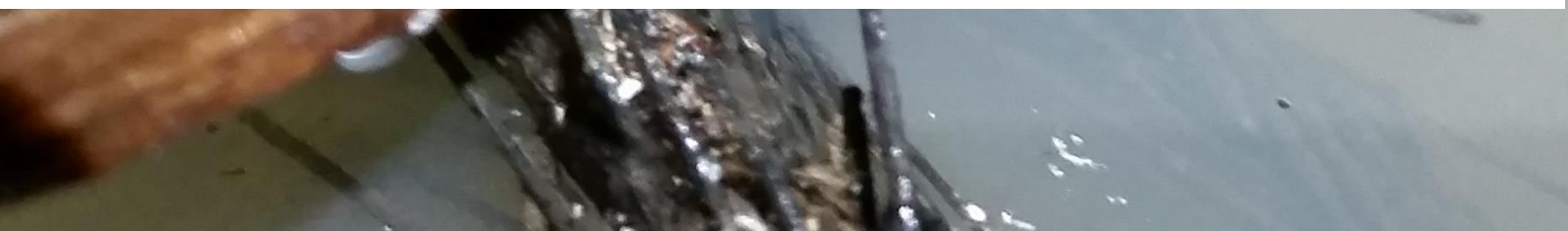
PACIFIC HIGHWAY UPGRADE: WOOLGOOLGA TO BALLINA

Sections 1 and 2 Green-thighed Frog Construction Monitoring: Year 2

LEWIS ECOLOGICAL

November 2018



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……..
Ben Lewis
(B. Applied Science Hons)

…8th November 2018……

Date

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Ben Lewis (Lewis Ecological Surveys) – Field Surveys, Report Author and Report Review.

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Photography - Lewis Ecological Surveys © else stated

Title Page – Green-thighed Frog in amplexus from newly established Site 3A at ch. 250000.

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Executive Summary

Year 2 monitoring for the Green-thighed Frog (*Litoria brevipalmata*) was performed at five paired BACI (Before-After-Control-Impact) sites (n=10) located in Section 1 and 2 of the Woolgoolga to Ballina Upgrade. Surveys were staggered and triggered by a combination of thunderstorm activity in late February and a low pressure system in mid-March which delivered in excess of 150 mm over 24 hours, the first suitable rainfall event of this magnitude since the early winter 2016 surveys that enabled Year 1 surveys.

The sampling regime was consistent with the Threatened Frog Management Plan (RMS 2015) in that breeding or calling surveys were undertaken during a period of intense rainfall and this was followed up by post breeding surveys of the ponds 35-55 days later in April to determine the overall success of the breeding event. Surveys of the constructed compensatory breeding ponds and some transect counts along the constructed permanent frog exclusion fencing were also incorporated so that some indices on their effectiveness or functionality could be determined.

Green-thighed Frogs were recorded at 8 (80%) of the 10 sites but not at Site 1B and Site 4A. Counts of frogs remained relatively low at between 1-7 individuals, but importantly, the counts comprised calling males, and on some occasions, amplecting pairs were observed. The post breeding surveys performed in the later part of April found tadpoles and froglets at four sites which included two impact sites and two control sites.

Surveys of the provided mitigation measures showed mixed success. None of the three compensatory pond areas recorded Green-thighed Frogs, however, frogs were recorded in the near proximity (i.e. < 100m) and all three areas provided temporarily inundated pools for more than 35-50 days. Surveys of the permanent frog exclusion fencing found the fence was not able to exclude all frogs from the roadway, however, it was effective at reducing the number of frogs in the order of magnitude of fourfold to sevenfold at most but not all instances.

The implications of the findings and how these compare with performance measures outlined in the Threatened Frog Management Plan (RMS 2015) are discussed.

1.0 INTRODUCTION

1.1 Project Overview and Background to this Monitoring

The Woolgoolga to Ballina Pacific Highway Upgrade comprises approximately 155 km of highway to achieve a four-lane divided road extending north of Woolgoolga at the northern extent of Sapphire to Woolgoolga Upgrade to south of Ballina where it ties into the southern extent of the Ballina bypass. The project includes grade separated interchanges, service roads and upgrades to local road connections and has the potential to be staged in 11 sections. The State Minister for Planning and Environment approved the project on 24th June 2014. On 14th August 2014, the Federal Minister for the Environment Greg Hunt approved the project in accordance with Part 9 of the *Environmental Protection and Biodiversity Conservation* Act (1999).

In order to enable commencement of construction in mid-2015, some key preconstruction survey tasks were to be undertaken as a priority. During preconstruction, baseline and targeted surveys of threatened species enabled the establishment of the monitoring program to be implemented on an ongoing basis to help manage and mitigate any potential impacts of the project on threatened species. Requirements for monitoring and mitigation measures throughout various stages of the project are outlined in a series of threatened species management plans.

The Threatened Frog Management Plan (RMS 2015) addresses the impacts of the upgrade and proposed mitigation on a number of threatened frog species including the Wallum Sedge Frog (*Litoria olongburensis*), Giant Barred Frog (*Mixophyes iteratus*) and Green-thighed Frog (*Litoria brevipalmata*). This management plan identifies both areas of known and potential habitat throughout the Project corridor and proposes a number of management actions to ensure the long-term survival of these species in the area of the project. In order to gauge the performance of these management actions a pre-construction baseline monitoring survey was undertaken (Niche 2014). This study selected 10 known sites (5 impact and 5 control) identified by Lewis Ecological Surveys during the design works package for Sections 1 and 2 (Lewis 2013 a,b) or from data supplied during other ecological investigations at sites deemed suitable control or reference sites.

To address the unbalanced data set, Roads and Maritime commissioned Lewis Ecological Surveys on the 20th February 2015 to update the baseline monitoring survey across Sections 1-8 by sampling the sites selected by Niche in Sections 1 and 2 and to locate, identify and collect the required data for Sections 3-8 (Lewis 2015). This survey would then provide a comparable data set from which successive monitoring events could be compared.

1.2 Updates and Adoption of Recommendations from Year 1 Monitoring

The following recommendations were adopted following Year 1 monitoring:

1. Update aspects of the Threatened Frog Species Management Plan (RMS 2015) and with that the following changes:
    a. The frog counts be the total number of Green-thighed Frogs recorded during Stage 1 surveys.
2. Amend monitoring Site 1B so that it is an adequate distance adjacent to the carriageway. Some suggested areas include Julies Road or alternatively Georges Road within Yuraygir State Conservation Area.
3. Amend monitoring Site 3A and relocate to the eastern side of Bald Knob Tick Gate Road (~ch. 25000).

1.3 Subject Species – Green-thighed Frog (*Litoria brevipalmata*)

1.3.1 Description

The Green-thighed Frog is a small to medium sized (max. 47 mm) hylid frog (Barker *et al.* 1995; Cogger 1995; Murphy and Turnbill 1999; Lemckert *et al.* 2006). It is a relatively distinct species with a prominent white upper lip, armpits and groin marked in lime green with black markings (Barker *et al.* 1995; Lemckert *et al.* 2006).

Plate 1-1. Green-thighed Frog (ad + juv).

1.3.2 Distribution

The Green-thighed Frog is distributed in coastal and sub coastal areas from near Bundaberg (Cordalba) in the north to Ourimbah (i.e. central coast NSW) in the south (Barker *et al.* 1995; Lemckert *et al.* 2006). Despite this relatively wide distribution, it is known from few areas (*see* Ehmann 1997).

1.3.3 Habitat and Ecology

The cryptic habits of the Green-thighed Frog ensured it remained unknown to science until 1972 (Tyler *et al.* 1972). The main habitat requirement of this species is warm temperate lowland forest, although more recent records have indicated other habitat types including dry sclerophyll forest, heathland and swamp forest are used (Nattrass and Ingram 1993; Lemckert 1999; Murphy and Turnbill 1999; Lewis 2000; Lewis 2006). The Green-thighed Frog is most often detected during breeding events between October and April when males congregate around flooded depressions and call from either the ground or low fallen branches or vegetation (Barker *et al.* 1995; Ehmann 1997; Lemckert *et al.* 2006). Typically, calling events occur when the breeding site has received at least 75 mm in 24 hours or around 150 mm over a 72 hour period (B. Lewis unpublished data).

2.0 SURVEY METHODS

Field surveys were performed in accordance with the Threatened Frog Species Management Plan (RMS 2015) and the adopted recommendations outlined in Section 1.2. The following details the areas surveyed along with the timing of field surveys and how the data were treated or analysed.

2.1 Site Selection

The location of BACI sites 1-5 in Section 1-2 were already identified from a selection of known Green-thighed Frog sites (*see* Niche 2014) identified from the design survey package (Lewis 2013a,b). The exception was to investigate suitable alternative locations for Site 1B and to relocate Site 3A to the eastern side of ch. 25000 (Bald Knob Tick Gate Road). Their distribution across the study area is shown in Figure 2-1.

2.2 Compensatory Breeding Ponds

At the time of monitoring, compensatory breeding ponds had been constructed adjacent to Redbank Creek (ch. 5600 East), Dirty Creek Range (ch. 11800 West), Halfway Creek (ch. 19100 W) whilst ponds up around chainage 25000 had not yet been constructed.

2.3 Frog Exclusion Fence Surveys

At the time of monitoring, any of the erected permanent frog fencing adjacent to the monitoring sites was surveyed to identify the status of Green-thighed Frogs and whether they were present on the road side of the fence or the habitat side of the fence. This involved surveys at Redbank Creek (ch. 5600 E), Falconers (ch. 11800 W), Halfway Creek (ch. 19100 W) and Glenugie where the south bound heavy vehicle checking station is located (ch. 26200 E).

Each survey was performed on a night when the calling/breeding surveys were being performed as this period is likely to reflect an increased period of activity. The survey involved a walking transect of between 125-500m, for 2 m either side of the fence using an 800 lumen powered head torch to record the numbers and types of frogs present.

2.4 Timing of Surveys

Weather patterns were constantly monitored between October 2016 through to May 2017 for the suitability of a rainfall event delivering >75 mm in 24 hours or alternatively 150 mm over 72 hours (Table A1).

During this time, each site was visited and an initial five minute listening survey was performed to identify calling individuals. This was followed by a search of any flooded habitat to visually identify any non-calling individuals present in and around the flooded areas. At each site, the following data was recorded: time at start and end of survey for each survey site, conditions during the survey (including temperature, humidity, cloud cover, relative wind intensity and rainfall) and species of frogs calling (*see* Section 2.3). Monitoring took place from the 28th February to the 20th March 2017, with some additional compensatory pond inspections on the 31st March.

The second round or post breeding survey was used to measure the breeding success at each site and these were performed on the 22nd-23rd April or around 35-55 days after the two potential breeding events. During the post breeding surveys, a fine scale mesh net (400 mm diameter) was used to sweep any of the residual water body. In an attempt to standardise this method, a minimum of 10 sweeps was undertaken per 25m^2 of water body. Any tadpoles captured were examined to determine if they were hylids representative of Green-thighed Frog, and if so, a sample was taken for further identification. The bank area within 5-10 m was also traversed to visually search for metamorphosed froglets over a set 20 minutes per site and the number of frogs recorded.

2.5 Abiotic Data

The following abiotic variables were collected during the survey:

- Air temperature (°C) measured with a thermometer at the start and finish of the frog survey and averaged;
- Relative humidity (%) measured with wet/dry bulb thermometer at the start and finish of the frog survey and averaged;
- Prevailing cloud cover was expressed as a percentage (%) coverage of the sky;
- Wind speed measured using a subjective scale (0 = no wind, 1 = light rustles of leaves on trees, 2 = leaves and branches moving and 3 = whole canopy moving); and
- Rain fall was also measured in a subjective scale (0 = no rain in past 24 hours, 1 = rain within 24 hours and 2 = rain during survey).
- Seasonal rainfall data was also collated for the period between October 2016 and May 2017 to assess when the surveys were performed and how they compared to other rainfall events within the perceived breeding period. The data were collated from Grafton Airport (058161).

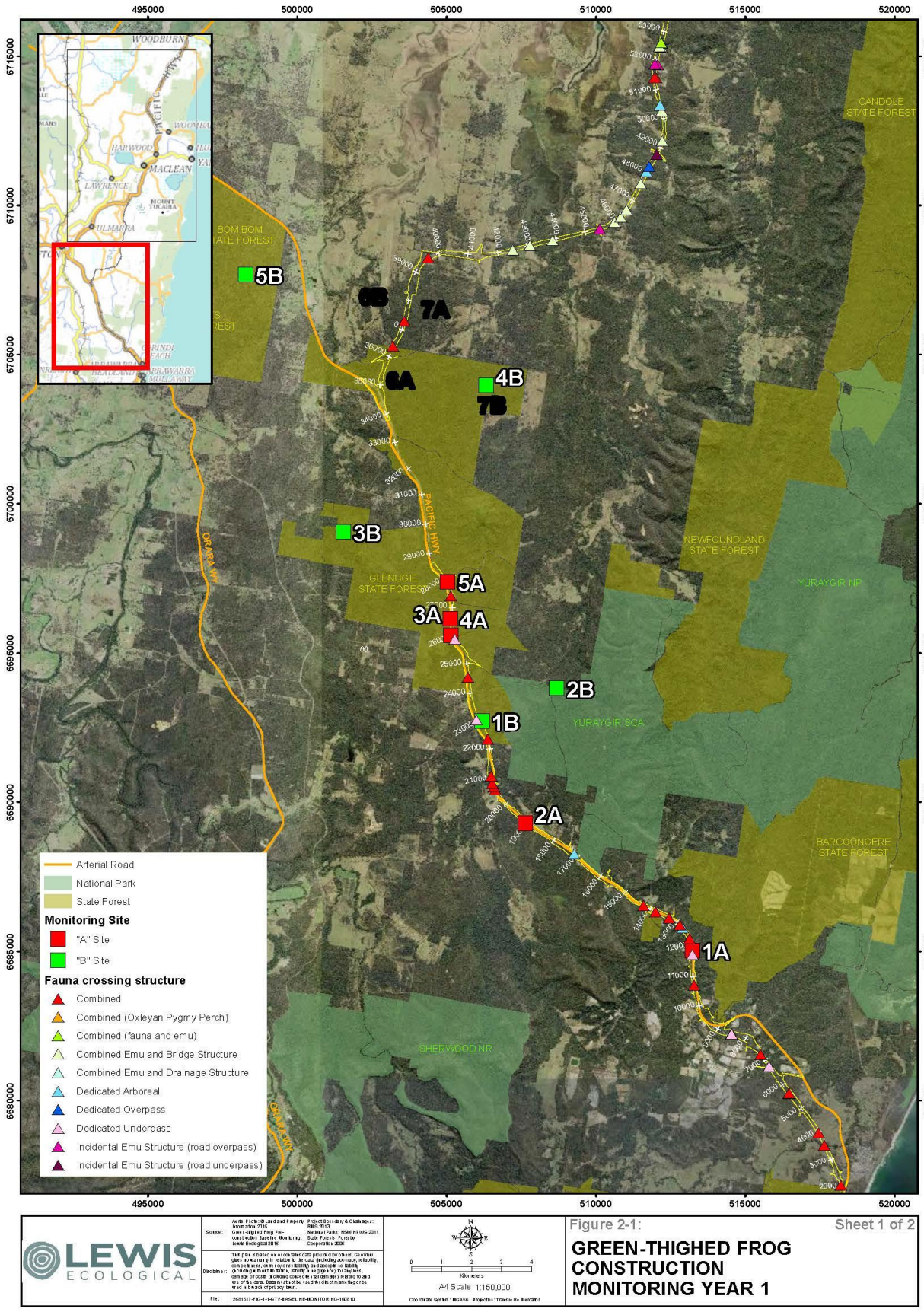

Figure 2-1. Locations of Green-thighed Frog BACI Sites 1-5 in Sections 1 and 2 of Woolgoolga to Ballina Upgrade.

3.0 MONITORING RESULTS

3.1 Frog Surveys

3.1.1 Stage 1 Surveys - Calling Intensity and Spotlighting

Green-thighed Frogs were recorded at 8 (40%) of the 10 sites and were absent from Site 1B and Site 4A (Figure 3-1; Figure 3-2). For consistency, the original Site 3A was also sampled during Year 2 and again no frogs were heard calling nor spotlighted. Attempts to locate a suitable alternative Site 1B were unsuccessful during Year 2 and the data presented here reflects the original Site 1B selected by Niche (2015).

Frogs were recorded from four (80%) of the impact sites and from four (80%) of the control sites. Frogs comprised both calling and non-calling males as well as female frogs (Table 3-1). At the newly established Site 3A, amplecting frogs were observed on the 28th February 2017 following a thunderstorm which initiated monitoring (*see* cover photo). Count sizes were generally small and in the order of 1-7 individuals.

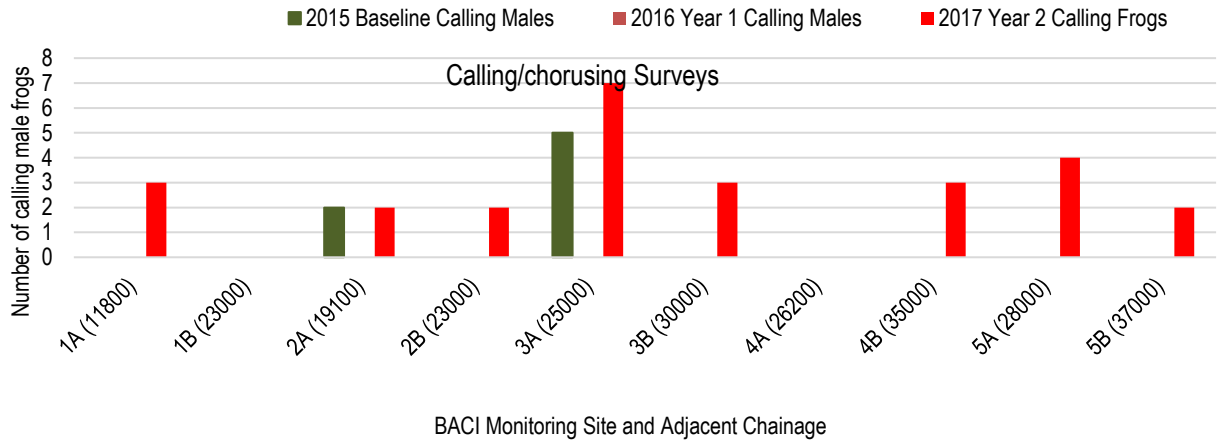

Figure 3-1. The number of calling male Green-thighed Frogs between the baseline surveys and during construction for Year 1 and Year 2 monitoring.

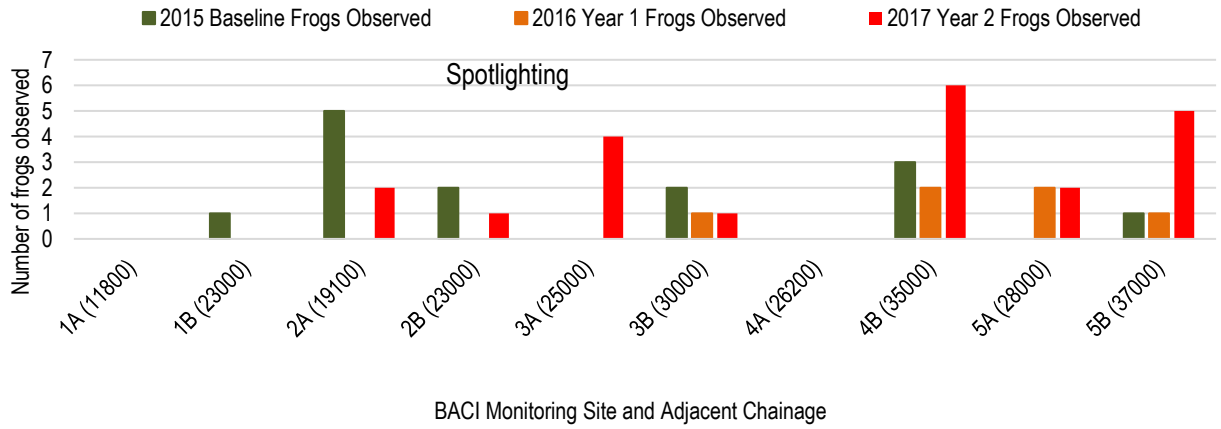

Figure 3-2. The number of Green-thighed Frogs observed between the baseline surveys (shaded) and Year 1 and 2 monitoring results.

Table 3-1. Summary of the Year 2 Green-thighed Frog surveys for BACI Sites 1-5 in Section 1 and 2 of W2B.

	Stage 1 – Calling/Breeding Surveys			Stage 2 – Post Breeding Follow-up Survey						
BACI Site	Date	No. Calling Males (chorusing intensity)	No. Frogs Spotlighted	Date	SA	Juv	Tads	Frog Management Mitigation Observed or Recorded	General Comments	Presence of Green-thighed Frogs Confirmed in 2015
1A ch.11800	16.03.2017	3	0	22.04.2017	0	0	0	i. Construction of permanent frog fencing commenced on western side of Upgrade. ii. Compensatory ponds constructed on western side. iii. Surveys performed in accordance with decision memo dated 22nd June 2015 and 12th November 2015 for minor changes to survey methods of the Threatened Frog Management Plan 2-1.	For the first time in two monitoring events, male Green-thighed Frogs were heard calling from this location. On this occasions, males were heard calling from an adjacent private property which has been recently developed for intensive horticulture. Remains a difficult site to monitor although the site can now be more safely accessed and reduced highway noise at the time of the surveys. Frogs are likely to opportunistically breed through the broader area so reliable and repeated sampling likely to remain difficult. Survey addendum methods not effective in locating frogs.	No
1B ch.23000	16.03.2017	0	0	22.04.2017	0	0	0	i. Site is impacted by works and not considered a control site. ii. No frog fencing observed.	Site is not considered a control site. It is immediately adjacent to the clearing footprint for the Upgrade and therefore an impact site. Alternative site was searched/surveyed for without success during Year 2 survey.	No
2A ch.19100	16.03.2017	2	2	22.04.2017	0	0	0	i. Frog fencing observed on both sides of the carriageway in both Giant Barred Frog and Green-thighed Frog configurations. ii. Compensatory ponds constructed on western side towards southern extent of frog exclusion fencing.	Male Green-thighed Frogs heard calling from one flooded depression around 500 m north of the constructed breeding ponds opposite the new south bound heavy vehicle checking station. Potential breeding area not well defined at this location with frogs likely to be scattered throughout the general area. Former roadside table drain previously identified as a 'hotspot' in 2013 (Lewis 2013b) now removed to accommodate newly constructed carriageway. Numbers recorded during Year 2 accord with the updated baseline monitoring data from 2015 which recorded far fewer frogs following the Kremnos Creek wildfire in August 2014.	Yes
2B ch.23000	16.03.2017	2	1	22.04.2017	0	0	0	Outside works footprint.	Small numbers of frogs recorded and this is consistent with baseline survey data. This site was also burnt during the Kremnos Creek fires.	Yes
3A ch.25800 (old)	01.03.2017	0	0	22.04.2017	0	0	0	i. No frog fencing observed.	Site burnt since the initial 2013 surveys and likely to have influenced frog numbers. Site has been replaced with new Site 3A documented below.	No

	Stage 1 – Calling/Breeding Surveys			Stage 2 – Post Breeding Follow-up Survey						
BACI Site	Date	No. Calling Males (chorusing intensity)	No. Frogs Spotlighted	Date	SA	Juv	Tads	Frog Management Mitigation Observed or Recorded	General Comments	Presence of Green-thighed Frogs Confirmed in 2015
3A ch.25000 (new)	28.02.2017	7	4	23.04.2017	1	5	0	i. Temporary frog fencing observed although damaged or failed at a number of locations. ii. Constructed ponds identified in the TFMP not constructed at the time of monitoring.	Adopted/recommended site for relocating Site 3A to Bald Knob Tick Gate Road moving 800 m south on eastern side of road (*see* Lewis 2016). Calling males, amplecting pairs and successful breeding recorded at this location. This area was one of the main breeding areas removed to accommodate the Upgrade.	Yes
3B ch.30000	01.03.2017	0	2	22.04.2017	0	0	0	Outside works footprint.	Site burnt since initial 2013 surveys and likely to have influenced frog numbers. Difficult site to pin point breeding areas and likely to vary based on extent of seasonal heavy rains, depressions left from upturned trees and localised earthworks and associated drainage.	Yes
4A ch.26200	28.02.2017	0	0	23.04.2017	0	0	0	i. Permanent frog fencing partly installed.	Site burnt since initial 2013 surveys and likely to have influenced frog numbers. Area prone to ongoing disturbance due to its proximity to road verge and routine maintenance or vehicles parking off the shoulder. Moreover, the retained breeding area will form part of a vegetated island median and not considered suitable for long term conservation of this site.	No
4B ch.35000	2.03.2017	3	6	23.04.2017	0	3	0	Outside works footprint.	Frogs are generally scattered throughout this section of Glenugie State Forest. Higher counts made here during Year 2 compared to previous monitoring events.	Yes
5A ch.28000	18.03.2017	4	1	23.04.2017	0	1	3	i. Partially installed frog fence including a mosaic of temporary and permanent. ii. Satellite compound although a wheeled portable structure located within known breeding habitat area.	Frogs recorded sporadically through the breeding area. Temporary tie in earth works have created some temporary breeding habitat for frogs. No Green-thighed Frogs recorded on the roadside of frog fence although a number of common species were observed.	Yes
5B ch.37000	19.03.2017	2	5	23.04.2017	0	2	0	Outside works footprint	Scattered throughout and site could be impacted by any trail upgrades. Road maintenance appears very infrequent in this part of Bom Bom State Forest.	Yes

3.1.3 Stage 2 Surveys – Post Breeding Counts of Tadpoles and Froglets

Tadpoles or juvenile frogs were recorded at 4 (40%) of the monitoring sites (Table 3-1). At Site 3A, one sub adult and five juvenile frogs were recorded during post breeding surveys on the 23rd April. This equates to around 55 days from the initial Stage 1 survey and 38 days from the second breeding/calling event and 23 days from a third potential breeding/calling event at the end of March. The presence of a sub adult frog indicates, either a rapidly developing frog from the late February rain event, or more likely, an earlier breeding event in response to a localised storm no captured via the Grafton Airport weather monitoring station and Grafton Rainfall Radar. Interestingly, no tadpoles were recorded during the standardised 10 sweeps of the residual pond.

At Site 4B, three juvenile froglets were captured around the drying pond (Table 3-1). These froglets may have originated from any of the heavy rainfall events from late February through to mid-March spanning 38-55 days from the post breeding survey on the 23rd April. At Site 5A, one juvenile and three tadpoles were recorded from the residual pond areas adjacent to the southern side of Franklins Road. This probably reflects the calling event recorded from the 18th March and perhaps the heavy rainfall event at the end of March and the start of April. At Site 5B, two juvenile froglets were recorded during active searches around the margins of the main pond along Stokers Road. No tadpoles were dip netted during the standardised 10 sweeps.

At the remaining sites (i.e. Site 1A, 1B, 2A, 2B, 3B, 4A), ponds were either dry (i.e. Site 1A, 4A, 3B) or contained some signs of frog fauna, most notably, Broad-palmed Frog (*Litoria latapalmata*), Bleating Tree Frog (*Litoria dentata*), Tyler's Tree Frog (*Litoria tyleri*)and/or Perons Tree Frog (*Litoria peronii*) and some *Limnodynastes* species, presumably Northern Banjo Frog (*Limnodynastes terraereginae*), Striped Marsh Frog (*Limnodynastes peroni*) and Ornate Burrowing Frog (*Platyplectrum ornatum*).

3.2 Constructed Breeding Ponds

No Green-thighed Frogs were recorded breeding in the constructed ponds at Redbank Creek (ch. 5600 E) nor at Site 1A (ch.11800 W) or Site 2A (ch. 19100 W). At Site 3A (ch. 25000) where the new impact site has been relocated, no compensatory breeding ponds were constructed at the time this monitoring was undertaken (i.e. late February through to late April 2017). A summary of the site inspections is presented below and in Table 3-2.

3.2.1 Redbank Creek Ponds (5600 E)

Monitoring commenced on the evening of 16th March 2017 where all four ponds had filled to capacity following an estimated 80 mm of rainfall in the past 60 hrs. At this time, no Green-thighed Frogs were heard or observed around the ponds, however, two male frogs were heard calling from the western side of the carriageway or around 100 m to the west. Chorusing males (*approx.* 7-10 males) were also heard at a new location around 1 km to the north where McLaughlin Road was being constructed at the time. Access constraints prevented any cursory surveys to the east of the constructed ponds, however, past approved access would indicate Green-thighed Frog is likely to inhabit that area.

A follow up survey two weeks later on the 31st March again revealed a similar situation as heavy rainfall had brought about localised flooding. A potential post breeding survey was performed on the 22nd April, 37 days after a localised calling/breeding event. All four ponds still retained water, however, the water had receded by 20 to 60% but still considered functional.

3.2.2 Falconers (11800 W)

Monitoring commenced on the evening of 16th March 2017 where the three upslope ponds had filled with sediment and the remaining two ponds had varying amounts of sediment following an estimated 80 mm of rainfall in the past 60 hrs. Although no Green-thighed Frogs were heard calling from around the ponds, male frogs were heard calling from the adjacent private property.

A follow up survey two weeks later on the 31st March again revealed a similar situation as heavy rainfall had brought about localised flooding, however, a fourth downslope pond had filled with sediment leaving only the lowest or fifth pond in a functional state. A potential post breeding survey was performed on the 22nd April, 37 days after a localised calling/breeding event. Four of the five ponds were dry and contained sediment, whilst the fifth pond contained around 10% capacity but considered functional at this time.

3.2.3 Halfway Creek (19100 W)

Monitoring of the Halfway Creek ponds commenced on the 28th February. At this time, all four ponds contained between 50-120 mm of water. Follow up surveys on the 16th March found all four ponds had filled to capacity following an estimated 80 mm of rainfall in the past 60 hrs. Although no Green-thighed Frogs were heard calling from around the ponds, male frogs were heard calling from a few hundred metres further to the north.

A post breeding survey performed on the 22nd April, 37 days after frogs were heard calling (i.e.16th March) found ponds contained around 10-25% of their capacity. The 100 mm rainfall event at the end of March is likely to have ensured water remained in these ponds throughout the post breeding monitoring period.

3.2.4 Bald Knob Tick Gate Road (25000 E)

At the time monitoring was performed, no breeding ponds had been constructed.

Table 3-2. Summary of compensatory frog pond monitoring during Year 2.

Site	Ch. + Side of Carriageway	Number of Constructed Ponds	First Survey	Second Survey	Third Survey	Comments
Redbank Creek	5600 East	4	16th March 2017 All ponds filled to capacity. Visual Water Quality – same as adjacent Redbank Creek and flooded depressions.	31st March 2017 All ponds filled to capacity. Visual Water Quality – same as adjacent Redbank Creek and flooded depressions.	22nd April 2017 Ponds receded and contain 20-60% capacity. Visual Water Quality – same as adjacent Redbank Creek and flooded depressions.	Without follow up rain, ponds likely to dry within 30 days.
Falconers	11800 West	5	16th March 2017. Three upslope ponds filled with sediment and no longer considered functional. Two lower ponds contained some sediment but filled with water and considered functional. Visual Water Quality – Turbid and continuing to rain at time of inspection.	31st March 2017. Fourth pond filled with sediment leaving only the fifth or lower pond filled with water. Visual Water Quality – Turbid flows resulted in four upslope ponds filling with sediment.	22nd April 2017. Fifth pond receded by 75% but still contained water and considered functional. Visual Water Quality – Fifth pond is only available water for inspection, clear but has sediment loading on bottom.	Most of the ponds filled with sediment and no longer considered functional. Follow up rainfall considered essential for pond five to retain water for more than 30 consecutive days. Frogs calling in adjacent areas indicating some suitable breeding habitat may be retained on adjacent private property.

Site	Ch. + Side of Carriageway	Number of Constructed Ponds	First Survey	Second Survey	Third Survey	Comments
Halfway Creek	19100 West	4	28th February 2017 Ponds contained between 50-120 mm water. Visual Water Quality – same as adjacent flooded areas to the south with a slight tannin stain.	16th March 2017 Ponds filled to capacity during heavy rainfall. Visual Water Quality – same as adjacent flooded areas to the south with a slight tannin stain.	22nd April 2017 Ponds receded to 10-25% of their capacity. Visual Water Quality – same as adjacent flooded areas to the south with a slight tannin stain.	Follow up rainfall required to ensure ponds retain water for more than 30 consecutive days.
Bald Knob Tick Gate Road	25000 East	Not constructed	Not applicable	Not applicable	Not applicable	Not constructed at the time of Year 2 monitoring.

3.3 Frog Fencing

Although no Green-thighed Frogs were found in close proximity to the frog exclusion fence, numerous other species of frog were recorded on both the habitat and road side of this fence (Table 3-3). Numbers of frogs were generally four to seven times higher on the habitat side of the fence indicating the fence design is effective at reducing frogs accessing the carriageway. Observations included both ground dwelling and tree frogs, the latter of which often choose to use the fence as a calling site adjacent to flooded ponds. At Site 4A, an equal number of frogs were recorded on either side of the fence.

Plate 3-1. Hylid tree frogs (*Litoria gracilenta*) using the habitat side of the frog exclusion fence as calling sites at Halfway Creek (Site 2A).

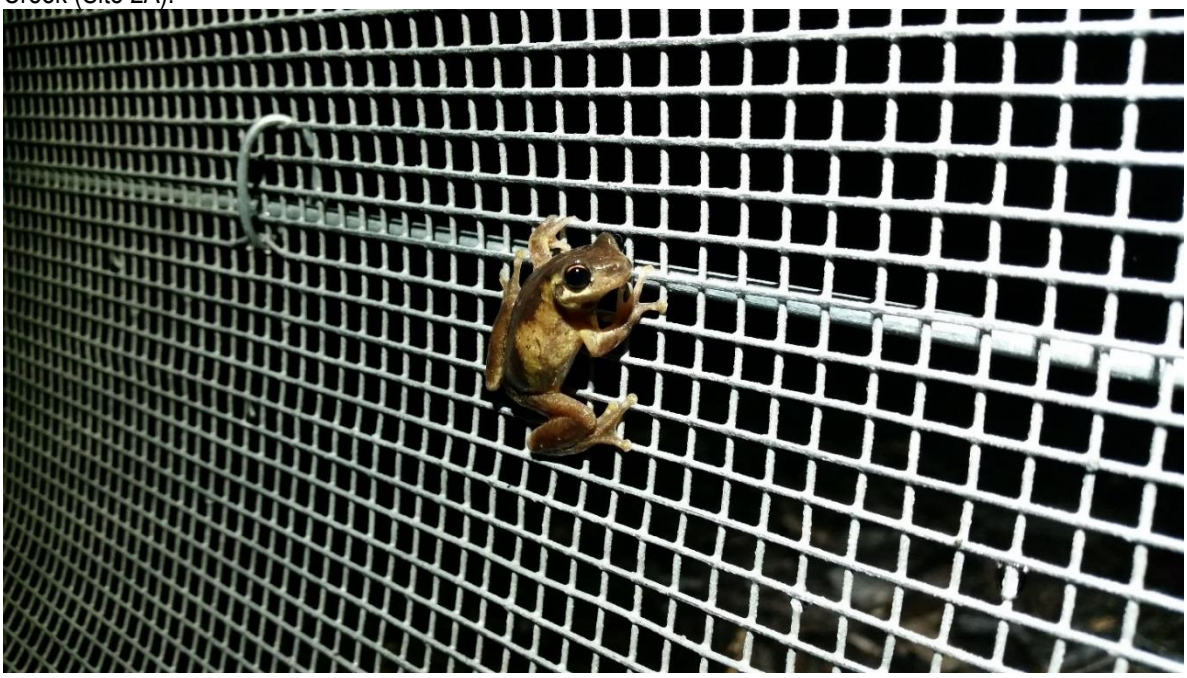

Plate 3-2. Example of other hylid frogs (i.e. *Litoria dentata*) using the habitat side of the frog exclusion fence at Site 5A.

Table 3-3. Summary of permanent frog exclusion fence monitoring during Year 2.

Site	Ch. + Side of Carriageway	Status of Fencing	Fencing Extent Surveyed	Frogs Within 2 m Habitat Side of Fence	Frogs on Road Side of Fence	Comments
Redbank Creek	5600 East	Nearing completion of permanent fence	5500-5625	*Litoria latapalmata* x 14 *Litoria nasuta* x 6 *Litoria dentata* x 3 *Platyplectrum ornatum* x 5 *Limnodynastes peroni* x 8 *Litoria gracilenta* x 7 *Crinia parinsignifera* (heard) Total = 43	*Litoria latapalmata* x 3 *Litoria dentata* x 1 *Platyplectrum ornatum* x 1 *Limnodynastes peroni* x 1 *Crinia parinsignifera* (heard) Total = 6	Some minor breaches and finishing attention at tie in to culvert and directional changes required. Majority of frogs found on habitat side indicating frog fence is effective with a ratio of 7.2 frogs to every frog on roadside.
Falconers	11800 West	Under construction	11700-11850	*Litoria latapalmata* x 4 *Litoria nasuta* x 1 *Litoria dentata* x 2 *Platyplectrum ornatum* x 1 Total = 8	*Limnodynastes peroni* x 1 *Litoria latapalmata* x 1 Total = 2	Steep batter associated with this area probably improves the functionality of the fence. Ratio reduced to 4 frogs on habitat side of fence to every frog on the road side of the fence.
Halfway Creek	19100 West	Constructed	19000-19500	*Litoria latapalmata* x 23 *Litoria nasuta* x 17 *Litoria dentata* x 43 *Platyplectrum ornatum* x 26 *Limnodynastes peroni* x 23 *Litoria gracilenta* x 15	*Litoria latapalmata* x 8 *Litoria nasuta* x 4 *Litoria dentata* x 2 *Platyplectrum ornatum* x 5 *Limnodynastes peroni* x 1 *Litoria gracilenta* x 1 *Limnodynastes terraereginae* x 5	Greater extent of frog fence walked than at other locations. One female Green-thighed Frog found just a few metres on the habitat side of the frog fence. Ratio at this location is 5.5 frogs for ever frog found on road side of fence.

Site	Ch. + Side of Carriageway	Status of Fencing	Fencing Extent Surveyed	Frogs Within 2 m Habitat Side of Fence	Frogs on Road Side of Fence	Comments
				Limnodynastes terraereginae x 24 *Crinia parinsignifera* x 15 + numerous heard Total = 186	*Crinia parinsignifera* x 8 + numerous heard Total = 34	
Bald Knob Tick Gate Road	25000 East	Temporary fence only	No counts performed	No counts performed	No counts performed	Temporary fence in various states of disrepair.
Old Highway Heavy Vehicle Checking Station	26200 West	Under construction	26100-26250	*Litoria latapalmata* x 4 *Litoria nasuta* x 7 *Litoria dentata* x 3 *Platyplectrum ornatum* x 1 *Litoria gracilenta* x 1 *Limnodynastes terraereginae x 2* *Limnodynastes tasmaniensis x 2* *Crinia parinsignifera* x heard Total = 20	*Litoria latapalmata* x 3 *Litoria nasuta* x 5 *Platyplectrum ornatum* x 4 *Litoria gracilenta* x 4 *Limnodynastes terraereginae x 1* *Crinia parinsignifera* x 3 + heard Total = 20	Residual pond on western side of fence which has attracted a number of frogs close to the roadside. Ponds themselves are bisected by old highway and the new carriageway under construction. Same number of frogs were recorded on either side of the fence.

3.5 Seasonal Rainfall and Associated Survey Conditions

Suitable seasonal conditions in the form of heavy rainfall events exceeding 50 mm in 24 hours or cumulative tallies exceeding 150 mm in 72 hours occurred on only a few occasions (Table A-2). Rainfall events exceeding 50 mm in 24 hours occurred on the 16th (63.8 mm), 18th March (92.4 mm) and the 31st March (86 mm) whilst cumulative tallies exceeding 150 mm over 72 hours only occurred on the 18th-20th March when the study area received 162.8 mm. Consequently, breeding may have occurred from late summer through to mid autumn.

4.0 DISCUSSION

Monitoring opportunities during Year 2 were again delayed in response to ongoing dry conditions, or more precisely, a lack of suitable rainfall events. Monitoring for Green-thighed Frog generally commences from around mid to late September each year, however, no suitable rainfall events occurred during the entirety of spring and summer and it wasn't until the 16th March 2017 before a rainfall exceeding 50 mm in 24 hrs was recorded. The sampling that occurred around the end of February and the start of March was in response to localised heavy falls where the actual monitoring sites were likely to have received a little more rainfall than the 30.6 mm recorded at Grafton Airport (Station 058161). Consequently, multiple surveys were required to achieve the calling/breeding dataset presented here with sampling at the end February into the start of March, again in mid March and some cursory follow up works in late March 2017.

Frogs were recorded at most of the BACI monitoring sites during Year 2, and with that, a twofold increase from Year 1 when frogs were recorded at only 40% of the sites. The apparent response or increase during Year 2 is nothing more than the variance in the sampling times given this round of monitoring was performed at the end of summer and during the early part of autumn as opposed to the start of winter for Year 1. Small numbers of frogs were recorded at both the impact and control treatments and no single site recorded markedly more frogs as they had done in the past when design surveys recorded hundreds of frogs calling from some locations such as Site 2A at ch.19100 (Lewis 2013).

In accordance with the recommendations outlined in the Year 1 monitoring report, an alternative Site 1B could not be located around Julies Road nor Georges Road in Yuraygir State Conservation Area despite some targeted survey works at the start of March and again in mid-March. For continuity, the original Site 1B was surveyed rather than having an omission of a control site for Year 2. Opportunities to locate a suitable site should be explored during Year 3.

Increased numbers of calling male frogs were recorded at Site 1A, 2B, the newly created Site 3A, Site 3B, Site 4B, Site 5A and Site B. Chorus intensity either equalled or exceeded the 2015 baseline data that was recollected to adjust for the Kremnos Creek wildfire in August 2014 (Lewis 2015). This increase in chorusing frogs probably reflects surveys coinciding with warmer ambient air temperatures than surveys performed when suitable rainfall eventually arrived at the start of winter in Year 1 (Lewis 2016).

Frogs continue to remain absent at old Site 3A which is located in a table drain immediately adjacent to ch. 25800. The alternative or adopted Site 3A (ch. 25000 E) was surveyed as part of Year 2 recommendations, and with this, frogs were recorded calling and in amplexus (i.e. mating) during surveys on the 28th February whilst post breeding surveys in the later part of April confirmed the success of this breeding event with a sub adult and juveniles. This breeding site tends to provide better breeding opportunities during drier seasons as the clay sub soils and higher water retention capabilities is shown in the presence of aquatic plants (Frogsmouth, *Philydrum lanuginosum*). Apart from some temporary frog fencing,

no other on ground management action was observed at this location during the survey. For example, the construction of permanent frog exclusion fencing or the commitment to construct compensatory breeding ponds at this location.

Year 2 monitoring surveys also found no frogs at Site 4A and it has only been the initial design surveys in 2013 which have recorded frogs at this location (Lewis 2013). As only north bound traffic are forecast to utilise this area in the future, Year 3 monitoring will provide some useful insights as the site will become isolated as a vegetated median on the eastern side of the old carriageway.

Monitoring during Year 2 was able to confirm frogs continue to reside and successfully breed at Site 5A. A similar outcome was achieved for Site 5B which had been relocated upslope to Stokers Road where small numbers of frogs have been recorded during both the baseline and Year 1 monitoring surveys. This site is susceptible to periodic road maintenance works, a not uncommon observation at many Green-thighed Frog breeding sites in north eastern NSW.

No Green-thighed Frogs were recorded using the compensatory frog ponds installed at Redbank Creek (ch. 5600 E), Falconers (ch. 11800 W) and Halfway Creek (ch. 19100 W). Ponds constructed at Redbank Creek held water over an extended period of more than 50 days and these were bolstered by multiple heavy rainfall events to suggest they had the potential to support Green-thighed Frog tadpoles through to a metamorphling stage. Further monitoring will provide useful information on how these ponds respond to varying rates of rainfall over time. The ponds constructed at Falconers appear more problematic. Four of the five ponds have filled with sediment and are no longer considered functional. The fifth pond contained water for an adequate amount of time during this round of monitoring, however, the combination of dispersive soils and reduced vegetation cover on the neighbouring batter is likely to result in this pond becoming less suitable in time. The Halfway Creek ponds required a considerable amount of rain (>100 mm) to fill them to capacity, and once filled, they tend to recede quickly over a few weeks. On this occasion, follow up rains were able to maintain water in each of these ponds and similar rainfall events will be required after each calling/breeding event for remain functional.

Year 2 provided an opportunity to evaluate the effectiveness or functionality of the permanent frog fencing at a number of locations. None of the surveys found Green-thighed Frogs close to or on the road side of the fence, however, data collected for all frog fauna found far fewer frogs inhabiting the road side of the exclusion fence than on the habitat side of the fence at Redbank Creek (ch. 5600 E), Falconers (ch. 11800 W) and Halfway Creek (ch. 19100 W). Often these ratios were in the order of magnitude four to seven times lower and at this stage of the monitoring program they appear effective. Interestingly, an equal number of frogs were recorded on both the road and habitat side at the old Glenugie Southbound Heavy Vehicle Checking Station (26600 W), a location which has created a fragmented island or vegetated median of retained vegetation that used to support a breeding site for Green-thighed Frog. Further monitoring of this site will prove useful in determining its role as an effective mitigation tool for threatened frog fauna.

How the data compares or performs against the prescriptions outlined in the Threatened Frog Management Plan is outlined in the following section.

5.0 PERFORMANCE INDICATORS AND CORRECTIVE ACTIONS

A series of performance indicators and corrective actions have been outlined in Section 7.2.3 of the Threatened Frog Species Management Plan (RMS 2015). This plan states that *should it become clear that sites that were occupied prior to road construction (i.e. established impact monitoring sites) have become unoccupied, or abundance (estimated using the transect counts) has declined beyond the identified thresholds (i.e. 25%) relative to control/reference sites, corrective actions must be implemented in accordance with those provided in Table 7-1.*

Year 2 monitoring collected data in relation to population monitoring and constructed compensatory ponds whilst the culverts and revegetation works monitoring is yet to commence. The original performing factor for the population monitoring was the number of male frogs calling during the Stage 1 or calling/breeding survey, however, the reality of this meant that sites which actually contained non calling frogs were scored a zero. Consequently, it was recommended (*see* R1a in Lewis 2016) to update this performance measure to the total count of frogs during the Stage 1 survey.

With the above taken into account, no further declines were recorded between Year 1 and Year 2, however, a decline remains evident at Site 1B, a site which has been recommended to be abandoned (Lewis 2016). At Site 4A, frogs have remained absent from the updated baseline field surveys through years 1 and 2.

Year 2 represents the first year when the constructed ponds at Redbank Creek (ch.5600E), Falconers (ch.11800W) and Halfway Creek (ch.19100W) have been monitored. Apart from no Green-thighed Frogs recorded using the ponds at Redbank Creek and Halfway Creek, they are considered suitable and provide potential breeding habitat that is Mosquito Fish free. Consequently, they are required to undergo two more seasons of monitoring without Green-thighed Frogs using them before any corrective action is required. In contrast, the ponds at Falconers ponds have been assessed as not performing on the basis that four of the five ponds have filled with sediment and are reliant on the fifth pond at present. Among the corrective actions identified is the requirement to perform a site specific investigation and with this undertake revegetation maintenance including replanting and erosion control.

Table 5-1. Performance indicators and corrective actions from the Threatened Frog Species Management Plan (RMS 2015).

Triggers for corrective actions	Corrective actions	Relevance to Year 2 Green-thighed Frog Monitoring	Results of Year 2 Green-thighed Frog Monitoring	Potential Contributing Factors	Corrective Action Required
Population Monitoring					
The absence of threatened frogs at impact sites identified as occupied in the baseline monitoring surveys. A relative decline in abundance of 25% or more at an impact site than its relative control site over 3 consecutive monitoring periods. Frog abundance determined by standardised transect counts: • Number of Wallum Sedge Frogs per 100 m2 of habitat; • Number of Giant Barred Frogs per 500 m of habitat; • Number of adult male Green-thighed Frogs per Stage 1 survey (breeding survey) (as outlined in Section 4.3).	Review monitoring methods immediately, considering further monitoring and assessment if there is a decline in population abundance. Investigate effectiveness of frog exclusion fencing immediately. Closely monitor habitat conditions over a period of three months to ensure they are suitable, in particular hydrology (hydro-period), water quality and vegetation. Assess the requirement for additional offsets where a threatened frog population is no longer present in a previously occupied area, and this habitat is deemed unsuitable for the target species.	Relevant	Green-thighed Frogs absent from Site 1B, old 3A and 4A. Site 1A, 2A, 3A and 5A recorded frogs and no notable declines. Site 4A continues to record no frogs which is consistent with the updated baseline survey of Lewis (2015).	Site 4A was poorly defined site and is subject to fragmentation, ongoing habitat disturbance and may only be occasionally used during moderate and major flood events. Monitoring sites can be difficult to monitor with data likely to be affected by prevailing road noise. Construction management actions may not have been effective with post clearing reports for Sections 1 and 2 not recording any frogs.	Wait until third monitoring event before determining the requirements for any corrective actions.
Underpass Structure Monitoring					
The use of the structure by less than 1% of the estimated population size. Connectivity structures not maintained (i.e. culverts clogged with debris or sedimentation). Frog exclusion fencing damaged or ineffective.	Review monitoring methods where goals are not achieved, by increasing frequency, intensity and duration, to ensure individuals are identified. Survey habitat adjoining the connectivity structures and undertake Landscape improvement (planting, weed removal) to improve habitat functionality. Survey and monitor crossing structures and frog fencing to ensure they are functional (i.e. are adequately maintained, including fencing is not damaged, and connectivity structure is operating correctly). Monitor twice per year. Assess the need for offsets if connectivity structures are identified as ineffective over three consecutive monitoring periods.	No relevant at this point in time. Structures are not operational.	Not Applicable	Not applicable	Not Applicable

Triggers for corrective actions	Corrective actions	Relevance to Year 2 Green-thighed Frog Monitoring	Results of Year 2 Green-thighed Frog Monitoring	Potential Contributing Factors	Corrective Action Required
Constructed Pond Monitoring					
Absence of threatened frogs and metamorphs at the compensatory ponds after three years since construction.	Investigation be undertaken to determine why there may be a lack of success and, as where recommended, changes be made to the habitat and monitored for effectiveness (i.e. 3 more years of monitoring) Review monitoring methods, considering timing and weather conditions to ensure individuals are identified. Review location of the compensatory pond and consider moving, and/or modifying or constructing additional ponds. Investigate habitat adjoining the upgraded highway and consider improving habitat condition and connectivity.	No relevant at this point in time. Ponds have recently been constructed in Section 1 and forecast into monitoring program for Year 2	Redbank Creek (ch. 5600) no sign of use. Halfway Creek (ch. 19100) no sign of use. Bald Knob Tick Gate Road (ch. 25000) ponds remain unconstructed	At Redbank Creek, frogs were heard calling from western side of road which confirm presence in the area. With time, these ponds are likely to be used. Frog population at Halfway Creek still undergoing a recovery from Kremnos Creek wildfire event in 2014 and with that there are lower numbers of frogs. Ponds not constructed at Bald Knob Tick Gate Road.	Construct ponds at Bald Knob Tick Gate Road (ch. 25000) as this area contained breeding habitat that was removed to accommodate the Upgrade.
Water pH exceeds 5.5 for Wallum Sedge Frog	Investigate ways to reduce pH of water.	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Visual water quality of the compensatory pond is not similar to nearby unimpacted and/or similar wetlands or is unsuitable for frog occupation.	Complete site specific investigation to identify the causes of the unsuitable hydrological conditions or water quality.	Redbank Creek (5600E) Falconers (11800W), Halfway Creek (19100W). Ponds at Bald Knob Tick Gate Road remain unconstructed.	Redbank Creek is similar as is Halfway Creek. Falconers contains high sediment loads (i.e. turbid).	Highly dispersive soils. Reduced vegetative cover on newly constructed batters	Applicable
No persistent water present in ponds (negative hydroperiod) despite recent rainfall.	Assess possible causes for water draining from the pond and apply physical corrective actions	Redbank Creek (5600E) Falconers (11800W), Halfway Creek (19100W). Ponds at Bald Knob Tick Gate Road remain unconstructed.	Redbank Creek and Halfway Creek ponds considered to contain functional amounts of water over consecutive numbers of days. Falconers only retained water in Pond 5 whilst remainder filled with sediment.	Follow up rain at 7 to 14 day intervals ensured most ponds retained water for an acceptable amount of time 35-55 days. At Falconers, sediment filled the ponds.	Applicable

Triggers for corrective actions	Corrective actions	Relevance to Year 2 Green-thighed Frog Monitoring	Results of Year 2 Green-thighed Frog Monitoring	Potential Contributing Factors	Corrective Action Required
Mosquito Fish present and threatened frogs / tadpoles absent.	Draining pond to remove Mosquito Fish and allow pond fill at the next rain event.	Redbank Creek (5600E) Falconers (11800W), Halfway Creek (19100W). Ponds at Bald Knob Tick Gate Road remain unconstructed.	No fish recorded in any of the constructed ponds.	Not Applicable	Not Applicable
Constructed habitat un-suitable for frogs (e.g. wetlands have un-suitable hydro-period (as determined from monitoring events), water quality or associated vegetation) as detailed in section 5.4.4.	Undertake revegetation maintenance, i.e. replanting, erosion control, weed control.	Redbank Creek (5600E) Falconers (11800W), Halfway Creek (19100W). Ponds at Bald Knob Tick Gate Road remain unconstructed.	Redbank Creek and Halfway Creek ponds considered to contain functional amounts of water over consecutive numbers of days. Falconers only retained water in Pond 5 whilst remainder filled with sediment.	Follow up rain at 7 to 14 day intervals ensured most ponds retained water for an acceptable amount of time 35-55 days. At Falconers, sediment filled the ponds.	Applicable at Falconers only (ch. 11800 W)
Revegetated native habitat in poor condition (e.g. >30% cover died, plant dieback).	Ensure wetlands are functioning as designed and present suitable habitat in terms of water quality and hydro-period.	Redbank Creek (5600E) Falconers (11800W), Halfway Creek (19100W). Ponds at Bald Knob Tick Gate Road remain unconstructed.	Redbank Creek plants with suitable species including *Juncus* and *Carax spp*. Falconers largely devoid of vegetative cover. Halfway Creek retained adjacent native ground cover.	At Falconers only, highly dispersive soils and sedimentation.	Applicable at Falconers only (ch. 11800 W)
Frog absence confirmed following monitoring surveys (it should be noted that a pond may be suitable for frogs, but not colonised).		Redbank Creek (5600E) Falconers (11800W), Halfway Creek (19100W). Ponds at Bald Knob Tick Gate Road remain unconstructed.	Redbank Creek ponds considered suitable. Only one of the Falconer ponds considered suitable, remainder are silted and contain no water. Halfway Creek ponds considered suitable.	At Falconers only, highly dispersive soils and sedimentation rendering ponds incapable of holding water.	Applicable at Falconers only (ch. 11800 W)

Triggers for corrective actions	Corrective actions	Relevance to Year 2 Green-thighed Frog Monitoring	Results of Year 2 Green-thighed Frog Monitoring	Potential Contributing Factors	Corrective Action Required
Riparian Habitat Revegetation					
Greater than 10% of riparian plants have died after first 12 months of maintenance. Greater than 20% of riparian plants have died after three years of maintenance. Total weed coverage is more than 30% in revegetation areas. Bank erosion causes unforeseen revegetation area instability.	Review maintenance schedule for revegetated areas immediately after trigger. Replace dead plants within one month of issue being identified. Increase weed control if required as soon as practicable or review control methods being used. Install physical measures to halt bank erosion within one month of issue being identified.	Not relevant at this point in time. Landscape and habitat rehabilitation is expected to commence during Year 2 of the Green-thighed Frog monitoring program	Not Applicable	Not Applicable	Not Applicable

6.0 CONCLUSIONS AND RECOMMENDATIONS

A dry spring and summer resulted in sampling for Year 2 being delayed until the end of February and into March 2017. At this time, calling male frogs and other non-calling male and female frogs were recorded at eight of the 10 monitoring sites, and this reflects a marked increase from Year 1 when only four sites recorded frogs during sampling at the start of winter.

Stage 2 post breeding surveys recorded signs of successful breeding at four sites including the newly adopted Site 3A, Site 5A and at control Site 4B and Site 5B. Again, this reflects improved site sampling conditions from Year 1 more so than any marked change or improvement in habitat. Successful breeding events commenced on the 28th February and were sporadic through March and into early April 2017.

With regard to compensatory breeding ponds, none of these were found to support calling or breeding frogs during their first monitoring season. Some encouraging data were obtained nonetheless, with Green-thighed Frogs being confirmed in the Redbank Creek area and the ponds retaining water at a rate that is commensurate to the development of their tadpoles. At Halfway Creek, the ponds require very heavy rainfall (>75 mm in 24 hrs) for them to reach their capacity and without follow up rain, they appear to recede quickly over a period of weeks. Further monitoring is required to assess how these may serve as compensatory breeding ponds over the next two seasons. The ponds at Falconers require some attention so that they function in the manner they are intended for and that the contributing factors causing the sedimentation are addressed.

The updated performance indicators would suggest frog numbers are within acceptable thresholds at all of the impact sites except Site 4A where frogs have remained absent during Year 1 and Year 2 monitoring. Whilst the Year 1 monitoring report raised concerns in relation to the effectiveness of management actions that accompanied the clearing and grubbing program, there are other contributing factors including the Kremnos Creek fire which burnt all of this site in late winter when aestivation and stored energy levels would be low for this species. The original records for this location were obtained during a moderate flood event for the Clarence River in January 2013, and since this time, there has been no comparable rainfall and localised flood event of this scale. Put simply, frogs may only breed here during very high rainfall events, a hypotheses that can only be explored should a similar weather event occur during the monitoring period.

In light of the Year 2 findings, the following recommendations are outlined in Table 6-1.

Table 6-1. Year 2 Green Thighed Frog Sections 1 & 2 recommendations and RMS responses.

ID No	Recommendation	Roads and Maritime Response
1.	Continue investigations into finding a suitable alternative monitoring Site 1B so that it is an adequate distance adjacent to the carriageway.	Adopted - RMS agrees with the recommendation to investigate finding an alternative monitoring Site 1B.
2.	Investigate in accordance with the corrective actions the functionality of compensatory breeding ponds at Falconers (ch.11800W).	Adopted – RMS has undertaken a site visit with ecologist to identify corrective actions including a combination of desilting and relocating frog ponds at Falconers. It is anticipated that works will be undertake in late 2018, early 2019.
3.	Construct compensatory frog ponds at Ch. 25000 (Bald Knob Tick Gate Road).	Adopted - RMS has undertaken a site visit with ecologist to investigate suitable locations to construct frog ponds at Ch. 25000 (Bald Knob Tick Gate Road). It is anticipated that these will be constructed in late 2018, early 2019.
4.	Survey effort should be increased so that it can allow for up to two suitable rainfall events to trigger sampling for Stage 1 calling and breeding surveys. Without this, sites are likely to record inaccurate low numbers of frogs, and in some cases, no frogs at all.	Not Adopted – Monitoring to continue in accordance with the baseline surveys and approved Threatened Frog Management Plan.
5.	The post breeding surveys known as stage 2 surveys incorporate an evening spotlight of 30 minutes duration as this proved useful to re confirm the presence of Green-thighed Frogs at multiple locations where the earlier surveys breeding/calling and tadpole/metamorph surveys could not (see Lewis 2015). Due consideration should be given to incorporating this abundance data into the performance measure as well.	Not Adopted – Monitoring to continue in accordance with the baseline surveys and approved Threatened Frog Management Plan.

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8.0 APPENDIX A – GREEN-THIGHED FROG SURVEY SUMMARY DATA & SEASONAL RAINFALL CONDITIONS

Table A1. Summary of Green-thighed Frog surveys in Sections 1 and 2: Year 1 (2016).

BACI Site	Adjacent Chainage	Site Name	Easting Northing	Stage 1 Survey Date	Time (24hr)	AT °C	Hum %	Wind	Rain	CC	No. Calling Males (chorusing intensity)	No. Frogs Spotlighted	Stage 2 Survey Date	Days After Chorusing	No. Sub Adults	No. Juv	No. Tads	Breeding Confirmed	Comments
Compensatory Breeding Pond - Redbank Creek	5600	Redbank Creek	E:516564 N:6680284	16.03.2017	2135-2205	21	100	0	2	100	0	0	22.04.2017	37	0	0	0	No	Two males were heard calling on western side of road in same tributary
1A	11800	Dirty Creek Range / Falconers	E:503224 N:6685035	01.03.2017	0155-0221	20	91	0	1	40	0	0	22.04.2017	52	0	0	0	No	Nil frogs on both sides of the road
1A	11800	Dirty Creek Range / Falconers	E:503224 N:6685035	16.03.2017	2255-2325	21	100	0	2	100	3	0	22.04.2017	37	0	0	0	No	All three were calling in an adjacent area ~ 75m west north west of constructed compensatory ponds
1A	11800	Dirty Creek Range / Falconers	E:503224 N:6685035	18.03.2017	2053-2117	21.7	97	0	2	100	2	0	22.04.2017	35	0	0	0	No	Frogs difficult to pin point but appear to be calling from in adjacent private property. Constructed ponds largely filled with sediment, however, bottom ponds still considered sufficient.
1A - Compensatory Breeding Pond - Dirty Creek Range	11800	Dirty Creek Range / Falconers	E:513172 N:6685262	01.03.2017	0155-0221	20	91	0	1	40	0	0	22.04.2017	52	0	0	0	No	Lower ponds considered more suitable than ponds upslope which had filled with sediment
1A - Compensatory Breeding Pond - Dirty Creek Range	11800	Dirty Creek Range / Falconers	E:513172 N:6685262	16.03.2017	2255-2325	21	100	0	2	100	0	0	22.04.2017	37	0	0	0	No	Lower ponds considered more suitable than ponds upslope which had filled with sediment
1A - Compensatory Breeding Pond - Dirty Creek Range	11800	Dirty Creek Range / Falconers	E:513172 N:6685262	18.03.2017	2053-2117	21.7	97	0	2	100	0	0	22.04.2017	35	0	0	0	No	Lower ponds considered more suitable than ponds upslope which had filled with sediment
1A - Frog Fencing	11750-11880	Dirty Creek Range / Falconers	E:513190 N:6685262	01.03.2017	0221-0247	20	91	0	1	40	0	0	not relevant	not relevant	not relevant	not relevant	not relevant	not relevant	Frog fencing incomplete at time of survey

BACI Site	Adjacent Chainage	Site Name	Easting Northing	Stage 1 Survey Date	Time (24hr)	AT °C	Hum %	Wind	Rain	CC	No. Calling Males (chorusing intensity)	No. Frogs Spotlighted	Stage 2 Survey Date	Days After Chorusing	No. Sub Adults	No. Juv	No. Tads	Breeding Confirmed	Comments
1A - Frog Fencing	11750-11880	Dirty Creek Range / Falconers	E:513190 N:6685262	16.03.2017	2320-2340	21	100	0	2	100	0	0	not relevant	not relevant	not relevant	not relevant	not relevant	not relevant	Frog fencing incomplete at time of survey
1A - Frog Fencing	11750-11880	Dirty Creek Range / Falconers	E:513190 N:6685262	18.03.2017	2110-2129	21.7	97	0	2	100	0	0	not relevant	not relevant	not relevant	not relevant	not relevant	not relevant	Frog fencing incomplete at time of survey
1B - Old (As per TFMP RMS 2015)	23000	Wells Crossing Beside Road	E:506185 N:6692721	28.02.2017	0103-0129	19.5	91	0	1	40	0	0	22.04.2017	53	0	0	0	No	Difficult to pin point specific calling/breeding site as original baseline records were from non-breeding frogs foraging
1B - Old (As per TFMP RMS 2015)	23000	Wells Crossing Beside Road	E:506185 N:6692721	16.03.2017	2055-2132	22	100	0	2	100	0	0	22.04.2017	37	0	0	0	No	Difficult to pin point specific calling/breeding site as original baseline records were from non-breeding frogs foraging
1B - Old (As per TFMP RMS 2015)	23000	Wells Crossing Beside Road	E:506185 N:6692721	18.03.2017	2346-0017	21	95	0	2	100	0	0	22.04.2017	35	0	0	0	No	Difficult to pin point specific calling/breeding site as original baseline records were from non-breeding frogs foraging
2A	19100	Halfway Creek	E:507641 N:6689299	28.2.2017	0227-0318	20	95	0	1	35	0	1	22.04.2017	53	0	0	0	No	Female on crest of low rise ~250 m north of compensatory breeding ponds
2A	19100	Halfway Creek	E:507641 N:6689299	16.3.2017	2346-0017	20	95	0	1	80	2	2	22.04.2017	37	0	0	0	No	Males calling from areas adjacent to constructed ponds
2A Compensatory Breeding Pond	19000	Halfway Creek	E:507644 N:6689255	28.2.2017	0227-0318	20	95	0	1	35	0	0	22.04.2017	53	0	0	0	No	Only common species using ponds
2A Compensatory Breeding Pond	19000	Halfway Creek	E:507644 N:6689255	16.3.2017	2346-0017	20	95	0	1	80	0	0	22.04.2017	37	0	0	0	No	Only common species using ponds
2A - Frog Fencing	18900-19300	Halfway Creek	E:507644 N:6689255	28.2.2017	0203-0227	20	95	0	1	35	0	0	not relevant	not relevant	not relevant	not relevant	not relevant	not relevant	Frog fencing partially effective although frogs calling from both sides of the fence.

BACI Site	Adjacent Chainage	Site Name	Easting Northing	Stage 1 Survey Date	Time (24hr)	AT °C	Hum %	Wind	Rain	CC	No. Calling Males (chorusing intensity)	No. Frogs Spotlighted	Stage 2 Survey Date	Days After Chorusing	No. Sub Adults	No. Juv	No. Tads	Breeding Confirmed	Comments
																			Observations and photographs suggests it is fit for purpose
2A - Frog Fencing	18900-19300	Halfway Creek	E:507644 N:6689255	16.3.2017	0010-0029	20	95	0	1	80	0	1	not relevant	not relevant	not relevant	not relevant	not relevant	not relevant	Frog fencing partially effective although frogs calling from both sides of the fence. Observations and photographs suggests it is fit for purpose
2B	23000	Yuraygir SRA	E:508694 N:6693816	01.03.2017	0049-0124	20	95	0	0	0	0	0	22.04.2017	52	0	0	0	No	Suspect frogs use adjacent areas more so than the main pond which is focus of the survey site
2B	23000	Yuraygir SRA	E:508694 N:6693816	16.03.2017	2154-2218	21	100	0	2	100	2	1	22.04.2017	35	0	0	0	No	Suspect frogs use adjacent areas more so than the main pond which is focus of the survey site
3A	25800	Glenugie Heavy Vehicle Checking Station North	E:505150 N:6695597	01.03.2017	0310-0335	20	95	0	2	100	0	0	22.04.2017	52	0	0	0	No	Frogs tend to utilise the broad area rather than concentrate along road verge
3A	25800	Glenugie Heavy Vehicle Checking Station North	E:505150 N:6695597	18.03.2017	0047-0115	21	95	0	2	100	0	0	22.04.2017	35	0	0	0	No	Frogs tend to utilise the broad area rather than concentrate along road verge
3B	30000	Glenugie West	E:501553 N:6699052	01.03.2017	2058-2125	21	82	0	1	55	0	2	22.04.2017	52	0	0	0	No	Difficult to determine precise breeding area as baseline survey data was developed from non-breeding observations during a non breeding period
3B	30000	Glenugie West	E:501553 N:6699052	18.03.2017	0206-0238	21	95	0	2	100	0	1	22.04.2017	35	0	0	0	No	Difficult to determine the precise breeding area as baseline survey data was

BACI Site	Adjacent Chainage	Site Name	Easting Northing	Stage 1 Survey Date	Time (24hr)	AT °C	Hum %	Wind	Rain	CC	No. Calling Males (chorusing intensity)	No. Frogs Spotlighted	Stage 2 Survey Date	Days After Chorusing	No. Sub Adults	No. Juv	No. Tads	Breeding Confirmed	Comments
																			developed from non-breeding observations during a non breeding period
4A	26200	Glenugie Heavy Vehicle Checking Station South	E:505127 N:6696150	28.2.2017	2338-0008	20	94	0	1	0	0	0	23.04.2017	54	0	0	0	No	Habitat is largely fragmented with small lineal strip of retained vegetation between old highway and construction works
4A	26200	Glenugie Heavy Vehicle Checking Station South	E:505127 N:6696150	18.03.2017	0314-0339	21	95	0	2	100	0	0	23.04.2017	36	0	0	0	No	Frogs remain difficult to survey for in this immediate vicinity due to traffic volume/noise
4A - Frog Fencing	26100-26250	Glenugie Heavy Vehicle Checking Station South	E:505167 N:6696111	28.2.2017	2217-2240	20	91	0	1	0	0	0	not relevant	not relevant	not relevant	not relevant	not relevant	not relevant	Ponds in verge area subject to ongoing disturbance and are prone to drying rapidly
4A - Frog Fencing	26100-26250	Glenugie Heavy Vehicle Checking Station South	E:505167 N:6696111	18.03.2017	0335-0354	21	95	0	2	100	0	0	not relevant	not relevant	not relevant	not relevant	not relevant	not relevant	Ponds in verge area subject to ongoing disturbance and are prone to drying rapidly
4B	35000	Glenugie East	E:506326 N:6703965	02.03.2017	0238-0310	19	83	0	1	0	3	6	23.04.2017	51	0	3	0	Yes	Juveniles are thought to have been attributed to the first rather than the second breeding/calling survey
4B	35000	Glenugie East	E:506326 N:6703965	18.03.2017	0438-0510	21	95	0	2	100	2	5	23.04.2017	36	0	0	0	Unconfirmed	No tadpoles or metamorphs indicating juvenile frogs probably were attributed to the earlier survey
5A	28000	Franklins Road	E:505038 N:6697387	28.2.2017	2303-2330	20	94	0	1	10	0	2	23.04.2017	54	0	3	0	Yes	Two females observed around ponds but appears as though

BACI Site	Adjacent Chainage	Site Name	Easting Northing	Stage 1 Survey Date	Time (24hr)	AT °C	Hum %	Wind	Rain	CC	No. Calling Males (chorusing intensity)	No. Frogs Spotlighted	Stage 2 Survey Date	Days After Chorusing	No. Sub Adults	No. Juv	No. Tads	Breeding Confirmed	Comments
																			breeding did take place based on juveniles 2 months later
5A	28000	Franklins Road	E:505038 N:6697387	18.03.2017	0403-0428	20.5	95	0	1	90	4	1	23.04.2017	35	0	1	3	Yes	Only two males and one female observed. Breeding appears to have been tied to earlier calling event
5A - Frog Fencing	27900-28050	Eastern side Franklins Road	E:505014 N:6697324	28.2.2017	2303-2330	20	94	0	1	10	0	0	not relevant	not relevant	not relevant	not relevant	not relevant	not relevant	Partially completed frog fence with some old temporary fence still installed. Common frogs found on both sides of the fence during breeding event surveys.
5A - Frog Fencing	27900-28050	Eastern side Franklins Road	E:505014 N:6697324	01.03.2017	0403-0428	20.5	95	0	1	90	0	0	not relevant	not relevant	not relevant	not relevant	not relevant	not relevant	Partially completed frog fence with some old temporary fence still installed. Common frogs found on both sides of the fence during breeding event surveys.
5B	37000	Stokers Road Bom State Forest	E:498275 N:6707681	01.03.2017	0447-0508	20	95	0	1	25	0	1	23.04.2017	53	0	0	2	0	Male observed beside flooding pool but not calling. Sub adult frogs are best found using a spotlighting active search survey and can be difficult to detect from daytime pond and peripheral searches
5B	37000	Stokers Road Bom State Forest	E:498275 N:6707681	19.03.2017	2055-2127	22	91	0	2	90	2	5	23.04.2017	34	0	0	2	0	Male observed beside flooding pool but not calling. Sub adult frogs are best found using a spotlighting active search survey and can be difficult to detect from daytime pond and peripheral searches
Site 3A New - Bald Knob	25000	Bald Knob Tick Gate Road	E: 505801 N: 6694708	28.2.2017	0018-0046	20	94	0	1	0	7	4	23.04.2017	55	1	5	0	Yes	Amplecting pair observed and photographed

BACI Site	Adjacent Chainage	Site Name	Easting Northing	Stage 1 Survey Date	Time (24hr)	AT °C	Hum %	Wind	Rain	CC	No. Calling Males (chorusing intensity)	No. Frogs Spotlighted	Stage 2 Survey Date	Days After Chorusing	No. Sub Adults	No. Juv	No. Tads	Breeding Confirmed	Comments
Tick Gate Road																			
Site 3A New - Bald Knob Tick Gate Road	25000	Bald Knob Tick Gate Road	E: 505801 N: 6694708	16.03.2017	2149-2216	20.5	93	0	2	95									

Table A2. Rainfall recorded between September 2016 and May 2017 from Grafton Airport station (058161) (BoM 2016).
Red shaded area reflects likely breeding/calling event and orange/amber a marginal breeding/calling event.

2016/2017	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	Mar-17	Apr-17	May-17
1st	0	0	0	1.4	0	0	6.6	0	0
2nd	0		0	0	1.4	0	3.8	0	0.2
3rd	4	0	0	0	13	0	1	2	0
4th	0	2.6	0	1.6	0	0	0	2.6	1.2
5th	0	0	0	0	7.8	0	0	2.6	0
6th	0	0	0	38.6	9.6	0	31	1.4	0.2
7th	0	0	0	1.6	23.4	0	0	0	0.2
8th	1	0	0	0.8	0.2	0	0	2	1.8
9th	0	0	11.6	6	0	4	0	0	0
10th	5	0	7.4	0	0	0	0	0	0
11th	4.4	0	0	0	0	0	0	0	0
12th	0	0	0	0	7.4	0	0	0	0
13th	0	0	7.2	0	4.6	0	0	0	1.4
14th	0	0	0.2	0	0	0.2	31.4	2.6	5.8
15th	5	0	0	0	3.4	3.2	24	0	7
16th	8.4	0	0	1	2.4	0	63.8	0	0.2
17th	0	0	0	0	0	0	0	0	0
18th	0.8	5.6	0	5.2	0	10.8	92.4	0.2	0
19th	3	0	0	0	0	1	45.6	0	1.2
20th	0	0	0	0	0	12.8	24.8	1	36.8
21st	2.4	0	0	0.8	10.6	0	5	1	0.2
22nd	0.8	1	0	0.4	0	0	4.8	0.2	0.2
23rd	0	2	0	0	0	0	0.2	0.2	1.2
24th	0	0	0.2	0	0	0	0	0	0.2
25th	0	0	0	0	0	0	0.2	0	0
26th	0.4	0	0	0	0	0	0	3.6	0
27th	0	0	0	0	16.8	0	0.8	5.6	0
28th	0	0.4	0	0	0	30.6	0	0	0.2
29th	0	9.4	2.6	0	0		0	0	1.6
30th	0	0	1.4	0	0		9.2	0	0
31st		0		0	0		86		0
Highest Daily	**8.4**	**9.4**	**11.6**	**38.6**	**23.4**	**30.6**	**92.4**	**5.6**	**36.8**