



Giant Barred Frog Monitoring 2022/2023

Oxley Highway to Kempsey, Pacific Highway Upgrade

Prepared for Transport for NSW

May 2023

Document control

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

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

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Cover photograph: Giant Barred Frog

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Executive summary

Context

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

Aims

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

Methods

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

Key results

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

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

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

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

Conclusions

Performance measures relating to undertaking monitoring have been met.

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

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

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

Management implications

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

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

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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): Niche 2022
 - *Spring 2022, summer and autumn 2023* (Year 8): Current report.

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

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

1.1.3 Baseline data

The EMP specifies the following regarding the Giant Barred Frog:

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

The EMP lists six sites to be monitored:

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

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

1.1.4 Purpose of this report

The purpose of this report is to summarise the methods and results of the 2022/2023 monitoring and determine if performance measures are being met, as per the EMP.

1.2 Performance Measures

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

- *Monitoring is undertaken during baseline surveys and Years 1 – 8 or until monitoring can demonstrate that mitigation measures are effective.*
- *Monitoring during Years 1 – 8 is undertaken at the Impact and Control sites where baseline monitoring was undertaken, subject to landowner agreement.*
- *Continued presence of Giant Barred Frogs during each survey event in Years 1 – 8 at sites where it was identified during baseline surveys, subject to access due to landowner agreement.*
- *Mitigation measures are effective as defined in the EPBC approval when all monitoring events are considered at Year 8.*
- *Median values of all downstream water quality monitoring at GBF habitat or potential habitat locations during construction and operation (Year 1 – 6) is less than the 80th percentile value of the upstream site (where 80th percentile is the value at which median values at the downstream site are above 80% of the recorded background water quality records), where this change is found to be attributable to construction or operation.*

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

1.3 Monitoring Timing

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

1.4 Reporting

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

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

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

1.5 Limitations

The following limitations to the monitoring procedure were encountered:

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

2. Methodology

2.1 Monitoring Sites

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

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

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

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

2.2 Giant Barred Frog Survey Method

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

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

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

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

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

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

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

2.3 Water Quality

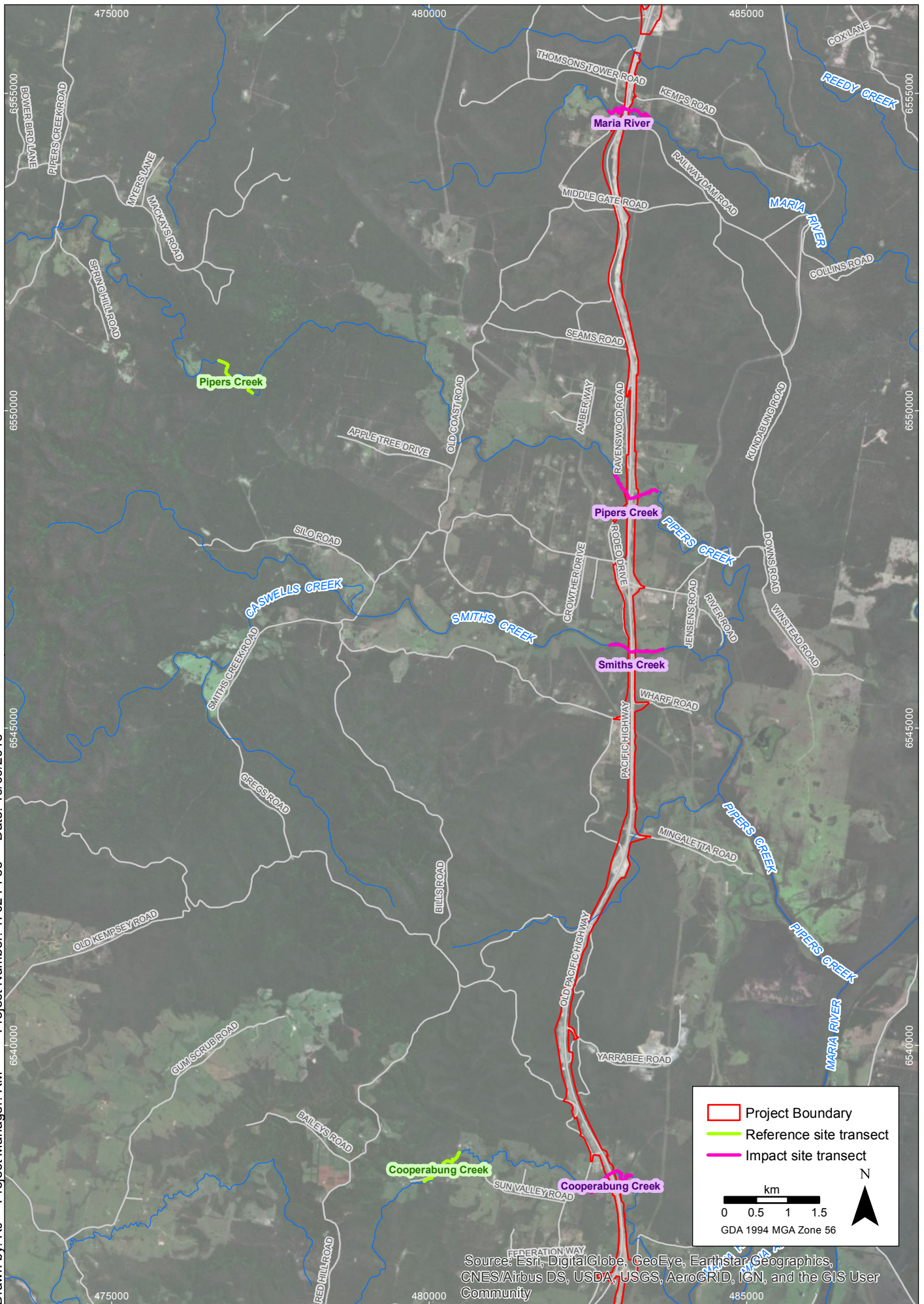
Water quality monitoring was not undertaken during the 2022/2023 monitoring period. The final operational water quality monitoring period and associated report was completed in 2021 (TfNSW 2021). A summary of the water quality data extracted from TfNSW (2021) from both upstream and downstream sites for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

2.4 Analysis

For 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

FIGURE 2

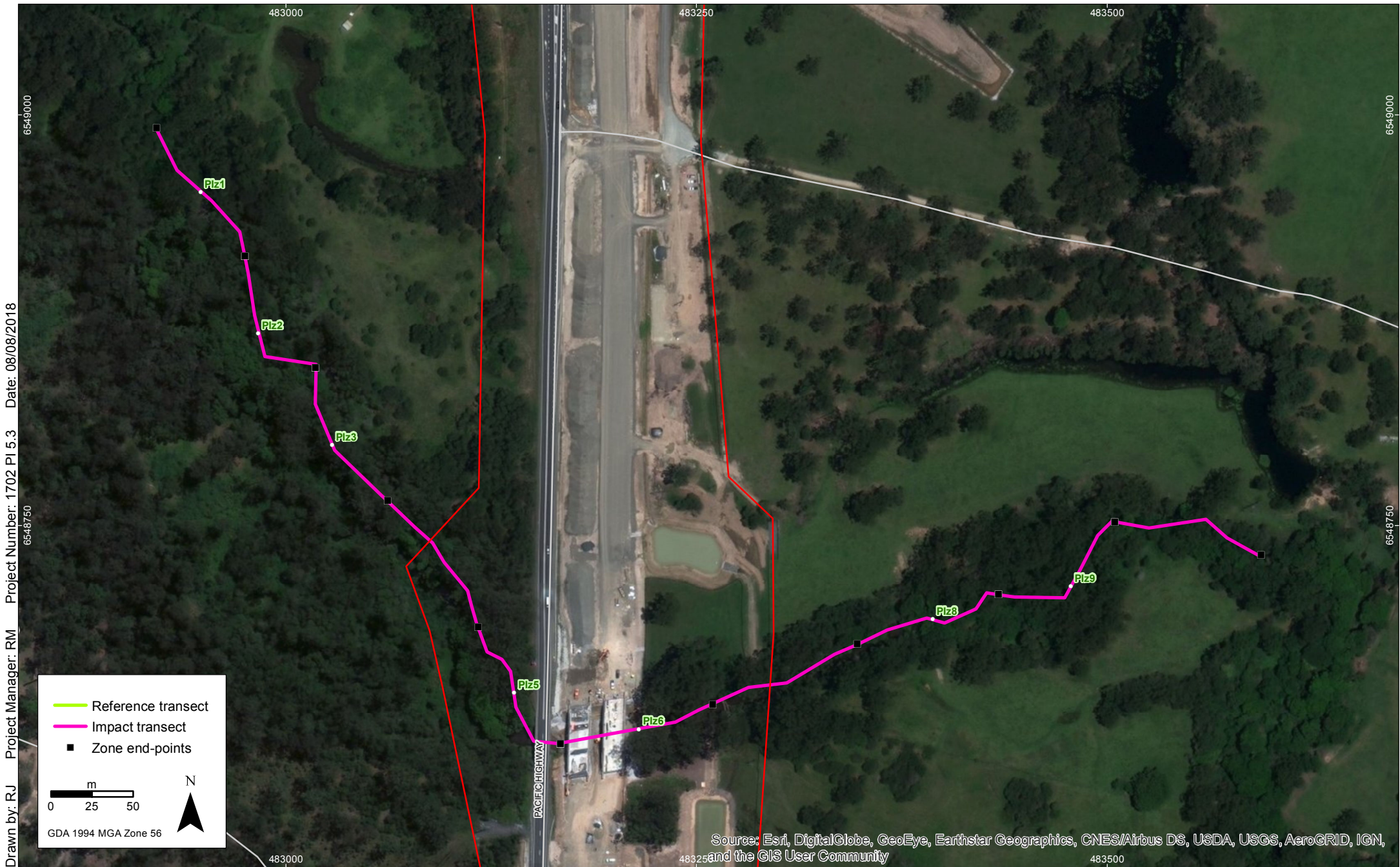
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Giant Barred Frog monitoring: Smiths Creek impact site
 Pacific Highway Upgrade - Oxley Highway to Kempsey

FIGURE 3

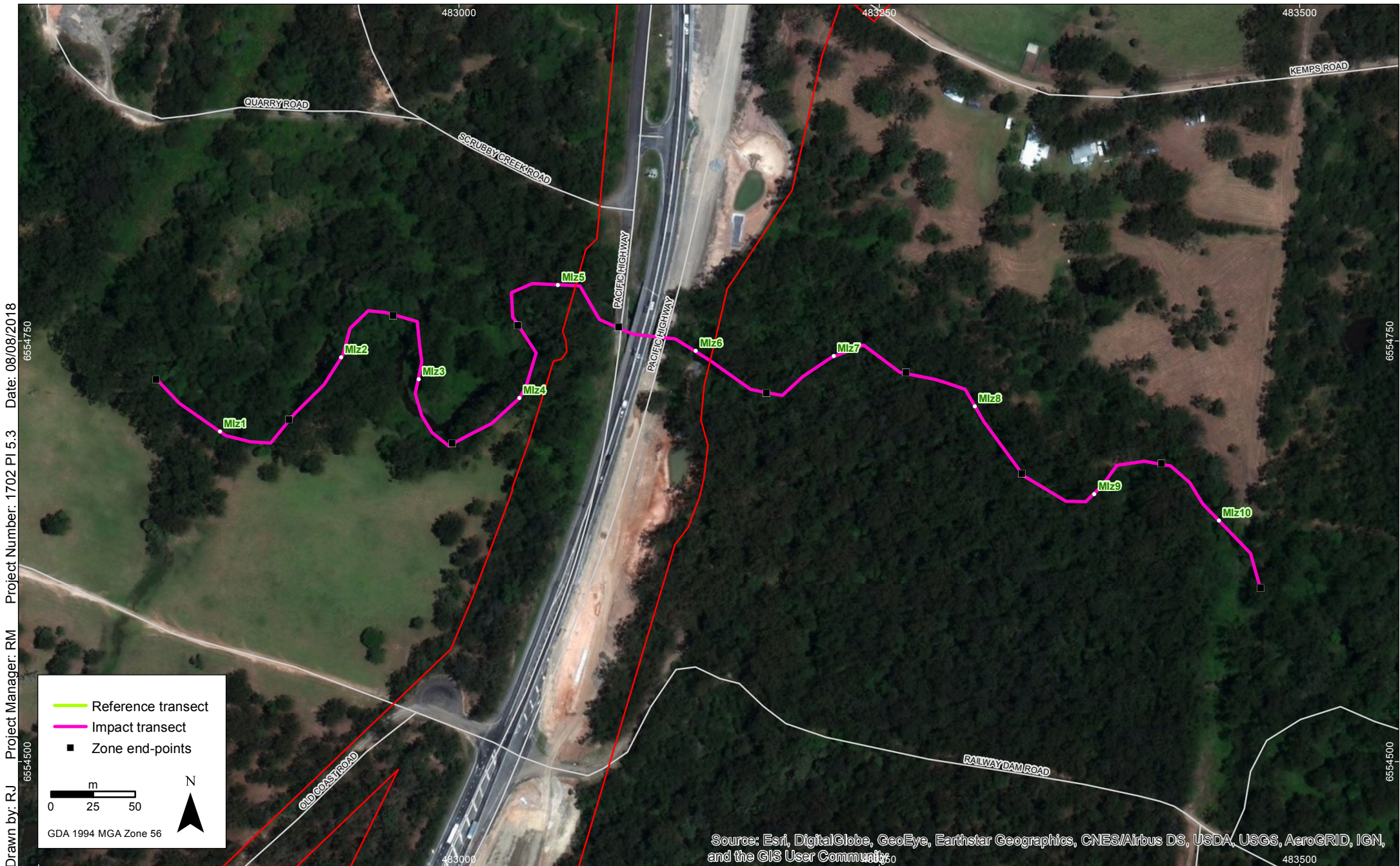
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Giant Barred Frog monitoring: Pipers Creek impact site
 Pacific Highway Upgrade - Oxley Highway to Kempsey

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



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

3. Results

3.1 2022/2023 Giant Barred Frog Monitoring Results

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

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

3.1.1 Survey results

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

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

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

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

3.1.2 Evidence of breeding

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

Table 2: Breeding evidence records 2022/2023

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

3.1.3 Weather conditions

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

Table 3: Weather conditions: 2022/2023 surveys

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

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

3.1.4 Habitat use

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

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

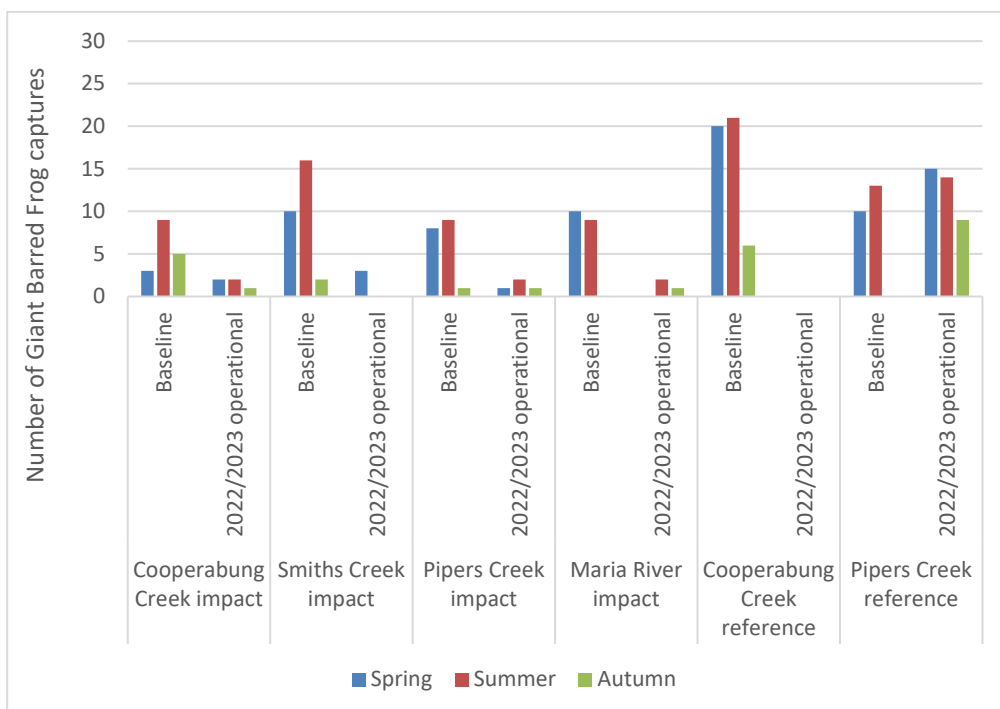
3.2 Comparison with Previous Surveys

3.2.1 Baseline and 2022/2023 surveys

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

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

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



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

3.2.2 Annual mean records

The mean number of records each year for each site is shown in Graph 2. All sites have demonstrated a general decreasing trend in the average number of captures at each 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 in the last two monitoring years after not being detected for two consecutive years (2019/2020 and 2020/2021). Frogs were again not detected at Cooperabung Creek reference site and have not been detected there since summer 2020.

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

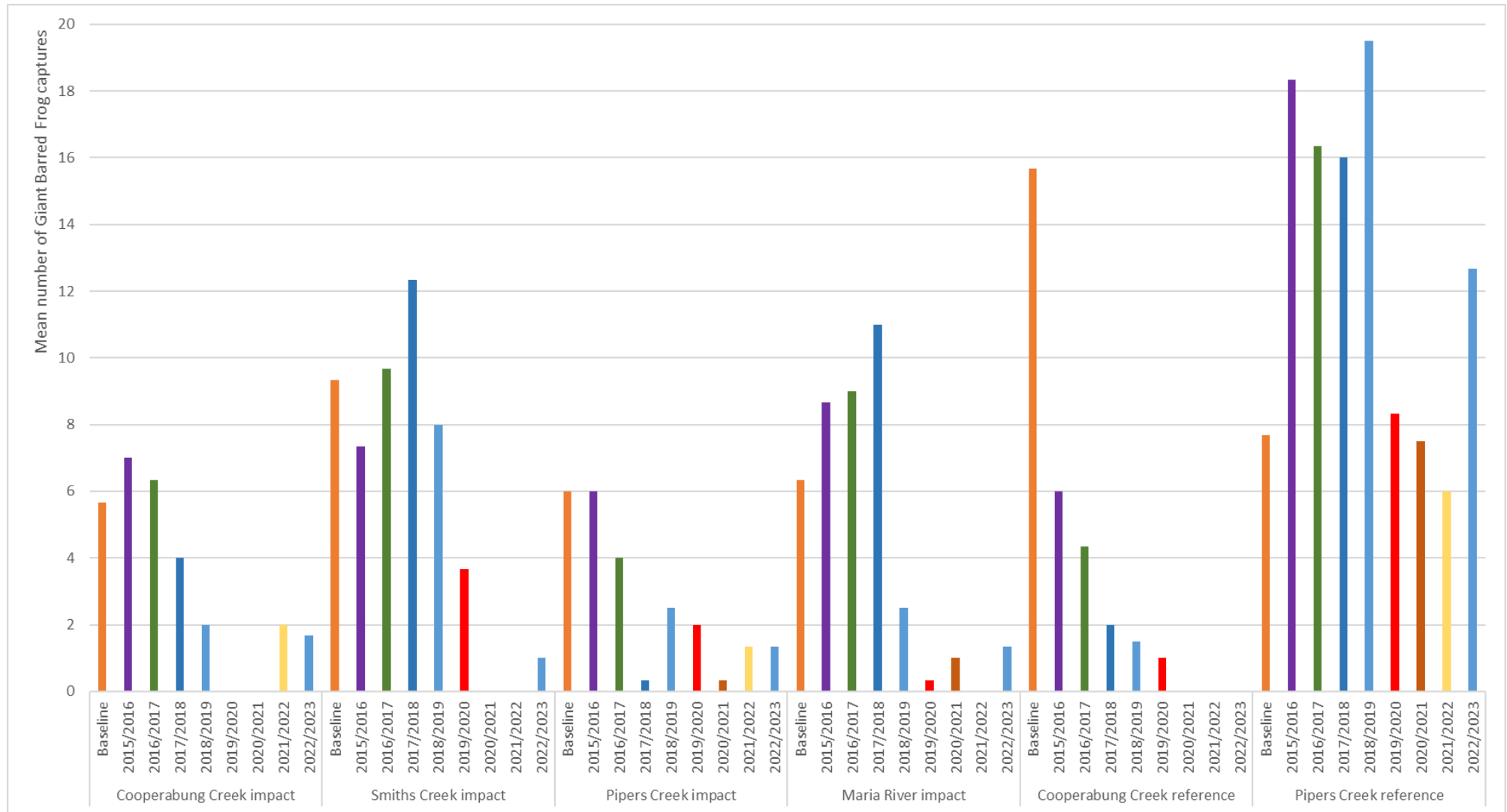
The mean number of Giant Barred Frogs recorded at Pipers Creek reference site increased substantially above baseline during the 2015/2016 monitoring period, where it remained stable, until decreasing back to baseline levels in 2019/2020 and subsequently below baseline in 2020/2021 and 2021/2022 monitoring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

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

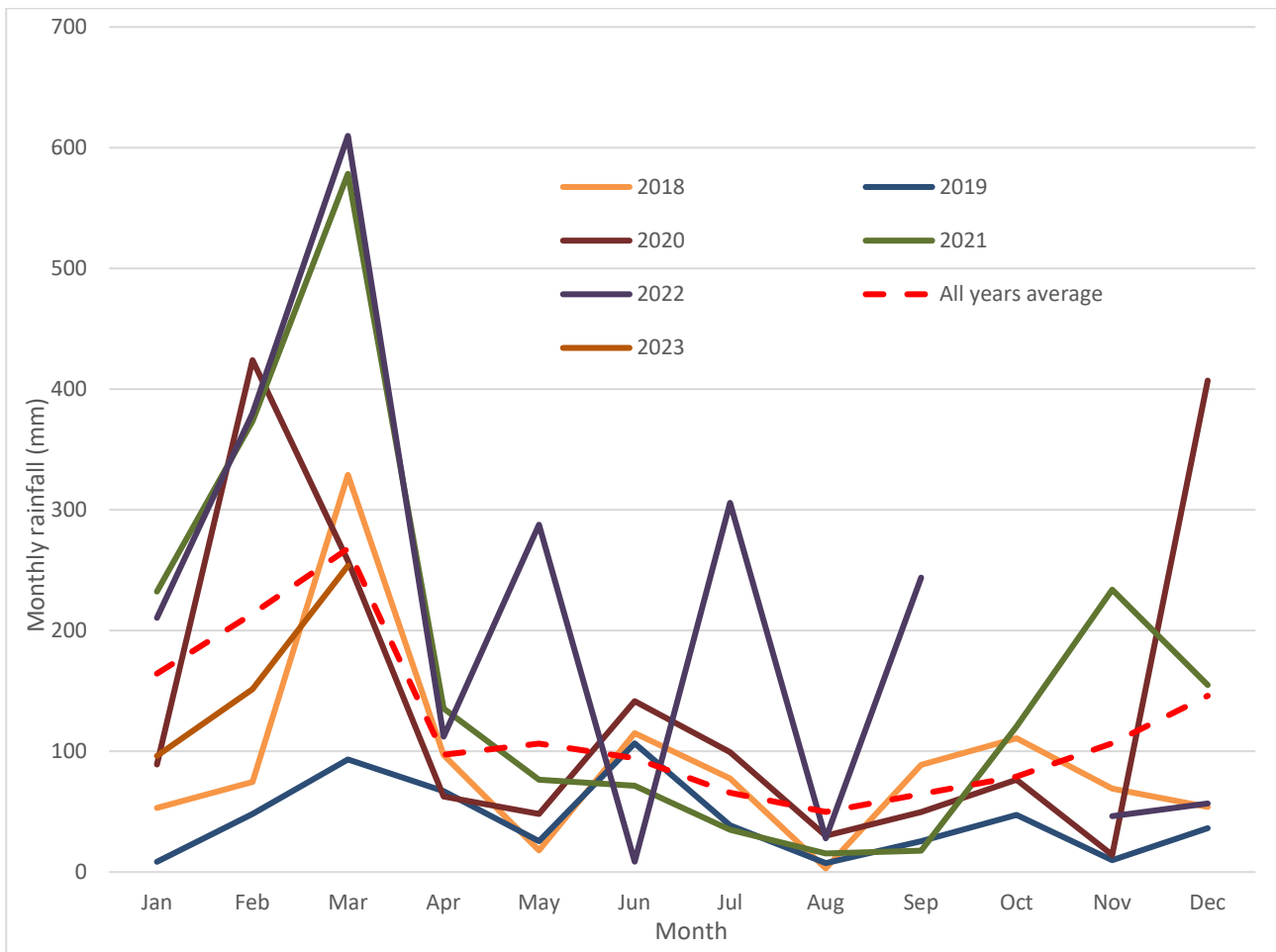
The mean number of Giant Barred Frogs recorded during the current monitoring period increased from the previous monitoring event at three of the six sites, Smiths Creek impact, Maria River impact and Pipers Creek reference. The remaining three sites decreased or remained the same. Mean records at all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

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

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



Graph 2: Mean annual Giant Barred Frog records by site



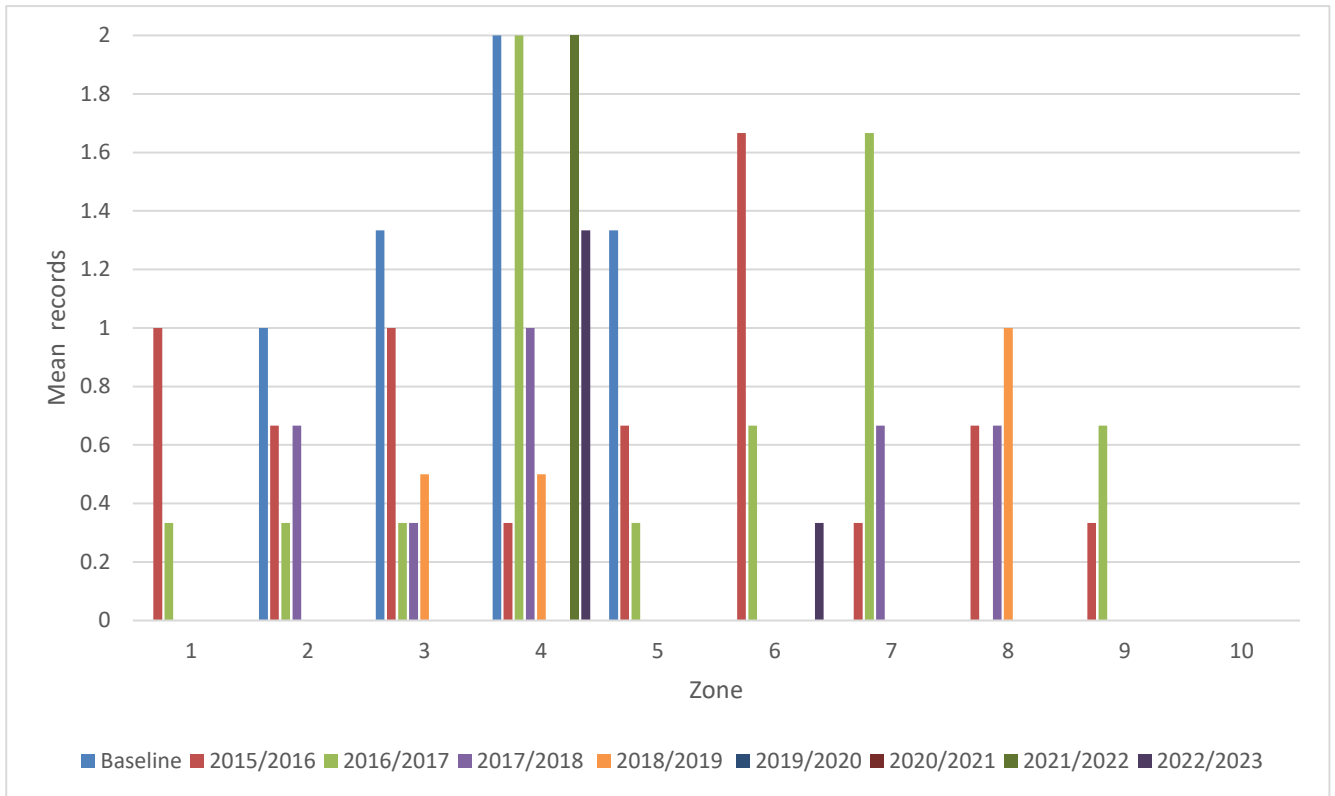
Graph 3: Monthly rainfall – All years monthly average and 2018-2023 monthly total rainfall

3.3 Density and Distribution

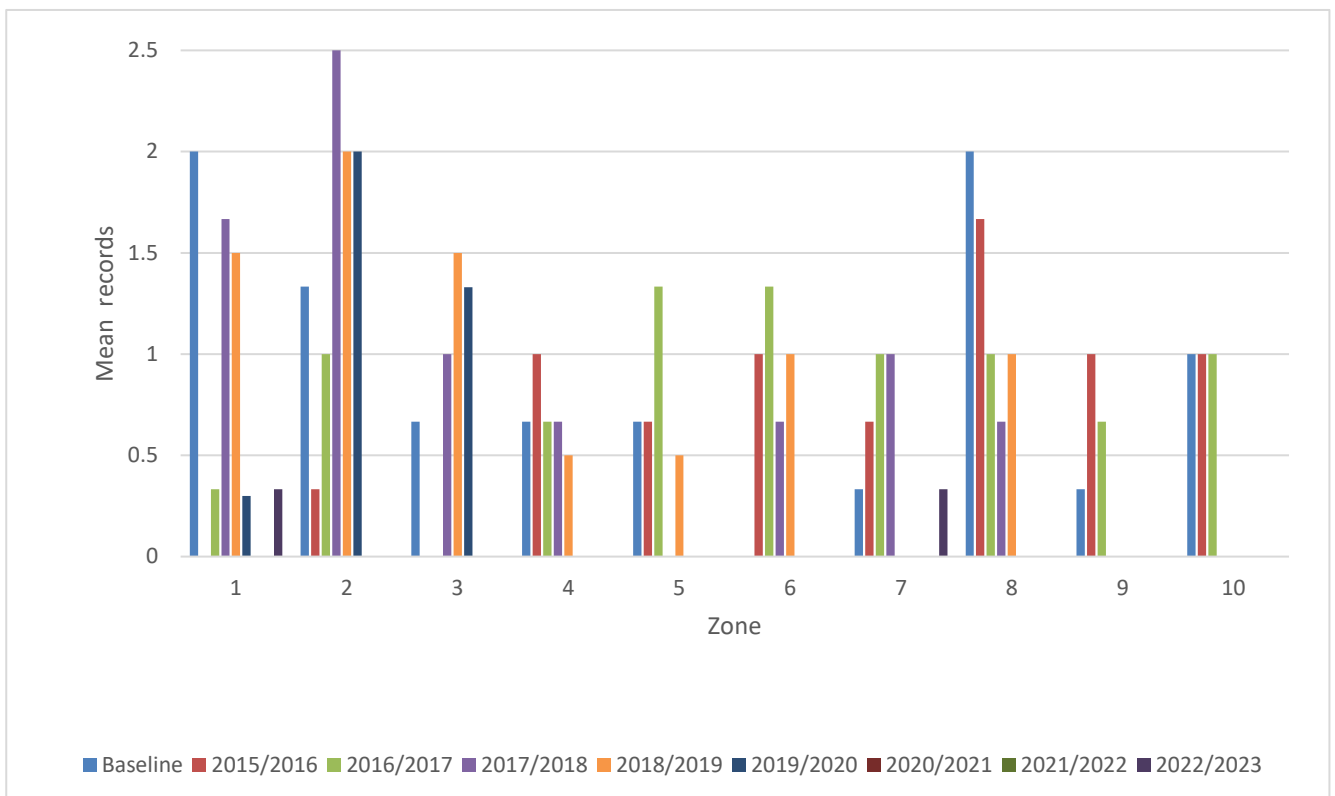
Graph 4 - Graph 9 present the density (*annual mean number of Giant Barred Frog records per zone*) and distribution of Giant Barred Frog records along the survey transect for each site and each monitoring period. Figure 8 - Figure 13 show the total number of captures within each zone over all monitoring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

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

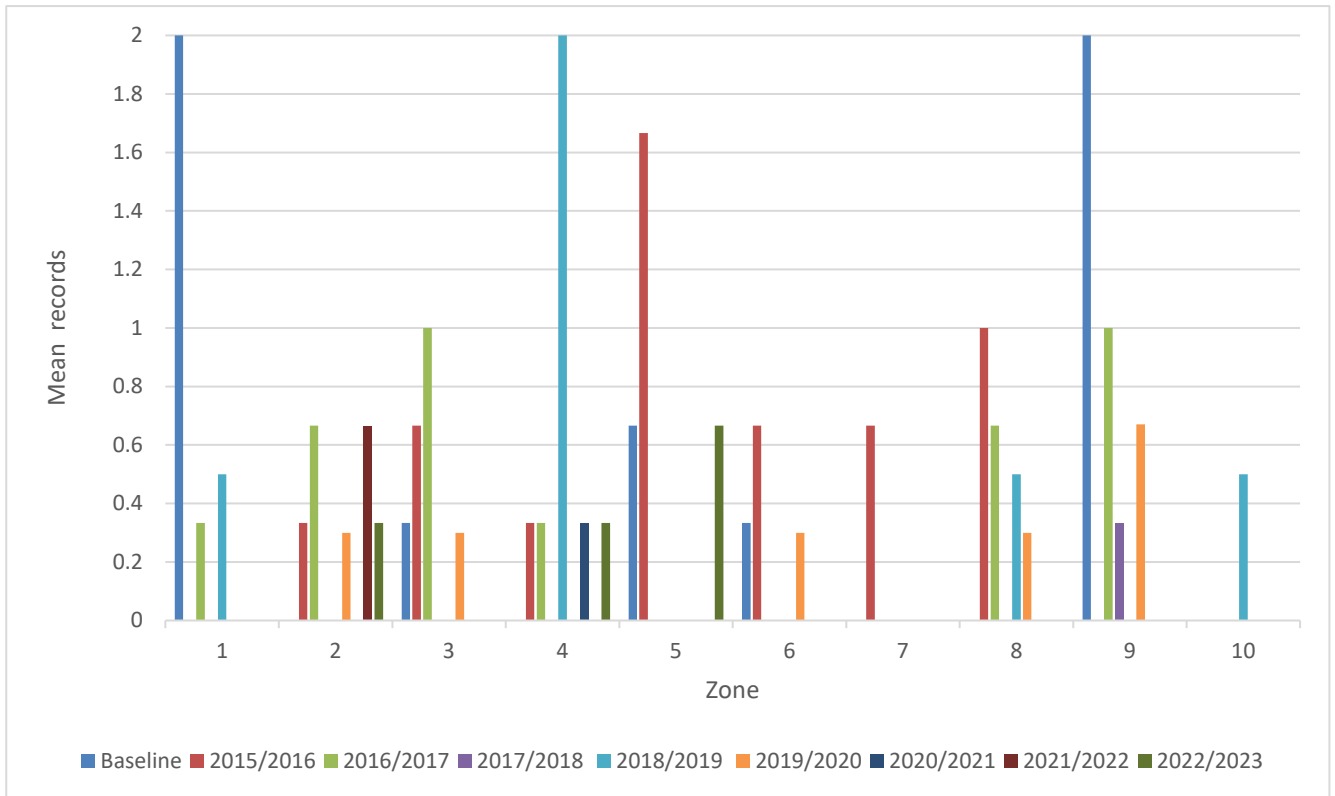
Figure 8 - Figure 13 show all capture records (i.e. cumulative records), whereby capture records (including recaptures) are shown as count ranges, where larger circles indicate larger frog counts. While density data indicates that frog distribution along the transects varies from year to year, when considering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



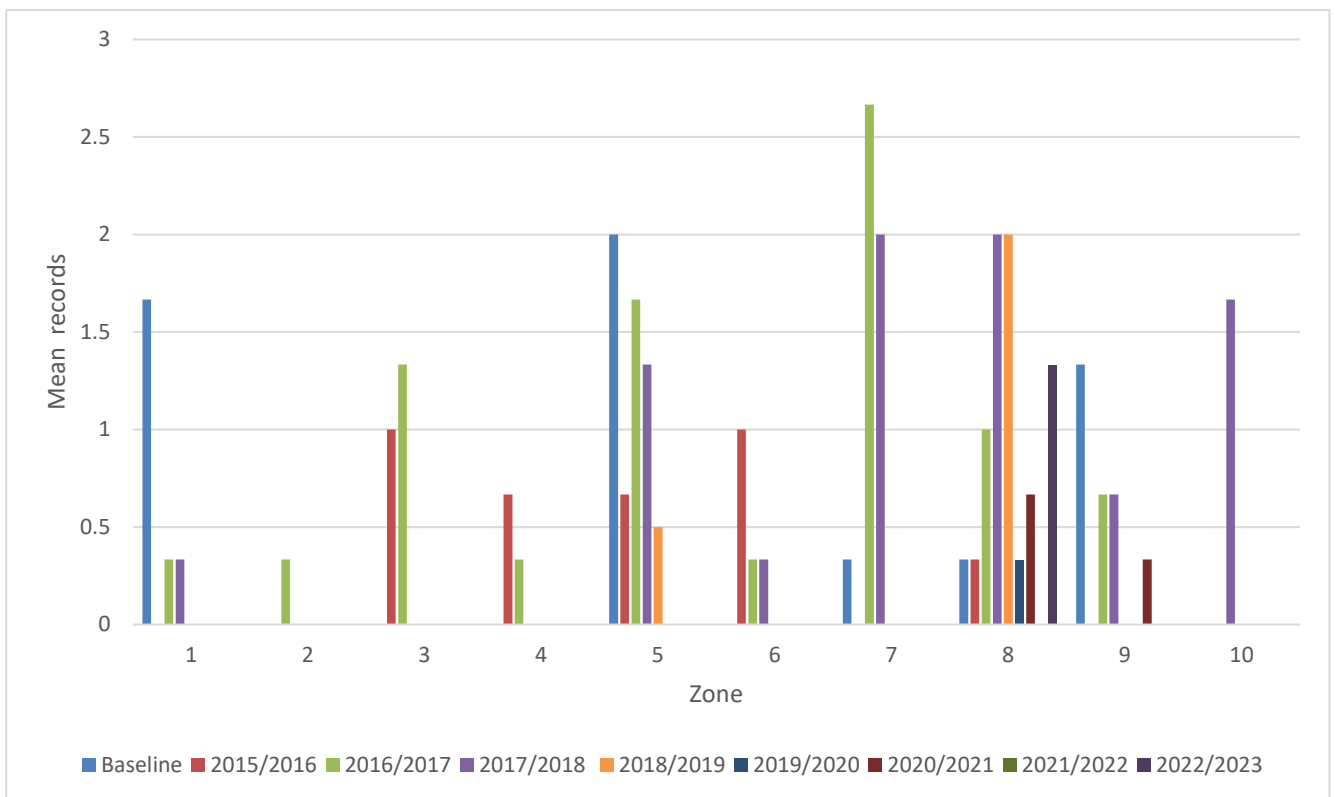
Graph 4: Cooperabung Creek impact site: mean number of Giant Barred Frogs per zone



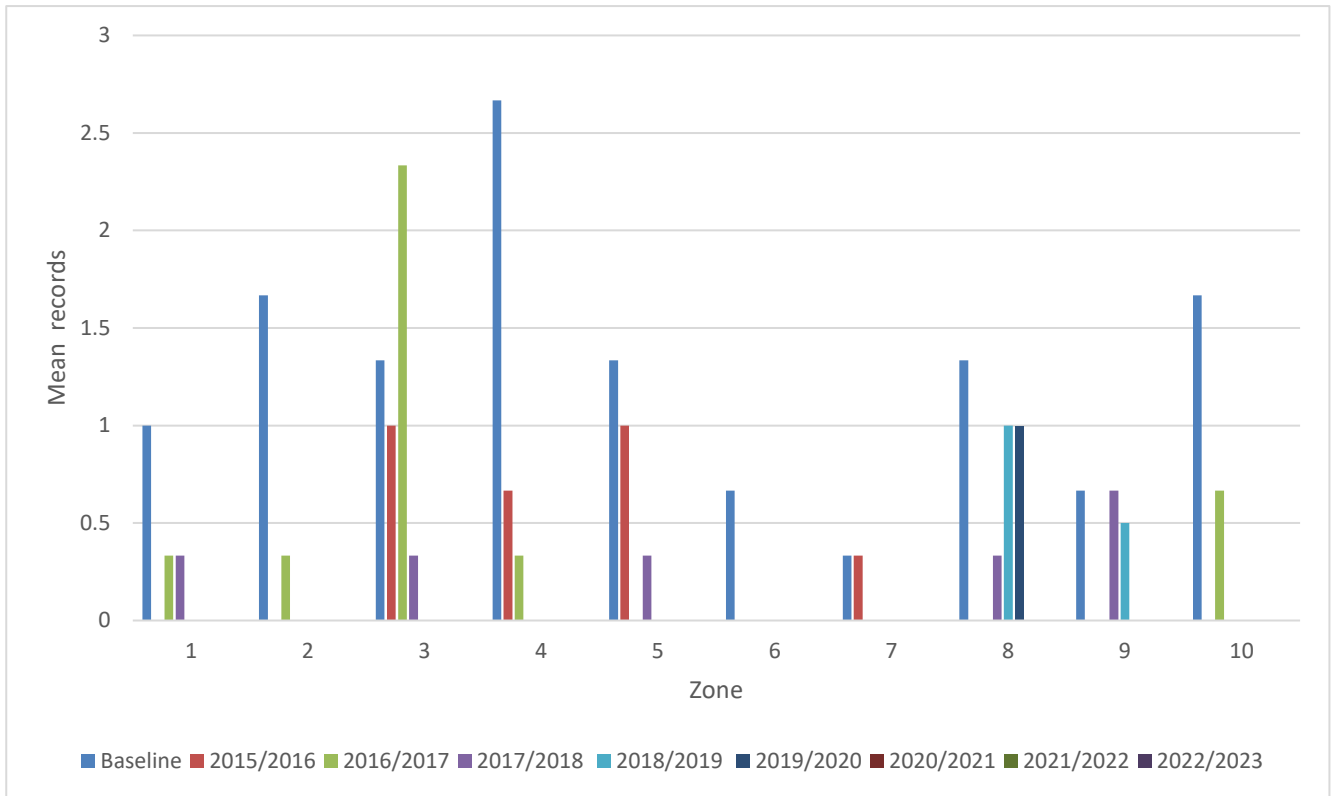
Graph 5: Smiths Creek impact site: mean number of Giant Barred Frogs per zone



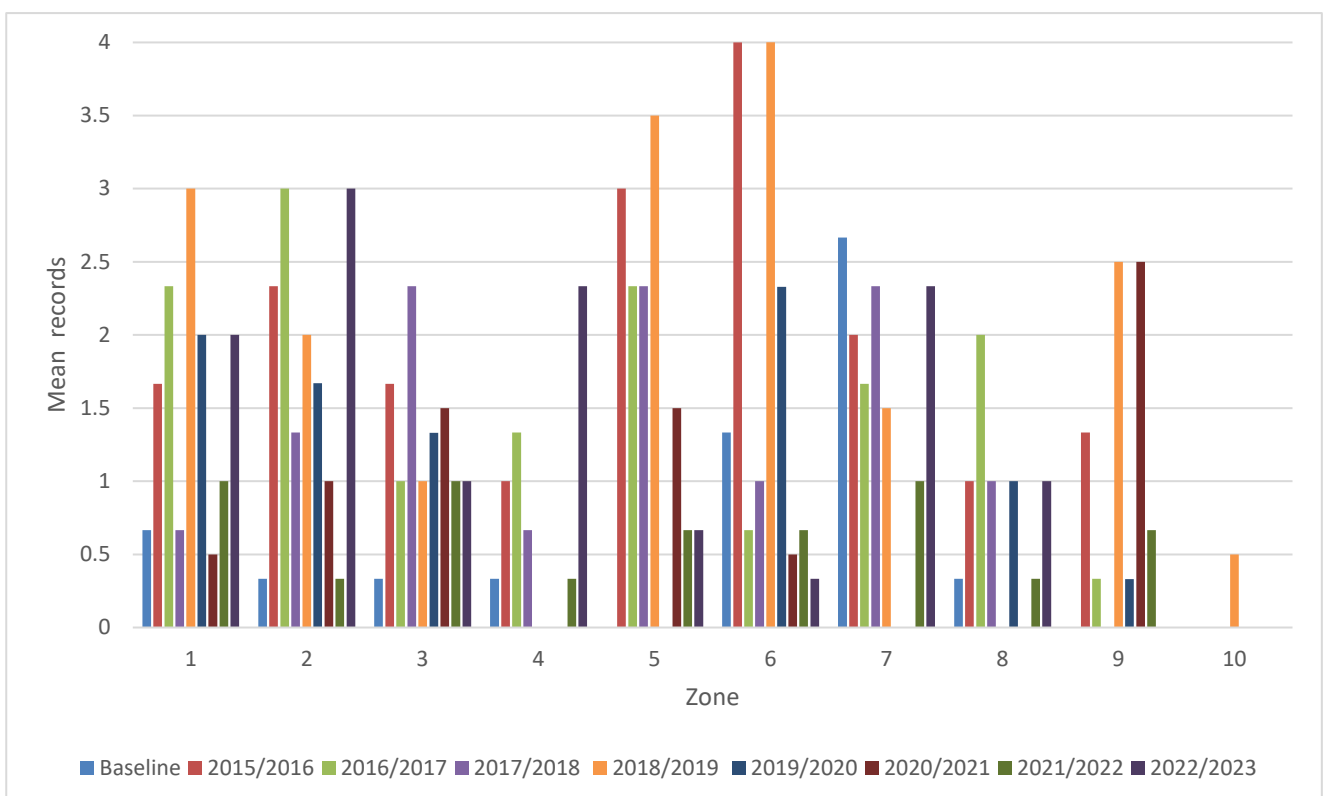
Graph 6: Pipers Creek impact site: mean number of Giant Barred Frogs per zone



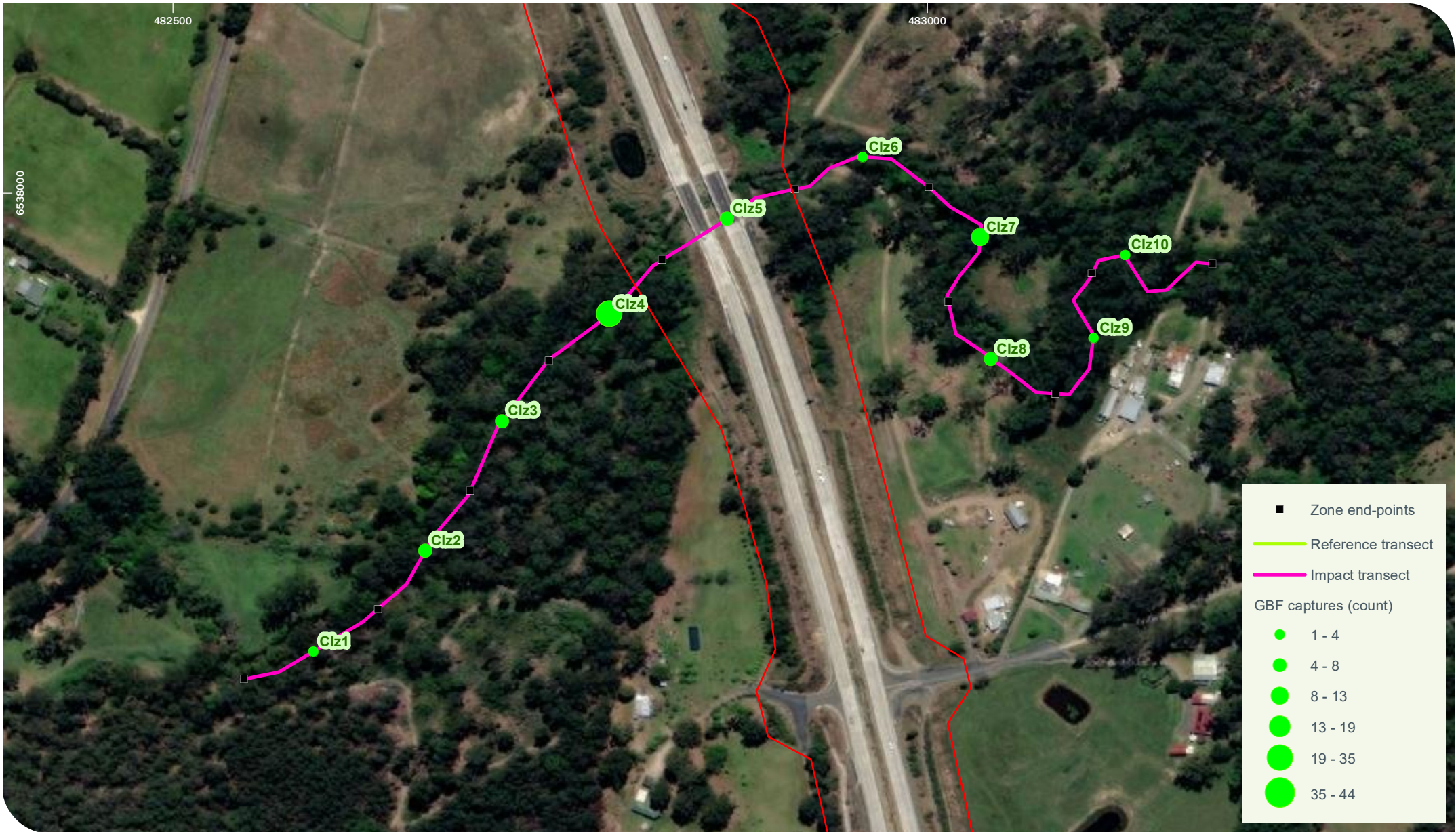
Graph 7: Maria River impact site: mean number of Giant Barred Frogs per zone



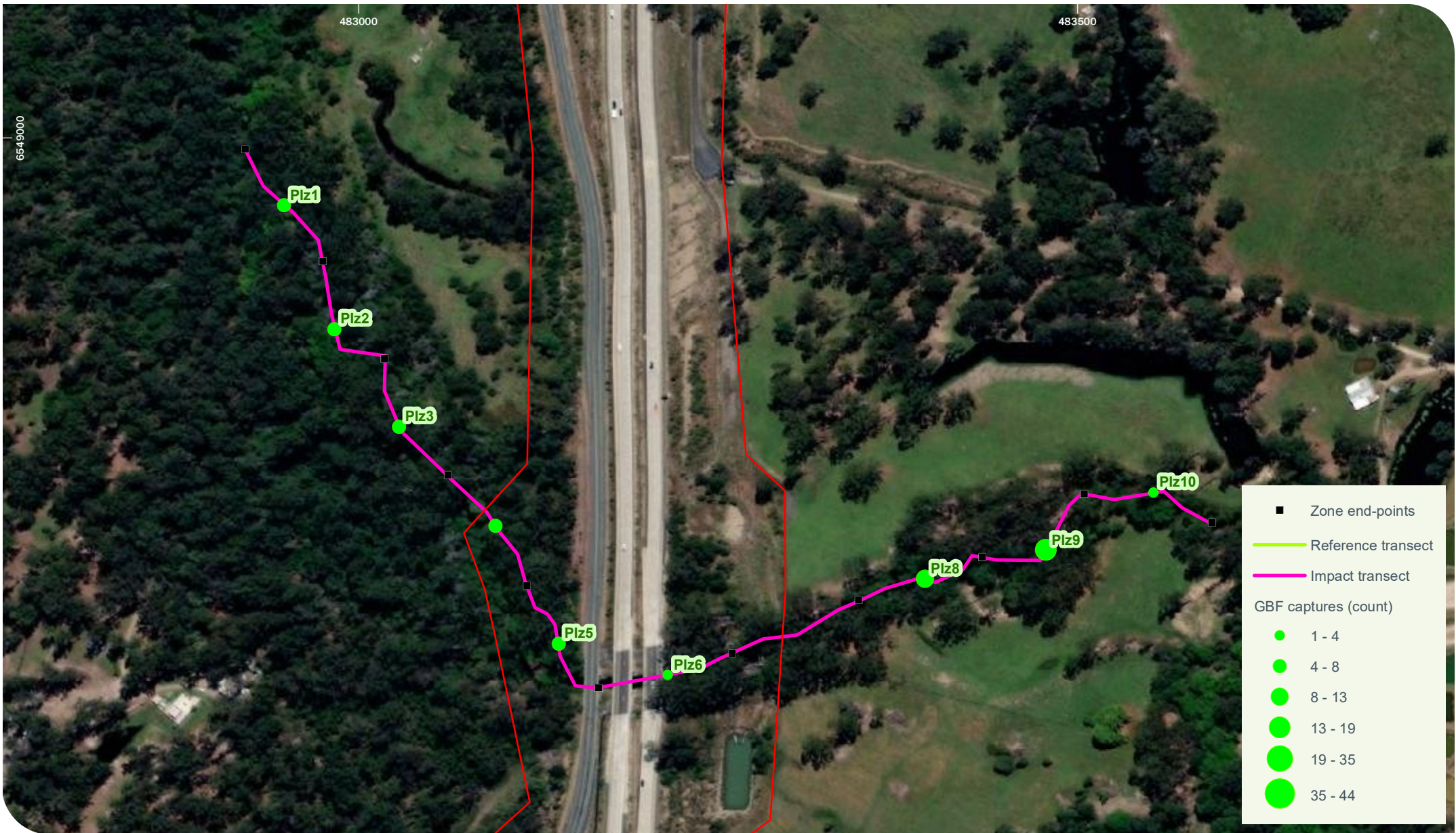
Graph 8: Cooperabung Creek reference site: mean number of Giant Barred Frogs per zone

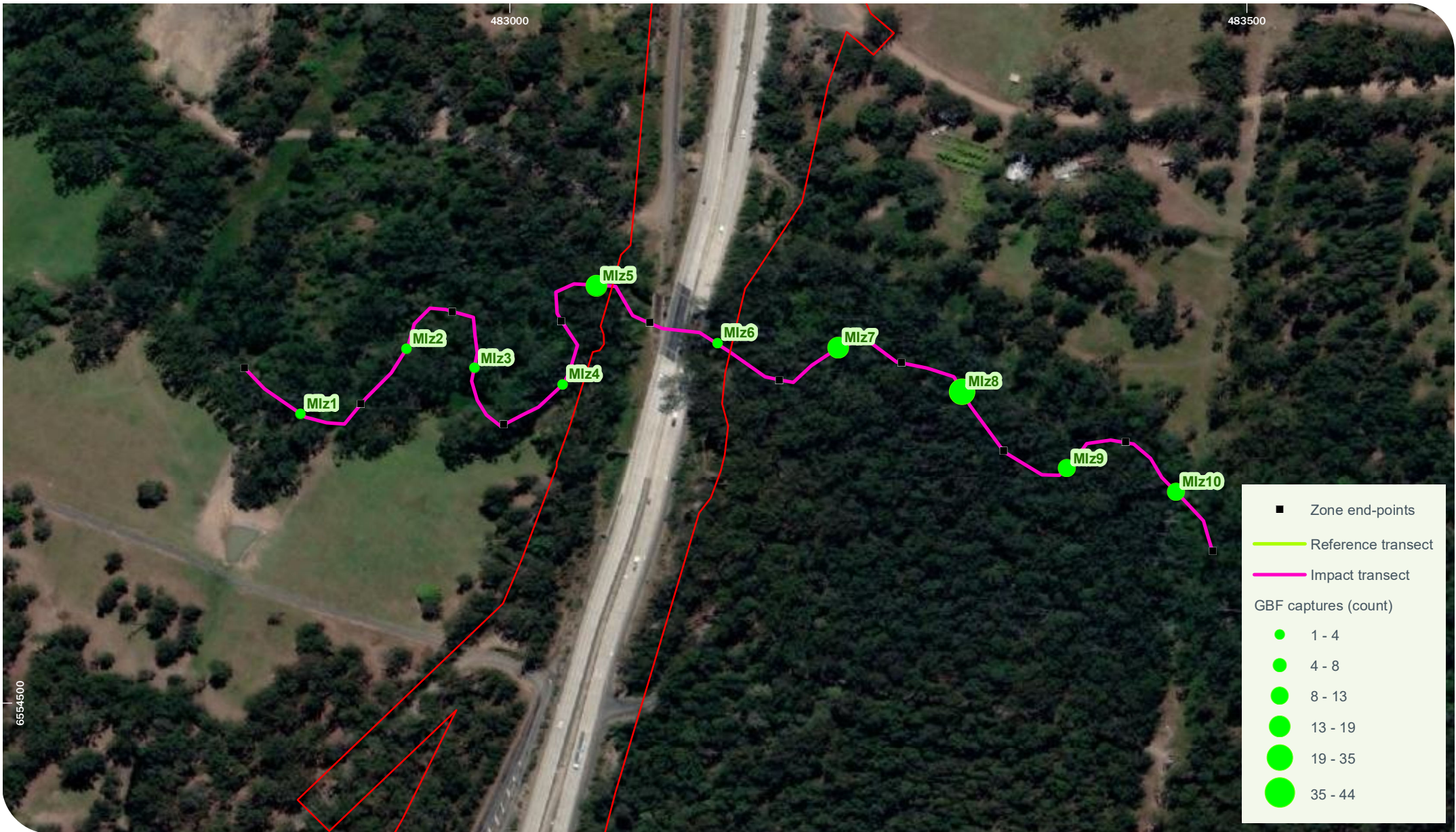


Graph 9: Pipers Creek reference site: mean number of Giant Barred Frogs per zone













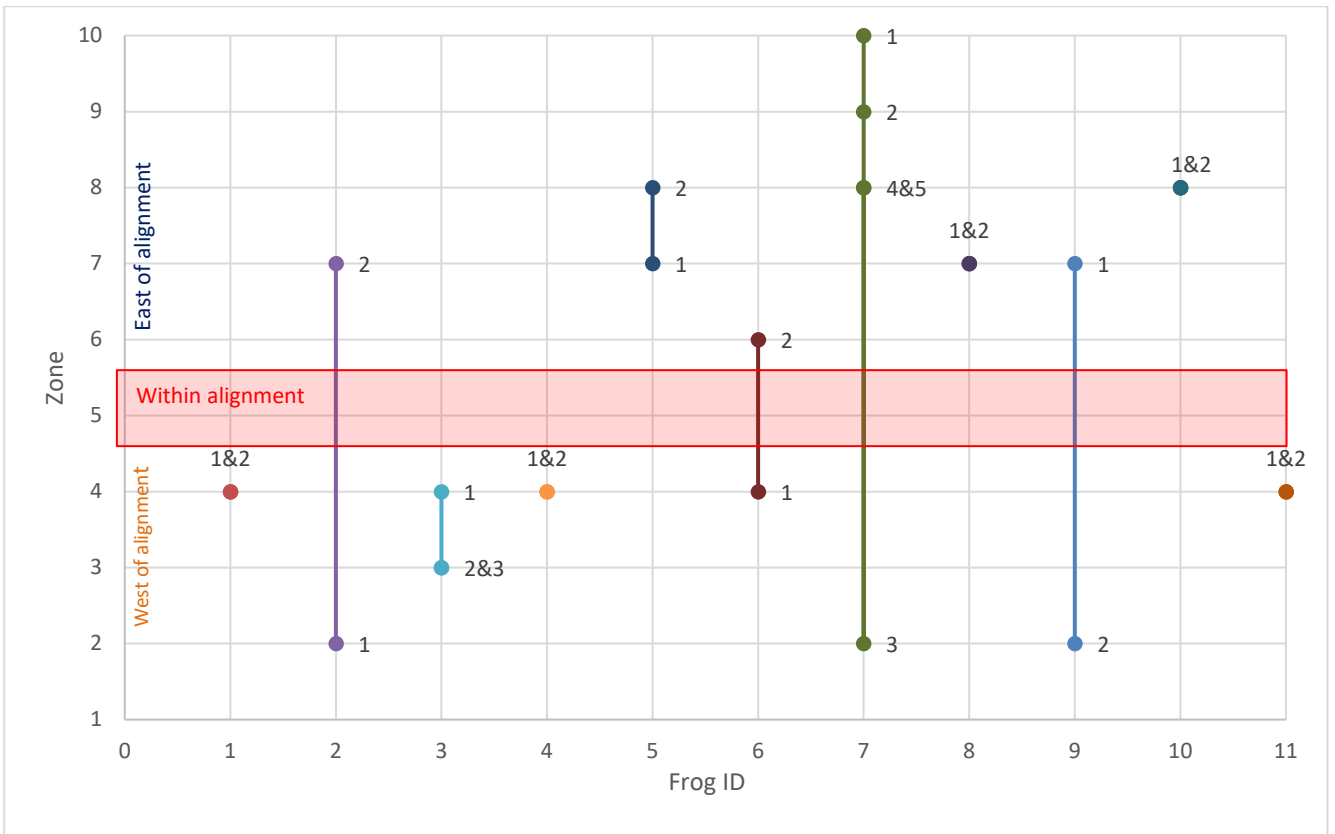
3.4 Movement

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

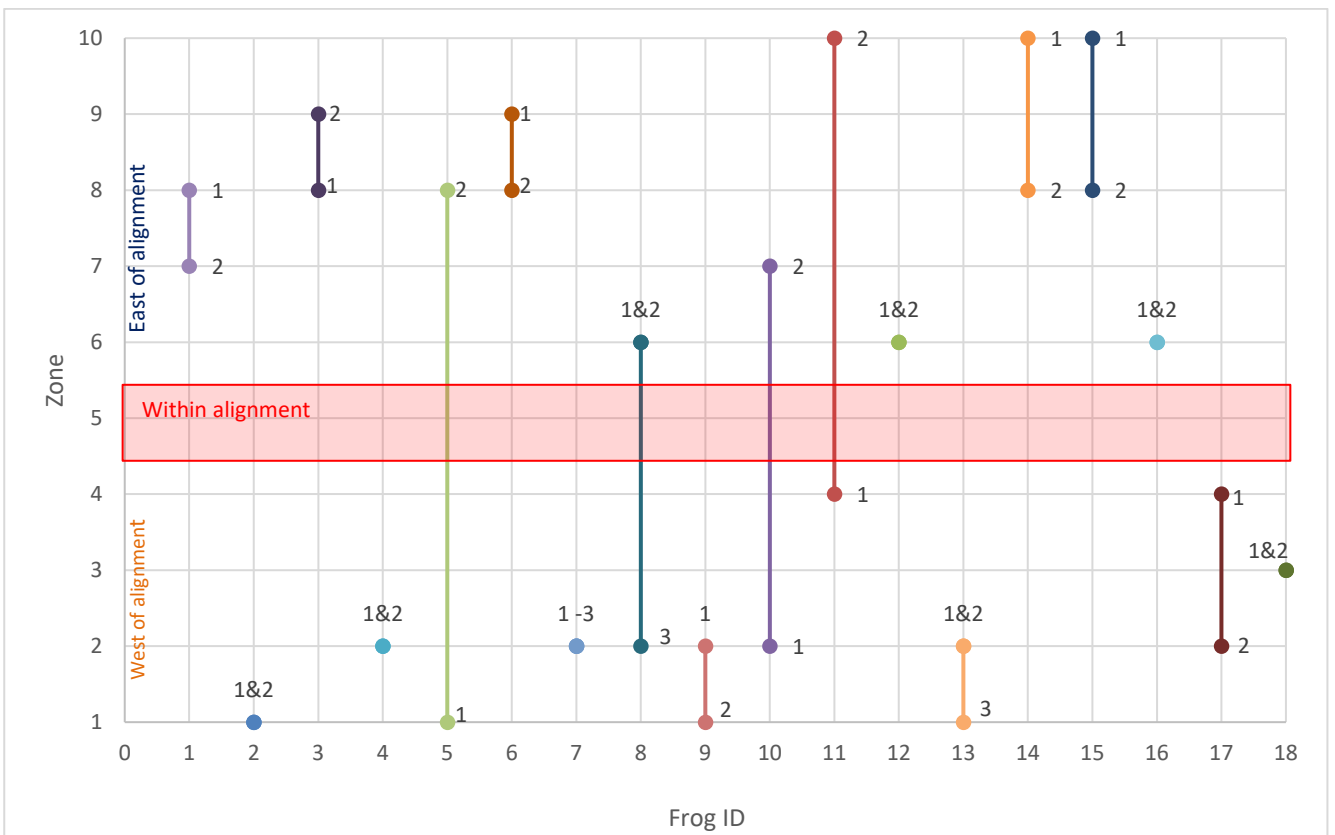
A total of 96 individuals have been recaptured on at least one occasion over all monitoring events. Of these, 52 recaptures have occurred at the impact sites. Twelve (23%) of these individuals from impact sites have been captured on both sides of the carriageway over successive monitoring events, demonstrating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

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

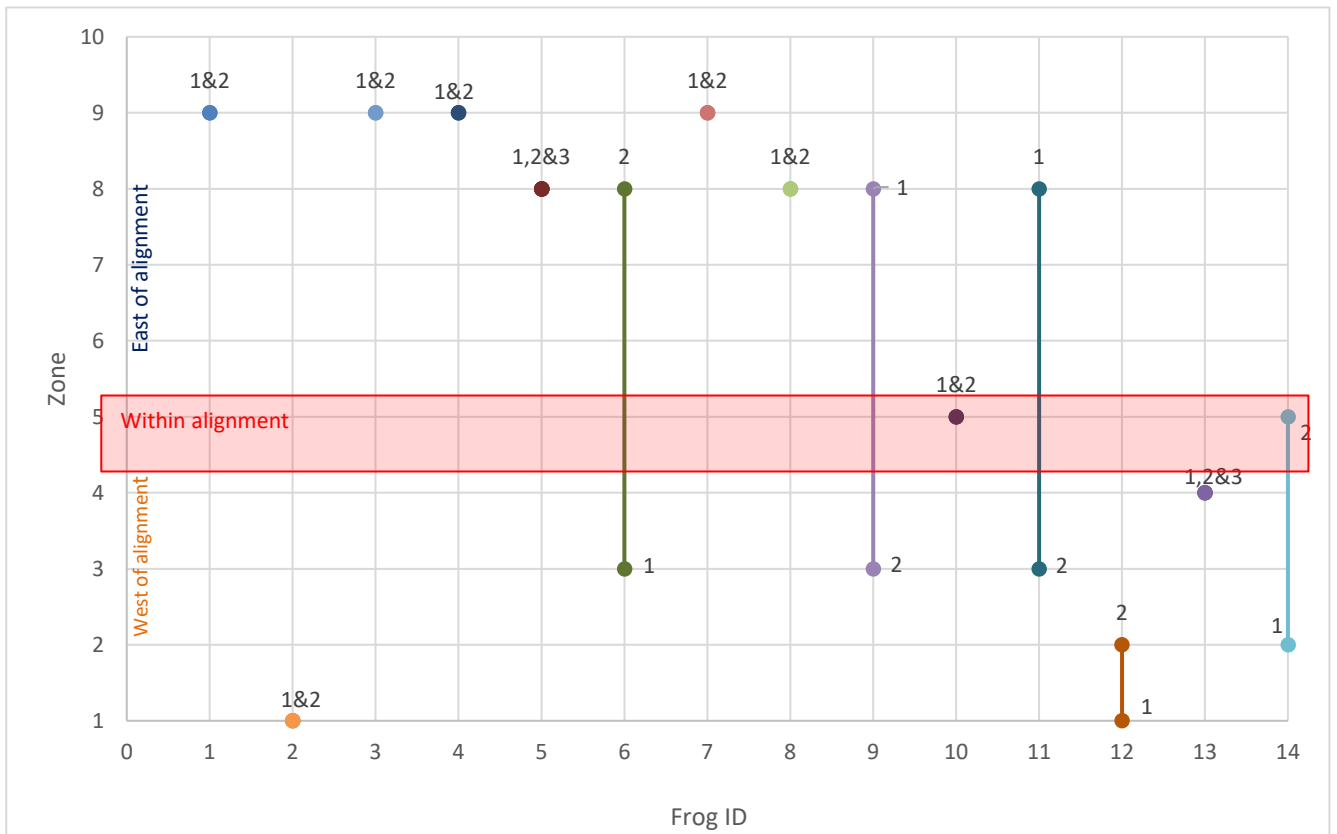
At the impact sites, while the monitored waterways continue uninterrupted under the carriageway, there is a distinct change in streamside vegetation within the area immediately under the carriageway. Under the carriageway at all impact sites, streamside vegetation ranges from limited to moderately dense,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



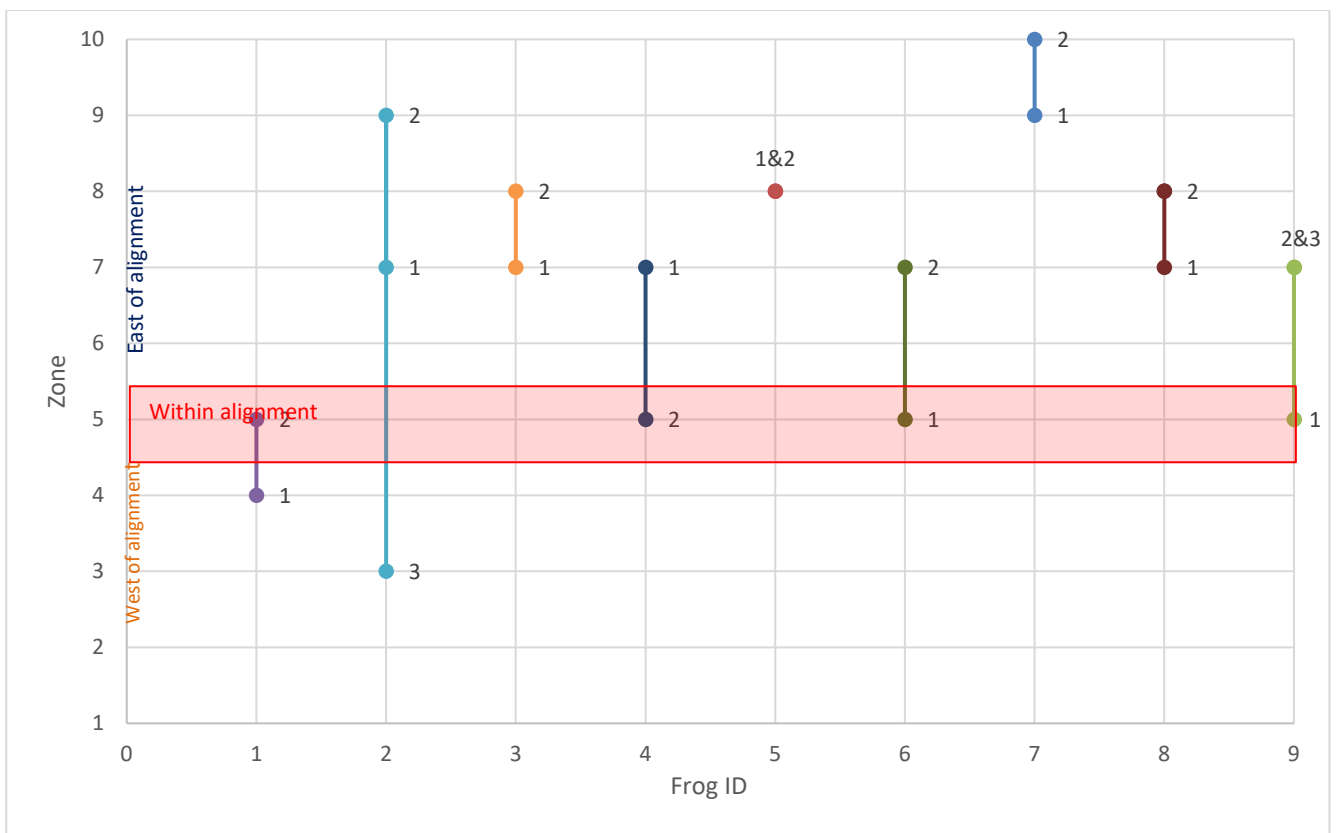
Graph 10: Cooperabung Creek impact site: recapture movement patterns



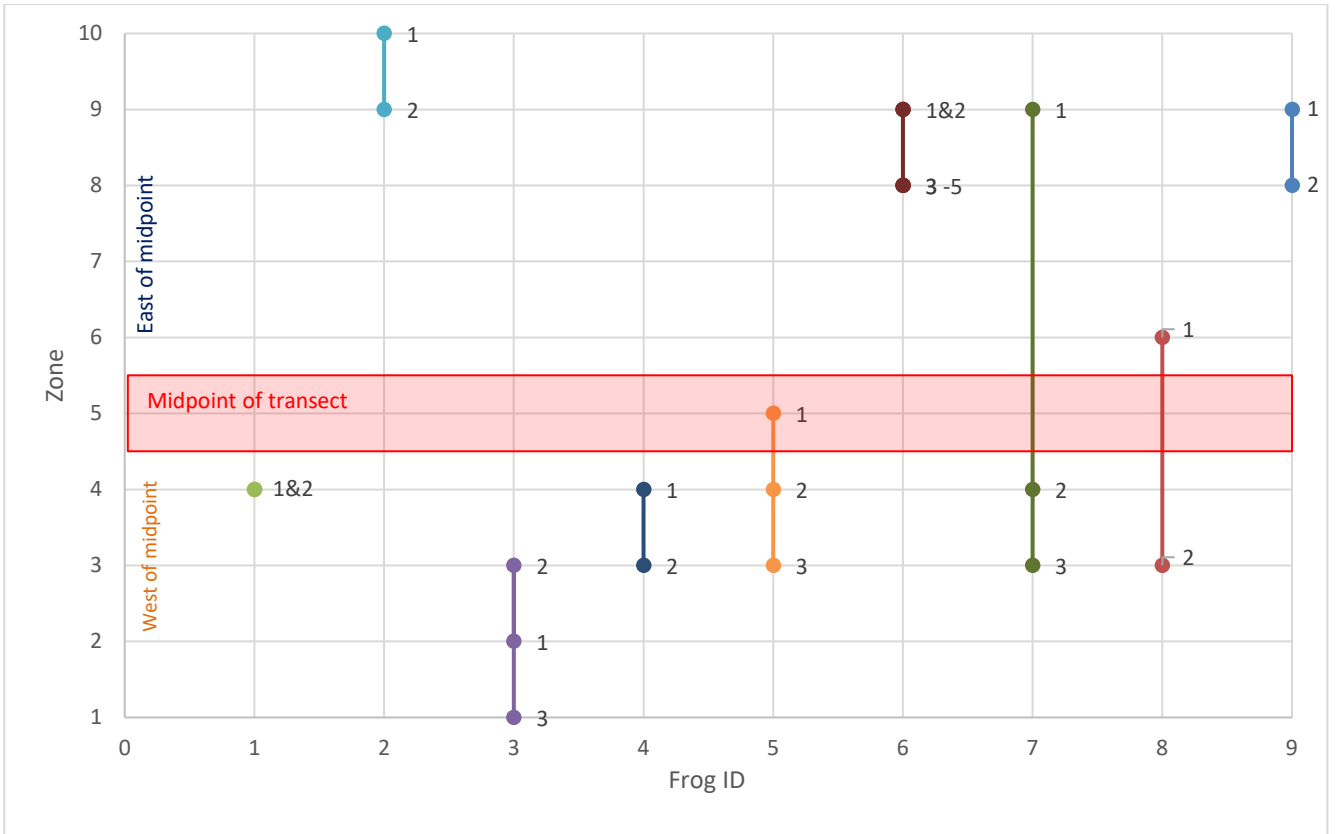
Graph 11: Smiths Creek impact site: recapture movement patterns



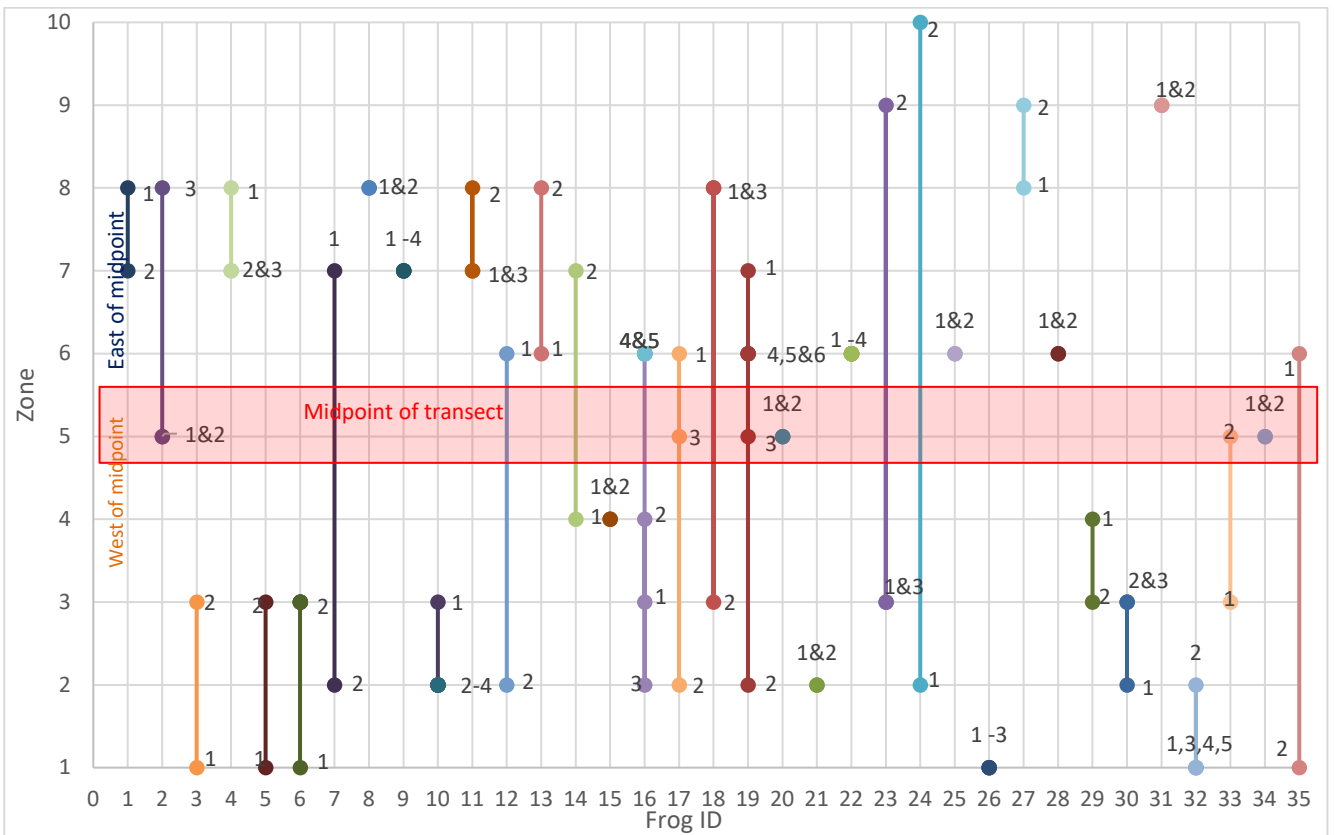
Graph 12: Pipers Creek impact site: recapture movement patterns



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), Year 7 (2021/2022) and Year 8 (2022/2023) survey results in relation to the performance measures is provided in Table 5.

Table 4: Performance measures and discussion of results.

Performance measure	Discussion
Monitoring is undertaken during baseline surveys and Years 1 – 8 or until monitoring can demonstrate that mitigation measures are effective.	This performance measure has been met for all years. Giant Barred Frog monitoring has been undertaken at all six baseline sites at least twice during the monitoring period according to the EMP to date.
Monitoring during Year 1 – 8 is undertaken at the Impact and Control sites where baseline monitoring was undertaken, subject to landowner agreement.	This performance measure has been met for all years. Giant Barred Frog monitoring has been undertaken at all six baseline sites at least twice during the monitoring period, where landowner agreement permitted.
Continued presence of Giant Barred Frogs during each survey event in Year 1 – 8 at sites where it was identified during baseline surveys, subject to access due to landowner agreement.	<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), 1 of 6 sites in Year 7 (2021/2022) and 3 of 6 sites in Year 8.</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 Barred Frogs were not recorded in spring at Cooperabung impact site or autumn at Pipers Creek impact site.</p>

Performance measure	Discussion
	<p>Year 8 (2022/2023): Giant Barred Frogs were not recorded at the Cooperabung reference site during 2022/2023 surveys. Giant Barred Frogs were not recorded in summer or autumn at Smiths Creek impact site or spring at Maria River impact site.</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 has been met.</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. However, surveys of the frog fence note a number of maintenance issues that may impair the integrity of the frog fence (Niche 2023). Recommendations have been made below.</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 8.</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 fluctuating densities. However, as trends are evident at both impact and reference sites, it is not possible to attribute these changes to the Project.</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 25% 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>The number and location of Giant Barred Frogs recorded has varied between season and year at all sites. All sites show fluctuating densities. However, as trends are evident at both impact and reference sites, it is not possible to attribute these changes to the Project.</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>This contingency measure is not considered relevant.</p>

5.2 Recommendations

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

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

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

Table 6: Recommendations

Performance measure	Action
Continued presence of Giant Barred Frogs during each survey event in Year 1 – 8 at sites where it was identified during baseline surveys, subject to access due to landowner agreement.	<p>This performance measure has been met for 3 of 6 sites in Year 8 (2022/2023).</p> <p>Giant Barred Frogs were</p> <ul style="list-style-type: none"> Not recorded at the Cooperabung Creek reference site, where it was recorded during all three baseline surveys. Not recorded at Smiths Creek impact site in summer or autumn 2022/2023 and Maria River impact site in spring 2022, where it was recorded during baseline surveys. <p>The Project area experienced drought conditions in 2019 with below average rainfall followed by substantially higher than average rainfall during 2020/2021 and 2021/2022 resulting in waterway flooding and highly variable water levels. Frogs have since been recorded at all impact sites in at least one season during Year 8 monitoring, including at sites where they had not been recorded for a number of years, demonstrating continued presence at these sites. Recent records likely reflect natural population fluctuations associated with extreme climatic conditions experienced from Year 4 to Year 6 (2019 to 2022).</p>

Performance measure	Action
	Given the number and location of Giant Barred Frogs recorded has varied between season and year at all sites and that trends are evident at both impact and reference sites, it is not possible to attribute these changes to the Project, therefore further monitoring is not recommended.
No change to densities, distribution, habitat use and movement patterns compared to baseline data during monitoring in Year 1 – 8, and then when all monitoring events are considered at Year 8.	<p>This performance measure has not been met.</p> <p>Given the number and location of Giant Barred Frogs recorded has varied between season and year at all sites and that trends are evident at both impact and reference sites, it is not possible to attribute these changes to the Project, therefore further monitoring is not recommended.</p>

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

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

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

Cooperabung Creek impact site

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

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

Table 8: Habitat details: Cooperabung Creek impact site

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

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

Table 9: Summary of captures: Cooperabung Creek impact site

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

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

Smiths Creek impact site

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

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

Table 11: Habitat details: Smiths Creek impact site

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

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

Table 12: Summary of captures: Smiths Creek impact site

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

Habitat: Microhabitat within these zones included leaf litter, flood 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)
27/10/2022	Start	22:21	18.2	17	96	100	0	0
	Finish	1:21	17.3	17	98	50	0	0
16/02/2023	Start	20:15		21				0
	Finish	23:00		21				0
05/04/2023	Start	18:27	21	20	60		0	30
	Finish	21:27	17	20			0	10

Table 14: Habitat details: Pipers Creek impact site

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

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

Table 15: Summary of captures: Pipers Creek impact site

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

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

Maria River impact site

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

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

Table 17: Habitat details: Maria River impact site

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

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

Table 18: Summary of captures: Maria River impact site

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

Habitat: Microhabitat within these zones included under grass and leaf litter. Lantana is very abundant along both side of the river banks and is the dominant vegetation from Miz1 to Miz5. Lantana has also increased it's dominance of the downstream side throughout all zones. Access in 2022/2023 to certain areas of the transect was not possible due to increased lantana.

Cooperabung Creek reference site

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

Date	Time		Air temp. °C	Water temp. °C	Humidity %	Stream depth (cm)	Wind (0-3, 0= no wind)	Cloud cover %	Rain (0-3, 0= no rain)
25/10/2022	Start	22:22	18.6	17	96	150	1	0	0
	Finish	0:30	16	17	88	50	0	0	0
9/12/2021	Start	22:25	21	21	82	50	0	0	0
	Finish	22:25	21	21	82	50	0	0	0
03/04/2023	Start	18:57	19	18		30	0	50	0
	Finish	23:46	18	18		30	0	40	0

Table 20: Habitat details: Cooperabung Creek reference site

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

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

Table 21: Summary of captures: Cooperabung Creek reference site

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

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

Pipers Creek reference site

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

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

Table 23: Habitat details: Pipers Creek reference site

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

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

Table 24: Summary of captures: Pipers Creek reference site

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

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

Annex 2 - Giant Barred Frog individual capture data

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

Table 25: Giant Barred Frog capture data

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

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

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

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