highest in clusters with mitigation and lowest in clusters with no mitigation. Lewis 2014 recommends that analyses should: "*Ensure any future comparison of Koala activity levels take into account the following baseline data and with a 10% tolerance level to account for variability:*

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

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

Table 6: Control, mitigation and no mitigation mean plot activity levels (%)

	Control								Mitigation								No Mitigation							
	Base	2015	2016	2017	2018	2019	2020	2022	Base	2015	2016	2017	2018	2019	2020	2022	Base	2015	2016	2017	2018	2019	2020	2022
All plots (n = plots surveyed)	4.0 (24) (SD6.4)	1.9 (38) (SD4.5)	0.5 (45) (SD1.4)	1.2 (48) (SD2.1)	2.5 (48) (SD6.4)	2.8 (47) (SD4.1)	1.9 (44) (SD5.7)	0.8 (43) (SD2.7)	8.1 (24) (SD11.0)	0.8 (24) (SD1.8)	1.2 (19) (SD2.3)	2.6 (24) (SD4.7)	2.9 (24) (SD4.5)	4.7 (22) (SD5.0)	2.4 (24) (SD3.0)	2.6 (22) (SD4.7)	2.6 (24) (SD4.2)	3.5 (21) (SD6.6)	0.6 (18) (SD1.3)	2.4 (21) (SD6.2)	2.1 (21) (SD3.7)	3.2 (20) (SD5.7)	1.4 (21) (SD2.7)	0.2 (20) (SD0.7)
Active plots (n = active plots)	8.8 (11) (SD6.9)	9.0 (10) (SD5.9)	3.9 (6) (SD1.4)	4.4 (13) (SD1.6)	9.2 (13) (SD9.5)	6.8 (19) (SD3.6)	9.2 (9) (SD9.8)	5.6 (6) (SD5.4)	12.9 (15) (SD11.5)	4.0 (5) (SD1.5)	4.7 (5) (SD1.8)	7.9 (8) (SD5.0)	7.0 (10) (SD4.6)	7.9 (13) (SD4.0)	5.1 (11) (SD2.3)	8.1 (7) (SD5.0)	7.0 (9) (SD3.9)	9.2 (8) (SD8.1)	3.3 (3) (SD0.0)	12.5 (4) (SD9.2)	7.2 (6) (SD3.3)	7.0 (9) (SD6.8)	5.0 (6) (SD2.0)	3.3 (1) (SD0)



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

NM = no mitigation; M = mitigation; C = control; PM = part mitigation.

3.4 Tree Species Use

A total of 2,550 trees were assessed across the 85 plots (30 at each plot). Koala scats were recorded at 28 (1.1%) of the trees surveyed. Surveyed trees included 28 different tree species (Table 7). The most commonly surveyed tree species were Tallowwood (*Eucalyptus microcorys*, 19.5%), Coastal Blackbutt (*E. pilularis*, 9.9%), Small-fruited Grey-Gum (*E. propinqua*, 8.9%), and Pink Bloodwood (*Corymbia intermedia*, 8.4%), together representing 51.0% of all trees surveyed. Koala scats were recorded at nine (32.1%) of the 28 different species (Table 7). Considering the percentage of individual tree species where scats were recorded, Koala scats were most commonly recorded beneath, Forest Red Gum (*E. tereticornis*, 25.0%, n = 4), Tallowwood (2.8%, n = 543) and White Stringybark (*E. globoidea*, 2.3% n = 132). Diameter at breast height for SCTs are provided in Annex 1.

The baseline study (Lewis 2014) suggests comparing activity levels at Tallowwood trees given that they are widespread, are frequently surveyed and yielded relatively high activity scores during baseline surveys (i.e. 9.5%). Use of Tallowwoods (percent of surveyed Tallowwoods with scats) was 2.68%, 0.75%, 4.7%, 5.3%, 6.6%, 4.8% and 2.8% in 2015, 2016, 2017, 2018, 2019, 2020, and 2022 respectively. As such, compared to the baseline surveys, activity at Tallowwood trees has been consistently lower. This reflects the overall lower activity levels observed since the baseline studies were undertaken.

It should be noted that interpretation of these data should be undertaken with caution, as it is unlikely to reflect the actual use of tree species by Koalas. The detectability of Koala scats is largely determined by the level of leaf litter and fallen bark around the base of trees. For example, species such as Sydney Blue Gums (*E. saligna*) and Flooded Gum (*E. grandis*) shed substantial amounts of bark in comparison to species such as Tallowwoods, resulting in dense, layered groundcover and leaf litter, amongst which scats are more difficult to find.

Table 7: Tree species surveyed – 2022 monitoring

Common name	Species name	Total surveyed	No. with scats	Percent use
Prickly-leaved Tea Tree	*Melaleuca styphelioides*	7		
Swamp Mahogany	*Eucalyptus robusta*	7		
Small-fruited Grey Gum	*Eucalyptus propinqua*	248	3	1.21
Coastal Blackbutt	*Eucalyptus pilularis*	276	1	0.36
Pink Bloodwood	*Corymbia intermedia*	234	1	0.43
Tallowwood	*Eucalyptus microcorys*	543	15	2.76
Forest Oak	*Allocasuarina torulosa*	20		
Grey Ironbark	*Eucalyptus siderophloia*	66		
Turpentine	*Syncarpia glomulifera*	205	1	0.49
White Stringy bark	*Eucalyptus globoidea*	132	3	2.27
White Mahogany	*Eucalyptus acmenoides*	49	1	2.04
Broad-leaved Paperbark	*Melaleuca quinquenervia*	9		
Thin-leaved Stringybark	*Eucalyptus eugenioides*	84		
Flooded Gum	*Eucalyptus grandis*	28		
Sydney Blue Gum	*Eucalyptus saligna*	63		
Forest Red Gum	*Eucalyptus tereticornis*	4	1	25.00
Thick-leaved Mahogany	*Eucalyptus carnea*	60		

Common name	Species name	Total surveyed	No. with scats	Percent use
Red Mahogany	*Eucalyptus resinifera*	75		
Red Bloodwood	*Corymbia gummifera*	167	2	1.20
Brush Box	*Lophostemon confertus*	38		
	Allocasuarina littoralis	10		
	Melaleuca linariifolia	24		
Scribbly Gum	*Eucalyptus haemostoma*	26		
Spotted Gum	*Corymbia maculata*	38		
Grey Ironbark	*Eucalyptus paniculata*	65		
	Melaleuca sp.	8		
Scribly Gum	*Eucalyptus signata*	44		
Swamp sheoak	*Casuarina glauca*	4		
Total		**2550**	**28**	

3.5 Weather Conditions

Weather conditions during the field surveys were generally warm to hot (maximum temperatures between 21.6 and 31.0 degrees) with a few light to heavy rainfall events (Port Macquarie weather station 060168, Table 8).

Table 8: Weather conditions - 2022 monitoring

Date	Rainfall (mm)	Temp (°C) (min)	Temp (°C) (max)	Wind speed at 9am (km/h)
9/12/2022	0	15.3	21.6	9
13/12/2022	7.2	10.4	24.6	15
15/12/2022	0	9.0	25.2	22
16/12/2022	0	12.8	21.8	19
6/1/2023	16.8	17.0	25.5	11
10/1/2023	0	13.6	27.4	20
11/1/2023	0	16.5	28.0	17
12/1/2023	0	18.1	26.8	2
13/2/2023	0	21.2	27.9	15
15/2/2023	0	16.7	26.4	9
20/2/2023	0	16.9	29.5	13
21/2/2023	0	19.1	28.8	6
22/2/2023	0	15.7	28.6	13
23/2/2023	58.6	17.8	25.5	20
27/2/2023	0	19.0	31.0	7
28/2/2023	3	17.1	29.0	9
2/3/2023	0	20.8	28.1	15

3.6 Road Kill

There were no Koala road kill records in 2022/2023. One Koala was identified as road kill in October 2020, within a partially fenced area of the highway on the northbound left lane near Barry's Creek. TfNSW inspected the area of the Koala road strike within days to review the fencing integrity. Minor tree limbs were removed from fauna fencing in the general area, but it was considered unlikely that these provided a potential access point. No holes or issues with the fencing were identified during the inspection. The individual likely entered the motorway from the unfenced intersection at Mingaletta Road or fallen tree limbs on the fauna fence near the U-turn bay at Barry's Creek, crossed from the southbound lane to the northbound land where it was hit.

Lewis 2014 notes that "*During the current baseline survey only one individual was recorded during the weekly surveys performed in October and January/February. Ad hoc monitoring which spanned a 7 month period revealed additional road killed individuals but was consistent with Koala being struck every 6-8 weeks during the breeding period*". As per recommendations with the baseline report, the baseline road kill has therefore been set to 1 individual every 8 weeks. Table 9 lists the Koala road kill for the Project recorded during road kill surveys for the Project and any additional records. There rate has not exceeded baseline rate however, in accordance with the performance measures, when considering a proportional reduction in Koala activity of 62% (from 5% to 1.9%) the adjusted road kill rate to reflect the reduced activity would be 1 Koala every 21 weeks. The 2022 Koala road kill rate has not exceeded the adjusted rate.

Table 9: Koala road kill records

Monitoring	Period	Date	Easting	Northing	Notes	Survey wks
Baseline*	2013-2014	4/10/2013	482178	6540579	Where the Project passes through Ballengarra State Forest	12
Clearing	2014-2015	17/11/2014	483187	6544354	Adult female struck on Tuesday/Wednesday (11/12th Nov)	35
		17/11/2014	483187	6544354	Young struck on Tuesday/Wednesday (11/12th Nov)	
		3/12/2014			300 m North of Yarrabee Rd	
		21/7/2015			200 m North of Yarrabee Rd	
Construction	2015-2016	22/12/2015			1 km north of Ravenswood Rd	50
Construction	2016-2017	5/10/2016	483413	6555959	Adolescent	49
		12/10/2016	482816	6553852	Adolescent	
Construction	2017-2018	Nil				14
Operational	2018-2019	17/9/2018			Young male. Barry's Creek	12
Operational	2019-2020	Nil				12
Operational	2020-2021	Oct 2020			Barry's Creek	12

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

3.7 Additional Survey Results

3.7.1 Spotlighting

Spotlighting surveys commenced in October 2019 and were again completed in November 2020 and November 2022 for the current monitoring period. Table 10 summarises the survey results to date. To date, only one Koala has been observed at the Cairncross impact and the Maria River control site (Figure 2) during the 2019 and 2020 monitoring, respectively.

As per the EMP, a detection frequency rate of 1 Koala/spotlight hour is considered as the baseline target density. To date baseline density has been recorded only at the Cairncross impact and Maria River control sites. Scats have also been recorded in these areas during SAT plot monitoring.

Koala presence at the Ballengarra and Maria River impact sites has been previously demonstrated via SAT plot monitoring at the nearest SAT plot clusters to these spotlighting transects. The absence of Koala observations during spotlighting surveys at the Ballengarra and Cairncross control sites is consistent with the predominantly absent records during SAT plot monitoring at the nearest clusters to these transects.

Table 10: 2022 spotlighting surveys results

Site	Survey#	# Koala 2019	# Koala 2020	# Koala 2022	Note
Ballengarra SF impact	1	0	0	0	
Ballengarra SF control	1	0	0	0	
Cairncross SF impact	1	0	0	0	
Cairncross SF control	1	0	0	0	
Maria River SF impact	1	0	0	0	
Maria River SF control	1	0	0	0	
Ballengarra SF impact	2	Not surveyed- fire	0	0	
Ballengarra SF control	2	Not surveyed- fire	0	0	
Cairncross SF impact	**2**	**1**	**0**	**0**	**Observed**
Cairncross SF control	2	0	0	0	
Maria River SF impact	2	Not surveyed- fire	0	0	
Maria River SF control	2	Not surveyed- fire	0	0	
Ballengarra SF impact	3	Not surveyed- fire	0	0	
Ballengarra SF control	3	Not surveyed- fire	0	0	
Cairncross SF impact	3	0	0	0	
Cairncross SF control	3	0	0	0	
Maria River SF impact	3	Not surveyed- fire	0	0	
Maria River SF control	**3**	Not surveyed- fire	**1**	**0**	**Observed**

3.7.2 Additional Koala records

Additional records of Koala presence have been obtained during surveys undertaken for other monitoring components of the Project. These records are summarised below and in Table 11. All occur in areas where Koalas were detected during SAT surveys.

Fauna underpass monitoring

There are a number of culverts and bridges along the length of the Project that may provide passage for Koalas (Figure 2). Fourteen of these are being monitored as part of the Fauna Underpass Monitoring component of the Project. Koalas have been photographed on remote cameras using four of the fauna underpasses to date and these are shown on Figure 2 (Niche 2019b, Niche 2021b).

Yellow-bellied Glider monitoring

A Koala was observed during spotlighting surveys undertaken as part of the Yellow-bellied Glider monitoring component of the Project within the Cairncross State Forest impact site (Figure 2) (Niche 2019c).

Spotted-tailed Quoll monitoring

Koalas have been photographed on remote cameras as part of the Spotted-tailed Quoll monitoring component of the Project within Cairncross State Forest, Ballengarra State Forest, and Maria River (Figure 2) (Niche 2018b and Niche 2020b).

Table 11: Additional Koala records

Monitoring type	Monitoring-specific site name	Date
Underpass	F9.70	16/12/2018
Underpass	F11.67	24/11/2018
Underpass	F33.40	23/11/2018
Yellow-bellied Glider	Cairncross SF impact	27/11/2018
Spotted-tailed Quoll	MM1B	Winter 2018
Spotted-tailed Quoll	MNM1D	Winter 2018
Spotted-tailed Quoll	MREF2D	Winter 2018
Spotted-tailed Quoll	BNM2B	Winter 2018
Spotted-tailed Quoll	BM1C	Winter 2018
Spotted-tailed Quoll	BM1A	Winter 2020
Spotted-tailed Quoll	CREF1B	Winter 2020
Spotted-tailed Quoll	MREF1A	Winter 2020
Underpass	C32.35	29/11/2020

3.8 NSW BioNet Wildlife Atlas

3.8.3 Distribution analysis

A total of 1611 Koala records within a 10 km buffer of the study area were reported as part of the baseline monitoring in 2014. The majority of these records (i.e. 1249 or 77%) were recorded between 2004-2014. In the current study, a total of 4808 Koala records occurred within 10 km buffer of the study area between

2004-2014 (inclusive), and 9087 Koala records occurred within 10 km buffer of the study area between 2014-2022 (inclusive). Records are shown in Figure 3.

Koala records from both periods are broadly distributed throughout the study area with a distinct clustering of records in the south-eastern precinct, which includes Port Macquarie, Lake Innes and Thrumster areas (Figure 3). A cluster of records between 2014-2022 is also evident to the west of Kundabung within Ballengarra State Forest (E1 and F1-F3). Records are consistently distributed throughout the Project corridor, concentrated in vegetated land parcels that the Project corridor bisects. A notable increase in post-construction records can be noted in the western portion of the study area around Cooperbung Hill and Mingaletta to Smiths Creek (grids E1, F1, F2 and F3).

There has not been a notable alteration in Koala record distribution pre and post construction.

3.8.4 Density analysis

As per the baseline analysis, a grid-based analysis of record density was used to assess density. Koala density for the pre-construction and post-construction periods are presented in Table 12 and Graph 7.

Koala record density has increased post-construction in 62% (36/58) of grids, with 33% (19/58) of grids decreasing in density (and 5% (3/58) showing no change in density (Graph 8)). Those grids with a decrease in record density consist of four of the 11 grids (36%) traversed by the Project, six of the 24 grids (25%) adjacent to the Project and nine of the 23 grids (39%) further from the Project.

Grids traversed by the Project corridor have the lowest Koala density, and grids adjacent to the Project corridor have the highest Koala density in both the pre-construction and post-construction periods (Graph 9). Average record density has increased for each group of grids post construction.

When considering mitigation treatments within grids that are intersected by the Project corridor, grids that feature a mix of mitigation and no mitigation sites had the highest pre-construction density and grids that feature either only mitigation or no mitigation sites had a similar density (Graph 10). Conversely, post-construction density was highest in grids that feature only mitigation sites and lowest in grids that contained no mitigation sites. All grids that feature mitigation sites increased in density post-construction, whereas 40% of grids that feature a mix of mitigation and no mitigation sites decreased in density post-construction and 50% of grids that feature no mitigation sites decreased in density post-construction (Graph 11).

The highest density of Koala records (pre and post-construction) occurs in the south-eastern portion of the study area in the vicinity of Port Macquarie (Figure 3).

Pre-construction records were highest in grid J4 (1034), followed by grid J5 (994) and grid K5 (846). The density within these grids has increased post-construction with the highest density and second greatest post construction increase in grid J5 (+449 to 1443), the second highest density and greatest post construction increase in grid K5 (+469 to 1315) and the third highest density and 6th greatest post construction increase in grid J4 (+254 to 1288). These results support the conclusions of the baseline report that these grids are likely to support high densities of Koala.

The neighbouring grids of K3 and K4 in the Lake Innes and Thrumster area recorded 158 and 378 pre-construction records respectively. Grid K3 features both mitigation and no mitigation sites for North and South Sancrox, while grid K4 features control sites for North Sancrox. While the number of records within grid K4 more than doubled post-construction (775), the greatest post-construction decrease in Koala density was observed in grid K3 (-59 from 158 to 99) which forms the southern extent of the Project

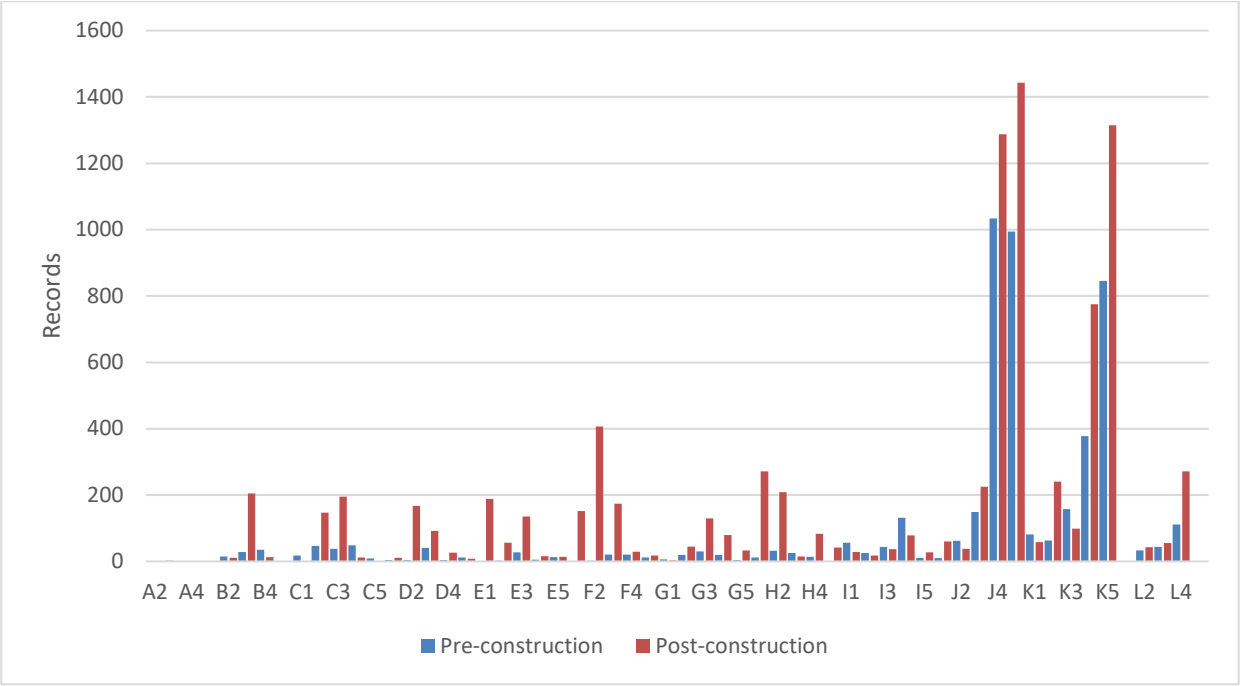
corridor. These results support the conclusions of the baseline report that these areas are likely to support medium to high densities of Koala.

Grid J3, which includes the Project corridor between Cairncross State Forest (south) and North Sancrox and features both mitigation and no mitigation sites recorded the 6th highest pre-construction density with 149, and 9th highest post-construction density with 225. Grid I1 which features control sites for Cairncross State Forest (north) returned 132 pre-construction Koala records and saw the second greatest post-construction decrease in Koala density (-54 from 132 to 78). These results support the conclusions of the baseline report that these areas are likely to support medium densities of Koala.

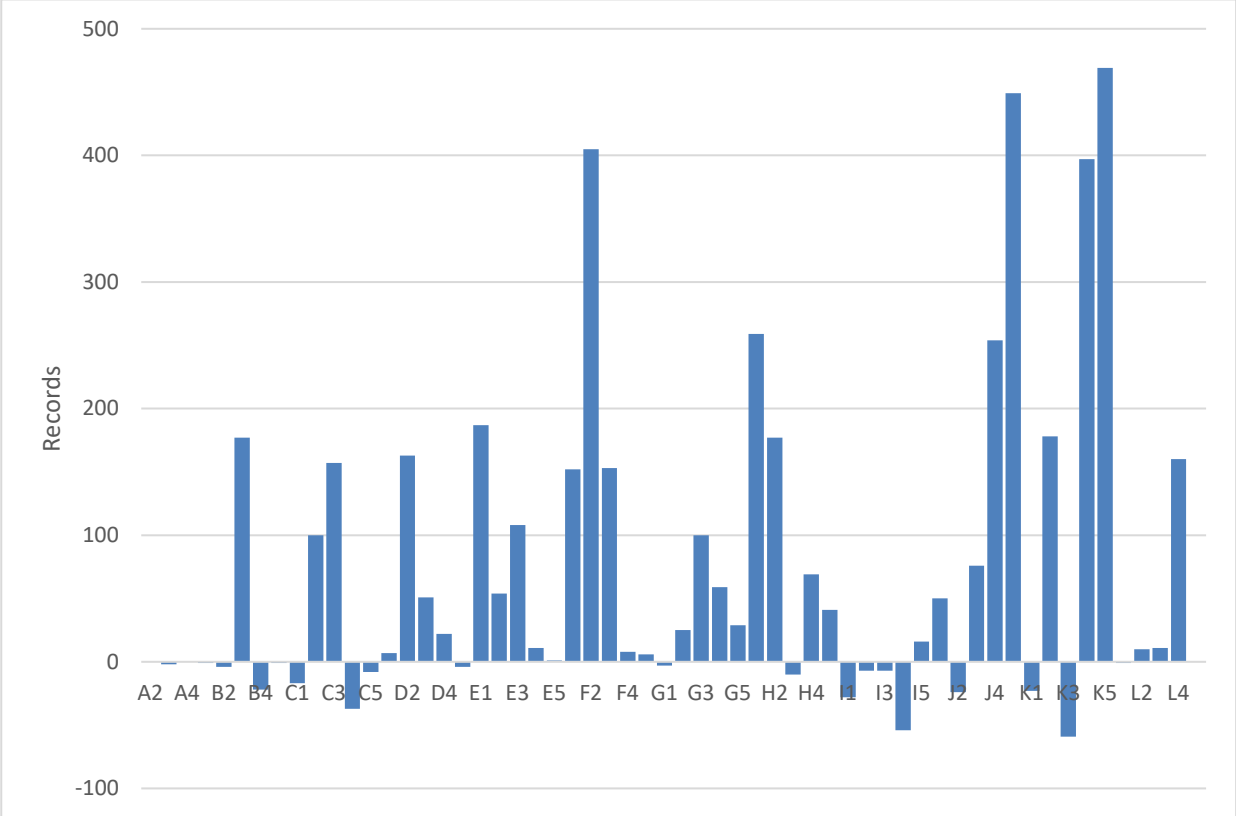
The majority of grids returned >10 records. 64% (37/58) of grids have >10 records both pre and post-construction, with 67% (39/58) of grids returning >10 pre-construction records, and 81% of grids returning >10 post-construction records.

Table 12: Koala density pre-construction and post-construction

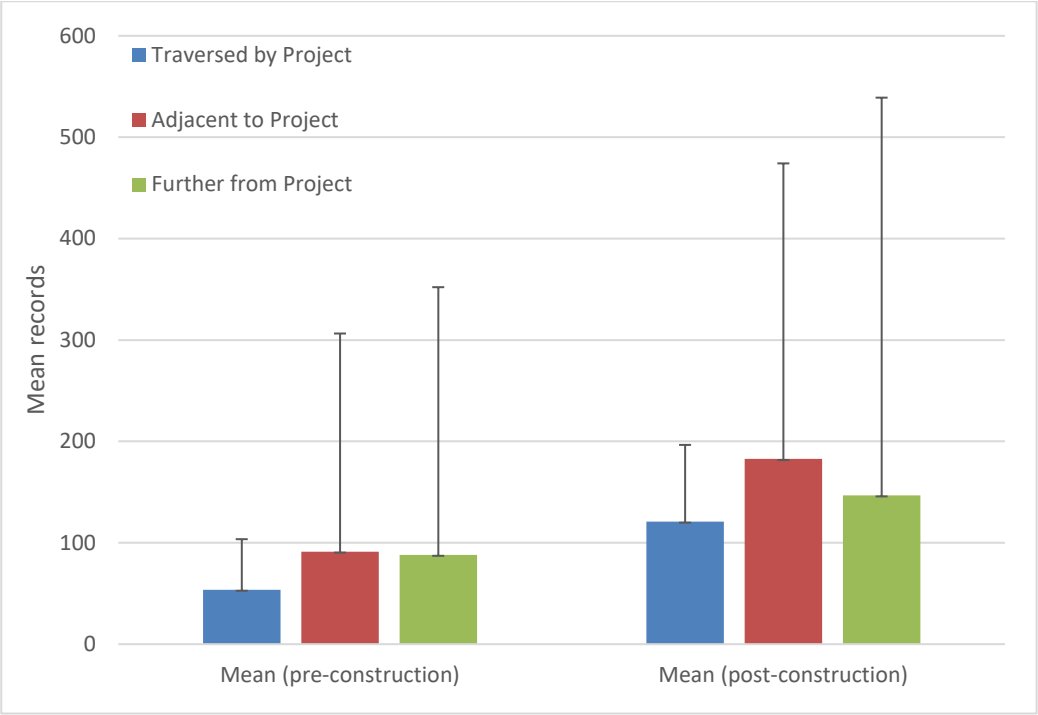
Grids traversed by Project (n = 11)		Grids adjacent to Project (n = 24)		Grids further from Project (n = 23)	
Grid	**Pre-construction/post-construction (difference)**	**Grid**	**Pre-construction/post-construction (difference)**	**Grid**	**Pre-construction/post-construction (difference)**
C3*	38/195 (+157)	B2	15/11 (-4)	A2	0/0 (no change)
D3^	41/92 (+51)	B3	28/205 (+177)	A3	2/0 (-2)
E3	27/135 (+108)	B4	35/13 (-22)	A4	0/0 (no change)
F3*	21/174 (+153)	C2	47/147 (+100)	B1	1/0 (-1)
G3^	30/130 (+100)	C4	49/12 (-37)	B5	1/0 (-1)
H2	32/209 (+177)	D2	4/167 (+163)	C1	18/1 (-17)
H3	25/15 (-10)	D4	4/26 (+22)	C5	9/1 (-8)
I2	25/18 (-7)	E2	2/56 (+54)	D1	4/11 (+7)
I3^	44/37 (-7)	E4	5/16 (+11)	D5	12/8 (-4)
J3^	149/225 (+76)	F2	2/407 (+405)	E1	1/188 (+187)
K3^	158/99 (-59)	F4	21/29 (+8)	E5	13/14 (+1)
		G2	20/45 (+25)	F1	0/152 (+152)
		G4	20/79 (+59)	F5	12/18 (+6)
		H1	12/271 (+259)	G1	6/3 (-3)
		H4	14/83 (+69)	G5	4/33 (+29)
		I1	56/28 (-28)	H5	1/42 (+41)
		I4	132/78 (-54)	I5	11/27 (+16)
		J2	62/38 (-24)	J1	10/60 (+50)
		J4	1034/1288 (+254)	J5	994/1443 (+449)
		K2	63/241 (+178)	K1	81/58 (-23)
		K4	378/775 (+397)	K5	846/1315 (+469)
		L2	33/43 (+10)	L1	1/0 (-1)
		L3	44/55 (+11)	L5	0/0 (no change)
		L4	111/271 (+160)		



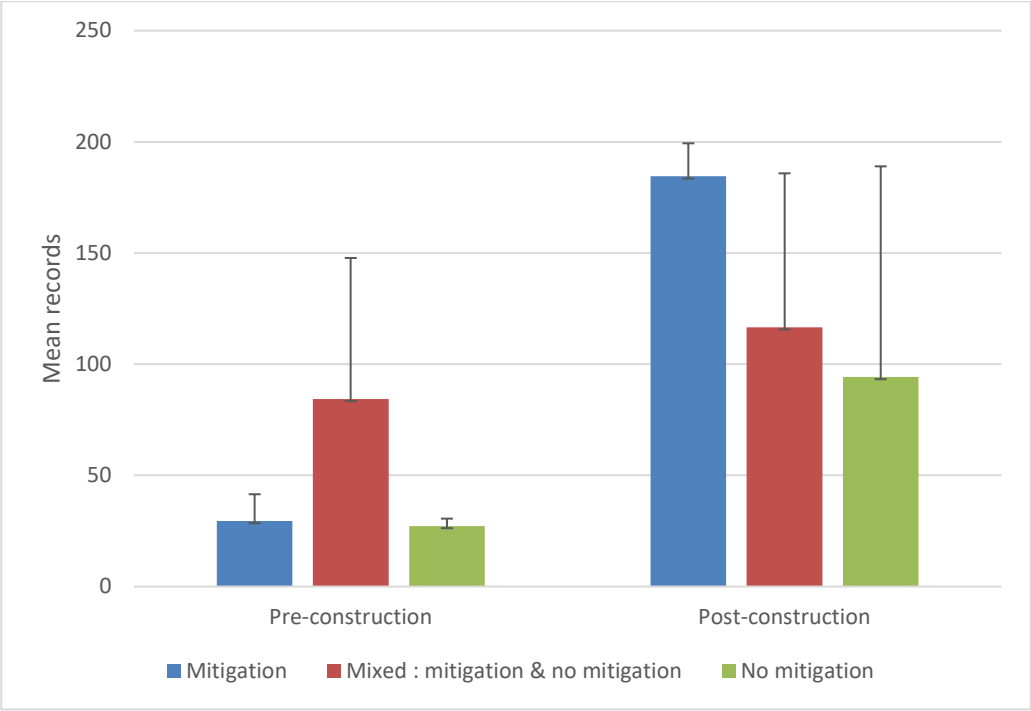
Graph 7: Koala density pre-construction and post-construction



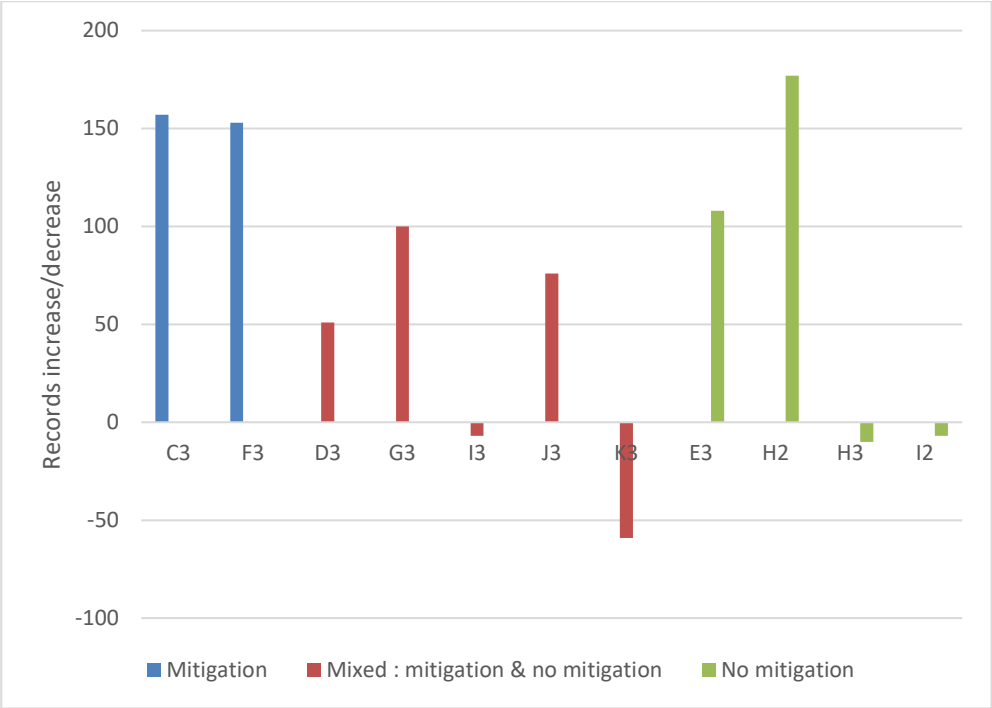
Graph 8: Koala record density increase/decrease post-construction



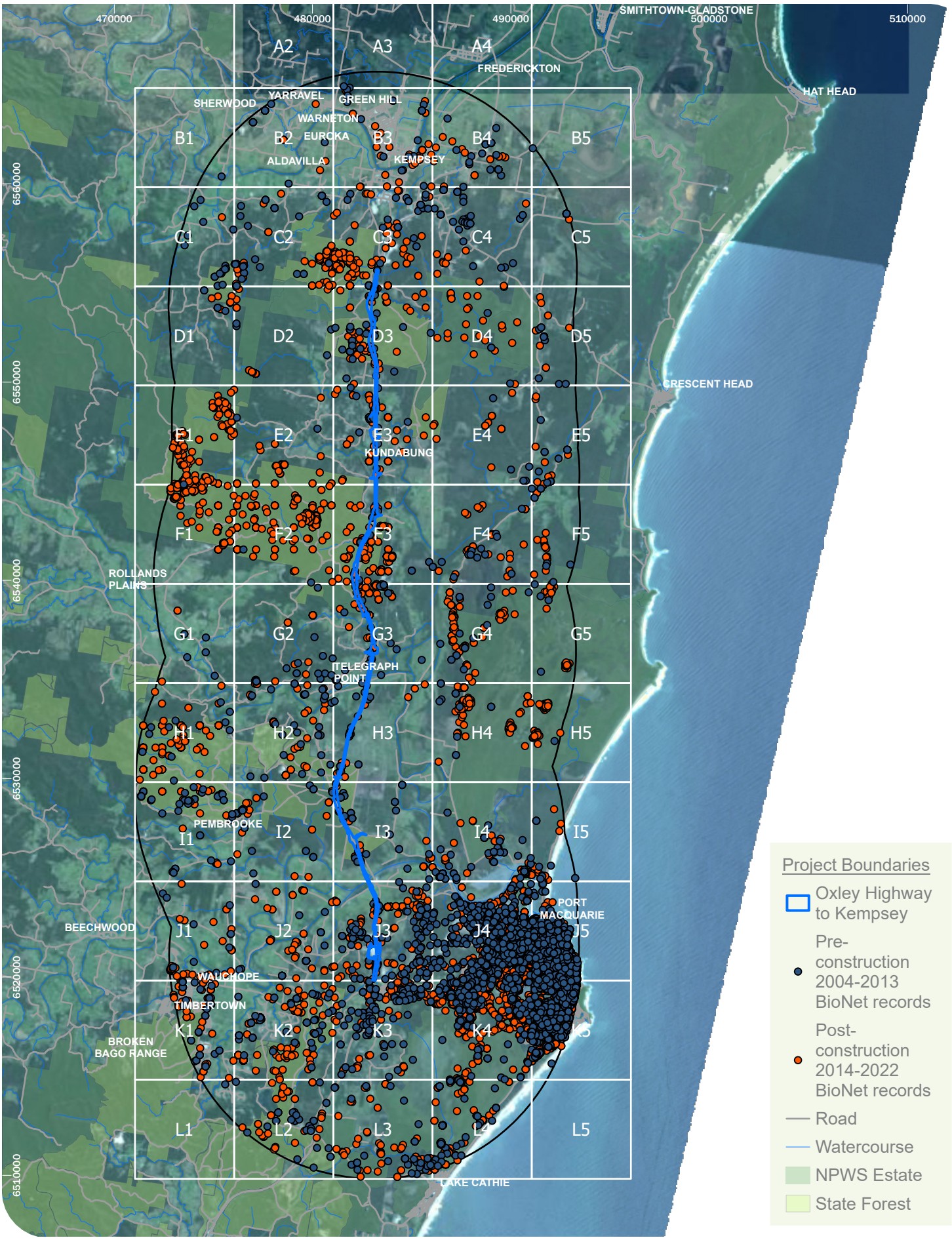
Graph 9: Koala density at different distances from the Project



Graph 10: Koala density pre-construction and post-construction in grids traversed by the Project



Graph 11: Increase/decrease in Koala density post-construction in grids traversed by the Project



Project Boundaries

- Oxley Highway to Kempsey
- Pre-construction 2004-2013 BioNet records
- Post-construction 2014-2022 BioNet records
- Road
- Watercourse
- NPWS Estate
- State Forest

Drawn by: File: T:\spatial\projects\a1700\a1702_OH2K_EcologyMaps\PI_5_Ecology_OH2KPI_51_Koala_SAT\2022\a1702_PI51_Koala_SAT.aprx Last updated: 8/25/2023 5:09 PM

niche Environment and Heritage

0 6
km
GDA 1994 MGA Zone 56

BioNet Koala records distibution and density

Koala Monitoring: Pacific Highway Upgrade - Oxley Highway to Kempsey

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

Figure 3

v2.0

4. Discussion

4.1 Performance Measures

A discussion of the 2022 survey results in relation to the performance measures is provided in Table 13.

Table 13: Performance measures

Performance measure	Response
Monitoring is undertaken during baseline surveys and from Year 1 – Year 6 & 8, or until mitigation measures are demonstrated to be effective.	**This performance measure has been met**. To date, SAT plot monitoring has been undertaken during baseline, Year 1 (2015), Year 2 (2016), Year 3 (2017), Year 4 (2018), Year 5 (2019), Year 6 (2020) and Year 8 (2022) of the Project.
Monitoring during Year 1 – Year 6 & 8 is undertaken at the Impact and Control sites where monitoring was undertaken during baseline surveys, subject to ongoing landowner agreement. Where landowner agreement cannot be obtained and the process in Section 3.1.2 of the EMP has been followed, this performance indicator will also be considered to have been met.	**This performance measure has been met**. Monitoring was undertaken at the same sites as surveyed in baseline surveys where access was possible. In 2015, eight of the baseline plots had to be relocated to nearby locations because they had been established in the construction site itself or because they were located on private property and access was not possible. Also, three of the baseline monitoring plots that could not be accessed could not be relocated because there weren't any suitable sites nearby. These three plots were all part of the same cluster (impact, no mitigation) located in the North Sancrox area. Details of all 96 monitoring plots are presented in Table 1 and the location of the 93 accessible monitoring plots are shown in Figure 1.
Mitigation measures are demonstrated to be effective as defined in the EPBC approval when all monitoring events are considered at Year 8.	**This performance measure has been met**. A summary of the efficacy of the mitigation measures to date in relation to treatment Type A: impact with mitigation (sufficiently large culverts and floppy top fencing), indicates: • Four of the 14 monitored culverts have recorded use by the Koala (Figure 2) • Since commencement of construction, nine Koalas have been recorded as road kill, four during clearing (2014-2015), three during construction (2015-2018) and two during operation (2018-current). The last construction Koala road kill occurred in October 2016, year 2 of the Project (Niche 2018c). The Project became operational in year 4, March 2018 and in September 2018 and October 2020 two separate Koala road kill events have occurred at Barry's Creek, between clusters MING1 and COOP2, with no recent records. In addition, areas of the Project where mitigation was implemented have all increased in Koala record density post construction.
Fauna fence is installed at a minimum in areas identified in Schedule 3 of the EPBC approval at Year 4.	**This performance measure has been met.** TfNSW have advised that fauna fencing is complete in all areas in accordance with Condition 3c and Schedule 3 of EPBC Approval 2012/6518.
Density: Koala spotlighting records are compared to and discussed with reference to the baseline records, with the baseline detection frequency rate of 1 Koala per spotlight hour considered as the baseline density, as recommended in the baseline report. Compare the NSW BioNet wildlife Atlas density ranking of 5 km^2 grids, as per the baseline report, between pre and post-construction at Year 8.	*Spotlighting* **This performance measure has been met at two sites to date: the Cairncross State Forest impact site and Maria River State Forest control site**. While Koalas have not been detected during spotlighting surveys at the Maria River and Ballengarra impact sites, their presence has been previously demonstrated via SAT plot monitoring at the nearest SAT plot clusters to these spotlighting transects. *BioNet Atlas analysis* **This performance measure has been met.** Grids traversed by the Project corridor have the lowest Koala density, and grids adjacent to the Project corridor have the highest Koala density in both the pre-construction and post-construction periods. Average record density has increased for each group of grids post construction.

Performance measure	Response
Movement: Reduction in Koala road kill compared to the baseline of 1 Koala road kill per 8 weeks for an average baseline plot activity level of 5%, whereby proportional changes in average plot activity level may be reflected in the acceptable level of koala road kill.	**This performance measure has been met in 2022.** There were no Koala road kill records during 2022/2023 monitoring.
Distribution: Compare the number of records and clustering of records, as per the baseline report, between pre-construction and construction/post-construction at year 8.	**This performance measure has been met.** The average density of records has increased in all areas and there has not been a notable alteration in Koala record distribution pre and post-construction.
Habitat Use: Koala SAT activity levels will be compared to the baseline activity levels data (below) with a 10% tolerance level, as recommended in the baseline report, to account for variability: • Broader study area set at 5% activity; • The treatment classes of mitigation set at 8.05%, no mitigation set at 2.64% and control / reference set at 4.03% • Comparison of percent tree use with baseline tree use.	**This performance measure has been met.** When considering all plots or active plots only, activity levels for each treatment type have not decreased from the baseline surveys beyond the recommended 10% tolerance level (4.9% to 1.1% and 10.1% to 6.7%). Nor is there a greater than 10% difference between treatment type (8.05% to 2.6%; 2.64% to 0.2% and 4.0% to 0.8%, for all plots). Use of Tallowwoods (percent of surveyed Tallowwoods with scats) was 2.68%, 0.75%, 4.7%, 5.3%, 6.6%, 4.8% and 2.8% in 2015, 2016, 2017, 2018, 2019, 2020, and 2022 respectively. As such, compared to the baseline surveys (9.5%), per cent use of Tallowwood trees has been consistently lower. This reflects the overall lower activity levels observed since the baseline studies were undertaken.

All performance measures have been met.

5. Recommendations

5.1 Contingency Measures and Recommendations

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those that are considered to be relevant to the Koala monitoring program are listed and discussed in Table 14. No additional mitigation actions are considered necessary based on the following:

- No significant changes from baseline surveys have been detected to date
- No significant change in the difference in activity between impact and control sites to date
- Koalas have been detected using four of the dedicated fauna underpasses within the Project area
- Average Koala record density has increased.

Table 14: 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.	• Investigate cause of decline in consultation with EPA and DoTE within two weeks of results reported by ecologist. • If the cause of the decline is considered most likely attributable to the upgrade of the highway, mitigation measures will be reviewed within two months of the above consultation.	**This contingency measure is not considered relevant.** No significant change has been detected in the difference in Koala presence at control and impact sites between baseline and subsequent monitoring events.
Increase in road kill rate from baseline rates when considering 62% proportional decrease in Koala activity level	• Commence review/modification of fauna exclusion fencing design, location or extent depending on species struck by vehicles within two weeks of results reported by ecologist. • Inspect fence for breaches and inform maintenance as necessary within two weeks of results reported by ecologist. • Any damage to fauna fencing will be temporarily repaired within one week of a breach being identified. • Permanent repair to occur as soon as possible and within two months of the breach being identified.	**This contingency measure is not considered relevant.** There were no Koala road kill records during 2022/2023 monitoring.

References

BioLink (2013). Port Macquarie-Hastings Koala Habitat and Population Assessment. Final report prepared by BioLink Ecological Consultants for Port Macquarie-Hasting Council.

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

Niche (2016). Koala Monitoring. Year 1 surveys - Oxley Highway to Kempsey Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

Niche (2017). Koala Monitoring 2016. Year 2 surveys - Oxley Highway to Kempsey Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

Niche (2018a). Koala Monitoring 2017. Year 3 surveys - Oxley Highway to Kempsey Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

Niche (2018b). Spotted-tailed Quoll monitoring 2018 - Oxley Highway to Kempsey Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

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

Niche (2019a). Koala Monitoring 2018. Year 4 surveys - Oxley Highway to Kempsey Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

Niche (2019b). Fauna underpass monitoring 2018/2019 - Oxley Highway to Kempsey Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

Niche (2019c). Yellow-bellied Glider monitoring 2018 - Oxley Highway to Kempsey Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

Niche (2020a). Koala Monitoring 2019. Year 5 surveys - Oxley Highway to Kempsey Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

Niche (2020b). Spotted-tailed Quoll monitoring 2020 - Oxley Highway to Kempsey Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

Niche (2021a). Koala Monitoring 2020. Year 6 surveys - Oxley Highway to Kempsey Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Transport for NSW, Port Macquarie, NSW.

Niche (2021b). Fauna underpass monitoring 2020/2021 - Oxley Highway to Kempsey Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

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.

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

TfNSW (2022). Oxley Highway to Kempsey Pacific Highway Upgrade Ecological Monitoring Program. Transport for NSW Update to report prepared by SMEC Hyder Joint Venture, February 2022.

Annex 1. Koala SAT results – 2022 monitoring

SCT = selection criteria tree; DBH = diameter at breast height in centimetres (cm); Radial = radial distance of search area from SCT in metres (m).

Monitoring Area	Treatment	Sub-category	Site_ID	Map ref	Activity	SCT	DBH (cm)	Radial (m)	2022 note
South Sancrox	Impact	No Mitigation	SANCROX E1	SSAN1	0.0	Tallowwood	45	28	
South Sancrox	Impact	No Mitigation	SANCROX E2		0.0	Tallowwood (not tagged)	60	20	
South Sancrox	Impact	No Mitigation	SANCROX E3		0.0	Tallowwood	48	30	
South Sancrox	Impact	Mitigation	SANCROX S1	SSAN2	0.0	Blackbutt	53	20	
South Sancrox	Impact	Mitigation	SANCROX S2		10.0	Thin-leaved Stringybark	56	20	
South Sancrox	Impact	Mitigation	SANCROX S3		0.0	Flooded Gum (noy tagged)	57	25	
South Sancrox	Control	Control	COWARRA SF1	SSAN3	0.0	Small-fruited Grey Gum (tag hacked off)	45	20	
South Sancrox	Control	Control	COWARRA SF2		0.0	Blackbutt	135	20	
South Sancrox	Control	Control	COWARRA SF3		0.0	Small-fruited Grey Gum	35	15	
South Sancrox	Control	New Control	SAT COWARRA NC1	SSAN4	3.3	Blackbutt	80	20	
South Sancrox	Control	New Control	SAT COWARRA NC2		0.0	*E. carnea*	37	20	
South Sancrox	Control	New Control	SAT COWARRA NC3		0.0	Blackbutt	39	25	
North Sancrox	Impact	No Mitigation	SANCROX N1						
North Sancrox	Impact	No Mitigation	SANCROX N2						
North Sancrox	Impact	No Mitigation	SANCROX N3						
North Sancrox	Impact	Mitigation	FERNBANK CK1	NSAN1	10.0	Tallowwood	75	25	
North Sancrox	Impact	Mitigation	FERNBANK CK2		10.0	Tallowwood	40	25	
North Sancrox	Impact	Mitigation	FERNBANK CK3		0.0	Tallowwood	50	20	
North Sancrox	Control	Control	LAKE INNES1	NSAN2		Tallowwood (not tagged)			
North Sancrox	Control	Control	LAKE INNES2			Swamp Mahogany			
North Sancrox	Control	Control	LAKE INNES3			Swamp Mahogany			
North Sancrox	Control	New Control	SAT COW4	NSAN3	0.0	Blackbutt	70	25	
North Sancrox	Control	New Control	SAT COW5		0.0	Small-fruited Grey Gum	25	25	
North Sancrox	Control	New Control	SAT COW6		3.3	*E. acmenoides*	36	25	

Monitoring Area	Treatment	Sub-category	Site_ID	Map ref	Activity	SCT	DBH (cm)	Radial (m)	2022 note
Cairncross State Forest (South)	Impact	No Mitigation	CAINCROSS SF1	CCS1	0.0	Tallowwood	36	20	
Cairncross State Forest (South)	Impact	No Mitigation	CAINCROSS SF2		0.0	Tallowwood	50	20	
Cairncross State Forest (South)	Impact	No Mitigation	CAINCROSS SF3		0.0	Tallowwood	50	20	
Cairncross State Forest (south)	Impact	No Mitigation	CAINCROSS SF16	CCS2	0.0	Tallowwood	50	18	
Cairncross State Forest (south)	Impact	No Mitigation	CAINCROSS SF17		0.0	Tallowwood	36	15	
Cairncross State Forest (south)	Impact	No Mitigation	CAINCROSS SF18		0.0	Tallowwood (not tagged)	100	26	
Cairncross State Forest (South)	Impact	Mitigation	CAINCROSS SF4	CCS3	3.3	Tallowwood	60	20	
Cairncross State Forest (South)	Impact	Mitigation	CAINCROSS SF5		0.0	Tallowwood	70	18	
Cairncross State Forest (South)	Impact	Mitigation	CAINCROSS SF6		0.0	Blackbutt	80	20	
Cairncross State Forest (South)	Control	Control	LIMEBURNERS CK1	CCS4	0.0	Scribbly Gum (not tagged)	45	25	
Cairncross State Forest (South)	Control	Control	LIMEBURNERS CK2		0.0	Scribbly Gum (not tagged)	180	30	
Cairncross State Forest (South)	Control	Control	LIMEBURNERS CK3		0.0	Scribbly Gum (not tagged)	50	25	
Cairncross State Forest (South)	Control	New Control	SAT PEVI1	CCS5	0.0	Sydney Blue Gum	55	20	
Cairncross State Forest (South)	Control	New Control	SAT PEVI2		0.0	Sydney Blue Gum	55	18	
Cairncross State Forest (South)	Control	New Control	SAT PEVI3		0.0	Sydney Blue Gum		15	
Cairncross State Forest (north)	Impact	No Mitigation	CAINCROSS SF7	CCN1	0.0	Blackbutt	80	20	
Cairncross State Forest (north)	Impact	No Mitigation	CAINCROSS SF8		0.0	Forest Red Gum	50	20	
Cairncross State Forest (north)	Impact	No Mitigation	CAINCROSS SF9		0.0	Blackbutt	75	25	
Cairncross State Forest (north)	Impact	Mitigation	CAINCROSS SF10	CCN2	0.0	Swamp Mahogany	35	20	
Cairncross State Forest (north)	Impact	Mitigation	CAINCROSS SF11		0.0	Tallowwood	60	20	
Cairncross State Forest (north)	Impact	Mitigation	CAINCROSS SF12		0.0	Tallowwood	75	15	
Cairncross State Forest (north)	Control	Control	CAINCROSS SF13	CCN3	0.0	Small-fruited Grey Gum	42	20	
Cairncross State Forest (north)	Control	Control	CAINCROSS SF14		0.0	Sydney Blue Gum	35	20	
Cairncross State Forest (north)	Control	Control	CAINCROSS SF15		0.0	Sydney Blue Gum (not tagged)	85	20	
Cairncross State Forest (north)	Control	New Control	SAT RR1	CCN4	0.0	Tallowwood	45	20	
Cairncross State Forest (north)	Control	New Control	SAT RR2		0.0	Small-fruited Grey Gum	57	20	
Cairncross State Forest (north)	Control	New Control	SAT RR3		0.0	Tallowwood	56	20	

Monitoring Area	Treatment	Sub-category	Site_ID	Map ref	Activity	SCT	DBH (cm)	Radial (m)	2022 note
Cooperabung Hill	Impact	No Mitigation	COOPERABUNG1	COOP1		Tallowwood			No Access-landholder no contact
Cooperabung Hill	Impact	No Mitigation	COOPERABUNG2		0.0	Small-fruited Grey Gum	55	30	
Cooperabung Hill	Impact	No Mitigation	COOPERABUNG3		3.3	Tallowwood	55	25	
Cooperabung Hill	Impact	Mitigation	COOPERABUNG4	COOP2	0.0	Tallowwood	33	20	
Cooperabung Hill	Impact	Mitigation	COOPERABUNG5		0.0	Tallowwood	24	18	
Cooperabung Hill	Impact	Mitigation	COOPERABUNG6		0.0	Tallowwood	67	20	
Cooperabung Hill	Control	Control	COOP HILL1	COOP3	0.0	Tallowwood	45	20	
Cooperabung Hill	Control	Control	COOP HILL2		3.3	Small Fruited Grey Gum	61	20	
Cooperabung Hill	Control	Control	COOP HILL3		3.3	Tallowwood	43	20	
Cooperabung Hill	Control	New Control	SAT FL1	COOP4	0.0	Red Mahogany	50	20	
Cooperabung Hill	Control	New Control	SAT ST1			Tallowwood			No access
Cooperabung Hill	Control	New Control	SAT ST2			Tallowwood			No access
Mingaletta to Smiths Creek	Impact	Mitigation	MIN-SMITHS CK1	MING1	0.0	Blackbutt	55	18	Underscrubbed and cattle present.
Mingaletta to Smiths Creek	Impact	Mitigation	MIN-SMITHS CK2		0.0	Tallowwood	85	30	Cattle and deep litter on creek line.
Mingaletta to Smiths Creek	Impact	Mitigation	MIN-SMITHS CK3			Small-fruited Grey Gum			Property sold no access
Mingaletta to Smiths Creek	Control	Control	BALLENGARA SF1	MING2	0.0	Tallowwood	40	25	Logged trees sparse
Mingaletta to Smiths Creek	Control	Control	BALLENGARA SF2		0.0	Tallowwood	32	20	
Mingaletta to Smiths Creek	Control	Control	BALLENGARA SF3		0.0	Tallowwood	45	20	
Mingaletta to Smiths Creek	Control	New Control	SAT BR1	MING3	0.0	Sydney Blue Gum	45	25	
Mingaletta to Smiths Creek	Control	New Control	SAT BR2		0.0	Sydney Blue Gum	59	20	
Mingaletta to Smiths Creek	Control	New Control	SAT BR3		0.0	Flooded Gum	68	20	
Kundabung Road to North of Pipers Creek	Impact	No Mitigation	KUNDABUNG 1	KUND1	0.0	Flooded Gum	24	25	
Kundabung Road to North of Pipers Creek	Impact	No Mitigation	KUNDABUNG 2		0.0	Tallowwood	90	25	
Kundabung Road to North of Pipers Creek	Impact	No Mitigation	KUNDABUNG 3		0.0	Pink Bloodwood	60	20	
Kundabung Road to North of Pipers Creek	Impact	Mitigation	KUNDABUNG 4	KUND2	16.7	Small Fruited Grey Gum	76	20	
Kundabung Road to North of Pipers Creek	Impact	Mitigation	KUNDABUNG 5		3.3	Blackbutt	37	18	

Monitoring Area	Treatment	Sub-category	Site_ID	Map ref	Activity	SCT	DBH (cm)	Radial (m)	2022 note
Kundabung Road to North of Pipers Creek	Impact	Mitigation	KUNDABUNG 6			Grey Ironbark			No Access-landholder no contact
Kundabung Road to North of Pipers Creek	Control	Control	KUMBATINE NP1	KUND3	0.0	Tallowwood	30	20	
Kundabung Road to North of Pipers Creek	Control	Control	KUMBATINE NP2		0.0	Tallowwood	60	20	
Kundabung Road to North of Pipers Creek	Control	Control	KUMBATINE NP3		0.0	*E. carnea*	60	20	
Kundabung Road to North of Pipers Creek	Control	New Control	SAT MAC1	KUND4	0.0	Red Mahogany	80	20	
Kundabung Road to North of Pipers Creek	Control	New Control	SAT MAC2		0.0	Spotted Gum	50	20	
Kundabung Road to North of Pipers Creek	Control	New Control	SAT MAC3		0.0	Spotted Gum	45	20	
Maria River State Forest	Impact	Part Mitigation	MARIA RIVER 1	MR1	0.0	Pink Bloodwood	35	25	
Maria River State Forest	Impact	Part Mitigation	MARIA RIVER 2		0.0	Tallowwood	45	20	
Maria River State Forest	Impact	Part Mitigation	MARIA RIVER 3		0.0	Tallowwood	26	22	
Maria River State Forest	Impact	Mitigation	MARIA RIVER 4	MR2	0.0	Thin-leaved Stringybark	40.5	20	
Maria River State Forest	Impact	Mitigation	MARIA RIVER 5		3.3	Tallowwood	66	25	
Maria River State Forest	Impact	Mitigation	MARIA RIVER 6		0.0	Tallowwood	36	20	
Maria River State Forest	Control	Control	MARIA NP1	MR3	0.0	Tallowwood	31	15	
Maria River State Forest	Control	Control	MARIA NP2		3.3	Tallowwood	63	20	
Maria River State Forest	Control	Control	MARIA NP3		16.7	Tallowwood	23	25	
Maria River State Forest	Control	New Control	SAT CO1	MR4	0.0	White Stringbark	40	27	
Maria River State Forest	Control	New Control	SAT CO3		0.0	Blackbutt	95	20	
Maria River State Forest	Control	New Control	SAT MAR 1		0.0	Tallowwood		20	

Niche Environment and Heritage

A specialist environmental and heritage consultancy.

Head Office

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

All mail correspondence should be through our Head Office

niche
Environment and Heritage

Spotted-tailed Quoll Monitoring 2022

Oxley Highway to Kempsey, Pacific Highway Upgrade

Prepared for Transport for NSW

May 2023

Document control

Project no.:	1702
Project client:	Transport for NSW
Project office:	Port Macquarie
Document description:	Spotted-tailed Quoll Monitoring 2022 Report
Project Director:	Lawrence Smith
Project Manager:	Radika Michniewicz
Authors:	Jodie Danvers
Internal review:	Radika Michniewicz
Document status:	R0
Local Government Area:	Kempsey and Port Macquarie-Hastings

Document revision status

Author	Revision number	Internal review	Date issued
Jodie Danvers	D1	Radika Michniewicz	2/05/2023
Jodie Danvers	R0		3/05/2023
Radika Michniewicz	R1		14/05/2023

Niche Environment and Heritage

Excellence in your environment.

ABN: 19 137 111 721

Head Office

Parramatta NSW 2150

All mail correspondence to:

PO Box 2443

North Parramatta NSW 1750

Phone: **02 9630 5658**

Email: **info@niche-eh.com**

Locations

Sydney

Bulli

Central Coast

Newcastle

Port Macquarie

Brisbane

Cairns

Cover photograph: Fauna captured on camera: Brown Bandicoot recorded in Fauna Underpass F22.32 within the Ballengarra State Forest Monitoring Area (left); Echidna recorded passing through combined culvert underpass C7.26 with Cairncross State Forest Monitoring Area (right).

Executive summary

Context

This report documents findings of the 2022 monitoring period, the third and last, for the Spotted-tailed Quoll (*Dasyurus maculatus*), as required for the Oxley Highway to Kempsey (OH2K) Pacific Highway upgrade project (the Project) and specified in the Oxley Highway to Kempsey (OH2K) Ecological Monitoring Program (EMP, TfNSW 2022). Transport for NSW (TfNSW) is required to manage and monitor the effectiveness of biodiversity mitigation measures implemented as part of the Project. The Spotted-tailed Quoll is one of the threatened species identified as requiring mitigation and monitoring during the operational phase of the Project.

Aim

The aim of the Spotted-tailed Quoll monitoring program is to determine whether the Project is meeting the performance indicators for the species, and provide corrective actions where required.

Method

Monitoring was undertaken in accordance with the EMP, in three broad areas of Cairncross State Forest, Ballengarra State Forest and Maria River State Forest. Cameras were deployed at fourteen fauna crossing locations within the three broad monitoring areas. Two motion-detecting cameras were deployed at each crossing location. Cameras were left to operate continuously from 1 June 2022 – 14 September 2022.

Key results

The Spotted-tailed Quoll was not recorded during the 2022 monitoring period and has not been recorded during either of two previous survey/monitoring events undertaken to date. These results are consistent with baseline findings. There were a total of 773 photo records, including 465 (61.2%) with native fauna (including the threatened Koala), 232 with (30.0%) introduced predators (including wild dogs, cats and foxes), and 50 (0.6%) with non-predatory introduced fauna.

As part of the analogous underpass monitoring program undertaken as part of the OH2K EMP, a Spotted-tailed Quoll was previously recorded during the 2018 underpass monitoring traversing underpass C36.40 (Niche 2018b).

Conclusion

The performance measure for all monitoring events has been met; monitoring was undertaken as per the EMP in Years 4, 6 and 8.

Management implications

Further monitoring is not recommended for the following reasons:

- Baseline (before construction) surveys did not record the Spotted-tailed Quoll.
- The species was detected using underpass C36.40 in 2018, a positive outcome given the low density, cryptic nature and expected low detection rate for this species.
- The detection of the species using underpass C36.40 supports the installation of box culverts as a mitigation measure to facilitate movement for this species.

Table of Contents

List of Figures

List of Tables

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 Climate Change, Energy, the Environment and Water (DCCEEW, previously 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) (TfNSW 2022) combines these approval conditions and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project. The Spotted-tailed Quoll (*Dasyurus maculatus*) was one threatened species identified as requiring monitoring following the completion of the Project's construction, during the operational phase.

1.1.1 Legal status

The Spotted-tailed Quoll is listed as vulnerable under the New South Wales *Biodiversity Conservation Act 2016* (BC Act) and endangered under the Commonwealth EPBC Act. Monitoring of the species is required under the Project's approval.

1.1.2 Monitoring framework

The survey design, methodology and performance indicators that define the Spotted-tailed Quoll monitoring program are specified in the EMP. The EMP requires monitoring of the Spotted-tailed Quoll on three occasions in total: in autumn or winter (preferably between March and Mid-July) in Year 4, 6 and 8 (operational phase of the Project).

After the Year 4 and 6 monitoring events (Niche 2018a, Niche 2020) the monitoring method was reviewed in consultation with the NSW Environment Protection Authority (EPA) and a revised method was approved by the EPA and DCCEEEW in accordance with the recommendations provided in Niche (2020).

The result of these recommendations are as follows:

- The previous monitoring program was discontinued.
- Camera monitoring resources were redirected to mitigation structures.
- Performance measures were updated.
- The EMP was updated to reflect the change in methods and performance measures.

As such, the current and final 2022 monitoring event has been undertaken in accordance with the updated EMP (TfNSW 2022).

1.1.3 Baseline data

No Spotted-tailed Quoll were recorded during baseline surveys conducted by Lewis Ecological in August 2013 (Lewis 2014).

One Spotted-tailed Quoll was previously recorded during the 2018 underpass monitoring traversing underpass C36.40 (combined culvert C36.40) in a westerly direction (Niche 2018b).

1.1.4 Purpose of this report

This report details the findings obtained from the third and final monitoring event for the Spotted-tailed Quoll.

The aims of this report are to summarise the methods and results of the 2022 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 Spotted-tailed Quoll:

- *Monitoring is undertaken in Year 4, 6 and 8 or until monitoring can demonstrate that mitigation measures are effective.*

1.3 Monitoring Timing

Monitoring is to be undertaken during autumn or winter, but preferably March – mid-July.

1.4 Reporting

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

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

All reports prepared under the EMP will be submitted to DCCEEW, the NSW Department of Planning and Environment (DPE) and the EPA.

2. Methodology

2.1 Monitoring Sites

Monitoring was undertaken in the three broad areas identified in the EMP and included Cairncross State Forest, Ballengarra State Forest and Maria River State Forest.

Cameras were deployed at fourteen fauna crossing locations (Table 1, Figure 1) within the three broad monitoring areas. Monitoring locations were determined based on their proximity to monitoring areas, connectivity between vegetated areas on either side of the highway, and position relative to existing creek lines.

Table 1: Monitoring sites

Area	Monitoring sites
Cairncross State Forest (dry sclerophyll forest with some swamp forest associations)	Combined culvert underpass C7.26 Fauna underpass F9.70 Combined culvert underpass C11.14/11.08 Fauna underpass F11.67
Ballengarra State Forest (dry sclerophyll forest with some moist forest and swamp forest associations)	Fauna underpass F20.54 Fauna underpass F21.24 Fauna underpass F22.32 Barry's Creek Bridge Fauna underpass F26.40
Maria River State Forest (dry sclerophyll forest with some moist forest and swamp forest associations)	Fauna underpass F33.40 Fauna underpass F34.72 Combined culvert underpass C36.40 Maria River Bridge Stumpy Creek Bridge

2.2 Survey Method

Two motion-detecting cameras were deployed at each crossing location. Cameras were installed to provide the best field of view of traversing fauna. Cameras were left to operate continuously for a period of not less than three months during the period from May to August. Battery change and functionality checks were completed at the one and two-month stages.

Data was collated and also added to the underpass monitoring data.

2.3 Analysis

Monitoring results were analysed in accordance with the performance measures specified within the EMP. In the case of the Spotted-tailed Quoll, performance measures are based on survey completion only; they do not specifically relate to the detection of this species and statistical analysis of data is not required.

niche Environment and Heritage

GDA 1994 MGA Zone 56

Monitoring sites

Oxley Highway to Kempsey - Spotted-tailed Quoll Monitoring sites

Niche PM: Radika Michniewicz
Niche Proj. #: 7208
Client: Transport for NSW (RMS Port Macquarie)

Figure 1

3. Results

3.1 2022 Monitoring Results

3.1.1 Monitoring details

Cameras were deployed at all 14 underpasses on 1 June 2022 and were operational for three months, until they were retrieved on 12-14 September 2022 (Table 2).

Results of the 2022 monitoring are provided in Annex 1 and a summary is provided in Table 3.

There were a total of 773 photo records, including 465 (61.2%) with native fauna, 232 (30.0%) with introduced predators (including wild dogs, cats and foxes) and 50 (6.5%) with non-predatory introduced fauna.

Table 2: Camera details

Area	Site	Deploy Date	Retrieve Date	Cam 1 #	Location/ direction	No. Photos	No. fauna photos	Cam 2 #	Location/ direction	No. Photos	No. fauna photos
Cairncross State Forest	C7.26	1/06/2022	14/09/2022	127	Mid/E	39	10	870	Mid/W	219	68
	F9.70	1/06/2022	14/09/2022	167	Mid/W	390	66	426	E /W	250	92
	C11.14/ 11.08	1/06/2022	12/09/2022	428	E	54	33	430	W	156	52
	F11.67	1/06/2022	14/09/2022	369	E	78	27	85	Mid/E	93	38
Ballengarra State Forest	F20.54	1/06/2022	14/09/2022	174	W	170	83	447	E/ W	92	53
	F21.24	1/06/2022	14/09/2022	125	Mid/E	79	33	178	Mid/W	118	26
	F22.32	1/06/2022	14/09/2022	393	E	115	61	433	W	494	154
	Barry's Creek Bridge	1/06/2022	14/09/2022	162	NE /W	678	17	141	SE/ W	90	10
	F26.4	1/06/2022	14/09/2022	382	E	503	286	374	W	506	319
Maria River State Forest	F33.40	1/06/2022	13/09/2022	397	W	132	67	424	E /W	309	123
	F34.72	1/06/2022	13/09/2022	134	E	237	79	446	East / W	307	104
	C36.4	1/06/2022	13/09/2022	65	Mid/E	39	2	378	Mid/W	46	4
	Maria River Bridge	1/06/2022	14/09/2022	155	NE /E	111	0	80	SW /E	129	52
	Stumpy Creek Bridge	1/06/2022	14/09/2022	373	NW / E NW	46	15	422	SW /E	508	21

3.1.2 Spotted-tailed Quoll

No Spotted-tailed Quoll were recorded at any of the monitoring sites during the 2022 monitoring.

As part of monitoring of mitigation measures for the Project, remotely triggered Scout Guard cameras were deployed in a number of selected combined and dedicated fauna underpasses. As mentioned, one Spotted-tailed Quoll was previously recorded during the 2018 underpass monitoring traversing underpass C36.40 (combined culvert C36.40) in a westerly direction (Niche 2018b). No Spotted-tailed Quolls were recorded during the 2022/2023 fauna underpass monitoring.

3.1.3 Other fauna

Native fauna

The most frequently recorded fauna from the Maria River and Ballengarra monitoring areas were medium ground-dwelling mammals, representing 34% of all records. Macropods and rodents and dasyurids were the next most frequently recorded native fauna, representing 25.9% and 8.4% of all records respectively. Of note was the detection of Koalas (vulnerable, BC Act and EPBC Act) at the Barrys Creek bridge and underpass F9.70 within the Ballengarra State Forest and Cairncross monitoring areas.

Introduced predatory fauna

Introduced predatory fauna, which may compete with the Spotted-tailed Quoll, included the European Red Fox (*Vulpes vulpes*), Cat (*Felis catus*), Wild (including Dingoes) and Domestic Dogs (*Canis familiaris*), and represented 26.4% of all records. All sites except three recorded predators on more than one occasion, with the Cairncross monitoring area representing 71% of the predator records across all sites.

Table 3: Summary of records

Area	Site	STQ	AM	M	MI	R&D	MGD	Bird	R	IP	Unk	Other
Cairncross	Combined culvert underpass C7.26	0		3			1		1	28		
	Fauna underpass F9.70	0	1	4			1			65		
	Combined culvert underpass C11.14/11.08	0		1			4			30		
	Fauna underpass F11.67	0		10	1					22		
Ballengarra	Fauna underpass F20.54	0		25		1	21		1			1
	Fauna underpass F21.24	0		6		1	14			2	3	
	Fauna underpass F22.32	0		9		6	46		3	11	1	
	Barry's Creek Bridge	0	3	7						3	2	
	Fauna underpass F26.4			64		44	83	2		31	2	2
Maria	Fauna underpass F33.40	0		54		1	16				2	
	Fauna underpass F34.72	0				5	71		1	5		
	Combined culvert underpass C36.4	0		8						2		
	Maria River Bridge	0	13	3		6	6					
	Stumpy Creek Bridge	0		6		1		1		5		
	total	0	17	200	1	65	263	3	6	204	10	3

STQ = Spotted-tailed Quoll; AM = arboreal mammals (Possums and Koala); M = macropods; MI = Microbat, R&D = rodents and dasyurids; MGD = medium ground dwelling mammals (Echidna, Bandicoot); R = reptile; IP = Introduced predator (Fox, Cat, Wild and Domestic Dog); Unk = Unknown/unidentified fauna; Other= non-native and non-fauna categories such as people, cars, cows, pigs, hares and horses.

4. Discussion and Recommendations

4.1 Performance Measures

A summary of the 2022 survey results in relation to the performance measures are provided in Table 4.

Table 4: Summary of performance measures for the 2022 monitoring period.

Performance measure	Discussion
Monitoring is undertaken in Year 4, 6 and 8 or until monitoring can demonstrate that mitigation measures are effective.	**This performance measure has been met for all Years.**

4.2 Recommendations

The EMP lists potential problems and contingency measures for various components of the monitoring program. There are no measures relevant to the Spotted-tailed Quoll monitoring program.

Further monitoring is not recommended for the following reasons:

- Baseline (before construction) surveys did not record the Spotted-tailed Quoll.
- The species was detected using underpass C36.40 in 2018, a positive outcome given the low density, cryptic nature and expected low detection rate for this species.
- The detection of the species using underpass C36.40 supports the installation of box culverts as a mitigation measure to facilitate movement for this species.

References

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

Niche (2018a). Spotted-tailed Quoll Monitoring 2018. Oxley Highway to Kempsey Pacific Highway upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

Niche (2018b). Fauna Underpass and Associated Fauna Fence Monitoring 2016/2017. Frederickton to Eungai Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

Niche (2020). Spotted-tailed Quoll Monitoring 2020. Oxley Highway to Kempsey Pacific Highway upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

TfNSW (2022). Oxley Highway to Kempsey Pacific Highway Upgrade Ecological Monitoring Program. Transport for NSW Update to report prepared by SMEC Hyder Joint Venture, February 2022.

Annex 1. Field Data – 2022 results

Monitoring Site	Cairncross State Forest				Ballengarra State Forest					Maria River State Forest				
Underpass	**C7.26**	**F9.70**	**C11.14/ 11.08**	**F11.67**	**F20.54**	**F21.24**	**F22.32**	**Barry's Ck**	**F26.4**	**F33.40**	**F34.72**	**C36.40**	**Maria River**	**Stumpy Ck**
Species/ fauna group														
Small ground-dwelling mammals														
Rattus rattus							Y (1)		Y (39)				Y (5)	Y (1)
Rodent/Marsupial					Y (1)		Y (3)		Y (4)	Y (1)	Y (4)			
Rodent						Y (1)	Y (2)		Y (1)		Y (1)		Y (1)	
Medium ground -dwelling mammals														
Echidna (*Tachyglossus aculeatus*)	Y (1)		Y (4)			Y (2)	Y (4)		Y (3)	Y (1)			Y (4)	
Long-nosed Bandicoot (*Perameles nasuta*)					Y (5)	Y (1)	Y (8)	Y (1)	Y (12)	Y (4)	Y (8)		Y (1)	
Bandicoot		Y (1)			Y (16)	Y (2)	Y (34)		Y (67)	Y (11)	Y (57)			
Northern Brown Bandicoot (*Isoodon macrourus*)						Y (9)			Y (1)		Y (6)		Y (1)	
Arboreal mammals														
Brushtail Possum													Y (3)	
Common Brushtail Possum (*Trichosurus vulpecula*)								Y (2)					Y (10)	
Koala (*Phascolarctos cinereus*)		Y (1)						**Y (1)**						
Macropods														
Eastern Grey Kangaroo (*Macropus giganteus*)	Y (3)	Y (2)	Y (2)	Y (5)	Y (14)	Y (5)		Y (2)	Y (33)	Y (5)	Y (5)		Y (1)	
Macropod sp.			Y (1)		Y (5)	Y (1)	Y (3)		Y (11)	Y (11)				
Swamp Wallaby (*Wallabia bicolor*)				Y (1)	Y (3)		Y (6)	Y (4)	Y (14)	Y (5)	Y (2)		Y (1)	Y (5)
Red-necked Wallaby (*Macropus rufogriseus*)													Y (1)	
Wallaby				Y (4)	Y (3)			Y (1)	Y (6)	Y (6)	Y (1)			Y (1)

Monitoring Site	Cairncross State Forest				Ballengarra State Forest					Maria River State Forest				
Underpass	**C7.26**	**F9.70**	**C11.14/ 11.08**	**F11.67**	**F20.54**	**F21.24**	**F22.32**	**Barry's Ck**	**F26.4**	**F33.40**	**F34.72**	**C36.40**	**Maria River**	**Stumpy Ck**
Species/ fauna group														
Reptiles														
Lace Monitor (*Varanus varius*)	Y (1)				Y (1)		Y (3)				Y (1)			
Introduced predators														
Fox (*Vulpes vulpes*)	Y (6)	Y (53)	Y (9)	Y (15)		Y (1)	Y (11)		Y (25)	Y (26)	Y (1)	Y (2)		Y (5)
Wild Dog (*Canis lupus*)	Y (22)	Y (13)	Y (21)	Y (7)		Y (1)		Y (3)	Y (2)					
Cat (*Felis catus*)									Y (4)	Y (1)	Y (4)			
Other														
Unknown						Y (3)	Y (1)	Y (2)	Y (2)	Y (2)				
Microbat				Y (1)										
Rabbit (*Oryctolagus cuniculus*)														
Bird					Y (1)				Y (2)					Y (1)
Pig									Y (2)					

Niche Environment and Heritage

A specialist environmental and heritage consultancy.

Head Office

Niche Environment and Heritage
PO Box 2443 North Parramatta NSW 1750
Email: info@niche-eh.com

All mail correspondence should be through our Head Office

niche
Environment and Heritage

Giant Barred Frog Monitoring 2022/2023

Oxley Highway to Kempsey, Pacific Highway Upgrade

Prepared for Transport for NSW

May 2023

Document control

Project no.:	1702
Project client:	Transport for NSW
Project office:	Port Macquarie
Document description:	Giant Barred Frog Monitoring 2022/2023 Report
Project Director:	Lawrence Smith
Project Manager:	Radika Michniewicz
Authors:	Jodie Danvers, Radika Michniewicz
Internal review:	Radika Michniewicz
Document status:	R1
Local Government Area:	Kempsey and Port Macquarie-Hastings

Author	Revision number	Internal review	Date issued
Jodie Danvers	D1	Radika Michniewicz	02/05/2023
Jodie Danvers	R0		04/05/2023
Radika Michniewicz	R1		17/05/2023

Cover photograph: Giant Barred Frog

Niche Environment and Heritage

A specialist environmental and heritage consultancy.

Head Office

Level 3, 93 George Street
Parramatta NSW 2150
All mail correspondence to:
PO Box 2443
North Parramatta NSW 1750
Email: info@niche-eh.com

Sydney

0488 224 888

Central Coast

0488 224 999

Port Macquarie

0488 774 081

Brisbane

0488 224 036

Cairns

0488 284 743

Executive summary

Context

This report documents findings of the final of five operational monitoring periods for the Giant Barred Frog (*Mixophyes iteratus*), as required for the Oxley Highway to Kempsey (OH2K) Pacific Highway Upgrade Project (the Project), and specified in the Oxley Highway to Kempsey (OH2K) Ecological Monitoring Program (EMP, TfNSW 2022). Transport for NSW (TfNSW) is required to manage and monitor the effectiveness of biodiversity mitigation measures implemented as part of the Project. The Giant Barred Frog is one of the threatened species identified as requiring mitigation and monitoring throughout the course of the construction and operational periods of the Project.

Aims

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

Methods

Six sites (two reference and four impact) were monitored in spring 2022 and summer 2023 and five sites (two reference and three impact) in autumn 2023, due to access constraints. Each site consists of a one kilometre transect along the creek line, divided into 10 x 100 metre zones. At the impact sites, the transects cross beneath the carriageway, the carriageway being the midpoint of the transect. Each monitoring location was surveyed in accordance with the monitoring method and design specified in the EMP. Surveys were undertaken after a sufficient rainfall trigger event (> 10 millimetres within a 24 hour period) and involved passive listening, call playback (upon arrival and at intervals during searches), active searching (within 20 metres of each creek bank) and habitat surveys within each of the 100 metre zones.

Key results

Surveys were undertaken on the 25 - 27 October 2022 (spring), 15 - 17 February 2023 (summer) and 3 – 4 April 2023 (autumn) after suitable rainfall. A total of 54 Giant Barred Frogs were recorded during the 2022/2023 monitoring period and 9% (n = 9) of those captured were recaptures.

Frogs were absent from the Cooperabung Creek reference site in all seasons. The highest mean number of Giant Barred Frogs was recorded at Pipers Creek reference site.

Evidence of breeding via the presence of juveniles or sub-adults, gravid females or reproductive males was observed at all sites where frogs were recorded during at least one survey event during 2022/2023 monitoring.

Analysis of frog movement in relation to the highway found that 12 (23%) of the 52 recaptures from impact sites have been captured on both sides of the carriageway over successive monitoring events. At the reference sites, 12 (27%) of the 44 recaptures have been captured on both sides of the transect midpoint over successive monitoring events.

Conclusions

Performance measures relating to undertaking monitoring have been met.

The performance measure relating to continued presence of Giant Barred Frogs during each survey event where it was identified during baseline surveys was met for three of the six sites. Giant Barred Frogs were:

- Not recorded at the Cooperabung reference sites, where it was recorded during all three baseline surveys.
- Not recorded at Smiths Creek impact site in summer or autumn 2022/2023 and Maria River impact site in spring 2022, where it was recorded during baseline surveys.

The performance measure relating to changes in density and mean records was not met. The number and location of Giant Barred Frogs recorded has varied between season and year at all sites. All sites show fluctuating densities. However, as trends are evident at both impact and reference sites, it is not possible to attribute these changes to the Project.

Management implications

Given the number and location of Giant Barred Frogs recorded has varied between season and year at all sites and that trends are evident at both impact and reference sites, it is not possible to attribute these changes to the Project, therefore further monitoring is not recommended.

However, it is reommended that maintenance actions are carried out in order to maintain the ongoing integrity of the frog fence.

Table of Contents

List of Figures

List of Graphs

List of Tables

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 Climate Change, Energy the Environment and Water (DCCEEW, previously the Department of Environment (DoE)) for Matters of National Environmental Significance (MNES) listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Ecological Monitoring Program (hereafter referred to as the EMP) (TfNSW 2022) combines these approval conditions and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project.

Transport for NSW (TfNSW) is required to manage and monitor the effectiveness of biodiversity mitigation measures implemented as part of the Project. The Giant Barred Frog (*Mixophyes iteratus*) was one threatened species identified as requiring mitigation and monitoring through the course of the Project's construction and operational periods.

1.1.1 Legal status

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

1.1.2 Monitoring framework

The design, methods and performance indicators that define the Giant Barred Frog monitoring program are specified in the EMP and Giant Barred Frog Management Strategy (GBFMS, Lewis 2013). Where there are discrepancies between the EMP and the GBFMS, the EMP takes precedence (Section 1.2 TfNSW 2022).

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

- Construction phase monitoring:
  - *Autumn 2015* (Year 1): Niche 2015a
  - *Spring 2015, summer and autumn 2016* (Year 1): Niche 2016
  - *Spring 2016, summer and autumn 2017* (Year 2): Niche 2017
  - *Spring 2017, summer 2018* (Year 3): Niche 2018.
- Operational phase monitoring:
  - *Autumn 2018* (Year 3)*:* Niche 2018
  - *Spring 2018, (summer 2019 insufficient rainfall) and autumn 2019* (Year 4): Niche 2019
  - *Spring 2019, summer and autumn 2020* (Year 5): Niche 2020
  - *Spring 2020, summer and autumn 2021* (Year 6): Niche 2021
  - *Spring 2021, summer and autumn 2022* (Year 7): Niche 2022
  - *Spring 2022, summer and autumn 2023* (Year 8): Current report.

This report addresses the fifth round (Year 8) of operational phase monitoring for the Project and is the final of nine monitoring reports for the Giant Barred Frog.

Water quality monitoring was previously conducted within Giant Barred Frog habitat and potential habitat. Water quality monitoring commenced prior to construction, continued during construction and continued for three years during the operational phase, with the final monitoring occurring in March 2021 (Niche 2021). All water monitoring results for the Giant Barred Frog impact sites have been included in previous reports.

1.1.3 Baseline data

The EMP specifies the following regarding the Giant Barred Frog:

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

The EMP lists six sites to be monitored:

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

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

1.1.4 Purpose of this report

The purpose of this report is to summarise the methods and results of the 2022/2023 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.*

- *At Year 8, no change to GBF densities, distribution, habitat use and movement patterns compared to baseline data.*

1.3 Monitoring Timing

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

1.4 Reporting

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

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

This report prepared under the EMP will be submitted to NSW Department of Planning and Environment (DPE), the NSW Environment Protection Authority (EPA) and DCCEEW.

1.5 Limitations

The following limitations to the monitoring procedure were encountered:

- As previously reported, Giant Barred Frogs have become difficult to detect and access in some areas along the transects due to the density of streamside vegetation including the growth of Lantana.
- Monitoring at Maria River Impact Site upstream (zone 1-5) was not undertaken in 2022/2023 as access to the transect was not possible due to the growth of lantana along the banks.
- Sections of the transect at Piper's Creek Impact Site upstream was not accessible during 2022/2023 surveys. Access was achieved where possible by going around large patches of lantana and circling back to the transect.

2. Methodology

2.1 Monitoring Sites

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

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

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

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

2.2 Giant Barred Frog Survey Method

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

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

- Overstorey vegetation cover (OS, expressed as per cent cover)
- Shrub cover (expressed as per cent cover)
- Ground cover (expressed as per cent cover)
- Leaf litter cover (expressed as per cent cover)
- Bare soil/earth (expressed as per cent cover)
- 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 location of all observed Giant Barred Frogs was recorded and, where possible, individuals were captured. Captured individuals were checked for recapture status and fitted with a Passive Integrated Transponder (PIT) tag if the individual was previously unknown. In accordance with the EMP, the following data were collected for captured individuals:

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

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

Temperature and humidity, per cent cloud cover and broad wind level (scale of 0-3 where 0 = no wind) were recorded for each survey. Rainfall (millimetres) within the previous 24 hours was recorded from the Port Macquarie Airport (Station No. 060168) and Kempsey Airport (Station No. 059007) Bureau of Meterorology weather stations.

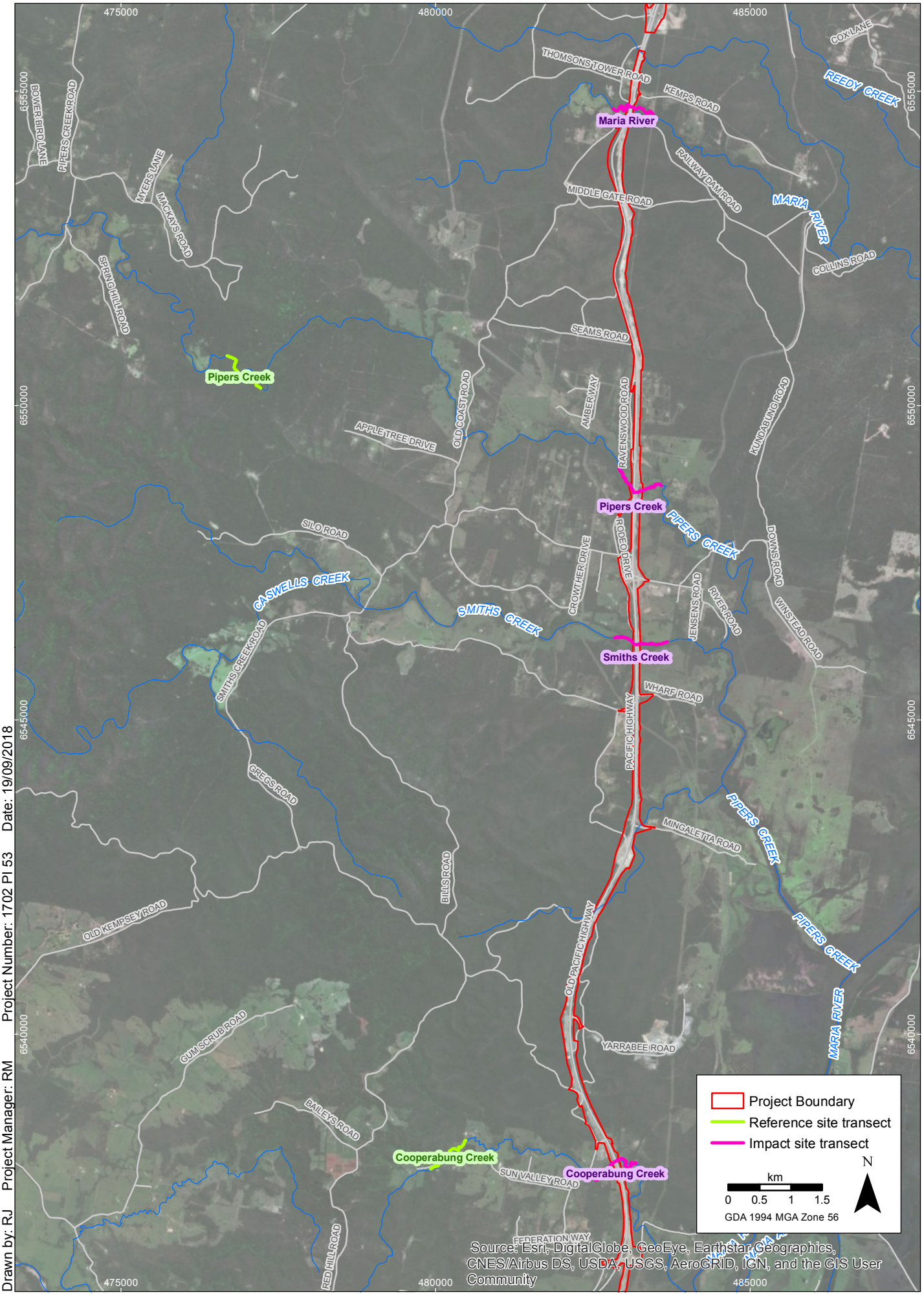
2.3 Water Quality

Water quality monitoring was not undertaken during the 2022/2023 monitoring period. The final operational water quality monitoring period and associated report was completed in 2021 (TfNSW 2021). A summary of the water quality data extracted from TfNSW (2021) from both upstream and downstream sites for Cooperabung Creek, Smiths Creek, Pipers Creek, and Maria River was included in the 2021/2022 monitoring period report (Niche 2021).

2.4 Analysis

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

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



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

Giant Barred Frog Monitoring Sites: overview

Pacific Highway Upgrade - Oxley Highway to Kempsey

FIGURE 1

niche Environment and Heritage

T:\spatial\projects\a1700\a1702_OH2K_Ecology\Maps\PI_5_Ecology_OH2K\PI_53_GiantBarredFrogMonitoring\20180807_report\1702_53_Figure_1_GBF_Overview.mxd

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

Giant Barred Frog monitoring: Cooperabung Creek impact site

Pacific Highway Upgrade - Oxley Highway to Kempsey

niche Environment and Heritage

T:\spatial\projects\a1700\a1702_OH2K_Ecology\Maps\PI_5_Ecology_OH2K\PI_53_GiantBarredFrogMonitoring\20180807_report\1702_53_Figures_2_7_GBF_Sites.mxd

FIGURE 2

Imagery: (c) DigitalGlobe

Giant Barred Frog monitoring: Smiths Creek impact site

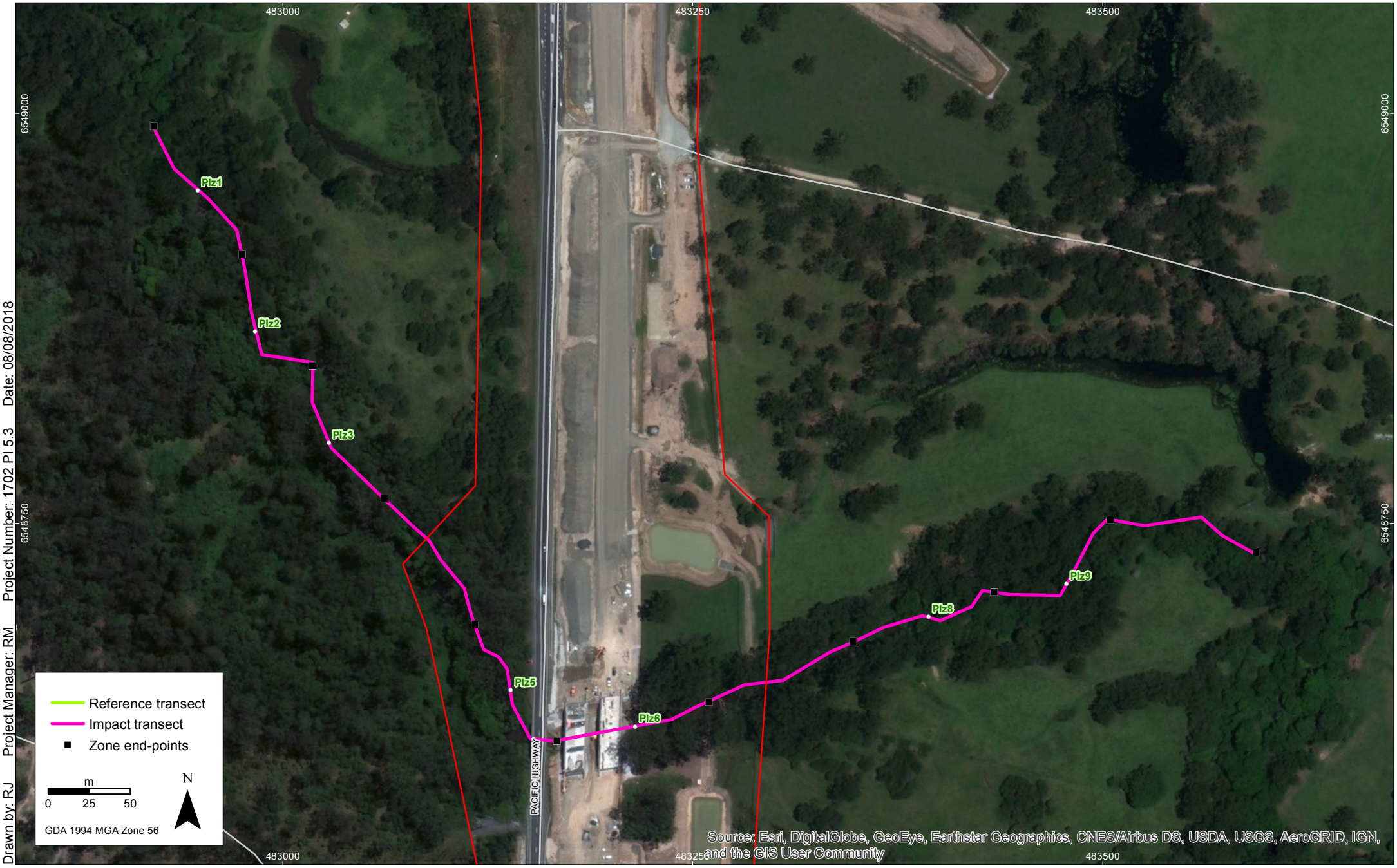
Pacific Highway Upgrade - Oxley Highway to Kempsey

niche Environment and Heritage

T:\spatial\projects\a1700\a1702_OH2K_Ecology\Maps\PI_5_Ecology_OH2K\PI_53_GiantBarredFrogMonitoring\20180807_report\1702_53_Figures_2_7_GBF_Sites.mxd

FIGURE 3

Imagery: (c) DigitalGlobe



Giant Barred Frog monitoring: Pipers Creek impact site

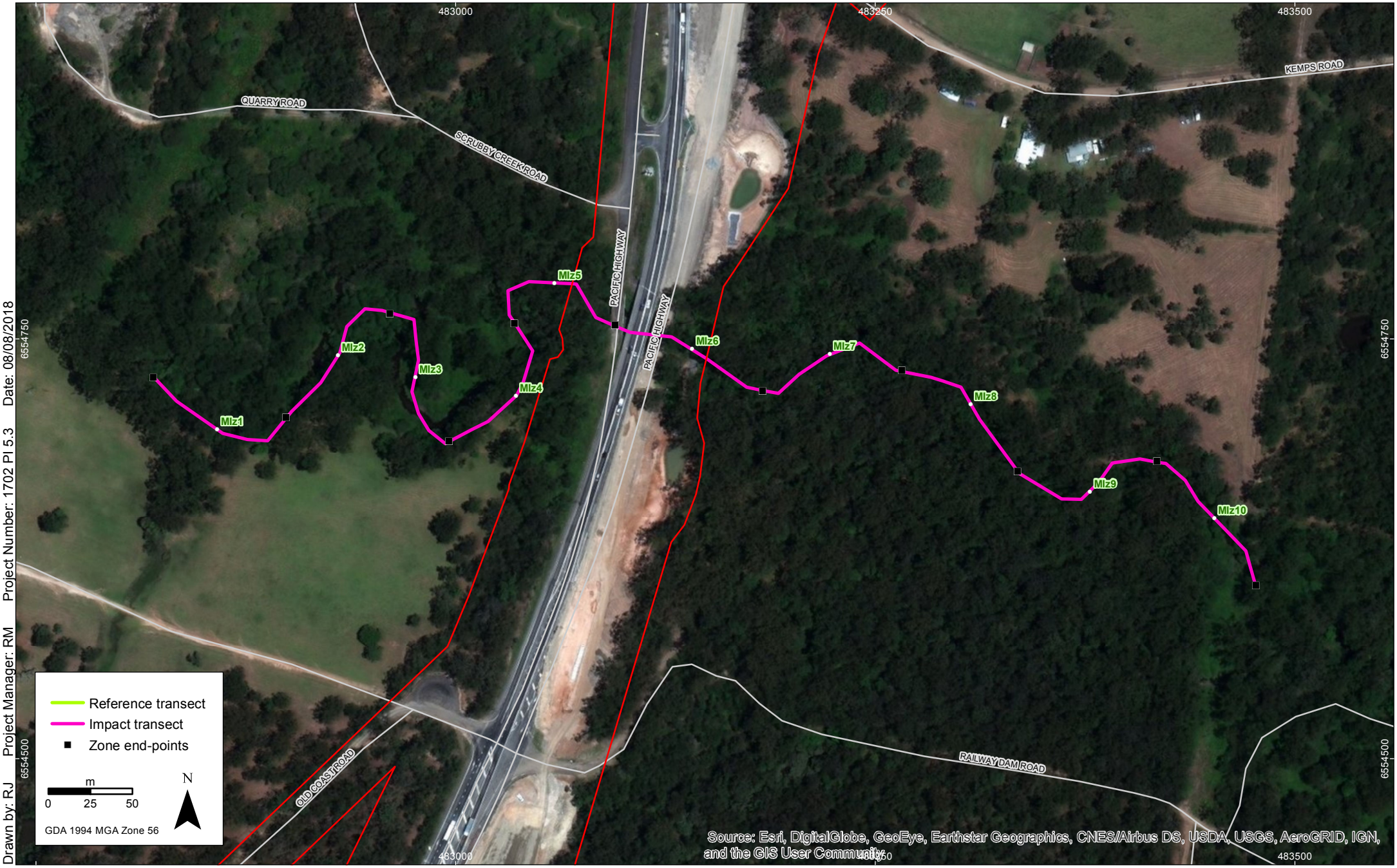
Pacific Highway Upgrade - Oxley Highway to Kempsey

niche Environment and Heritage

T:\spatial\projects\a1700\a1702_OH2K_Ecology\Maps\PI_5_Ecology_OH2K\PI_53_GiantBarredFrogMonitoring\20180807_report\1702_53_Figures_2_7_GBF_Sites.mxd

FIGURE 4

Imagery: (c) DigitalGlobe



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

Giant Barred Frog monitoring: Maria River impact site

Pacific Highway Upgrade - Oxley Highway to Kempsey

FIGURE 5

Imagery: (c) DigitalGlobe

niche Environment and Heritage

T:\spatial\projects\a1700\a1702_OH2K_Ecology\Maps\PI_5_Ecology_OH2K\PI_53_GiantBarredFrogMonitoring\20180807_report\1702_53_Figures_2_7_GBF_Sites.mxd

Giant Barred Frog monitoring: Cooperabung Creek reference site

Pacific Highway Upgrade - Oxley Highway to Kempsey

niche Environment and Heritage

T:\spatial\projects\a1700\a1702_OH2K_Ecology\Maps\PI_5_Ecology_OH2K\PI_53_GiantBarredFrogMonitoring\20180807_report\1702_53_Figures_2_7_GBF_Sites.mxd

FIGURE 6

Imagery: (c) DigitalGlobe

Giant Barred Frog monitoring: Pipers Creek reference site

Pacific Highway Upgrade - Oxley Highway to Kempsey

niche Environment and Heritage

T:\spatial\projects\a1700\a1702_OH2K_Ecology\Maps\PI_5_Ecology_OH2K\PI_53_GiantBarredFrogMonitoring\20180807_report\1702_53_Figures_2_7_GBF_Sites.mxd

FIGURE 7

Imagery: (c) DigitalGlobe

3. Results

3.1 2022/2023 Giant Barred Frog Monitoring Results

Field data are presented in Annex 1 and Annex 2. Survey dates and trigger rainfall events measured at Port Macquarie Airport (Station No. 060168) weather station for summer and autumn and Kempsey Weather Station (Station No. 059007) for spring were as follows:

- 25 – 27 October 2022 (spring): 37.4 millimetres recorded on 24 October 2022 prior to surveys
- 15 - 17 February 2023 (summer): 21.6 millimetres recorded on 15 February 2023 prior to surveys
- 3 - 4 April 2023 (autumn): 22.8 millimetres recorded on 29 March 2023 prior to surveys.

3.1.1 Survey results

A total of 54 Giant Barred Frogs were recorded in spring, summer and autumn during the 2022/2023 monitoring surveys. Giant Barred Frogs were recorded at four of the six sites during spring, summer and autumn surveys (Table 1). Of the 54 frogs recorded, 44 were captured, of which four were recaptures (9%). Frogs were absent from the Cooperabung Creek reference site in all seasons. In spring, frogs were recorded at Pipers Creek impact site (1), Pipers Creek reference site (15), Smiths Creek impact site (3) and Cooperabung impact site (2). In summer, frogs were recorded at Cooperabung Creek impact site (2), Maria River impact site (3), Pipers Creek impact site (2) and Pipers Creek reference site (14). In autumn, frogs were recorded at Cooperabung Creek impact site (1), Maria River impact site (1), Pipers Creek impact site (1) and Pipers Creek reference site (9). The Pipers Creek reference site recorded the highest mean number of Giant Barred Frogs, with frogs recorded in spring, summer and autumn.

The cumulative MNA (10 years) is highest at the Pipers Creek reference site (MNA = 228) and Smiths Creek impact site (MNA = 125). As mentioned in Section 2.4, this estimate of MNA is likely an overestimate of the population as calculation of the MNA does not take dispersal or deaths into account.

Table 1: Giant Barred Frogs recorded at each site during 2022/2023 surveys

Data set	Cooperabung Creek impact	Smiths Creek impact	Pipers Creek impact	Maria River impact	Cooperabung Creek reference	Pipers Creek reference
Spring (2022)	2	3	1	0	0	15
Summer (2023)	2	0	2	3	0	14
Autumn (2023)	1	0	1	1	0	9
Mean number of frogs over the monitoring period	1.7	1	1.3	1.3	0	12.7
Standard Error (SE)	0.6	1.7	0.6	1.5	0	3.2
Recaptures	1	0	1	0	0	2
New captures	4	3	3	3	0	27
Uncaptured	0	0	0	1	0	9
Total	5	3	4	4	0	38
Cumulative MNA	63	125	56	99	74	228

3.1.2 Evidence of breeding

Table 2 presents records of breeding evidence. Evidence of breeding via the presence of juveniles or sub-adults, gravid females or reproductive males was observed at all sites where frogs were recorded during at least one survey event during 2022/2023.

Table 2: Breeding evidence records 2022/2023

Monitoring site	Season	Juveniles	Sub-adults	Gravid females	Nuptial pads
Cooperabung Creek impact	Spring			2	
	Summer				
	Autumn	1			
Maria River impact	Spring				
	Summer				
	Autumn				
Pipers Creeks impact	Spring				
	Summer			1	
	Autumn				
Smiths Creek impact	Spring			1	1
	Summer				
	Autumn				
Cooperabung Creek reference	Spring				
	Summer				
	Autumn				
Pipers Creek reference	Spring		3		
	Summer	1			
	Autumn	1			

3.1.3 Weather conditions

The prevailing weather conditions encountered during the field surveys are summarised in Table 3 (Port Macquarie Airport, Station No. 060168). Additional details of the prevailing micrometeorological conditions at the six sites during the field surveys are presented in Annex 1.

Table 3: Weather conditions: 2022/2023 surveys

Date	Min temp (˚C)	Max temp (˚C)	Humidity (%)	Rainfall 24 hours prior (mm)	Rainfall 7 days (mm)	Rainfall 30 days (mm)
25/10/2022*	14.7	28.5	57	14.6	113	152.4
26/10/2022*	14.4	29.7	48	6.2	119	158.6
27/10/2022*	14.2	30.5	56	0	114.2	158.4
15/02/2023	16.7	26.4	62	21.6	22.8	107.8
16/02/2023	13.3	27.2	58	0	22.8	103
17/02/2023	13.7	28.1	60	0	22.8	98.2
03/04/2023	15.4	21.1	86	6.4	70.2	259.6
04/04/2023	15.9	22.3	93	11.6	42.8	271.2
05/04/2023	17.5	24.8	71	21.6	41.6	291.2

*= Weather taken from Kempsey Weather Station due to missing weather data for the Port Macquarie Weather Station.

3.1.4 Habitat use

Habitat information collected for each site is presented in Annex 1. Microhabitat use was highly variable. Frogs were recorded on, and buried within, leaf litter, using flood debris as shelter, on bare ground or creek banks and under logs and vegetation. Most frogs were captured between 1-10 metres from the creeks, with the furthest frog being found 20 metres from the creek.

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

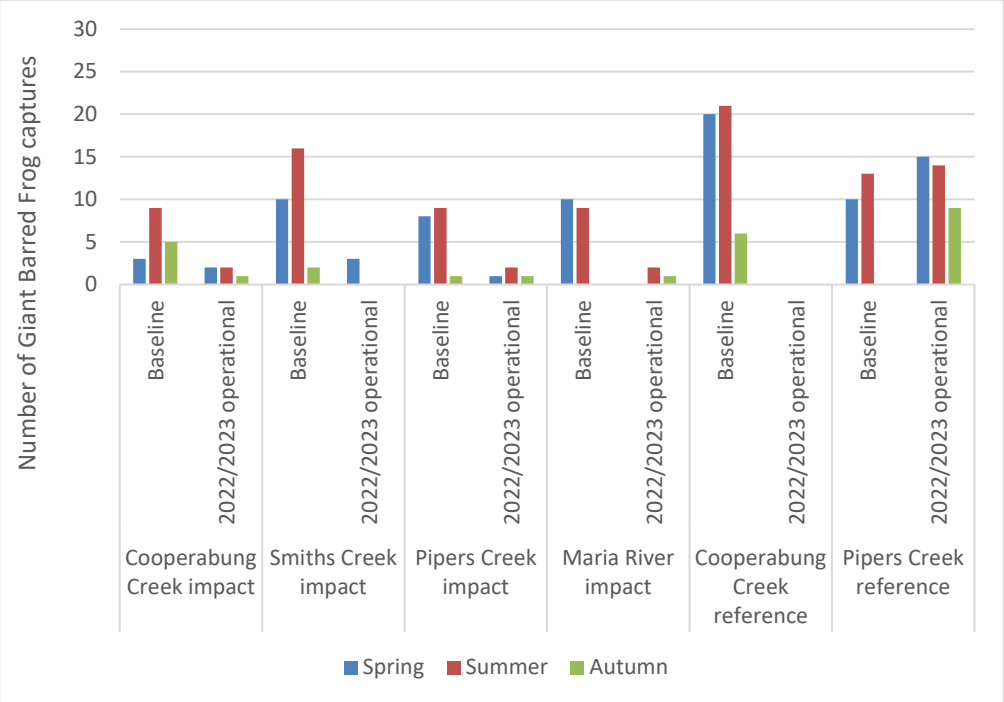
3.2 Comparison with Previous Surveys

3.2.1 Baseline and 2022/2023 surveys

Graph 1 presents the Giant Barred Frog records for baseline and the 2022/2023 operational monitoring surveys.

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

Giant Barred Frogs were recorded at four of the six sites during spring, summer and autumn during 2022/2023 surveys. Giant Barred Frogs were not recorded at Cooperabung Creek reference site during the 2022/2023 surveys, where it was recorded during baseline surveys. Giant Barred Frogs were not recorded at Maria River impact site in spring or Smiths Creek impact site in summer and autumn where it was recorded during baseline surveys.



Graph 1: Giant Barred Frog records: baseline and 2022/2023 monitoring

3.2.2 Annual mean records

The mean number of records each year for each site is shown in Graph 2. All sites have demonstrated a general decreasing trend in the average number of captures at each montoring event since 2018/2019.

The mean number of Giant Barred Frogs recorded at Cooperabung Creek impact site and Cooperabung Creek reference site has decreased annually since 2015/2016. However, frogs were recorded at the Cooperabung Creek impact site in the last two monitoring years after not being detected for two consecutive years (2019/2020 and 2020/2021). Frogs were again not detected at Cooperabung Creek reference site and have not been detected there since summer 2020.

A similar annual decrease is evident at Pipers Creek impact site, however the mean number of frogs captured increased during 2021/2022 monitoring period and remained at the same level during the 2022/2023 monitoring period.

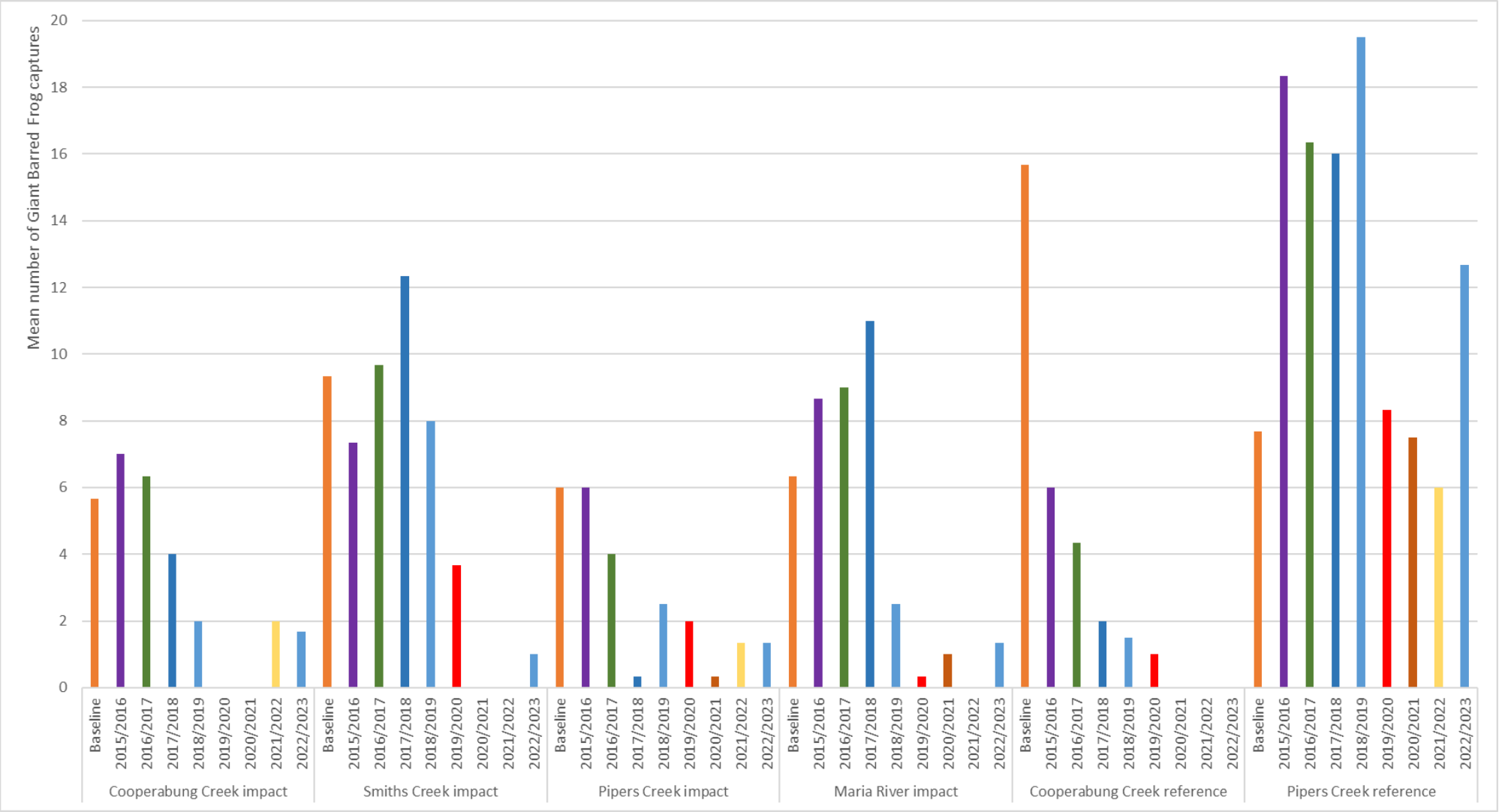
The mean number of Giant Barred Frogs recorded at Pipers Creek reference site increased substantially above baseline during the 2015/2016 monitoring period, where it remained stable, until decreasing back to baseline levels in 2019/2020 and subsequently below baseline in 2020/2021 and 2021/2022 monitoring periods. During 2022/2023 monitoring recorded another substainial increase, taking the mean number of frogs above baseline.

The mean number of Giant Barred Frogs recorded at Smiths Creek impact site and Maria River impact site increased annually from 2015/2016 until 2018/2019. After this time the mean decreased substantially at both these sites and has continued to decrease, such that no frogs were recorded at Simths Creek impact and Maria River impact sites during 2021/2022. The 2022/2023 montioring recorded low levels of frogs recorded again at both Maria River and Smiths Creek.

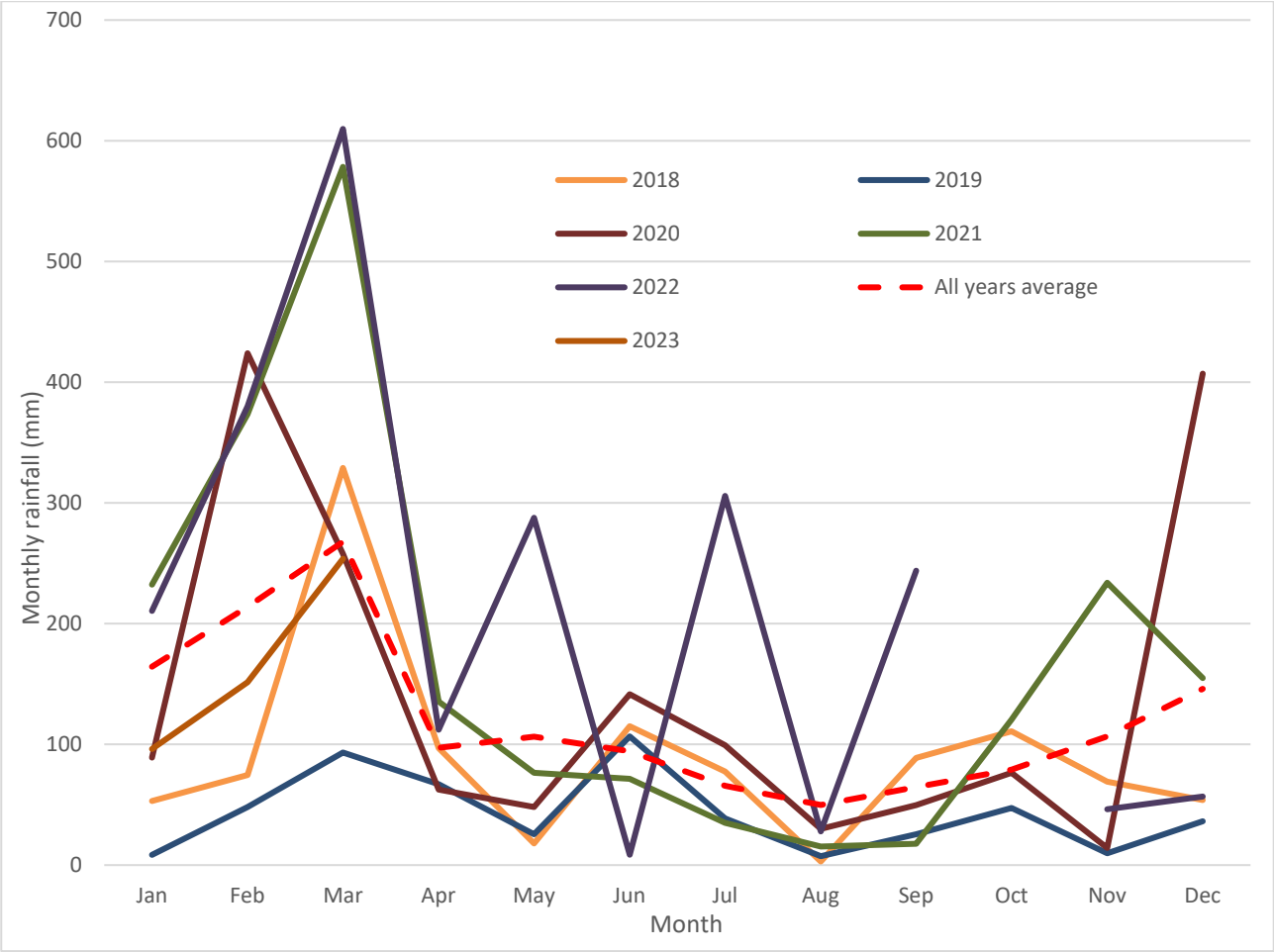
The mean number of Giant Barred Frogs recorded during the current monitoring period increased from the previous monitoring event at three of the six sites, Smiths Creek impact, Maria River impact and Pipers Creek reference. The remaining three sites decreased or remained the same. Mean records at all sites except for the Pipers Creek reference sites are currently lower than baseline and decreasing trends have been evident at both reference and impact sites.

The above-average rainfall conditions observed over the spring/summer periods of 2020/2021 and 2021/2022 follow the long-term drought conditions experienced across the Project area in 2019. It is possible that the population changes observed at all sites are in response to these changing conditions. A population response to improved waterway conditions after the 2020/2021 and 2021/2022 rainfall may be evidenced by the increased capture rates at some sites, but also hindered by difficult (flooding) survey conditions.

Given the lack of a distinct difference in population trends between impact and reference sites, it is not possible to attribute observed changes in frog numbers to the Project.



Graph 2: Mean annual Giant Barred Frog records by site



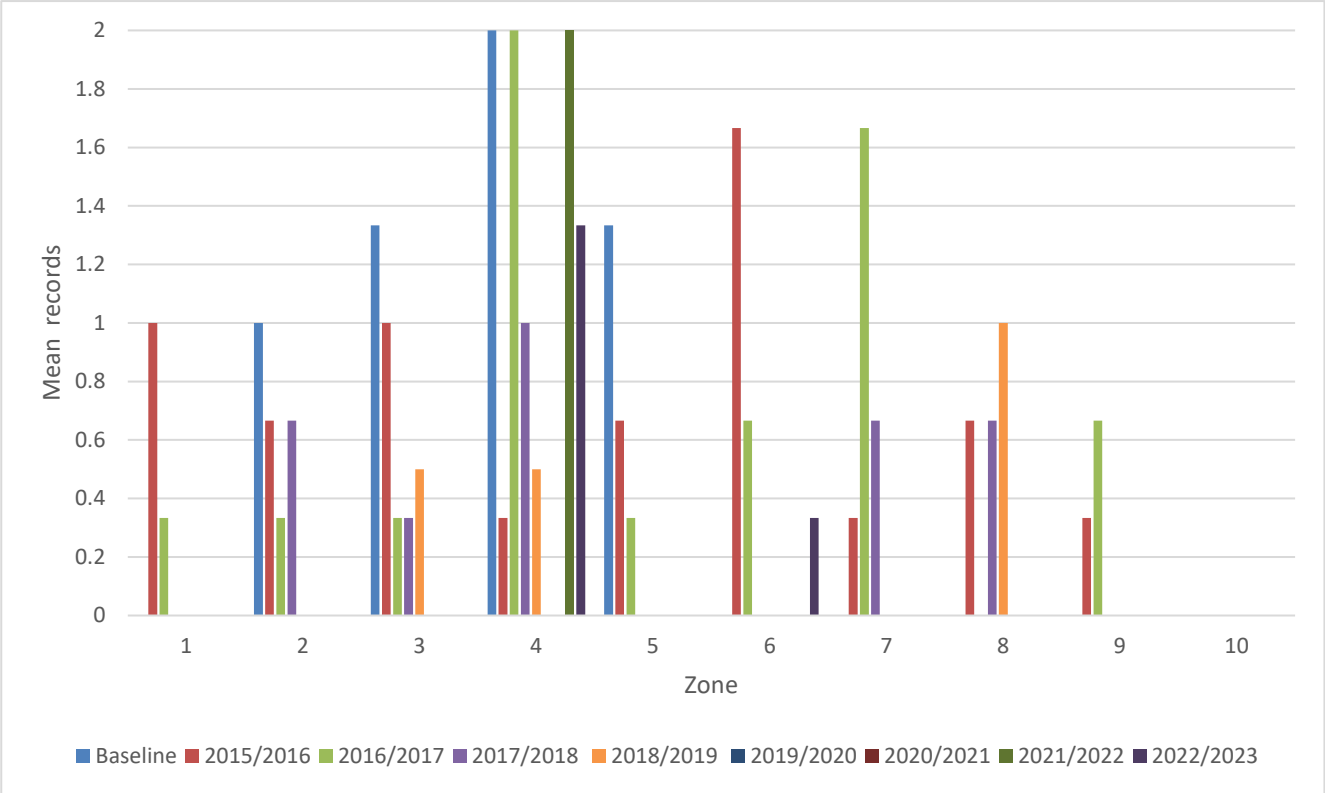
Graph 3: Monthly rainfall – All years monthly average and 2018-2023 monthly total rainfall

3.3 Density and Distribution

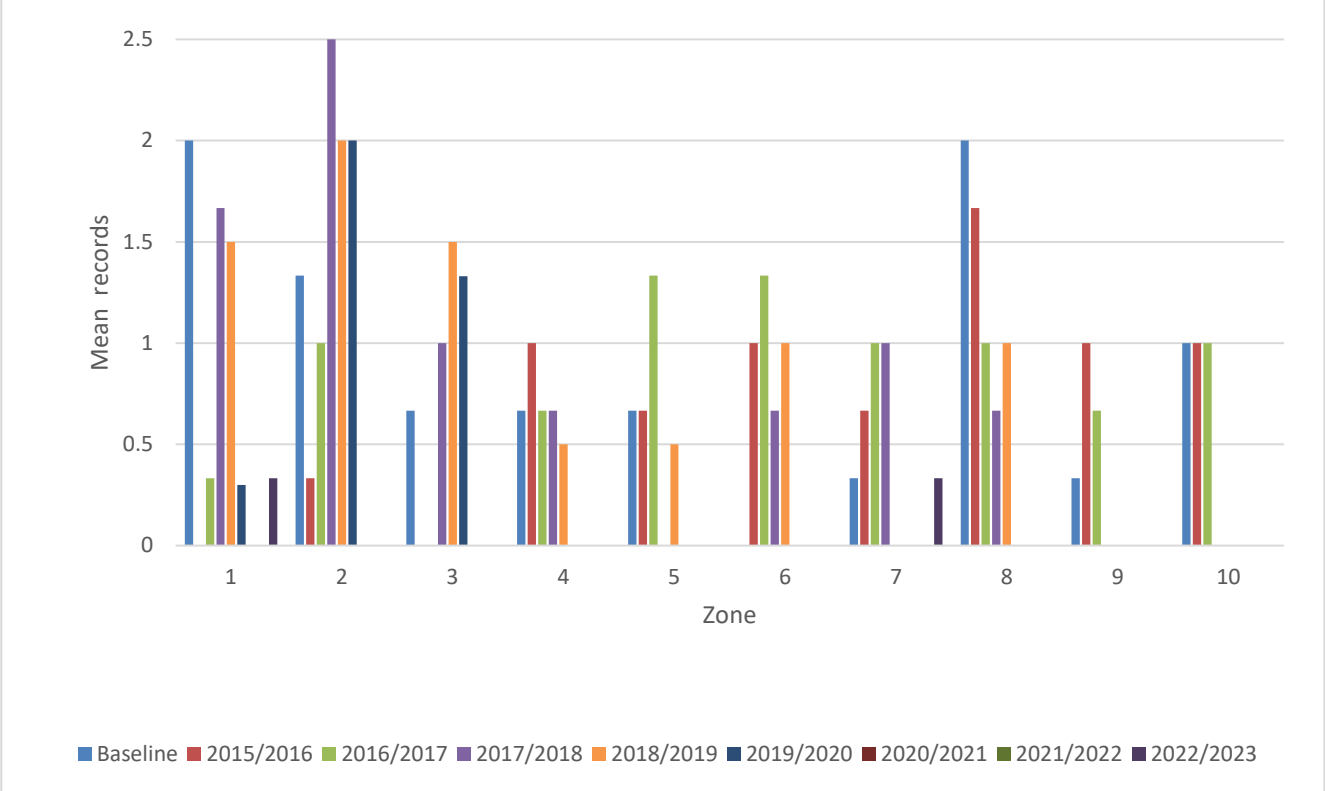
Graph 4 - Graph 9 present the density (*annual mean number of Giant Barred Frog records per zone*) and distribution of Giant Barred Frog records along the survey transect for each site and each monitoring period. Figure 8 - Figure 13 show the total number of captures within each zone over all monitoring periods.

The density of Giant Barred Frogs has been considered as the *mean number of records per year per zone* (Graph 4 to Graph 9). While the zones may vary in size slightly due to the nature of the creek's bank formation and the non-linear nature of the creek line, the zones themselves are consistent between years. As such comparisons can be made within the same zone between years to help identify trends in changing frog numbers. There is no consistent trend evident at any site for frogs to be found in any particular zone. Density appears to be highly variable across the years and along the transect and there is no evidence of lower frog densities within zones 5 and 6, i.e. under the carriageway and immediately adjacent.

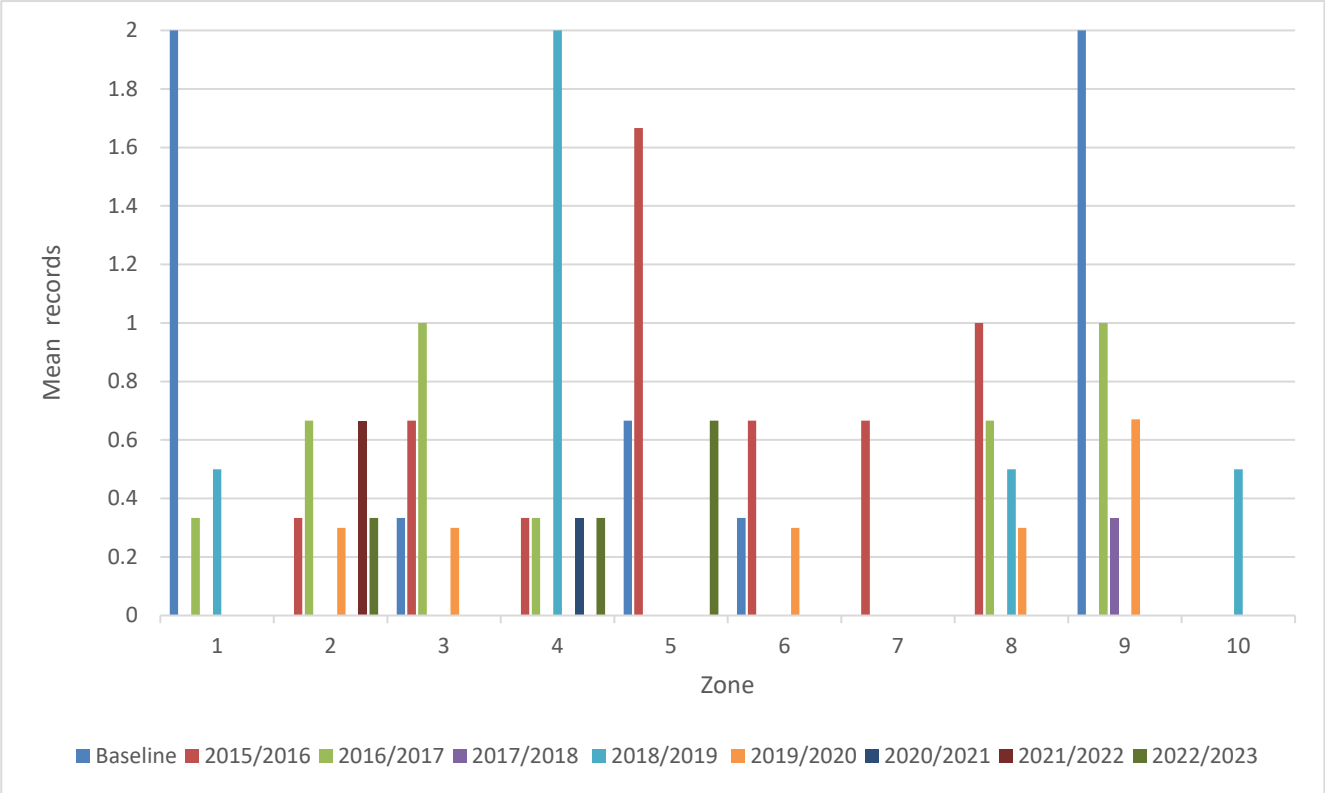
Figure 8 - Figure 13 show all capture records (i.e. cumulative records), whereby capture records (including recaptures) are shown as count ranges, where larger circles indicate larger frog counts. While density data indicates that frog distribution along the transects varies from year to year, when considering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



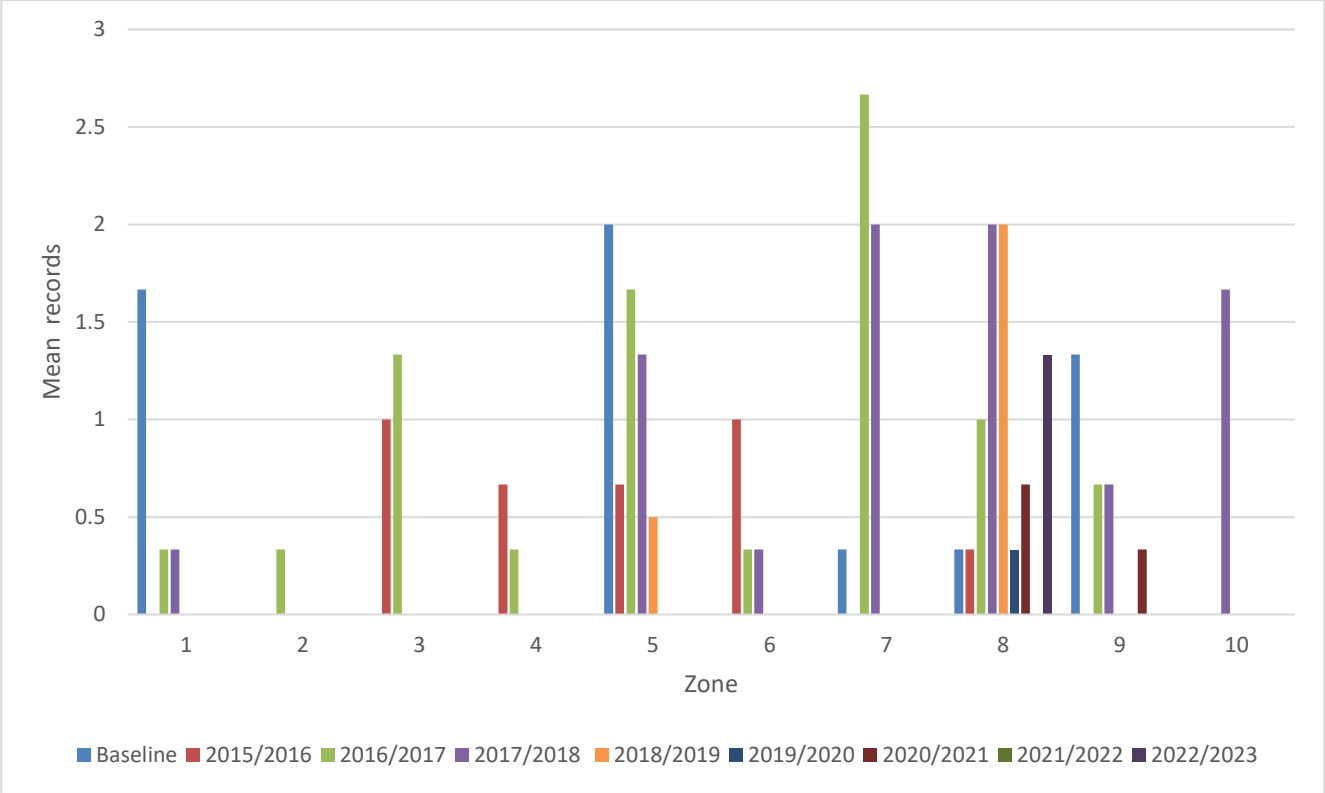
Graph 4: Cooperabung Creek impact site: mean number of Giant Barred Frogs per zone



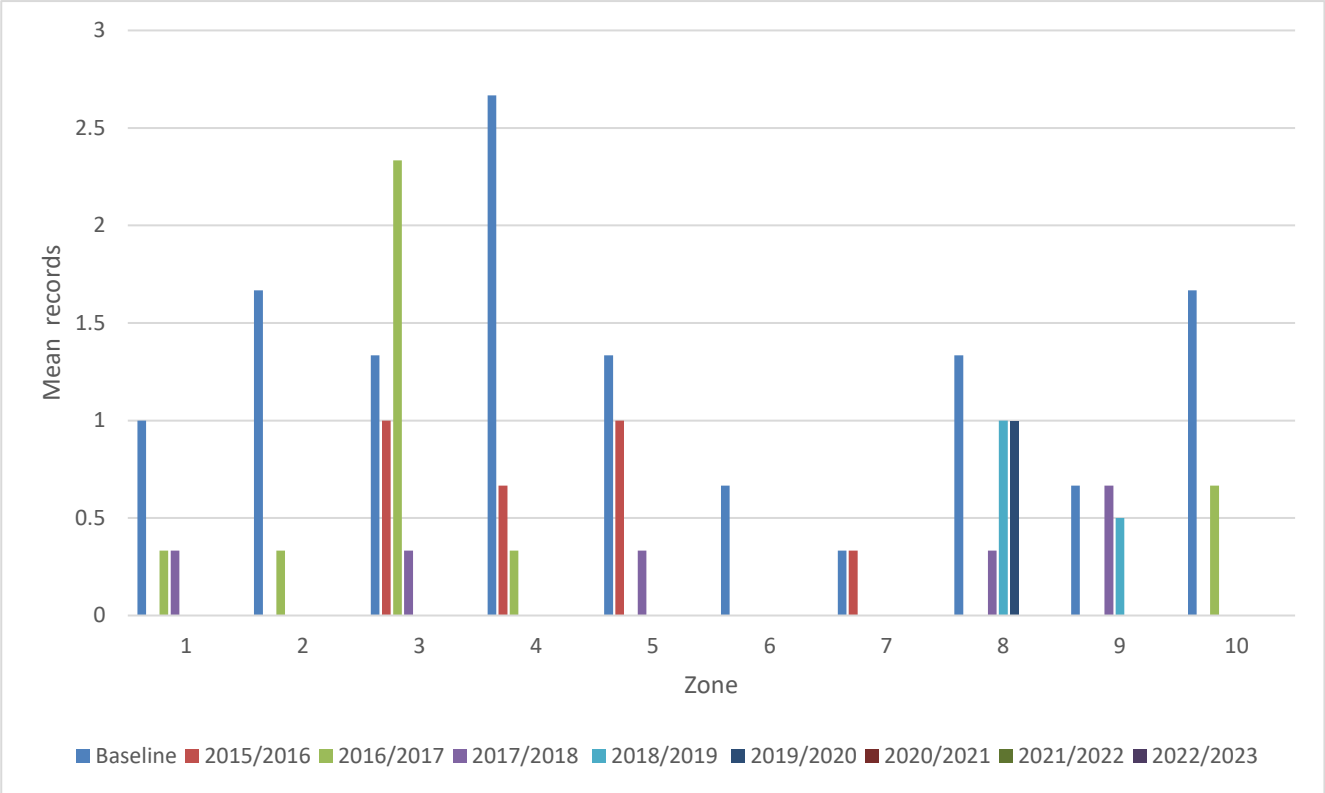
Graph 5: Smiths Creek impact site: mean number of Giant Barred Frogs per zone



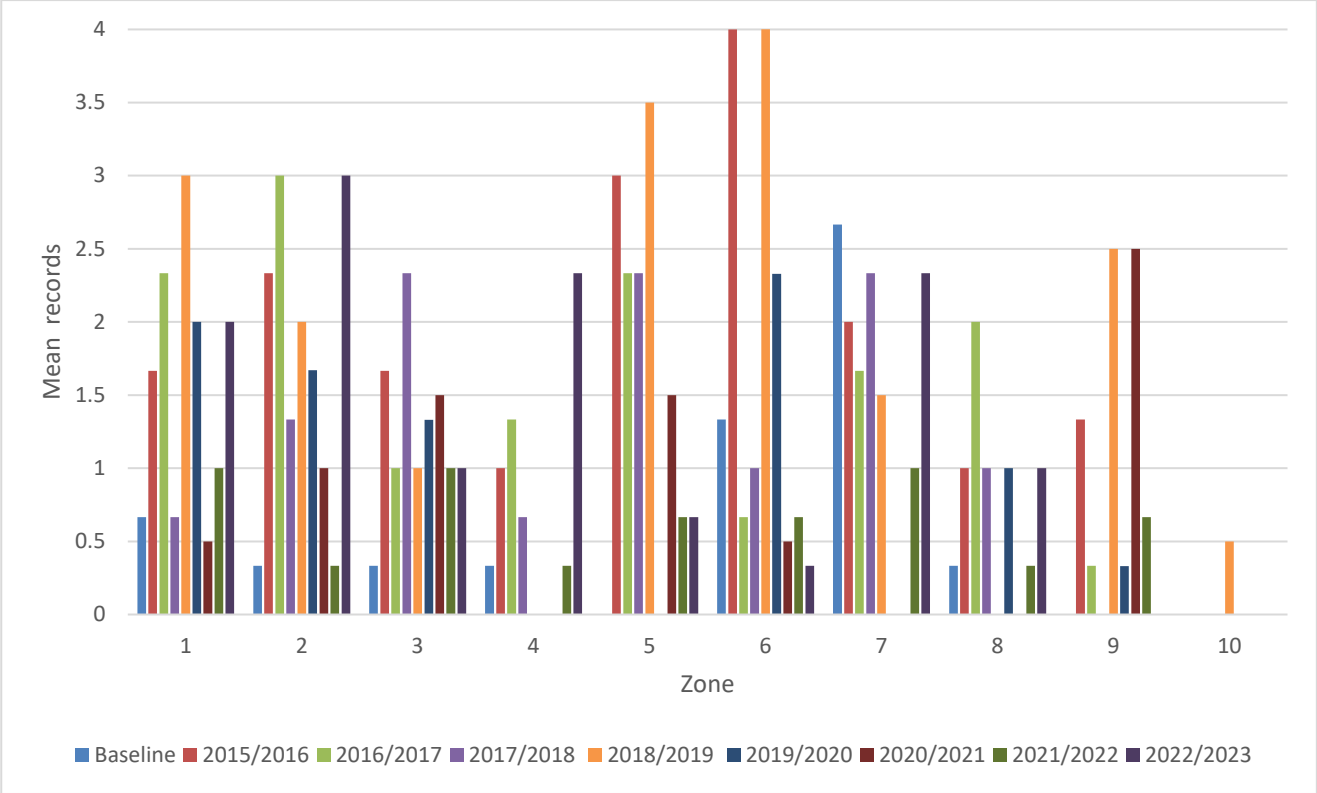
Graph 6: Pipers Creek impact site: mean number of Giant Barred Frogs per zone



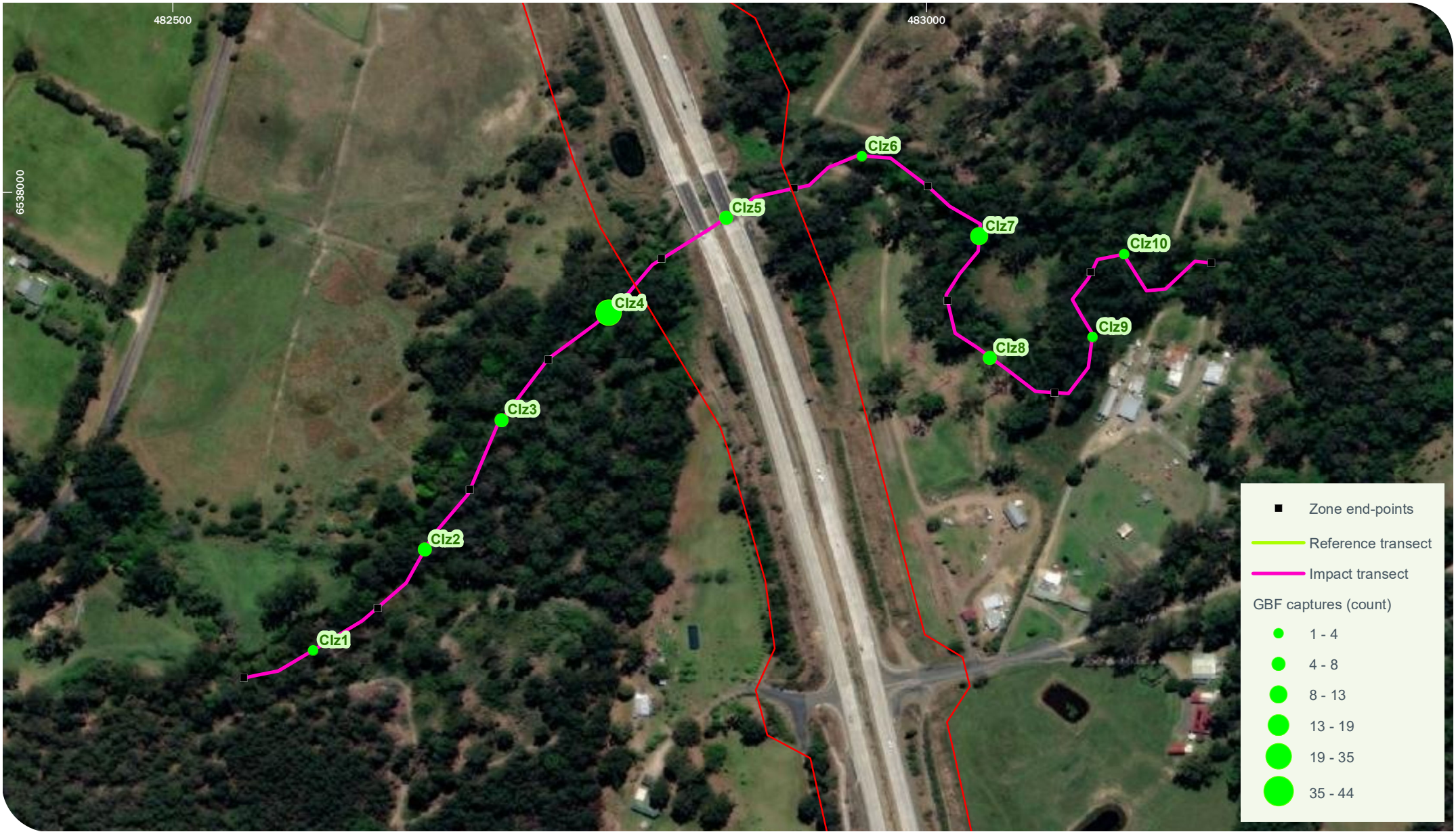
Graph 7: Maria River impact site: mean number of Giant Barred Frogs per zone



Graph 8: Cooperabung Creek reference site: mean number of Giant Barred Frogs per zone



Graph 9: Pipers Creek reference site: mean number of Giant Barred Frogs per zone



niche Environment and Heritage

0 80
m
GDA 1994 MGA Zone 56

Niche PM: Jodie Danvers
Niche Proj. #: 1702 PI 5.3
Client: Transport for NSW

Giant Barred Frog capture distribution: Cooperabung Creek impact site

Pacific Highway Upgrade - Oxley Highway to Kempsey

Figure 8

Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Drawn by: Last updated: 4/12/2023 1:59:18 PM File: T:\spatial\projects\a1700\a1702_OH2K_Ecology\Maps\PI_5_Ecology_OH2K\PI_53_GiantBarredFrogMonitoring\20230412_GBF_Counts\1702_53_Figures_8_13_GBF_Counts2022.mxd

niche Environment and Heritage

N

0 100

m

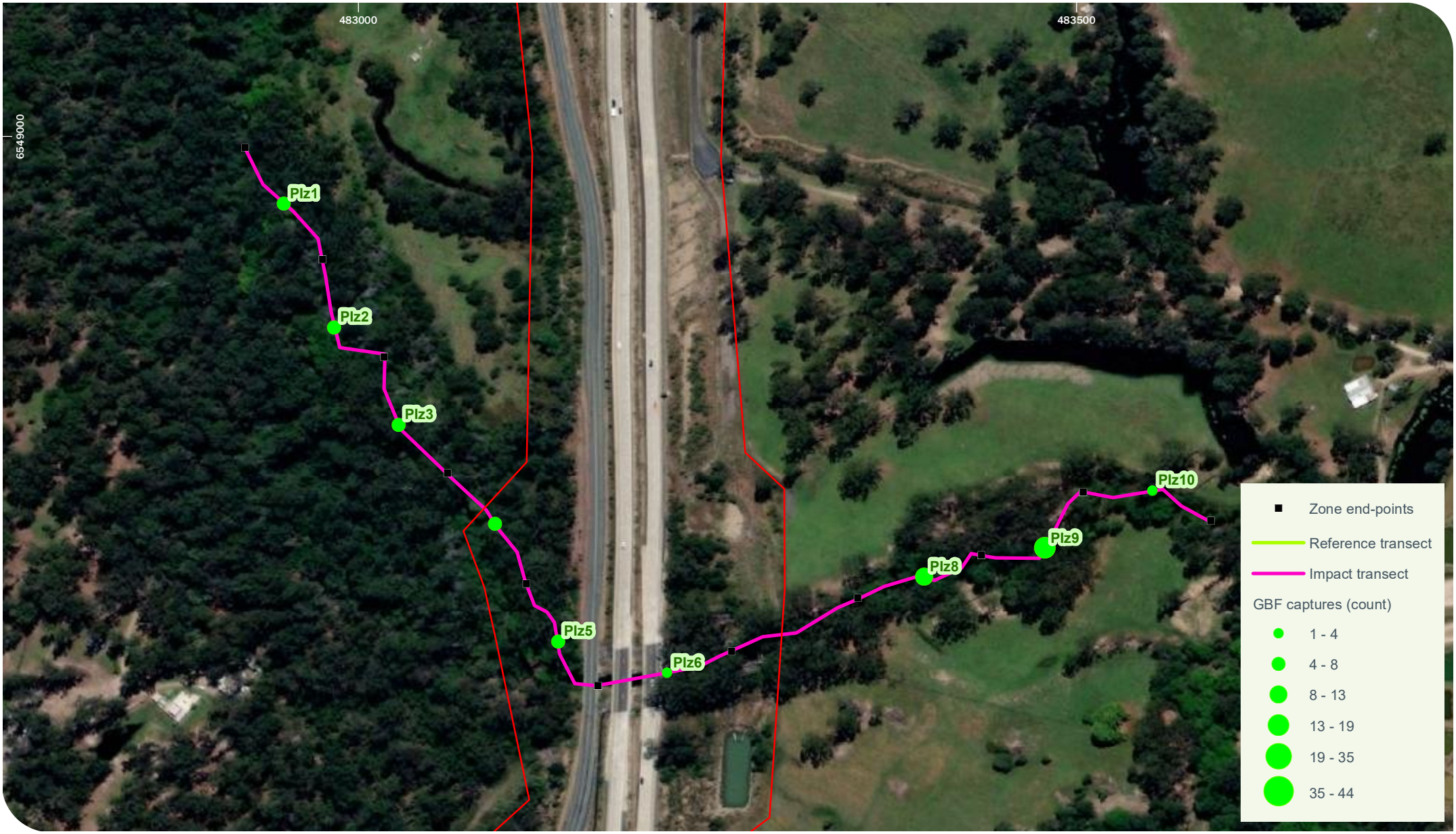
GDA 1994 MGA Zone 56

Niche PM: Jodie Danvers
Niche Proj. #: 1702 PI 5.3
Client: Transport for NSW

Giant Barred Frog capture distribution: Smiths Creek impact site

Pacific Highway Upgrade - Oxley Highway to Kempsey

Figure 9



niche Environment and Heritage

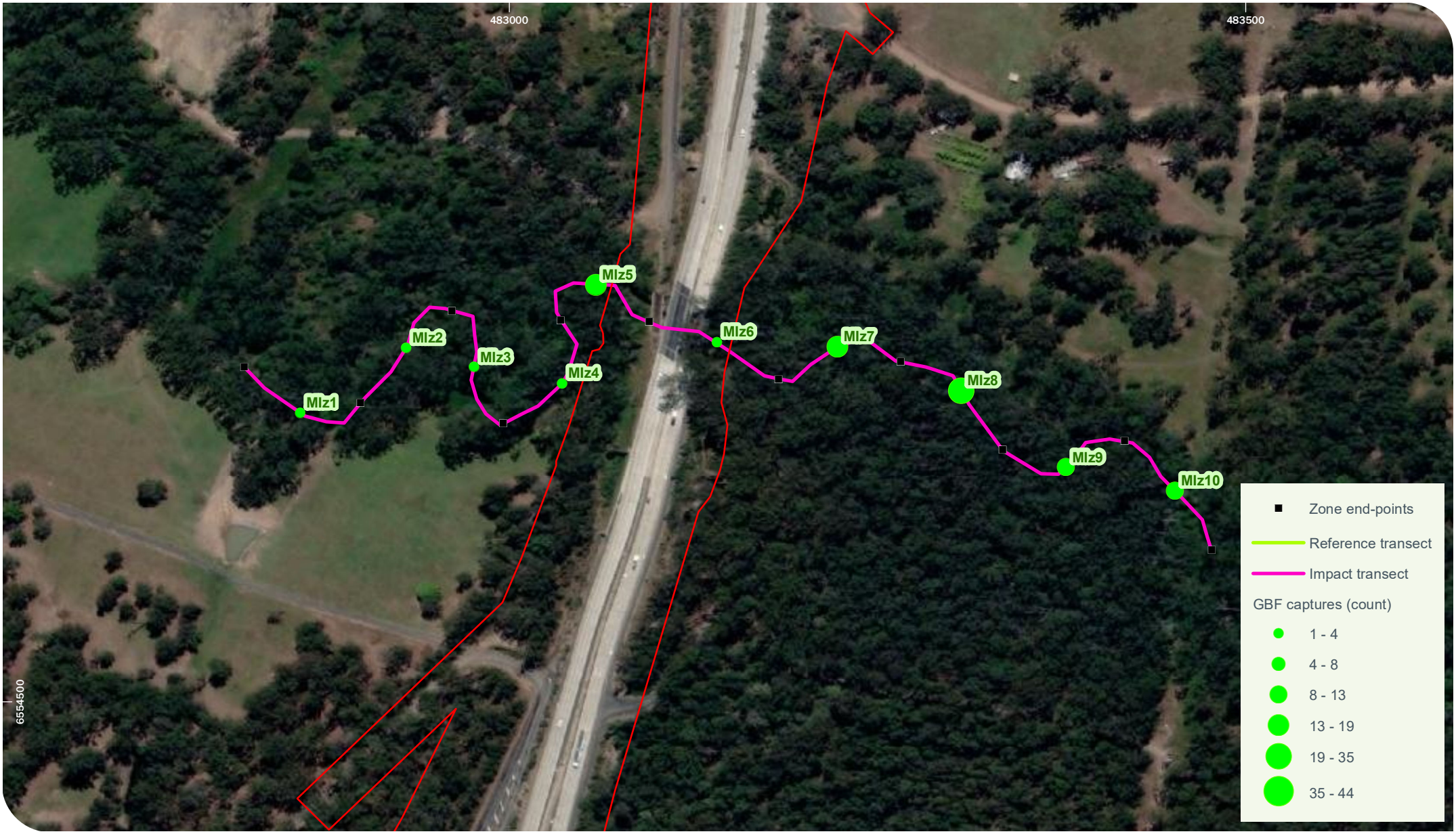
0 80
m
GDA 1994 MGA Zone 56

Niche PM: Jodie Danvers
Niche Proj. #: 1702 PI 5.3
Client: Transport for NSW

Giant Barred Frog capture distribution: Pipers Creek impact site

Pacific Highway Upgrade - Oxley Highway to Kempsey

Figure 10



niche Environment and Heritage

0 80
m
GDA 1994 MGA Zone 56

Niche PM: Jodie Danvers
Niche Proj. #: 1702 PI 5.3
Client: Transport for NSW

Giant Barred Frog capture distribution: Maria River impact site

Pacific Highway Upgrade - Oxley Highway to Kempsey

Figure 11

niche Environment and Heritage

0 100
m
GDA 1994 MGA Zone 56

Niche PM: Jodie Danvers
Niche Proj. #: 1702 PI 5.3
Client: Transport for NSW

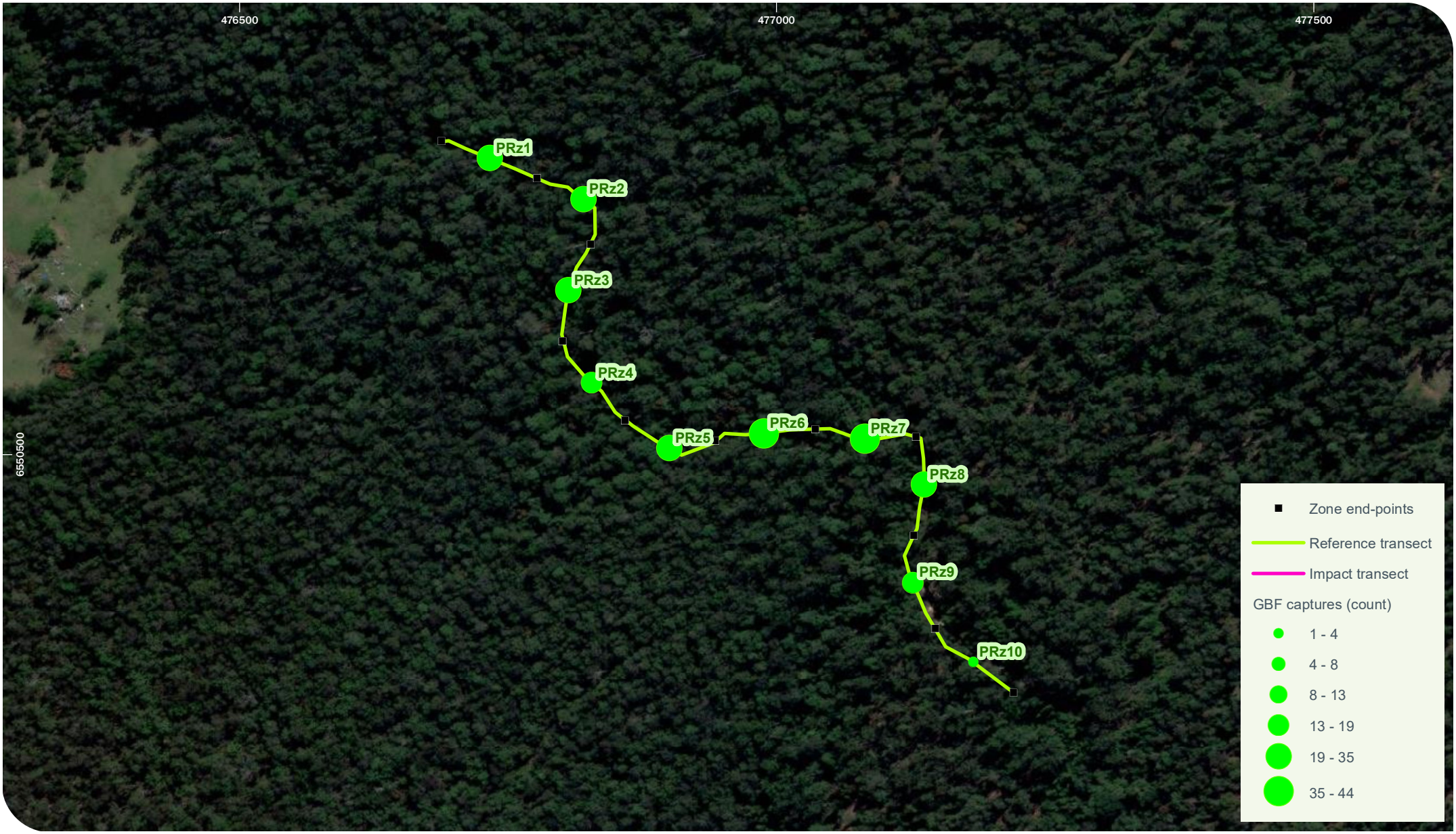
Giant Barred Frog capture distribution: Cooperabung Creek reference site

Pacific Highway Upgrade - Oxley Highway to Kempsey

Figure 12

Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Drawn by: Last updated: 4/12/2023 1:59:18 PM File: T:\spatial\projects\a1700\a1702_OH2K_Ecology\Maps\PI_5_Ecology_OH2K\PI_53_GiantBarredFrogMonitoring\20230412_GBF_Counts\1702_53_Figures_8_13_GBF_Counts2022.mxd



niche Environment and Heritage

0 100
m
GDA 1994 MGA Zone 56

Niche PM: Jodie Danvers
Niche Proj. #: 1702 PI 5.3
Client: Transport for NSW

Giant Barred Frog capture distribution: Pipers Creek reference site

Pacific Highway Upgrade - Oxley Highway to Kempsey

Figure 13

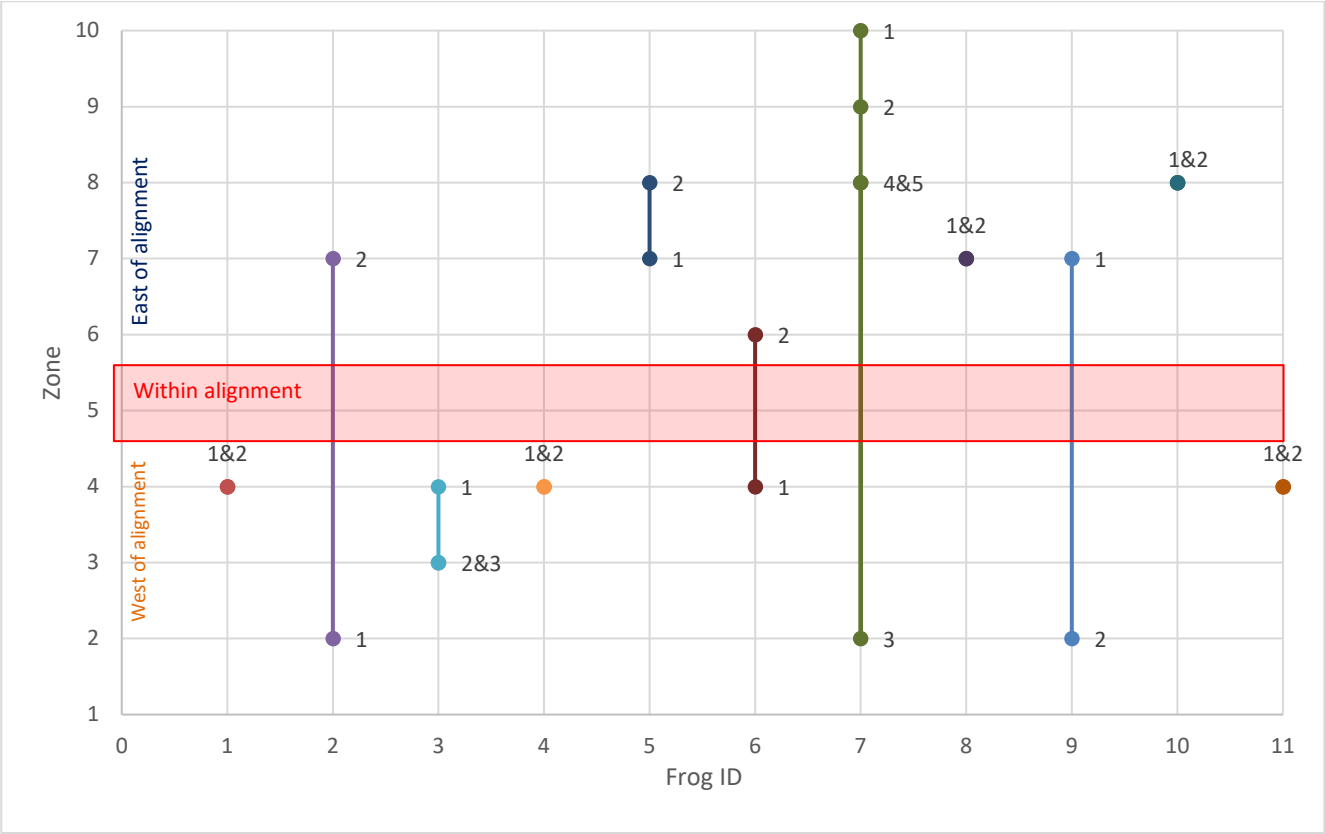
3.4 Movement

Recapture data of PIT-tagged individuals was used to determine movements along the transects, and notably, past the midpoint of the transect i.e. from one side of the carriageway to the other at the impact sites. It should be noted that this analysis does not imply that individuals that have not been found on opposite sides of the carriageway have not traversed at some time. Graph 10 - Graph 15 show the movement patterns of individual recaptured Giant Barred Frogs at each site and the data is summarised for each site below. As reference sites by their nature do not traverse the carriageway, a transect midpoint has been included to provide an indication of movements along the transects and permit comparison between reference and impact sites. The reference transect midpoint was chosen as the arbitrary location by which to assess movement along the transect (i.e. equal zones on either side). It should be noted that comparisons made between impact and reference sites do not take into account other potentially confounding factors such as site specific population ecology. Capture order is indicated by the numbers beside each capture point and a single capture point indicates recaptures within the same zone.

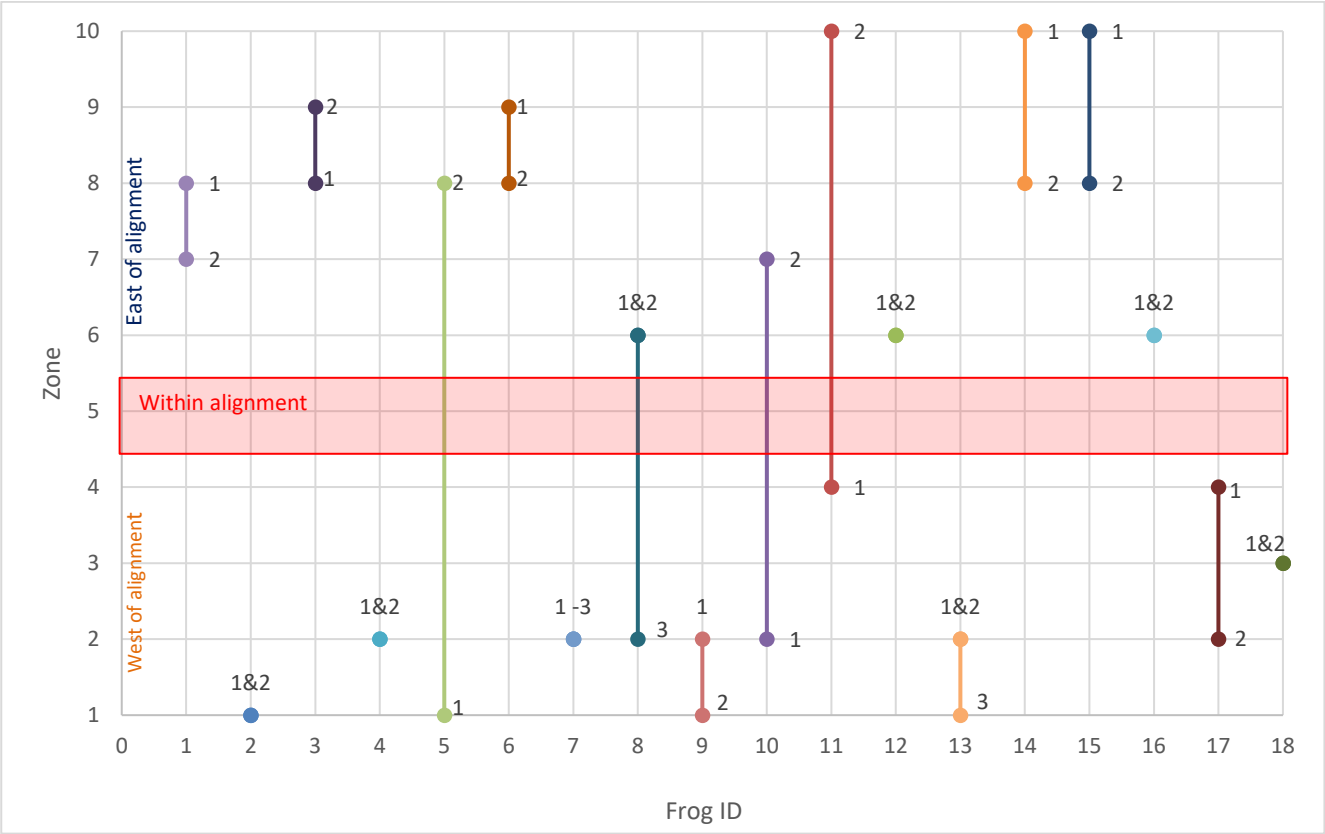
A total of 96 individuals have been recaptured on at least one occasion over all monitoring events. Of these, 52 recaptures have occurred at the impact sites. Twelve (23%) of these individuals from impact sites have been captured on both sides of the carriageway over successive monitoring events, demonstrating retained connectivity for this species under the carrageway. Of the 44 recaptures at the reference sites, 12 (27%) have been captured on both sides of the midpoint over successive monitoring events. The results at each of the monitoring sites are as follows:

- *Cooperabung Creek impact site*: Eleven Giant Barred Frogs have been recaptured over all monitoring periods. Of these individuals, four (36%) have been captured on both sides of the carriageway, including one individual (ID#7) that traversed on at least two occasions.
- *Smiths Creek impact site*: Eighteen Giant Barred Frogs have been recaptured over all monitoring periods. Of these individuals, four (22%) have been captured on both sides of the carriageway.
- *Pipers Creek impact site*: Fourteen Giant Barred Frogs have been recaptured over all monitoring periods. Of these individuals, three (21%) have been captured on both sides of the carriageway.
- *Maria River impact site*: Nine Giant Barred Frogs have been recaptured over all monitoring periods. Of these individuals, one (11%) has been captured on both sides of the carriageway.
- *Cooperabung Creek reference site*: Nine Giant Barred Frogs have been recaptured over all monitoring periods. Of these individuals, two (22%) have been captured on both sides of the transect midpoint.
- *Pipers Creek reference site*: Thirty-fve Giant Barred Frogs have been recaptured over all monitoring periods. Of these individuals, ten (29%) have been captured on both sides of the transect midpoint. including three individuals (ID#18, 19 and 23) that have traversed on at least two occasions.

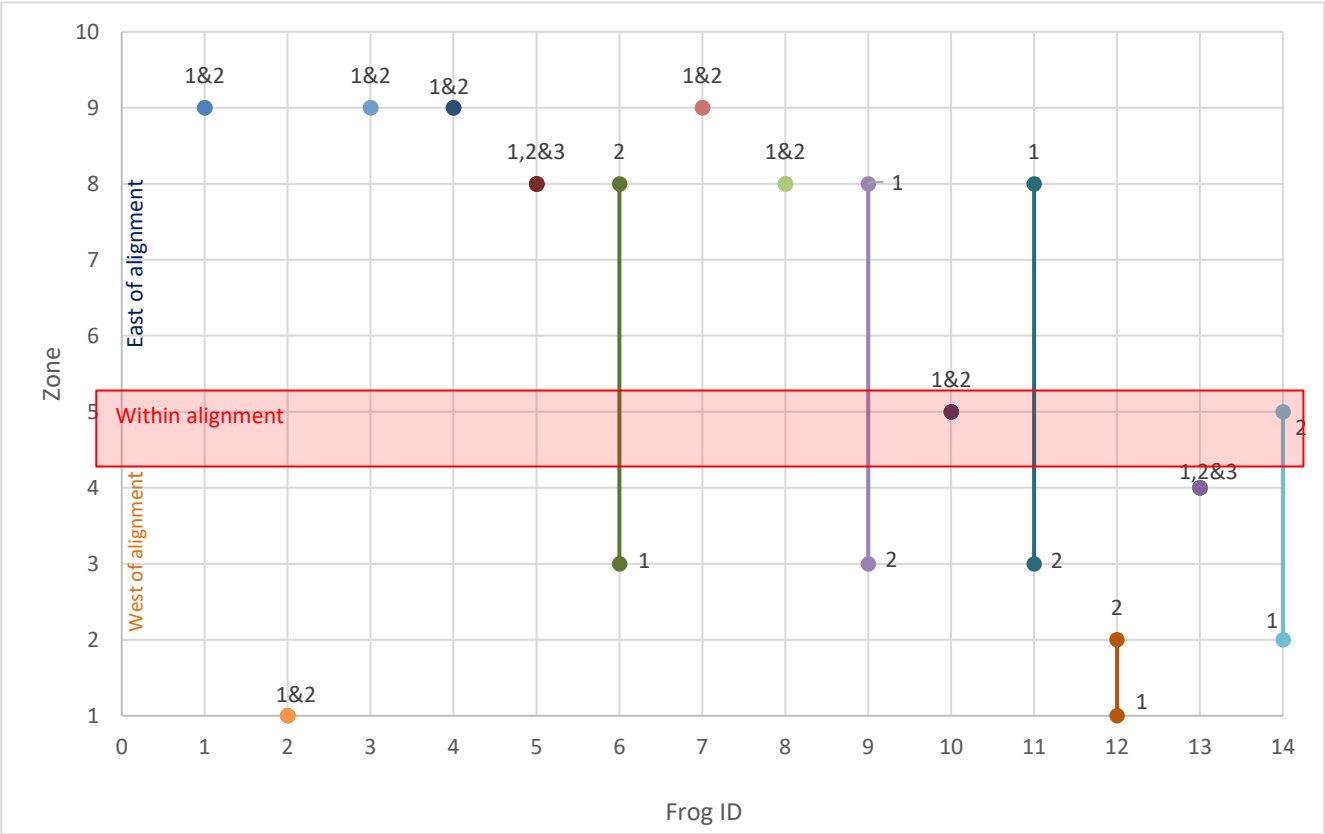
At the impact sites, while the monitored waterways continue uninterrupted under the carriageway, there is a distinct change in streamside vegetation within the area immediately under the carriageway. Under the carriageway at all impact sites, streamside vegetation ranges from limited to moderately dense, represented by patches of shrubs and/or *Lomandra* spp. The streamside habitat in these areas consists of native vegtation,large rocks and boulders or bare ground. Despite changes in streamside habitat immediately under the carriageway, a number of Giant Barred Frogs have been recorded traversing the carriageway. The percentage of Giant Barred Frogs found to have traversed the impact site midpoints do not appear to differ substantially from the percentage of Giant Barred Frogs found to have traversed the reference site midpoints.



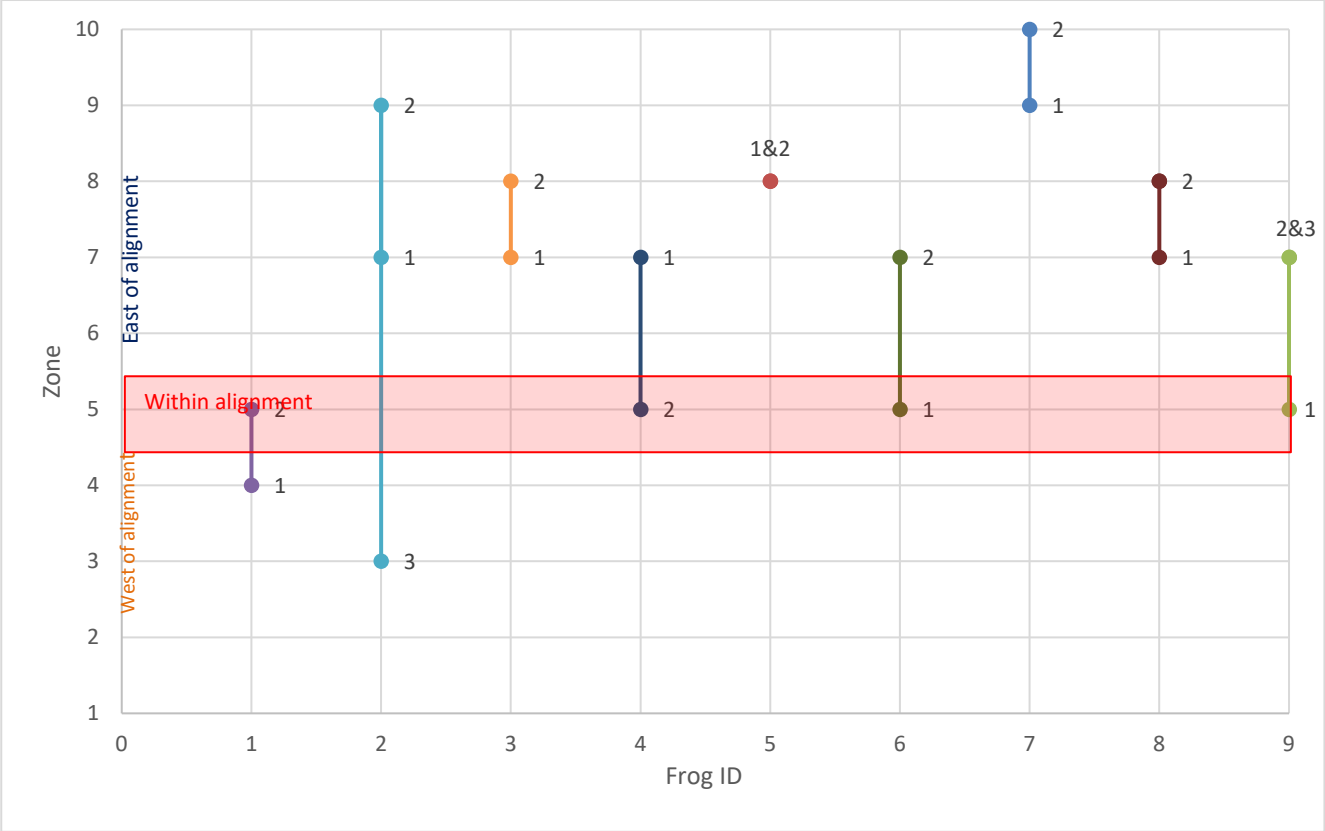
Graph 10: Cooperabung Creek impact site: recapture movement patterns



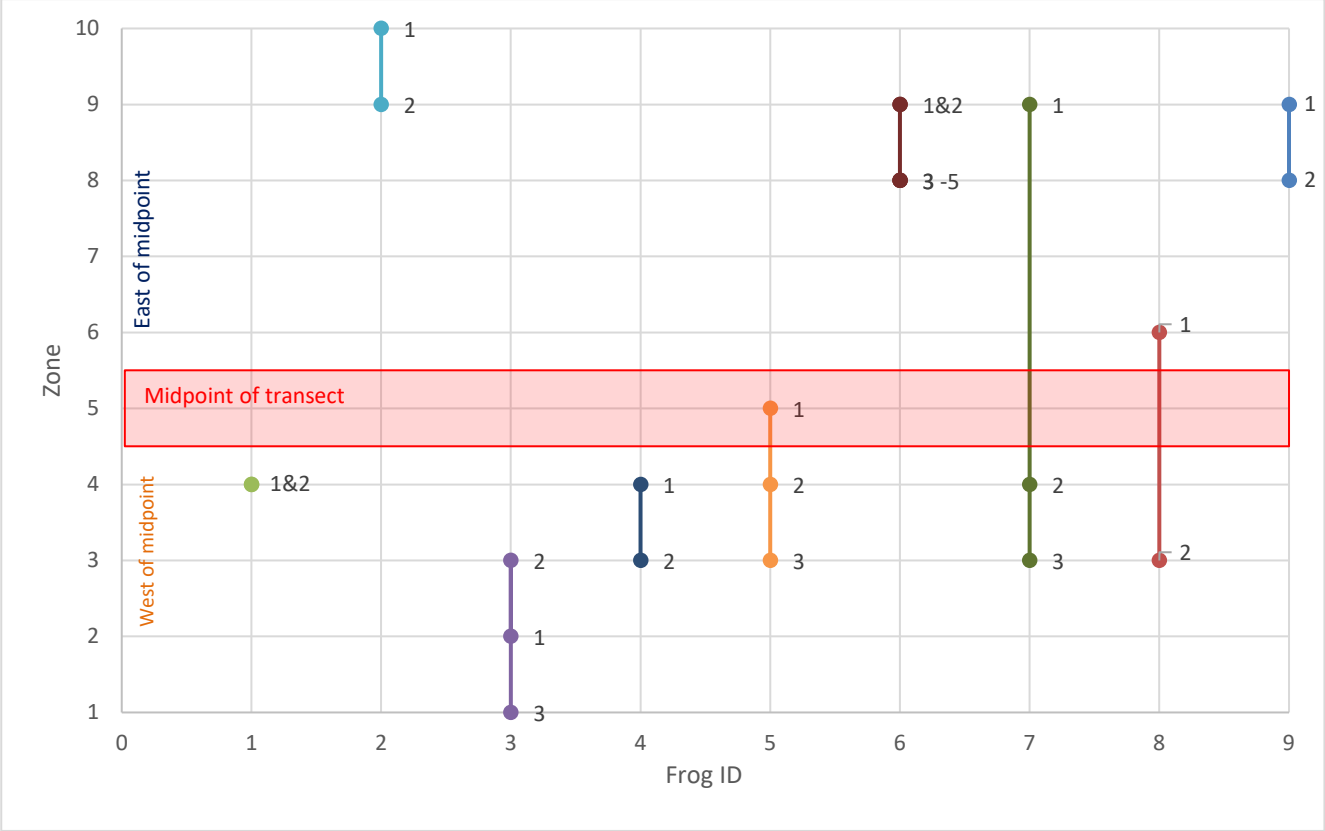
Graph 11: Smiths Creek impact site: recapture movement patterns



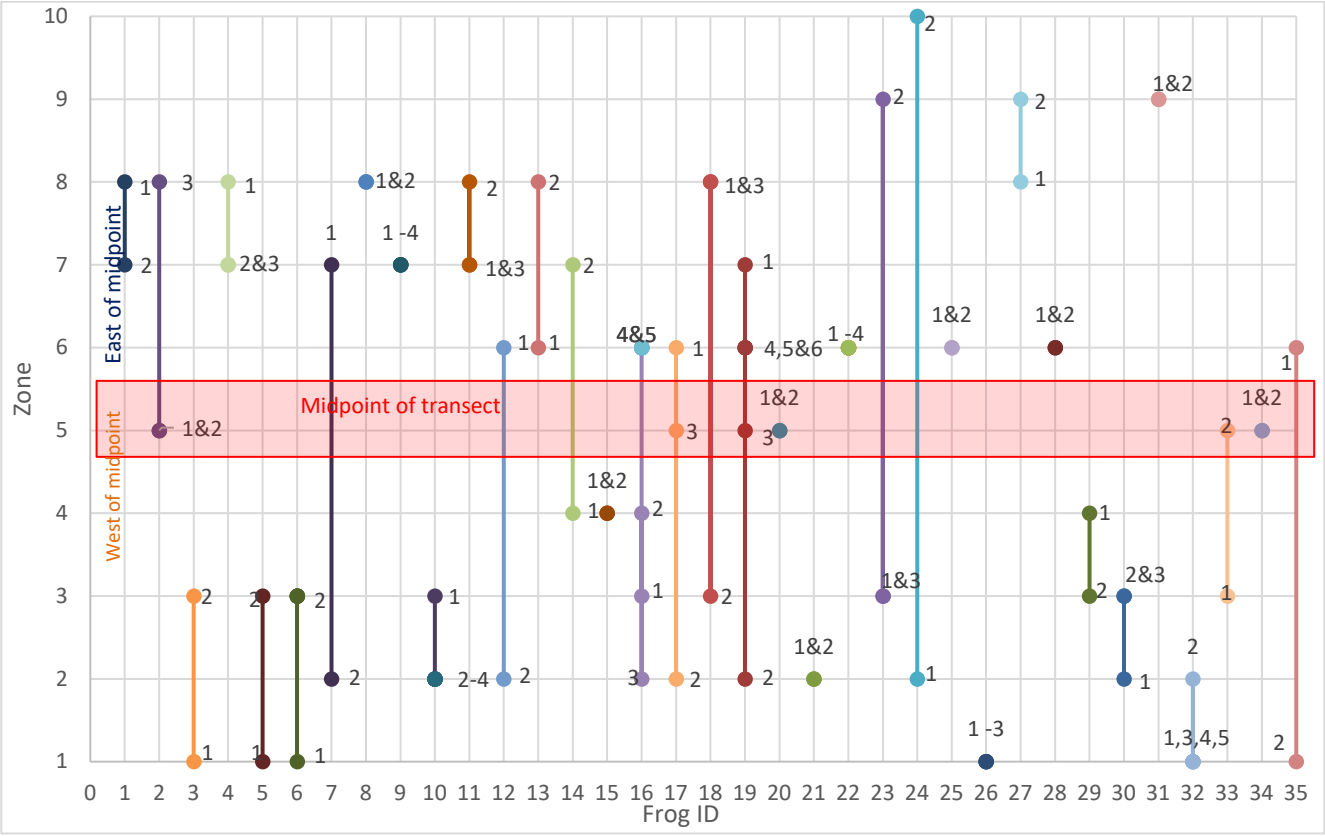
Graph 12: Pipers Creek impact site: recapture movement patterns



Graph 13: Maria River impact site: recapture movement patterns



Graph 14: Cooperabung Creek reference site: recapture movement patterns



Graph 15: Pipers Creek reference site: recapture movement patterns

4. Discussion

4.1 Performance Measures

A summary of Year 1 (2015/2016), Year 2 (2016/2017), Year 3 (2017/2018), Year 4 (2018/2019), Year 5 (2019/2020), Year 6 (2020/2021), Year 7 (2021/2022) and Year 8 (2022/2023) survey results in relation to the performance measures is provided in Table 5.

Table 4: Performance measures and discussion of results.

Performance measure	Discussion
Monitoring is undertaken during baseline surveys and Years 1 – 8 or until monitoring can demonstrate that mitigation measures are effective.	**This performance measure has been met for all years**. Giant Barred Frog monitoring has been undertaken at all six baseline sites at least twice during the monitoring period 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 all years**. Giant Barred Frog monitoring has been undertaken at all six baseline sites at least twice during the monitoring period, 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), 5 of 6 sites in Year 2 (2016/2017), Year 3 (2017/2018), Year 4 (2018/2019), 3 of 6 sites in Year 5 (2019/2020), 2 of 6 sites in Year 6 (2020/2021), 1 of 6 sites in Year 7 (2021/2022) and 3 of 6 sites in Year 8.** Baseline: Giant Barred Frogs were recorded at all six monitoring sites in spring and summer and at four sites in autumn. Giant Barred Frogs were not recorded at the Maria River impact site and Pipers Creek reference site during the autumn 2014 baseline survey. Year 1 (2015/2016): Giant Barred Frogs were detected at all six sites during all surveys. Year 2 (2016/2017): Giant Barred Frogs were detected at all six sites in spring and summer and five sites in autumn. Not recorded at Pipers Creek impact site during the autumn 2017 survey where it was detected during baseline surveys. Year 3 (2017/2018): Giant Barred Frogs were detected at all six sites in spring and five sites in summer and autumn. Not recorded at Pipers Creek impact site during summer and autumn 2018 where it was detected during baseline surveys. Year 4 (2018/2019): Giant Barred Frogs were detected at five sites in spring and all six sites in autumn. Not recorded at Cooperabung Creek reference site during spring 2018 where it was detected during baseline surveys. Year 5 (2019/2020): Giant Barred Frogs were not recorded at Cooperabung Creek impact site, where it was recorded during all three baseline surveys. Not recorded at Maria River impact during summer 2020, where it was recorded during baseline surveys and not recorded at Cooperabung Creek reference site during spring 2019, where it was detected during baseline surveys. Year 6 (2020/2021): Giant Barred Frogs were not recorded at Cooperabung Creek impact, Smiths Creek impact and Cooperabung reference sites during 2020/2021 surveys. Giant Barred Frogs were not recorded during autumn surveys (Pipers Creek reference site was not surveyed). Giant Barred Frogs were detected in summer at Maria River impact, Pipers Creek impact and Pipers Creek reference sites. Giant Barred Frogs were detected during spring surveys only at Maria River impact and Pipers Creek reference sites. Year 7 (2021/2022): Giant Barred Frogs were not recorded at Smiths Creek impact, Maria River impact and Cooperabung reference sites during 2021/2022 surveys. Giant Barred Frogs were not recorded in spring at Cooperabung impact site or autumn at Pipers Creek impact site.

Performance measure	Discussion
	Year 8 (2022/2023): Giant Barred Frogs were not recorded at the Cooperabung reference site during 2022/2023 surveys. Giant Barred Frogs were not recorded in summer or autumn at Smiths Creek impact site or spring at Maria River impact site.
Mitigation measures are effective as defined in the EPBC approval when all monitoring events are considered at Year 8.	**This performance measure has been met.** Mitigation measures for the Giant Barred Frog include protection of habitat during clearing and construction, pre-clearing surveys, installation of Giant Barred Frog fence and an unexpected finds procedure (Lewis 2013). Construction related mitigation measures were successfully implemented and may be deemed to have been effective as frogs observed during works were captured and released safely, and no threatened fauna mortaliites due to clearing operations were reported. The effectiveness of the Giant Barred Frog Frence is assessed using the outcomes of road kill surveys and targeted threatened frog searches. To date, Giant Barred Frogs have not been identified as road kill. However, surveys of the frog fence note a number of maintenance issues that may impair the integrity of the frog fence (Niche 2023). Recommendations have been made below. Results (review of movement patterns of re-captured individuals showing records along the creek on either side of the carriageway) indicate that Giant Barred Frogs are moving underneath the road. It is unknown if they used the underpasses, however, no breaches of the frog fencing were observed during surveys.
Median values of all downstream water quality monitoring at GBF habitat or potential habitat locations during construction and operation (Year 1 – 6) is less than the 80th percentile value of the upstream site (where 80th percentile is the value at which median values at the downstream site are above 80% of the recorded background water quality records), where this change is found to be attributable to construction or operation.	This performance measure is not applicable for Year 8.
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 not been met.** The number and location of Giant Barred Frogs recorded has varied between season and year at all sites. All sites show fluctuating densities. However, as trends are evident at both impact and reference sites, it is not possible to attribute these changes to the Project. As discussed, the high rainfall experience in 2020/2021 and 2021/2022 resulted in highly variable water levels, waterway flooding and expansive water flows across floodplains. The above-average rainfall conditions observed over the spring/summer periods of 2020/2021 and 2021/2022 follow the long-term drought conditions experienced across the Project area in 2019. It is possible that the population changes observed at all sites are in response to these changing conditions. Low capture rates may be a result of population impacts from drought conditions followed by waterway flooding, which is also likely to reduce capture and observation rates simply due to the likely dispersal of individuals across a broader wet area. A population response to improved waterway conditions after the 2020/2021 rainfall may be evidenced by the increased capture rates at some somes, but also hindered by difficult (flooding) survey conditions. Within-year movement patterns that would permit comparison between baseline and subsequent monitoring events is not possible due to lack of data (surveys and captures are too infrequent), however, assessment of movement patterns of recaptured individuals over all surveys show that 25% of recaptured frogs have been found to traverse from one side of the carriageway to the other.

5. Recommendations

5.1 Contingency Measures

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

Table 5: 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.	The number and location of Giant Barred Frogs recorded has varied between season and year at all sites. All sites show fluctuating densities. However, as trends are evident at both impact and reference sites, it is not possible to attribute these changes to the Project. The potential influence of environmental variables, such as drought and widespread flooding, may have contributed to the decreasing trend in records/observations. **This contingency measure is not considered relevant**.

5.2 Recommendations

A summary of those performance indicators that were not met in the 2022/2023 monitoring period, recommended corrective actions and general recommendations are provided in Table 7.

Given the number and location of Giant Barred Frogs recorded has varied between season and year at all sites and that trends are evident at both impact and reference sites, it is not possible to attribute these changes to the Project, therefore further monitoring is not recommended.

However, it is recommended that maintenance actions specified within the Fauna Fence and Roadkill Monitoring 2022/2023 Report (Niche 2023) are carried out in order to maintain the ongoing integrity of the frog fence.

Table 6: Recommendations

Performance measure	Action
Continued presence of Giant Barred Frogs during each survey event in Year 1 – 8 at sites where it was identified during baseline surveys, subject to access due to landowner agreement.	**This performance measure has been met for 3 of 6 sites in Year 8 (2022/2023).** Giant Barred Frogs were • Not recorded at the Cooperabung Creek reference site, where it was recorded during all three baseline surveys. • Not recorded at Smiths Creek impact site in summer or autumn 2022/2023 and Maria River impact site in spring 2022, where it was recorded during baseline surveys. The Project area experienced drought conditions in 2019 with below average rainfall followed by substainally higher than average rainfall during 2020/2021 and 2021/2022 resulting in waterway flooding and highly variable water levels. Frogs have since been recorded at all impact sites in at least one season during Year 8 monitoing, including at sites where they had not been recorded for a number of years, demonstrating continued presence at these sites. Recent records likely reflect natural population fluctuations associated with extreme climatic conditions experienced from Year 4 to Year 6 (2019 to 2022).

Performance measure	Action
	Given the number and location of Giant Barred Frogs recorded has varied between season and year at all sites and that trends are evident at both impact and reference sites, it is not possible to attribute these changes to the Project, therefore further monitoring is not recommended.
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 not been met.** Given the number and location of Giant Barred Frogs recorded has varied between season and year at all sites and that trends are evident at both impact and reference sites, it is not possible to attribute these changes to the Project, therefore further monitoring is not recommended.

References

GHD (2010). Oxley Highway to Kempsey Environmental Assessment. Report prepared for the Roads and Maritime Services.

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

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

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

Niche (2016). Giant Barred Frog monitoring: 2015/2016 – Oxley Highway to Kempsey, Pacific Highway Upgrade. Report prepared for Roads and Maritime Services by Niche Environment and Heritage Pty Ltd.

Niche (2017). Giant Barred Frog monitoring: 2016/2017 – Oxley Highway to Kempsey, Pacific Highway Upgrade. Report prepared for Roads and Maritime Services by Niche Environment and Heritage Pty Ltd.

Niche (2018). Giant Barred Frog monitoring: 2017/2018 – Oxley Highway to Kempsey, Pacific Highway Upgrade. Report prepared for Roads and Maritime Services by Niche Environment and Heritage Pty Ltd.

Niche (2019). Giant Barred Frog monitoring: 2018/2019 – Oxley Highway to Kempsey, Pacific Highway Upgrade. Report prepared for Roads and Maritime Services by Niche Environment and Heritage Pty Ltd.

Niche (2020). Giant Barred Frog monitoring: 2019/2020 – Oxley Highway to Kempsey, Pacific Highway Upgrade. Report prepared for Roads and Maritime Services by Niche Environment and Heritage Pty Ltd.

Niche (2021). Giant Barred Frog monitoring: 2020/2021 – Oxley Highway to Kempsey, Pacific Highway Upgrade. Report prepared for Roads and Maritime Services by Niche Environment and Heritage Pty Ltd.

Niche (2022). Giant Barred Frog monitoring: 2021/2022 – Oxley Highway to Kempsey, Pacific Highway Upgrade. Report prepared for Roads and Maritime Services by Niche Environment and Heritage Pty Ltd.

Niche (2023). Fauna Fence and Road Kill Monitoring 2022/2023. Oxley Highway to Kempsey Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for TfNSW, Port Macquarie, NSW.

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

TfNSW (2022). Oxley Highway to Kempsey Pacific Highway Upgrade Ecological Monitoring Program. Roads and Maritime Update to report prepared by SMEC Hyder Joint Venture, February 2022.

Annex 1 – 2022/2023 data summary for each monitoring site

Cooperabung Creek impact site

Table 7: Summary of surveys and prevailing abiotic variables: Cooperabung Creek impact site

Date	Time		Air temp. °C	Water temp. °C	Humidity %	Stream depth (cm)	Wind (0-3, 0= no wind)	Cloud cover %	Rain (0-3, 0= no rain)
25/10/2022	Start	22:22	18.6	16	96	150	1	0	0
	Finish	01:00	16	16	88	50	0	0	0
016/02/2023	Start	22:25	21	21	82	50	0	0	0
	Finish	01:00	21	21	82	50	0	0	0
03/04/2023	Start	22:15	18	20	unk	1	0	90	1
	Finish	01:10	17	20	unk	1	0	70	1

Table 8: Habitat details: Cooperabung Creek impact site

Zone	OS %	Sh %	G %	LL %	BE %	Cattle	Pools	Riffles	DoP (cm)	EF	Frogs detected	FB
3	75	5	80	5	2	no	1	2	100	yes	no	Unk
4	80	5	70	38	10	no	1	0	100	yes	yes	Unk
5	50	25	60	25	0	no	1	1	100	yes	no	Unk

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

Table 9: Summary of captures: Cooperabung Creek impact site

	Spring 2022	Summer 2023	Autumn 2023
Number of frogs recorded	2	2	0
Number of adult males	0	0	0
Number of adult females	2	2	0
Number of sub-adults	0	0	0
Number of juveniles	0	0	1
Number of recaptures	0	0	0

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

Smiths Creek impact site

Table 10: Summary of surveys and prevailing abiotic variables: Smiths Creek impact site

Date	Time		Air temp. °C	Water temp. °C	Humidity %	Stream depth (cm)	Wind (0-3, 0= no wind)	Cloud cover %	Rain (0-3, 0= no rain)
25/10/2022	Start	19:38	19.7	17	88	100	1	100	2
	Finish	19:38	17.1	17	100	100	1	5	0
16/02/2023	Start	23:00		21					0
	Finish	01:30		21					0
05/04/2023	Start	21:39	17	20	35	1	0	20	0
	Finish	23:55	16	20			1	20	0

Table 11: Habitat details: Smiths Creek impact site

Zone	OS %	Sh %	G %	LL %	BE %	Cattle	Pools	Riffles	DoP (cm)	EF	Frogs detected	FB
1	30	5	10	5	80	no	1	0	200	yes	yes	Unk
2	50	5	20	15	20	no	1	1	200	yes	yes	Unk
3	80	5	2	80	10	no	1	0	200	yes	no	Unk
4	70	30	70	50	1	no	1	0	200	yes	no	Unk
5	2	20	50	10	0	no	2	1	200	yes	no	Unk
6	15	2	50	2	50	yes	1	1	200	yes	no	Unk
7	25	2	80	15	10	yes	3	1	100	yes	yes	Unk
8	60	2	80	5	15	yes	2	1	100	yes	no	Unk
9			50	25	1	yes	2	0	100	yes	no	Unk
10	2	1	80	5	15	yes	1	0	150	yes	no	Unk

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

Table 12: Summary of captures: Smiths Creek impact site

	Spring 2022	Summer 2023	Autumn 2023
Number of frogs recorded	3	0	0
Number of adult males	1	0	0
Number of adult females	2	0	0
Number of sub-adults	0	0	0
Number of juveniles	0	0	0
Number of recaptures	0	0	0

Habitat: Microhabitat within these zones included leaf litter, flood debri under log and on bare ground.

Pipers Creek impact site

Table 13: Summary of surveys and prevailing abiotic variables: Pipers Creek impact site

Date	Time		Air temp. °C	Water temp. °C	Humidity %	Stream depth (cm)	Wind (0-3, 0= no wind)	Cloud cover %	Rain (0-3, 0= no rain)
27/10/2022	Start	22:21	18.2	17	96	100	0	0	0
	Finish	1:21	17.3	17	98	50	0	0	0
16/02/2023	Start	20:15		21					0
	Finish	23:00		21					0
05/04/2023	Start	18:27	21	20	60		0	30	0
	Finish	21:27	17	20			0	10	0

Table 14: Habitat details: Pipers Creek impact site

Zone	OS %	Sh %	G %	LL %	BE %	Cattle	Pools	Riffles	DoP (cm)	EF	Frogs detected	FB
1	98	10	5	2	95	no	0	0	200	yes	no	Unk
2	95	30	25	2	75	no	0	1	200	yes	yes	Unk
3	80	50	2	90	10	no	1	1	200	yes	no	Unk
4	85	15	5	85	10	no	0	0	100	yes	yes	Unk
5	50	35	70	50	0	no	1	2	100	yes	yes	Unk
6	50	60	90	5	5	yes	0	0	100	yes	no	Unk
7	5	2	50	1	50	yes	0	0	100	yes	no	Unk
8	50	1	90	5	5	yes	0	1	200	yes	no	Unk
9	20	2	50	2	50	yes	0	1	60	yes	no	Unk
10	15	10	80	2	20	yes	0	0	100	yes	no	Unk

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

Table 15: Summary of captures: Pipers Creek impact site

	Spring 2022	Summer 2023	Autumn 2023
Number of frogs recorded	1	2	1
Number of adult males	1	0	0
Number of adult females	0	2	1
Number of sub-adults	0	0	0
Number of juveniles	0	0	0
Number of recaptures	0	0	1

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

Maria River impact site

Table 16: Summary of surveys and prevailing abiotic variables: Maria River impact site

Date	Time		Air temp. °C	Water temp. °C	Humidity %	Stream depth (cm)	Wind (0-3, 0= no wind)	Cloud cover %	Rain (0-3, 0= no rain)
27/10/2022	Start	0:38	17.3	17	100	50	0	0	0
	Finish	03:20	15.7	17	100	100	0	0	0
15/02/2023	Start	1:46	15.2	21	100	50	0	0	0
	Finish	3:46	14.8	21	100	50	0	0	0
04/04/2023	Start	0:48	18	20	unk	1	0	100	0
	Finish	1:11	18	20	100	1	1	100	1

Table 17: Habitat details: Maria River impact site

Zone	OS %	Sh %	G %	LL %	BE %	Cattle	Pools	Riffles	DoP (cm)	EF	Frogs detected	FB
6	30	80	5	10	80	no	1	0		yes	no	Unk
7	90	60	5	45	50	no	1	0		yes	no	Unk
8	70	60	10	95	5	no	1	0		no	yes	Unk
9	85	70	50	10	20	no	1	0		yes	no	Unk

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

Table 18: Summary of captures: Maria River impact site

	Spring 2022	Summer 2023	Autumn 2023
Number of frogs recorded	0	3	1
Number of adult males	0	2	1
Number of adult females	0	1	0
Number of sub-adults	0	0	0
Number of juveniles	0	0	0
Number of recaptures	0	0	0

Habitat: Microhabitat within these zones included under grass and leaf litter. Lantana is very abundant along both side of the river banks and is the dominant vegetation from MIz1 to MIz5. Lantana has also increased it's dominance of the downstream side throughout all zones. Access in 2022/2023 to certain areas of the transect was not possible due to increased lantana.

Cooperabung Creek reference site

Table 19: Summary of surveys and prevailing abiotic variables: Cooperabung Creek reference site

Date	Time		Air temp. °C	Water temp. °C	Humidity %	Stream depth (cm)	Wind (0-3, 0= no wind)	Cloud cover %	Rain (0-3, 0= no rain)
25/10/202	Start	22:22	18.6	17	96	150	1	0	0
	Finish	0:30	16	17	88	50	0	0	0
9/12/2021	Start	22:25	21	21	82	50	0	0	0
	Finish	22:25	21	21	82	50	0	0	0
03/04/2023	Start	18:57	19	18		30	0	50	0
	Finish	23:46	18	18		30	0	40	0

Table 20: Habitat details: Cooperabung Creek reference site

Zone	OS %	Sh %	G %	LL %	BE %	Cattle	Pools	Riffles	DoP (cm)	Frogs detected	EF	FB
1	30	25	5	80	0	no	1	2	20	no	yes	Unk
2	50	2	70	30	5	yes	1	2	50	no	yes	Unk
3	80	15	5	35	60	no	1	4	40	no	yes	Unk
4	90	40	20	70	10	yes	2	3	50	no	yes	Unk
5	50	35	20	15	20	yes	2	2	50	no	yes	Unk
6	80	15	50	38	10	no	2	3	50	no	yes	Unk
7	20	5	90	10	0	yes	0	2	0	no	yes	Unk
8	50	50	60	20	0	yes	0	2	0	no	yes	Unk
9	95	2	1	50	50	yes	2	3	50	no	yes	Unk
10	95	10	1	20	80	no	0	3	50	no	yes	Unk

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

Table 21: Summary of captures: Cooperabung Creek reference site

	Spring 2022	Summer 2023	Autumn 2023
Number of frogs recorded	0	0	0
Number of adult males	0	0	0
Number of adult females	0	0	0
Number of sub-adults	0	0	0
Number of juveniles	0	0	0
Number of recaptures	0	0	0

Habitat: Microhabitat found being used included grass and *Lomandra longifolia*.

Pipers Creek reference site

Table 22: Summary of surveys and prevailing abiotic variables: Pipers Creek reference site

Date	Time		Air temp. °C	Water temp. °C	Humidity %	Stream depth (cm)	Wind (0-3, 0= no wind)	Cloud cover %	Rain (0-3, 0= no rain)
26/10/2022	Start	19:46	21.3		80	40	0	50	0
	Finish	23:47	17.5		100		0	5	0
15/02/2023	Start	20:37	15.8		99	20	0	0	0
	Finish	1:04	14		99	40	0	8	0
04/04/2023	Start	18:33	20		100	50	0	100	1
	Finish	0:01	18			50	0	100	1

Table 23: Habitat details: Pipers Creek reference site

Zone	OS %	Sh %	G %	LL %	BE %	Cattle	Pools	Riffles	DoP (cm)	EF	Frogs detected	FB
1	90	10	30	50	2	no	3	3	150	yes	yes	NA
2	20	2	50	2	5	no	2	2	150	yes	yes	NA
3	50	15	60	5	10	no	3	3	200	yes	yes	NA
4	98	20	5	95	5	no	2	3	200	yes	yes	NA
5	80	30	5	75	15	no	2	3	200	yes	yes	NA
6	90	50	15	50	15	no	2	3	200	yes	yes	NA
7	70	15	100	2	0	no	2	2	200	yes	yes	NA
8	10	50	80	15	10	no	1	2	150	yes	yes	NA

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

Table 24: Summary of captures: Pipers Creek reference site

	Spring 2022	Summer 2023	Autumn 2023
Number of frogs recorded	15	14	9
Number of adult males	4	9	4
Number of adult females	4	4	4
Number of sub-adults	3	0	0
Number of juveniles	0	1	1
Number of recaptures	0	0	0

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

Annex 2 - Giant Barred Frog individual capture data

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

Table 25: Giant Barred Frog capture data

Site	Location	Season	Sex	Age	Reproductive status	L	W	DW	pit_tag_code	Capture status	Z	Activity	Microhabitat
Impact	Cooperabung Creek	Spring	Female	Adult	Gravid	110	197	3.5	00079EA6E1	Recapture	4	Sitting	tree base
Impact	Cooperabung Creek	Spring	Female	Adult	Gravid	110	225	10	0007E032F1	First time capture	4	Sitting	tree base
Impact	Cooperabung Creek	Summer	Female	Adult	Light Nuptial Pads	84	97	4	Not tagged	First time capture	4	Sitting	tree base
Impact	Cooperabung Creek	Summer	Female	Adult	Not Gravid	96	161	2	0007E0E1DE	First time capture	6	Sitting	bank
Impact	Cooperabung Creek	Autumn	Unk	Juvenile	Immature	43	25	3	Not tagged	First time capture	4	Sitting	leaf litter
Impact	Maria River	Summer	Male	Adult	Light Nuptial Pads	71	65	3	0007A3E0F9	First time capture	8	Sitting	leaf litter,lomandra
Impact	Maria River	Summer	Male	Adult	n/a	Unk	Unk	5	Not tagged	Uncaptured	8	Buried	leaf litter
Impact	Maria River	Summer	Female	Adult	Not Gravid	99	163	4	0007E0512A	First time capture	8	Sitting	leaf litter
Impact	Maria River	Autumn	Male	Adult	Unk	75	65	8	Not tagged	First time capture	8	Sitting	creek bank
Impact	Pipers Creek	Spring	Male	Adult	Light Nuptial Pads	71	62	3	0007A3A4E9	First time capture	4	Sitting	bank
Impact	Pipers Creek	Summer	F	Adult	Non-gravid	89	133	15	0007A3EB3F	First time capture	5	Jumping	Grass/Shrubs
Impact	Pipers Creek	Autumn	Female	Adult	Not Gravid	98	180	6	0007E0E1CD	Recapture	5	Sitting	leaf litter
Impact	Pipers Creek	Summer	F	Adult	Possible Gravid	103	185	5	0007E0E1CD	First time capture	2	Active	Grassy
Reference	Pipers Creek Ref	Spring	Female	Adult	Not Gravid	86	98	2.5	0007E0AE19	First time capture	1	Sitting	leaf litter
Reference	Pipers Creek Ref	Spring	Unk	Sub Adult	Immature	60	25	3	0007A3BB2F	First time capture	1	Sitting	leaf litter
Reference	Pipers Creek Ref	Spring	Female	Adult	Not Gravid	90	130	5	0007E0B7D7	First time capture	2	Sitting	tree base
Reference	Pipers Creek Ref	Spring	Unk	Sub Adult	Immature	56	28	1	0007E0E327	First time capture	2	Jumping	lomandra
Reference	Pipers Creek Ref	Spring	Unk	Sub Adult	Immature	55	25	2	Not tagged	First time capture	2	Sitting	bare ground

Site	Location	Season	Sex	Age	Reproductive status	L	W	DW	pit_tag_code	Capture status	Z	Activity	Microhabitat
Reference	Pipers Creek Ref	Spring	Male	Adult	Unk	73	70	2.5	0007E0A8BD	First time capture	2	Sitting	bare ground
Reference	Pipers Creek Ref	Spring	Male	Adult	Light Nuptial Pads	71	61	4	0007A0F03B	First time capture	6	Sitting	tree base
Reference	Pipers Creek Ref	Spring	Female	Adult	Not Gravid	91	128	10	00079EAA9B	First time capture	8	Sitting	leaf litter
Reference	Pipers Creek Ref	Spring	Female	Adult	n/a	Unk	Unk	4	Not tagged	Uncaptured	2	Sitting	bare ground
Reference	Pipers Creek Ref	Spring	Female	Adult	n/a	Unk	Unk	4	Not tagged	Uncaptured	1	Sitting	bare ground
Reference	Pipers Creek Ref	Spring	Male	Adult	n/a	Unk	Unk	4	Not tagged	Uncaptured	4	Sitting	bank
Reference	Pipers Creek Ref	Spring	Male	Adult	n/a	Unk	Unk	5	Not tagged	Uncaptured	7	Sitting	bank
Reference	Pipers Creek Ref	Spring	Unk	Adult	n/a	Unk	Unk	3	Not tagged	Uncaptured	7	Sitting	bank
Reference	Pipers Creek Ref	Spring	Unk	Adult	n/a	Unk	Unk	4	Not tagged	Uncaptured	7	Sitting	bank
Reference	Pipers Creek Ref	Spring	Unk	Adult	n/a	Unk	Unk	1	Not tagged	Uncaptured	8	Sitting	lomandra
Reference	Pipers Creek Ref	Summer	Male	Adult	n/a	69	65	6	0007A0F03B	Recapture	1	Sitting	flood debri
Reference	Pipers Creek Ref	Summer	Male	Adult	Light Nuptial Pads	72	64	2	0007E032BF	First time capture	1	Buried	leaf litter
Reference	Pipers Creek Ref	Summer	Female	Adult	Not Gravid	96.5	152	5	0007A386B4	First time capture	2	Sitting	bank
Reference	Pipers Creek Ref	Summer	Male	Adult	Light Nuptial Pads	79	70	5	0007A389E0	First time capture	2	Sitting	leaf litter
Reference	Pipers Creek Ref	Summer	Male	Adult	Light Nuptial Pads	77	63	4	0007E0E35D	First time capture	2	Sitting	lomandra
Reference	Pipers Creek Ref	Summer	Male	Adult	Light Nuptial Pads	75	71	3	0007A3E102	First time capture	3	Buried	leaf litter
Reference	Pipers Creek Ref	Summer	Female	Adult	Not Gravid	93	140	10	0007E03552	First time capture	4	Jumping	leaf litter
Reference	Pipers Creek Ref	Summer	Male	Adult	Light Nuptial Pads	74	62	3	0007E0E36E	First time capture	4	Sitting	lomandra
Reference	Pipers Creek Ref	Summer	Male	Adult	Light Nuptial Pads	66	65	1.5	0007E0AB3C	Recapture	4	Sitting	tree base
Reference	Pipers Creek Ref	Summer	Female	Adult	Not Gravid	91	140	3	0007DF01D8	First time capture	5	Jumping	leaf litter
Reference	Pipers Creek Ref	Summer	Unk	Juvenile	Immature	20	Unk	2	Not tagged	First time capture	5	Sitting	leaf litter
Reference	Pipers Creek Ref	Summer	Female	Adult	Not Gravid	94	160	10	0007E0E536	First time capture	7	Sitting	leaf litter
Reference	Pipers Creek Ref	Summer	Male	Adult	Light Nuptial Pads	65	65	3	0007A0EBE1	First time capture	7	Sitting	leaf litter
Reference	Pipers Creek Ref	Summer	Male	Adult	n/a	Unk	Unk	4	Not tagged	Uncaptured	7	Buried	bank
Reference	Pipers Creek Ref	Autumn	Unk	Juvenile	Unk	46	15	20	Not tagged	First time capture	1	Sitting	tree base,leaf litter
Reference	Pipers Creek Ref	Autumn	Female	Adult	Unk	92	130	16	Not tagged	First time capture	2	Sitting	leaf litter,tree base

Site	Location	Season	Sex	Age	Reproductive status	L	W	DW	pit_tag_code	Capture status	Z	Activity	Microhabitat
Reference	Pipers Creek Ref	Autumn	Male	Adult	Unk	71	70	10	Not tagged	First time capture	3	Sitting	creek bank
Reference	Pipers Creek Ref	Autumn	Female	Adult	Unk	74	60	10	Not tagged	First time capture	3	Sitting	leaf litter
Reference	Pipers Creek Ref	Autumn	Female	Adult	Not Gravid	70	Unk	7	Not tagged	First time capture	4	Jumping	under log
Reference	Pipers Creek Ref	Autumn	Female	Adult	Not Gravid	84	75	5	Not tagged	First time capture	4	Sitting	leaf litter
Reference	Pipers Creek Ref	Autumn	Male	Adult	Unk	69	70	5	Not tagged	First time capture	7	Sitting	leaf litter
Reference	Pipers Creek Ref	Autumn	Male	Adult	Unk	74	60	17	Not tagged	First time capture	8	Sitting	leaf litter
Reference	Pipers Creek Ref	Autumn	Male	Adult	n/a	n/a	n/a	n/a	Not tagged	Uncaptured	4	Sitting	creek bank
Impact	Smiths Creek	Spring	Female	Adult	Gravid	105	150	10	0007E03183	First time capture	2	Sitting	leaf litter
Impact	Smiths Creek	Spring	Female	Adult	Not Gravid	102	158	5	0007A39C16	First time capture	1	Sitting	leaf litter
Impact	Smiths Creek	Spring	Male	Adult	Moderate Nuptial Pads	69	47	2.5	0007A38A08	First time capture	7	Sitting	tree base

Niche Environment and Heritage

A specialist environmental and heritage consultancy.

Head Office

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

All mail correspondence should be through our Head Office

niche
Environment and Heritage

Fauna Fence and Road Kill Monitoring 2022/2023

Oxley Highway to Kempsey, Pacific Highway Upgrade

Prepared for Transport for NSW

June 2023

Document control

Project no.:	1702
Project client:	Transport for NSW
Project office:	Port Macquarie
Document description:	Fauna Fence and Road Kill Monitoring 2022/2023 report
Project Director:	Lawrence Smith
Project Manager:	Radika Michniewicz
Authors:	Jodie Danvers
Internal review:	Radika Michniewicz
Document status:	R0
Local Government Area:	Kempsey and Port Macquarie Hastings

Document revision status

Author	Revision number	Internal review	Date issued
Jodie Danvers	D1	Radika Michniewicz	4/05/2023
Jodie Danvers	D1	Radika Michniewicz	15/05/2023
Radika Michniewicz	R0		16/06/2023

Niche Environment and Heritage

Excellence in your environment.

ABN: 19 137 111 721

Head Office

Level 4, 460 Church Street
Parramatta NSW 2150
All mail correspondence to:
PO Box 2443
North Parramatta NSW 1750
Phone: **02 9630 5658**
Email: **info@niche-eh.com**

Locations

Sydney
Central Coast
Bulli
Newcastle
Port Macquarie
Brisbane
Cairns

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

Executive summary

Context

This report documents findings of the 2022/2023 monitoring period, which includes the final of three monitoring periods for the fauna fence and the final of four operational monitoring periods for road kill, as required by the Oxley Highway to Kempsey (OH2K) Ecological Monitoring Program (EMP, TfNSW 2022).

Aims

The aim of the fauna fence and road kill monitoring program is to determine if purpose built fauna fences are preventing fauna from crossing the road, thereby reducing road kill. The aims of this report are to summarise the methods and results of the 2022/2023 monitoring period and determine if performance measures are being met and provide corrective actions where required, as per the EMP.

Methods

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

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

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

Key Results

Key results of the 2022/2023 fauna fence and road kill monitoring were:

- A number of maintenance issues were identified including vegetation encroachment, fallen trees, fence damaged by floods and gaps underneath the fence (caused by environmental factors i.e. water or erosion, platting or netting lifting and detached Phascogale panels).
- No threatened frog species were identified during searches for threatened frogs, fence monitoring or road kill surveys.
- There were a total of 43 road kill records for the autumn, spring and summer 2022/2023 road kill monitoring events, including 20 in autumn, 11 in spring and 12 in summer. Birds, small mammals, reptiles, and medium mammals were the most commonly recorded fauna groups.
- Of the 30 road kill records (excluding birds) from the 2022/2023 monitoring period, nine (30%) records were within and 21 (70%) records were outside fenced areas. Considering the data with regard to the extent of fencing along the highway, calculation of a road kill per kilometre rate (excluding birds) showed the rate of road kill in unfenced areas (6.4 kilometres; 3.28 records/kilometre) to be substantially higher than the rate in fenced areas (30.6 kilometres; 0.29 records/kilometre).
- Of the 43 road kill records, only one arboreal mammal was recorded. The single arboreal mammal was recorded within 200 metres of an aerial crossing. Considering all road kill records, six were recorded within 200 m of an aerial crossing. Calculation of a *road kill per kilometre* rate therefore showed the rate of road kill within 200 metres of aerial crossings (5.2 kilometres; 1.15 records/kilometre) to be similar to outside this boundary (31.8 kilometres; 1.16 records/kilometre).

- Of the 30 road kill records (excluding birds) eight occurred within 200 metres of underpasses. The rate of road kill within 200 metres of fauna underpasses/bridges (19.2 kilometres; 0.42 records/kilometre) was lower than the rate outside this boundary (17.8 kilometres; 1.23 records/kilometre).
- The overall average weekly road kill rate for the same three seasons has decreased from baseline values (8.0) to 2018/2019 (7.7), 2019/2020 (3.8), 2020/2021 (5.8) and 2022/2023 (3.6).

Conclusions

All performance measures for both the fauna fence and road kill monitoring have been met:

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

Management Implications

Given that all performance measures were met there are no recommendations based on the outcomes of the completed monitoring. Further monitoring is not considered necessary.

However, it is recommended that maintenance be undertaken as required to maintain the integrity of the fauna fence and minimise the opportunity for fence breaches.

Table of Contents

List of Figures

List of Tables

List of Graphs

1. Introduction

1.1 Context

The Oxley Highway to Kempsey (OH2K) section of the Pacific Highway Upgrade Project (the Project) was approved in 2012 subject to various Ministers Conditions of Approval (MCoA) and a Statement of Commitments (SoC). A subsequent approval with additional conditions of consent (CoA) was granted in 2014 by the then Commonwealth Department of Environment (DoE) for Matters of National Environmental Significance (MNES) listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1995* (EPBC Act). The Ecological Monitoring Program (hereafter referred to as the EMP) (TfNSW 2022) combines these approval conditions and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project.

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

1.1.1 Monitoring framework

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

Fauna fence

The EMP requires fauna fence monitoring to occur during the operational phase of the Project in Years 4, 6 and 8.

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

- Autumn 2018 and spring/summer 2018/2019: Year 4 surveys (Niche 2019)
- Autumn 2020 and spring/summer 2020/2021: Year 6 surveys (Niche 2021).
- Autumn 2022 and spring/summer 2022/2023: Year 8 surveys (current report).

This report represents the final of three reports required for the fauna fence monitoring and constitutes the Year 8 autumn 2022 and spring/summer 2022/2023 monitoring.

Road kill

Road kill monitoring was required for baseline, during clearing, during construction and upon completion of the Project (operational) in Years 4, 5, 6 and 8. The road kill monitoring framework provided within the EMP and the reporting status to date is shown in Table 1. The 2022/2023 monitoring period represents the fourth operational monitoring period and includes autumn (April 2022), spring (October 2022) and summer (January 2023). This report represents the final of four reports required for the operational phase monitoring.

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 (2016a) *27 July 2016 – 28 July 2017*: Niche (2017a) *4 August 2017 – March 29 2018*: Niche (2018)	Weekly (Note: as the opening of the Project occurred in three stages, weekly monitoring of the Project continued in the unopened sections of the Project to satisfy construction monitoring requirements.)	Entire length of existing highway in Project area
Within one month of opening of the Project	Twelve week post-opening periods were as follows: • Ku2K: from 3 November 2017 • OH2Ku Stage 1: from 17 November 2017 • OH2Ku Stage 2: from 30 March 2018 All in Niche (2018).	Weekly for 12 weeks. If this period does not coincide with the season (i.e. October (spring), January (summer) and April (autumn) in which baseline surveys were undertaken, also undertake weekly surveys during the first survey period (April, October or January) to occur after the opening of the Project (to allow for comparison to baseline results).	Entire length of completed Project
Upon completion of the Project (operational phase)	Year 4: • Spring (October 2018) • Summer (January 2019) • Autumn (April 2019) All in Niche (2019). Year 5: • Spring (October 2019) • Summer (January 2020) • Autumn (April 2020) All in Niche (2020). Year 6: • Spring (October 2020) • Summer (January 2021) • Autumn (April 2021) Year 8: • Autumn (April 2022) • Spring (October 2022) • Summer (January 2023) Current report.	Weekly during October (spring), January (summer) and April (autumn (12 weeks) in Year 4, 5, 6 and 8, or until mitigation measures can be demonstrated to have been effective as defined in the EPBC approval.	Entire length of completed Project

1.1.2 Background data

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

- Standard floppy-top fencing: *Permanent floppy top fencing will comprise of a heavily galvanised, floppy-top mesh fauna fence. Mesh one metre wide will be attached to the base of the fauna fencing and laid over the ground away from the carriageway to provide an effective barrier to burrowing animals. The mesh must be pinned to the ground with metal pins every metre without any gaps between the mesh and the ground. Fauna exclusion fencing at underpass entrances will have wide angled openings to encourage usage by fauna and must have a minimum length of 200 metres of fauna fencing on each side of the underpass and on each side of the carriageway or road*.
- Frog fencing:

- *Giant Barred Frog fencing is to be at least 900 millimetres in height and will comprise of gauze size 30-40 millimetres to prevent frogs from moving through the fence, yet allow for the flow of overland water. The gauze will include a small return of not less than 150 millimetres on the ground.*
- *Green-thighed Frog fencing is to comprise of 500 millimetres high neoprene rubber sheeting (>4 millimetre thickness) including a small rubber return of not less than 100 millimetres on the ground. The fence must consist of a hot dip galvanized pressed sheet metal or powder coated aluminium pressed sheet mounted on a galvanized star picket*. This fencing was unsuccessful and has since been replaced. Transport for NSW (TfNSW) removed the neoprene sheeting and replaced it with vermin-proof mesh, as approved on the Pacific Highway Upgrade between Woolgoolga and Ballina. These frog fencing replacement works were completed in November 2018.
- Where both frog species occur in association the frog fencing must account for both morphologies.

- Phascogale fencing: *Phascogale fencing is attached to floppy top fauna fencing. At the base of floppy top fauna fences, a second layer of mesh is installed to 200 millimetres above ground level height, offset from the first layer of mesh to create maximum opening size of 25 millimetres. Above 200 millimetres, 600 millimetre hot dip galvanised pressed steel sheet or powder coated aluminium pressed sheet are affixed to the floppy top fauna fencing.*

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

1.1.3 Purpose of this report

This report documents findings of the 2022/2023 monitoring period, which includes the final of three monitoring periods for the fauna fence and the final of four operational monitoring periods for road kill. The aims of this report are to summarise the methods and results of the 2022/2023 monitoring and determine if performance measures are being met, as per the EMP.

1.2 Performance Measures

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

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

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

- *Lower rates of road kill in proximity (i.e. areas of the main carriageways within areas adjacent to installed fauna fencing, and within 200 metres of rope bridges and fauna underpasses) to fauna fencing, rope bridges and fauna underpasses than in sections of the upgrade not near wildlife crossing structures or fauna fences in Year 1 – 6 & 8 monitoring events*
- *Reduced incidence of road kill from baseline conditions during monitoring events in Years 1-6 & 8 and when all monitoring events are considered at Year 8*

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

1.3 Monitoring Timing

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

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

1.4 Reporting

Annual reporting of monitoring results will outline:

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

All reports prepared under the EMP will be submitted to the NSW Department of Planning and Environment (DPE) and the NSW Environment Protection Authority (EPA).

1.5 Limitations

- Identification and detection of road kill was limited to what can be observed whilst travelling at 80 kilometres per hour (km/hr) as it is not considered safe to stop on the operational highway. As such:
    - Some road kill fauna were identified to the vertebrate group level only.
    - Some records were classified as 'unknown' as road kill fauna could not be identified as a result of extensive collision damage.
    - It is possible that small fauna such as frogs, snakes, small mammals and birds have been under-counted as small-sized road kill fauna have the potential to be partially or wholly removed by scavenger animals, resulting in impossible identification from the vehicle.
- Safety issues prevent the removal of road kill following each survey and therefore, despite efforts, road kill may have been recorded multiple times over the four weekly surveys resulting in double-counting and 'unknown' records as the condition of the animal deteriorated.

2. Methodology

2.1 Monitoring Sites

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

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

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

2.2 Survey Methods

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

2.2.1 Fauna fence inspections

Fauna fence monitoring was completed in autumn 2022 (April-May 2022) and summer 2022/2023 (February 2023). Surveys involved inspection of the fauna fence on foot for 200 metres north and south of the monitored underpasses and on both sides of the carriageway. In addition, the entire length of phascogale and frog fence was surveyed as well as the edge of the highway in proximity to fencing where possible and safe to do so. Possible breaches, damage and maintenance issues, such as impinging vegetation growth, were noted and their location recorded.

2.2.2 Frog searches

Searches for threatened frog species were undertaken on both sides of the frog fence in spring 2022 (October 2022) and summer 2022/2023 (February 2023) to identify the presence of any frogs that may have breached the frog fence. Surveys were timed to follow rainfall in order to coincide with frog movement where possible. Table 2 shows the rainfall recorded by Bureau of Meteorology (BOM) weather stations prior to surveys.

Table 2: Threatened frog survey dates and 24 hour rainfall

Survey date	Season	Previous 24hr rainfall Kempsey Airport (mm)	Previous 24hr rainfall Port Macquarie Airport (mm)
21/10/2022	Spring	4.2	3.6
16/02/2023	Summer	12.4	21.6

2.2.3 Road kill surveys

Road kill surveys of the entire Project were undertaken once a week for four weeks during April 2022 (autumn), October 2022 (spring) and January/February 2023 (summer). These surveys involved observations made from a vehicle travelling at approximately 80 km/hr. Road kill fauna observed on the road and within three metres of the road verge were recorded by the passenger. Due to the safety issues associated with the operational highway, it was not possible to stop the vehicle to closer inspect or remove road kill. Road kill records were grouped into general fauna groups for analysis.

2.3 Data analysis

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

3. Results

3.1 Fence Inspections

Detailed fauna fence inspection results/required actions were provided to TfNSW for maintenance purposes. All high priority items, such as damage or gaps in the fauna fence, or where the fence is not functioning properly or missing panels, have been rectified. Medium and lower priority items, such as vegetation maintenance, are programmed as part of the ongoing highway maintenance works. Results of the autumn 2022 and summer 2023 inspections are summarised below.

3.1.1 Maintenance

Maintenance actions were categorised as vegetation clearing, fence maintenance or fence gaps. A number of maintenance issues were identified during the 2022/2023 monitoring, the majority of which relate to vegetation clearing. There were 24 priority maintenance actions (where the integrity of the fence had been compromised) identified, four of which relate to flood damaged fencing where total replacement of sections is required, seven of which relate to fallen trees damaging the fence or providing a means of traversing the fence and 13 of which relate to gaps in the fence due to lifting or missing Phascogale panelling. Priority works are expected to be completed by the end of 2023, noting that high priority works identified as part of the autumn 2022 summer 2023 inspection have been programmed to be completed by the end of June 2023, where possible. The remaining actions are considered to be preventative maintenance actions to ensure ongoing fence integrity. Preventative maintenance will be actioned throughout the remainder of 2023/2024 financial year and are subject to other network priorities.

3.1.2 Possible breaches

No breaches or evidence of breaches were observed during 2022/2023 monitoring.

While no fauna was recorded on the highway-side of the fauna fence during fence inspections, undertaking maintenance to address identified gaps, clear vegetation and ensure secure fastening of the base netting or phascogale panels is required to prevent breaches from occurring.

3.2 Threatened Frog Searches

Diurnal targeted searches for threatened frogs were undertaken on the 21 October 2022 (spring) and 16 February 2023 (summer). No threatened frog species were identified during the targeted surveys. Similarly, no threatened frog species were identified during the fence monitoring or road kill surveys.

3.3 Road Kill Surveys

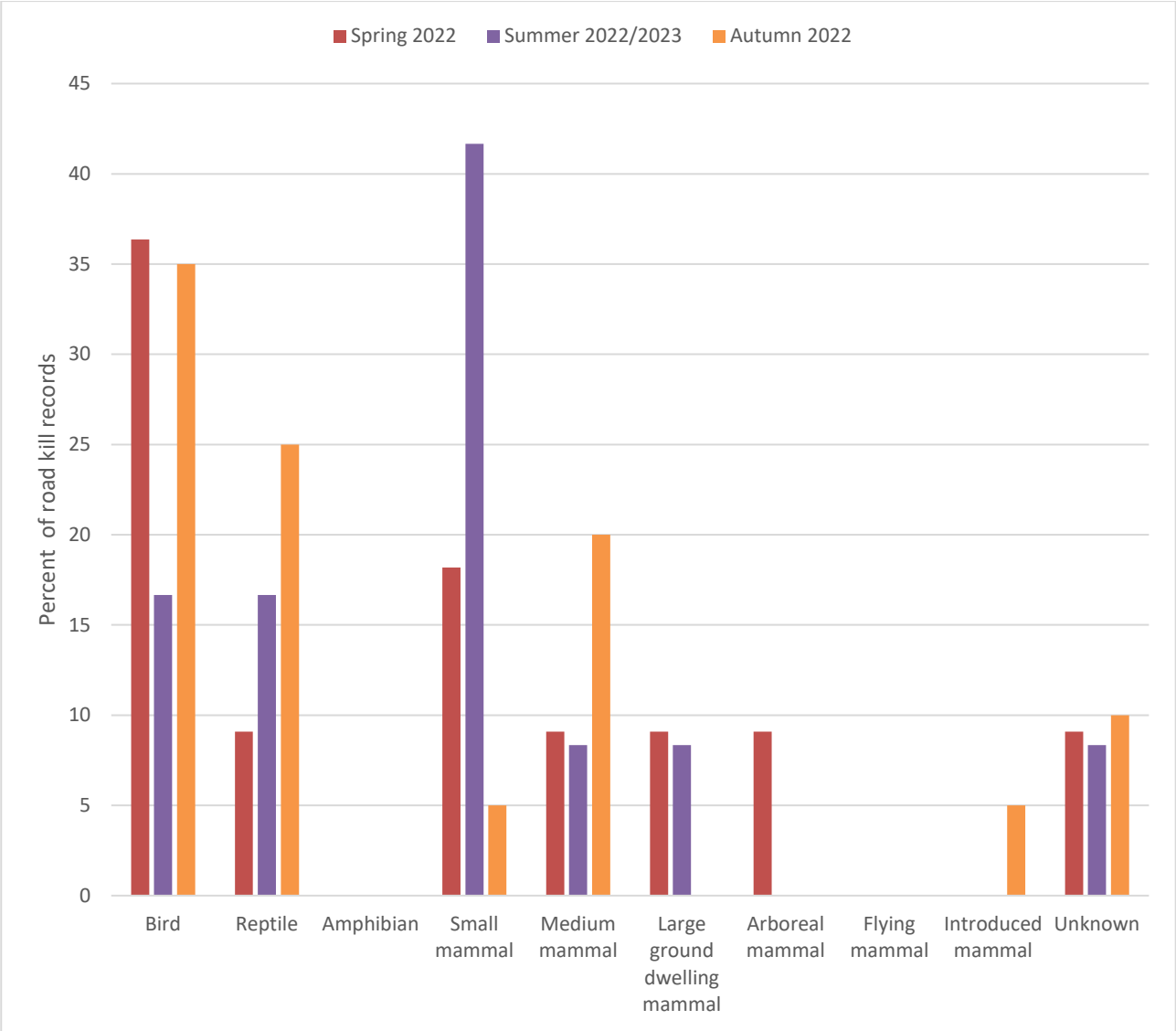
Road kill results are provided in Annex 1. The distribution of road kill records is in shown in Figure 1.

3.3.3 Total alignment

Fauna categories for analysis were defined as follows:

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

There were a total of 43 road kill records for the autumn, spring and summer 2022/2023 road kill monitoring events, including 20 in autumn, 11 in spring and 12 in summer. The percentage of road kill records for each fauna category for the current monitoring period is presented in Graph 1. Combining spring, summer and autumn results, birds (30.2% of road kill, n = 13), small mammals (18.6% of road kill, n = 8), reptiles (18.6% of roadkill, n = 8) and medium mammals (14.0%, n = 6), were the most commonly recorded fauna groups.



Graph 1: 2022/2023 road kill records

3.3.4 Threatened fauna

Table 3 lists the threatened species identified as road kill throughout the Project to date. Two Koala's were reported as roadkill in 2018/2019 and 2020/2021 (reported in Niche 2019 and 2021) and one Brush-tailed Phascogale in 2019/2020 (reported in Niche 2020) during the operational monitoring.

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

No threatened species have been recorded as road kill since October 2020.

Table 3: Threatened species road kill to date

Monitoring type (report)	Monitoring period	Threatened species identified as road kill (number recorded)
Baseline (Lewis 2014)	2013-2014	• Koala (1*) • Grey-headed Flying Fox (2)
Clearing (Niche 2015)	2014-2015	• Koala (4) • Grey-headed Flying Fox (1) • Masked Owl (2) • Spotted-tail Quoll (1)
Construction (Niche 2016b)	2015-2016	• Koala (1)
Construction (Niche 2017b)	2016-2017	• Koala (2)
Construction (Niche 2018)	2017-2018	Nil
Operational (Niche 2019)	2018-2019	• Koala (1)
Operational (Niche 2020)	2019-2020	• Brush-tail Phascogale (1)
Operational (Niche 2021)	2020-2021	• Koala (1)

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

3.3.5 Fauna fence

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

An analysis of the number of road kill events (excluding the bird records) that occurred either within or outside of fenced sections of the Project was undertaken. Road kill observations made at the edge of a fenced area, or in an area where fencing was present on one side of the carriageway only, were considered to be outside of the fenced area. Of the 30 road kill records (excluding birds) from the 2022/2023 monitoring period, nine (30%) records were within and 21 (70%) records were outside fenced areas. Considering the data with regard to the extent of fencing along the highway, calculation of a *road kill per kilometre* rate (excluding birds) showed the rate of road kill in unfenced areas (6.4 kilometres; 3.28 records/kilometre) to be substantially higher than the rate in fenced areas (30.6 kilometres; 0.29 records/kilometre).

3.3.6 Fauna crossings

An analysis of road kill within 200 metres of fauna crossing structures has been undertaken in order to address the trigger for contingency measures. As discussed in Section 2.3, fauna crossing zones were created by grouping fauna crossings that occurred within 400 metres of each other (i.e. their 200 metre boundary overlapped). The road kill records that occurred within these zones were compared to road kill records outside of these zones. Aerial crossings and underpasses (including bridges and culverts) were analysed separately.

Aerial crossings

There are 18 aerial crossings along the entire length of the Project that fall into nine separate zones. Both rope bridges and glider pole crossings were considered in this analysis. The Project consists of 5,176 metres that fall within 200 metres of an aerial crossing, and therefore 31,824 metres outside of these zones.

Of the 43 road kill records, only one arboreal mammal was recorded. Other records are considered to be irrelevant for the analysis of road kill in proximity of aerial crossings as ground-dwelling fauna (for example,

macropods, Echidnas, bandicoots, reptiles) or birds/bats. The single arboreal mammal was recorded within 200 metres of an aerial crossing during the 2022/2023 road kill surveys. Considering all road kill records, six were recorded within 200 m of an aerial crossing. Calculation of a *road kill per kilometre* rate therefore showed the rate of road kill within 200 metres of aerial crossings (5.2 kilometres; 1.15 records/kilometre) to be similar to outside this boundary (31.8 kilometres; 1.16 records/kilometre).

Underpasses

There are 42 culverts and 12 bridge areas throughout the Project that are considered to provide fauna passage under the carriageway, which fall into 39 separate zones. The Project consists of 19,175 metres that fall within 200 metres of an underpass/bridge, and therefore 17,825 metres outside of these zones. Of the 30 road kill records (excluding birds) from the 2022/2023 monitoring period, eight occurred within 200 metres of underpasses, while the remaining 22 occurred outside this boundary. Calculation of a *road kill per kilometre* rate (excluding birds) found the rate of road kill within 200 metres of fauna underpasses/bridges (19.2 kilometres; 0.42 records/kilometre) to be lower than the rate outside this boundary (17.8 kilometres; 1.23 records/kilometre).

3.3.7 Comparison with baseline and previous monitoring

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

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

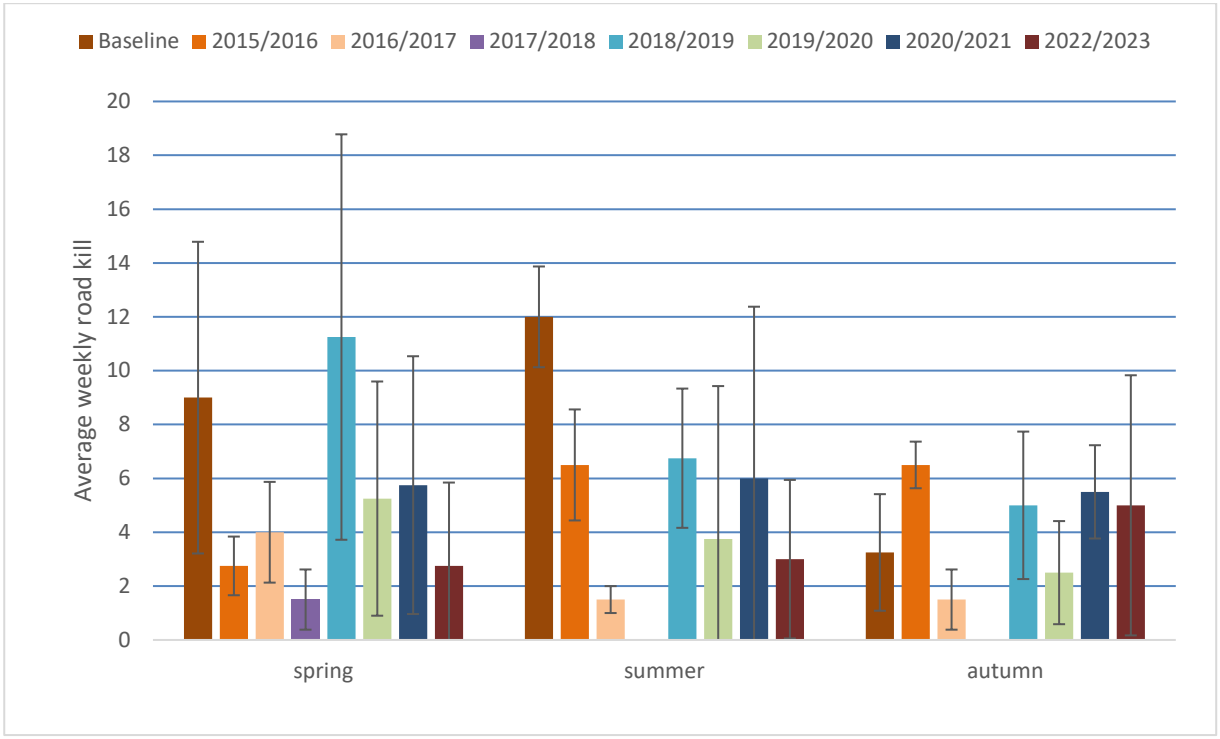
In order to compare the results of the baseline surveys with that of subsequent monitoring periods, the average weekly road kill for the four survey weeks undertaken in each season of the baseline surveys (spring (October), summer (January), autumn (May)), was compared to the same four weeks of each subsequent monitoring event. While autumn weekly road kill rates were higher in the 2022/2023 monitoring period (5.0) than during baseline (3.3), spring and summer weekly road kill rates were lower in the 2022/2023 monitoring period (2.8 and 3.0 respectively) compared to baseline (9.0 and 11.8 respectively). Therefore, the overall average weekly road kill rate has decreased from baseline surveys with a value of 8.0 to 3.6 for the same three seasons.

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

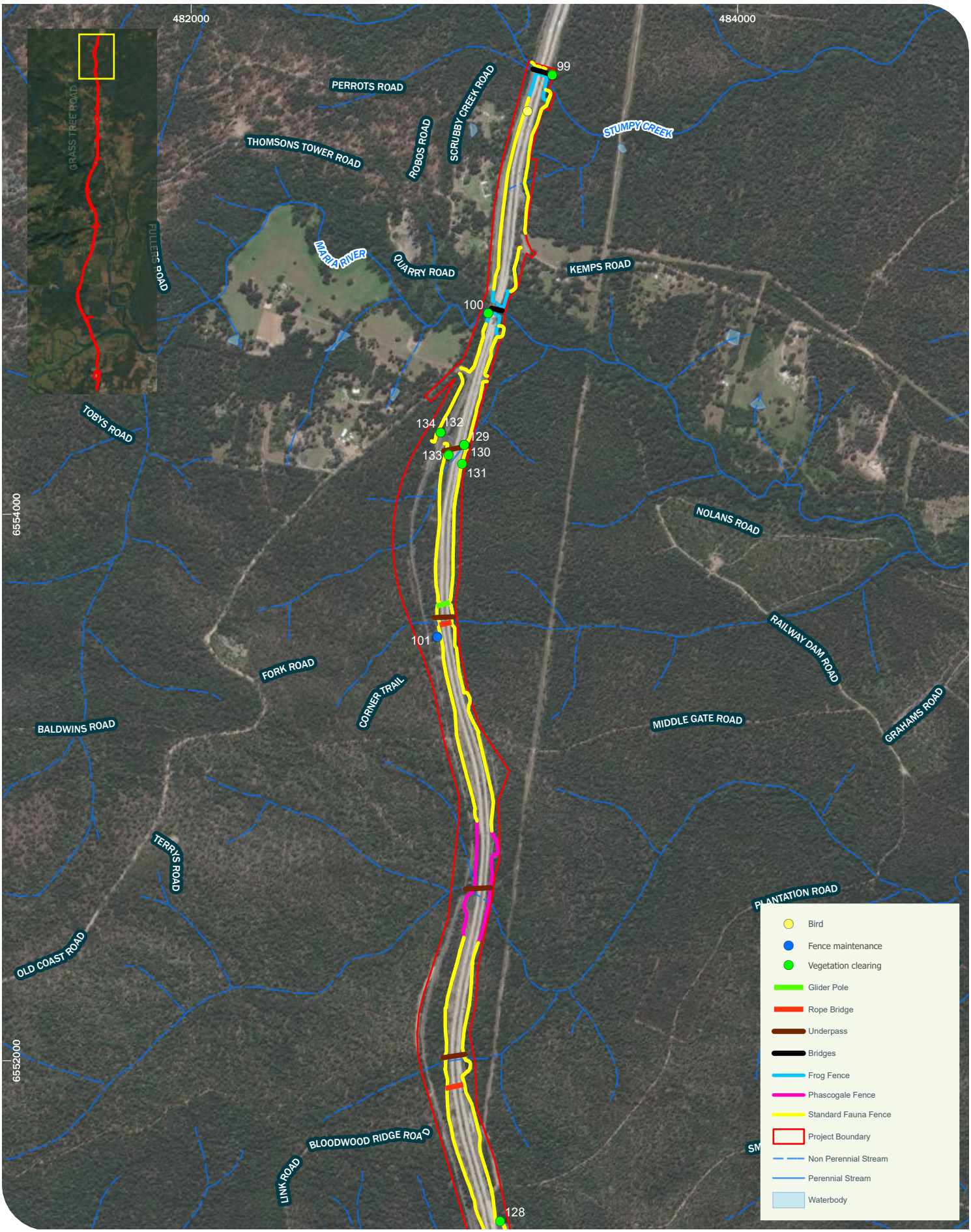
Table 4: Weekly road kill rates for monitoring undertaken along the entire Project alignment

Monitoring period		Spring (n)	Summer (n)	Autumn (n)	Winter (n)	Annual (n)
Baseline	**2013/2014**	9.5 (4)	11.8 (4)	3.3 (4)	No surveys	8.0 (12)
Construction phase	**2015/2016 (all surveys)**	4.2 (13)	5.8 (14)	6.7 (13)	4.1 (12)	5.0 (52)
	2015/2016 (4 weeks)	2.75 (4)	6.5 (4)	6.5 (4)	3.0 (4)	
	2016/2017 (all surveys)	3.3 (13)	2.6 (13)	2.0 (12)	2.2 (14)	2.3 (52)
	2016/2017 (4 weeks)	4.0 (4)	1.5 (4)	1.5 (4)	2.5 (4)	
	2017/2018 (all surveys)	2.9 (9)	No surveys*	No surveys*	3.3 (4)	3.0 (13)
	2017/2018 (4 weeks)	1.5 (4)	No surveys*	No surveys*	3.3 (4)	
12-week post-opening	**2017/2018 (all sections combined)**					4.5 (12)
Operational	**2018/2019**	11.3 (4)	6.8 (4)	5.0 (4)	No surveys	7.7 (12)
Operational	**2019/2020**	5.3 (4)	3.8 (4)	2.5 (4)	No surveys	3.8 (12)
Operational	**2020/2021**	5.8 (4)	6.0 (4)	5.5 (4)	No surveys	5.8 (12)
Operational	**2022/2023**	2.8 (4)	3.0 (4)	5.0 (4)	No surveys	3.6 (12)

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



Graph 2: Average (±SD, n = 4) weekly road kill in spring, summer and autumn



niche Environment and Heritage

0 400 m

Fauna fence maintenance actions - Summer 2022/2023 1

Oxley Highway to Kempsey Pacific Highway Upgrade

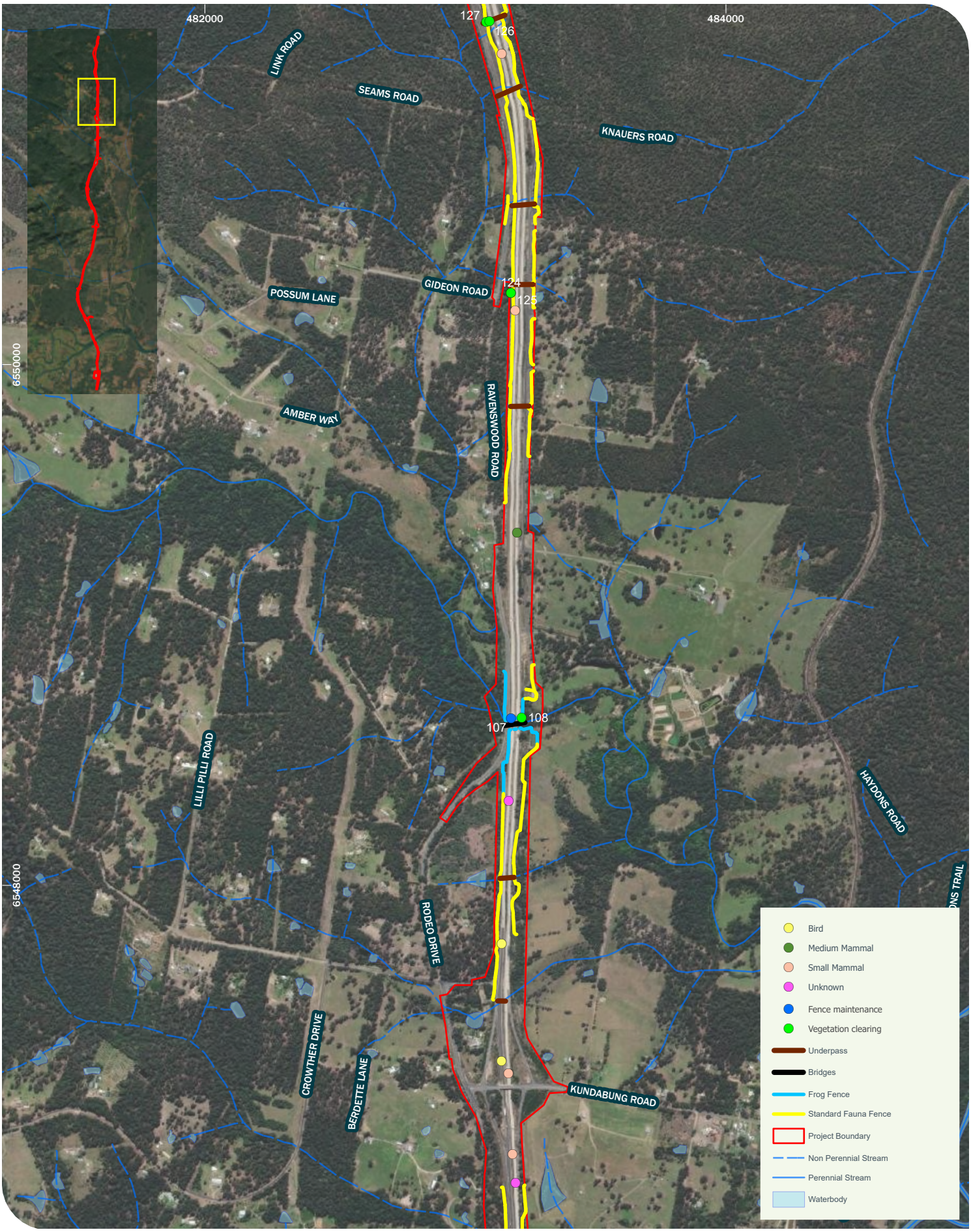
Niche PM: Radika Michniewicz
Niche Proj. #: 1702 PI 5.11
Client: TfNSW

Figure 1.1

Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Drawn by: File: T:\spatial\projects\a1700\a1702_OH2K_Ecology\Maps\a1702_OH2K_Ecology.aprx Last updated: 5/26/2023 4:30 PM

v2.0



Drawn by: File: T:\spatial\projects\a1700\a1702_OH2K_EcologyMaps\a1702_OH2K_EcologyAprx Last updated: 5/26/2023 4:30 PM

niche Environment and Heritage

0 400 m

Fauna fence maintenance actions - Summer 2022/2023 2

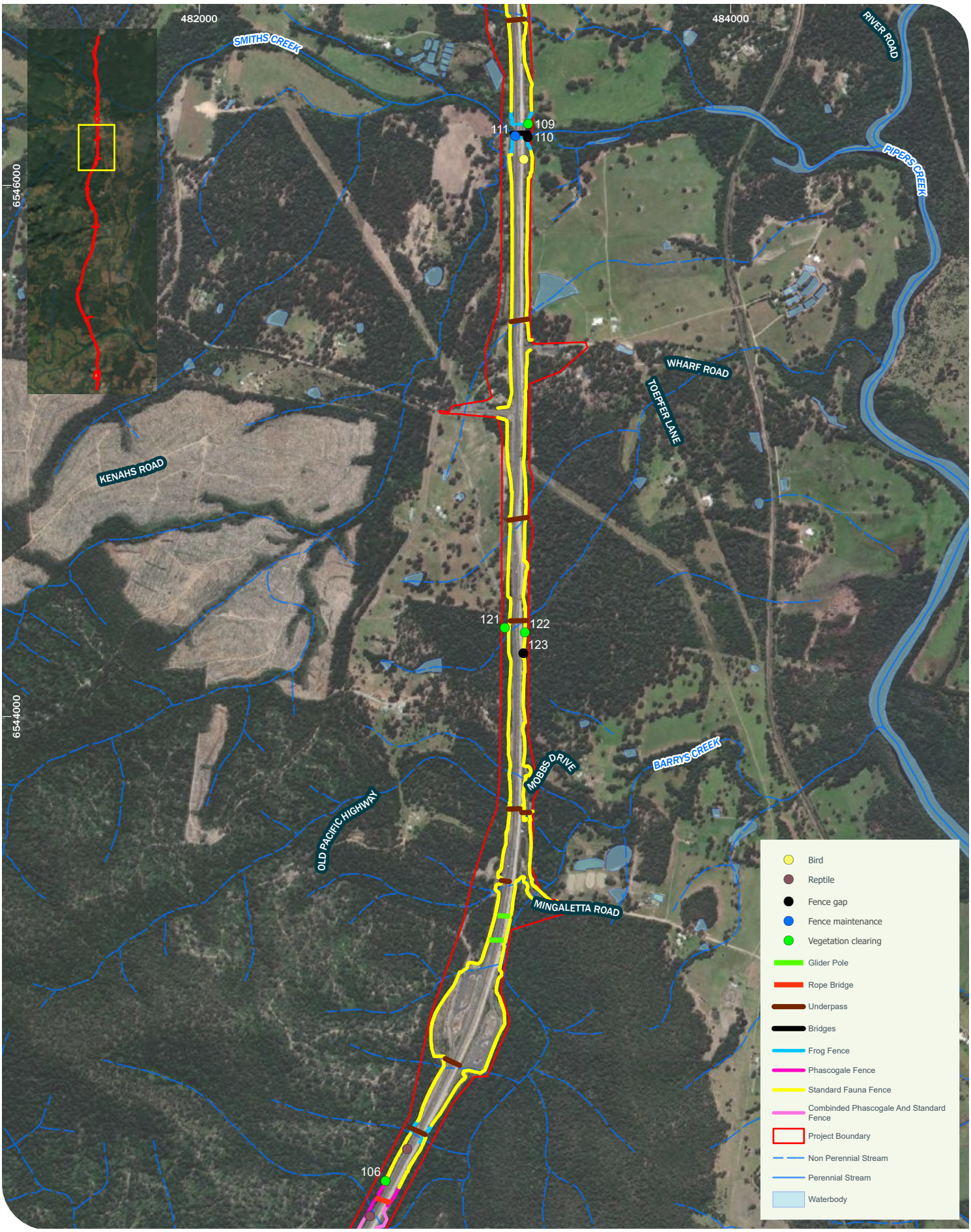
Oxley Highway to Kempsey Pacific Highway Upgrade

Niche PM: Radika Michniewicz
Niche Proj. #: 1702 PI 5.11
Client: TfNSW

Figure 1.2

Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

v2.0



Drawn by: File: T:\spatial\projects\a1700\a1702_OH2K_EcologyMaps\a1702_OH2K_EcologyAprx Last updated: 5/26/2023 4:30 PM

niche Environment and Heritage

0 400 m

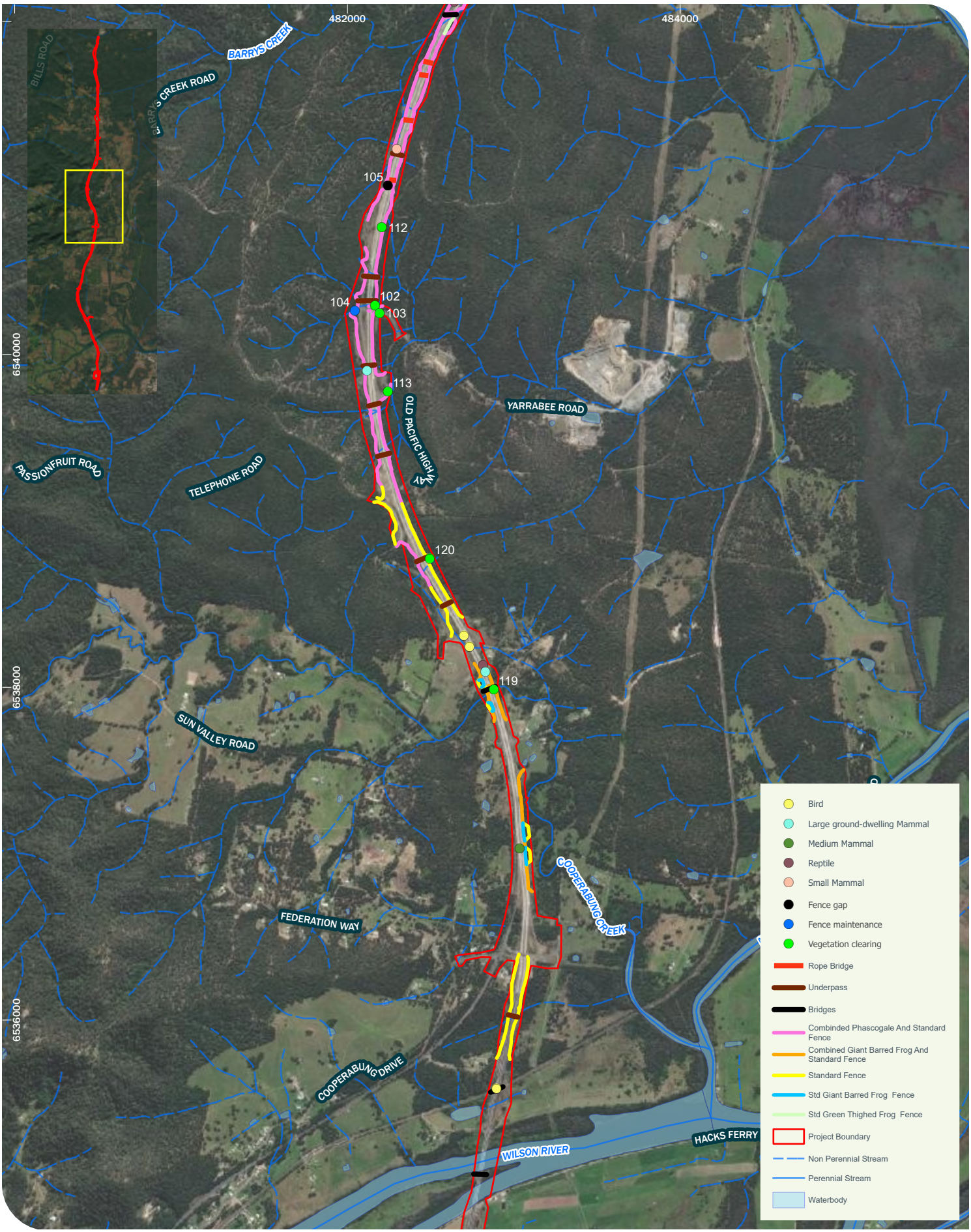
Fauna fence maintenance actions - Summer 2022/2023 3

Oxley Highway to Kempsey Pacific Highway Upgrade

Niche PM: Radika Michniewicz
Niche Proj. #: 1702 PI 5.11
Client: TfNSW

Figure 1.3

v2.0



Drawn by: File: T:\spatial\projects\a1700\a1702_OH2K_EcologyMaps\a1702_OH2K_EcologyAprx Last updated: 5/26/2023 4:30 PM

niche Environment and Heritage

0 600
m

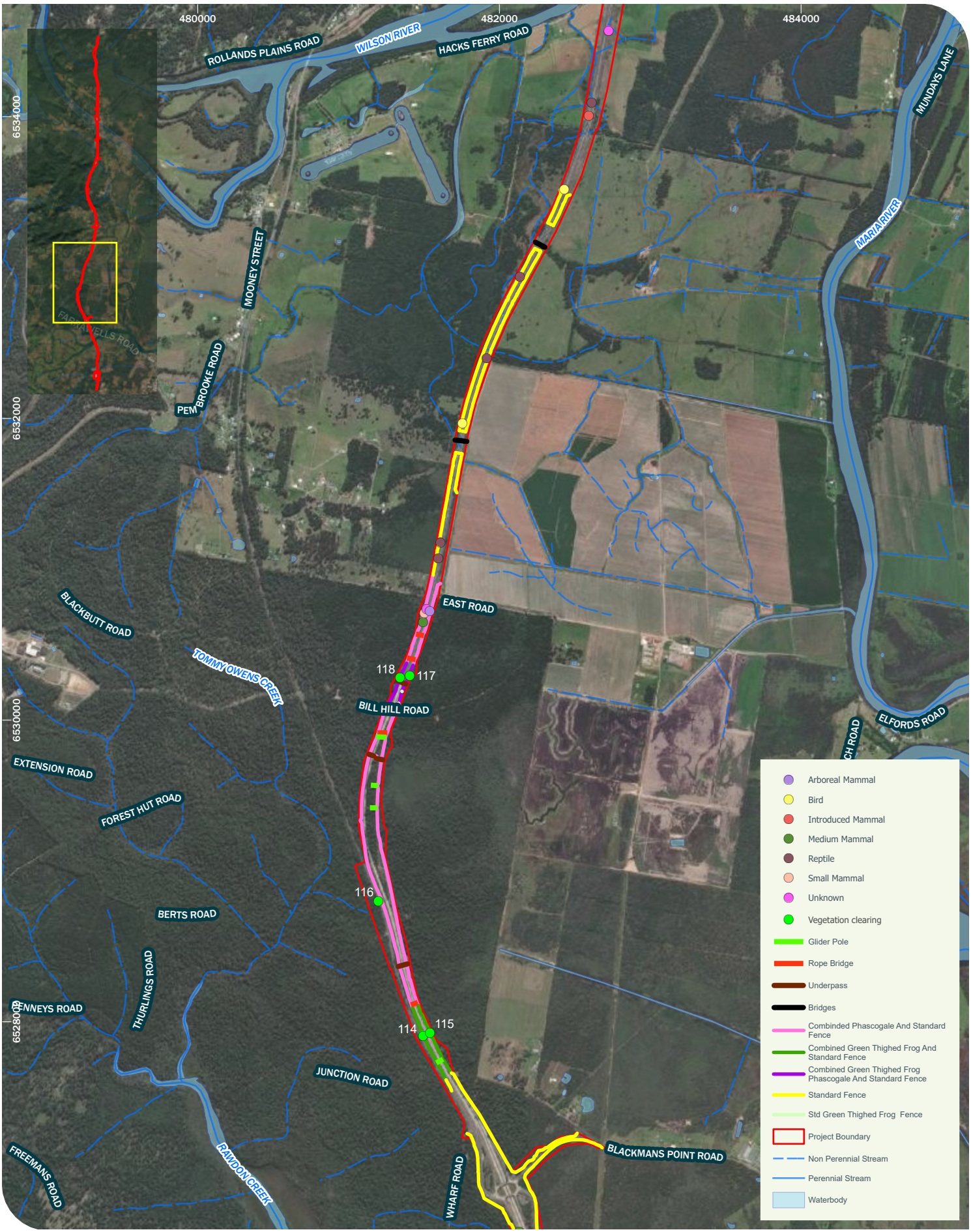
Fauna fence maintenance actions - Summer 2022/2023 4

Oxley Highway to Kempsey Pacific Highway Upgrade

Niche PM: Radika Michniewicz
Niche Proj. #: 1702 PI 5.11
Client: TfNSW

Figure 1.4

v2.0



Drawn by: File: T:\spatial\projects\a1700\a1702_OH2K_EcologyMaps\a1702_OH2K_Ecology.aprx Last updated: 5/26/2023 4:30 PM

niche Environment and Heritage

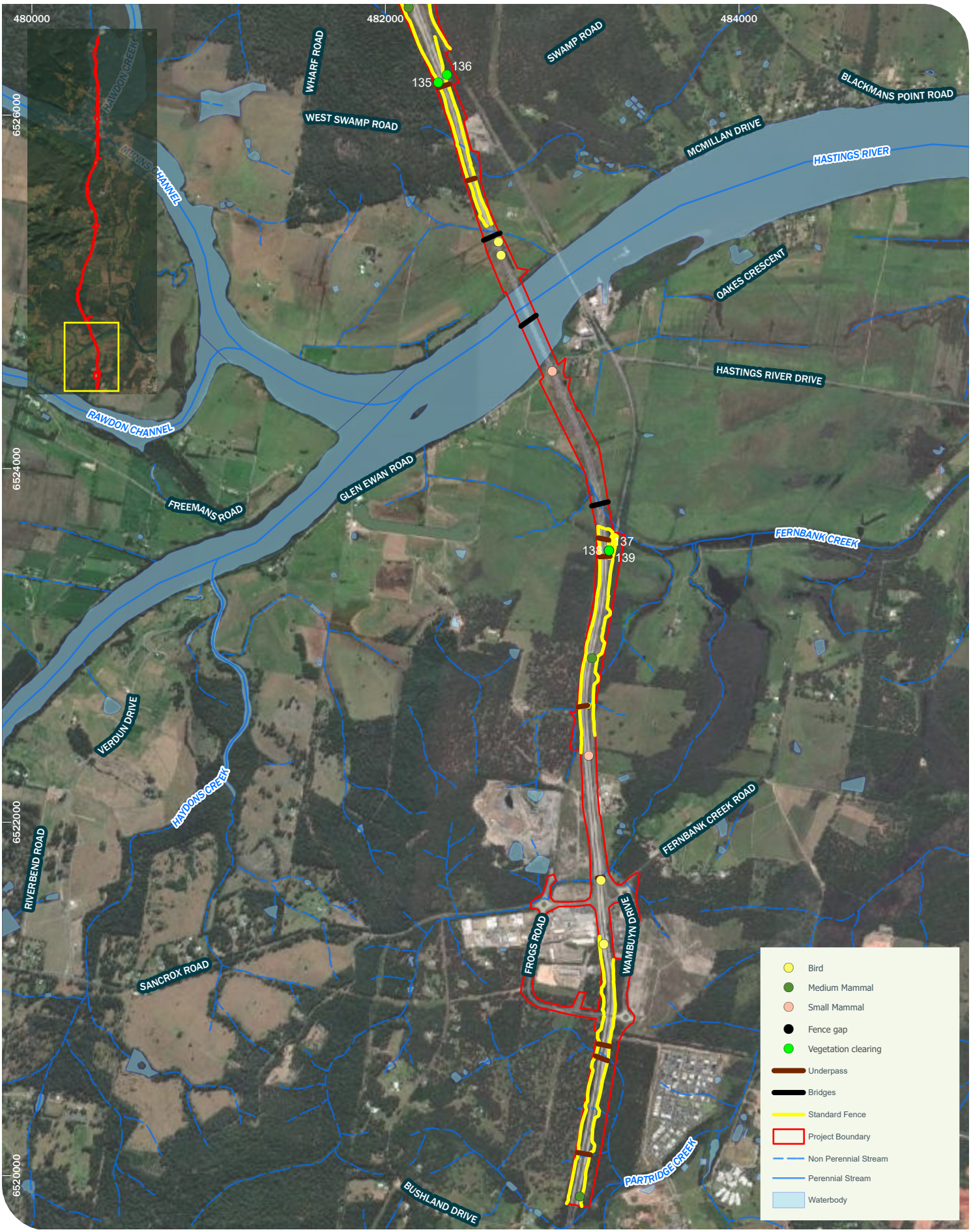
0 800 m

Fauna fence maintenance actions - Summer 2022/2023 5

Oxley Highway to Kempsey Pacific Highway Upgrade

Niche PM: Radika Michniewicz
Niche Proj. #: 1702 PI 5.11
Client: TfNSW

Figure 1.5



niche Environment and Heritage

0 600 m

Fauna fence maintenance actions - Summer 2022/2023 6

Oxley Highway to Kempsey Pacific Highway Upgrade

Niche PM: Radika Michniewicz
Niche Proj. #: 1702 PI 5.11
Client: TfNSW

Figure 1.6

Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Drawn by: File: T:\spatial\projects\a1700\a1702_OH2K_Ecology\Maps\a1702_OH2K_Ecology.aprx Last updated: 5/26/2023 4:30 PM

v2.0

4. Discussion

4.1 Performance Measures

4.1.1 Fauna fence

A summary of survey results to date in relation to the fauna fence performance measures are provided in Table 5.

Table 5: Indicators of success for fauna fencing

Performance measure	Discussion
No records of Giant Barred Frog or Green-thighed Frog road kill on the main carriageways directly adjacent to installed frog fencing in any monitoring event during Years 4, 6 & 8.	**This performance measure has been met.** No Giant Barred Frog or Green-thighed Frog road kill have been recorded to date.
Lower rates of road kill in proximity to fauna fencing than in sections of the upgrade not near fauna fencing during all monitoring events (Year 4, 6 & 8).	**This performance measure has been met.** Of the 30 road kill records (excluding birds) from the 2022/2023 monitoring period, nine (30%) records were within and 21 (70%) records were outside fenced areas. Considering the data with regard to the extent of fencing along the highway, calculation of a *road kill per kilometre* rate (excluding birds) showed the rate of road kill in unfenced areas (6.4 kilometres; 3.28 records/kilometre) to be substantially higher than the rate in fenced areas (30.6 kilometres; 0.29 records/kilometre).
Reduced incidence of road kill from baseline conditions.	**This performance measure has been met.** The overall average weekly road kill rate for the same three seasons has decreased from baseline values (8.0) to 2018/2019 (7.7), 2019/2020 (3.8), 2020/2021 (5.8) and 2022/2023 (3.6).
Fauna fence is installed at a minimum in areas identified in Schedule 3 of the EPBC approval at Year 4.	**This performance measure has been met.** TfNSW have advised that all fauna fencing as identified in Schedule 3 of the EPBC approval has been installed.

4.1.2 Road kill

A summary of survey results in relation to the road kill performance measures are provided in Table 6.

Table 6: Performance measures for road kill monitoring

Performance measure	Discussion
Lower rates of road kill in proximity (i.e. areas of the main carriageways within areas adjacent to installed fauna fencing, and within 200 m 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 has been met.** *Fauna fence*: Of the 30 road kill records (excluding birds) from the 2022/2023 monitoring period, nine (30%) records were within and 21 (70%) records were outside fenced areas. Considering the data with regard to the extent of fencing along the highway, calculation of a road kill per kilometre rate (excluding birds) showed the rate of road kill in unfenced areas (6.4 kilometres; 3.28 records/kilometre) to be substantially higher than the rate in fenced areas (30.6 kilometres; 0.29 records/kilometre). *Aerial crossing 200 metre boundary*: Of the 43 road kill records, only one arboreal mammal was recorded. The single arboreal mammal was recorded within 200 metres of an aerial crossing. Considering all road kill records, six were recorded within 200 m of an aerial crossing. Calculation of a *road kill per kilometre* rate therefore showed the rate of road kill within 200 metres of aerial crossings (5.2

Performance measure	Discussion
	kilometres; 1.15 records/kilometre) to be similar to outside this boundary (31.8 kilometres; 1.16 records/kilometre). *Underpass 200 metre boundary*: Of the 30 road kill records (excluding birds) eight occurred within 200 metres of underpasses. The rate of road kill within 200 metres of fauna underpasses/bridges (19.2 kilometres; 0.42 records/kilometre) was lower than the rate outside this boundary (17.8 kilometres; 1.23 records/kilometre).
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 has been met.** The overall average weekly road kill rate for the same three seasons has decreased from baseline values (8.0) to 2018/2019 (7.7), 2019/2020 (3.8), 2020/2021 (5.8) and 2022/2023 (3.6).
Fauna exclusion fencing is installed at a minimum in the locations identified in Schedule 3 of the EPBC approval at Year 4.	**This performance measure has been met.** TfNSW have advised that all fauna fencing as identified in Schedule 3 of the EPBC approval has been installed.

5. Recommendations

5.1 Contingency Measures and Recommendations

The EMP lists potential problems and contingency measures for the Project's mitigation measures. Those that are related to the fauna fence monitoring program are listed and discussed in Table 7.

Given that all performance measures were met there are no recommendations based on the outcomes of the 2022/2023 monitoring period specifically relating to contingency measures.

However, it is recommended that maintenance be undertaken as required to maintain the integrity of the fauna fence and minimise the opportunity for fence breaches.

Table 7: Contingency measures for fauna fencing

Potential problems	Contingency measure	Discussion of proposed measure
Breach in fauna fencing. High rates of fauna road strike mortality within 200 metres of fauna underpasses.	Commence review/modification of fauna exclusion fencing design, location or extent depending on species struck by vehicles within two weeks of results reported by ecologist.	Road kill rates were lower in proximity to underpasses. **This contingency measure is not considered relevant.**
	Inspect fence for breaches and inform maintenance as necessary within two weeks of results reported by ecologist. Any damage to fauna fencing will be temporarily repaired within one week of a breach being identified.	**This contingency measure is not considered relevant**.
	Permanent repair to occur as soon as possible and within two months of the breach being identified.	**This contingency measure is not considered relevant**.

References

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

Niche (2015). OH2K Pacific Highway Upgrade. Annual Ecological Monitoring Report 2015. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

Niche (2016a). Road kill report 2015/2016- Oxley Highway to Kempsey, Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

Niche (2016b). OH2K Pacific Highway Upgrade. Annual Ecological Monitoring Report 2016. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

Niche (2017a). Road kill monitoring 2016/2017- Oxley Highway to Kempsey, Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

Niche (2017b). OH2K Pacific Highway Upgrade. Annual Ecological Monitoring Report 2017. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

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

Niche (2019). Fauna Fence and Road Kill Monitoring 2018/2019. Oxley Highway to Kempsey, Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

Niche (2020). Road Kill Monitoring 2019/2020. Oxley Highway to Kempsey, Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Transport for NSW, Port Macquarie, NSW.

Niche (2021). Fauna Fence and Road Kill Monitoring 2020/2021. Oxley Highway to Kempsey, Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Transport for NSW, Port Macquarie, NSW.

TfNSW (2022). Oxley Highway to Kempsey Pacific Highway Upgrade Ecological Monitoring Program. Transport for NSW Update to report prepared by SMEC Hyder Joint Venture, February 2022.

Annex 1 – 2022/2023 road kill survey data

Season	Date	Latitude	Longitude	Species	Native/ introduced	Assigned vertebrate group
Autumn	6/04/2022	-31.459523	152.820815	Bandicoot	Native	Medium Mammal
Autumn	6/04/2022	-31.358491	152.805425	Echidna	Native	Medium Mammal
Autumn	6/04/2022	-31.354691	152.806495	Turtle	Native	Reptile
Autumn	6/04/2022	-31.328217	152.817041	Rabbit	Introduced	Introduced Mammal
Autumn	6/04/2022	-31.313958	152.820254	Bird	Unknown	Bird
Autumn	6/04/2022	-31.300945	152.82175	Bandicoot	Native	Medium Mammal
Autumn	6/04/2022	-31.289992	152.818595	Bird of Prey	Native	Bird
Autumn	6/04/2022	-31.252752	152.819177	Snake	Native	Reptile
Autumn	6/04/2022	-31.219131	152.82385	Kookaburra	Native	Bird
Autumn	6/04/2022	-31.323139	152.818427	Unidentified	Unknown	Unknown
Autumn	6/04/2022	-31.34273	152.809903	Skink	Native	Reptile
Autumn	6/04/2022	-31.406938	152.81738	Water Bird	Native	Bird
Autumn	13/04/2022	-31.357943	152.805527	Small mammal	Unknown	Small Mammal
Autumn	13/04/2022	-31.353729	152.80665	Reptile	Native	Reptile
Autumn	13/04/2022	-31.327434	152.817231	Water Dragon	Native	Reptile
Autumn	13/04/2022	-31.28939	152.818243	Bird	Unknown	Bird
Autumn	20/04/2022	-31.3577	152.805666	Unknown mammal	Unknown	Unknown
Autumn	20/04/2022	-31.208052	152.823002	Pigeon	Introduced	Bird
Autumn	20/04/2022	-31.428192	152.822905	Echidna	Native	Medium Mammal
Autumn	27/04/2022	-31.332619	152.815317	Bird	Native	Bird
Spring	5/10/2022	-31.442803	152.823585	Magpie	Native	Bird
Spring	5/10/2022	-31.280917	152.677786	Kangaroo	Native	Large ground-dwelling Mammal
Spring	5/10/2022	-31.263002	152.814062	Unidentified small mammal	Unknown	Small Mammal
Spring	5/10/2022	-31.199035	152.823307	Unidentified	Unknown	Unknown
Spring	5/10/2022	-31.357836	152.805898	Possum	Native	Arboreal Mammal
Spring	5/10/2022	-31.439535	152.823416	Magpie	Native	Bird
Spring	5/10/2022	-31.346608	152.808197	Bird	Unknown	Bird
Spring	12/10/2022	-31.337854	152.812223	Turtle	Unknown	Reptile
Spring	12/10/2022	-31.189743	152.823668	Medium mammal	Unknown	Medium Mammal
Spring	12/10/2022	-31.407626	152.817528	Bird of Prey	Native	Bird
Spring	21/10/2022	-31.43316	152.822711	Small mammal	Unknown	Small Mammal
Summer	16/01/2023	-31.255024	152.817704	Lace Monitor	Native	Reptile
Summer	16/01/2023	-31.203983	152.823013	Bird	Native	Bird

Season	Date	Latitude	Longitude	Species	Native/ introduced	Assigned vertebrate group
Summer	16/01/2023	-31.173147	152.823079	Bandicoot	Native	Small Mammal
Summer	16/01/2023	-31.134517	152.824111	Kookaburra	Native	Bird
Summer	16/01/2023	-31.212283	152.823563	Unidentified	Unknown	Unknown
Summer	16/01/2023	-31.290984	152.819451	Diamond Python	Native	Reptile
Summer	1/02/2023	-31.394962	152.812064	Echidna	Native	Medium Mammal
Summer	7/02/2023	-31.413537	152.820571	Small mammal	Unknown	Small Mammal
Summer	7/02/2023	-31.182048	152.823602	Small mammal	Unknown	Small Mammal
Summer	7/02/2023	-31.208481	152.823281	Small mammal	Unknown	Small Mammal
Summer	7/02/2023	-31.211288	152.823443	Small mammal	Unknown	Small Mammal
Summer	7/02/2023	-31.291354	152.819597	Wallaby	Native	Large ground-dwelling Mammal

Niche Environment and Heritage

A specialist environmental and heritage consultancy.

Head Office

Niche Environment and Heritage
PO Box 2443 North Parramatta NSW 1750
Email: info@niche-eh.com

All mail correspondence should be through our Head Office

niche
Environment and Heritage

Fauna Underpass Monitoring 2022/2023

Oxley Highway to Kempsey, Pacific Highway Upgrade

Prepared for Transport for NSW

May 2023

Niche Environment and Heritage
Excellence in your environment.
ABN: 19 137 111 721

Head Office
Level 4, 460 Church Street
Parramatta NSW 2150
All mail correspondence to:
PO Box 2443
North Parramatta NSW 1750
Phone: **02 9630 5658**
Email: **info@niche-eh.com**

Locations
Sydney
Bulli
Central Coast
Newcastle
Port Macquarie
Brisbane
Cairns

Document control

Project no.:	1702
Project client:	Transport for NSW
Project office:	Port Macquarie
Document description:	Fauna Underpass Monitoring 2022/2023 Report
Project Director:	Lawrence Smith
Project Manager:	Radika Michniewicz
Authors:	Jodie Danvers
Internal review:	Radika Michniewicz
Document status:	R0
Local Government Area:	Kempsey and Port Macquarie Hastings

Document revision status

Author	Revision number	Internal review	Date issued
Jodie Danvers	D1	Radika Michniewicz	1/05/2023
Jodie Danvers	R0		2/05/2023

Cover photograph: Red-necked Wallaby in F26.40 (left), Echidna in F22.32 (middle) and two Short-eared Brushtail Possum recorded using fauna furniture in C4.46 (right) during late spring/summer surveys.

Executive summary

Context

This report documents findings of the 2022/2023 monitoring period, the final of three monitoring periods for the fauna underpasses, as required for the Oxley Highway to Kempsey (OH2K) Pacific Highway Upgrade Project (the Project), and specified in the Oxley Highway to Kempsey Ecological Monitoring Program (EMP, TfNSW 2022).

Aims

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

Methods

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

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

Key Results

The key results of the 2022/2023 fauna underpass monitoring were as follows:

- A minimum of two of the fauna groups were recorded at all underpasses. Small ground-dwelling mammals were the most frequently recorded group at all underpasses, followed by macropods, arboreal mammals and reptiles (12 underpasses). Frogs were recorded using one underpass (C36.40).
- The three target threatened species listed on the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act), the Koala, the Giant Barred Frog and Spotted-tail Quoll, were not recorded using the underpasses in 2022/2023.
- One of the two non-EPBC Act target species, the Brush-tailed Phascogale was recorded using two of the underpasses (F20.54 and F22.32). Species identified as indicator species for the Brush-tailed Phascogale were recorded at all underpasses. Indicator species for the Green-thighed Frog (i.e. other frog species) were not recorded.
- Non-native predators including cats, dogs and foxes, were detected at 13 of 14 monitored underpasses (excluding C36.40). Three of the 14 monitored underpasses showed high use by non-native predators.
- To date, EPBC Act listed species, the Koala and Spotted-tailed Quoll, have been recorded at four and one underpass respectively.
- The 2022/2023 average weekly road kill decreased from that recorded during baseline monitoring from 8.0 to 3.6. Two road kill records were within 200 metres of monitored underpasses. There has not been an increase in road kill in proximity to monitored underpasses from baseline.

Conclusions

Performance measures are considered to have been met to date. The use of the underpasses by fauna, as measured and monitored according to the EMP, indicates that the underpasses allow fauna the opportunity for movement within home ranges, for dispersal and/or re-colonisation. The performance measure regarding use of underpasses by the Koala has been met at four underpasses and one underpass for the Spotted-tailed Quoll. Results indicate successful use by Indicator species for the Brush-tailed Phascogale. The performance indicator requiring a reduced incidence of road kill from baseline monitoring was met.

Management Implications

This report presents the results of the final of three monitoring events. Given the successful use by a range of native fauna from different fauna groups it is considered that the underpasses have been a successful mitigation measure allowing species to cross safely under the carriageway and maintain connectivity for adjacent habitat. Therefore, there are no further monitoring measures recommended beyond requirements of the EMP. However, maintenance of fauna fencing particularly within 200 m of underpasses is considered important in continued successful crossing by native fauna.

Table of Contents

List of Figures

List of Tables

1. Introduction

1.1 Context

The Oxley Highway to Kempsey (OH2K) section of the Pacific Highway Upgrade Project (the Project) was approved by the NSW Department of Environment and Planning in 2012 subject to various Ministers Conditions of Approval (MCoA) and a Statement of Commitments (SoC). A subsequent approval with additional conditions of consent (CoA) was granted in 2014 by the then Commonwealth Department of Environment (DoE) for Matters of National Environmental Significance (MNES) listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1995* (EPBC Act). The Ecological Monitoring Program (hereafter referred to as the EMP) (TfNSW 2022) combines these approval conditions and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project.

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

1.1.1 Monitoring framework

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

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

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

- Autumn 2018 and spring/summer 2018/2019: Year 4 surveys (Niche 2019a)
- Autumn 2020 and spring/summer 2020/2021: Year 6 surveys (Niche 2021a)
- Autumn 2022 and spring/summer 2022/2023: Year 8 surveys (current report).

This report represents the final of three reports required for the underpass monitoring – Year 8 autumn 2022 and spring/summer 2022/2023.

1.1.2 Background data

Underpass selection

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

- All dedicated fauna underpasses will be monitored.
- Combined underpasses that are 50 metres or more in length, and located in proximity to intact native vegetation (fauna habitat) will be monitored.
- No combined culverts that are located in cleared, disturbed or modified areas will be monitored.
- No combined culverts that are located within 600 metres of another monitored underpass will be monitored.

- No incidental underpasses will be monitored (small culverts that are not intended to allow for the passage of fauna but may be used incidentally by small fauna).

Indicator species

The EMP provides a list of indicator and target (threatened) species to determine the successful use of fauna crossing structures. These species are those that have been previously recorded in proximity to the Project or are known to occur in the Project area and were considered as being potentially adversely affected by the Project. Section 2.2.4 of the EMP states: *"The effectiveness of wildlife crossings will be based on their use by fauna groups previously recorded in proximity to the Project (<one kilometre). It is assumed that the Project bisects the habitat of at least some individuals from each of the nominated fauna groups (Table 4). Fauna species known to occur within the Project area that may be potentially adversely affected by the upgrade are listed in Table 5. These species will indicate the successful usage of crossing structures."* Table 1 lists the five fauna groups that are to be used to assess the effectiveness of the underpasses, as well as the indicator and target species for each of the five groups. It should be noted that while this report discusses the target and indicator species nominated for each underpass, all performance indicators do not directly relate to the use of the underpasses by these fauna groups.

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

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

1.1.3 Purpose of this report

This report details the findings obtained from the third operational monitoring event for the fauna underpasses. The aims of this report are to summarise the methods and results of the 2022/2023 monitoring and determine if performance measures are being met, as per the EMP.

1.2 Performance Measures

The EMP specifies the following performance measures for fauna underpasses:

- *Complete safe crossing by the targeted EPBC species, the Spotted-tailed quoll and Koala, at a sufficient frequency as defined in Section 1.5 of the EMP. This would ensure that the underpass performance measure would trigger the contingency measures in section 5 for underpass performance after each koala monitoring event to review / modify underpass furniture, habitat, monitoring and if required, agency discussions.*
- *For non-EPBC species (Brush-tailed Phascogale), the complete safe crossing of the nominated underpass by the target species or their indicator species on at least one occasion in order to demonstrate opportunity for dispersal and re-colonisation (excluding frogs which are unlikely to be detected using camera monitoring).*
- *For fauna groups, the complete safe crossing of the nominated underpass by one or more individuals on at least once occasion from each of the relevant fauna groups (small ground-dwelling mammals, arboreal mammals and macropods) to demonstrate opportunity for dispersal and re-colonisation*
- *Reduced incidence of road kill from baseline conditions.*

1.3 Monitoring Timing

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

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

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

1.4 Reporting

Annual reporting of monitoring results will include:

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

All reports prepared under the EMP will be submitted to the NSW Department of Planning and Environment (DPE) and the NSW Environment Protection Authority (EPA).

1.5 Limitations

Limitations relevant to the survey methodology that potentially impact on efficacy of the program include:

- Due to their small size and cryptic nature, frogs and smaller reptiles are difficult to detect within the underpasses using the current survey methods and thus if present, may have gone undetected.
- The EMP requires installation of sand plots at combined underpasses, which serve as combined drainage/fauna culverts. It was considered that sand plots established across the active drainage channel of the culvert would likely wash away. In consultation with Transport for NSW (TfNSW) it was therefore determined that sand plots would be established across the entire width of the underpass only if the drainage channel was not inundated with water.
- The EMP requires an assessment of the effectiveness of the underpasses for species listed under the Commonwealth EPBC Act, with 'effective' defined in Section 1.5 of the EMP as "*Result in the complete, safe crossing of the crossing by the targeted EPBC species at a sufficient frequency to ensure that habitat connectivity is maintained or improved from baseline conditions (determined by surveys condition 4a and information provided in the preliminary documentation), and ongoing population viability by providing opportunities for species dispersal and re-colonisation; and result in reduced incidence of road kill from baseline conditions (determined by surveys condition 4a and information provided in the preliminary Documentation*". The EMP does not define what "*sufficient frequency*" would be and baseline crossing frequencies are unknown and therefore cannot be used to assess the success of the underpasses. In addition, this monitoring program does not provide a means of

measuring dispersal and re-colonisation of species or population viability. The limitations of the EMP with regards to this performance measure are discussed in detail in Table 14.

2. Methods

2.1 Monitoring Sites

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

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

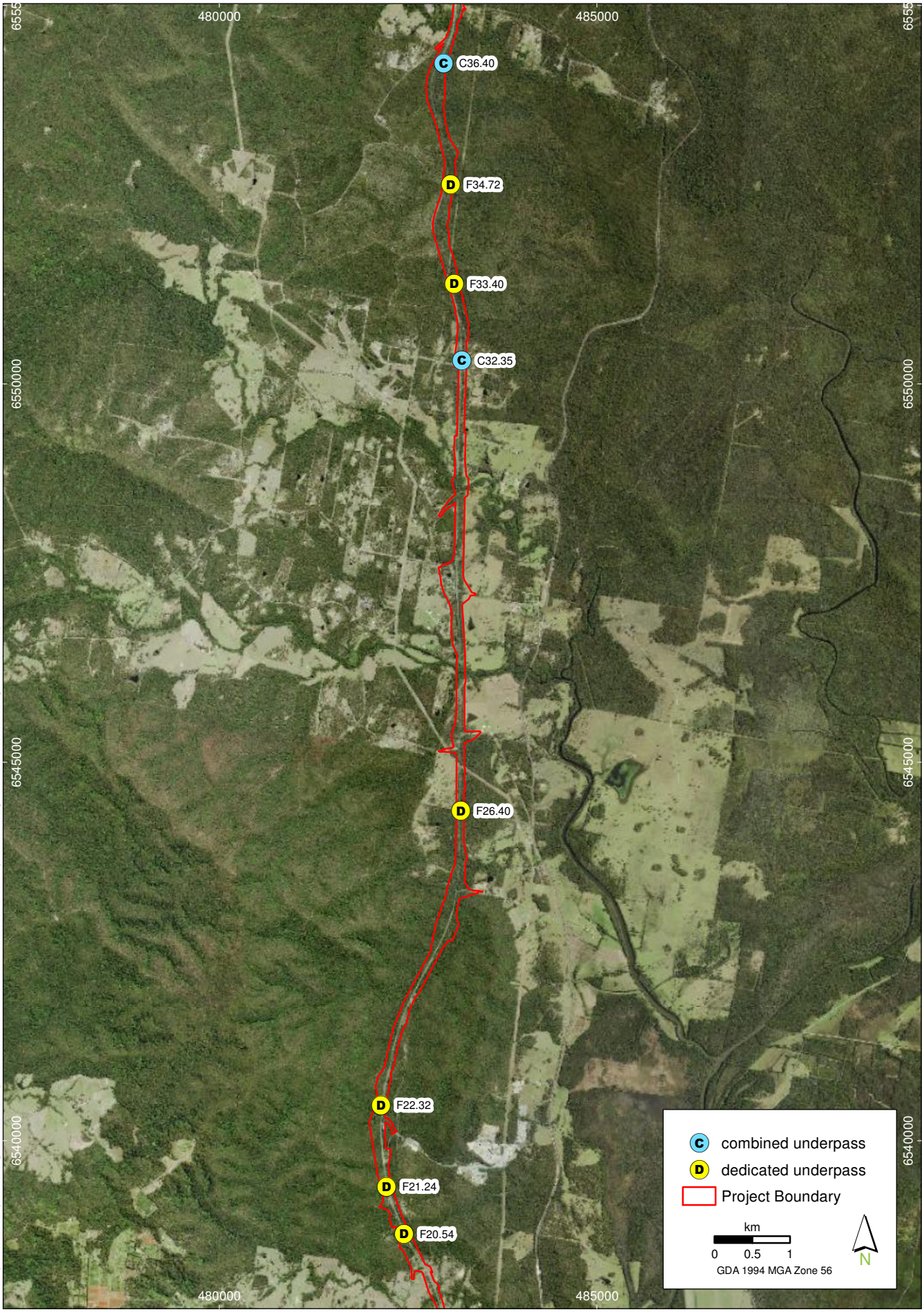
		Underpass number													
Target fauna group/species	**Indicator species**	**F1.04**	**F1.62**	**C4.46**	**C7.26**	**F9.70**	**F11.67**	**F20.54**	**F21.24**	**F22.32**	**F26.40**	**C32.35**	**F33.40**	**F34.72***	**C36.40**
Fauna group/species (target threatened species)															
Frogs (Green-thighed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

+ The Brush-tailed Phascogale was not previously nominated at any underpass in Table 12 of the EMP but has been included based on Table 13 of EMP. *Nominated fauna groups/species are based on the two closest underpasses and proximity of recorded Green-thighed Frog habitat.

2.2 Survey Method

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

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



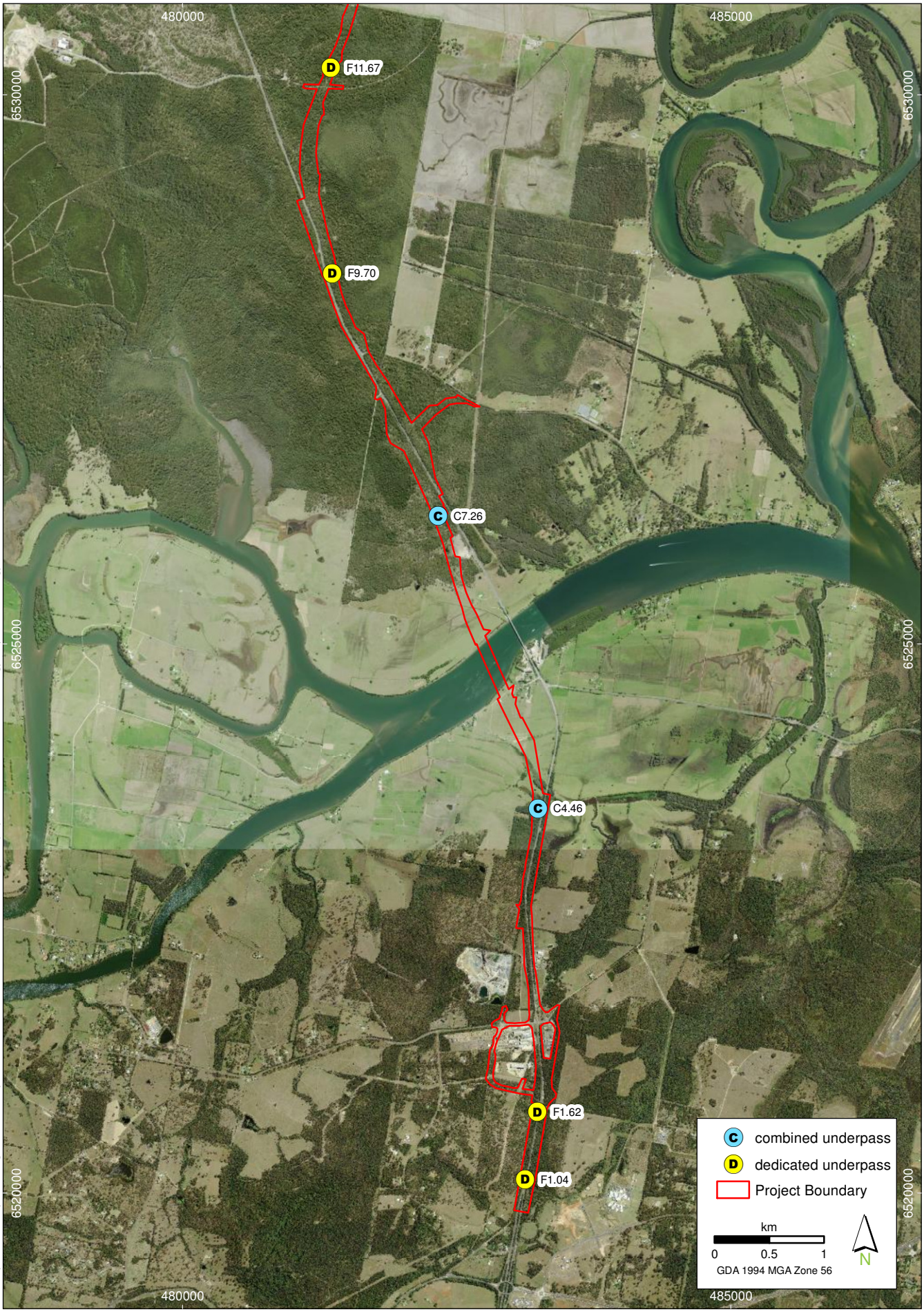
Drawn by: GT Project Manager: RM Project Number: 1702 PI 5.9 Date: 6/6/2019 T:\SpatialWorking\a1702\1702_PI_59_Figure_1_UnderpassLocations_North2.mxd

Fauna Underpass Locations - North

Oxley Highway to Kempsey - PI 5.9 Fauna Underpass Monitoring

FIGURE 1

Imagery: (c) LPI 2013



Fauna Underpass Locations - South

Oxley Highway to Kempsey - PI 5.9 Fauna Underpass Monitoring

niche Environment and Heritage

FIGURE 2

Imagery: (c) LPI 2013

3. Results

3.1 2022/2023 Monitoring Summary

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

3.1.1 Monitoring periods

The 2022/2023 monitoring periods were as follows:

- Autumn 2022: 30 March 2022 – 1 and 7 June May 2022
- Late spring/early summer 2022/2023: 3-4 November 2022 – 4 January 2023.

Hair tube surveys were undertaken in the first two weeks of the monitoring period. Sand plots were monitored for eight nights in autumn (10 – 19 May 2022) and late spring/summer (8 – 16 December 2022). As the deployment periods were longer than the minimum 60 days, any species recorded outside of the 60 day monitoring period were considered as value adding data and included in the assessment of underpass use by fauna groups.

Camera details, including monitoring dates and durations, for autumn and spring/summer surveys are provided in Annex 1.

3.1.2 Remote cameras

Table 4 provides a summary of the fauna records for the monitored underpasses. Cameras captured a total of 1708 fauna records over the two monitoring periods. A proportion (12.1%) of records were unidentified, which consisting of partial and/or unclear images and could not be identified as either native or introduced fauna, including unidentified small mammals recorded as rodents. Of those records that were identified, 57.0% were identified as native fauna.

Table 4: 2022/2023 camera fauna record summary

Underpass	# fauna records	# natives	# non native	# unidentified	# introduced predator	% native	% introduced predator
F1.04	50	15	34	1	34	30.0	68.0
F1.62	120	83	35	2	34	69.2	28.3
C4.46	236	163	70	3	46	69.1	19.5
C7.26	16	2	12	2	5	12.5	31.3
F9.70	64	5	37	22	16	7.8	25.0
F11.67	88	23	49	16	16	26.1	18.2
F20.54	212	151	38	23	4	71.2	1.9
F21.24	279	172	45	62	4	61.6	1.4
F22.32	226	110	68	49	1	48.7	0.4
F26.40	165	114	45	6	1	69.1	0.6
C32.35	75	56	16	3	6	74.7	8.0
F33.40	115	58	49	8	2	50.4	1.7
F34.72	61	21	31	9	4	34.4	6.6
C36.40	1	0	0	1	0	0.0	0.0
TOTALS	1708	973	529	206	173	57.0	10.1

3.1.3 2022/2023 native fauna use of underpasses

Results of the different survey methods were combined to provide an overall assessment of the use of monitored underpasses by the nominated fauna groups, however only the small ground-dwelling mammals, arboreal mammals and macropods, i.e. not frogs or reptiles, factor into the determination of performance measure outcomes. While a specific means of determining a "*complete safe crossing"* by targeted EPBC species is not specified in the EMP, it is considered that animals captured on remote cameras within the underpass are using the underpass to complete successful crossings. Table 5 shows the use of underpasses by fauna groups and target species. Shaded squares indicate the underpasses where fauna groups/target species were nominated (Table 3). A summary of the use of underpasses by the respective fauna groups is as follows:

- Frogs: Scat recorded at one of the 14 nominated underpasses (C36.40).
- Small ground-dwelling mammals: recorded at all 14 nominated underpasses represented by rodents, antechinus, bandicoots and the Echidna.
- Arboreal mammals: recorded at seven of the nine nominated underpasses, and at five additional underpasses; represented by the Brushtail Possum.
- Macropods: recorded at 12 of the 14 nominated underpasses (excluding F1.04 and C36.40); represented by the Eastern Grey Kangaroo (*Macropus giganteus*), Red-necked Wallaby (*Macropus rufogriseus*) and Swamp Wallaby (*Wallabia bicolor*).
- Reptiles: recorded at 12 of the 14 nominated underpasses; represented predominantly by the Eastern Water Dragon (*Intellagama lesueurii*) and Lace Monitor (*Varanus varius*).

Table 5: 2022/2023 native fauna use of underpasses

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

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

3.1.4 2022/2023 EPBC target species

Three of the five target threatened species (Table 1) are listed under the EPBC Act, including the Koala (*Phascolarctos cinereus*), Giant Barred Frog (*Mixophyes iteratus*) and Spotted-tailed Quoll (*Dasyurus maculatus*). These species were specifically nominated as target species at all, one and 10 of the underpasses respectively, however only the Koala and Spotted-tailed Quoll factor into the determination of performance measure outcomes.

The Koala was not recorded using any underpass during the 2022/2023 monitoring period. Neither the Giant Barred Frog or the Spotted-tailed Quoll were recorded within the underpasses during the 2022/2023 monitoring.

3.1.1 2022/2023 non-EPBC target species and presence of indicator species

Non-EPBC target threatened species include the Green-thighed Frog (*Litoria brevipalmata*) and Brush-tailed Phascogale, however only the Brush-tailed Phascogale factors into the determination of performance measure outcomes. The Brush-tailed Phascogale was recorded at two of the 14 underpasses (F20.54 and F22.32) during the 2022/2023 monitoring period, once in autumn and once in spring/summer.

Indicator species for the Brush-tailed Phascogale include those species included in the small ground-dwelling mammal fauna group and the arboreal mammal fauna group. While the Brush-tailed Phascogale

was not specifically nominated at individual underpasses, for the purpose of assessment, it is assumed that this species is a general target at all underpasses where the small ground-dwelling mammals and/or arboreal mammal fauna groups have been nominated, i.e. at all underpasses. Representatives of the small ground-dwelling fauna group were detected at all of the 14 underpasses with at least one indicator species at any underpass and representatives of the arboreal mammal group were recorded at seven of the nine nominated underpasses.

The Green-thighed Frog was specifically nominated as a species that may 'possibly' (TfNSW 2022) use F33.40 and C36.40. Indicator species for this target species include those species listed within the frog fauna group, however only amphibian scats were recorded at one underpass (C36.40) during the 2022/2023 monitoring periods. F33.40 is located approximately 150 metres (western side of carriageway) and 250 metres (eastern side of carriageway) south of Green-thighed Frog ponds constructed as part of the Project's mitigation requirements for this species, in proximity to a site where the species was recorded during targeted surveys (Site 16, Lewis 2013). However, no Green-thighed Frogs have been recorded at these ponds during the two monitoring events undertaken by Niche as part of the Project's Green-thighed Frog pond monitoring in 2016/2017 and 2018/2019 (Niche 2017a; Niche 2018a). It should be noted that it is unlikely that, if present, individuals from the identified Site 16 population would travel the required distance to F33.40 (Lemckert and Slatyer 2002). C36.40 is within 400 metres of a targeted survey site (Site 17, exact location not provided; Lewis 2013) identified as a likely location for the species and visited during targeted surveys. However, no Green-thighed Frogs were recorded at this site during the targeted surveys.

3.1.2 2022/2023 use of underpasses by non-native predators

Non-native predators including cats, dogs and foxes, were detected at 13 of the 14 monitored underpasses. Table 6 shows the non-native predators recorded using each underpass and the percentage of all identified fauna records that were non-native predators.

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

Three of the 14 monitored underpasses showed high use by non-native predators, notably cats and foxes. The highest use was recorded at the following four underpasses: F1.04, F1.62, and C7.26 with visitation by non-native predators accounting for 68.0%, 28.3% and 31.3% of visitations respectively. Visitation by dogs was low in comparison.

Table 6: 2022/2023 exotic predator use of underpasses

	Underpass number													
Species	**F1.04**	**F1.62**	**C4.46**	**C7.26**	**F9.70**	**F11.67**	**F20.54**	**F21.24**	**F22.32**	**F26.40**	**C32.35**	**F33.40**	**F34.72**	**C36.40**
Fox (*Vulpes vulpes*)	30	21	46	0	2	4	3	1	1	1	6	1	2	0
Cat (*Felis catus)*	4	13	0	0	0	0	0	1	0	0	0	1	0	0
Dog (*Canis familiaris/dingo*)	0	0	0	5	14	12	1	2	0	0	0	0	2	0
Percentage of visitations	**68.0**	**28.3**	19.5	**31.1**	25.0	18.2	1.9	1.4	0.4	0.6	8.0	1.7	6.6	0.0

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

3.2 Cumulative Use

Combined results from the 2018/2019, 2020/2021 and 2022/2023 monitoring events are presented below.

3.2.1 Cumulative native fauna use of underpasses

Table 7 shows the cumulative use of underpasses by fauna groups and target species to date. All but one of the fauna groups (frogs), have been recorded using all of fourteen underpasses. A summary of the use of underpasses by the respective fauna groups is as follows:

- Frogs: Scat recorded at one of the 14 nominated underpasses (C36.40).
- Small ground-dwelling mammals: recorded at all nominated underpasses; represented by rodents, antechinus, bandicoots, the Echidna and the Spotted-tailed Quoll.
- Arboreal mammals: recorded at all nine nominated underpasses, and at five additional underpasses; represented by the Brushtail Possum and the Koala.
- Macropods: recorded at all 14 nominated underpasses; represented by the Eastern Grey Kangaroo, Red-necked Wallaby and Swamp Wallaby.
- Reptiles: recorded at all 14 nominated underpasses; represented predominantly by the Eastern Water Dragon and Lace Monitor.

Table 7: Cumulative fauna use of underpasses - 2018/2019, 2020/2021 and 2022/2023

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

[+] The Brush-tailed Phascogale was not specifically nominated at any underpass in Table 12 of the EMP. Shaded cells are the nominated underpasses *Nominated fauna groups/species are based on the two closest underpasses.

3.2.2 Cumulative EPBC Act listed target species

As outlined in section 3.3, three target species are listed under the EPBC Act including the Koala, Giant Barred Frog and Spotted-tailed Quoll, however only the Koala and Spotted-tailed Quoll factor into the determination of performance measure outcomes. To date, the Koala and the Spotted-tailed Quoll have been recorded using five underpasses during the 2018/2019 and 2020/2021 monitoring periods; the Koala has been detected using F9.70, F11.67, C32.35 and F33.40, and the Spotted-tailed Quoll has been detected using C36.40. Details of these records are provided in Table 8 and discussed below. The Giant Barred Frog has not been detected using any underpasses.

Three of the four underpasses used by the Koala are dedicated fauna underpasses with installed fauna furniture. The fourth underpass used by the Koala (C32.35) is a combined drainage/fauna culvert without installed fauna furniture. All Koalas were recorded on the ground. The Spotted-tailed Quoll was detected using a nominated combined drainage/fauna culvert heading in a westerly direction on the raised fauna footpath.

The Giant Barred Frog was specifically nominated as a species that may 'possibly' (TfNSW 2022) use C36.40. Given the constructed state of C36.40, the intermittent water flow within the underpass and in the drainage line connecting to the underpass, and the absence of habitat within the underpass to facilitate movement (including shelter such as leaf litter, vegetation, rocks and logs), it is considered unlikely that this species would use this underpass. The nearest baseline record is from Maria River, approximately 500 metres to the north (Lewis 2014). Giant Barred Frog monitoring for the Project has shown that this species is traversing the Pacific Highway within the monitored waterways under bridges (Niche 2018b).

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

Table 8: Cumulative EPBC Act listed species recorded in underpasses

Season	Underpass	Date	Time	Species	Position	Direction
Autumn	C36.40	28/05/2018	2:43:37	Spotted-tailed Quoll	Ground	West
Spring/summer	F33.40	23/11/2018	5:41:47	Koala	Ground	East
Spring/summer	F11.67	24/11/2018	23:16:54	Koala	Ground	East
Spring/summer	F9.70	16/12/2018	11:06:19	Koala	Ground	East
Spring/summer	C32.35	29/11/2020	7:13:29	Koala	Ground	West

3.2.3 Cumulative non-EPBC Act listed target species and presence of indicator species

Non-EPBC target threatened species include the Green-thighed Frog and Brush-tailed Phascogale, however only the Brush-tailed Phascogale factors into the determination of performance measure outcomes.

Indicator species for the Brush-tailed Phascogale include those species within the small ground-dwelling mammal fauna group and the arboreal mammal fauna group. Representatives of the small ground-dwelling fauna group were detected at all underpasses with at least two indicator species at any underpass. Representatives of the arboreal mammal group were recorded at eight of the nine nominated underpasses indicating relatively high use of the underpasses by these fauna groups.

Indicator species for the Green-thighed Frog include those species listed within the frog fauna group, however no amphibians were detected at any of the underpasses during the 2018/2019 and 2020/2021. During the 2022/2023 monitoring periods the presence of amphibians at C36.40 was recorded based on scat detected.

3.2.4 Cumulative use of underpasses by non-native predators

Non-native predators including cats, dogs and foxes, have been detected at all of the fourteen monitored underpasses. Table 9 shows the non-native predators recorded using each underpass and Table 10 shows the percentage of all identified fauna records that were non-native predators. The majority (11 of 14) of the monitored underpasses showed high use by non-native predators during at least one monitoring period. At least two of the three different non-native predators have been recorded at each underpass, with all three recorded at 12 of 14 underpasses. Non-native predator use at underpasses has increased at five of the monitored underpasses since 2018/2019 monitoring and at two of the underpasses since 2020/2021.

Table 9: Cumulative frequency of exotic predator use of underpasses (number of records)

	Underpass number													
Species	**F1.04**	**F1.62**	**C4.46**	**C7.26**	**F9.70**	**F11.67**	**F20.54**	**F21.24**	**F22.32**	**F26.40**	**C32.35**	**F33.40**	**F34.72**	**C36.40**
Fox (*Vulpes vulpes*)	**84**	**54**	**57**	**56**	**30**	12	9	4	**18**	**31**	7	**54**	6	4
Cat (*Felis catus)*	9	18	9	9	10	1	9	**6**	4	5	**33**	27	**26**	**25**
Dog (*Canis familiaris/dingo*)	1	0	1	10	15	**19**	**10**	4	3	13	0	2	**28**	2

Bold indicates exotic predator which occurs most frequently at each underpass.

Table 10: Cumulative exotic predator use of underpasses to (percentage of all fauna recorded)

	Underpass number													
Species	**F1.04**	**F1.62**	**C4.46**	**C7.26**	**F9.70**	**F11.67**	**F20.54**	**F21.24**	**F22.32**	**F26.40**	**C32.35**	**F33.40**	**F34.72**	**C36.40**
2018/2019	**53.1**	**43.3**	14.5	12.7	21.0	1.8	20.8	20.0	8.0	**36.6**	**30.0**	**35.2**	**34.7**	**27.8**
2020/2021	**28.6**	**46.2**	7.6	**79.7**	**31.6**	**29.4**	17.0	5.3	**75.0**	20.0	**54.9**	**41.9**	**35.9**	**39.4**
2022/2023	**68.0**	**28.3**	19.5	**31.1**	25.0	18.2	1.9	1.4	0.4	0.6	8.0	1.7	6.6	0.0

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

3.3 Road Kill

3.3.1 Weekly road kill rate

As part of the road kill monitoring component of the Project, road kill surveys were undertaken in April 2022 (autumn), October 2022 (spring) and January 2023 (summer), involving weekly surveys of the entire length of the Project for four weeks in each season. Detailed reporting of these surveys is presented in Niche (2023).

There were a total of 43 road kill records for the spring, summer and autumn 2022/2023 road kill monitoring events, including 20 in autumn, 11 in spring and 12 in summer. Baseline surveys were undertaken prior to the commencement of construction for 12 weeks in spring 2013, summer 2014 and autumn 2014. Monitoring took place weekly for four weeks in each of the seasons as required by the EMP. Baseline surveys recorded 96 animals as road kill during the three monitoring events, representing 33 species and an average weekly road kill for spring, summer and autumn of 9.5, 11.8 and 3.3 respectively. Table 11 shows the average weekly road kill for across all years, stages of the Project and seasons to date.

Spring and summer weekly road kill rates were lower in the 2022/2023 monitoring period than during baseline surveys (2.8 *cf* 9.5 and 3.0 *cf* 11.8 respectively), while autumn 2023 was higher than baseline for the same period (5.0 *cf* 3.3). The overall average weekly road kill rate (calculated for the same three seasons) was similar during the baseline surveys and for the first year of operation (8.0 and 7.7 respectively), however the road kill rate for the last three years of operational monitoring has been lower (3.8 in 2019/2020, 5.8 in 2020/2021 and 3.6 in 2022/2023).

3.3.2 Road kill within 200 metres of monitored fauna underpasses

Table 12 shows the road kill records within 200 metres of monitored underpasses during 2022/2023, 2020/2021, 2018/2019 and baseline monitoring events. There were a total of two road kill records within 200 metres of monitored underpasses during 2022/2023 monitoring (F33.40 and C32.35), decreased from the three road kill records during the 2021/2022, 2020/2021 and 2018/2019 surveys respectively. Baseline road kill surveys included five road kill within 200 metres of monitored underpasses including F1.04, F34.72, F22.32 and C7.26.

3.3.3 Threatened species road kill

Table 13 lists the threatened species identified as road kill throughout the Project to date. One Koala was identified in October 2020, within a partially fenced area of the highway on the northbound left lane near Barry's Creek. TfNSW inspected the area of the Koala road strike within days to review the fencing integrity. Minor tree limbs were removed from fauna fencing in the general area, but it was considered unlikely that these provided a potential access point. No holes or issues with the fencing were identified during the inspection. The individual likely entered the motorway from the unfenced intersection at Mingaletta Road or fallen tree limbs on the fauna fence near the U-turn bay at Barry's Creek, crossed from the southbound lane to the northbound land where it was hit.

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

There have been no threatened species road kill recorded since the 2020/2021 monitoring period.

Table 11: Average weekly road kill rate for all monitoring to date

Monitoring period		Spring (n)	Summer (n)	Autumn (n)	Winter (n)	Annual (n)
Baseline	**2013/2014**	9.5 (4)	11.8 (4)	3.3 (4)	No surveys	8.0 (12)
Construction phase	**2015/2016 (all surveys)**	4.2 (13)	5.8 (14)	6.7 (13)	4.1 (12)	5.0 (52)
	2015/2016 (4 weeks)	2.75 (4)	6.5 (4)	6.5 (4)	3.0 (4)	
	2016/2017 (all surveys)	3.3 (13)	2.6 (13)	2.0 (12)	2.2 (14)	2.3 (52)
	2016/2017 (4 weeks)	4.0 (4)	1.5 (4)	1.5 (4)	2.5 (4)	
	2017/2018 (all surveys)	2.9 (9)	No surveys*	No surveys*	3.3 (4)	3.0 (13)
	2017/2018 (4 weeks)	1.5 (4)	No surveys*	No surveys*	3.3 (4)	
12-week post-opening	**2017/2018 (all sections combined)**					4.5 (12)
Operational	**2018/2019**	11.3 (4)	6.8 (4)	5.0 (4)	No surveys	7.7 (12)
Operational	**2019/2020**	5.3 (4)	3.8 (4)	2.5 (4)	No surveys	3.8 (12)
Operational	**2020/2021**	5.8 (4)	6.0 (4)	5.5 (4)	No surveys	5.8 (12)
Operational	**2022/2023**	2.8 (4)	3.0 (4)	5.0 (4)	No surveys	3.6 (12)

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

Table 12: Road kill within 200 metres of monitored fauna underpasses and distance from underpass

Monitoring event	Season	Species	Native/ introduced	Fauna category	Underpass	Distance (metres)
2022/2023	Summer	Bandicoot	Native	Small Mammal	F33.40	135
2022/2023	Summer	Small mammal	Unknown	Small Mammal	C32.35	98
2020/2021	Autumn	Bandicoot	Native	Medium mammal	C32.35	14.6
2020/2021l	Autumn	Snake	Native	Reptile	F11.67	34.6
2020/2021l	Autumn	Snake	Native	Reptile	F11.67	35.4
2020/2021l	Summer	Kookaburra	Native	Bird	C7.26	57.1
2018/2019	Spring	Medium Mammal	unknown	Medium ground dwelling mammal	C32.35	136.8
2018/2019	Summer	Medium Mammal	unknown	Medium ground dwelling mammal	F21.24	31.9
2018/2019	Summer	Kangaroo	native	Large ground dwelling mammal	C32.35	54.3
Baseline	Autumn	Brushtail Possum	native	Arboreal Mammal	F1.04	67.0
Baseline	Spring	Lace Monitor	native	Reptile	F34.72	77.8
Baseline	Spring	Koala	native	Arboreal Mammal	F22.32	117.3
Baseline	Summer	Eastern Grey Kangaroo	native	Large ground dwelling mammal	C7.26	150.4
Baseline	Summer	Red-necked Wallaby	native	Large ground dwelling mammal	F22.32	150.5

Table 13: Threatened species road kill to date

Monitoring type (report)	Monitoring period	Threatened species identified as road kill (number recorded)
Baseline (Lewis 2014)	2013-2014	• Koala (1*) • Grey-headed Flying Fox (2)
Clearing (Niche 2015)	2014-2015	• Koala (4) • Grey-headed Flying Fox (1) • Masked Owl (2) • Spotted-tail Quoll (1)
Construction (Niche 2016)	2015-2016	• Koala (1)
Construction (Niche 2017b)	2016-2017	• Koala (2)
Construction (Niche 2018c)	2017-2018	Nil
Operational (Niche 2019b)	2018-2019	• Koala (1)
Operational (Niche 2020)	2020-2021	• Brush-tail Phascogale (1)
Operational (Niche 2021b)	2020-2021	• Koala (1)

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

4. Discussion

4.1 Performance Measures

A summary and discussion of the 2022/2023 fauna underpass monitoring results in relation to the performance measures is provided in Table 14.

Table 14: Performance measures

Performance measure	Discussion
Complete safe crossing by the targeted EPBC species, the Spotted-tailed quoll and Koala, at a sufficient frequency as defined in Section 1.5 of the EMP. This would ensure that the underpass performance measure would trigger the contingency measures in section 5 for underpass performance after each koala monitoring event to review / modify underpass furniture, habitat, monitoring and if required, agency discussions.	**This performance measure is considered to have been met.** Section 1.5 of the EMP defines an 'effective' crossing as: "*Result in the complete, safe crossing of the crossing by the targeted EPBC species at a sufficient frequency to ensure that habitat connectivity is maintained or improved from baseline conditions (determined by surveys condition 4a and information provided in the preliminary documentation), and ongoing population viability by providing opportunities for species dispersal and re-colonisation; and result in reduced incidence of road kill from baseline conditions (determined by surveys condition 4a and information provided in the preliminary Documentation*". The crossing frequency required to determine effective habitat connectivity for each EPBC species and baseline crossing frequencies are unknown. As such, it is not possible to determine if fauna are crossing with 'sufficient frequency' and therefore it is not possible to use this metric to assess the success of the underpasses. In addition, the monitoring program does not provide a means of measuring dispersal and re-colonisation of species. However, it is considered that the monitoring scope permits comment on the use of underpasses as demonstrating *opportunity* for dispersal and reduction in road kill. This performance measure has therefore been assessed in this manner for each of the three EPBC Act listed species. To date, the Koala and Spotted-tailed Quoll have been recorded during the monitoring. The Koala was recorded in both the 2018/2019 and 2020/2021 monitoring periods whilst the Spotted-tailed Quoll has only been recorded on one occasion in 2018/2019. The Koala was recorded using one underpass in 2020/2021 and three underpasses in 2018/2019, each on a single occasion. These events all occurred within the spring/summer monitoring event, which may reflect seasonal movement patterns of the species. The detection of this species within a number of underpasses may be considered as demonstration of 'successful crossing at a sufficient frequency' as the records demonstrates that the underpasses provide opportunity for dispersal. In addition, the baseline road kill monitoring report (Lewis 2014) states that, based on baseline Koala road kill records, "*the baseline count for road kill should be set at 1 individual per 8 weeks*". Koala road kill has therefore not increased from the baseline count. The Spotted-tailed Quoll has only been recorded on one occasion in 2018/2019 within a single underpass. Given the low densities and cryptic nature of this species, it is considered unlikely that this species would be detected at all of the nominated underpasses. Spotted-tailed Quoll monitoring (two events of 21 consecutive nights using 36 cameras over 2,700 ha and repeated within three different areas) within the Project Area has not resulted in the detection of this species. In addition, one event during 2022/2023 monitored 14 fauna crossing locations within three broad monitoring areas for not less than three months from 1 June to 14 September 2022, also resulting in no detection of the species. The detection of this species within an underpass may be considered as demonstration of 'successful crossing at a sufficient frequency' as the record demonstrates that the underpass provides opportunity for dispersal, and there have been no incidences of road kill recorded for this species since construction.
For non-EPBC species (Brush-tailed Phascogale), the complete safe crossing of the nominated underpass by the target species or their indicator species on at least one occasion in order to demonstrate opportunity for dispersal and re-colonisation (excluding frogs which are unlikely to be detected using camera monitoring).	**This performance measure has been met.** The Brush-tailed Phascogale was recorded using two of the 14 underpasses during 2022/2023 monitoring periods. The species was recorded on one occasion in underpasses F20.54 and F22.32, in autumn and summer, respectively. Indicator species (small ground-dwelling mammals and/or arboreal mammals) for the Brush-tailed Phascogale were recorded using all 14 underpasses in 2022/2023.

Performance measure	Discussion
For fauna groups, the complete safe crossing of the nominated underpass by one or more individuals on at least once occasion from each of the relevant fauna groups (small ground-dwelling mammals, arboreal mammals and macropods) to demonstrate opportunity for dispersal and re-colonisation.	**This performance measure has been met.** All underpasses have records of crossings by representatives from all of the three specified fauna groups, as follows: • Small ground-dwelling mammals: recorded at all nominated underpasses; represented by rodents, antechinus, bandicoots, the Echidna and the Spotted-tailed Quoll. • Arboreal mammals: recorded at all nine nominated underpasses, and at five additional underpasses; represented by the Brushtail Possum and the Koala. • Macropods: recorded at all 14 nominated underpasses; represented by the Eastern Grey Kangaroo, Red-necked Wallaby and Swamp Wallaby.
Reduced incidence of road kill from baseline conditions.	**This performance measure has been met.** The annual average weekly road kill rate has decreased from baseline to 2022/2023 operational monitoring (8.0 in baseline *cf. 3.6* in 2022/2023).

5. Recommendations

5.1 Contingency Measures

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those that are related to the underpass monitoring program are listed and discussed in Table 15.

Table 15: Contingency measures

Potential problem	EMP contingency measure	Discussion of proposed measure
No recorded presence of indicator species from the nominated classes in underpasses.	Commence review/modification of fauna furniture associated with underpasses within two weeks of results reported by ecologist.	Four of the five fauna groups have been detected at all monitored underpasses. Frogs have been detected using only one underpass during monitoring events, however monitoring methods do not favour their detection. **This contingency measure is not considered relevant.**
No recorded presence of cover- dependent species or fauna species with low mobility in underpasses.	Commence review/modification of habitat (i.e. vegetation composition and structure; type and abundance of natural habitat features) adjoining the underpass within two weeks of results reported by ecologist.	All three relevant fauna groups have been detected using all 14 underpasses. Frogs have been detected using only one underpass during monitoring events, however monitoring methods do not favour their detection. **This contingency measure is not considered relevant.**
Increased incidence of road kill from baseline conditions, in proximity to underpasses, particularly target species.	Commence review/modification of frequency and/or timing of monitoring periods within two weeks of results reported by ecologist.	Overall annual weekly road kill rates have decreased compared to baseline monitoring. Two road kill fauna were recorded during 2022/2023 monitoring within 200 metres of monitored underpasses (F33.40 and C32.35) and five road kill fauna were recorded within 200 metres of four different underpasses during baseline monitoring (F1.04, F34.72, F22.32 and C7.26). There has not been an increase in road kill in proximity to monitored underpasses. No target species (the Koala) was recorded as road kill during the 2022/2023 monitoring period. The baseline monitoring report (Lewis 2014) states that, based on baseline Koala road kill records, "*the baseline count for road kill should be set at 1 individual per 8 weeks*". Koala road kill has not increased from the baseline count. **This contingency measure is not considered relevant.**
Inferior results compared to baseline surveys for the EPBC species, relevant to reference site monitoring.	If it is not reasonable or feasible to redesign/modify the underpass, discussions with EPA, DP&I and DoTE will be undertaken to determine if additional biodiversity offsets are required within 1 month of above reviews being completed.	Comparison of underpass records with EPBC species reference site monitoring may be undertaken only at a superficial level due to the different means of data collection of the different monitoring components. Koalas were recorded along the entire length of the Project during baseline surveys (Lewis 2014). The Koala was recorded using four underpasses in areas where the Koala was recorded during the baseline surveys (Niche 2019c). The Spotted-tailed Quoll was not recorded during baseline surveys (Niche 2018d) but was recorded using one nominated underpass during the 2018/2019 fauna underpass monitoring. The Giant Barred Frog has been recorded traversing the Project under constructed bridges at locations where it was recorded during baseline surveys (Niche 2018b), but not using the nominated underpass, which is considered unlikely to provide suitable habitat for this species. **This contingency measure is not considered relevant.**

5.2 Recommendations

Given the successful use by a range of native fauna from different fauna groups it is considered that the underpasses have been a successful mitigation measure allowing species to cross safely under the carriageway and maintain connectivity for adjacent habitat. Underpasses are a key mitigation measure in reducing the impact of the highway as a major barrier to native fauna. Therefore, there are no further monitoring measures recommended beyond requirements of the EMP. However, maintenance of fauna fencing particularly within 200 m of underpasses is considered important in continued successful crossing by native fauna.

References

Lemckert, F. and Slatyer, C. (2002) Short-term movements and habitat use by the threatened Green-thighed Frog *Litoria brevipalmata* (Anura: Hylidae) in mid-coastal New South Wales. *Australian Zoologist* 32 (1): 56-61.

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

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

Niche (2015). OH2K Pacific Highway Upgrade. Annual Ecological Monitoring Report 2015. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

Niche (2016). OH2K Pacific Highway Upgrade. Annual Ecological Monitoring Report 2016. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

Niche (2017a). Green-thighed Frog Monitoring 2016/2017 Oxley Highway to Kempsey Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

Niche (2017b). OH2K Pacific Highway Upgrade. Annual Ecological Monitoring Report 2017. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

Niche (2018a). Green-thighed Frog Monitoring 2018 Oxley Highway to Kempsey Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

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

Niche (2018c). OH2K Pacific Highway Upgrade. Annual Ecological Monitoring Report 2018. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

Niche (2018d). Spotted-tailed Quoll Monitoring 2018 Oxley Highway to Kempsey Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

Niche (2019a). Fauna Underpass Monitoring 2018/2019. Oxley Highway to Kempsey Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for TfNSW, Port Macquarie, NSW.

Niche (2019b). Fauna Fence and Road Kill Monitoring 2018/2019. Oxley Highway to Kempsey Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

Niche (2019c). Koala Monitoring 2018. Year 4 surveys - Oxley Highway to Kempsey Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

Niche (2020). Road Kill Monitoring 2019/2020. Oxley Highway to Kempsey Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for TfNSW, Port Macquarie, NSW.

Niche (2021a). Fauna Underpass Monitoring 2020/2021. Oxley Highway to Kempsey Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for TfNSW, Port Macquarie, NSW.

Niche (2021b). Fauna Fence and Road Kill Monitoring 2020/2021. Oxley Highway to Kempsey Pacific Highway Upgrade. Prepared by Niche Environment and Heritage Pty Ltd for Transport for NSW, Port Macquarie, NSW.

TfNSW (2022). Oxley Highway to Kempsey Pacific Highway Upgrade Ecological Monitoring Program. Transport for NSW Update to report prepared by SMEC Hyder Joint Venture, February 2022.

Sandpiper Ecological (2015). Pacific Highway Upgrade: Glenugie. Operation phase fauna crossing structure monitoring program. Report prepared for NSW Roads and Maritime Services.

Sandpiper Ecological (2017). Pacific Highway Upgrade: Sapphire to Woolgoolga. Operation phase fauna crossing monitoring program – year 1. Report prepared for NSW Roads and Maritime Services.

Annex 1 – 2022/2023 camera results

Table 16: 2022/2023 remote camera records – F1.04, F1.62, C4.46, C7.26, F9.70, F11.67 and F20.54

Underpass	F1.04		F1.62		C4.46		C7.26		F9.70		F11.67		F20.54	
Fauna group / Species	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**
Small ground-dwelling mammals														
Antechinus sp.					Y (3)	Y (2)			Y (1)					Y (1)
Bandicoot				Y (4)										Y (6)
Northern Brown Bandicoot (*Isoodon macrourus*)				Y (1)										
Long-nosed Bandicoot (*Perameles nasuta*)				Y (3)										Y (2)
Echidna (*Tachyglossus aculeatus*)														Y (1)
Spotted-tailed Quoll (*Dasyurus maculatus*)*														
Rattus fuscipes														
Rattus rattus					Y (10)	Y (12)		Y (7)	Y (15)	Y (6)	Y (4)	Y (29)	Y (29)	Y (5)
Rattus spp.														
Rodent/Marsupial	Y (1)		Y (1)			Y (2)		Y (2)	Y (18)	Y (4)	Y (4)	Y (12)	Y (19)	Y (4)
Arboreal mammals														
Brushtail Possum			Y (7)	Y (1)	Y (36)	Y (36)	Y (2)						Y (27)	Y (21)
Common Brushtail Possum (*Trichosurus vulpecula*)		Y (15)	Y (2)		Y (5)	Y (44)								
Short-eared Brushtail Possum (*Trichosurus caninus*)			Y (16)	Y (1)	Y (8)	Y (9)							Y (31)	Y (17)
Brush-tailed Phascogale (*Phascogale tapoatafa*)													Y (1)	
Koala														
Koala (*Phascolarctos cinereus*)*														

Underpass	F1.04		F1.62		C4.46		C7.26		F9.70		F11.67		F20.54	
Fauna group / Species	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**
Macropods														
Eastern Grey Kangaroo (*Macropus giganteus*)			Y (2)	Y (22)		Y (1)			Y (1)	Y (2)	Y (1)	Y (5)	Y (2)	Y (9)
Macropod sp.			Y (1)	Y (14)								Y (2)		Y (1)
Swamp Wallaby (*Wallabia bicolor*)				Y (1)										
Red-necked Wallaby (*Macropus rufogriseus*)				Y (2)										Y (7)
Wallaby			Y (2)	Y (2)							Y (4)		Y (1)	
Reptiles														
Blue-tongue Lizard (*Tiliqua scincoides*)														
Eastern Water Dragon (*Intellagama lesueurii*)					Y (5)									
Lace Monitor (*Varanus varius*)				Y (2)	Y (1)	Y (13)						Y (6)		Y (23)
Snake														
Other														
Microbat										Y (1)				Y (1)
Unk Mammal				Y (1)										
Rattus rattus														
Raven (*Corvus* sp.)														
Wood Duck (*Chenonetta jubata*)														
Fox (*Vulpes vulpes*)	Y (30)		Y (7)	Y (14)		Y (46)			Y (2)		Y (4)		Y (3)	
Deer				Y (1)		Y (2)								
Cat (*Felis catus*)	Y (3)	Y (1)	Y (9)	Y (4)										
Wild Dog (*Canis lupus*)							Y (5)		Y (14)		Y (1)	Y (11)		Y (1)
Swallow														

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

Table 17: 2022/2023 remote camera records – F21.24, F22.32, F26.40, C32.35, F33.40, F34.72 and C36.40

Underpass	F21.24		F22.32		F26.40		C32.35		F33.40		F34.72		C36.40	
Fauna group / Species	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**
Small ground-dwelling mammals														
Antechinus sp.	Y (2)	Y (29)	Y (3)	Y (5)		Y (7)								
Bandicoot	Y (4)		Y (2)	Y (1)		Y (5)		Y (2)	Y (10)	Y (2)				
Northern Brown Bandicoot (*Isoodon macrourus*)				Y (1)										
Long-nosed Bandicoot (*Perameles nasuta*)	Y (1)								Y (2)	Y (3)				
Echidna (*Tachyglossus aculeatus*)				Y (1)		Y (1)				Y (1)				
Spotted-tailed Quoll (*Dasyurus maculatus*)*														
Black Rat (*Rattus rattus*)	Y (1)	Y (40)	Y (9)	Y (58)	Y (21)	Y (23)	Y (10)		Y (18)	Y (29)	Y (5)	Y (22)		
Rattus sp.	Y (7)	Y (19)	Y (17)	Y (25)						Y (6)		Y (4)		
Rodent/Marsupial	Y (11)	Y (23)	Y (1)	Y (6)		Y (6)	Y (3)			Y (2)		Y (3)		
Arboreal mammals														
Brushtail Possum	Y (46)	Y (26)	Y (14)	Y (27)	Y (13)	Y (4)		Y (1)			Y (4)			
Common Brushtail Possum (*Trichosurus vulpecula*)	Y (10)	Y (12)	Y (14)	Y (1)		Y (10)					Y (3)	Y (4)		
Short-eared Brushtail Possum (*Trichosurus caninus*)	Y (30)	Y (5)	Y (1)	Y (1)	Y (2)									
Brush-tailed Phascogale (*Phascogale tapoatafa*)				Y (1)										
Koala														
Koala (*Phascolarctos cinereus*)*														
Macropods														
Grey Kangaroo (*Macropus giganteus*)	Y (1)				Y (1)	Y (11)								
Macropod sp.		Y (1)	Y (3)		Y (3)				Y (3)	Y (1)	Y (1)			
Swamp Wallaby (*Wallabia bicolor*)			Y (3)	Y (2)		Y (16)			Y (11)	Y (16)				

Underpass	F21.24		F22.32		F26.40		C32.35		F33.40		F34.72		C36.40	
Fauna group / Species	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**
Wallaby			Y (3)	Y (1)	Y (1)	Y (1)				Y (4)	Y (6)			
Red-necked Wallaby (*Macropus rufogriseus*)				Y (1)		Y (5)				Y (1)			Y (1)	
Reptiles														
Blue-tongue Lizard (*Tiliqua scincoides*)														
Eastern Water Dragon (*Intellagama lesueurii*)					Y (2)									
Lace Monitor (*Varanus varius*)		Y (3)		Y (24)		Y (25)				Y (1)		Y (1)		
Unk Skink														
Other														
Microbat	Y (1)		Y (1)			Y (1)	Y (1)					Y (1)		
Rattus rattus														
Unk Mammal														
Raven (*Corvus* sp.)														
Wood Duck (*Chenonetta jubata*)														
Fox (*Vulpes vulpes*)	Y (1)		Y (1)			Y (1)	Y (6)		Y (1)		Y (2)			
Hare (*Lepus 27uropaeus*) / Rabbit (*Oryctolagus cuniculus)*														
Cat (*Felis catus*)	Y (1)								Y (1)					
Wild Dog (*Canis lupus*)		Y (2)										Y (2)		
Unk Bird					Y (5)		Y (13)					Y (1)		
Lewin's Honeyeater														
Superb Fairy Wren														
Welcome Swallow							Y (39)							

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

Table 18: Autumn 2022 camera details

Underpass	Camera	Operating for entire period (Y/N)	Install date	Retrieve date	Operational days	Location	Direction facing (E/W)	Number of fauna records	Notes
F1.04	156	Y	30/03/2022	7/06/2022	67	Top	W	4	
F1.04	162	Y	30/03/2022	7/06/2022	67	Bottom	W	29	
F1.62	399	Y	30/03/2022	7/06/2022	67	Top	E	34	
F1.62	422	Y	30/03/2022	7/06/2022	67	Bottom	W	20	
C4.46	443	Y	30/03/2022	7/06/2022	67	Top	E	69	
C4.46	870	Y	30/03/2022	7/06/2022	67	Bottom	E	0	
C7.26	127	Y	30/03/2022	1/06/2022	61	Bottom	E	5	
C7.26	380	Y	30/03/2022	1/06/2022	61	Top	E	2	
F9.7	383	Y	30/03/2022	1/06/2022	61	Bottom	E	17	
F9.7	423	Y	30/03/2022	1/06/2022	61	Top	W	34	
F11.67	387	Y	30/03/2022	1/06/2022	61	Top	E	8	
F11.67	425	Y	30/03/2022	1/06/2022	61	Bottom	E	23	
F20.54	120	Y	30/03/2022	1/06/2022	61	Top	E	68	
F20.54	415	Y	30/03/2022	1/06/2022	61	Bottom	E	6	
F21.24	125	Y	30/03/2022	1/06/2022	61	Top	W	1	
F21.24	442	Y	30/03/2022	1/06/2022	61	Bottom	E	117	
F22.32	175	Y	30/03/2022	1/06/2022	61	Bottom	E	11	
F22.32	431	Y	30/03/2022	1/06/2022	61	Top	E	59	
F26.4	194	Y	31/03/2022	1/06/2022	60	Bottom	E	5	
F26.4	373	Y	31/03/2022	1/06/2022	60	Top	E	36	
C32.35	80	Y	31/03/2022	1/06/2022	60	Bottom	W	33	
C32.35	435	N	31/03/2022	1/06/2022	48	Bottom	E	0	19/5/2022 last photo
F33.4	72	Y	31/03/2022	1/06/2022	60	Bottom	E	28	
F33.4	432	N	31/03/2022	1/06/2022	22	Top	E	19	Camera 427 replaced after found not to be triggering on 11/5

F34.72	134	Y	31/03/2022	1/06/2022	60	Bottom	E	11	
F34.72	377	Y	31/03/2022	7/06/2022	66	Top	E	10	
C36.4	65	Y	31/03/2022	1/06/2022	60	Bottom	W	1	
C36.4	378	N	31/03/2022	1/06/2022	60	Bottom	E	0	Camera error taking videos.

Table 19: Spring/summer 2022/2023 camera details

Underpass	Camera #	Operating for entire period (Y/N)	Install date	Retrieve date	Operational days	Location	Direction facing (E/W)	Number of fauna records	Notes
F1.04	433	N	4/11/2022	3/01/2023	40	Bottom	W	17	
F1.04	447	N	4/11/2022	3/01/2023	35	Top	W	0	
F1.62	430	Y	4/11/2022	3/01/2023	60	Top	W	62	
F1.62	178	Y	4/11/2022	3/01/2023	60	Bottom	W	4	
C4.46	424	Y	4/11/2022	3/01/2023	60	Bottom	W	107	
C4.46	870	Y	4/11/2022	3/01/2023	60	Top	W	60	
C7.26	432	Y	3/11/2022	3/01/2023	60	Bottom	E	0	
C7.26	426	Y	3/11/2022	3/01/2023	60	Top	W	9	
F9.7	194	Y	3/11/2022	3/01/2023	60	Bottom	W	2	
F9.7	167	Y	3/11/2022	3/01/2023	60	Top	W	11	
F11.67	85	Y	3/11/2022	3/01/2023	60	Bottom	W	10	
F11.67	423	Y	3/11/2022	3/01/2023	60	Top	E	47	
F20.54	156	Y	3/11/2022	3/01/2023	60	Bottom	E	49	
F20.54	174	Y	3/11/2022	3/01/2023	60	Top	W	89	
F21.24	443	Y	3/11/2022	3/01/2023	60	Top	E	158	
F21.24	127	Y	3/11/2022	3/01/2023	60	Bottom	E	3	
F22.32	125	Y	3/11/2022	3/01/2023	60	Bottom	E	33	
F22.32	382	Y	3/11/2022	3/01/2023	60	Top	W	123	
F26.4	65	Y	3/11/2022	3/01/2023	60	Bottom	E	64	

Underpass	Camera #	Operating for entire period (Y/N)	Install date	Retrieve date	Operational days	Location	Direction facing (E/W)	Number of fauna records	Notes
F26.4	369	Y	3/11/2022	3/01/2023	60	Top	E	60	
C32.35	397	Y	3/11/2022	3/01/2023	60	Bottom	E	42	
F33.4	72	Y	3/11/2022	3/01/2023	60	Bottom	E	22	
F33.4	374	Y	3/11/2022	3/01/2023	60	Top	E	46	
F34.72	134	Y	3/11/2022	3/01/2023	60	Bottom	E	6	
F34.72	422	Y	3/11/2022	3/01/2023	60	Top	E	34	
C36.4	141	Y	3/11/2022	3/01/2023	60	Bottom	W	0	
C36.4	378	N	3/11/2022	3/01/2023	43	Top	E	0	

Annex 2 – 2022/2023 scat, track and hair-tube results

Table 20: 2022/2023 sand plot survey results

Species	C4.46	C7.26	C32.35	C36.40
Fox		Y	Y	
Rodent	Y	Y	Y	Y
Echidna				
Cat		Y	Y	Y
Dog		Y	Y	
Brushtail Possum				Y
Koala				
Bandicoot	Y		Y	Y
Lace Monitor		Y		
Water Dragon			Y	
Macropod		Y		
Reptile	Y	Y		Y
Mammal				

Y = detected

Table 21: 2022/2023 tracks and scats results

Species	F1.04	F1.62	C4.46	C7.26	F9.70	F11.67	F20.54	F21.24	F22.32	F26.40	C32.35	F36.4
Bird				T	T				T			
Macropod		Y				T	T	T	T			
Possum						T						
Microbat								I		I	I/C	I
Rodent			C/T		T	T/C	T			C	C	C
Frog												C
Cat/Fox		T		T					T			
Dog					T	T			T		C	
Deer	T											

I = observed, C = scat, T = track

Table 22: 2022/2023 hair tube results

Season	Monitoring year	Underpass	Location	number of tubes	Hair tube deploy date	Hair tube retrieve date	Tubes with hair (samples sent for ID)	Species idenditifed
Autumn	2022	F1.04	OH2K	10	30/03/2022	12/05/2022	1	*Rattus* sp.
Autumn	2022	F1.62	OH2K	10	30/03/2022	12/05/2022	1	Human
Autumn	2022	C4.46	OH2K	10	30/03/2022	12/05/2022	11	*Trichosurus* sp.
Autumn	2022	C7.26	OH2K	10	30/03/2022	11/05/2022	3	*Rattus rattus, Rattus* sp.
Autumn	2022	F9.70	OH2K	10	30/03/2022	10/05/2022	0	NA
Autumn	2022	F11.67	OH2K	10	30/03/2022	10/05/2022	8	*Rattus rattus*
Autumn	2022	F20.54	OH2K	10	30/03/2022	10/05/2022	2	*Rattus rattus, Trichosurus* sp.
Autumn	2022	F21.24	OH2K	10	30/03/2022	11/05/2022	9	*Trichosurus* sp.
Autumn	2022	F22.32	OH2K	10	30/03/2022	11/05/2022	5	*Rattus rattus, Trichosurus* sp.
Autumn	2022	F26.40	K2K	10	30/03/2022	10/05/2022	2	*Rattus* sp., *Trichosurus* sp.
Autumn	2022	C32.35	K2K	10	30/03/2022	10/05/2022	3	*Rattus rattus, Rattus* sp.
Autumn	2022	F33.40	K2K	10	30/03/2022	11/05/2022	7	*Rattus rattus, Rattus* sp.
Autumn	2022	F34.72	K2K	10	30/03/2022	10/05/2022	12	*Trichosurus* sp.
Autumn	2022	C36.40	K2K	10	30/03/2022	11/05/2022	3	Human, *Rattus* sp., *Trichosurus* sp.
Summer	2022	F1.04	OH2K	10	4/11/2022	9/12/2022	2	*Trichosurus* sp.
Summer	2022	F1.62	OH2K	10	4/11/2022	9/12/2022	1	*Trichosurus* sp.
Summer	2022	C4.46	OH2K	10	4/11/2022	9/12/2022	8	*Rattus rattus, Trichosurus* sp.
Summer	2022	C7.26	OH2K	10	3/11/2022	7/12/2022	0	NA
Summer	2022	F9.70	OH2K	10	3/11/2022	7/12/2022	2	Macopod
Summer	2022	F11.67	OH2K	10	3/11/2022	7/12/2022	7	*Rattus rattus, Rattus* sp.
Summer	2022	F20.54	OH2K	10	3/11/2022	7/12/2022	1	*Trichosurus* sp.
Summer	2022	F21.24	OH2K	10	3/11/2022	7/12/2022	7	*Trichosurus* sp.
Summer	2022	F22.32	OH2K	10	3/11/2022	7/12/2022	6	*Rattus rattus, Rattus* sp.
Summer	2022	F26.40	K2K	10	3/11/2022	7/12/2022	0	NA
Summer	2022	C32.35	K2K	10	3/11/2022	7/12/2022	3	*Trichosurus* sp., *Perameles nasuta*
Summer	2022	F33.40	K2K	10	3/11/2022	7/12/2022	1	*Wallabia bicolor*
Summer	2022	F34.72	K2K	10	3/11/2022	7/12/2022	7	*Rattus* sp., *Trichosurus* sp.
Summer	2022	C36.40	K2K	10	3/11/2022	7/12/2022	0	NA

Niche Environment and Heritage

A specialist environmental and heritage consultancy.

Head Office

Niche Environment and Heritage
PO Box 2443 North Parramatta NSW 1750
Email: info@niche-eh.com

All mail correspondence should be through our Head Office