

Oxley Highway to Kempsey

2021/2022 Annual Ecological Monitoring Report

Transport for NSW | October 2022

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Purpose

This report provides an update on the ecological monitoring associated with the Oxley Highway to Kempsey Pacific Highway upgrade.

This report covers the period from **22 July 2021 to 21 July 2022** and has been prepared in accordance with the Oxley Highway to Kempsey Ecological Monitoring Program (Version 3 and 4 2019), for submission to the Department of Planning and Environment and Environment Protection Authority (EPA).

This report includes monitoring outcomes for Giant Barred Frog and Green Thighed Frog monitoring undertaken in the 2021/22 reporting period.

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

Table 1 identifies the species / mitigation measures monitored for the OH2K project in accordance with the Ecological Monitoring Program (Version 3 and 4 2019), and also highlights the specific species / mitigation monitoring included in this 2020/21 report (**Appendices A – B**).

Table 1 Ecological monitoring requirements and reporting outcomes

Species / mitigation monitored	Timing	Done/ yet to be done	Reporting
Koala	Spring/Summer	<p>Year 3 monitoring (2017) completed.</p> <p>Year 4 monitoring (2018) completed.</p> <p>Year 5 monitoring undertaken in spring 2019 and summer 2019/20.</p> <p>Year 6 monitoring undertaken spring 2020 and summer 2020/21.</p> <p>Year 8 monitoring scheduled for spring 2022 and summer 2022/2023.</p>	<p>Year 8 monitoring report to be provided following spring 2022 and summer 2022/2023 monitoring.</p>
Spotted-tail Quoll	Autumn/winter	<p>Year 4 monitoring (2018) completed.</p> <p>Year 6 monitoring undertaken in autumn/winter 2020.</p> <p>Year 8 monitoring scheduled for autumn/winter 2022.</p>	<p>Year 8 report to be provided following autumn/winter monitoring 2022.</p>

Giant Barred Frog	Spring, Summer and Autumn	<p>Year 3 monitoring (2017/18) completed.</p> <p>Year 4 monitoring (2018/19) completed.</p> <p>Year 5 monitoring undertaken in spring 2019, summer 2019/20 and autumn 2020.</p> <p>Year 6 monitoring undertaken spring 2020, summer 2020/21 and autumn 2021.</p> <p>Year 7 monitoring scheduled for spring 2021, summer 2021/22 and autumn 2022</p> <p>Year 8 monitoring scheduled for spring 2022, summer 2022/23.</p>	Year 7 monitoring included in this report Appendix A
Brush-tailed phascogale	Winter and summer year 4, 6 and 8.	<p>Year 4 monitoring (2018) completed.</p> <p>Year 6 monitoring undertaken winter 2020 and summer 2020.</p> <p>Year 8 monitoring scheduled for winter 2022 and summer 2022</p>	Year 8 monitoring report to be provided following winter and summer 2022 monitoring.
Yellow-bellied Glider	August-December year 4, 6 and 8.	<p>Year 4 monitoring (2018) completed</p> <p>Year 6 monitoring Undertaken in August-December 2020</p> <p>Year 8 monitoring scheduled for August-December 2022</p>	Year 8 monitoring report to be provided following autumn and summer 2022 monitoring.
Squirrel Glider	April-August year 4, 6 and 8.	<p>Year 4 monitoring (2018) completed.</p> <p>Year 6 monitoring undertaken April-August 2020.</p> <p>Year 8 monitoring scheduled for April-August 2022.</p>	Year 8 monitoring report to be provided following autumn 2022 monitoring.
Aerial Crossings	Autumn and spring/summer year 4, 6 and 8.	<p>Year 4 monitoring (2018) completed.</p> <p>Year 6 monitoring undertaken autumn and spring/summer 2020.</p> <p>Year 8 monitoring scheduled autumn and spring/summer 2022</p>	Year 8 monitoring report to be provided following autumn and spring/summer 2022 monitoring.
Widened Median	June-September year 4, 6 and 8.	<p>Year 4 monitoring (2018) completed.</p> <p>Year 6 monitoring Undertaken June-September 2020</p>	Year 8 monitoring report to be provided following autumn and winter 2022 monitoring.

		Year 8 monitoring scheduled for June-September 2022	
Green-thighed Frog	Summer (although ultimately rainfall dependent) on four occasions during operational phase (year 4-7)	<p>Year 4 (2017/2018) monitoring completed.</p> <p>Year 5 2018/19 monitoring not undertaken due to lack of rain as per EMP. Recent approved updates to the EMP permits flexibility for future monitoring to permit alternative rainfall events deemed suitable by the project ecologist.</p> <p>Year 6 2019/20 undertaken summer 2019/2020</p> <p>Year 7 2020/21 scheduled dependent if suitable rainfall event occurs in accordance with required trigger recommendations.</p> <p>Year 8 2021/22 scheduled dependent if suitable rainfall event occurs (to account for missed Year 5).</p>	Year 7 monitoring included in this report Appendix B.
Nest Box	Summer and winter year 4, 6 and 8.	<p>Year 4 summer 2018 and winter 2018 complete</p> <p>Year 6 monitoring undertaken summer 2020 and winter 2020</p> <p>Year 8 monitoring scheduled for summer 2022 and winter 2022</p>	Year 8 monitoring report to be provided following summer and winter 2022 monitoring.
Bat box	Summer and winter year 4, 6 and 8.	<p>Year 4 summer 2018 and winter 2018 complete</p> <p>Year 4 outcomes recommended discontinuing monitoring due to lack of uptake.</p> <p>Additional roost structure analyses determined uptake of new underpass structures by target species.</p> <p>Ongoing monitoring/reporting not required.</p>	No further monitoring / Reporting

Fauna underpass Monitoring Report	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 Year 8 monitoring scheduled for late autumn 2022, late spring /early summer 2022	Year 8 monitoring report to be provided following autumn and spring/summer 2022 monitoring.
Fauna Fence and Road Kill Report	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 Roadkill - October 2020, January 2021, and April 2021. Fauna Fence - Autumn 2020 and spring/summer 2020/2021 Year 8 monitoring scheduled for October 2022, January 2023 and April 2023	Year 8 monitoring report to be provided following spring 2022 and summer/autumn 2023 monitoring.
Revegetation and landscaping	Monthly through construction and 1 year after operation	Year 4 monitoring (2018/19) completed. Year 5 monitoring (2019/20) completed	No further Reporting

Statutory and planning framework

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

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

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

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

- a) an adaptive monitoring program to assess the effectiveness of the mitigation measures identified in conditions B1, B4, B7 and B31(b) and allow amendment to the measures if necessary. The monitoring program shall nominate performance parameters and criteria against which effectiveness will be measured and include operational road kill surveys to assess the effectiveness of fauna crossings and exclusion fencing implemented as part of the project;*
- b) mechanisms for developing additional monitoring protocols to assess the effectiveness of any additional mitigation measures implemented to address additional impacts in the case of design amendments or unexpected threatened species finds during construction (where these additional impacts are generally consistent with the biodiversity impacts identified for the project in the documents listed under condition A1);*
- c) monitoring shall be undertaken during construction (for construction-related impacts) and from opening of the project to traffic (for operation/ ongoing impacts) until such time as the effectiveness of mitigation measures can be demonstrated to have been achieved over a minimum of three successive monitoring periods (i.e 6 years) after opening of the project to traffic, unless otherwise agreed by the Director General. The monitoring period may be reduced with the agreement of the Director General in consultation with the OEH and DPI (Fishing and Aquaculture), depending on the outcomes of the monitoring;*
- d) provision for the assessment of the data to identify changes to habitat usage and whether this can be directly attributed to the project;*
- e) details of contingency measures that would be implemented in the event of changes to habitat usage patterns directly attributable to the construction or operation of the project; and*
- f) provision for annual reporting of monitoring results to the Director General and the OEH and DPI (Fishing and Aquaculture), or as otherwise agreed by those agencies.*

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

The initial Oxley Highway to Kempsey Ecological Monitoring Program was approved by the Department of Planning & Environment on 25 January 2014. This was updated in 2016 (Version 2) and approved by the Department on 6 December 2016.

The EMP was further updated (Version 3 and 4) in 2019 and approved by the Department on 20 August 2019.

The species and mitigation monitoring reports included in the appendices to this annual report have been assessed against the 2019 Version 3 and 4 EMP.

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 amendments to the Ecological Monitoring Program were for updates to the Spotted-tail Quoll monitoring methodology.

Appendix A – Giant-barred Frog



Giant Barred Frog Monitoring 2021/2022

Oxley Highway to Kempsey, Pacific Highway Upgrade

Prepared for Transport for NSW

September 2022

Document control

Project no.:	1702
Project client:	Transport for NSW
Project office:	Port Macquarie
Document description:	Giant Barred Frog Monitoring 2021/2022 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	17/8/2022
Jodie Danvers	D1	Radika Michniewicz	31/08/2022
Radika Michniewicz	R0		31/8/2022
Radika Michniewicz	R1		7/9/2022

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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 fourth 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 and summer and five sites (two reference and three impact) in autumn, 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 11-14 October 2021 (spring), 7-9 December 2021 (summer) and 26-28 May 2022 (autumn) after suitable rainfall. A total of 28 Giant Barred Frogs were recorded during the 2021/2022 monitoring period and 27% (n = 6) of those captured were recaptures. Frogs were absent from Smiths Creek impact, Maria River impact and 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 2021/2022.

Analysis of frog movement in relation to the highway found that 12 (24%) of the 50 recaptures from impact sites have been captured on both sides of the carriageway over successive monitoring events. At the reference sites, 11 (26%) of the 43 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 to date.

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

The performance measure relating to changes in density and mean records was not met. All sites appear to 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.

Management implications

Given the variable nature of annual mean records among sites, the evidence of decreasing trends at reference sites and the lack of a distinct difference between impact and reference sites, it is not possible to attribute observed changes in frog numbers to the Project. As such, it is recommended that monitoring continue as per the EMP.

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1. Introduction

1.1 Context

The Oxley Highway to Kempsey (OH2K) section of the Pacific Highway Upgrade Project (the Project) was approved in 2012 subject to various Ministers Conditions of Approval (MCoA) and a Statement of Commitments (SoC). A subsequent approval with additional conditions of consent (CoA) was granted in 2014 by the Commonwealth Department of 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): Current report.

This report addresses the fourth round (Year 7) of operational phase monitoring for the Project and is the eighth of nine monitoring reports for the Giant Barred Frog. The next round of operational monitoring will commence in spring 2022.

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 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 2021/2022 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 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 was not undertaken in autumn 2022 as access to the transect was not possible due to the growth of Lantana along the banks.

2. Methodology

2.1 Monitoring Sites

Monitoring was undertaken at the four impact and two reference sites in spring, summer and autumn. In autumn the Maria River Impact site was inaccessible due to excessive Lantana growth preventing access to the creek, therefore only five sites were monitored in autumn 2022. 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 Meteorology weather stations.

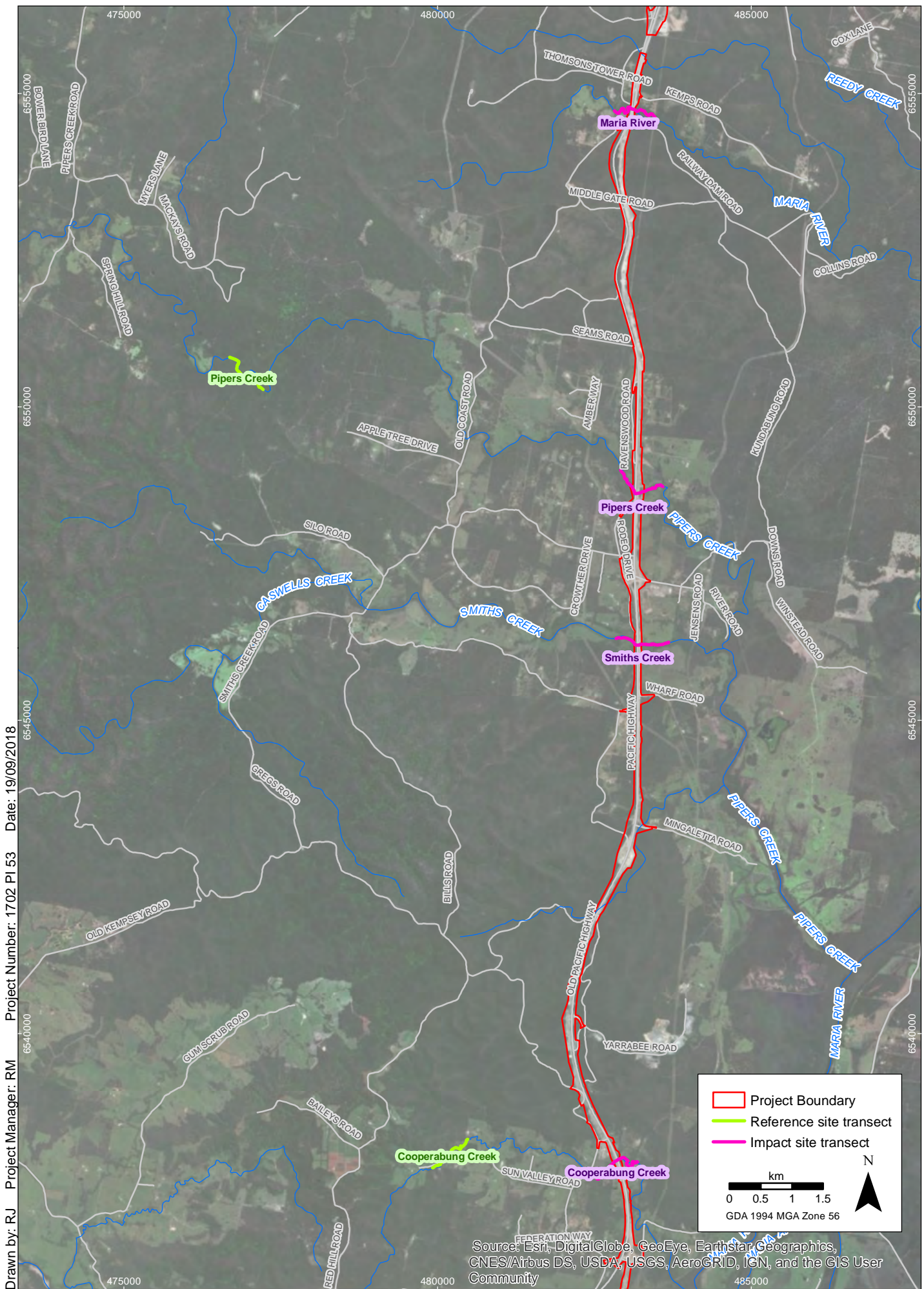
2.3 Water Quality

Water quality monitoring was not undertaken during the 2021/2022 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 previous report (Niche 2021).

2.4 Analysis

For consistency 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 overestimate 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



Imagery: (c) LPI DigitalGlobe 2015



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



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

FIGURE 3

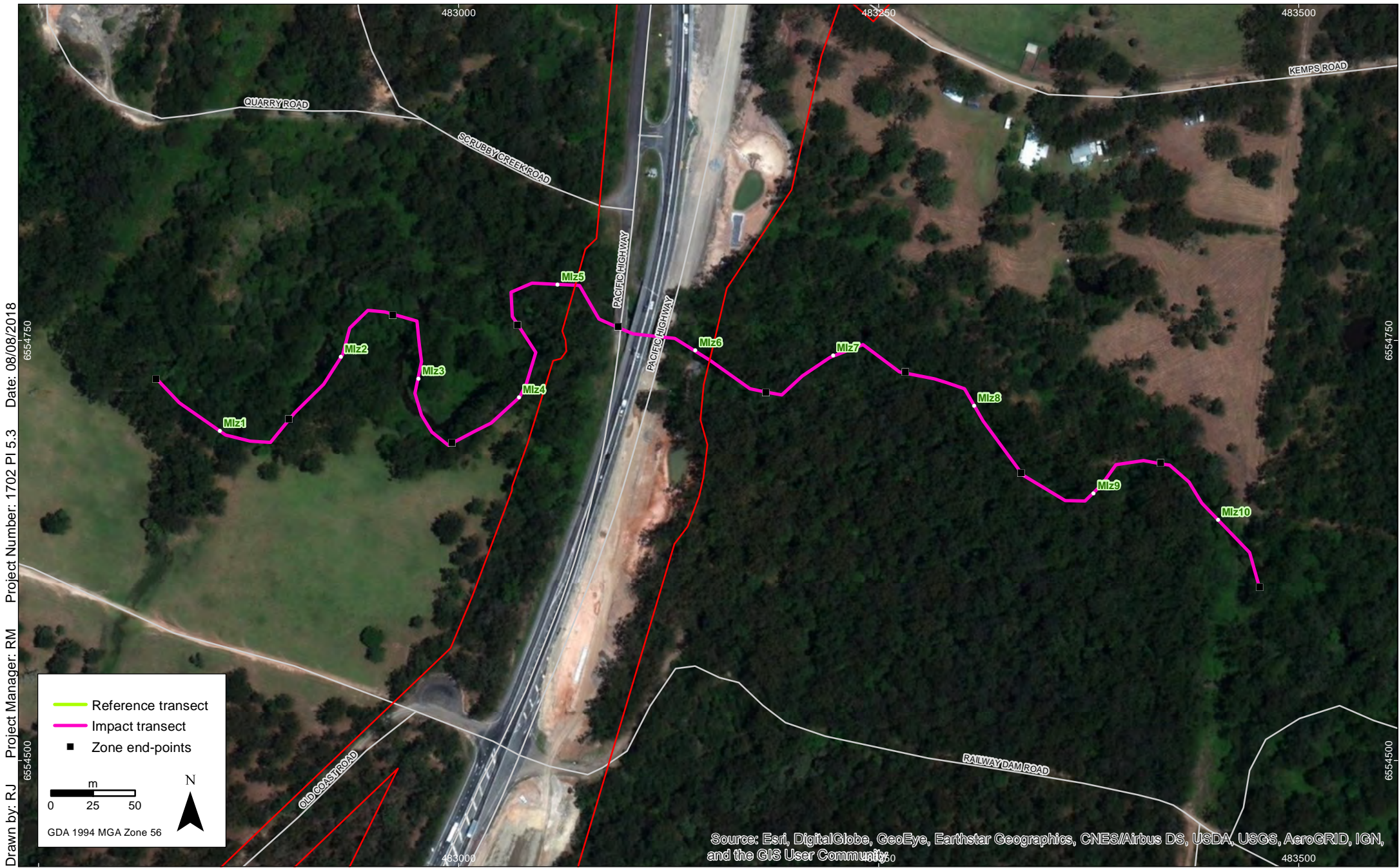
Imagery: (c) DigitalGlobe



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

FIGURE 4

Imagery: (c) DigitalGlobe



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

FIGURE 5

Imagery: (c) DigitalGlobe



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

FIGURE 6

Imagery: (c) DigitalGlobe



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

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

3. Results

3.1 2021/2022 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 were as follows:

- 11 – 14 October 2021 (spring): 16.4 millimetres recorded on 11 October 2022 prior to surveys
- 7 - 9 December 2021 (summer): 44.6 millimetres recorded on 5 December 2022 prior to surveys
- 26 - 28 April 2022 (autumn): 18.6 millimetres recorded on 23 April 2022 prior to surveys.

3.1.1 Survey results

A total of 28 Giant Barred Frogs were recorded in spring, summer and autumn during the 2021/2022 monitoring surveys. Giant Barred Frogs were recorded at one of the six sites during spring surveys, at two sites during the summer and autumn surveys (Table 1). Of the 28 frogs recorded, 22 were captured, of which six were recaptures (27%). Frogs were absent from Smiths Creek impact, Maria River impact and Cooperabung Creek reference sites in all seasons. In spring, frogs were recorded at Pipers Creek impact site (1) and Pipers Creek reference site (6). In summer, frogs were recorded at Cooperabung Creek impact site (1), Pipers Creek impact site (3) and Pipers Creek reference site (10). In autumn, frogs were recorded at Cooperabung Creek impact site (5), and Pipers Creek reference site (2). 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 (9 years) is highest at the Pipers Creek reference site (MNA = 201) and Smiths Creek impact site (MNA = 121). 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 2021/2022 surveys

Data set	Cooperabung Creek impact	Smiths Creek impact	Pipers Creek impact	Maria River impact	Cooperabung Creek reference	Pipers Creek reference
Spring (2021)	0	0	1	0	0	6
Summer (2021)	1	0	3	0	0	10
Autumn (2022)	5	0	0	No survey	0	2
Mean number of frogs over the monitoring period	2	0	1.3	0	0	6
Standard Error (SE)	2.6	0	1.5	0	0	4.0
Recaptures	0	0	1	0	0	5
New captures	4	0	2	0	0	10
Uncaptured	2	0	1	0	0	3
Total	6	0	4	0	0	18
Cumulative MNA	59	121	53	95	74	201

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 2021/2022.

Table 2: Breeding evidence records 2021/2022

Monitoring site	Season	Juveniles	Sub-adults	Gravid females	Nuptial pads
Cooperabung Creek impact	Spring				
	Summer			1	
	Autumn			1	
Maria River impact	Spring				
	Summer				
	Autumn	No survey	No survey	No survey	No survey
Pipers Creeks impact	Spring			1	
	Summer		2		
	Autumn				
Smiths Creek impact	Spring				
	Summer				
	Autumn				
Cooperabung Creek reference	Spring				
	Summer				
	Autumn				
Pipers Creek reference	Spring		5	1	
	Summer		1		1
	Autumn				

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: 2021/2022 surveys

Date	Min temp (°C)	Max temp (°C)	Humidity (%)	Rainfall 24 hours prior (mm)	Rainfall 7 days (mm)	Rainfall 30 days (mm)
11/10/2021	17.2	18.6	96	16.4	16.4	39.8
13/10/2021	14.7	21.1	65	31.0	81.2	104.6
14/10/2021	16.5	23.1	85	0.6	81.8	105.2
7/12/2021	17.6	26.1	80	0.4	67.0	298.6
8/12/2021	16.7	25.7	72	17.8	69.6	291.6
9/12/2021	17.3	26.1	74	12.8	78.6	304.4
26/04/2022	14.2	21.7	78	4.0	34.8	303.4
27/04/2022	15.3	24.2	75	2.4	37.2	281.8
28/04/2022	15.3	25.9	69	1.6	38.8	251.2

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).

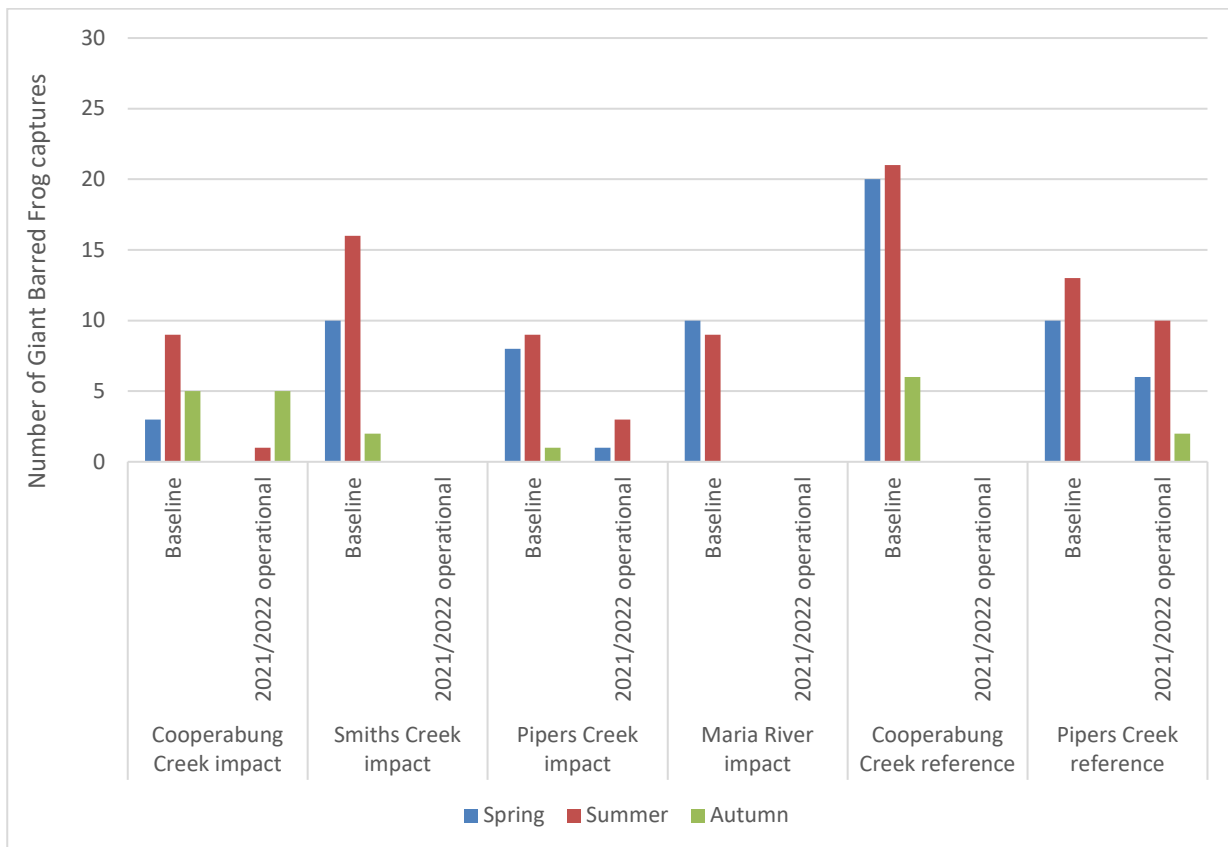
3.2 Comparison with Previous Surveys

3.2.1 Baseline and 2021/2022 surveys

Graph 1 presents the Giant Barred Frog records for baseline and the 2021/2022 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 two of the six sites during spring and autumn and three sites during summer 2021/2022 surveys. Giant Barred Frogs were not recorded at Cooperabung Creek reference site, Smiths Creek impact site or Maria River impact site during the 2021/2022 surveys, where it was recorded during baseline surveys. Giant Barred Frogs were not recorded at Pipers Creek impact site in autumn or Cooperabung Creek impact site in spring where it was recorded during baseline surveys.



Graph 1: Giant Barred Frog records: baseline and 2021/2022 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 monitoring 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 for the first time since autumn 2019. 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 the current monitoring period.

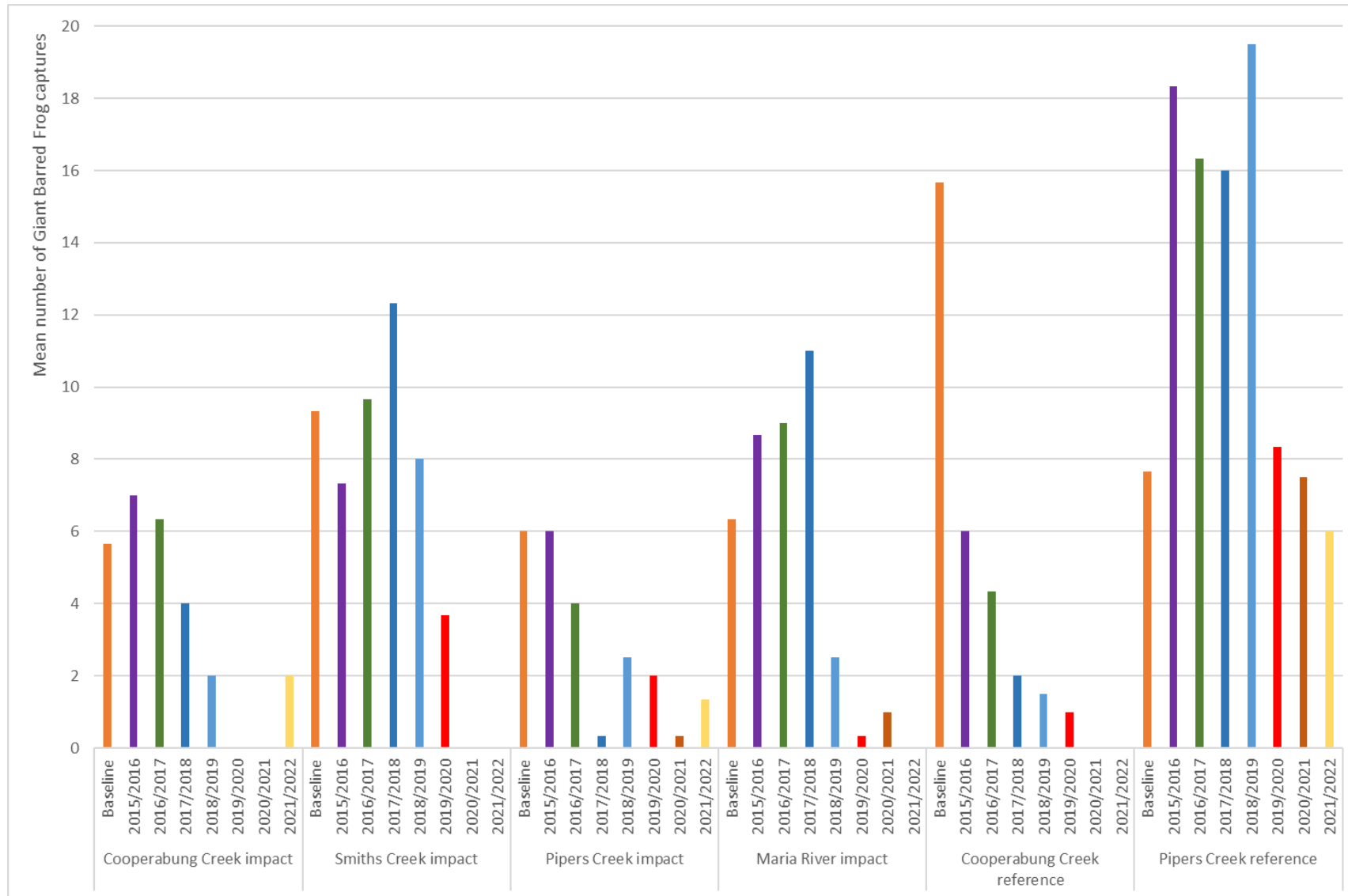
The mean number of Giant Barred Frogs recorded at Pipers Creek reference site increased substantially above baseline during the 2015/2016 monitoring period, where it remained stable, until decreasing back to baseline levels in 2019/2020 and subsequently below baseline in 2020/2021 and 2021/2022 monitoring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

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 Smiths Creek impact and Maria River impact sites during the current monitoring period.

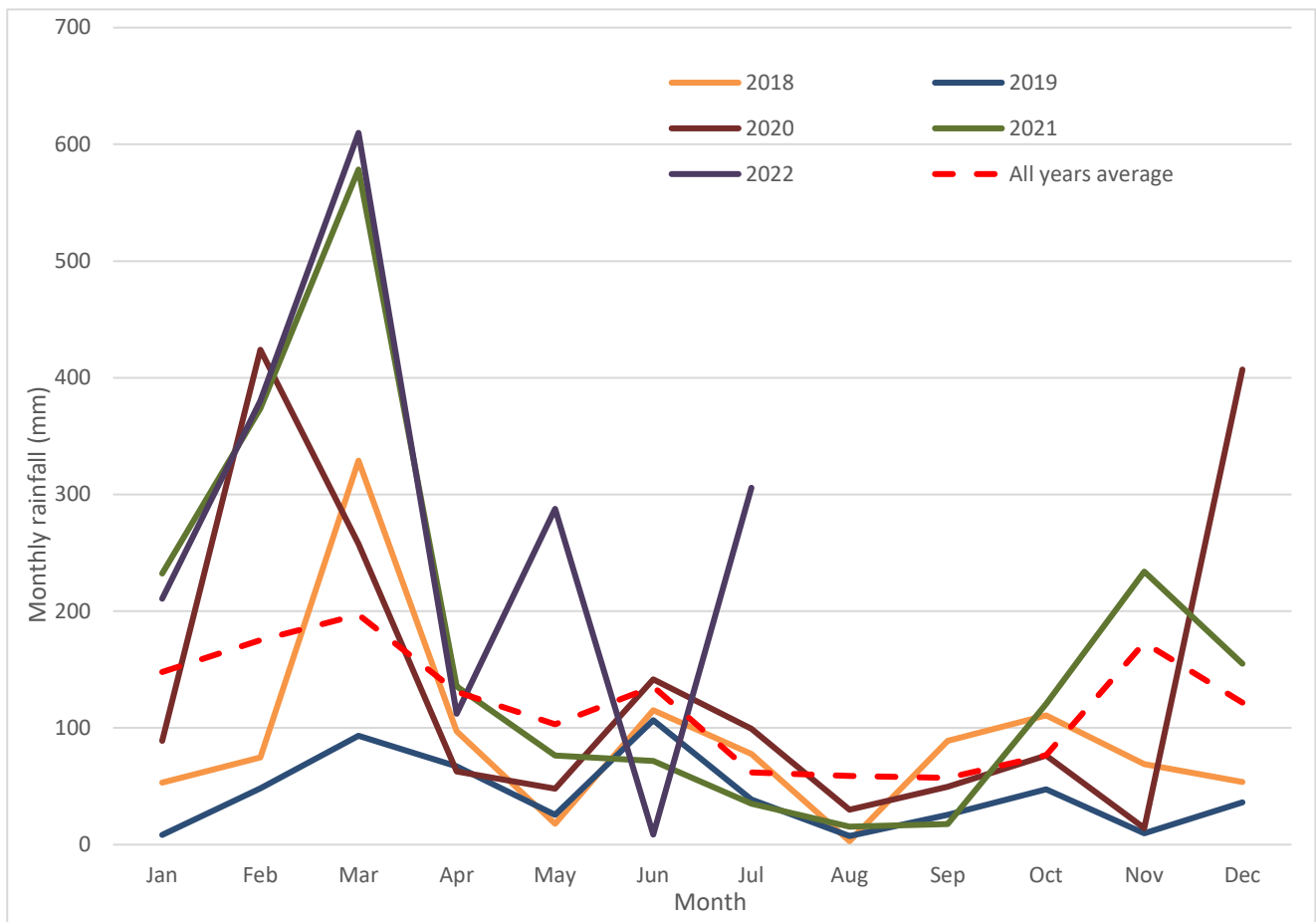
The mean number of Giant Barred Frogs recorded during the current monitoring period increased from the previous monitoring event at two of the six sites, Cooperabung impact and Pipers Creek impact. The remaining four sites decreased or remained the same. Mean records at all sites are currently lower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

As during the 2020/2021 monitoring period, 2021/2022 experienced higher than average rainfall from October 2021 to May 2022 (Graph 3). This 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.

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



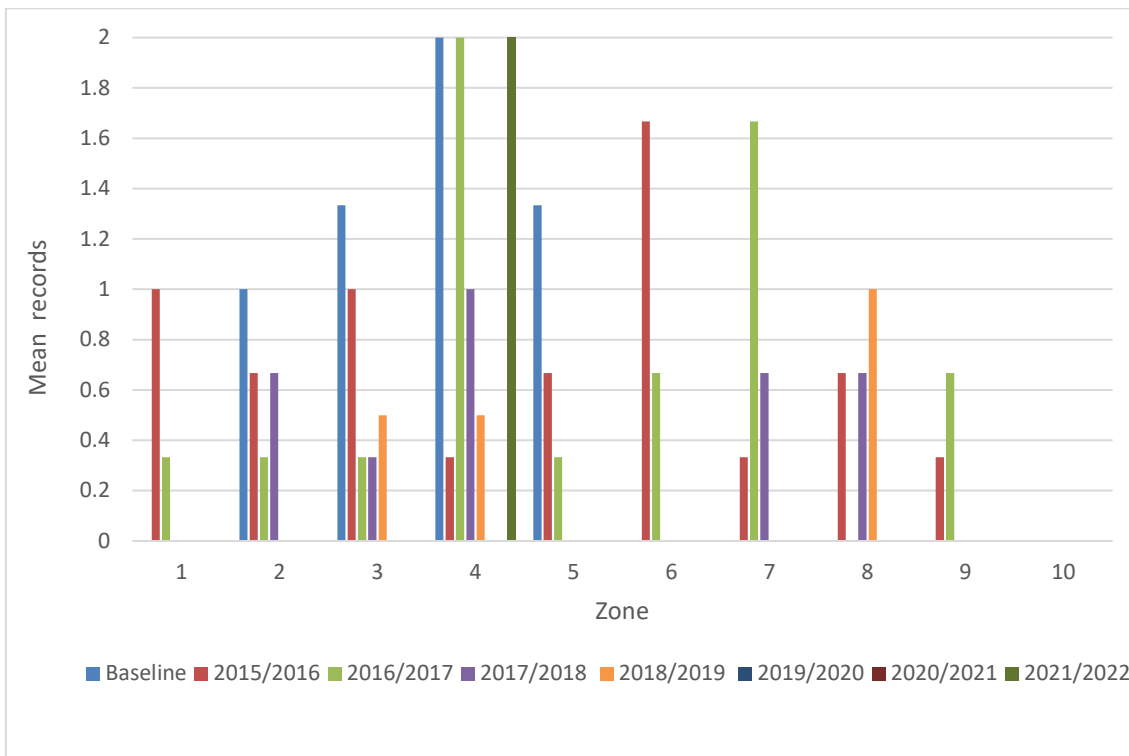
Graph 3: Monthly rainfall – All years monthly average and 2018-2022 monthly total rainfall

3.3 Density and Distribution

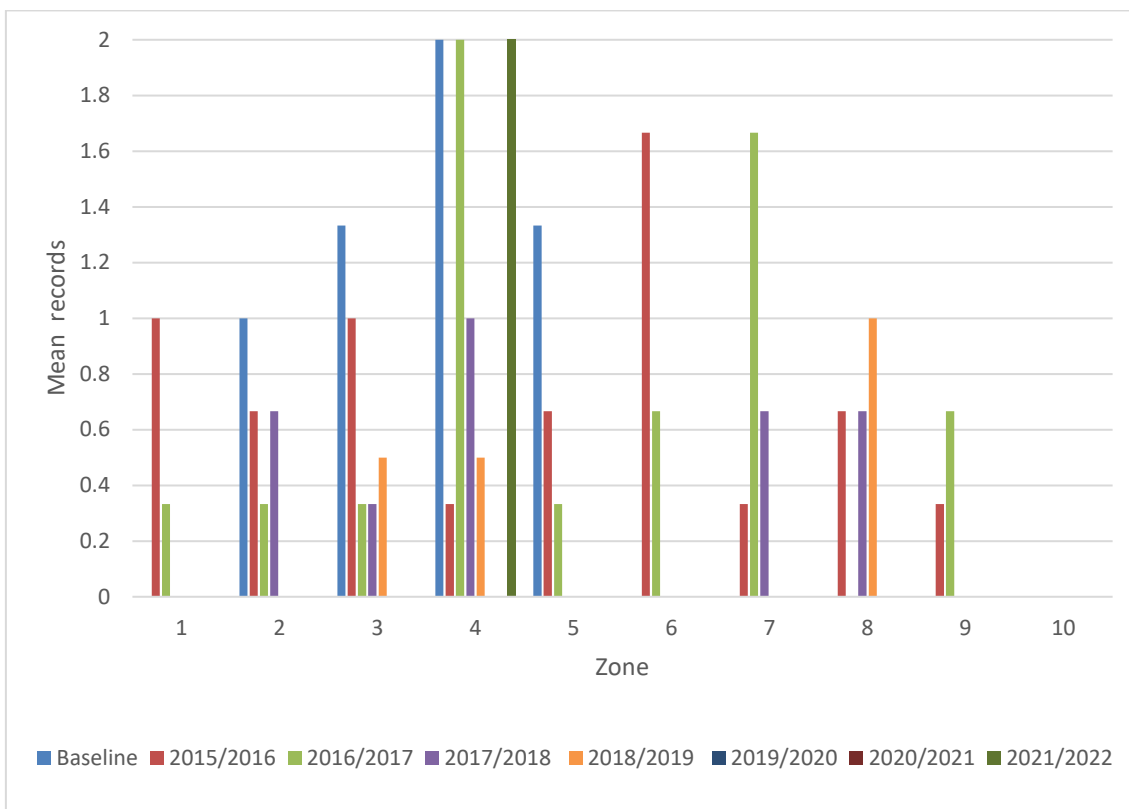
Graph 4 - Graph 9 present the density (*annual mean number of Giant Barred Frog records per zone*) and distribution of Giant Barred Frog records along the survey transect for each site and each monitoring period. Figure 8 - Figure 13 show the total number of captures within each zone over all monitoring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

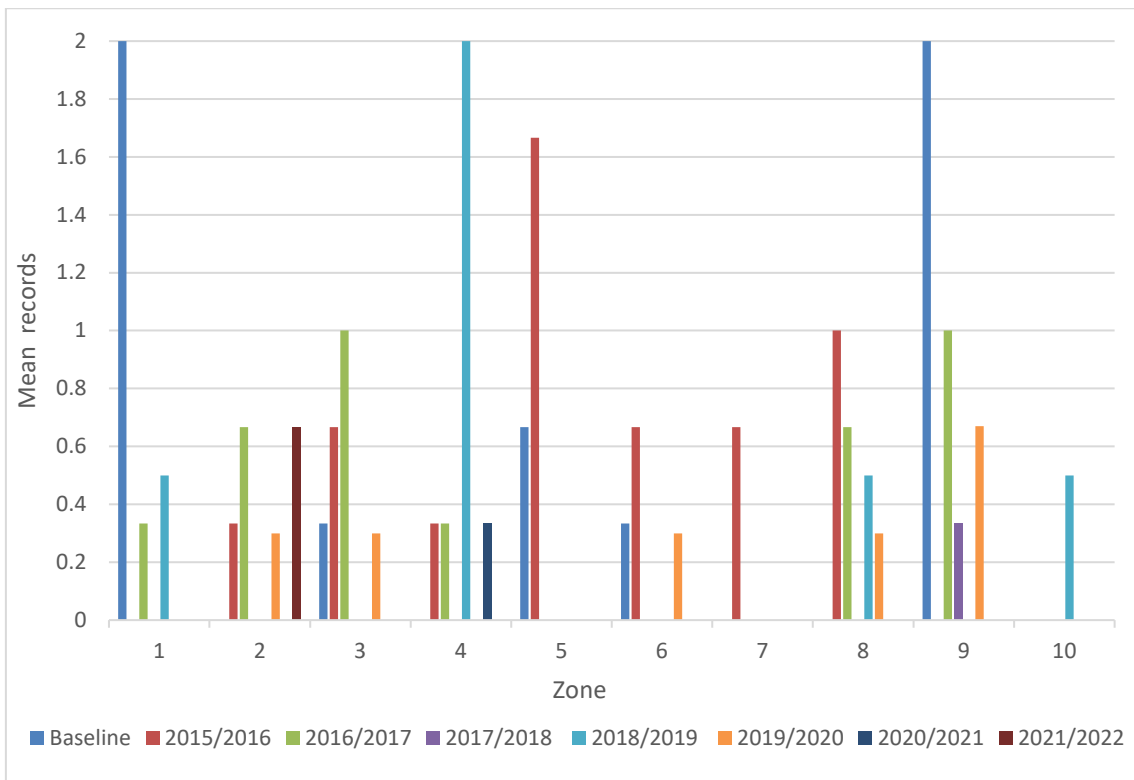
Figure 8 - Figure 13 show all capture records (i.e. cumulative records), whereby capture records (including recaptures) are shown as count ranges, where larger circles indicate larger frog counts. While density data indicates that frog distribution along the transects varies from year to year, when considering 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.



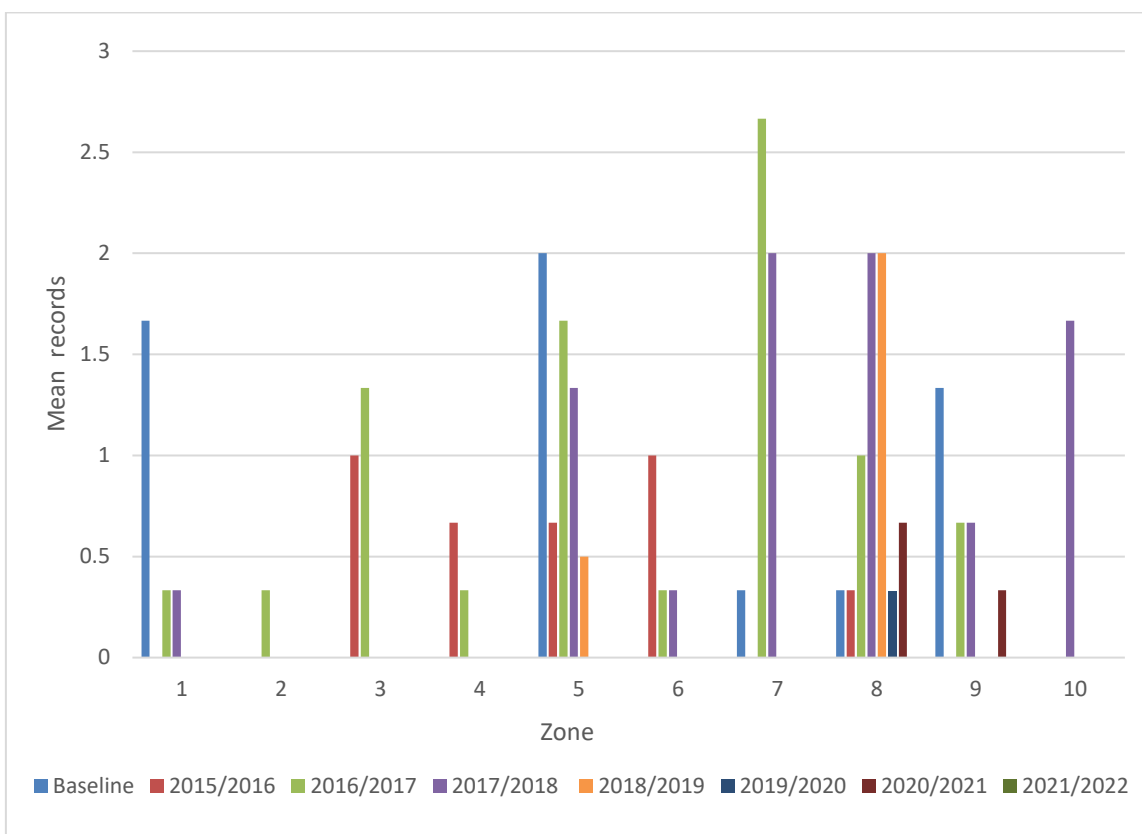
Graph 4: Cooperabung Creek impact site: mean number of Giant Barred Frogs per zone



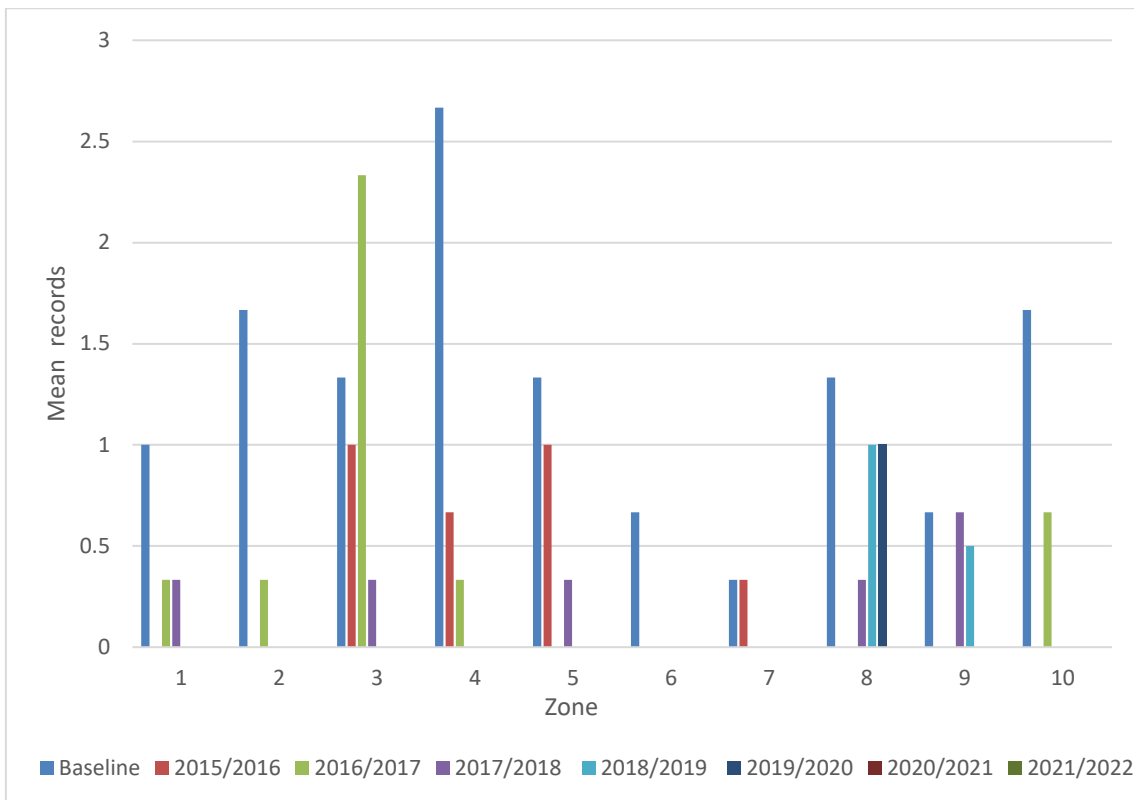
Graph 5: Smiths Creek impact site: mean number of Giant Barred Frogs per zone



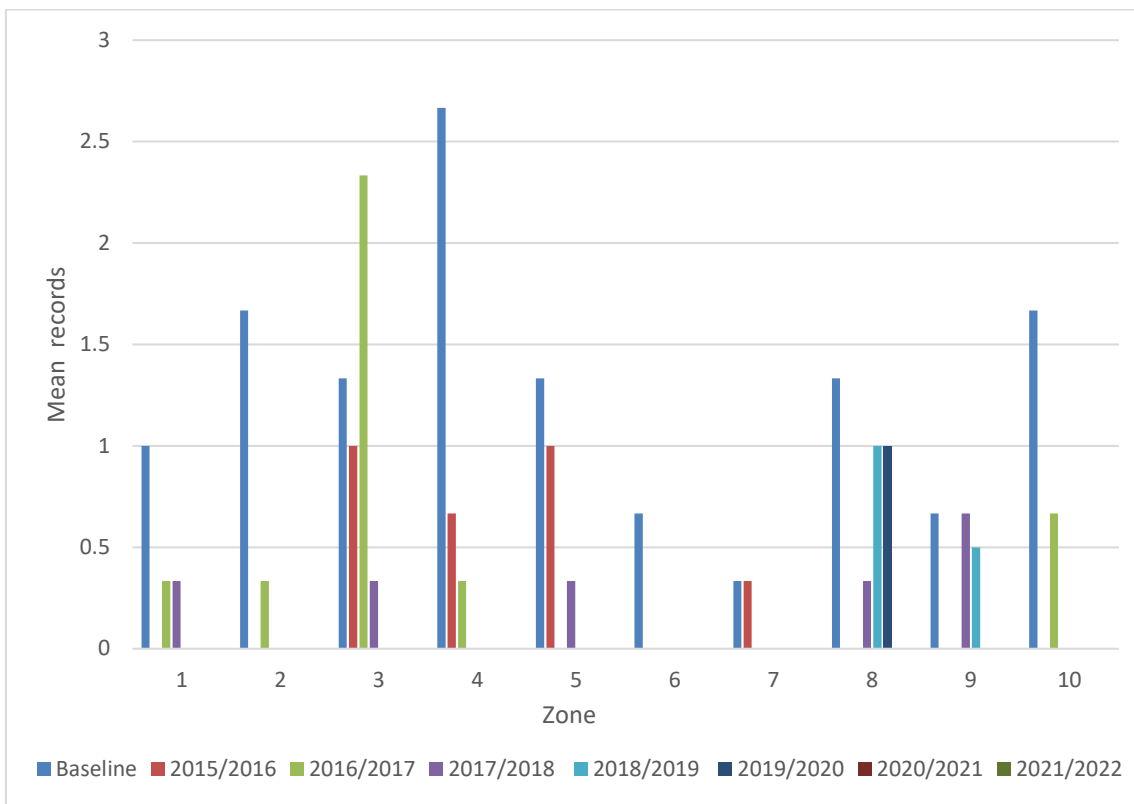
Graph 6: Pipers Creek impact site: mean number of Giant Barred Frogs per zone



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



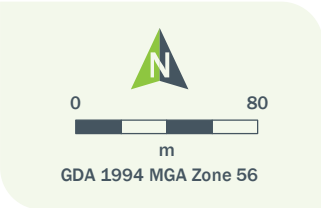
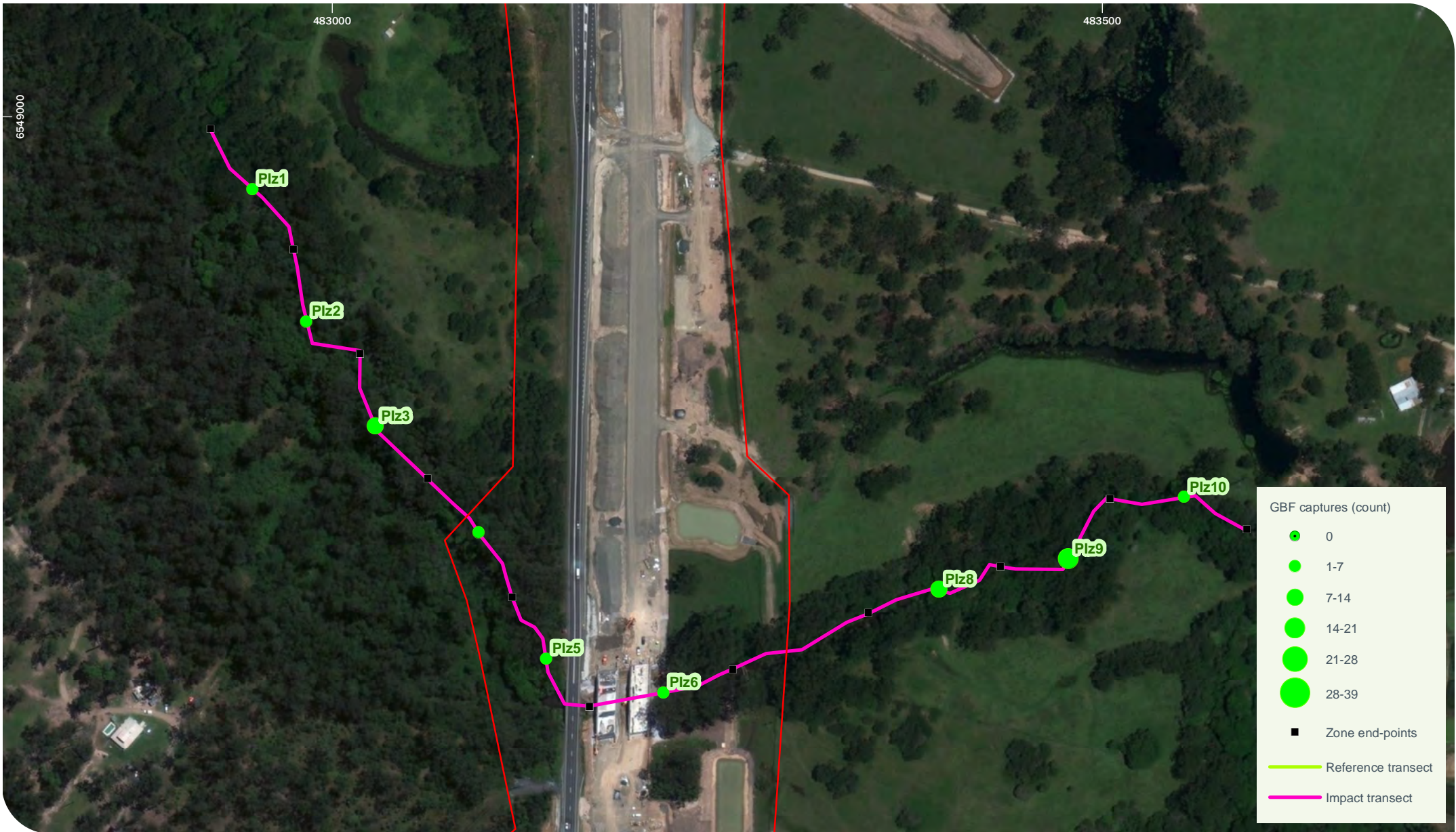
Graph 8: Cooperabung Creek reference site: mean number of Giant Barred Frogs per zone



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



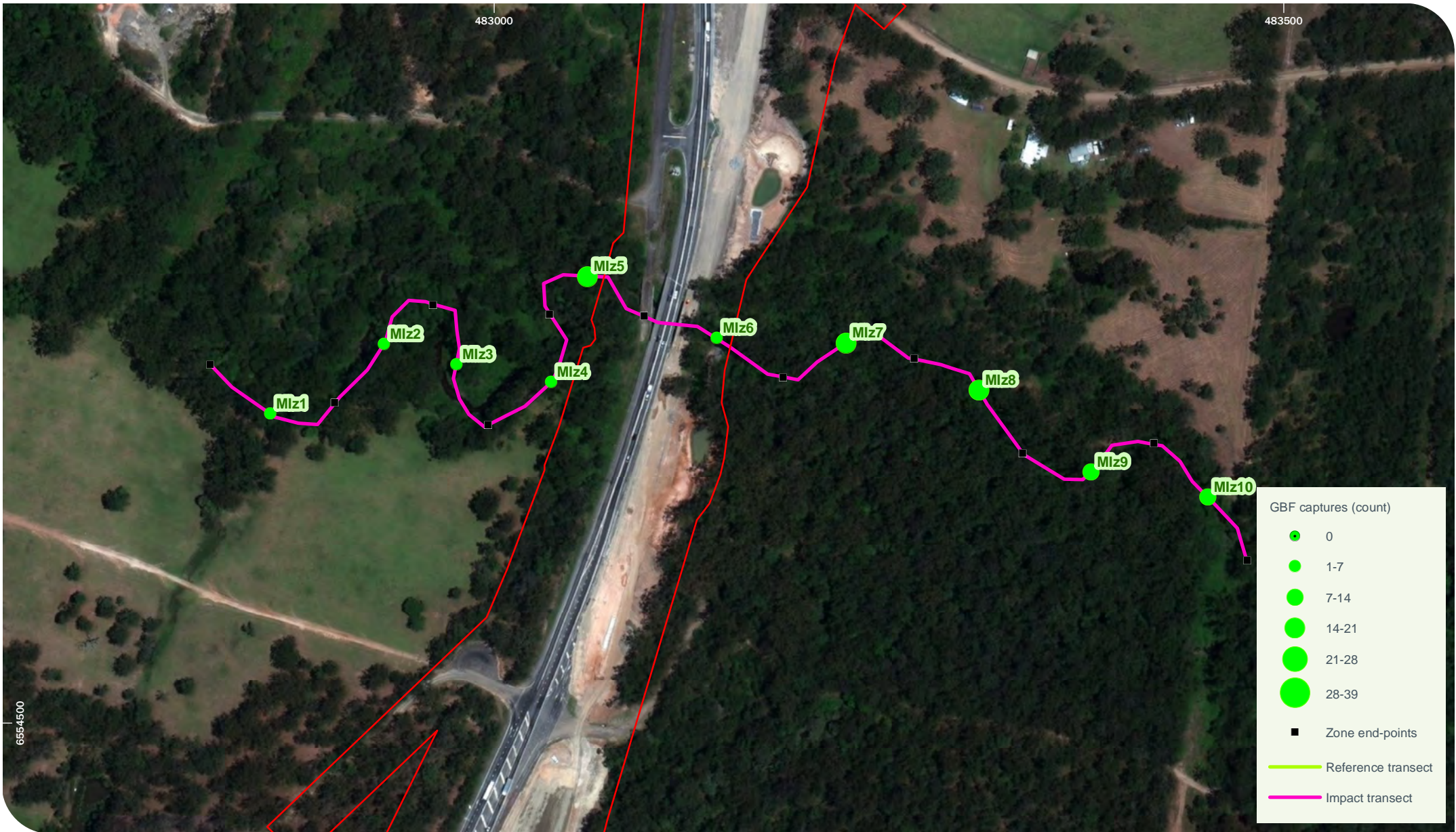




Niche PM: Jodie Danvers
 Niche Proj. #: 1702 PI 5.3
 Client: Transport for NSW

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

Figure 10







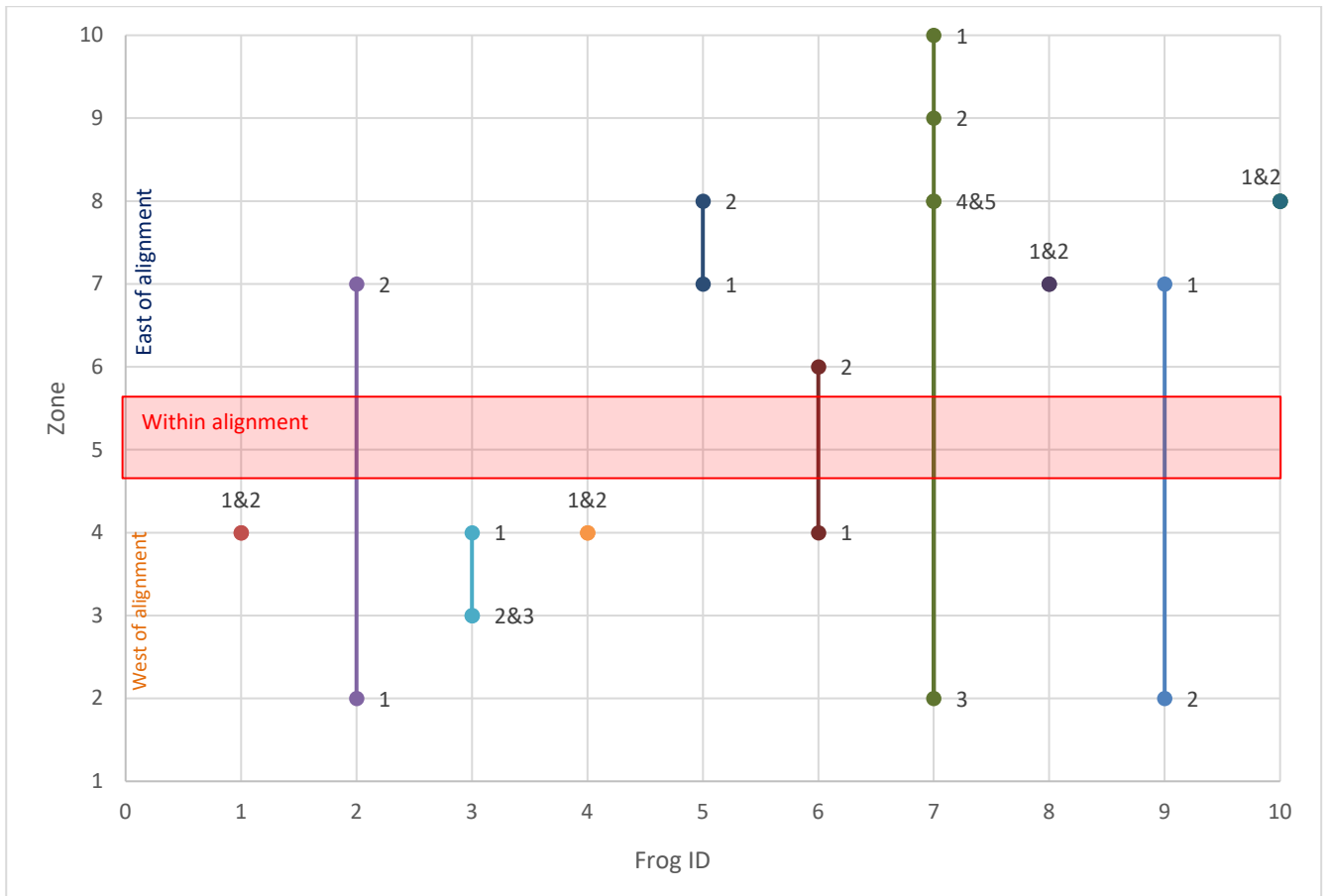
3.4 Movement

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.

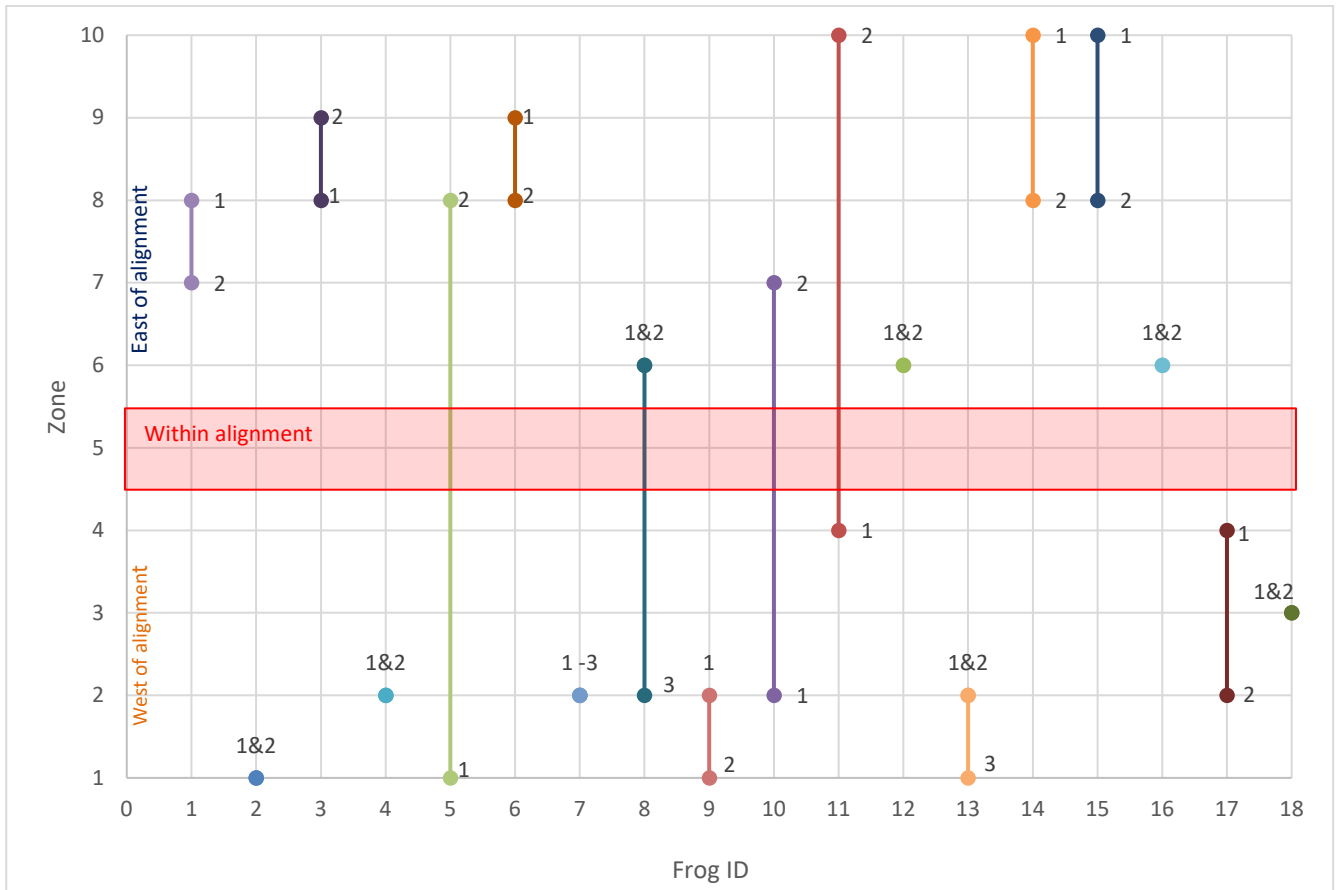
A total of 93 individuals have been recaptured on at least one occasion over all monitoring events. Of these, 50 recaptures have occurred at the impact sites. Twelve (24%) of these individuals from impact sites have been captured on both sides of the carriageway over successive monitoring events, demonstrating retained connectivity for this species under the carrageway. Of the 43 recaptures at the reference sites, 11 (26%) 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*: Ten Giant Barred Frogs have been recaptured over all monitoring periods. Of these individuals, four (40%) have been captured on both sides of the carriageway, including one individual (ID#7) that traversed on at least two occasions.
- *Smiths Creek impact site*: Eighteen 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*: Thirteen Giant Barred Frogs have been recaptured over all monitoring periods. Of these individuals, three (23%) 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-four Giant Barred Frogs have been recaptured over all monitoring periods. Of these individuals, nine (26%) 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.

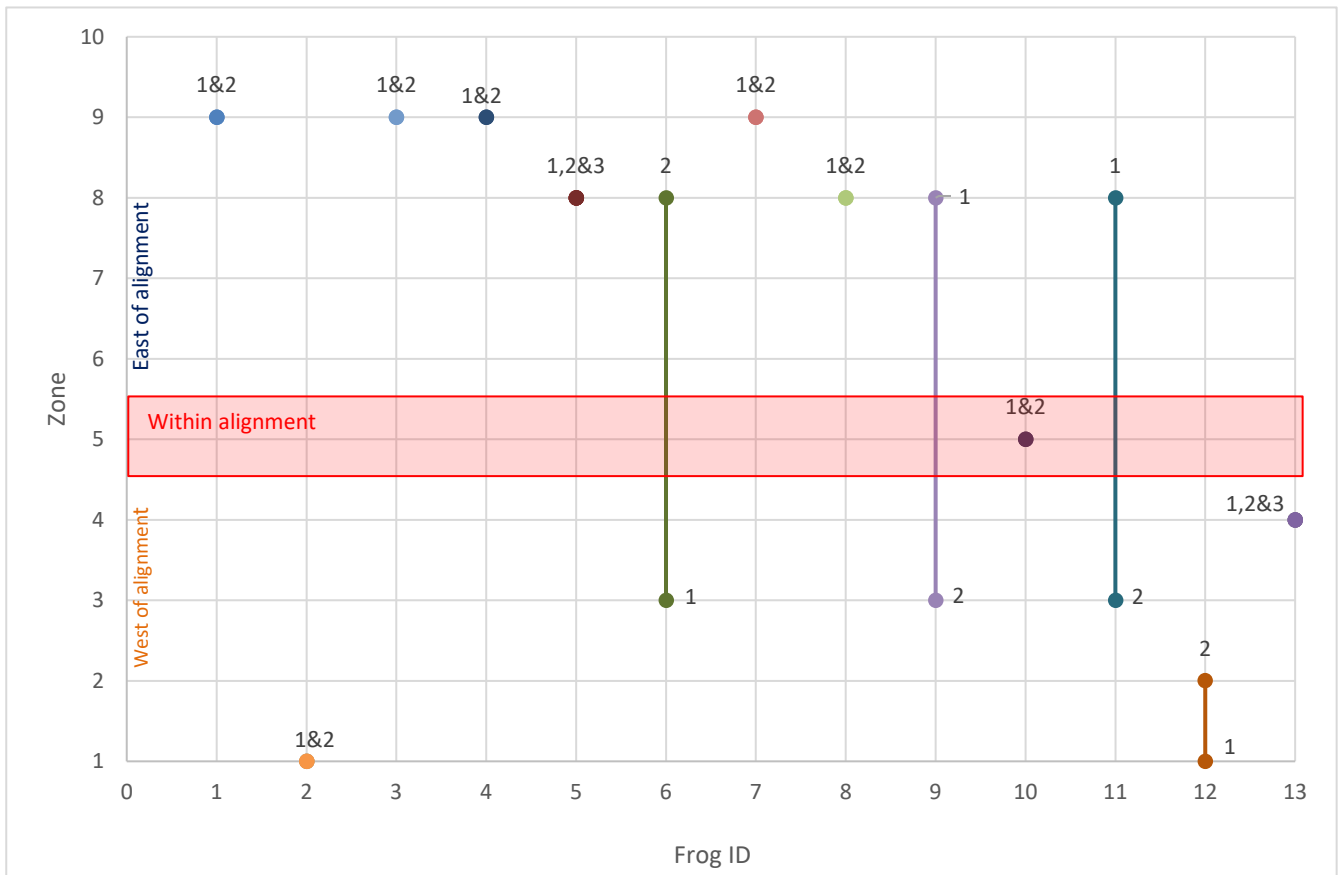
At the impact sites, while the monitored waterways continue uninterrupted under the carriageway, there is a distinct change in streamside vegetation within the area immediately under the carriageway. Under the carriageway at all impact sites, streamside vegetation ranges from limited to moderately dense, represented by patches of shrubs and/or *Lomandra* spp. The streamside habitat in these areas consists of native vegetation, 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.



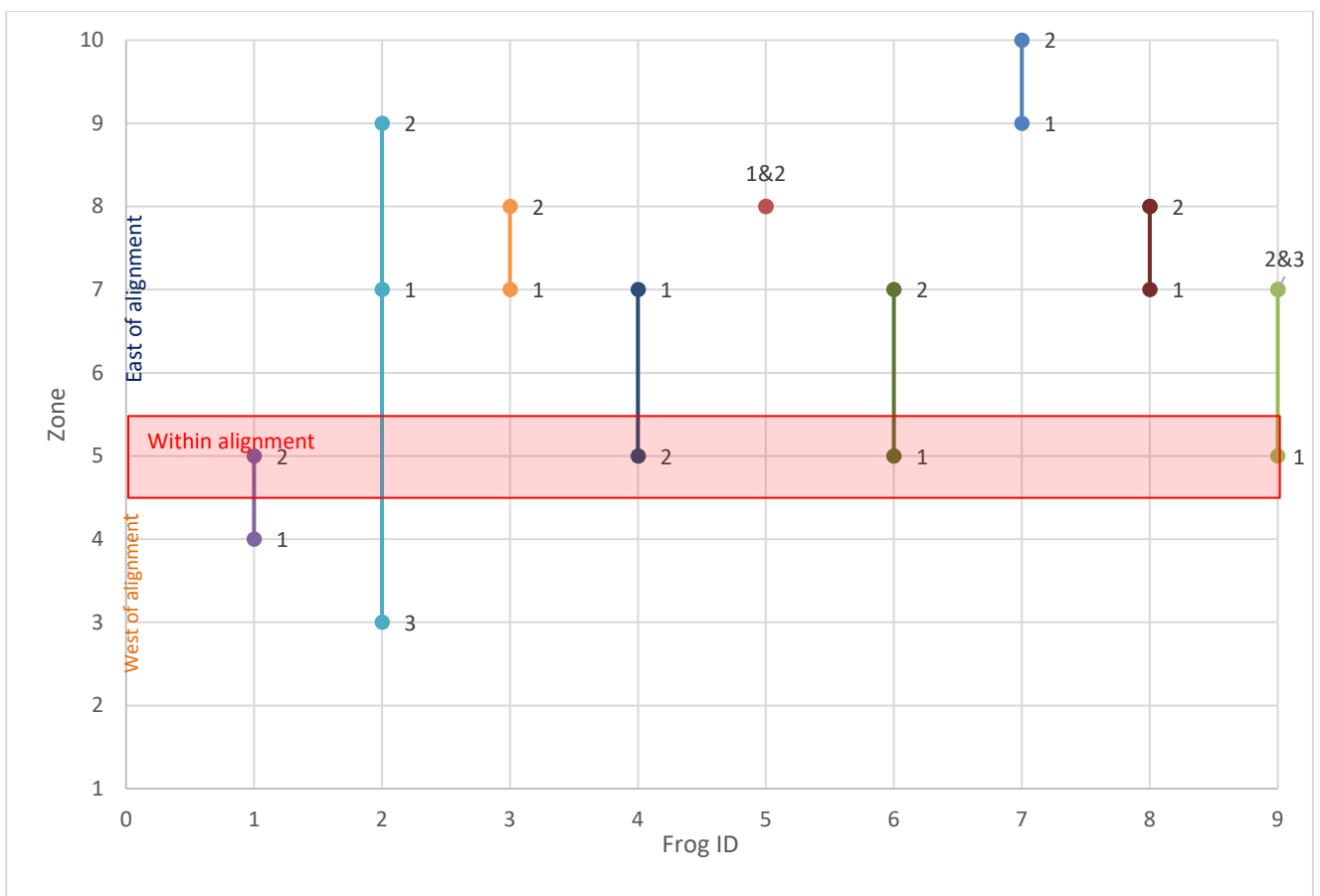
Graph 10: Cooperabung Creek impact site: recapture movement patterns



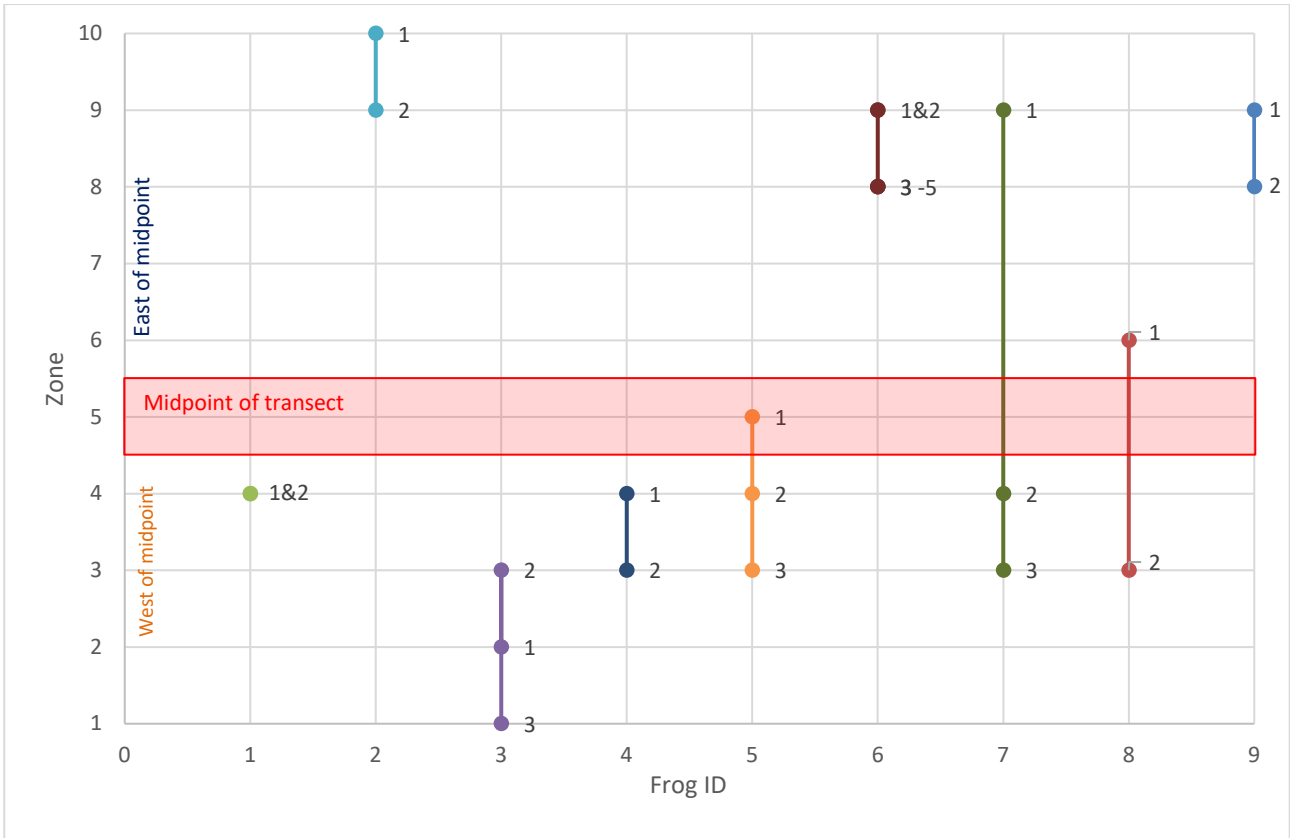
Graph 11: Smiths Creek impact site: recapture movement patterns



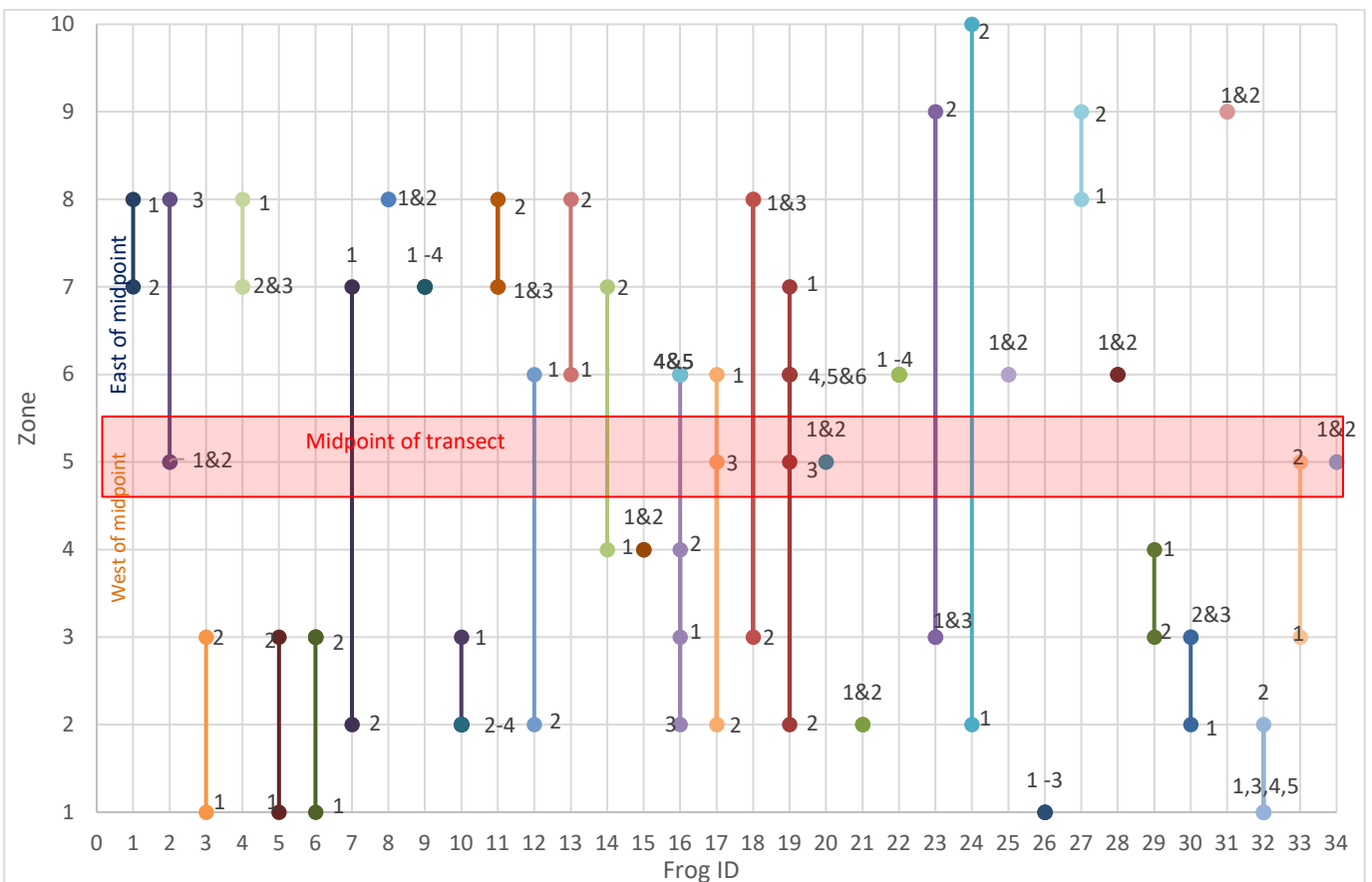
Graph 12: Pipers Creek impact site: recapture movement patterns



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) and Year 7 (2021/2022) 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. Autumn 2021/2022 surveys were not undertaken at the Maria River impact site due to inaccessibility after an increase in the growth of Lantana along the bank.
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. Autumn 2021/2022 surveys were not undertaken at the Maria River impact site due to inaccessibility after an increase in the growth of lantana along the bank.
Continued presence of Giant Barred Frogs during each survey event in Year 1 – 8 at sites where it was identified during baseline surveys, subject to access due to landowner agreement.	<p>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) and 1 of 6 sites in Year 7 (2021/2022).</p> <p>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.</p> <p>Year 1 (2015/2016): Giant Barred Frogs were detected at all six sites during all surveys.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>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</p>

Performance measure	Discussion
	<p>Barred Frogs were not recorded in spring at Cooperabung impact site or autumn at Pipers Creek impact site.</p>
<p>Mitigation measures are effective as defined in the EPBC approval when all monitoring events are considered at Year 8.</p>	<p>This performance measure is not yet applicable.</p> <p>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).</p> <p>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 mortalities due to clearing operations were reported.</p> <p>The effectiveness of the Giant Barred Frog Fence 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.</p> <p>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.</p>
<p>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.</p>	<p>This performance measure is not applicable for Year 7.</p>
<p>No change to densities, distribution, habitat use and movement patterns compared to baseline data during monitoring in Year 1 – 8, and then when all monitoring events are considered at Year 8.</p>	<p>This performance measure has not been met.</p> <p>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.</p> <p>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 sites, but also hindered by difficult (flooding) survey conditions.</p> <p>Within-year movement patterns that would permit comparison between baseline and subsequent monitoring events is not possible due to lack of data (surveys and captures are too infrequent), however, assessment of movement patterns of recaptured individuals over all surveys show that 24% of recaptured frogs have been found to traverse from one side of the carriageway to the other.</p>

5. Recommendations

5.1 Contingency Measures

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those that are considered relevant to the Giant Barred Frog monitoring program are listed and discussed in Table 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.	<p>The cause of the decline in populations at impacts sites will be investigated in consultation with EPA and DoTE within two weeks of results reported by ecologist.</p> <p>If the cause of decline is considered most likely attributed to the upgrade of the highway (and not another event such as bushfire), mitigation measures, such as the location and types of fauna crossings and fauna fencing will be reviewed within two months of the above consultation being completed.</p>	<p>All sites show an overall decreasing trend in mean records. However, as this decreasing trend is evident at both impact and reference sites, it is not possible to attribute these changes to the Project.</p> <p>The potential influence of environmental variables, such as drought and widespread flooding, may have contributed to the decreasing trend in records/observations.</p> <p>The apparent reduction in Giant Barred Frog numbers, however, is noted and will be considered in future monitoring events. This contingency measure is not yet considered relevant.</p>

5.2 Recommendations

A summary of those performance indicators that were not met in the 2021/2022 monitoring period, recommended corrective actions and general recommendations are provided in Table 7.

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.	<p>This performance measure has been met for 1 of 6 sites in Year 7 (2021/2022).</p> <p>Giant Barred Frogs were</p> <ul style="list-style-type: none"> Not recorded at Smiths Creek impacts site, Maria River impact site and Cooperabung Creek reference site, where it was recorded during all three baseline surveys. Not recorded at Cooperabung Creek impact site in spring 2021 and Pipers Creek impact site in autumn 2021, where it was recorded during baseline surveys. <p>Due to extreme climatic conditions and reduced records at all sites (impact and reference) it is recommended that monitoring continue as per the EMP.</p> <p>It should be noted that Giant Barred Frogs have become difficult to detect and access in some areas along the transects due to the density of stream-side vegetation.</p>
No change to densities, distribution, habitat use and movement patterns compared to baseline data during monitoring in Year 1 – 8, and then when all monitoring events are considered at Year 8.	<p>This performance measure has not been met.</p> <p>As discussed in Table 6, 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. It is recommended that monitoring continue as per the EMP.</p> <p>Due to extreme climatic conditions and reduced records at all sites (impact and reference) it is recommended that monitoring continue as per the EMP.</p>

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Annex 1 – 2021/2022 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)
13/10/2021	Start	23:31	17.1	16	89	200	0	100	0
	Finish	01:00	17.1	16	89	200	0	100	0
9/12/2021	Start	22:17	20	21	80	50	0	15	0
	Finish	23:45	19.6	21	80	60	0	20	0
27/04/2022	Start	20:00	20.4	22	90	35	0	100	1
	Finish	21:45	18.9	21	93	50	0	100	1

Table 8: Habitat details: Cooperabung Creek impact site

Zone	OS %	Sh %	G %	LL %	BE %	Cattle	Pools	Riffles	DoP (cm)	EF	Frogs detected	FB
4	90	5	5	100	0	no	2	0	150	yes	no	Unk
3	80	50	58	30	25	yes	3	3	50	yes	no	Unk
5	10	15	50	15	10	yes	2	2	40	yes	no	Unk
6	90	28	50	20	10	yes	2	2	40	yes	no	Unk
7	40	20	5	60	15	yes	3	2	50	yes	no	Unk
8	50	30	50	50	5	no	3	2	40	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 2021	Summer 2021	Autumn 2022
Number of frogs recorded	0	1	5
Number of adult males	0	0	2
Number of adult females	0	1	1
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 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)
14/10/2021	Start	21:14	15.8	17	98	30	3	0	0
	Finish	23:00	15	17	86	40	3	0	0
7/12/2021	Start	22:51	19.6	21	80	60	1	10	0
	Finish	22:51	19.6	21	80	100	0	2	0
28/04/2022	Start	19:55	18.5	21	98	40	0	0	0
	Finish	21:55	17.9	21	100	40	0	0	0

Table 11: Habitat details: Smiths Creek impact site

Zone	OS %	Sh %	G %	LL %	BE %	Cattle	Pools	Riffles	DoP (cm)	EF	Frogs detected	FB
3	90	5	5	60	20	no	2	0	100	yes	no	Unk
4	75	15	10	25	50	no	1	0	150	yes	no	Unk
2	85	2	5	60	10	no	2	0	100	yes	no	Unk
1	95	5	90	10	0	no	2	0	150	yes	no	Unk
5	15	5	10	5	50	no	91	0	100	yes	no	Unk
6	50	5	2	50	50	yes	1	0	100	yes	no	Unk
7	50	5	80	15	10	yes	2	0	100	yes	no	Unk
8	50	2	5	10	68	yes	2	0	150	yes	no	Unk
9	50	5	0	80	20	yes	0	0	150	yes	no	Unk
10	50	15	50	25	10	yes	1	0	200	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 2021	Summer 2021	Autumn 2022
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 within these zones included leaf litter, flood debris 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)
11/10/2021	Start	19:36	15	17	90	40	0	100	0
	Finish	21:50	14.8	17	86	180	1	100	0
7/12/2021	Start	20:02	21.4	21	92	50	1	5	0
	Finish	22:51	19.7	21	80	50	1	50	0
27/04/2022	Start	20:00	20.4	22	90	35	0	100	1
	Finish	21:45	18.9	21	93	50	0	100	1

Table 14: Habitat details: Pipers Creek impact site

Zone	OS %	Sh %	G %	LL %	BE %	Cattle	Pools	Riffles	DoP (cm)	EF	Frogs detected	FB
5	50	20	2	100	0	no	1	0	150	yes	no	Unk
4	20	50	60	10	2	no	1	0	150	yes	yes	Unk
3	80	30	0	25	80	yes	1	1	100	yes	no	Unk
2	75	45	80	25	10	no	3	2	30	yes	no	Unk
1	80	55	30	50	15	no	2	1	50	yes	no	Unk
6	10	0	20	5	80	yes	1	0	200	yes	no	Unk
7	50	2	5	5	90	yes	2	2	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, - = unknown

Table 15: Summary of captures: Pipers Creek impact site

	Spring 2021	Summer 2022	Autumn 2022
Number of frogs recorded	0	3	0
Number of adult males	0	0	0
Number of adult females	1	1	0
Number of sub-adults	0	2	0
Number of juveniles	0	0	0
Number of recaptures	0	0	0

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)	
11/10/2021	Start	22:11	14.6	17	86	0	1	100	0
	Finish	24:10	14	17	86	50	2	100	1
9/12/2021	Start	0:12	20	21	100	40	0	100	2
	Finish	2:06	19	21	100	50	0	100	3
26/04/2022	Start	22:49	16.7	21	100	40	0	100	0
	Finish	Not surveyed							

Table 17: Habitat details: Maria River impact site

Zone	OS %	Sh %	G %	LL %	BE %	Cattle	Pools	Riffles	DoP (cm)	FB	EF	Frogs detected
6	70	80	85	60	5	no	2	0	100		yes	no
10	75	80	80	90	0	no	1	0	150		yes	
9	90	50	10	100	0	no	2	0	100		yes	
5	85	80	70	28	10	no	1	0	200		yes	no
1	60	100										no
2	50	100										
3	50	100				no					yes	no
4	70	100				no					yes	no
7	75	60	100	30	15	no	3	0	100		yes	no
8	75	80	25	70	0	no	2	0	100		yes	no

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 2021	Summer 2021	Autumn 2022
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 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 Mlz1 to Mlz5. Lantana has also increased it's dominance of the downstream side throughout all zones. Access in Autumn 2022 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)
14/10/2021	Start	19:20	20	17	89	50	3	5	0
	Finish	21:00	20	17	80	40	3	0	0
9/12/2021	Start	20:01	21.2	21	96	60	0	80	0
	Finish	20:01	20.2	21	80	50	0	20	0
28/04/2022	Start	17:53	21.7	23	85	20	1	15	0
	Finish	19:35	21	23	88	25	0	5	0

Table 20: Habitat details: Cooperabung Creek reference site

Zone	OS %	Sh %	G %	LL %	BE %	Cattle	Pools	Riffles	DoP (cm)	Frogs detected	EF	FB
2	20	15	70	10	5	no	3	4	60	yes	no	2
3	30	15	60	15	10	no	2	4	40	yes	no	3
4	95	5	10	40	20	no	2	6	50	yes	no	4
5	20	50	25	50	10	no	2	2	40	yes	no	5
6	50	5	90	5	0	no	1	5	40	yes	no	6
7	95	45	10	55	5	no	1	6	60	yes	no	7
5	55	20	15	55	5	no	2	3	50	yes	no	5
8	95	15	10	70	20	no	1	5	50	yes	no	8

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 2021	Summer 2021	Autumn 2022
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)	
13/10/2021	Start	19:41	16.3	16	100	30	0	100	1
	Finish	23:00	15.9	16	100	20	0	100	2
8/12/2021	Start	20:23	20.6	21	90	20	0	50	0
	Finish	24:00	20	21	100	40	1	100	3
26/04/2022	Start	18:24	18	21	94	20	0	100	0
	Finish	22:00	16.8	21	100	50	0	100	0

Table 23: Habitat details: Pipers Creek reference site

Zone	OS %	Sh %	G %	LL %	BE %	Cattle	Pools	Riffles	DoP (cm)	EF	Frogs detected	FB
5	90	30	10	10	70	no	3	2	40	yes	no	
4		30	2	50	40	no	10	5	100	yes	yes	
3	60	15	1	90	10	no	5	4	100	yes	yes	
2	90	10	50	35	5	no	4	4	50	yes	yes	
1	85	10	10	25	30	no	4	3	40	yes	no	
6	95	45	5	10	40	no	3	2	100	yes	no	
7	30	10	90	10	2	no	2	2	100	yes	no	

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 2021	Summer 2021	Autumn 2022
Number of frogs recorded	6	10	2
Number of adult males	0	8	0
Number of adult females	1	0	1
Number of sub-adults	5	0	0
Number of juveniles	0	0	0
Number of recaptures	1	3	1

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	Piper's Creek	Spring	Female	Adult	Potential Gravid	102	250	3	007A0D205	Recapture	4	Sitting	under log
Reference	Piper's Creek	Spring	Unk	Sub Adult	Immature	43	25	10	NA	Immature	4	Jumping	leaf litter
Reference	Piper's Creek	Spring	Unk	Sub Adult	Immature	44	25	3	NA	Immature	3	Jumping	bare ground
Reference	Piper's Creek	Spring	Unk	Sub Adult	Light Nuptials	51		4	007A0B105	First time	3	Sitting	bare ground
Reference	Piper's Creek	Spring	Unk	Sub Adult	Immature	50	30	10	007A11BBE	First time	2	Sitting	leaf litter
Reference	Piper's Creek	Spring	Female	Adult	Potential Gravid	82	120	5	00791EB93	Recapture	3	Sitting	leaf litter
Reference	Piper's Creek	Spring	Unk	Sub Adult	Immature	52	35	5	007A3A948	First time	7	Sitting	leaf litter
Impact	Piper's Creek	Summer	Unk	Sub Adult		53	28	5	007A0E349	First time	5	Sitting	tree base
Impact	Piper's Creek	Summer	Unk	Sub Adult	Immature	64	47	4	0007E034F4	First time	2	Sitting	leaf litter
Impact	Piper's Creek	Summer	Female	Adult	n/a			3.5	NA	Uncaptured	2	Sitting	leaf litter
Reference	Piper's Creek	Summer	Male	Adult	Dark Nuptial Pads	63.5	55	5	0007E032CF	First time	5	Sitting	bank
Reference	Piper's Creek	Summer	Male	Adult	Light Nuptial Pads	74	80	1.5	007A0ECDD	Recapture	5	Sitting	lomandra
Reference	Piper's Creek	Summer	Male	Adult	Moderate Nuptial Pads	86	100	3	0007A3F00E	Recapture	1	Sitting	bank,leaf litter
Reference	Piper's Creek	Summer	Male	Sub Adult	Moderate Nuptial Pads	71	55	2	007A3E78F	First time	1	Sitting	bank
Reference	Piper's Creek	Summer	Male	Adult	Light Nuptial Pads	75	73	2	00079206C4	Recapture	6	Sitting	lomandra
Reference	Piper's Creek	Summer	Male	Adult	Moderate Nuptial Pads	65	58	3	0007E0319C	First time	6	Jumping	leaf litter
Reference	Piper's Creek	Summer	Unk	Adult	n/a			2	NA	Uncaptured	7	Sitting	bank
Reference	Piper's Creek	Summer	Male	Adult		69	65	1	0007A0F51A	First time	9	Sitting	
Reference	Piper's Creek	Summer	Male	Adult	Light Nuptial Pads	68	63	5	0007A0CB98	First time	9	Sitting	lomandra
Reference	Piper's Creek	Summer	Unk						NA	Uncaptured	7	Sitting	
Impact	Cooperabung Creek	Summer	Female	Adult	Gravid	101	235	1	0007E0342B	First time	4	Sitting	flood debri

Site	Location	Season	Sex	Age	Reproductive status	L	W	DW	pit_tag_code	Capture status	Z	Activity	Microhabitat
Reference	Piper's Creek	Autumn	Female	Adult	Not Gravid	79	90	10	0007A3F00E	Recapture	1	Sitting	leaf litter
Reference	Piper's Creek	Autumn	Unk	Adult	n/a	70		8	NA	Uncaptured	8	Jumping	flood debri
Impact	Cooperabung Creek	Autumn	Female	Adult	Gravid	95	200	2.5	00079EA6E1	First time capture	4	Sitting	leaf litter
Impact	Cooperabung Creek	Autumn	Male	Adult	Moderate Nuptial Pads	56	55	3	0007A3CC7F	First time capture	4	Jumping	flood debri
Impact	Cooperabung Creek	Autumn	Unk	Adult	n/a			0.3	NA	Uncaptured	4	Sitting	lomandra
Impact	Cooperabung Creek	Autumn	Male	Adult	Light Nuptial Pads	59	50	20	0007A2F05A	First time capture	4	Sitting	leaf litter
Impact	Cooperabung Creek	Autumn	Unk	Adult	n/a			1	NA	Uncaptured	4	Sitting	bare ground

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

Appendix B – Green-thighed Frog



Green-thighed Frog Monitoring 2021/2022

Breeding Ponds

Oxley Highway to Kempsey, Pacific Highway Upgrade

Prepared for Transport for NSW

October 2022

Document control

Project no.:	1702 (5.15)
Project client:	Transport for NSW
Project office:	Port Macquarie
Document description:	Green-thighed Frog monitoring 2021/2022: breeding ponds report
Project Director:	Lawrence Smith
Project Manager:	Radika Michniewicz
Authors:	Jodie Danvers
Internal review:	Radika Michniewicz
Document status:	R0
Local Government Area:	Port Macquarie-Hastings and Kempsey

Document revision status

Author	Revision number	Internal review	Date issued
Jodie Danvers	D1	Radika Michniewicz	15/08/2022
Radika Michniewicz	R0		10/10/2022

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Cover photograph: Green-thighed Frog located at Site 3W in 2022 (left) and Site 3W (Pond 4) during Stage 2 2022 monitoring (right).

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 the 2021/2022 monitoring period, the fourth monitoring event for the Green-thighed Frog breeding ponds, as required for the Oxley Highway to Kempsey (OH2K) Pacific Highway upgrade project (the Project). Transport for NSW (TfNSW) is required to manage and monitor the effectiveness of biodiversity mitigation measures implemented as part of the Project, including installation of 25 breeding ponds for the Green-thighed Frog (at five sites). Monitoring of ponds is to be performed in accordance with the methodology presented in the Ecological Monitoring Program (EMP) (TfNSW 2022).

Aims

The aim of the Green-thighed Frog breeding ponds monitoring is to determine if Green-thighed Frogs are using the purpose-built compensatory breeding habitat and thus determine whether the Project is meeting the performance indicators for the species. Corrective actions are also to be provided where required.

Methods

Surveys were undertaken in accordance with the EMP in two stages. Stage 1 surveys focussed on adult frog detection after a sufficient rainfall trigger; Stage 2 surveys focussed on tadpole detection (indicating successful breeding). Stage 1 surveys involved a 30-minute nocturnal active search at the Collombatti reference site and at each of the constructed pond sites, as well as a peripheral habitat search. Stage 2 surveys involved a 20-minute active search of the ponds and adjacent vegetation and dip-netting of ponds. During Stage 2 surveys, pond depth was recorded, presence of fish and predatory larvae noted, and a photograph was taken from a designated reference point.

Key results

The key results are as follows:

- Stage 1 surveys were undertaken on 25 February 2022 after rainfall that was deemed suitable by the Project Ecologist: 24 hour rainfall between 46-71 millimetres; cumulative rainfall over 72 hours between 113.4-175.6 millimetres.
- Stage 2 surveys were undertaken on the 31 March and 8 April 2022, 33 and 41 days after Stage 1 surveys.
- One Adult Green-thighed Frog was identified in habitat adjacent to Site 3W.
- No Green-thighed Frogs were identified at the Collombatti Reference Site, Site 1 (E or W) or Site 4 (E or W) during Stage 1 surveys.
- Stage 1 pond depth at Sites 1 and 3W varied between 10-50 centimetres, Site 4W contained water at only two ponds and all ponds at Site 4E were dry.
- Green-thighed Frog tadpoles were not identified at any site.
- Ponds at Site 1 (E&W), Site 3W and Site 4W held water at Stage 2 surveys, while all ponds at Site 4E were dry.
- *Gambusia (Gambusia holbrooki)* was identified at Site 1E (pond 2). A number of ponds holding water contained predatory invertebrates.

Conclusions

One of the three performance indicators of success has been met for Site 3W only, with the continued presence of Green-thighed Frogs at this site. The remaining sites (Sites 1 (E&W) and 4 (E&W), i.e. 20 of the 25 constructed ponds) have met the performance indicators for unsuccessful mitigation: Green-thighed

Frogs continue to be absent from Sites 1 (E&W) and 4 (E&W) and Site 4 (E&W) ponds are not retaining water for a sufficient amount of time to enable tadpoles to reach metamorphosis.

Management implications

A number of identified potential problems and contingency measures presented in the EMP are considered relevant due to the absence of Green-thighed Frogs from some monitoring sites and the constructed ponds not holding water for sufficient time after rain. Due to these outcomes, recommendations for further surveys of peripheral habitat to establish the ongoing persistence/existence of natural breeding sites of the species were developed in consultation with and endorsed by the NSW Environment Protection Authority (EPA) and TfNSW. Additional surveys have been approved and are awaiting appropriate surveys conditions and a trigger rainfall event.

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1. Introduction

1.1 Context

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

1.1.1 Legal status

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

1.1.2 Monitoring framework

Green-thighed Frog monitoring is to be performed in accordance with the EMP and the Green-thighed Frog Management Strategy (Lewis 2013), with the EMP taking precedence where inconsistencies occur. Construction involved direct and indirect impacts on known Green-thighed Frog habitat areas, which prevented post-construction monitoring. Therefore, monitoring relates to their presence/potential presence within purpose-built constructed breeding ponds, as per the EMP.

The EMP states: *"Monitoring will be undertaken on five occasions commencing in Years 3-7 (construction and operation phase). Each monitoring event should be at least 10-12 months apart but ultimately dependant on rainfall events."*, and that *"The first round of monitoring (Year 3) is to commence once the vegetation on the edges of the constructed ponds is considered sufficient (>20% groundcover), to be determined by a suitably qualified Ecologist."*

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

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

The monitoring of frog fences is being undertaken as part of the fauna fence monitoring (in conjunction with underpass monitoring periods). These results are detailed in the reporting for the fauna fence monitoring component of the Project and are summarised in this report.

The 2021/2022 monitoring represents the fourth monitoring event. To date, these monitoring events have been reported as follows:

- 2016/2017: Niche (2017).
- 2017/2018: Niche (2018).
- 2018/2019: insufficient rainfall to trigger surveys.
- 2019/2020: Niche (2020).

- 2020/2021: surveys not completed due to timeframes involved in changes in methodology to address unsuccessful mitigation. This monitoring event will be undertaken as the fifth monitoring event, when survey triggers are met.
- 2021/2022: current report.

To date, four monitoring events have occurred. The EMP states that monitoring is to occur on five occasions. The fifth monitoring event will be undertaken during the 2022/2023 season, when survey triggers are met.

1.1.3 Baseline data

Green-thighed Frogs were identified from seven locations during baseline surveys (Lewis 2013, Figure 1), however no tadpoles, metamorphs or juvenile Green-thighed Frogs were recorded at identified breeding sites 57 days after rain events enabled identification of adult frogs. As construction of the Project directly or indirectly impacted seven known habitat areas, frog breeding ponds were proposed at these locations. The Green-thighed Frog Management Strategy (Lewis 2013) states: “Frog breeding ponds will be constructed at four locations, two within the Oxley Highway to Kundabung Upgrade section and two within the Kundabung to Kempsey section.”

The EMP provides a summary of the location of the proposed breeding ponds:

- “Ch.9050-9350. Five ponds to be constructed on each side of the carriageway.
- Ch.11550. Five ponds to be constructed on each side of the carriageway (Project Ecologist to investigate the suitability of ponds in consultation with RMS and the EPA and be guided by the results of pre-clearing surveys).
- Ch.30660. Five ponds to be constructed on the western side of the carriageway.
- Ch.33650. Five ponds to be constructed on each side of the carriageway.”

It was determined in consultation with the NSW Environment Protection Authority (EPA) that the construction of 10 ponds at Ch. 11550 was not warranted due to several surveys finding no record of Green-thighed Frogs in the area around Ch. 11550. In addition, it was determined that breeding habitat remained available locally outside the Project boundary. As such, monitoring has been undertaken of ponds constructed at the remaining three areas (baseline sites 20, 11 and 16).

1.1.4 Purpose of this report

This report complies with the monitoring requirements described within the approved EMP and the Green-thighed Frog Management Strategy (Lewis 2013) and details the findings from the fourth monitoring period. It represents the fourth monitoring event. The aims of this report are to summarise the methods and results of the 2021/2022 monitoring, determine if performance measures are being met, and to comment on the need for contingency measures, as per the EMP.

1.2 Performance Measures

The Green-thighed Frog Management Strategy and the EMP specify a number of performance indicators against which the success of the compensatory habitat will be measured. These are listed in Table 1 along with their inclusion in the relevant document.

Table 1: Performance indicators

Performance indicator	GThF MS	EMP
Performance indicators of success		
Continued presence of Green-thighed Frog at two/three or more of the three/four breeding pond sites.	✓	✓

Performance indicator	GThF MS	EMP
Green-thighed Frogs calling from the edge of the constructed ponds.	✓	✓
The presence of tadpoles, juveniles or metamorphs at the frog breeding ponds during Stage 2 surveys.	✓	✓
Signs of the mitigation being unsuccessful		
Absence of Green-thighed Frogs from one or more of the four sites (GThF MS)	✓	✓
Absence of Green-thighed Frogs from the area (EMP)		
Ponds not holding water for a sufficient time to enable tadpoles to reach metamorphosis.	✓	✓
Ponds holding water for too long and representing unsuitable habitat (i.e. permanent versus ephemeral).	✓	✓
Exotic fish fauna recorded in breeding ponds.	✓	

GThF MS = Green-thighed Frog Management Strategy (Lewis 2013); EMP = Ecological Monitoring Program (TfNSW 2022).

1.3 Monitoring Timing

The EMP specifies that:

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

1.4 Reporting

Annual reporting of monitoring results is required to include:

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

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

1.5 Limitations

The following limitations to the monitoring procedure were encountered:

- A definitive statement as to the fulfilment of performance indicators relating to ponds drying too soon or holding water for too long cannot be made for some or all of the ponds, due to surveys requiring Stage 2 surveys to be undertaken 30-40 days after Stage 1 and the minimum water retention period of 30 days and maximum water retention period of 60 days. As such, data concerning the presence of water in the ponds prior to or after Stage 2 surveys cannot be captured without additional surveys, which were beyond the identified scope of the monitoring program.
- Significant rainfall events between Stage 1 and Stage 2 surveys influenced the water depth of constructed ponds at Stage 2 surveys.

2. Survey Methods

2.1 Monitoring Sites

The monitoring site locations are shown in Figures 1 to 4. These sites correspond to the proposed pond locations as required by the EMP and are described in Table 2. The Collombatti site was used as the reference site.

Table 2: Survey sites

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

2.2 Survey Method

The survey method described within the EMP (extracted from the Green-thighed Frog Management Strategy) was employed for all surveys and is provided below.

“Monitoring of the constructed breeding ponds would ideally be undertaken on a rainfall event basis when 24-hour rainfall totals exceed 75 millilitres or a cumulative total of 150 millilitres over a 72-hour period. Such rainfall events would be monitored via the Bureau of Meteorology (BOM) website, specifically the Port Macquarie (Station No. 060183) and/or Kempsey (Station No. 059017) weather stations. Where sufficient rainfall is unlikely to occur during the monitoring period, the Project Ecologist will determine whether smaller rainfall events are suitable to conduct a monitoring event. The suitability of the rainfall trigger chosen would be subject to the reference site visit outlined in Stage 1 below. Surveys would be performed using a two-stage process outlined below.

a) Stage 1 – Determining Presence and Breeding Activity

Upon the study area receiving the required rainfall, a reference site would be visited to determine the extent of Green-thighed Frog activity. The survey would comprise a 30 minute nocturnal active search at each of the four breeding pond areas (sites) using a hand held spotlight. Peripheral habitats (i.e. <50 m) would also be surveyed at this time. Upon the completion of Stage 1 surveys the next stage would be implemented.

b) Stage 2 – Determining the Success of the Breeding Event

All sites would be subject to follow-up surveys between 30-40 days after Stage 1 to assess the outcome of the breeding event. This follow up survey will comprise:

- *A 20 minute active search for metamorphs and juvenile frogs around the pond edge and vegetation immediately adjacent to the pond (i.e. <10 m).*
- *Dip-netting of the constructed pond and subsequent tadpole identification. Specific attention will be given toward identifying the presence of fish (both native and exotic) along with predatory invertebrates such as dytiscid larvae.*

- *The depth of the ponds would be measured from the permanently installed water staff.*
- *Photo taken from a designated photo point (to be established during the first Stage 2 survey)."*

2.3 Consideration of adjacent habitat

Given the lack of pond use to date, it was decided, in consultation with TfNSW, that habitat immediately adjacent to the constructed ponds should be inspected for its suitability as Green-thighed Frog breeding habitat. These inspections were completed during the current monitoring event.

2.4 Analysis

Monitoring results are to be analysed in accordance with the performance indicators specified within the EMP. In the case of the Green-thighed Frog, performance measures are based on presence/absence results and pond habitat quality and do not require statistical comparison between survey events.



Green-thighed Frog constructed breeding pond locations
 Pacific Highway Upgrade - Oxley highway to Kempsey

FIGURE 1

Imagery: (c) LPI 2014-10-06



Green-thighed Frog constructed breeding ponds - Site 1
Pacific Highway Upgrade - Oxley highway to Kempsey

FIGURE 2

Imagery: (c) NearMap 2017-12-13

Path: T:\spatial\projects\1700\1702_OH2K_Ecology\Maps\PI_5_Ecology_OH2K\PI_515_GTF\report_20200623\1702_PL1515_GTF_Figure_3_site_3.mxd
Date: 01-Jul-20
Project Number: 1702 PL15.15
Project Manager: RM
Drawn by: GT



Green-thighed Frog constructed breeding ponds - Site 3
Pacific Highway Upgrade - Oxley highway to Kempsey



Green-thighed Frog constructed breeding ponds - Site 4
Pacific Highway Upgrade - Oxley highway to Kempsey

FIGURE 4

Imagery: (c) DigitalGlobe 2019

3. Results

Field data from Stage 1 and Stage 2 monitoring for all sites are provided in Annex 1. Photo monitoring results are provided in Annex 2.

3.1 Frog Fence Monitoring

Frog fence monitoring is detailed within the fauna fence reporting component for the Project. Minor maintenance issues, such as vegetation encroaching on fences, were identified. No Green-thighed Frogs were identified as road kill. Detailed survey results, discussion and recommendations will be provided within the fauna fence monitoring report.

3.2 Stage 1 – Determining Presence and Breeding Activity

3.2.1 Conditions

Suitable rainfall within the 2021/2022 monitoring period, as specified within the EMP, did not occur until February 2022, almost two years after the previous trigger and monitoring event (February 2020). Stage 1 surveys were undertaken on 25 February 2022 when rainfall was deemed suitable by the Project Ecologist. Rainfall and temperatures for relevant weather stations are provided in Table 3.

Table 3: Rainfall and temperatures for 25 February 2022

BOM weather station	24hr rainfall (mm)	72hr rainfall (mm)	Min temperature °C	Max. temperature °C
Port Macquarie Airport AWS #60139	71	175.6	21.5	27.5
Kempsey Airport AWS #59007	46	113.4	21.4	27.5

3.2.2 Nocturnal active searches

One adult Green-thighed Frogs was identified at Site 3W; the individual was observed in adjacent habitat. No Green-thighed Frogs were calling at the time of surveys.

No Green-thighed Frogs were identified at the Collombatti Reference Sites, Site 1 or Site 4 during Stage 1 surveys.

A number of frog species were heard calling at the Collombatti reference site, Site 1, Site 3W and Site 4W. Other species identified include the Striped Marsh Frog (*Limnodynastes peronii*), Common Eastern Froglet (*Crinia signifera*), Eastern Dwarf Tree Frog (*Litoria fallax*), Tyler’s Tree Frog (*Litoria tyleri*), Dusky Toadlet (*Uperoleia fusca*) and Great Barred Frog (*Myxophyes fasciolatus*).

These results are summarised in Table 4.

3.2.3 Pond depth during Stage 1

Water depth of the ponds varied during Stage 1 surveys and can be summarised as follows:

- Collombatti reference site: 55 cm
- Site 1W: between 10-30 cm
- Site 1E: between 40 cm
- Site 3W: between 40-50 cm
- Site 4W: between 0-25 cm (ponds 1, 2 and 3 were dry).
- Site 4E: did not hold water.

Table 4 presents Stage 1 water depths.

3.2.4 Vegetation structure and other observations

As discussed in Niche (2018), it is possible that invasive grass species present at many ponds is too dense and possibly unsuitable for Green-thighed Frogs, a species that requires leaf litter for foraging (OEH 2018) and a more open low ground vegetation (Hero 2004), such as ferns and mat rushes. Each site is discussed below and site photos provided in Annex 2 show the level of vegetation and exposure of ponds at each site.

Site 1

Site 1 (E&W) ponds are surrounded by dense exotic perennial grasses (*Andropogon* sp. and *Setaria* sp.) with sedges or rushes within and around ponds. Ponds are positioned within an exposed sunny location without canopy cover. The presence of bulrushes at pond 1 and 3 at Site 1E and pond 5 Site 1W may indicate that these ponds are acting as semi-permanent water bodies and holding water for too long.

Site 3W

Ponds at Site 3W are surrounded by dense exotic grasses with some sedge or rush vegetation present within ponds and at pond edges. Canopy is predominately absent with some cover provided by adjacent native midstorey and canopy. The adjacent habitat to the west consists of a larger ephemeral pond within a swamp forest providing good habitat for Green-thighed Frogs. The canopy is predominately Paperbark species and the ground cover includes the presence of *Lomandra* spp.. Pond 4 was observed to be overflowing into the adjacent habitat during both Stage 1 and Stage 2 surveys.

Site 4

Site 4E ponds are situated on a ridgetop within a narrow strip of open forest that is bounded by the Pacific Highway and a wide easement. The forest vegetation immediately surrounding ponds provides some cover with a native midstorey and predominately grassy ground layer. Site 4W ponds are partially exposed with limited canopy cover, however vegetation growth has increased at the site and cover is provided by a native midstorey. Site 4E and 4W ponds are notably shallower than other sites and are not capable of holding water for 30 days, if at all.

3.3 Stage 2 - Determining the Success of the Breeding Event

Stage 2 surveys were undertaken on 31 March 2022 and 8 April 2022, 33 and 41 days after Stage 1 surveys. Surveys at Collombatti Reference Site and Site 4E were undertaken at a later date (41 days) due to access limitations associated with the extensive rainfall and flooding.

3.3.1 Active searches and dip-netting

A number of tadpoles were caught at the Collombatti reference site, Site 1 (E&W), Site 3W and Site 4W. All of the five ponds at Site 4 E were dry during Stage 2 surveys.

Tadpoles were identified as either Striped Marsh Frog, Whirring Tree Frog, *Mixophyes* spp. or *Crinia* spp. Unidentified specimens were not Green-thighed Frog tadpoles.

3.3.2 Predatory fish and invertebrates

Various predatory invertebrates were detected at Collombatti reference site, Sites 1 (E&W, 3 ponds), 3W (2 ponds) and 4W (pond 1). Predatory fish were detected in one pond at Site 1 (E&W), species included *Gambusia* (*Gambusia holbrooki*). Predator presence is summarised as follows:

- Site 1W: two of five ponds with at least one predator type
- Site 1E: one of five ponds with at least one predator type
- Site 3W: two of five ponds with predatory invertebrates
- Site 4W: one pond with predatory invertebrates, remaining ponds dry
- Site 4E: no predators detected (ponds dry).

3.3.3 Pond depth during Stage 2

Table 4 provides the Stage 1 and Stage 2 water levels, including the hydroperiod requirements according to Lewis (2013). According to Lewis (2013), ponds should have a maximum depth of 400 mm and hold water for between 30-40 days at sunny exposed sites or 50-60 days at shaded locations. The constructed ponds can be classed as both sunny exposed sites and shaded sites (see Table 4). Water should therefore be retained up to 40 days in exposed ponds or 60 days in shaded ponds. Stage 2 surveys were undertaken 33 and 41 days after Stage 1.

Water levels during Stage 2 surveys can be summarised as follows:

- Site 1W - all five constructed ponds held water (10-30 cm deep)
- Site 1E - all five constructed ponds held water (20-54 cm deep)
- Site 3W - all five constructed ponds held water (40-55 cm deep)
- Site 4W - all five constructed ponds held water (7-40 cm deep)
- Site 4E - all five constructed ponds were dry.

Minimum water retention period – 30 days

Stage 2 water depth was impacted by rainfall immediately prior to surveys. Port Macquarie Airport Weather Station recorded 77.8 mm of rainfall in the 24 hours prior to surveys. Despite this rainfall, all ponds at Site 4E were dry during Stage 2 surveys, therefore the assumption can be made that Site 4E ponds do not hold water for the minimum required 30 or 50 days (depending on sun exposure; Lewis (2013) and see Table 7). Site 4W all held water during Stage 2 surveys but given three ponds did not hold water during Stage 1, they were also considered to not hold water for the minimum required period. All Site 1 (E&W) and Site 3W ponds were considered to successfully retain water for the minimum required period (i.e. more than 30 days).

Maximum water retention period – 40-60 days

Given that Stage 2 surveys for successful ponds holding water for the minimum required period were undertaken 33 days after Stage 1 surveys and Lewis (2013) states a suitable hydroperiod of up to 40 days for exposed sites or up to 60 days for shaded sites, it is not possible to state if ponds held water beyond the

suggested hydroperiod. In addition, as water retention is dependent not only on pond permeability but on weather conditions and local rainfall, it is difficult to draw conclusions regarding the likelihood of ponds to dry within the recommended hydroperiod.

While assessment of water levels after Stage 2 was not possible due to survey limitations, it was considered likely that ponds with water levels of 30 cm or above during Stage 2 monitoring would have retained water for periods beyond 40 days, but this is difficult to estimate beyond 60 days (maximum hydroperiod prescribed by Lewis (2013)). Research has shown that an extended hydroperiod is unlikely to impact the breeding of this species, as long as the pond is ephemeral (Lemckert *et al.* 2006, and Lemckert *pers. comm.*). Therefore, water retention within ponds somewhat beyond the preferred hydroperiod is not considered as important to the survival of this species as the retention of water for periods long enough to allow for metamorphosis to occur.

Table 4: Monitoring results summary

Site	Hydroperiod (Lewis 2013)	Site condition	GTF	Other frog species	Pond	Stage 1 depth (cm)	Stage 2 depth (cm)	Minimum water retention period	Maximum water retention period
1W	Ponds to support water for up to 30-40 days	Sunny exposed ponds. Established vegetation surrounding ponds.		Common Eastern Froglet	1	30	26	Successful	Not available due to survey limitations
					2	10-20	30	Successful	Not available due to survey limitations
					3	10-20	21	Successful	Not available due to survey limitations
					4	20	10	Successful	Not available due to survey limitations
					5	20	21	Successful	Not available due to survey limitations
1E		Sunny ponds with vegetation immediately adjacent to east. Established vegetation immediately surrounding ponds.		Common Eastern Froglet	1	40	20	Successful	Not available due to survey limitations
					2	40	54	Successful	Not available due to survey limitations
					3	40	40	Successful	Not available due to survey limitations
					4	40	40	Successful	Not available due to survey limitations
					5	40	40	Successful	Not available due to survey limitations
3W	Ponds to support water for up to 30-60 days depending on whether the location is shaded or unshaded.	Sunny ponds with vegetation immediately adjacent to the west	Yes – in adjacent habitat	Striped Marsh Frog, Common Eastern Froglet, Dusky Toadlet, Tyler's Tree Frog, Eastern Dwarf Tree Frog	1	40-50	50	Successful	Not available due to survey limitations
					2	40-50	55	Successful	Not available due to survey limitations
					3	40-50	43	Successful	Not available due to survey limitations
					4	40-50	40	Successful	Not available due to survey limitations
					5	40-50	45	Successful	Not available due to survey limitations
4W	Ponds to support water for 30 days*	Partially shaded ponds with native midstorey, grassy groundcover and limited canopy cover.			1	0	22	Unsuccessful	Did not retain water
					2	0	15	Unsuccessful	Did not retain water
					3	0	7	Unsuccessful	Did not retain water
					4	15	35	Successful	Not available due to survey limitations
					5	25	40	Successful	Not available due to survey limitations
4E	Ponds to support water for 30 days*	Shaded ponds amongst surrounding open woodland. Little to no ground cover immediately surrounding ponds.			1	0	0	Unsuccessful	Did not retain water
					2	0	0	Unsuccessful	Did not retain water
					3	0	0	Unsuccessful	Did not retain water
					4	0	0	Unsuccessful	Did not retain water
					5	0	0	Unsuccessful	Did not retain water

* Ponds at sunny exposed sites should hold surface water for between 30-40 days, and between 50-60 days at shaded locations (Lewis 2013). Discussions with TfNSW concluded that Site 4 (E&W) ponds should be classified as shaded or only partly shaded. Metamorphosis may occur within 28 days (Lewis 2013) and field records show metamorphosis occurring at an exposed site within 40 days (Lemckert *et al.* 2006). As such, it is considered that ponds at Site 4 (E&W) should support water for 30-60 days to allow for a range of sunny and shaded locations, to provide enough time for metamorphosis to occur (in accordance with Table 3-1, Lewis 2013).

3.4 Cumulative Results

Summary results of monitoring events to date are provided in Table 5, with records of Green-thighed Frogs shaded in darker grey. To date, Green-thighed Frogs have not been detected at Site 1 (E&W) or Site 4 (E&W), while Site 3W has shown success in all four monitoring periods. Site 4 ponds are considered to have shown insufficient water retention in three monitoring periods. Water retention post-survey is difficult to determine due to the survey design, but is considered less important than detection of insufficient water retention, and is not included in the cumulative results.

Table 5: Cumulative monitoring results

Site (pond)	2016/2017			2017/2018			2019/2020			2021/2022		
	# GTF	#GTF TP	Pond WR	# GTF	#GTF TP	Pond WR	# GTF	#GTF TP	Pond WR	# GTF	#GTF TP	Pond WR
Ref	1	0	Y	0	0	Y	2, 3C	0	Y	0	0	Y
1W(1)	0	0	Y	0	0	Y	0	0	Y	0	0	Y
1W(2)	0	0	Y	0	0	Y	0	0	Y	0	0	Y
1W(3)	0	0	Y	0	0	Y	0	0	Y	0	0	Y
1W(4)	0	0	Y	0	0	Y	0	0	Y	0	0	Y
1W(5)	0	0	Y	0	0	Y	0	0	Y	0	0	Y
1E(1)	0	0	Y	0	0	Y	0	0	Y	0	0	Y
1E(2)	0	0	Y	0	0	Y	0	0	Y	0	0	Y
1E(3)	0	0	Y	0	0	Y	0	0	Y	0	0	Y
1E(4)	0	0	Y	0	0	Y	0	0	Y	0	0	Y
1E(5)	0	0	Y	0	0	Y	0	0	Y	0	0	Y
3W(1)	0	0	Y	C	0	Y	0	0	Y	0	0	Y
3W(2)	0	0	Y	1, C	1	Y	0	0	Y	0	0	Y
3W(3)	0	0	Y	C	0	Y	0	0	Y	1 (adjacent)	0	Y
3W(4)	1	0	Y	1, C	3	Y	1 (adjacent)	0	Y	0	0	Y
3W(5)	1	0	Y	C	0	TS	0	0	Y	0	0	Y
4W(1)	0	0	TS	0	0	TS	0	0	TS	0	0	TS
4W(2)	0	0	TS	0	0	TS	0	0	TS	0	0	TS
4W(3)	0	0	TS	0	0	TS	0	0	TS	0	0	TS
4W(4)	0	0	TS	0	0	TS	0	0	TS	0	0	Y
4W(5)	0	0	TS	0	0	TS	0	0	TS	0	0	Y
4E(1)	0	0	TS	0	0	TS	0	0	TS	0	0	TS
4E(2)	0	0	TS	0	0	TS	0	0	TS	0	0	TS
4E(3)	0	0	TS	0	0	TS	0	0	TS	0	0	TS
4E(4)	0	0	TS	0	0	TS	0	0	TS	0	0	TS
4E(5)	0	0	TS	0	0	TS	0	0	TS	0	0	TS

C = heard calling in vicinity of pond; #GTF TP = number of Green-thighed Frog tadpoles; Pond WR = minimum water retention period met; Y = Yes; TS = water not retained for the minimum period.

3.5 Consideration of Adjacent Habitat and Pond Location

Given the lack of records of Green-thighed Frogs at the constructed breeding ponds to date, habitat immediately adjacent to the constructed ponds was inspected for its suitability as Green-thighed Frog breeding habitat and a brief review of the location of the constructed ponds with regard to the baseline records was undertaken (Niche 2020). Table 6 provides details of monitoring sites and baseline survey information. It should be noted that the two areas where Green-thighed Frogs have not been detected (Sites 1 and 4) were heavily impacted by habitat removal during construction. The species persists at Site 3 where direct impacts did not occur.

To date, Green-thighed Frogs have been observed at the constructed ponds only at Site 3W and tadpoles have been found within the constructed ponds. This would indicate that where a population of Green-thighed Frogs persists, the ponds may provide breeding habitat, where the pond conditions are suitable. The remaining sites therefore may either not be in proximity to a population and/or may not provide suitable breeding conditions. It is considered likely that Site 1W and Site 4(E&W) ponds are not located in an area (or are separated from by a road) that would support a population of Green-thighed Frogs and are therefore unlikely to be used for breeding. Site 1E lies adjacent to potential habitat, however Green-thighed Frogs have not been detected at or adjacent to Site 1E to date during the monitoring.

3.6 Incidental records 2020/2021

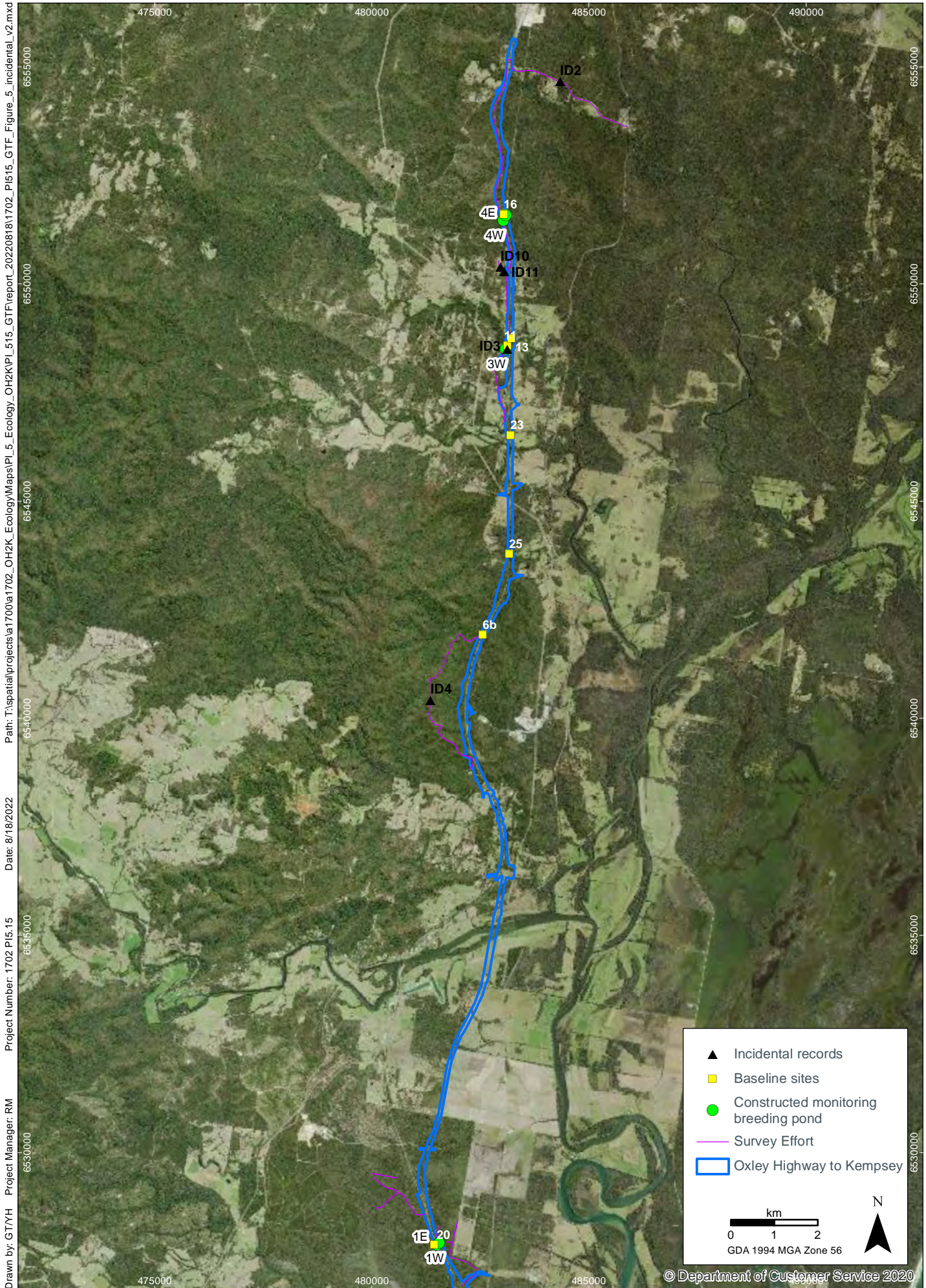
After substantial rainfall in December 2020, TfNSW completed incidental surveys of accessible tracks and trails in proximity to the Project area. Green-thighed Frogs were identified calling from a number of locations, shown in Figure 5. These records are summarised as follows:

- ID2: calling from wheel ruts along Kemps Road (1000 m from Project)
- ID3: 5-10 calling from the edge of the Site 3W pond in exposed areas and from within the Setaria
- ID4: <5 calling from one small forestry dam high on a ridge top (650 m from Project)
- ID10: calling from flooded area in paddock away from the road (150 m from Project)
- ID11: individual crossing road (49 m from Project).

These records demonstrate ongoing presence at a number of locations in proximity to the Pacific Highway.

Table 6: Adjacent habitat and constructed pond location review

Site (map ID)	Proposed frog pond sites (EMP)	Baseline site	Baseline location details	Baseline notes (Lewis 2013)	Location comment	Adjacent habitat comment
1 (E&W)	Five ponds each side of the carriageway	20	Blackmans Point Road	> 3 males calling on western side of highway. Another 2-3 males calling 300 m north on the eastern side of highway.	<p>Ponds constructed as per Lewis (2013). East and west ponds are located at the chainage point where the species was identified of the western side of carriageway. The species was detected 300 m further north on the eastern side.</p> <p>The western ponds are isolated in a strip of vegetation between the Pacific Highway and Telegraph Road.</p> <p>Extensive works occurred in this location in association with the Blackmans Point Road Interchange.</p>	<p>1W: ponds are located within a linear strip of disturbed grassy habitat sitting between Telegraph Point Road and the Pacific Highway, which is unlikely to represent suitable breeding habitat. The western side of Telegraph Point Road is predominantly woodland, which may support areas of suitable breeding habitat.</p> <p>1E: ponds are located in a low lying densely vegetated wet area, which may represent suitable breeding habitat. The adjacent vegetation is a densely vegetated swamp forest, and may support suitable breeding habitat.</p>
3W	Five ponds on the western side of the carriageway	11	South west side of Pipers Creek	<p>No tadpoles, metamorphs or juvenile frogs recorded. Some small pools of water to 30 mm with tadpoles of other species seeking refuge in leaf litter.</p> <p>Males chorusing in regrowth Acacia vegetation around 30-40 m west of existing highway.</p>	<p>Ponds constructed as per Lewis (2013). Ponds directly adjoin adjacent suitable habitat to the west.</p> <p>This area was not directly impacted by the Project.</p>	<p>Ponds are located immediately adjacent to a swamp sclerophyll forest, which represents suitable breeding habitat. Green-thighed Frogs have been consistently recorded in this area.</p>
4 (E&W)	Five ponds on each side of the carriageway	16	South east of Bloodwood Rest Area on top of cut within existing powerline easement	<p>No tadpoles, metamorphs or juvenile frogs recorded. Main pools occur on the access track running east across the powerline easement.</p>	<p>Ponds constructed as per Lewis (2013). Eastern ponds are located within isolated vegetation between the Pacific Highway and an access track constructed to access the power easement.</p> <p>The section of the easement where the species was identified was directly impacted by the Project and is no longer present.</p>	<p>4W: ponds are located on a north-south slope within a linear strip of woodland habitat sitting between Ravenswood Road and the Pacific Highway, which is unlikely to represent suitable breeding habitat. The western side of Ravenswood Road drops off into a gully with some sclerophyll vegetation, which may represent suitable breeding habitat.</p> <p>4E: ponds are located on a hill crest within a linear strip of vegetation between the Pacific Highway and an access track, which is unlikely to represent suitable breeding habitat.</p>



Drawn by: GT/YH Project Manager: RM
 Project Number: 1702.P15.15 Date: 8/18/2022
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Incidental records

Pacific Highway Upgrade - Oxley highway to Kempsey

FIGURE 5

Imagery: (c) LPI 2014-10-06



4. Discussion

A discussion of the 2021/2022 monitoring results in relation to the performance measures detailed in the EMP and the Green-thighed Frog management Strategy (Lewis 2013) is provided in Table 7 and Table 8.

Table 7: Performance indicators of success

Performance indicators of success	Discussion
Continued presence of Green-thighed Frog at two or more of the three breeding pond sites.	This performance measure has not been met. An individual Green-thighed Frog was identified in adjacent habitat at only one (Site 3W) of the three breeding pond sites.
Green-thighed Frogs calling from the edge of the constructed ponds.	This performance measure has been met for one of the three sites. An individual Green-thighed Frog was observed at Site 3W only and the species has been consistently recorded in the vicinity of this site in each monitoring period.
The presence of tadpoles, juveniles or metamorphs at the frog breeding ponds during Stage 2 surveys.	This performance measure has not been met. No Green-thighed Frog tadpoles were caught during the 2021/2022 surveys.

Table 8: Signs of the mitigation being unsuccessful

Performance indicators of unsuccessful mitigation	Discussion
Absence of Green-thighed Frogs from one or more of the three sites (GThF MS). Absence of Green-thighed Frogs from the area (EMP).	This performance indicator of unsuccessful mitigation has been met. Green-thighed Frogs were not recorded at two (Site 1 and Site 4) of the three breeding pond sites or within the broader area of these sites.
Ponds not holding water for a sufficient time to enable tadpoles to reach metamorphosis.	This performance indicator of unsuccessful mitigation has been met for 8 of the 25 constructed ponds. According to Lewis (2013), ponds should have a maximum depth of 400 mm and hold water for between 30-40 days at sunny exposed sites or 50-60 days at shaded locations. Water should therefore be retained for at least 30 days and up to 60 days in these ponds. Stage 2 surveys were undertaken 33 and 41 days after Stage 1. All ponds at Site 1 and Site 3 contained water during Stage 1 and Stage 2 surveys, i.e. they held water long enough for breeding cycles to occur as per Lewis (2013). This performance indicator of unsuccessful mitigation has therefore not been met for these sites. During Stage 1 surveys Site 4W and 4E ponds were found to be dry except for two ponds at Site 4W holding 15-25 cm of water. However, all ponds at Site 4W were holding during Stage 2 surveys due to significant rainfall between the two monitoring event notably immediately prior to Stage 2 surveys. It is therefore considered that eight of the 10 ponds did not hold water for the minimum required 30 or 50 days (depending on sun exposure; Lewis (2013)). This performance indicator of unsuccessful mitigation has therefore been met for these 8 ponds.
Ponds holding water for too long and representing unsuitable habitat (i.e. permanent versus ephemeral).	This performance indicator of unsuccessful mitigation cannot be assessed due to survey limitations. Given that Stage 2 surveys were undertaken 33 days after Stage 1 surveys for Sites 1, 3W and 4W and Lewis (2013) states a suitable hydroperiod of up to 40 days for exposed sites or up to 60 days for shaded sites, it is not possible to state if ponds have held water beyond the suggested hydroperiod. However, water retention within ponds somewhat beyond the preferred hydroperiod is not considered as important to the survival of this species as the retention of water for long enough to allow for metamorphosis to occur.

Performance indicators of unsuccessful mitigation	Discussion
Exotic fish fauna recorded in breeding ponds (GThF MS).	This performance indicator of unsuccessful mitigation has been met at Site 1E. Exotic fish were recorded in constructed pond 2 at Site 1E for the 2021/2022 monitoring period. Other predatory invertebrates were recorded in a number of ponds.

GThF MS = Green-thighed Frog Management Strategy (Lewis 2013); EMP = Ecological Monitoring Program (TfNSW 2022).

5. Recommendations

5.1 Contingency Measures

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those considered relevant to the Green-thighed Frog monitoring program are listed and discussed in Table 9.

Table 9: Contingency measures

Potential problem	Contingency measure proposed in EMP	Discussion of proposed measure
Ponds not used by Green-thighed frog.	Survey adjacent areas to confirm frogs remain in area. Review/modify ponds to improve potential site suitability problems.	Green-thighed Frogs have not been recorded at Site 1 (E&W) or Site 4 (E&W) during any surveys. This contingency measure is considered relevant.
Ponds not holding water long enough to enable breeding to succeed.	Review/modify ponds either by placing a semi permeable layer or further excavation.	A number of ponds were dry at Stage 1 surveys, as per Table 8. This contingency measure is considered relevant.
Ponds holding water for too long encouraging competition from non-target frog fauna.	Improve drainage.	Site 1 E&W has at least three ponds with bulrushes and one with exotic fish, which may indicate they are holding water for too long. This contingency measure is considered relevant.
Exotic fish species recorded in breeding ponds.	Modify pond to ensure it dries out.	Exotic fish were observed in pond 2 at Site 1E. This contingency measure is considered relevant.

5.2 Recommendations

Recommendations in Table 10 below are provided to address the proposed contingency measures identified in the EMP and corrective actions provided in the Green-thighed Frog Management Strategy.

Following previous recommendations, works to improve water retention of the ponds at Site 4 (E&W) were undertaken in 2017 and 2018 (Niche 2020). Successive works to decrease the permeability of the material forming the ponds proved unsuccessful. Similar works were also undertaken at Site 4W.

Table 10: Signs of the mitigation being unsuccessful and corrective actions

Performance indicators of unsuccessful mitigation	Action described in GThF MS	Note	Recommendations developed in consultation with and endorsed by TfNSW and EPA.
Absence of Green-thighed Frogs from one or more of the four sites (GThF MS) Absence of Green-thighed Frogs from the area (EMP).	The corrective action for this would be to firstly, implement additional surveys of adjacent areas to confirm Green-thighed Frogs remain in that general area, and secondly,	Applies to: Site 1 (E&W) and Site 4 (E&W)	Compensatory habitat for the Green-thighed Frog has been provided for within the offset strategy for the Project. Offset areas were assessed and considered to provide suitable habitat for this species. As such, the intent of the constructed frog ponds was not to provide compensation for lost habitat but to provide artificial habitat to act as an experimental mitigation for this species (Parsons Brinckerhoff 2006): "A suggested mitigation measure to account for the loss of potential breeding habitat is the creation of artificial breeding ponds adjacent to the new road. Such breeding ponds have not been constructed or trialled previously. Although such ponds have been suggested on other sections of the Pacific Highway where the species occurs, they have not as yet been constructed or trialled. As such the

Performance indicators of unsuccessful mitigation	Action described in GThF MS	Note	Recommendations developed in consultation with and endorsed by TfNSW and EPA.
	undertake a review and if deemed necessary modify the ponds to improve any site suitability problems.		<p>creation of frog breeding ponds should be considered experimental.” (Parsons Brinckerhoff 2007).</p> <p>Given the lack of success of constructed ponds to date a number of tasks were completed. The following actions have been undertaken:</p> <ul style="list-style-type: none"> TfNSW have undertaken works to improve ponds at site 4E on at least three separate occasions using four different approaches, however ponds still do not hold water for the required period.
Ponds not holding water for a sufficient time to enable tadpoles to reach metamorphosis.	The corrective action for this would involve a review and if deemed necessary, modify the ponds by placing a semi permeable layer or further excavation.	Applies to: all ponds at Site 4E and Site 4W.	<ul style="list-style-type: none"> A review of background and baseline data was undertaken to gain a better understanding of the baseline survey areas and observations. Baseline data and review of satellite imagery has been used to inform the key areas for extended surveys (where property access is possible) to demonstrate ongoing presence/existing natural breeding sites in proximity to the Project. Reconnaissance surveys have been completed to ground truth aerial data/mark access tracks and waypoint locations that are considered to contain suitable habitat. Photos/waypoints regarding habitat suitability of the peripheral (accessible) habitat were taken and limitations of the search area have been determined.
Ponds holding water for too long and representing unsuitable habitat (i.e. permanent versus ephemeral).	The corrective action for this would be to improve drainage to ensure the pond dries out.	Cannot be accurately assessed due to survey limitations.	<ul style="list-style-type: none"> An incidental survey after a trigger rainfall was completed in December 2020 by TfNSW within areas identified as key areas for extended surveys, the results of which are included in this report. Additional information regarding the suitability of habitat adjacent to constructed ponds has been gathered and included in this report. <p>Given the ongoing and unchanging lack of success of the constructed ponds and the demonstration of ongoing persistence of the species in proximity to the Pacific Highway, it is recommended that:</p> <ul style="list-style-type: none"> No further amelioration works be completed on the unsuccessful ponds. Extended surveys in habitat adjacent to the ponds be completed, as previously agreed and described in Niche (2020).

GThF MS = Green-thighed Frog Management Strategy (Lewis 2013); EMP = Ecological Monitoring Program (RMS 2016)

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Annex 1. 2021/2022 monitoring results

Stage 1 field data

Site	Pond	Date	Time	Water depth (cm)	GTF observed from pond	GTF calling from pond	GTF observed 10-100 m from pond	GTF calling 10-100 m from pond	Comments/other species	Air temp (°C)	Humidity	Wind	Cloud cover %
Collombatti Ref site		25/02/2022	20:15	55	0	0	0	0	Striped March Frog, Great Barred Frog, Eastern Dwarf Tree Frog	25	91	0	100
1 W	1	25/02/2022	23:20	30	0	0	0	0		24	88	0	100
	2			10-20	0	0	0	0					
	3			10-20	0	0	0	0					
	4			20	0	0	0	0					
	5			20	0	0	0	0					
1 E	1	25/02/2022	23:40	40	0	0	0	0	Striped Marsh Frog, <i>Crinia signifera</i>	24	88	0	100
	2			40	0	0	0	0					
	3			40	0	0	0	0					
	4			40	0	0	0	0					
	5			40	0	0	0	0					
3 W	1	25/02/2022	22:13	40-50	0	0	0	0	Striped Marsh Frog, <i>Crinia signifera</i>	22	96	0	100
	2			40-50	0	0	0	0					
	3			40-50	0	0	1	0					
	4			40-50	0	0	0	0					
	5			40-50	0	0	0	0					
4 W	1	25/02/2022	22:52	0	0	0	0	0		22	100	0	100
	2			0	0	0	0	0					
	3			0	0	0	0	0					
	4			15	0	0	0	0					

Site	Pond	Date	Time	Water depth (cm)	GTF observed from pond	GTF calling from pond	GTF observed 10-100 m from pond	GTF calling 10-100 m from pond	Comments/other species	Air temp (°C)	Humidity	Wind	Cloud cover %
	5			25	0	0	0	0					
4 E	1	25/02/2022	21:50	0	0	0	0	0		22	96	0	100
	2			0	0	0	0	0					
	3			0	0	0	0	0					
	4			0	0	0	0	0					
	5			0	0	0	0	0					















Stage 2 field data


Site	Pond	Depth (cm)	No. GTF (juv)	No. of tadpoles	Tadpoles identified	Presence of Fish	Predatory Invertebrates	Comments
Ref	Collombatti	40	0	15	Crinia sp., Mixophyes spp.	Y	Y	
1W	1	30	0	0		N	Y	Nymph
	2	21	0	0		N	N	
	3	10	0	10	Striped March Frog	N	Y	Nymph
	4	21	0	3	Striped March Frog	N	N	
	5	20	0	1	Striped March Frog	N	N	Bulrush in pond (typha)
1E	1	54	0	0		N	N	Bulrush in pond (typha)
	2	40	0	0		Y	N	Gambusia
	3	40	0	2	Striped March Frog	N	N	Bulrush in pond (typha)
	4	40	0	0		N	N	More open
	5	50	0	2	Unidentified	N	N	Dense juncus sp.
3W	1	55	0	1	Striped March Frog	N	N	
	2	43	0	0		N	N	
	3	40	0	0		N	N	
	4	45	0	5	Striped March Frog, Crinia sp., Litoria sp.	N	Y	Likely presence of Lomandra spp. within the ground layer. potentially also <i>Litoria tyleri</i> or <i>L. peronii</i>
	5	22	0	6	Striped Marsh Frog	N	Y	
4W	1	15	0	5	Crinia sp.	N	Y	
	2	7	0	0		N	N	
	3	35	0	0		N	N	Open canopy
	4	40	0	0		N	N	Open canopy
	5	26	0	0		N	N	Open canopy
4E	1	0	0	0		NA	NA	
	2	0	0	0		NA	NA	
	3	0	0	0		NA	NA	

Site	Pond	Depth (cm)	No. GTF (juv)	No. of tadpoles	Tadpoles identified	Presence of Fish	Predatory Invertebrates	Comments
	4	0	0	0		NA	NA	
	5	0	0	0		NA	NA	

Annex 2. Photo monitoring

Individual pond photos

Site	Pond 1	Pond 2	Pond 3	Pond 4	Pond 5
1W 2017					
1W 2018					
1W 2020					

<p>1W 2022</p>					
<p>1E 2017</p>					
<p>1E 2018</p>					

1E
2020



1E
2022



3W
2017



3W
2018



3W
2020



3W
2022



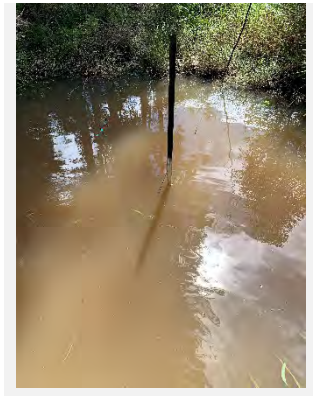
<p>4E 2017</p>		<p>*</p>	<p>*</p>	<p>*</p>	<p>*</p>
<p>4E 2018</p>					
<p>4E 2020</p>					

<p>4E 2022</p>					
<p>4W 2017</p>				<p>*</p>	<p>*</p>
<p>4W 2018</p>					

4W
2020



4W
2022



NA = not applicable, * group pond photos provided in Table 14.

Site photos

Site ID	Summer 2017	2018	2020	2022
Collombati Reference				
Site 1W				

Site 1E



Site 3W



Site 4W



Site 4E



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