Woolgoolga to Ballina Pacific Highway Upgrade

Threatened Frog Monitoring Annual Report 2020/21

Version 4.0

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……..
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…13th October 2022……

Date

LEWIS ECOLOGICAL

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

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

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..

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*) 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 (Lewis 2014 a.b.c). The objective of these studies were to identify known threatened frog sites and to collect baseline data on the population and habitat condition. In summary, these studies along with some earlier construction monitoring have identified the following:

- The constructed carriageway bisects numerous areas of known Green-thighed Frog habitat with 10 locations selected along with a further 10 paired reference sites for monitoring; and
- The constructed carriageway bisects five areas of known Wallum Sedge Frog habitat with a further five reference sites selected for monitoring.

With construction completed in late 2020, Pacific Complete (PC) engaged Jacobs to implement the BACI population monitoring surveys. The following reports on these findings.

2.0 STATUS OF THE MONITORING PROGRAMS

This report covers the following monitoring periods:

- Wallum Sedge Frog monitoring program in Year 4 of the construction phase in Sections 8, 9 and 10. This is the fourth year of construction monitoring; and
- Green-thighed Frog monitoring program schedule for Year 6 for Sections 1 and 2 but only Year 5 in Sections 3, 6 and 7. This is the third year of operational monitoring in Section 1 and 2 and the first year of operational monitoring in Sections 3, 6 and 7.

3.0 WALLUM SEDGE FROG (*LITORIA OLONGBURENSIS*)

3.1 Species Profile

3.1.1 Description

The Wallum Sedge Frog (*Litoria olongburensis*) is a small species that reaches a maximum length 30 mm. It is smooth light green or light brown above, cream and granular below. A dark brown streak runs from the nostril to the eye, then from behind the eye down the side of the body. From the eye, this streak is bordered below by a raised white stripe that breaks into a series of spots towards the flank. The snout is pointed and undercut and the call is a very rapid buzz, repeated several times (OEH 2014).

Wallum Sedge Frog tadpoles are deep-bodied and high-finned (Anstis 2002). The snout is rounded in dorsal view and rounded to truncate in lateral view. The eyes are laterodorsal and the iris has a broad gold ring around the pupil. Nares open in the anterior direction with a very slight lateral tilt. The dorsum of the tadpole is a dark purple-brown or sooty grey colour with or without darker mottling. The tail, which terminates in a flagellum (long, lash-like appendage), is heavily mottled with dark brown or grey and sometimes orange. The flagellum is usually darkly pigmented and therefore conspicuous in the Wallum Sedge Frog tadpole. The venter is silver-white overlain with a copper sheen that continues halfway up the sides of the body, where it strongly contrasts with the dark dorsal pigmentation. Rolling blue sheen may be visible over the sides of the body. Best seen out of water, this blue sheen extends half-way along the tail. Tadpoles of the Wallum Sedge Frog reach a maximum total length of 37 mm (13 mm body length) and are found hovering in mid-water or, more commonly, resting or grazing on matted sedges (Anstis 2002; Meyer *et al.* 2006).

Plate 3-1. Adult Wallum Sedge Frog at Site 2B in Broadwater National Park.

3.1.2 Distribution

Wallum Sedge Frog Frogs are found in coastal wallum swamps from Fraser Island in southern Queensland to Yuraygir National Park in northern NSW (OEH 2014). Within the W2B corridor they have been previously recorded from Sections 8-10 (Lewis 2014).

3.1.3 Habitat and Ecology

The Wallum Sedge Frog is an "acid" frog confined to the coastal sandplain wallum swamps. Their life-cycle is adapted to the acidic pH (2.8-5.5) of these wetlands. Frogs are highest in abundance in relatively undisturbed wallum swamps. Breeding habitat is characterised by the presence of emergent sedges, with upright species such as *Baumea* spp. and *Schoenus* spp. preferred by adult frogs for perching. Frogs can be found in breeding habitat throughout the year although there appears to be some localised movements during or shortly after rainfall (Lewis and Goldingay 2005). Breeding occurs mainly in spring, summer and autumn after rain. Eggs are laid singly in water at the base of sedges (OEH 2014).

Plate 3-2. Wallum Sedge Frog habitat along the W2B corridor (adjacent ch. 148550).

3.1.4 Conservation Status

The Wallum Sedge Frog is currently listed as Vulnerable pursuant to the NSW *Biodiversity Conservation* Act (2016) and Commonwealth *Environment Protection and Biodiversity Conservation* Act (1999; OEH 2014; DoE 2014). Threatening processes that have been identified include:

- Destruction and degradation of wallum habitat for coastal development;
- Reduction of water quantity and/or quality (including changes to pH) in coastal wetland habitat;
- Changes in average and extreme temperatures and the amount and timing of rainfall due to climate change;
- Severe fires in very dry periods that result in insufficient refuge remaining post-fire;
- Roadkill (it has been estimated that >10,000 Wallum Sedge Frogs are killed annually on one 4km stretch of road near Lennox Head; Goldingay and Taylor 2006); and
- Predation of tadpoles and eggs by the Plague Minnow (*Gambusia holbrooki*). While little is known of the extent of Plague Minnow predation on Wallum Sedge Frogs, it must be considered a potential threat (OEH 2014).

3.2 Survey Methods

Field surveys were performed in accordance with the Threatened Frog Management Plan (RMS 2013). The following details the areas surveyed along with the timing of field surveys and how the data were treated or analysed.

3.2.1 Site Selection and Treatment Design

All five sampling sites known as Site 1A, 1B, 2A, 2B, 3A, 3B, 4A, 4B, 5A and 5B occur within Section 8-10 (Figure 2-1). Sampling accords with the BACI (Before-After-Control-Impact) approach which consists of the following:

- Impact sites which are identified in this instance with an 'A" and may be potentially impacted by construction works or once the newly constructed carriageway is completed. Potential impacts may include but are not necessarily limited to habitat removal, a reduction in habitat connectivity, increased road strike, facilitating the distribution and increasing densities of exotic predators;
- Reference or control sites which are identified in this instance with an 'B" and possess similar geographic landscape and habitat traits as the impact sites, but are located a sufficient distance (>200 m) and ideally upstream of the Upgrade. If this was not possible, a nearby sub catchment with similar attributes was also considered sufficient.

3.2.2 Timing of Surveys

Field surveys were comprised of two sampling periods with each event taking place generally within 7 days of a 10 mm rainfall event in the past 24 hours. This meant that the summer or calling breeding survey was performed at the start of February 2020 and a follow up post breeding survey to determine the level of breeding success was performed in late May 2020 (Appendix A). Both surveys coincided with substantial rainfall a week or two beforehand with the initial survey conducted after drought conditions where all of the sites had been dry. Only summer surveys were performed at Wardell and Bogotville (Section 10) due to the direction from TfNSW that construction had been completed in early 2020 and monitoring should recommence when the highway is in operation in late 2020.

3.2.3 Frog Surveys

Frog surveys were performed in the following manner and in accordance with the required hygiene protocols followed (DECC 2008):

- Surveys were performed generally within 7 days of a notable rainfall event (>10 mm in 24 hrs) using the Bureau of Meteorology (BoM) weather stations at Evans Head (058212) whilst the previous Woodburn station (58061) has ceased recording (*see* Table A4 in Appendix 3). At other times, the BoM website and radar images from Grafton were used to determine more fine scale survey requirements post rainfall;
- Surveys commenced at 30 minutes after dark with the latest surveys being performed up to around 0230 hrs;
- A 50 metre transect was installed at some sites whilst a timed 20 minute search was used as other sites where a 50 m transect could not be installed dur to the small size of the habitat;
- All surveys involved the use of active search with a head lamp (Led Lensor H14R rated 850 lumens); and
- For all frogs that were detected, the age class was determined with:
    - Adults defined as being >16 mm; Sub adult <16 mm; and
    - Juvenile showing some form of a tail tad from recent metamorphosis.

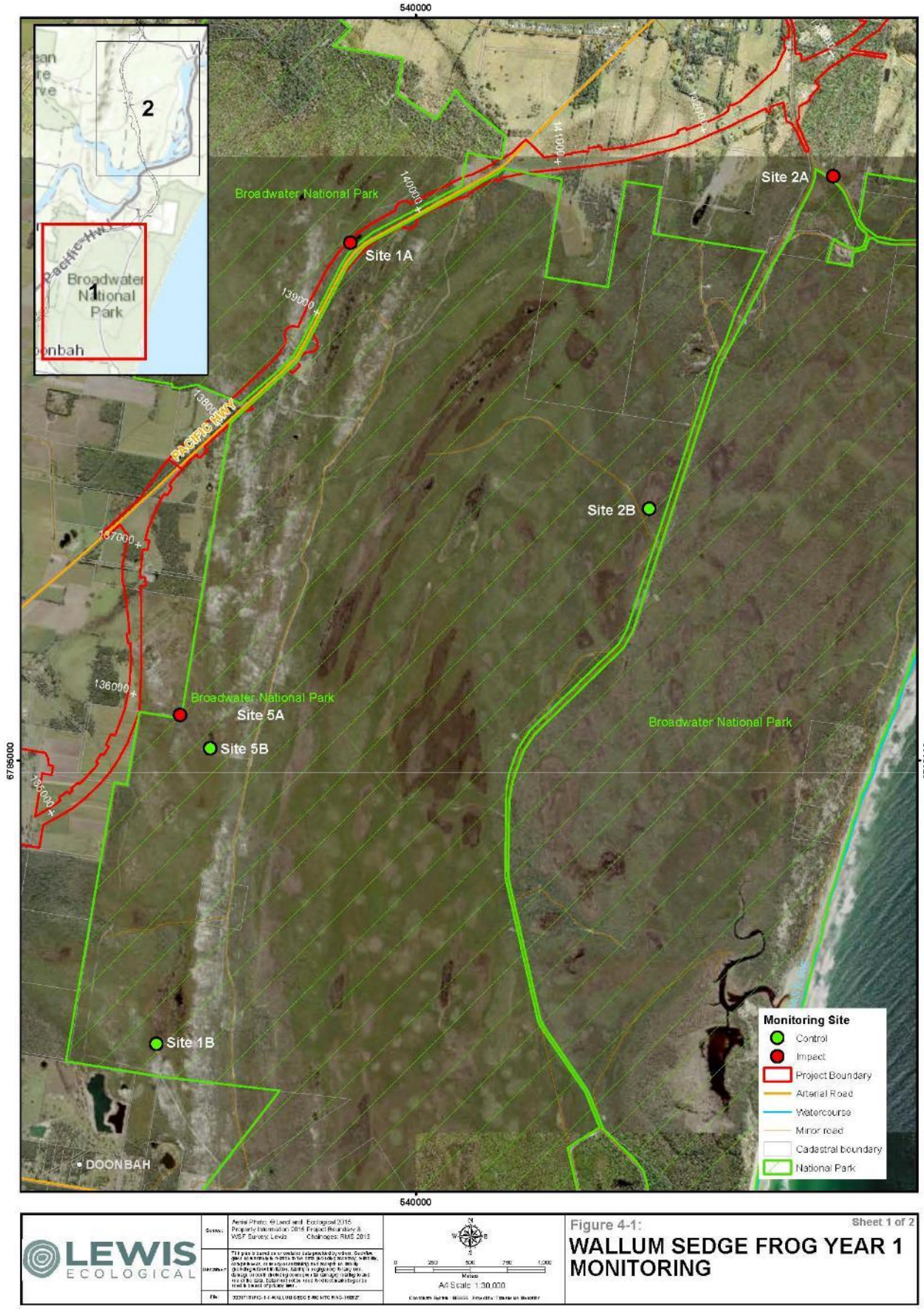

Figure 3-1. Locations of Wallum Sedge Frog BACI Monitoring Sites in Sections 8 and 9 of Woolgoolga to Ballina Upgrade.

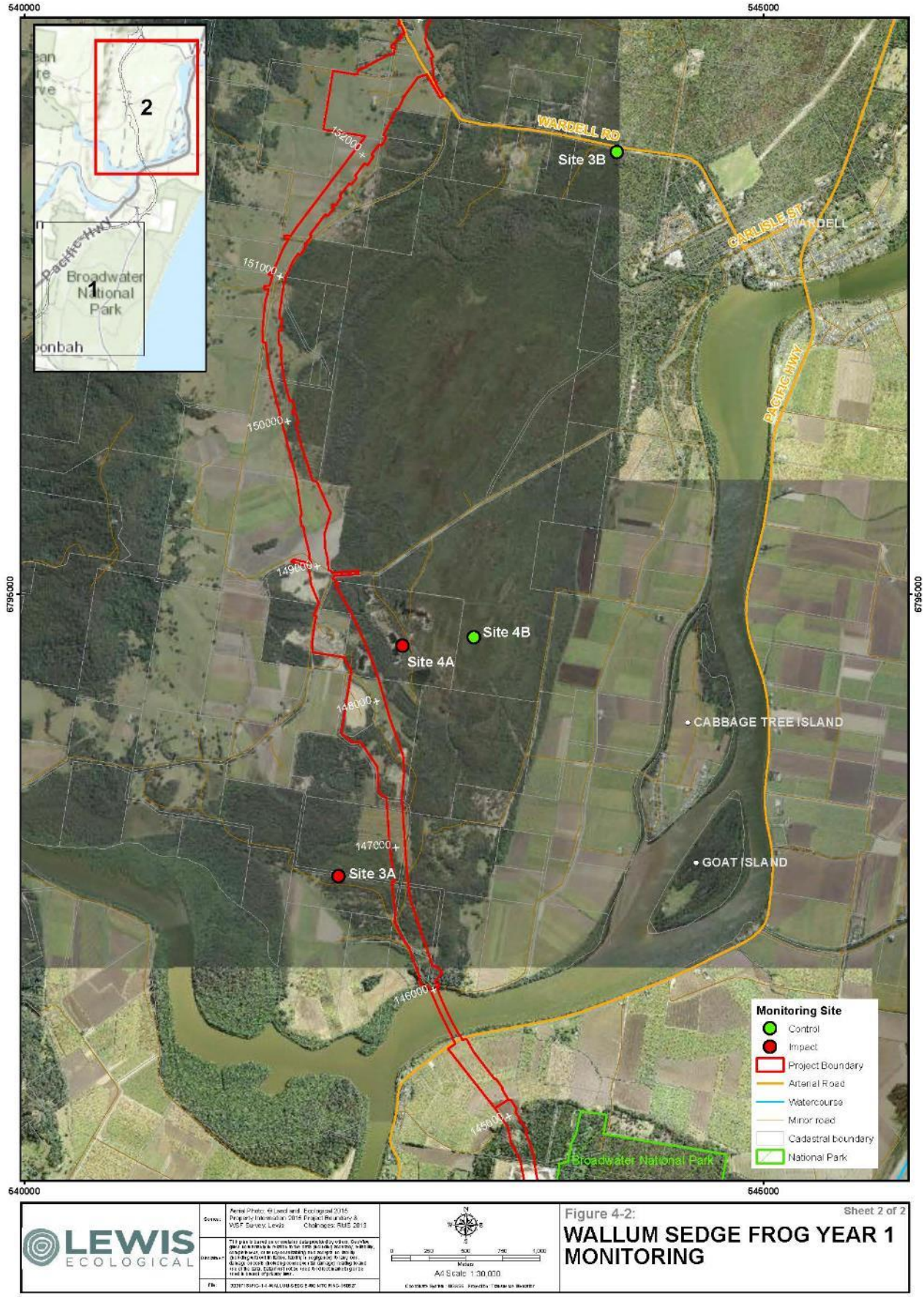

Figure 3-2. Locations of Wallum Sedge Frog BACI Monitoring Sites in Section 10 of the Woolgoolga to Ballina Upgrade.

3.2.4 Abiotic Data

The following abiotic variables were collected during the survey:

- The amount of rain fall was calculated for the periods 24 hours, 48 hours and 7 days prior to each survey using the weather station at Evans Head (058212);
- 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;
- Water level measured with a tape measure generally at the start of the transect or alternatively at the deepest point along the transect;
- pH level measured using a hand held meter, if water was present;
- 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).

3.2.5 Connectivity Structures & Permanent Frog Fence Monitoring

Four connectivity and permanent frog fence areas have been nominated for monitoring. At the time of this monitoring, these structures were not fully complete with regards to landscaping treatment, fencing and soft passage.

3.2.6 Compensatory Breeding Ponds

No locations or status was provided for the proposed compensatory breeding ponds during the Year 4 monitoring program. Consequently, no monitoring was performed.

3.3 Year 4 Construction Monitoring Results

3.3.1 Sedge Frog Abundance

Wallum Sedge Frogs were recorded at 7 (70%) of the 10 monitoring sites during Year 4 (Table 3-1; Figure 3-3). No sedge frogs were recorded at Site 2A (Broadwater Beach Road), 3A (Bagotville) and Site 3B (Wardell Road). The highest counts of sedge frogs were recorded at the control sites located in Broadwater National Park with 32 and 28 frogs per 100m^2 of habitat at Site 2B and 5B respectively (Figure 3-3). Overall, sedge frog numbers were comparable to the previous Year 3 monitoring, but remain lower than the baseline surveys at Site 1A (Broadwater West), 3A (Bagotville), Site 4A (Ballina Shire Council), Site 4B (Jali Lands) and Site 5A (McDonalds; Figure 3-3).

Adult frogs were recorded at seven sites, however, they were only recorded during the summer survey at Site 1A (Broadwater West) and 5A (McDonalds) whilst a single adult was only found during the late autumn survey at Site 4B (Jali Lands; Figure 3-4) which contained some surface water following heavy autumn rain leading up to the survey.

Sub adult frogs were only recorded at three sites all located within Broadwater National park (Site 1B, 2B, 5B) indicating at least some successful breeding had occurred in the 2020 season and shortly after the prolonged drought. Sub adults were recorded during both the summer and late autumn surveys at these locations. Juvenile frogs were also recorded at these same three locations and the vast majority of these were recorded during the second survey in late autumn.
No tadpoles were recorded during either of the surveys.

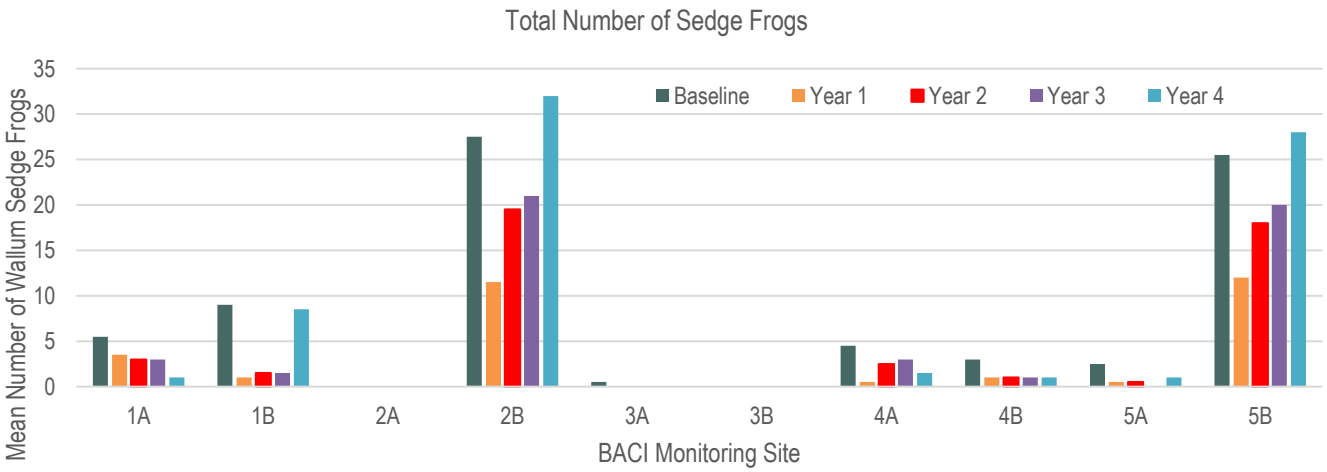

Figure 3-3. Total wallum sedge frog counts between baseline survey, Year 1, Year 2, Year 3 and Year 4 monitoring.

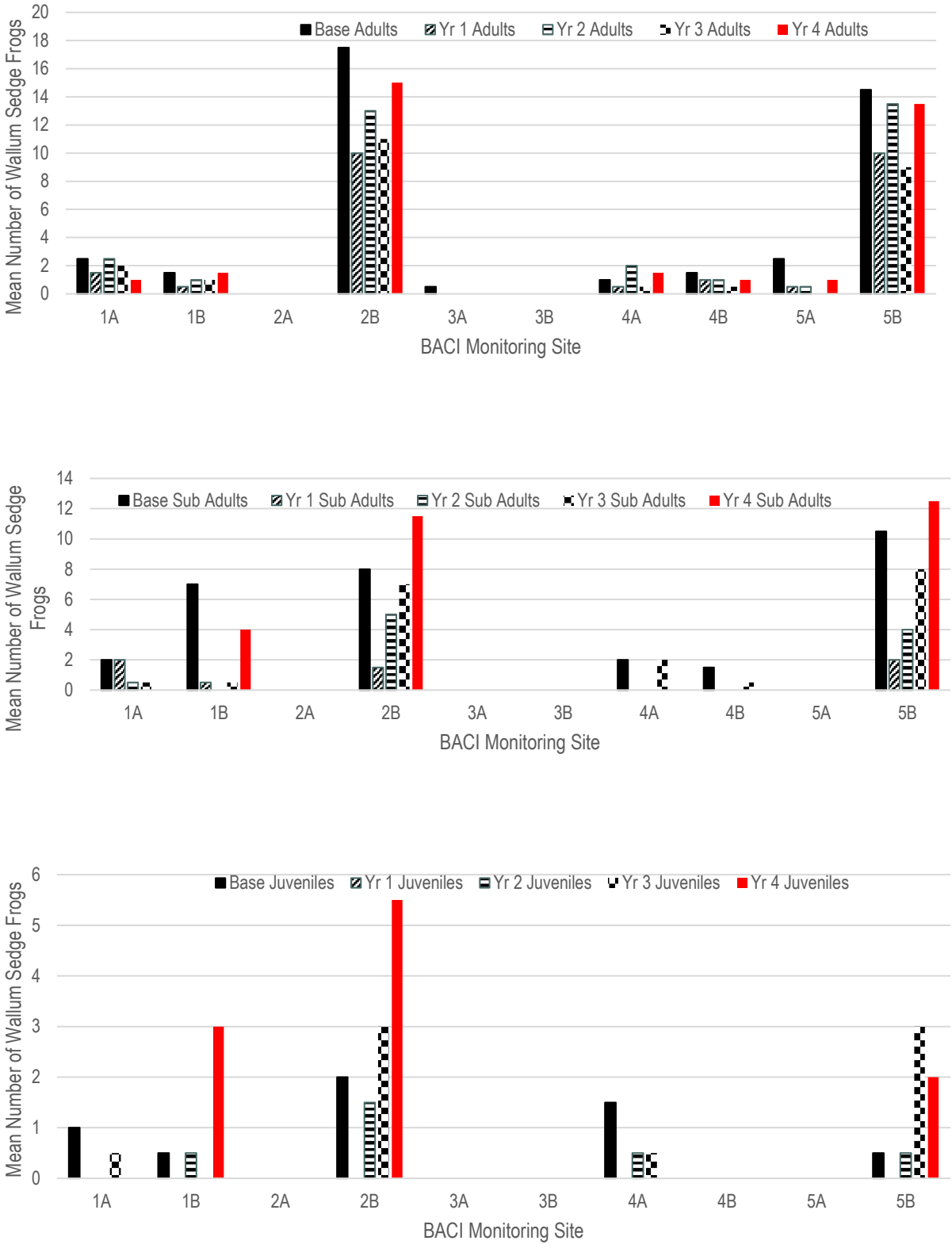

Figure 3-4. Wallum sedge frog counts across three age classes between baseline survey and subsequent monitoring in Year 1, 2, 3 and 4.

Table 3-1. Summary of the sites and mean Wallum Sedge Frog counts between baseline survey and Years 1-4.

BACI Site	Treatment Class	Site Name	Chainage Extent	Base Adults	Yr 1 Adults	Yr 2 Adults	Yr 3 Adults	Yr 4 Adults	Comments
1A	Impact	Broadwater West	139500	2.5	1.5	2.5	2	1	Numbers less than half baseline survey. A lot of *Azolla spp* present, appears to have eutrophication.
1B	Control	Broadwater West	133000–132000	1.5	0.5	1	1	1.5	Numbers consistent with baseline survey.
2A	Impact	Broadwater Beach Road	143000–142000	0	0	0	0	0	Frogs have remained absent from this site since monitoring program commenced
2B	Control	Broadwater East	137000-138000	17.5	10	13	11	15	Frog numbers relatively consistent. Site has been monitored by author for almost 25 years
3A	Impact	Bagotville	146000-147000	0.5	0	0	0	0	Frogs have disappeared since the initial baseline survey.
3B	Control	Wardell Road	151000-152000	0	0	0	0	0	Frogs have remained absent from this site since monitoring program commenced
4A	Impact	Ballina Shire Council Quarry	148000-149000	1	0.5	2	0.5	1.5	Frog numbers slightly higher than baseline survey
4B	Control	Jali Land	148000-149000	1.5	1	1	0.5	1	Frog numbers relatively consistent since monitoring commenced.
5A	Impact	McDonalds	135900	2.5	0.5	0.5	0	1	Frog numbers have declined since baseline survey.
5B	Control	Broadwater National Park	135800	14.5	10	13.5	9	13.5	Frog numbers relatively consistent since monitoring commenced.

BACI Site	Treatment Class	Site Name	Chainage Extent	Base Sub Adults	Yr 1 Sub Adults	Yr 2 Sub Adults	Yr 3 Sub Adults	Yr 4 Sub Adults	Comments
1A	Impact	Broadwater West	139500	2	2	0.5	0.5	0	Decline from earlier monitoring events.
1B	Control	Broadwater West	133000–132000	7	0.5	0	0.5	4	Similar to baseline survey.
2A	Impact	Broadwater Beach Road	143000–142000	0	0	0	0	0	No record of breeding at this location since monitoring began.
2B	Control	Broadwater East	137000-138000	8	1.5	5	7	11.5	Highest number of sub adults since monitoring began.
3A	Impact	Bagotville	146000-147000	0	0	0	0	0	No record of breeding.

3B	Control	Wardell Road	151000-152000	0	0	0	0	0	No record of breeding.
4A	Impact	Ballina Shire Council Quarry	148000-149000	2	0	0	2	0	No record of breeding.
4B	Control	Jali Land	148000-149000	1.5	0	0	0.5	0	No record of breeding.
5A	Impact	McDonalds	135900	0	0	0	0	0	No record of breeding. Site often too dry at time of monitoring.
5B	Control	Broadwater National Park	135800	10.5	2	4	8	12.5	Highest number of juveniles since monitoring began.

BACI Site	Treatment Class	Site Name	Chainage Extent	Base Juveniles	Yr 1 Juveniles	Yr 2 Juveniles	Yr 3 Juveniles	Yr 4 Juveniles	Comments
1A	Impact	Broadwater West	139500	1	0	0	0.5	0	No evidence of breeding during this round of monitoring.
1B	Control	Broadwater West	133000–132000	0.5	0	0.5	0	3	Highest number of juveniles since monitoring began.
2A	Impact	Broadwater Beach Road	143000–142000	0	0	0	0	0	No juveniles recorded at this site since monitoring began.
2B	Control	Broadwater East	137000-138000	2	0	1.5	3	5.5	Highest number of juveniles since monitoring began.
3A	Impact	Bagotville	146000-147000	0	0	0	0	0	No juveniles recorded at this site since monitoring began.
3B	Control	Wardell Road	151000-152000	0	0	0	0	0	No juveniles recorded at this site since monitoring began.
4A	Impact	Ballina Shire Council Quarry	148000-149000	1.5	0	0.5	0.5	0	Decline in number of juveniles recorded.
4B	Control	Jali Land	148000-149000	0	0	0	0	0	No juveniles recorded at this site since monitoring began.
5A	Impact	McDonalds	135900	0	0	0	0	0	No juveniles recorded at this site since monitoring began.
5B	Control	Broadwater National Park	135800	0.5	0	0.5	3	2	Highest number of juveniles since monitoring began.

Yr – Year

3.3.2 Constructed Breeding Ponds

At the time of Year 4 monitoring, no compensatory breeding ponds had been constructed for sedge frogs. Shortly after the second survey, a site investigation was performed at the request of TfNSW with it concluding the construction of compensatory ponds around ch. 140000 was problematic in that it would require additional clearing in an area where Wallum Froglets (*Crinia tinnula*) were calling and any newly constructed pond would attract the exotic Cane Toad (*Rhinella marina*). Consequently, the pond was not constructed.

3.3.3 Frog Fencing

Permanent frog fencing was installed between the following three chainage extents:

- 139000 adjacent to the bridge in Broadwater National Park;
- 139400 139600 (200m) which is adjacent to Site 1A; and
- 139900 to 140100 (200 m) which is a few hundred metres to the north of Site 1A where twin 450 mm culverts.

As the main carriageway was not completed at the time of the surveys, no frog fence surveys were performed.

3.4 Discussion

Monitoring during Year 4 found fewer sedge frogs then during the baseline surveys conducted in 2014. This trend of fewer sedge frogs has remained relatively consistent over the past four rounds of construction monitoring. During this round of monitoring, surveys were performed a fortnight after heavy flooding rains where the monitoring sites received in excess of 150 mm of rainfall in mid January 2020. Whilst this is thought to have greatly assisted in detecting sedge frogs along the monitoring transects, the overall lower trend in the numbers of frogs is undoubtedly linked to the very low rainfall in the previous winter, spring and first half of summer. During such conditions, sedge frog survival would be lower than during a season of average to above average rainfall.

The seasonal effects of below average rainfall were best reflected in the numbers of both sub adults and juvenile sedge frogs, both indicators of breeding and forecast recruitment into the adult population. Monitoring revealed that only those sites (1B, 2B, 5B) located within Broadwater National Park recorded successful breeding during this round of monitoring. These sites differ in that they are directly linked or form part of the large dunal wetland system that originates from the Pliocene era and are relatively unmodified by anthropogenic disturbances of roads and agricultural drainage channels. Meanwhile, sites such as 1A (Broadwater West), 2A (Broadwater Beach Road), 3A (Bagotville), 3B (Wardell Road), 4A (Ballina Shire Council), 4B (Jali Land), 5A (McDonalds) occur in either small discreet wetlands and often in close proximity to roads, quarry activities or agricultural drainages that have altered surface and sub surface water flows.

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

3.5 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 4 monitoring includes the population monitoring component, but not the connectivity structures, compensatory ponds and revegetation works as they are either not yet complete or do not form part of the Wallum Sedge Frog management (RMS 2015). The performing factor for the population monitoring is the number of Wallum Sedge Frogs per 100 m2 of habitat. With this, the numbers or actual counts of sedge frogs has declined in a relative manner across both the impact and control sites. These have been summarised in Table 3-2 and as follows:

- ***Site 1 – Broadwater West***
    - Year 1 with 36% decline at impact treatment compared to an 89% decline at the control site.
    - Year 2 with 45% decline at the impact treatment compared to the 83% decline at the control site.
    - Year 3 with 45% decline at the impact treatment compared to the 83% decline at the control site.
    - Year 4 with 82% decline at the impact treatment compared to the 6% decline at the control site.

  Both sites have declined with the impact treatment continuing to decline whilst the control treatment has virtually recovered to pre-construction baseline densities.

- Site 2 – ***Broadwater North*** where no sedge frogs have been recorded along the transect since monitoring began. Meanwhile, the control site continues to record relatively high densities of sedge frogs.

- Site 3 – ***Bagotville and Wardell Road*** where sedge frogs have declined at the impact site by 100% to zero since construction monitoring commenced whilst sedge frogs have not been recorded at the control site adjacent Wardell Road. It should be noted that only summer surveys were performed at this location due to the direction from TfNSW that construction had been completed in early 2020 and monitoring should recommence when the highway is in operation in late 2020.

- Site 4 – ***Ballina Shire Council and Jali Land***

    - Year 1 with an 89% decline at the impact treatment compared to a 67% decline at the control site.
    - Year 2 with a 44% decline at the impact treatment compared to a 67% decline at the control site.
    - Year 3 with a 33% decline at the impact treatment compared to a 67% decline at the control site
    - Year 4 with a 67% decline at both the impact and control treatment sites.

It should be noted that only summer surveys were performed at this location due to the direction from TfNSW that construction had been completed in early 2020 and monitoring should recommence when the highway is in operation in late 2020.

- Site 5 – ***McDonalds and Broadwater National Park***
    - Year 1 with an 80% decline at the impact treatment compared to a 53% decline at the control site.
    - Year 2 with an 80% decline at the impact treatment compared to a 29% decline at the control site.
    - Year 3 with a 100% decline at the impact treatment compared to a 22% decline at the control site.
    - Year 4 with a 60% decline at the impact treatment compared to a 10% increase at the control site.

  Decline exceeding 25% relative to each treatment have been exceeded at the impact site and corrective action required.

Some of the reported declines can be partly explained by natural variation or population fluctuation in response to summer sampling occurring soon after drought breaking rainfall where there had been too little time for populations to recover or simply the reduced surface water levels had reduced habitat suitability along the monitoring transect (*see* Lewis and Goldingay 2005). At Site 1, sedge frog numbers have continued to decline at the impact treatment whilst the control site has almost completely recovered to pre-construction baseline densities. Sampling during Year 4 has identified an increase of aquatic weeds at Site 1A, particularly Azolla (*Azolla spp*) which is often an indication of increased nutrient loads. This also coincides with an increase in the number of common frog fauna, particularly Eastern Sedge Frog (*Litoria fallax*), Tylers Tree Frog (*Litoria tyleri*) and the exotic Cane Toad. It is suspected that sedge frogs will disappear from this monitoring site.

At Site 2 (Broadwater Beach Road), the ongoing absence of sedge frogs suggests there has been a change in the habitat and it is now less suitable than it has during the past. Other wallum species including Wallum Froglet (*Crinia tinnula*) and Wallum Rocket Frog (*Litoria freycineti*) frequent the site, but tend to prefer more littoral habits then sedge frogs. At the adjacent control site (2B), the reported fluctuations probably represent a true indication of year to year variability. This site has been the subject of ongoing sedge frog monitoring over the past 25 years and always tends to yield numbers of adult frogs along with sub adults and juveniles depending on the sampling time.

Site 3 and 4 were only monitored during the summer period of Year 4 due to a TfNSW decision to delay monitoring given there had already been three consecutive construction monitoring events and for monitoring to reconvene once the Project became operational. With only half the data available, nothing conclusive can be drawn nor can any corrective actions be considered.

The reported decline at Site 5 is thought to be directly linked to surface water levels at the impact site. This site tends to support sedge frogs when it has received substantial rainfall and the water table rises. At other times, the sedge swamp

tends to retract leaving the site dry and less suitable as habit for sedge frogs. These changes in surface water are considered natural variation and not from the Upgrade.

In accordance with Section 7.2.3 of the Threatened Frog Species Management Plan (RMS 2015) no corrective actions are required as none of the other four sites have triggered a reported decline in abundance of 25% or more over three consecutive monitoring periods. Site 1 is starting to show a trend that does warrant concern though with an ongoing decline at the impact site whilst there has been an almost complete recovery at the control site. Some obvious cues are present at Site 1A, that being an influx of Cane Toad, Eastern Sedge Frog and Tylers Tree Frog along with an abundance of *Azolla spp.* indicating an increase in nutrient loads.

Table 3-2. Performance indicators and corrective actions from the Threatened Frog Species Management Plan (RMS 2015) for Wallum Sedge Frog.

Triggers for corrective actions	Corrective actions	Relevance to Year 4 Wallum Sedge Frog Monitoring	Results of Year 4 Wallum Sedge 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 3.3).	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	Compared to the baseline survey, Wallum Sedge Frogs • ***Site 1 – Broadwater West*** o Year 1 with 36% decline at impact treatment compared to an 89% decline at the control site. o Year 2 with 45% decline at the impact treatment compared to the 83% decline at the control site. o Year 3 with 45% decline at the impact treatment compared to the 83% decline at the control site. o Year 4 with 82% decline at the impact treatment compared to the 6% decline at the control site. Both sites have declined with the impact treatment continuing to decline whilst the control treatment has virtually recovered to pre-construction baseline densities. • Site 2 – ***Broadwater North*** where no sedge frogs have been recorded along the transect since monitoring began. Meanwhile, the control site continues to record relatively high densities of sedge frogs. • Site 3 – ***Bagotville and Wardell Road*** where sedge frogs have declined at the impact site by 100% to zero since construction monitoring commenced whilst sedge frogs have not been recorded at the control site adjacent Wardell Road.	Population impacted by the ongoing drought throughout 2019 and into start of 2020. Eutrophication and competitor frog numbers increased at Site 1A. Reduced monitoring events at Site 3 and 4 where only one survey (i.e. summer) was performed at direction of TfNSW.	None at this stage. Consideration should be given to the continuing decline at Site 1A. At Site 5, declines recorded but these are linked to natural variation of water levels.

Triggers for corrective actions	Corrective actions	Relevance to Year 4 Wallum Sedge Frog Monitoring	Results of Year 4 Wallum Sedge Frog Monitoring	Potential Contributing Factors	Corrective Action Required
			• Site 4 – ***Ballina Shire Council and Jali Land*** o Year 1 with an 89% decline at the impact treatment compared to a 67% decline at the control site. o Year 2 with a 44% decline at the impact treatment compared to a 67% decline at the control site. o Year 3 with a 33% decline at the impact treatment compared to a 67% decline at the control site o Year 4 with a 67% decline at both the impact and control treatment sites. • Site 5 – ***McDonalds and Broadwater National Park*** o Year 1 with an 80% decline at the impact treatment compared to a 53% decline at the control site. o Year 2 with an 80% decline at the impact treatment compared to a 29% decline at the control site. o Year 3 with a 100% decline at the impact treatment compared to a 22% decline at the control site. o Year 4 with a 60% decline at the impact treatment compared to a 10% increase at the control site. Decline exceeds 25% over three consecutive monitoring periods.		
Underpass Structure Monitoring					
The use of the structure by less than 1% of the estimated population size.	Review monitoring methods where goals are not achieved, by increasing frequency, intensity and duration, to	Not relevant as sites have not been completed.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.

Triggers for corrective actions	Corrective actions	Relevance to Year 4 Wallum Sedge Frog Monitoring	Results of Year 4 Wallum Sedge Frog Monitoring	Potential Contributing Factors	Corrective Action Required
Connectivity structures not maintained (i.e. culverts clogged with debris or sedimentation). Frog exclusion fencing damaged or ineffective.	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.				
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	No compensatory ponds have been constructed to date.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.

Triggers for corrective actions	Corrective actions	Relevance to Year 4 Wallum Sedge Frog Monitoring	Results of Year 4 Wallum Sedge Frog Monitoring	Potential Contributing Factors	Corrective Action Required
	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.				
Water pH exceeds 5.5 for Wallum Sedge Frog	Investigate ways to reduce pH of water.	No compensatory ponds have been constructed to date.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.
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.	No compensatory ponds have been constructed to date.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.
No persistent water present in ponds (negative hydro period) despite recent rainfall.	Assess possible causes for water draining from the pond and apply physical corrective actions	No compensatory ponds have been constructed to date.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.
Mosquito Fish present and threatened frogs / tadpoles absent.	Draining pond to remove Mosquito Fish and allow pond fill at the next rain event.	No compensatory ponds have been constructed to date.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.
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 of the TFSMP (RMS 2015).	Undertake revegetation maintenance, i.e. replanting, erosion control, weed control. Ensure wetlands are functioning as designed and present suitable habitat in terms of water quality and hydro-period.	No compensatory ponds have been constructed to date.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.

Triggers for corrective actions	Corrective actions	Relevance to Year 4 Wallum Sedge Frog Monitoring	Results of Year 4 Wallum Sedge Frog Monitoring	Potential Contributing Factors	Corrective Action Required
Revegetated native habitat in poor condition (e.g. >30% cover died, plant dieback).	Undertake revegetation maintenance, i.e. replanting, erosion control, weed control. Ensure wetlands are functioning as designed and present suitable habitat in terms of water quality and hydro-period.	No compensatory ponds have been constructed to date.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.
Frog absence confirmed following monitoring surveys (it should be noted that a pond may be suitable for frogs, but not colonised).	Undertake revegetation maintenance, i.e. replanting, erosion control, weed control. Ensure wetlands are functioning as designed and present suitable habitat in terms of water quality and hydro-period.	No compensatory ponds have been constructed to date.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.
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 applicable as site not in riparian habitat.	Not Applicable	Not Applicable	Not Applicable

3.6 Conclusions and Recommendations

Year 4 monitoring during the summer and late autumn of 2020 found sedge frogs at seven of the 10 monitoring sites. There remains a continued absence of sedge frogs from Site 2A (Broadwater Beach Road) and from both of the Site 3 treatments (Bagotville and Wardell Road) which tend to represent small populations that may undergo periodic localised extinctions in response to stochastic events like fires and drought. Site 2A appears unaffected by the Upgrade as the vegetation communities remain the same, the water pH is within the tolerance range of sedge frogs and the area is periodically inundated and has contained surface water during a number of sampling events. Site 3A occurs only a couple of hundred metres downslope of the Upgrade yet the only changes appear to have been some periodic slashing of the sedges by the property owner whilst Site 3B occurs adjacent to Wardell Road and has been subject to a range of impacts arising from easement management and a continual increase in the abundance of competitor species, particularly Tylers Tree Frog which is suspected of not only competing for resources but may also predate on the smaller sedge frog. Both of the Site 3 treatments were only subject to an initial summer monitoring event so the opportunities for detecting frogs was halved during this round of monitoring.

Year 4 provided the first opportunity to assess the performance of the monitoring program in accordance with the TFMP (RMS 2015). Sedge frog numbers were found to have increased at some control sites (2B, 5B), but overall had declined, often in the magnitude of 60-100%. There is a worrying trend occurring at Site 1A (Broadwater West) with the site continuing to decline and there are cues to suggest there has been increased nutrient loadings which have culminated in both an increase of Azolla and competitor frog species whilst the removal of dense dry heath to accommodate the Upgrade had previously provided a barrier to toad movements.

Based on the Year 4 findings, the following recommendation is outlined in Table 3-3.

Table 3-3. Recommendations following Year 4 Wallum Sedge Frog population monitoring and Transport for NSW response.

Recommendation No	Recommendation	Transport for NSW Response
1	Perform some additional surveys in areas adjacent (<300 m) of Site 2A, 3A, 3B to qualify existence of local sedge frog population. **Note** that frog numbers have remained at zero over most of the monitoring program or decline to zero during construction monitoring.	Adopted.

4.0 GREEN-THIGHED FROG (*LITORIA BREVIPALMATA*)

4.1 Species Profile

4.1.1 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 or yellowish in some instances but always with black markings (Barker *et al.* 1995; Lemckert *et al.* 2006).

Plate 4-1. Green-thighed Frog from Bald Knob Tick Gate Road (Site 3A).

4.1.2 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).

4.1.3 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).

4.2 Survey Methods

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

4.2.1 Site Selection

The location of BACI sites 1-5 are located in Section 1 and 2 whilst sites 6 to 10 are located in Section 3-7 and were selected during follow up surveys and updating of baseline information in 2015 (Lewis 2015; Figure 5-1).

4.2.2 Timing of Surveys

Weather patterns were constantly monitored between October 2020 through to May 2021 for the suitability of implementing field surveys during or immediately after a rainfall event delivering >50-75 mm in 24 hours, or alternatively 150 mm over 72 hours (Table A1). Consequently, stage one sampling took place on the 15-19th of December 2020.

During stage one calling surveys, 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. Searches of the adjacent permanent frog fence were also performed at this time. At each site, the following 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. Some additional surveys were performed in accordance with the adoption of Recommendation 4 from the last round of monitoring (Lewis 2020). This included an additional survey adjacent to Site 2A and further north towards Kungala Road and a broader survey in areas of adjacent habitat at Site 10A – Tabbimoble. Site 1B was not surveyed due to the fact it is in fact an impact site and not a control site.

The second round or post breeding surveys were used to measure the breeding success at each site and these were performed between the 31st December and 1st January 2021 through to the 23-25th January 2021. 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.

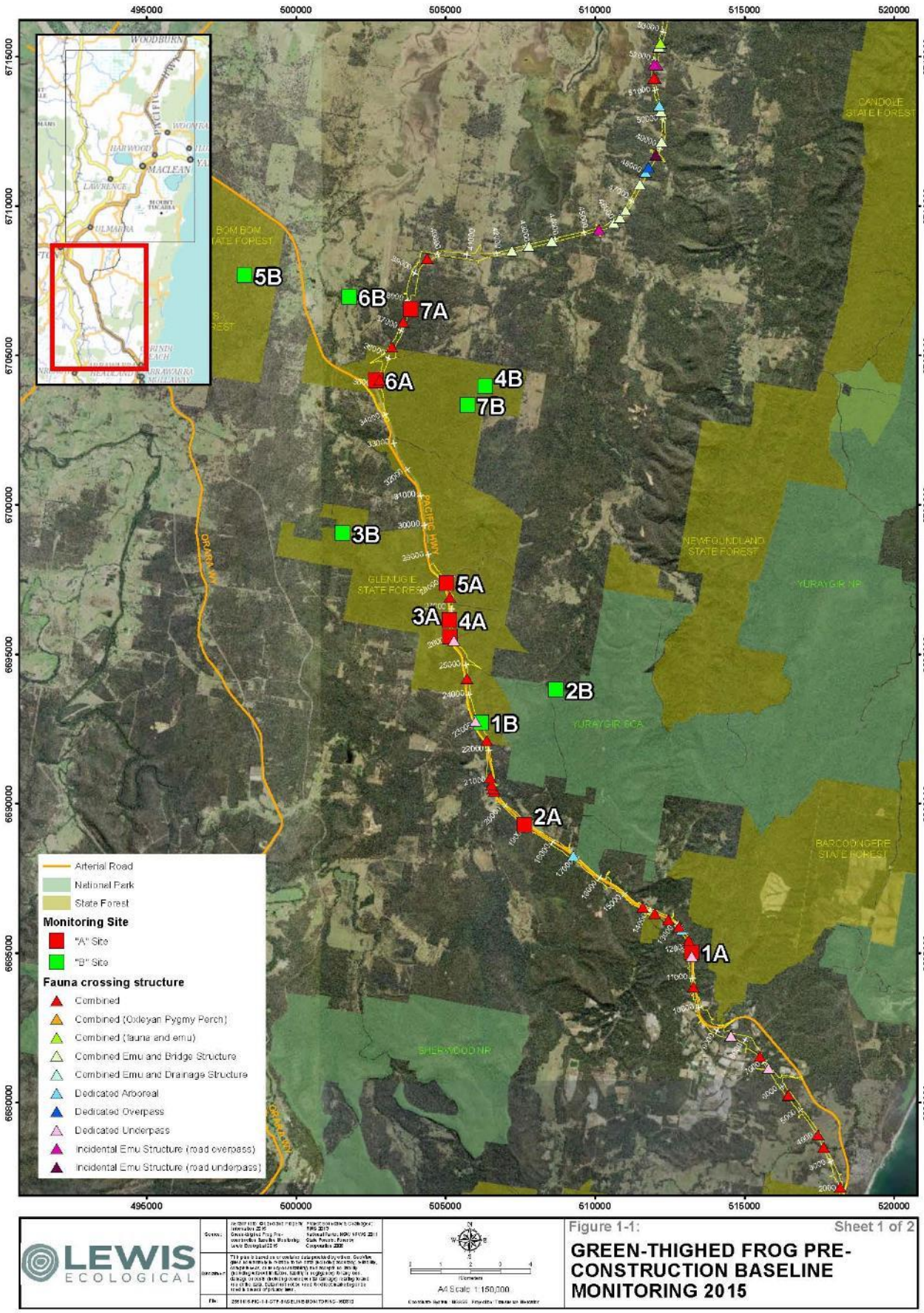

Figure 4-1. Locations of Green-thighed Frog BACI Sites 1-7 between ch.11800–40000.

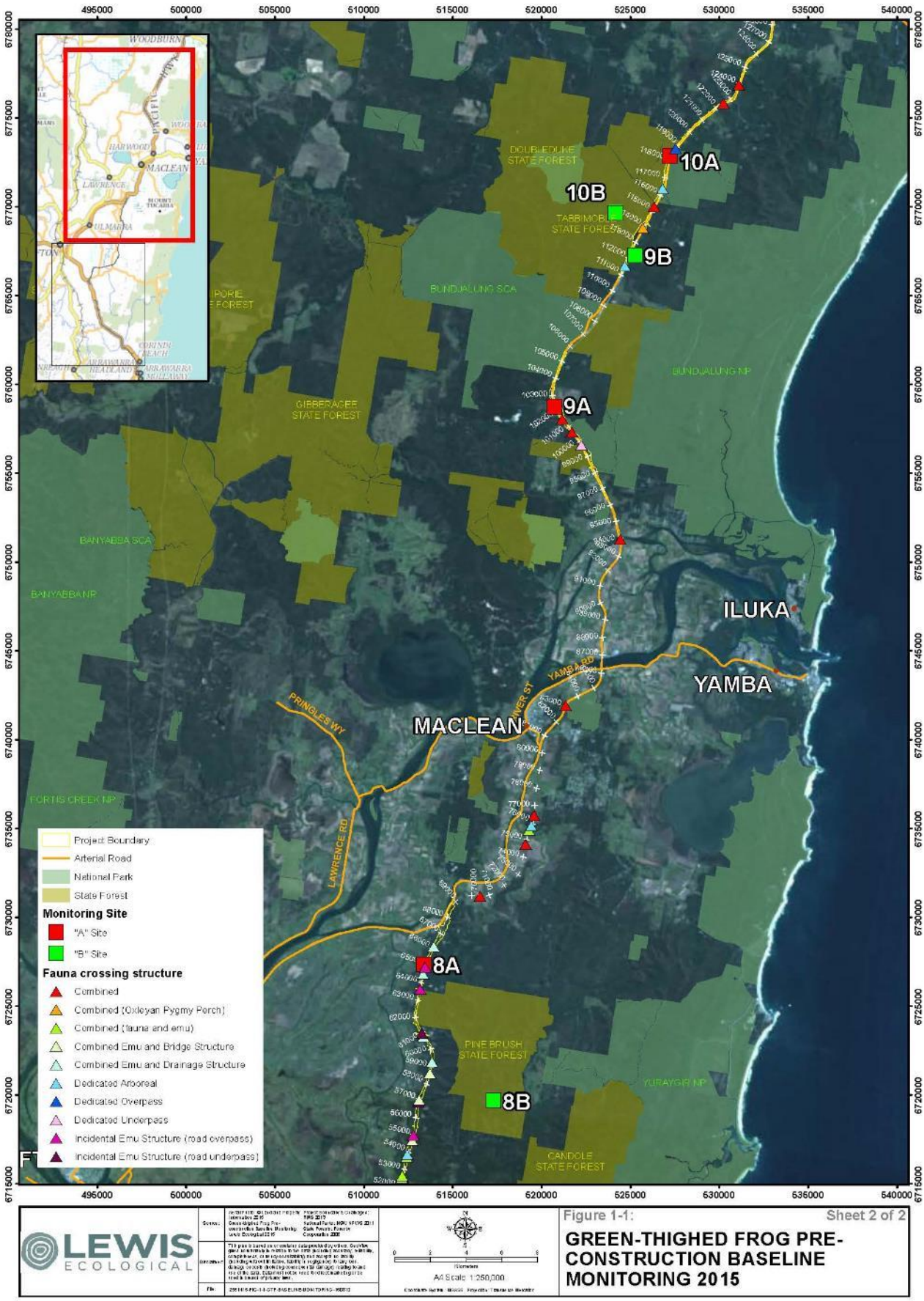

Figure 4-2. Locations of Green-thighed Frog Control and Impact sites between ch. 57500–118500.

4.2.3 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 September 2019 and the end of May 2021 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) for the southern sites and from New Italy (058097) for the northern sites.

4.2.4 Connectivity Structure Monitoring

Eleven connectivity structures have been nominated for Green-thighed Frog monitoring and extend from ch. 19180 (BACI Site 2A) to 118464 (BACI Site 10A; Table 4-1). At each site, a 20-25 min search was used to detect frogs within 100 m of the connectivity structure. Captured frogs were toe clipped with a single digit partially removed before the wound was dressed with Vetbond surgical adhesive. Frogs captured on the eastern side of the carriageway were marked on their left hand using the outer finger. Frogs captured on the western side of the carriageway were marked on their right hand using the outer finger.

Table 4-1. Summary of the connectivity structure monitored during the 2020/2021 Green-thighed Frog surveys for BACI Sites 1-10.

Chainage	Structure Type	Corresponding Frog Fence Extent
19180	RCBC	1900 to 19400 (400 m)
24570	RCBC	24500 to 25000 (500 m)
27420	RCBC	27700-28000 (300m)
35075	RCBC	34200 to 35200 (1000m)
37330	RCBC	36100 to 38300 (2200 m)
64400	Arch	64200 to 65100 (900 m)
102500	Not applicable	102100 to 102600 (500 m)
102670	RCP	just outside
111750	RCP	111800 to 112100 (300m)
111756	RCP	111800 to 112100 (300m)
118464	Bridge - Tabbimoble floodway	118100 to 118600 (500m)

4.3 Monitoring Results

4.3.1 Stage 1 Surveys - Calling Intensity and Spotlighting

Green-thighed Frogs were recorded at 15 (79%) of the 19 sites as part of Year 6 monitoring in Sections 1 and 2 and Year 5 in Sections 3-7 (Table 3-1; Figure 3-1). Frogs were recorded from six (60%) of the impact sites and from nine (100%) of the control sites. Counts and chorusing male frogs were regularly in the order of 2-5 calling males with some notable exceptions, in particular:

- Bald Knob Tick Gate Road (Site 3A) where 15 males were heard and 11 frogs spotlighted with one male a couple of metres from one of the constructed compensatory ponds;
- Airport Road (Site 6B) where 11 males were heard and nine frogs were spotlighted, and
- Jackybulbin (Site 9A) where 7 males were heard and 11 frogs spotlighted.

Frogs numbers continue to remain low in Section 1 with no frogs recorded from Site 1A (Falconers) and the southern portion of Section 2 where no frogs were recorded from Site 2A (Halfway Creek). The implementation of recommendation 4 to survey an adjacent area to Site 2A was successful in recording at least two calling males from an area closer to Kungala Road. No amplecting or mating frogs were recorded during this round of monitoring.

Plate 4-3. Green-thighed Frog observed and heard calling at Site 9A (ch.102500) in December 2020.

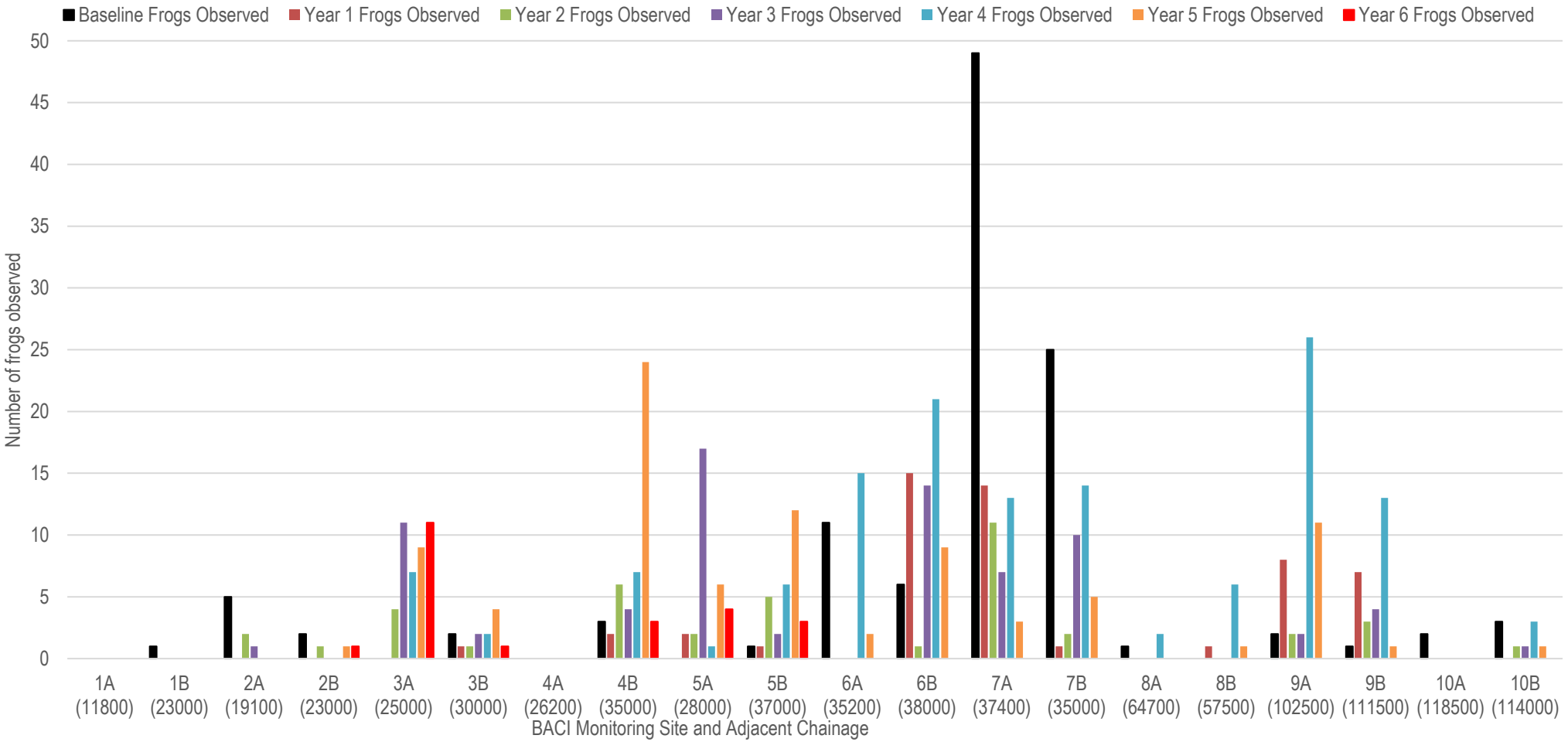

Figure 4-4. The number of Green-thighed Frogs spotlighted between the baseline survey, construction and operational monitoring in Years 1-6 at Sites 1-5 and Years1-5 at Sites 6-10.

Table 4-1. Summary of the 2020/2021 Green-thighed Frog surveys for BACI Sites 1-10.

	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 (Baseline Surveys Lewis 2015)
1A ch.11800	15.12.2020	0	0	23.01.2021	0	0	0	i. Permanent frog fencing installed adjacent to the compensatory breeding ponds. ii. Compensatory ponds constructed on western side. iii. New ponds have been desilted and reconstructed. Some have silted up again but overall considered fit for purpose.	Frogs are likely to opportunistically breed through the broader area so reliable and repeated sampling likely to remain difficult.	No
1B ch.23000	Not surveyed								Reference site identified in Niche (2014) is actually an impact site.	No
2A ch.19100	15.12.2020	0	0	23.01.2021	0	0	0	i. Permanent 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. iii. Culvert underpass provides some habitat connectivity but flooded when breeding events occur and these frogs don't tend to swim in flowing water.	Area appears to dry more rapidly. Adjacent table drains probably increased drainage in this area. Ponds dried out between breeding event and the 1st January 2021. Filled intermittently thereafter. TfNSW applied bentonite on the 25th May 2021, 3 years after the initial recommendation (*see* Lewis 2018; 2019; 2020). Adjacent site surveyed further north near Kungala Road where two males were heard calling intermittently. Implementation of recommendation 4 from previous monitoring (*see* Lewis 2020).	Yes
2B ch.23000	15.12.2020	2	1	23.01.2021	0	0	0	Outside works footprint.	Site was used again for second consecutive season but in an adjacent drain to main pond area.	Yes
3A ch.25000 (new)	15.12.2020	15	11	23.01.2021	0	3	2	i. Newly constructed compensatory breeding ponds installed in late winter 2018.	Site monitored for the first time in the operational phase. One male frog was 2 m from a constructed pond during the initial survey, remainder were around an old borrow pit pond with females.	Yes

	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 (Baseline Surveys Lewis 2015)
								ii. Permanent frog fencing installed. iii. RCP culvert located 250 m to the south as a form of habitat connectivity.	No juveniles or tadpoles recorded in the compensatory ponds. The juvenile frogs and tadpoles were recorded from edge of borrow pit pond.	
3B ch.30000	15.12.2020	2	1	23.01.2021	0	0	0	Outside works footprint.	Site likely to have dried out in a manner similar to Site 2A and 6B at the end of December 2020. Only filled intermittently until Feb/March when monitoring surveys had been completed.	Yes
4A ch.26200	16.12.2020	0	0	24.01.2021	0	0	0	i. Newly installed permanent frog fencing observed.	Site monitored for the first time in the operational phase.	No
4B ch.35000	16.12.2020	2	3	24.01.2021	0	0	0	Outside works footprint.	Site suspected of drying out completely in late December into early January. Frogs probably breed successfully later in the season in response to March 2021 rainfall event.	Yes
5A ch.28000	15.12.2020	5	4	24.01.2021	0	0	0	i. Permanent frog fence installed. ii. No compensatory ponds installed due to natural depressions that provide the same function and are currently used by frogs.	Site monitored for the first time in the operational phase. Site was impacted by a fire in mid November 2020. Damaged frog fencing was repaired in a timely manner (i.e. within weeks).	Yes
5B ch.37000	16.12.2020	2	3	24.01.2021	0	2	0	Outside works footprint.	Juveniles were found in aquatic vegetation growing at edge of main water body.	Yes
6A (35200)	16.12.2020	3	2	24.01.2021	0	0	0	i. Permanent frog fence installed. ii. Compensatory ponds installed in adjacent areas but not surveyed. iii. Combined culvert installed.	Main breeding area removed by carriageway. No constructed breeding ponds were observed in the adjacent area. Advice on adjacent ponds provided in April/May 2021.	Yes

	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 (Baseline Surveys Lewis 2015)
6B (38000)	15.12.2020	11	9	24.01.2021	0	0	0	Outside of works footprint. Occurs close to bitumen roadway.	Pond dried out too quickly at the end of December and start of January. Frogs suspected of breeding again in March.	Yes
7A (37400)	16.12.2020	0	3	24.01.2021	0	0	0	i. Permanent frog fencing installed. ii. Compensatory frog ponds installed on both sides of the carriageway. iii. Combined culvert installed in general area.	No frogs recorded using the compensatory ponds. This is expected to change in time based on observations on the way frogs breed at this site (i.e. move around and have bred in different depressions and stump holes since monitoring began). More compensatory ponds installed and advice provided in April/May 2021 after field surveys completed for this round of monitoring.	Yes
7B (35000)	16.12.2020	2	5	24.01.2021	0	2	1	Outside works footprint.	Site suspected of drying out completely in late December into early January. Frogs probably breed successfully later in the season in response to March 2021 rainfall event.	No
8A (64700)	16.12.2020	4	0	24.01.2021	0	0	0	i. Permanent frog fence installed. ii. Compensatory frog ponds constructed.	Frogs appear to have shifted their breeding site since pre construction baseline surveys were performed. Frogs now seem to breed on an adjacent private property where access has been previously denied. The mere fact that frogs are still calling in this general area eludes to an ongoing population.	No
8B (57500)	16.12.2020	3	1	24.01.2021	0	0	0	Outside works footprint.	Frogs continue to change their breeding site not unlike Site 7A. Calling frogs were recorded from the drainage line further to the north some 250m from the original calling site. The original calling site is often impacted by cattle whom may drink from the pond and make it more prone to drying out in a number of weeks.	No
9A (102500)	16.12.2020	7	11	24.01.2021	0	2	0	i. Permanent frog exclusion fencing observed. ii. The installed RCP culverts provide marginal opportunity at improving habitat connectivity.	Frog numbers have actually increased at this site but it is not known whether it is more concentrated following loss of habitat to accommodate the Upgrade. Dip-netting for tadpoles proved difficult at this site with grasses and sedges.	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 (Baseline Surveys Lewis 2015)
								iii. Compensatory frog ponds reported in April/May but not constructed at the time field surveys were performed.		
9B (111500)	15.12.2020	2	1	24.01.2021	0	3	0	Outside works footprint.	Calling frog numbers are likely to have been underestimated due to the intensity of other frog species calling. Juvenile were located at edge of leaf litter and sticks at the northern pond site.	No
10A (118500)	15.12.2020	0	0	24.01.2021	0	0	0	i. Permanent frog fence installed on the western side where the monitoring site was previously located. ii. Bridge structure completed. iii. Compensatory ponds observed on eastern side and opposite to the side where frog ponds were supposed to be constructed. iv. Additional surveys employed in accordance with recommendation 4 from last round of monitoring (Lewis 2020).	Numerous Cane Toad observed around drainage line. Frogs are proving difficult to locate at this site.	Yes
10B (114000)	15.12.2020	2	1	24.01.2021	0	0	0	Outside works footprint	Area has been altered following importation of rock and road works to improve drainage in this area. Frogs still using some of the longitudinal drainage not altered by recent forestry works along Glencoe Road.	No

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

Both tadpoles and juvenile frogs were recorded during this round of monitoring (Table 4-1). Tadpoles were recorded at two sites; Site 3A (Bald Knob Tick gate Road) and 7B (Glenugie State Forest) whilst juvenile frogs were recorded at five sites including three reference sites and two impact sites. No sub adults were recorded during the monitoring, due in part to the early season sampling and the fact that post breeding surveys were conducted around 40 days after the breeding event.

4.3.3 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 in mid December 2020 and again in mid March 2021 during this round of monitoring (Table A-2). Rainfall events exceeding 50 mm in 24 hours occurred on the 12th, 13th and 15th December in Section 1-3 and on the 13th, 14th and 15th December in Section 6 and 7 and this was followed up with rainfall events on 22nd and 23rd March. Although rainfall tallies exceeded 300 mm over five consecutive days in mid December, a number of the breeding sites had dried out by the start of January (Plate 4-4).

Plate 4-4. Site 6A (Airport Road) that had dried out only 16 days after heavy rainfall.

4.3.4 Constructed Breeding Ponds

No Green-thighed Frogs were recorded breeding in the constructed ponds at Redbank Creek (ch. 5600 E) nor at Falconers (Site 1A; ch.11800 W) and Halfway Creek (Site 2A; ch. 19100 W) in the bottom end of Section 2. Further north at wells Crossing, one calling male was recorded adjacent to constructed ponds at Bald Knob Tick gate Road (Site 3A; ch. 25000) whilst no frogs were recorded from surveyed constructed ponds at Glenugie (Site 7A; ch. 37400), Tyndale (Site 8A; ch. 64700) and what appeared to be some constructed ponds on the opposite side of the Upgrade at Tabbimoble Swamp (Site 10A; ch. 118500). A summary of the site inspections is presented below and summarised in Table 4-2.

i. Redbank Creek Ponds (5600 E)

Monitoring commenced on the 15th December 2020 following a rainfall event of approximately 300 mm over the 12-15th December leaving all four ponds filled to capacity (Plate 4-5). At this time, no Green-thighed Frogs were heard or observed around the ponds yet at least one male frog was heard calling from the western side of the carriageway. A follow up survey 17 days later on the 1st January 2021 found these ponds had reduced in capacity to between 10-35% with some storm activity in the week leading up to the pond inspection. Additional surveys on the 24th January had found all four ponds still contained water, albeit at varying levels from 30% to 60% capacity. During these surveys, approximately 10 juvenile Broad-palmed Frog (*Litoria latopalmata*) were recorded around the *Juncus* sedges growing at the edge of these ponds along with some other hylids, particularly the Bleating Tree Frog (*Litoria dentata*). Similar to past surveys at this site, no Green-thighed Frog metamorphs, juveniles or tadpoles were recorded.

The key finding was the fact that ponds still continue to dry at differing rates, so they continue to align with the design intensions of the Threatened Frog Management Plan (RMS 2015).

Plate 4-5. Redbank ponds in mid December 2020 showing 100% capacity and adequate vegetation growth.

ii. Falconers (11800 W)

Monitoring commenced on the evening of the 15th December 2020 where all five ponds had filled and over flowed following an estimated 300 mm rainfall event between the 12 and 15th December (Plate 4-6). Similar to more recent monitoring efforts, no Green-thighed Frogs were heard calling from around the ponds.

A follow up survey on the 1st January showed all five ponds contained water with capacity measured at 25-65% and they were likely to have contained water throughout the past 17 days. A follow up survey on the 24th January or around 41 days after the initial site survey found two ponds had almost dried out completely whilst the remaining three ponds contained between 10-35% of their capacity. Only Broad-palmed Frog and Bleating Tree Frog metamorphs and tadpoles were found. Whilst some ponds have shown some increased siltation, ponds were drying out at differing rates and with that, they meet the design intensions of the Threatened Frog Management Plan.

Plate 4-6. Pond inspection in mid December 2020 at Falconers (ch.11800) with some showing signs of siltation.

iii. Halfway Creek (19100 W)

Monitoring commenced on the evening of the 15th December 2020 where all three ponds had filled and over flowed following an estimated 300 mm rainfall event. No Green-thighed Frogs were heard calling or observed around the ponds, although large numbers of other common frog fauna were present, namely Ornate Burrowing Frog, Scarlet-sided Pobblebonk, Bleating Tree Frog and Rocket Frog.

A follow up survey on the 1st January found the ponds had receded to between 20-45% of their capacity over the past 17 days. Another inspection on the 24th January found one pond contained around 25% capacity whilst the other two ponds

contained less than 5% and were close to drying out. Some thunderstorm activity may have assisted in the ponds retaining water over the 41 day period.

Some management intervention is required at this site as has been recommended previous monitoring rounds.

iv. Bald Knob Tick Gate Road (25000 E)

Monitoring commenced on the 15th December where all five ponds had filled to capacity following an estimated 300 mm of rainfall in the past 72 hrs. At this time, one male Green-thighed Frog was heard and observed just metres from one of the constructed ponds whilst the remainder of frogs were located at an adjacent disused borrow pit.

A follow up survey 16 days later on the 1st January found all ponds had remained near capacity at 75-90% (Plate 4-7). The following pond survey coincided with stage 2 post breeding surveys on the 23rd January when pond levels had receded to between 25-65%. Surveys found metamorphs frogs that were identified as Bleating Tree Frog and Broad-palmed Frog, but no Green-thighed Frog.

Little vegetation still exists around three of the five ponds, however, the ponds dry out at differing rates and this meets the design intend outlined in the Threatened Frog Management Plan (Plate 4-7).

Plate 4-7. Constructed ponds at Bald Knob Tick Gate Road (Site 3A) on the 1st January 2021 still holding water.

v. Glenugie Site 7A (ch. 37400)

Monitoring for the first time of these newly constructed ponds commenced on the evening of the 16th December 2020 where four ponds on either side of the carriageway had filled and over flowed following an estimated 300 mm of rainfall over the past few days (Plate 4-8). No Green-thighed Frogs were heard calling or observed around the ponds, although a number of other species were encountered, namely Bleating Tree Frog and Broad-palmed Frog.

A follow up survey on the 1st January found the ponds had receded to between 40-80% of their capacity over the past 16 days. Another inspection on the 24th January found one pond contained around 10% capacity whilst the other seven ponds contained between 30-70% of their capacity. It is suspected that some thunderstorm activity may have assisted in the ponds retaining water over the 41 day period. Inspections around the pond edge found metamorphs of both Bleating Tree Frog and Broad-palmed Frog and a number of tadpoles belonging to the same species.

Plate 4-8. Constructed ponds at Site 7A (ch.37330) in mid December 2020.

v. Tyndale Site 8A (ch. 64700)

Monitoring for the first time of these newly constructed ponds commenced on the evening of the 16th December 2020 where the three ponds on either side of the carriageway had filled and over flowed following an estimated 300 mm of rainfall over the past few days (Plate 4-9). No Green-thighed Frogs were heard calling or observed around the ponds, although a number of other species were encountered, namely Ornate Burrowing Frog, Bleating Tree Frog, Dusky Toadlet and Scarlet-sided Pobblebonk.

A follow up survey on the 31st December found the ponds had receded to between 40-60% of their capacity over the past 15 days. Another inspection on the 24th January found one pond contained around 20% capacity whilst the other two ponds contained 40% of their capacity. It is suspected that some thunderstorm activity may have assisted in the ponds retaining water over the 41 day period as this site contains porous substrate. Inspections around the pond edge found no metamorphs and a number of tadpoles were identified as Green-thighed Frog.

Plate 4-9. Constructed ponds at Tyndale Site 8A (ch.37330) in mid December 2020.

Table 4-2. Summary of compensatory frog pond monitoring during Year 6 in Section 1 and 2 and Year 5 in Sections 3, 6 and 7.

Site	Ch. + Side of Carriageway	Number of Constructed Ponds	First Survey	Second Survey	Third Survey	Comments
Redbank Creek	5600 East	4	15th December 2020 All ponds filled to capacity. Visual Water Quality – same as adjacent Redbank Creek and flooded depressions.	1st January 2021 Ponds at 10-35%. Visual Water Quality – same as adjacent Redbank Creek. No flooded depressions to compare with, dried up.	24th January 2021 Ponds increased to 30-60% capacity with follow up rain. All ponds appear to have held water for entire duration of 40 days. Visual Water Quality – same as adjacent Redbank Creek.	Ponds continue to fluctuate and would dry out completely if no rainfall for approximately 50-60 days. Green-thighed Frog known from western side of Upgrade and several hundred metres to the north at the McLaughlin Road overpass.
Falconers	11800 West	5	15th December 2020 All ponds filled to capacity. All five ponds filled to a depth of 200-300 mm. Visual Water Quality – Turbid from steep batter run off but likely to settle once rain ceases.	1st January 2021 Ponds have receded to 25-65% capacity over past 16 days. Visual Water Quality – Similar to surrounding area. Visibility 100 mm or bottom.	24th January 2021 Two ponds almost completely dry whilst remaining three at 10-35% capacity. Visual Water Quality – Similar to surrounding area. Visibility 100 mm or bottom.	Follow up rainfall still considered essential for ponds to retain water for more than 30 consecutive days. Ponds drying at a time period consistent with the requirements of the Threatened Frog Management Plan.
Halfway Creek	19100 West	3	15th December 2020 All ponds filled to capacity. Contain 200-350 mm of water. Visual Water Quality – same as adjacent flooded areas to the south with a slight tannin stain.	1st January 2021 Ponds measured at 20-45% capacity and drying at a rapid rate without follow up rainfall. Visual Water Quality – same as adjacent flooded areas to the south with a slight tannin stain.	24th January 2021 Ponds virtually dry and one at 25% capacity. Visual Water Quality – Either clear or dry.	Without consistent follow up rain of >20 mm every 10 days, ponds tend to dry out. Require intervention to slow draining.
Bald Knob Tick Gate Road	25000 East	5	15th December 2020 All ponds filled to capacity. Contain 250-350 mm of water. Visual Water Quality – same as adjacent flooded areas – turbid from surrounding sodic soils.	1st January 2021 Ponds remain at 75-90% or around 170-340 mm in depth. Visual Water Quality – Similar to surrounding area. Still turbid but considered suitable for tadpoles.	24th January 2021 Ponds 25-65%. Visual Water Quality – Similar to surrounding area. Still turbid but considered suitable for tadpoles given the records from the neighbouring borrow pit.	One male frog calling from near one of the constructed ponds but still no confirmed breeding. Different drying times is consistent with the design intentions outlined in the Threatened Frog Management Plan.
Section 3	Ch.37400 (both sides)	8	15th December 2020 All ponds filled to capacity. Contain 250-400 mm of water.	1st January 2021 Ponds remain at 40-80% or around 130-290 mm in depth.	24th January 2021 Ponds 10-70%.	Ponds have received timber and other habitat treatments including sedge plantings. Pond suitability likely to improve over time.

Site	Ch. + Side of Carriageway	Number of Constructed Ponds	First Survey	Second Survey	Third Survey	Comments
			Visual Water Quality – same as adjacent flooded areas – turbid from surrounding sodic soils.	Visual Water Quality – Similar to surrounding area. Still turbid but considered suitable for tadpoles.	Visual Water Quality – Similar to surrounding area. Still turbid but considered suitable for tadpoles given the records from the neighbouring borrow pit.	
	64700 West	3	16th December 2020 All ponds filled to capacity. Contain 350-400 mm of water. Visual Water Quality – same as adjacent flooded areas – turbid from surrounding sodic soils.	31st December 2020 Ponds remain at 40-60% or around 150-230 mm in depth. Visual Water Quality – Similar to surrounding area. Still turbid but considered suitable for tadpoles.	24th January 2021 Ponds at 20-40% capacity. Visual Water Quality – Similar to surrounding area. Still turbid but considered suitable for tadpoles given the records from the neighbouring borrow pit.	Ponds probably require follow up rainfall to ensure sufficient water over a 40-50 day period. Ponds have received tubestock plantings.
Section 6	Advised after field surveys completed.					Details provided via email on the 28th April 2021.
Section 7	Advised after field surveys completed.					Details provided via email on the 28th April 2021.

4.3.5 Connectivity Structure Monitoring

Green-thighed Frogs were recorded adjacent to two of the 10 structures with one female clipped on the western side of the carriageway at ch. 37330 (i.e. Site 7A) and nine frogs captured and clipped from the western side of the carriageway at Site 9A where a round concrete pipes have been constructed at ch. 102670 (Table 4-3).

Table 4-3. Summary of connectivity structure monitoring performed during Year 6 at Sites 1-5 and for Year 5 at Sites 6-10.

Chainage	Structure Type	Length / specs	Frog Fence	Number of Green-thighed Frogs (finger-clip) Left outer finger is east side. Right outer finger is west side.	Comments
19180	RCBC	3.0 x 3.0 x 50 m	1900 to 19400 (400 m)	No captures	Culvert tends to flood during rainfall periods that are suitable for Green-thighed Frog breeding. Green-thighed Frog don't tend to swim around in large ponds or streams of free standing/ flowing water.
24570	RCBC	3.0 x 3.0 x 23 m	24500 to 25000 (500 m)	No captures	Site under construction. Contractor working on underpass.
27420	RCBC	3.0 x 3.0 x 40 m	27420 to 28000 (580 m)	No captures	Area was burnt by wildfire in November 2020
35075	RCBC		34200 to 35200 (1000m)	No captures	
37330	RCBC		36100 to 38300 (2200 m)	Female on west side received left toe clipped	Away from culvert to the north side.
64400	Arch		64200 to 65100 (900 m)	No captures	
102670	RCP		102100 to 102600 (500 m)	Eight males and 1 female toe clipped on west side of carriageway.	Frogs concentrated on western side.
111750	RCP		111800 to 112100 (300m)	No captures	
111756	RCP		111800 to 112100 (300m)	No captures	
118464	Bridge - Tabbimoble floodway	20 m span	118100 to 118600 (500m)	No captures	Toads around the crossing structure.

4.3.6 Frog Fencing

No Green-thighed Frogs were recorded on the road side of the installed permanent fencing at any of the 10 sites (Table 5-4). Although no Green-thighed Frogs were recorded on the road side of the fenced sections, some other frogs were, and they included both tree frogs (i.e. hylids) and ground dwelling frogs (i.e. myobatrachids). The most notable of these sites is Redbank Creek where the road was littered with many hundreds of dead frogs (Plate 4-10). This site is located within an area of divided road with a vegetated median. The vegetated median is not frog fenced.

Green-thighed Frogs were also recorded as road kill with one male recorded at the control Site 6B along Airport Road which is not part of the highway nor does it contain a frog fence (Plate 4-11).

Table 4-4. Summary of permanent frog exclusion fence monitoring during Year 6 at Sites 1-5 and for Year 5 at Sites 6-10.

Site	Ch. + Side of Carriageway	Status of Fencing	Fencing Extent Surveyed	Green-thighed Frogs Within 2 m Habitat Side of Fence	Green-thighed Frogs on Road Side of Fence	Comments
Redbank Creek (Not a BACI monitoring Site)	5600 East	Completed permanent fence	5500-5625	Nil	Nil	Some minor breaches and finishing attention at tie in points to culvert and directional changes required. Numerous frogs found struck on the carriageway. Vegetation median not fenced. Refer to Plate 4-10 from mid December 2020.
Falconers (Site 1A)	11800 West	Completed permanent fence	11700-11850	Nil	Nil	Steep batter associated with this area probably improves the functionality of the fence but number of points mesh does not connect with the ground.
Halfway Creek (Site 2A)	19100 West	Completed permanent fence	19000-19500	Nil	Nil	Deep table drain on road side appears to attract frog fauna. Number of breach points at turn points and ties to culvert areas plus gaps with mesh on ground. Frogs found on both sides of the fence including frogs breeding on the road side of the fence.
Bald Knob Tick Gate Road (Site 3A)	25000 East	Completed permanent fence	24500-25000	Nil	Nil	Most of the frogs encountered were on the habitat side of the fence. Fence appears effective at reducing rather than eliminating frog movements out onto the carriageway.
Old Highway Heavy Vehicle Checking Station (Site 4A)	26200 West	Completed permanent fence	26100-26250	Nil	Nil	Far fewer frogs through this area than previous surveys. Area had been recently burnt in the past 4-6 weeks. Fewer frogs on the road side of the fence.
Franklins Road (Site 5A)	28000 East	Completed permanent fence	27900-28050	Nil	Nil	Some minor breach points in the fence but considered effective at reducing frog movements out onto the carriageway. Damaged sections of the fence from the Nov 2020 fire had been repaired before the breeding surveys were undertaken in mid December 2020.
Pheasant Creek (Site 6A)	35200	Completed permanent fence	35050-35300	Nil	Nil	Some minor breach points in the fence but considered effective at reducing frog

Site	Ch. + Side of Carriageway	Status of Fencing	Fencing Extent Surveyed	Green-thighed Frogs Within 2 m Habitat Side of Fence	Green-thighed Frogs on Road Side of Fence	Comments
						movements not eliminating them from accessing the carriageway.
Old Six Mile Lane (Site 7A)	38000	Completed permanent fence	37230-37500	1	Nil	One male frog found 2 m from fence and ~100m north of the culvert and was toe clipped. Number of miner breach points observed including near wing walls of connectivity culvert ch. 37330 (Plate 4-12).
Tyndale Crown Reserve (Site 8A)	64700	Completed permanent fence	64600-64750	Nil	Nil	Majority of frogs found on habitat side of frog fence.
Jackybulbin (Site 9A)	102500	Completed permanent fence	102100 to 102600	Nil	Nil	Large numbers of frogs in this area. Majority on habitat side of the fence.
Tabbimoble North (Site 10A)	118500	Completed permanent fence	118100 to 118600	Nil	Nil	Large numbers of frogs in this area. Majority on habitat side of the fence.

Plate 4-10. South bound carriageway at Redbank Creek where many hundreds of road kill frogs were recorded adjacent to constructed frog ponds and permanent frog fence.

Plate 4-11. Road kill Green-thighed Frog at the reference Site 6B on Airport Road.

Plate 4-12. Example of a breach point at a monitored connectivity structure: Site 7A ch. 37330 inlet side of wing wall.

4.4 Discussion

Green-thighed Frog monitoring over the 2020/2021 season continues to record frogs at most of the monitoring sites yet there is similarly a continuation of notable absences of frogs from Falconers (Site 1A), Halfway Creek (Site 2A), Glenugie Old Heavy Vehicle Checking Station (Site 4A) and Tabbimoble (Site 10A). Pre-construction surveys found frogs at all four of these sites in either 2013 or 2015 or during both years (Lewis 2013a, b; Lewis 2015). Frogs at Falconers have now remained absent for a number of years following clearing to accommodate the Upgrade along with clearing of adjacent lands for blue berry production. Simply surveying a few further adjacent areas is problematic due to access constraints yet it may be the only approach to demonstrate that a local population remains in this area. A similar situation has unfolded at Halfway Creek (Site 2A) where several frogs were present during the baseline surveys in 2015 and many more just two years earlier (Lewis 2013b). Numbers have continued to decline since construction despite a number of mitigation actions in the form of compensatory ponds and frog fencing. Monitoring of the ponds themselves has continued to show they dry too quickly to enable tadpoles to reach metamorphosis without follow up rainfall. The longitudinal drains that direct water through the culvert at ch.19100 and into Halfway Creek continue to move water away from this area much quicker than it had in the past. The adoption of the recommendation to proceed with some additional adjacent surveys proved useful when two calling males were heard from around 600-700 m further north toward Kungala Road. Interestingly, the longitudinal drainage in this area is less intrusive of the adjacent habitat and some viable breeding habitat may have been retained.

Further north at Site 4A (Glenugie Old Heavy Vehicle Checking Station), this site has not recorded frogs since the initial pre-construction surveys of 2013 whilst the second updated round was unable to detected frogs (Lewis 2013b; Lewis 2015). Even then, frogs were calling from a range of micro habitats on both sides of the old carriageway and there was no well-defined breeding site. This round of monitoring coincided with the first operational survey where the newly constructed carriageway was open to traffic and the old carriageway has been returned to a service road and subject to reclamation works. Some additional monitoring is warranted for at least the next two seasons so that three consecutive operational monitoring events can be completed and to more fully evaluate whether frogs will return to this area.

At the northern end of the project, Site 10A (Tabbimoble north) proved difficult to locate frogs even with the implementation of last year's recommendation to sample additional adjacent areas to locate a population. This additional time was expended further downstream or two the west of the carriageway without success. It is difficult to understand why this has happened as a relatively small area of habitat has been removed to accommodate the carriageway. This site is considered somewhat important in that it represents the most northern population within the W2B project corridor and perhaps some additional effort is warranted to determine whether the population still exists.

Monitoring at most of the sites continue to yield frogs and the numbers are often comparable to the baseline survey of 2015 (Lewis 2015). One difficulty of counting frogs with this sort of monitoring program is that road noise can make it difficult to accurately locate frogs, and secondly, there are almost always more numbers of other common species of frog,

so the aural range can be drastically reduced. In some cases such as Jackybulbin (Site 9A) there were so many Tylers Tree Frog, Graceful Tree Frog and Bleating Tree Frog that the surveyor had to be within a few metres to hear the call of the Green-thighed Frog (Plate 4-13).

Plate 4-13. Example of calling site and calling intensity of non target species at Jackybulbin during mid December surveys. Tylers Tree Frogs.

This round of monitoring was similar to sampling during the 2018/2019 season when heavy rainfall fell in mid December 2018 before drying to the point that some ponds dried out before tadpoles could have reached metamorphosis. This occurred at only some of the constructed compensatory ponds and also at some of the natural or reference sites. The constructed ponds at Halfway Creek (ch. 19180) continue to dry too rapidly and the required intervention has only recently taken place on the 25th May 2021 (TfNSW email dated 26/5/2021).

Compensatory ponds in Section 3 were monitored for the first time during this round of sampling. Whilst field surveys were unable to detect Green-thighed Frogs using these ponds, general monitoring of water levels revealed that they dry at rates consistent with the requirements of the Threatened Frog Management Plan. At Site 7A, ponds have been constructed on both sides of the carriageway and not far from a combine use culvert that is accompanied with permanent frog fencing. Green-thighed Frogs have been recorded calling and breeding in depressions similar to those constructed, so there may be some success here in time. Meanwhile, the ponds constructed in the road reserve adjacent to Tyndale Crown land appear fit for purpose in that they dry at different rates. The only perceived problem is the fact that calling frogs can now only be located on private property around 150 m to the south which is different from when the baseline surveys were conducted and frogs were regularly using the drains along the access track. Monitoring will prove useful in evaluating improved habitat conditions for Green-thighed Frog at this location.

For the remaining sites, notification on the completion of constructed compensatory ponds was provided on the 28th April, sometime after field monitoring had been completed. Monitoring for the first time is scheduled during the 2021/2022 season.

How the data collected for Year 6 and 5 compares or performs against the prescriptions outlined in the Threatened Frog Management Plan is outlined in the following section.

4.5 Performance Measures 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.*

Monitoring during the 2020/2021 season includes the population monitoring component as well as the compensatory ponds in Sections 1, 2 and 3, but not Section 6 and 7. Underpass structure monitoring and permanent frog fence monitoring also forms part of the performance related monitoring where structures and permanent frog fencing has been completed.

4.5.1 Population Monitoring

The performing factor for the population monitoring is the number of frogs observed following a recommendation from earlier surveys (Lewis 2017). Most sites recorded sufficient numbers of frogs with counts compared to the past baseline surveys (Table 4-5). Where there has been declines, in most cases these have not exceeded the threshold of >25% relative to the reference site over three consecutive monitoring events. This is not the case at Halfway Creek (Site 2A) which has undergone a continued decline to the point frogs are now absent over the past three rounds of monitoring whilst the reference site has declined by 50%, leaving a relative decline of 50%, far greater than the 25% threshold. It is a similar situation at Tabbimoble north where frogs have declined by 100% at the impact site (ch.118500) compared to 67% at the control site and this has been the case for four monitoring periods now (Table 4-5; Table 4-6) .

Other sites which have showed a downward trajectory include Site 6 where numbers have declined by 80% yet the reference site has increased by 50%. This decline wasn't evidence during last year's monitoring so there is time for this population to recover before some form of corrective intervention is required. In some ways a more drastic decline has also been recorded further north at Glenugie with Site 7 declining by 94% but this is mirrored to some extent at the reference site which declined by 80%. Again, last year's monitoring showed less dramatic declines so it may be more a factor of missing the peak activity of Green-thighed Frogs this year compared to last year.

4.5.2 Connectivity Structures and Permanent Frog fencing

Surveys performed at the 10 connectivity structures found no frogs had completed a passage from one side of the road to the other (Table 4-6). In reality, and in most cases this was the first year of more intensive sampling where frogs were captured and marked at Glenugie (Site 7A) and Jackybulbin (Site 9A). Monitoring during successive years will provide an opportunity for their recapture and assessment as to whether these frogs have moved across the carriageway.

Table 4-5. Green-thighed Frog abundance between the baseline survey and Years 1-6 (Site 1-5) in Section 1 and 2 and Years 1-5 (Sites 6-10) in Section 3, 6 and 7.

BACI Site	Treatment Class	Site Name	Base No. Frogs	Yr 1 No. of Frogs	Yr 2 No. of Frogs	Yr 3 No. of Frogs	Yr 4 No. of Frogs	Yr 5 No. of Frogs	Yr 6 No. of Frogs	Comments
1A ch.11800	Impact	Falconers	0	0	0	0	0	0	0	No frogs spotlighted at this site since some route investigation surveys in 2013 (Lewis 2013) which pre dates the baseline surveys. Site was selected in a site selection study (Niche 2014).
1B ch.23000	Control	Wells Crossing	1	0	0	0	0	0	0	Site is not a control site as it occurs adjacent to the Upgrade. Site was selected in a site selection study (Niche 2014).
2A ch.19100	Impact	Halfway Creek	5	0	2	1	0	0	0	Frog numbers have declined to zero. Corrective action included some additional surveys which located frogs at a nearby adjacent area indicating the population is still present.
2B ch.23000	Control	Yuraygir SCA	2	0	1	0	0	1	1	Population remains present with low numbers recorded sporadically throughout the monitoring program. Zeros probably reflect either surveys which have just missed ideal weather conditions.
3A ch.25000 (new)	Impact	Bald Knob Tick Gate Road	0	0	4	11	7	9	11	The zero's reflect an impact site from the site selection study (Niche 2014). The increased numbers in more recent years reflect an adopted recommendation to shift the impact site 500 m back to bald Knob Tick Gate Road where frogs have been consistently recorded.
3B ch.30000	Control	Glenugie West	2	1	1	2	2	4	1	Small numbers of frogs consistently recorded.
4A ch.26200	Impact	Glenugie	0	0	0	0	0	0	0	A site located between the Old Pacific Highway and the Upgrade where sampling has always proved problematic. Frogs occur a few hundred metres to the west just not at the selected monitoring site.
4B ch.35000	Control	Morilla Road North	3	2	6	4	7	24	3	Numbers have remained consistent with a notable peak in Year 5 reflect ideal timing of the survey.
5A ch.28000	Impact	Franklins Road	0	2	2	17	1	6	4	Numbers have improved since the baseline survey.
5B ch.37000	Control	Bom Bom State Forest	1	1	5	2	6	12	3	Numbers have remained consistent throughout the monitoring period.
6A (35200)	Impact	Pheasant Creek	11	nd	nd	nd	15	2		Frogs remain at this site following construction albeit with some changes in habitat use. The no data (nd) reflects when access constraints prevented surveys from being undertaken.
6B (38000)	Control	Airport Road	6	15	1	14	21	9		Numbers have remained consistent throughout the monitoring period.
7A (37400)	Impact	Six Mile Lane	49	14	11	7	13	3		Numbers of frogs have declined, however, they are comparable to the reference or control site at Morilla Road South.
7B (35000)	Control	Morilla Road South	25	1	2	10	14	5		Numbers of frogs have declined, however, they are comparable to the impact site to the south of Six Mile Lane.

BACI Site	Treatment Class	Site Name	Base No. Frogs	Yr 1 No. of Frogs	Yr 2 No. of Frogs	Yr 3 No. of Frogs	Yr 4 No. of Frogs	Yr 5 No. of Frogs	Yr 6 No. of Frogs	Comments
8A (64700)	Impact	Tyndale Crown Reserve	1	0	0	0	2	0		Numbers of frogs remain sporadic with access constraints to the south limiting sampling.
8B (57500)	Control	Pine Brush State Forest	0	1	0	0	6	1		Numbers remain sporadic at this site which tends to have a very ephemeral breeding site so there is probably some shift in habitat use.
9A (102500)	Impact	Mororo West	2	8	2	2	26	11		Numbers of frogs have increased markedly since the baseline survey including a quick post fire recovery in early 2020 several weeks after a major wildfire burnt the site.
9B (111500)	Control	Mororo East	1	7	3	4	13	1		Numbers of frogs are quite sporadic but their presence is consistent with detections during each monitoring survey.
10A (118500)	Impact	Glencoe Road	2	0	0	0	0	0		The documented breeding site was removed to accommodate the Upgrade and frogs have not been recorded since the baseline survey. Corrective actions have included additional surveys which have not been able to detect presence in adjacent areas.
10B (114000)	Control	Tabbimoble	3	0	1	1	3	1		Frog numbers have remained consistently low with this site influenced by the extent of road maintenance works by Forestry Corporation along Glencoe Road.

Permanent frog fence surveys tied into this connectivity found no frogs on the carriageway side of the fence, although a number of potential breach points were observed at Redbank Creek, Site 1A , 2A, 6A, 7A and 9A (Plate 4-12).

4.5.3 Compensatory Breeding Ponds

Surveys were unable to detect Green-thighed Frogs using the constructed compensatory ponds at Redbank Creek (ch5600E), Falconers (ch11800W), Halfway Creek (ch19100W), Bald Knob Tick Gate Road (ch. 25000E), Glenugie (ch.37330E+W) and Tyndale (ch.64700W) with monitoring spanning between 1-5 years.

Most of the ponds tends to work in a manner consistent with the requirements of the Threatened Frog Management Plan (RMS 2015). There is an ongoing exception to this at Halfway Creek (Site 2A) where the recommended action to apply an inhibiter such as bentonite has only been completed in May 2021. To monitor its effect will require a survey during the 2021/2022 season. Meanwhile, the sedimentation of some ponds at Falconers (Site 1A) has reduced the number of available ponds to three, however, these tend to function in a suitable manner.

Ponds are believed to have been constructed at Jackybulbin near Site 9A as well as some ponds at Tabbimoble north (Site 10A). Some cursory surveys were performed around the ponds at Tabbimoble north but given their location on the eastern side of the carriageway, additional monitoring efforts were abandoned until the final pond locations were advised in April 2021.

4.5.4 Riparian Habitat Revegetation

As the ponds nor monitoring sites occur in riparian areas, the riparian habitat revegetation parameters appear irrelevant at this time.

Table 4-6. Performance indicators and corrective actions from the Threatened Frog Species Management Plan (RMS 2015).

Triggers for corrective actions	Corrective actions	Relevance to 2019/20 Green-thighed Frog Monitoring	Results of 2020/2021 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).	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	Site 1 – No change at impact site whilst reference site has declined by 100% to zero. Site 2 – Frog numbers have declined 100% over the past 3 years at the impact treatment. Frog numbers have fluctuated from 100% to 50% decline. Relative decline between the two treatments exceeds 25%. Site 3 – The impact treatment was relocated and since then, the site has consistently recorded frogs. Meanwhile the control site fluctuates between 1-4 frogs. Site 4 - Remains static with no frogs recorded at the impact treatment and the same number of frogs as the baseline survey at the control treatment. Site 5 – Both treatments have increased since the baseline survey. Site 6 – Impact treatment has recently declined by	Site 1A and 4A were poorly selected monitoring sites (*see* Niche 2014). Frogs are likely to still occur in the immediate area (i.e. <500 m). A targeted survey could confirm this. At Site 2A, improved drainage from the Upgrade has reduced drying periods for temporary flooded depressions and drains where frogs used to breed. Surveys in adjacent area detected two calling males near Kungala Road. At Site 6A, improved drainage has reduced suitability as breeding site. At Site 8A, changes in drainage patterns have resulted in a shift in the way the residual frog population uses the site. At Site 10A, loss of breeding pond and no new pond detected despite some suitable areas.	Site 8A – Perform second round of monitoring with newly constructed ponds before investigating a change in sampling strategy.

Triggers for corrective actions	Corrective actions	Relevance to 2019/20 Green-thighed Frog Monitoring	Results of 2020/2021 Green-thighed Frog Monitoring	Potential Contributing Factors	Corrective Action Required
			82% whilst control site has increased by 50%. First monitoring period where decline of this magnitude recorded. Site 7 – Both sites have declined since the baseline with 94% at the impact and 80% at the control site. Site 8 – The impact site has declined 100% to zero whilst the reference site has increased. Previous monitoring recorded an increase in population size across both treatment classes. Site 9 – The impact sites has increased fivefold whilst the reference sites remains largely static. Site 10 – The impact site has decreased to zero or 100% over the past 5 years whilst the control site has declined by 67% but recovered last year.		
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	Review monitoring methods where goals are not achieved, by increasing frequency, intensity and duration, to ensure individuals are identified.	Relevant	Surveys marked frogs at Site 7A with 1 individual and 9 individuals at Site 9A.	Sampling has only just commenced so not possible to determine connectivity at most of the sites.	Nil

Triggers for corrective actions	Corrective actions	Relevance to 2019/20 Green-thighed Frog Monitoring	Results of 2020/2021 Green-thighed Frog Monitoring	Potential Contributing Factors	Corrective Action Required
exclusion fencing damaged or ineffective.	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.		All other nominated structures under construction.		
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.	Section 1 & 2 - 3-5 rounds of pond monitoring have been completed. Section 3 – 1 round of pond monitoring. Section 6 and 7 – No pond monitoring to date (email on 28.04.2021 stating ponds installed).	Section 1 and 2 – No confirmed use via amplecting frogs nor tadpoles or juveniles at pond edge. 1 male observed calling close to pond at Site 3A (Bald Knob Tick Gate Road). Section 3 – No confirmed use during first round of monitoring.	Section 1 – At Redbank Creek, more suitable habitat on western side of the carriageway yet ponds were constructed on the eastern side. Ponds at Falconers provide frog breeding habitat. Likely to be other similar habitat used by frogs in locality (i.e. <500m). Section 2 – Corrective action at Site 2A ponds was delayed until 25th May 2021 so no monitoring has taken place since treatment. Longitudinal drains remove water too quickly. Ponds at Bald Knob Tick Gate Road (ch. 25000) compliment some existing habitat which has been the preferred breeding site. Use of existing depressions at Franklins Road (ch. 28000) was less successful due to fire activity in this	1. Perform a calling/breeding survey on the western side of Redbank Creek to determine the extent of suitable breeding habitat.

Triggers for corrective actions	Corrective actions	Relevance to 2019/20 Green-thighed Frog Monitoring	Results of 2020/2021 Green-thighed Frog Monitoring	Potential Contributing Factors	Corrective Action Required
				area only 6 weeks before the breeding event. Section 3 - At Site 7A, the new carriageway has probably improved drainage through this area, and with that, it may take some time to locate the current main breeding site. At Site 8A, frogs have shifted their breeding site to an adjacent private property whilst the ponds were only monitored for their first time during this round of monitoring. Ponds are located in an area where pre construction surveys found numerous Green-thighed Frogs.	
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.	Relevant	Water quality at all ponds is comparable to surrounding habitat, often turbid from sodic soils.	Comparable to surrounding habitat.	Nil
No persistent water present in ponds (negative hydro period) despite recent rainfall.	Assess possible causes for water draining from the pond and apply physical corrective actions	Five rounds of monitoring have been completed at Sections 1 and 2 where ponds have been constructed at four sites and monitoring performed over five seasons at three sites and three season at Site 3A. First round of monitoring at ponds in Section 3 (Site 7A, 8A).	Section 1 and 2 - Ponds held water at variable rates and considered to have met design intentions at Redbank Creek, Falconers and Bald Knob Tick Gate Road but not at Halfway Creek (ch.19180). Section 3 – Pond drying rates met the design requirements of holding water for 40-50 days.	Section 1/2 – Longitudinal drains draw water away from the ponds too quickly. No bentonite or clay has been applied to the ponds until 25/05/2021. Proximity of services and the project boundary limit the extent and location of ponds.	

Triggers for corrective actions	Corrective actions	Relevance to 2019/20 Green-thighed Frog Monitoring	Results of 2020/2021 Green-thighed Frog Monitoring	Potential Contributing Factors	Corrective Action Required
		Notification of pond construction in Section 6 and 7 provided on 28th April 2021, after this round of monitoring was completed.			
Mosquito Fish present and threatened frogs / tadpoles absent.	Draining pond to remove Mosquito Fish and allow pond fill at the next rain event.	Five rounds of monitoring have been completed at Sections 1 and 2 where ponds have been constructed at four sites and monitoring performed over five seasons at three sites and three season at Site 3A. First round of monitoring at ponds in Section 3 (Site 7A, 8A). Notification of pond construction in Section 6 and 7 provided on 28th April 2021, after this round of monitoring was completed.	No Mosquito Fish recorded.	Ponds are drying out to ensure they remain fish free.	Nil.
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 of the TFSMP (RMS 2015).	Undertake revegetation maintenance, i.e. replanting, erosion control, weed control. Ensure wetlands are functioning as designed and present suitable habitat in terms of water quality and hydro-period.	Five rounds of monitoring have been completed at Sections 1 and 2 where ponds have been constructed at four sites and monitoring performed over five seasons at three sites and three season at Site 3A.	1. Ponds at Redbank Creek, Falconers and Bald Knob Tick Gate Road functioning as suitable Green-thighed Frog breeding habitat. 2. Ponds at Halfway Creek drying too quickly and require rectification	At Halfway Creek, longitudinal drains act as a sump to the surrounding area with the area drying out rapidly. There are also other infrastructure including Telstra and Optic Fibre between the frog fence and the Project boundary leaving very little room.	

Triggers for corrective actions	Corrective actions	Relevance to 2019/20 Green-thighed Frog Monitoring	Results of 2020/2021 Green-thighed Frog Monitoring	Potential Contributing Factors	Corrective Action Required
		First round of monitoring at ponds in Section 3 (Site 7A, 8A). Notification of pond construction in Section 6 and 7 provided on 28th April 2021, after this round of monitoring was completed.	works. The longitudinal table drain beside carriageway has increased drainage in this area and requires compensatory measures for Green-thighed Frog. 3. Ponds in Section 3 appear to be suitable but only one round of monitoring has been performed.		
Revegetated native habitat in poor condition (e.g. >30% cover died, plant dieback).	Undertake revegetation maintenance, i.e. replanting, erosion control, weed control. Ensure wetlands are functioning as designed and present suitable habitat in terms of water quality and hydro-period.	Not relevant.	Not Applicable	Not Applicable	Not Applicable
Frog absence confirmed following monitoring surveys (it should be noted that a pond may be suitable for frogs, but not colonised).	Undertake revegetation maintenance, i.e. replanting, erosion control, weed control. Ensure wetlands are functioning as designed and present suitable habitat in terms of water quality and hydro-period.	Relevant	Redbank Creek, Falconers and Bald Knob Tick Gate Road – ponds are constructed in a suitable manner and considered functional. Halfway Creek – Ponds during this round of monitoring dried out too quickly. Glenugie (Site 7A) – Ponds constructed in a suitable manner and considered function during their first round of monitoring.	At Halfway Creek, longitudinal drains act as a sump to the surrounding area and increased drying times. Difficult area to position ponds away from other infrastructure and services combined with close proximity of the project boundary. At Site 8A, ponds are competing with a new breeding site on private land that cannot be accessed to assess population size and stability.	

Triggers for corrective actions	Corrective actions	Relevance to 2019/20 Green-thighed Frog Monitoring	Results of 2020/2021 Green-thighed Frog Monitoring	Potential Contributing Factors	Corrective Action Required
			Tyndale (Site 8A) - Ponds constructed in a suitable manner and considered function during their first round of monitoring.		
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 – locations are not within riparian zones.	Not relevant	Not relevant	Not relevant

4.6 Conclusions and Recommendations

Monitoring for the Green-thighed Frog was triggered by the first suitable rainfall event which commenced on the 12th December and continued to almost the 19th December 2020. This rainfall event was a broad weather system which allowed surveys to be conducted over the entire study area in a manner similar to the last round of monitoring. A second similar weather system delivered a more intense rainfall event in mid March 2021 but the sites were not surveyed due to the earlier season sampling.

Frogs were recorded at 15 monitoring sites summarised as six impact sites and nine of the control sites. Sampling in Section 1 has continued to produce mixed results. No frogs were recorded at Falconers (Site 1A), Halfway Creek (Site 2A) and the table drain areas near the Old Southbound Heavy Vehicle Checking Station (Site 4A) yet frogs were observed and heard calling from Bald Knob Tick Gate Road (Site 3A) and Franklins Road (Site 5A). Both Site 4A and 5A had been burnt by a wildfire event 6 weeks before sampling took place. The adoption of Recommendation 4 from the previous monitoring event proved useful in locating another population of Green-thighed Frog adjacent to Halfway Creek with two males heard calling from further to the north near Kungala Road. Inspections of this area found that that it probably does not drain as quickly as those areas around 700m to the south, and therefore less impacted by the Upgrade.

Further north in Section 3, frogs were found at both treatments at Site 7 and Site 8. Numbers of frogs were markedly lower than the last round of monitoring and also the baseline survey. The fact that both treatments at Site 7 showed a consistent pattern of decline suggests this effect may be linked to environmental cues rather than anything specifically related to the Upgrade. One thought is the survey occurred when the frogs weren't as active as the rain had temporarily eased off. Meanwhile at Site 8, the impact treatment in Tyndale Crown Reserve now appears less suitable than it had during the pre construction baseline surveys given frogs now tend to call from nearby private property when they were previously concentrated around the gravel access track and its associated drains. The newly constructed ponds will assist future monitoring efforts at this location.

Sampling in Section 6 and 7 had mixed results. Surveys at Jackybulbin (Site 9A) continued to show increased numbers of frogs at the impact site but less so at the reference site further to the north east. One difficulty with sampling Site 9B on this occasion was the calling intensity of other more common species which made detection difficult and the timed search around and within the flooded pond was confounded by continuous observations of other frogs. No Green-thighed Frogs were recorded on the road side of the fence, however, there were numbers of both ground dwelling and tree frogs that suggest the fence acts more as a deterrent rather than a barrier. Vegetation was recorded growing up along the fence and this generally acts as a purchase point whilst gaps in the mesh at ground level enable ground dwelling frogs to move under the fence. Some surveys associated with the culvert on the eastern side of the carriageway failed to locate any frogs for marking whilst nine frogs were clipped on the western side and provide an opportunity to assess the role of the culvert as a means of providing some habitat permeability.

Site 10A continues to prove problematic with another round of sampling and despite the adoption of Recommendation 4 to increase survey effort, no Green-thighed Frogs could be located. The carriageway removed an old disused borrow pit which had been confirmed as a successful breeding site during the pre construction baseline surveys (Lewis 2015). On this occasion, sampling effort had been increased to include an area of swamp forest around 100-200m downstream of the monitoring site where the only difference in frog fauna was the lack of Cane Toads. Some cursory surveys of what appeared to be some constructed ponds on the eastern side of the carriageway also failed to detect Green-thighed Frogs and it is a little unclear why ponds were constructed on the opposite side of the carriageway to where the BACI monitoring and perceived impacts were taking place.

The data obtained during this round of monitoring was assessed against the performance indicators and proposed that some additional surveys on the western side of Redbank Creek would prove useful. This is in response to no Green-thighed Frogs recorded using the constructed ponds on the eastern side of the carriageway yet frogs have been heard calling from the western side of the carriageway. At Site 8A, remaining two rounds of monitoring should be performed at the newly constructed ponds before any specific corrective actions can be explored. It is thought that constructing the ponds close to where frogs previously inhabited the access road and drains may attract them back into the area given the residual forest hasn't changed. At Site 10A, some additional survey effort on the eastern side of the carriageway may be of benefit as this area hasn't been the focus of past monitoring efforts yet compensatory ponds appear to have been constructed in this area.

Based on the 2020/2021 findings, the following recommendations and Transport for NSW responses have been presented in Table 4-7.

Table 4-7. Recommendations following 2020/21 Green-thighed Frog monitoring and Transport for NSW responses.

Recommendation No	Recommendation	Transport for NSW Response
1	TfNSW inspect fences for reported breach points at Redbank Creek, Site 7A and 9A.	Adopted - TfNSW will inspect and repair breach points. Additional survey to include a check on western side of Redbank Creek for any breach points that may be responsible for the road strike illustrated in Plate 4-10.
2	Conduct broader surveys at the following locations in the 2021/2022 season to confirm presence of population: 1. Redbank Creek given no Green-thighed Frogs have been recorded using the compensatory ponds yet they have been heard calling from the western side of the carriageway but no knowledge of their breeding habitat. 2. Tabbimoble (Site 10A) on eastern side of the carriageway.	Adopted. At Redbank Creek and Tabbimoble, a one off survey will be performed in the 2021/2022 season.

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7.0 APPENDIX A – RAW FROG SURVEY AND RAINFALL DATA

Table A1. Summary of Wallum Sedge Frog surveys during the 2020 monitoring season.

1st and 2nd February 2020											22nd May 2020										
	Count 1	Count 1	Count 1	Count 1	Water Depth	Air Temp	Humidity	Rainfall	Cloud Cover	pH	Count 2	Count 2	Count 2	Count 2	Water Depth	Air Temp	Humidity	Rainfall	Cloud Cover	pH	
BACI Site	Adults	Sub Adults	Juveniles	Tadpoles							Adults	Sub Adults	Juveniles	Tadpoles							Comments
1A	1	0	0	0	240	22	76	1	75	5.5	0	0	0	0	230	15	81	0	25	5.3	A lot of Azolla, common competitor frogs and toads
1B	1	1	0	0	190	22	76	1	75	4.0	2	7	6	0	200	15	80	0	25	4.2	Site regenerating and getting denser
2A	0	0	0	0	190	21	77	1	90	4.2	0	0	0	0	190	15	79	0	30	4.3	Surface water but still no sedge frogs
2B	14	2	1	0	350	20	78	1	80	4.0	16	21	10	0	390	15	80	0	30	4.1	Most reliable site in the monitoring program
3A	0	0	0	0	230	20	81	1	65	3.9	ns	ns	ns	0	220	14	87	0	25	4.0	Must be other sites nearby
3B	0	0	0	0	260	22	78	1	65	5.5	ns	ns	ns	0	280	16	81	0	25	5.6	Site appears to have deteriorated in terms of acidic frog suitability
4A	1	0	0	0	320	21	66	1	40	4.7	ns	ns	ns	0	370	16	81	0	0	4.9	Not much has changed
4B	1	0	0	0	100	19	70	1	50	4.2	ns	ns	ns	0	150	16	81	0	0	4.4	Part of site periodically slashed
5A	1	0	0	0	140	22	77	1	70	4.1	0	0	0	0	130	15	81	0	0	4.4	Only has frogs when water level is up. Site has improved since the Upgrade.
5B	11	3	0	0	380	22	80	1	50	4.2	16	22	4	0	370	15	81	0	0	4.5	Site appears to be a source population.

Table A2. Summary of Green-thighed Frog surveys during the 2020/21 monitoring season.

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 Stage 1 Survey	No. Sub Adults	No. Juv	No. Tads	Breeding Confirmed	Comments
Compensatory Breeding Pond - Redbank Creek	5600	Redbank Creek	E:516564 N:6680284	07.02.2020	2125-2145	23	100	0	2	100	0	0	22.03.2020	44	0	0	0	No	Other frogs using the constructed ponds.
1A	11800	Dirty Creek Range / Falconers	E:503224 N:6685035	07.02.2020	2206-2226	22	95	0	2	100	0	0	22.03.2020	44	0	0	0	No	Site under construction
1A - Compensatory Breeding Pond - Dirty Creek Range (Falconers)	11800	Dirty Creek Range / Falconers	E:513172 N:6685262	20.01.2020	2255-2315	23	83	0	1	30	0	0	29.02.2020	40	0	0	0	No	Constructed ponds held more water for longer during this round of monitoring. Frogs may now use an alternative unknown site.
1A - Frog Fencing	11750-11880	Dirty Creek Range / Falconers	E:513190 N:6685262	20.01.2020	2347-0010	22	85	0	1	25	2	1	29.02.2020	40	0	2	0	Yes	Using side table drain off shoot from main pond.
1B - Old (As per TFMP RMS 2015)	23000	Wells Crossing Beside Road	E:506185 N:6692721	21.01.2020	0023-0045	21	81	0	1	25	11	9	29.02.2020	39	0	7	2	Yes	Using an alternative site near constructed breeding ponds
2A	19100	Halfway Creek	E:507641 N:6689299	21.01.2020	0132-0153	21	83	0	1	25	2	4	29.02.2020	39	0	0	0	No	No clear breeding site at this location just stump holes from fallen trees or grader turn outs
2A Compensatory Breeding Pond	19000	Halfway Creek	E:507644 N:6689255	20.01.2020	0351-0410	20	95	0	1	80	0	0	29.02.2020	40	0	0	0	No	Site under construction
2A - Frog Fencing	18900-19300	Halfway Creek	E:507644 N:6689255	20.01.2020	0257-0318	21	100	0	2	100	18	24	29.02.2020	40	0	15	2	Yes	Site unaffected by recent fires
2B	23000	Yuraygir SRA	E:508694 N:6693816	20.01.2020	2100-2120	24	82	0	1	25	2	6	29.02.2020	40	0	7	3	Yes	Frogs favoured ponds with dense litter and sticks during this breeding event
3A	25800	Bald Knob Tick Gate Road	E:505801 N:6694708	20.01.2020	0432-0455	20	95	0	1	80	9	12	29.02.2020	40	0	7	2	Yes	Ponds retained a lot more water during this round of sampling. Success recorded at nearby borrow pit disused but at least calling males and female showed up at comp. pond.
3B	30000	Glenugie West	E:501553 N:6699052	08.02.2020	0002-0022	22	100	0	2	98	11	15	22.03.2020	43	0	2	0	Yes	Found in small offshoot of drainage line
4A	26200	Glenugie Heavy Vehicle Checking Station South	E:505127 N:6696150	19.01.2020	2010-2025	21	100	0	3	100	20	21	29.02.2020	41	0	17	2	Yes	Held more water given follow up rains
4A - Frog Fencing	26100-26250	Glenugie Heavy Vehicle Checking Station South	E:505167 N:6696111	08.02.2020	0035-0055	22	100	0	2	98	15	13	22.03.2020	43	0	3	0	Yes	Using pond from old stump hole
4B	35000	Glenugie East	E:506326 N:6703965	20.01.2020	0215-0235	21	100	0	2	100	7	14	29.02.2020	40	0	5	0	Yes	Pond almost dry
5A	28000	Franklins Road	E:505038 N:6697387	20.01.2020	0005-0025	21	100	0	2	100	5	2	28.02.2020	39	0	0	0	No	Difficult to determine as frogs now call from private property not accessible whilst adjacent drains dry too quickly and nearby borrow pit seldom has Green-thighed Frogs
5A - Frog Fencing	27900-28050	Eastern side Franklins Road	E:505014 N:6697324	20.01.2020	0120-0140	21	100	0	2	100	8	6	28.02.2020	39	0	0	0	No	Frogs now appear to favour drainage line to the north
5B	37000	Stokers Road Bom State Forest	E:498275 N:6707681	19.01.2020	2108-2128	22	100	0	2	100	25	26	28.02.2020	40	0	11	0	Yes	Site contained a lot more water than during previous breeding events
6A	35200	Pheasant Creek	E:502672 N:6704172	19.01.2020		2228-2252	22	100	0	2	100	15	13		28.02.2020	40	0	5	2
6B	38000	Airport Road	E:501766 N:6706969	19.01.2020	2145-2200	22	100	0	2	100	0	0	28.02.2020	40	0	0	0	No	Only drainage line and an occasional stump hole from fallen tree provided breeding habitat

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 Stage 1 Survey	No. Sub Adults	No. Juv	No. Tads	Breeding Confirmed	Comments
7A	38000	Old Six Mile Lane	E:503837 N:6706546	19.01.2020	2145-2200	22	100	0	2	100	3	3	28.02.2020	40	0	0	0	No	Likely to have bred in adjacent area
7B	35000	Glenugie East	E:505733 N:6703338	07.02.2020	2125-2145	23	100	0	2	100	0	0	22.03.2020	44	0	0	0	No	Other frogs using the constructed ponds.
8A	64700	Tyndale Crown Reserve	E:513362 N:6727361	07.02.2020	2206-2226	22	95	0	2	100	0	0	22.03.2020	44	0	0	0	No	Site under construction
8A - Frog Fencing	64600-64800	Tyndale Crown Reserve	E:513362 N:6727361	20.01.2020	2255-2315	23	83	0	1	30	0	0	29.02.2020	40	0	0	0	No	Constructed ponds held more water for longer during this round of monitoring. Frogs may now use an alternative unknown site.
8B	57500	Pine Brush State Forest	E:517300 N:6719708	20.01.2020	2347-0010	22	85	0	1	25	2	1	29.02.2020	40	0	2	0	Yes	Using side table drain off shoot from main pond.
9A	102500	JackyBulbin	E:520731 N:6758742	21.01.2020	0023-0045	21	81	0	1	25	11	9	29.02.2020	39	0	7	2	Yes	Using an alternative site near constructed breeding ponds
9A – Frog Fencing	102100 - 102600	JackyBulbin	E:520731 N:6758742	21.01.2020	0132-0153	21	83	0	1	25	2	4	29.02.2020	39	0	0	0	No	No clear breeding site at this location just stump holes from fallen trees or grader turn outs
9B	111500	Tabbimobile East	E:525262 N:6767265	20.01.2020	0351-0410	20	95	0	1	80	0	0	29.02.2020	40	0	0	0	No	Site under construction
10A	118500	Tabbimoble North	E:527238 N:6772864	20.01.2020	0257-0318	21	100	0	2	100	18	24	29.02.2020	40	0	15	2	Yes	Site unaffected by recent fires
10A – Frog Fencing	118500	Tabbimoble North	E:527238 N:6772864	20.01.2020	2100-2120	24	82	0	1	25	2	6	29.02.2020	40	0	7	3	Yes	Frogs favoured ponds with dense litter and sticks during this breeding event
10B	114000	Glencoe Road	E:524143 N:6769665	20.01.2020	0432-0455	20	95	0	1	80	9	12	29.02.2020	40	0	3	0	Yes	Ponds retained a lot more water during this round of sampling

Table A3. Rainfall data (Grafton Airport - Station 58161 New Italy – Station 58097) with survey dates (shaded red) for Green-thighed Frog surveys at Sites 1-10 during the 2020/21 monitoring season.

Garfton Airport - Station 58161	2020	2020	2020	2021	2021	2021	2021	2021
	Oct	Nov	Dec	January	February	March	April	May
1st	no data	no data	no data	0.6	1.4	0.2	0	7.8
2nd	no data	no data	no data	5.2	0.2	7.2	2.4	0.4
3rd	no data	no data	no data	4.2	0	0	0.2	0.2
4th	no data	no data	no data	1.4	0	9		0.2
5th	no data	no data	no data	0.2	0	0	4	5.8
6th	no data	no data	no data	4.2	0	0.2	14	31.2
7th	no data	no data	no data	30.2	3	0	23.4	0.2
8th	no data	no data	no data	4.6	0.4	0.2	5.4	0
9th	no data	no data	no data	0.6	0	15.8	0.2	0.2
10th	no data	no data	no data	0.4	0	18.6	0.2	8.4
11th	no data	no data	no data	0	1.2	0.2	0	0
12th	no data	no data	52.8	0.6	0	27.4	0	0.2
13th	no data	no data	55.6	0	0	0.2	0	8.6
14th	no data	no data	39.4	0	12	0	0	0.2
15th	no data	no data	89.8	0	0	36	0	0
16th	no data	no data	39.6	9.2	2.8	0.2	0	0.2
17th	no data	no data	25.4	0	13.6	1	4.2	0
18th	no data	no data	13.4	0	4	21	17.8	0
19th	no data	no data	1.4	3.8	7	34.6	0.2	0.2
20th	no data	no data	0.2	2.8	25	16.8	0	0.2
21st	no data	no data	0	0.2	24.4	36	0.2	0
22nd	no data	no data	0	0	4.6	128.2	0	0
23rd	no data	no data	0	0	0.2	64	0	0.4
24th	no data	no data	0	0	59	30.8	0.2	0
25th	no data	no data	0	0	27.6	0.2	0	0.8
26th	no data	no data	15.8	0	22.8	0	0	0
27th	no data	no data	9.4	0	0.4	0	0	0.4
28th	no data	no data	0	0.2	34.4	0	0	0
29th	no data	no data	0.6	0		0	0.6	0
30th	no data	no data	16.4	0		0.2	4.6	0
31st			0	6.8		0		0

New Italy Station 58097	2020	2020	2020	2021	2021	2021	2021	2021
	Oct	Nov	Dec	January	February	March	April	May
1st	0	12.4	0	6.6	0.2	1.6	0.6	25.4
2nd	0	0	0	16.8	0	0	24.2	1.4
3rd	0	0	1.6	0.8	6.4	2	1	2
4th	0	0	0	0	0	17.8	2.4	4
5th	0	0	0	0	0	0	12.6	7.6
6th	0	0	1	1.2	0.5	0	43	10.2
7th	0	0	2.6	30	0	4.6	24.8	0
8th	0	0	4.6	10	0.4	0.6	11.2	0
9th	0	0	0	10	0	24.6	3.4	0
10th	0	0	0	4.5	0	7	0	0
11th	0	0	5.2	3.6	4.5	46.2	0	2.4
12th	0	0	46.2	0	0.2	0	0	0
13th	0	0	60.2	0	0	0	0	0
14th	0	4	65.2	0	0	0	0	0
15th	0	4	86.4	0	27	28.6	0	0
16th	0	0	20	1.2	16.2	7.6	0	0
17th	0	0	14	0	17.6	6	0	0
18th	0	0	5	0	39.6	6	7.2	0
19th	11.6	0	0	0	17.2	20	0	0
20th	1	0	0	17.8	48.2	5.6	0	0
21st	0	0	32	3.6	4.6	14	0	0
22nd	0	0	2	0	0	62.2	0	1.4
23rd	0	0	0	0	0	118.6	0	1
24th	0	0	0	0	5.6	42.2	0	0
25th	2	0	0	0	0	0	0	0

New Italy Station 58097	2020	2020	2020	2021	2021	2021	2021	2021
	Oct	Nov	Dec	January	February	March	April	May
26th	28.6	*0*	*0*	*0*	*6*	*0*	*0*	*0*
27th	0	*0*	*0*	*0*	*2.6*	*0*	*0.2*	*0*
28th	0	*0*	*0*	*0*	*1.6*	*0*	*1.6*	*0*
29th	4.2	*0*	*0*	*2*		*4.6*	*4*	*0*
30th	0.2	*0*	*28*	*0*		*0*	*0*	*0*
31st				*3*				*0*