



Fauna Fence and Road Kill Monitoring 2022/2023

Oxley Highway to Kempsey, Pacific Highway Upgrade

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

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Executive summary

Context

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

Aims

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

Methods

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

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

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

Key Results

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

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

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

Conclusions

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

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

Management Implications

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

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

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1. Introduction

1.1 Context

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

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

1.1.1 Monitoring framework

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

Fauna fence

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

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

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

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

Road kill

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

Table 1: Road kill monitoring

Project phase	Monitoring event: report	Timing of survey	Location
Baseline	<i>spring 2013, summer 2014, autumn 2014:</i> Niche (2015)	Weekly during October (spring), January (summer) and April (autumn) prior to commencement of construction (12 weeks).	Entire length of existing highway in Project area
During clearing operations	<i>November 2014- July 2015:</i> Niche (2015)	Daily	Portion of existing highway adjacent to clearing operations
One month following clearing operations			
For the duration of construction	<i>8 August 2015 – 22 July 2016:</i> Niche (2016a) <i>27 July 2016 – 28 July 2017:</i> Niche (2017a) <i>4 August 2017 – March 29 2018:</i> Niche (2018)	Weekly (Note: as the opening of the Project occurred in three stages, weekly monitoring of the Project continued in the unopened sections of the Project to satisfy construction monitoring requirements.)	Entire length of existing highway in Project area
Within one month of opening of the Project	Twelve week post-opening periods were as follows: <ul style="list-style-type: none"> • Ku2K: from 3 November 2017 • OH2Ku Stage 1: from 17 November 2017 • OH2Ku Stage 2: from 30 March 2018 All in Niche (2018).	Weekly for 12 weeks. If this period does not coincide with the season (i.e. October (spring), January (summer) and April (autumn) in which baseline surveys were undertaken, also undertake weekly surveys during the first survey period (April, October or January) to occur after the opening of the Project (to allow for comparison to baseline results).	Entire length of completed Project
Upon completion of the Project (operational phase)	Year 4: <ul style="list-style-type: none"> • Spring (October 2018) • Summer (January 2019) • Autumn (April 2019) All in Niche (2019). Year 5: <ul style="list-style-type: none"> • Spring (October 2019) • Summer (January 2020) • Autumn (April 2020) All in Niche (2020). Year 6: <ul style="list-style-type: none"> • Spring (October 2020) • Summer (January 2021) • Autumn (April 2021) Year 8: <ul style="list-style-type: none"> • Autumn (April 2022) • Spring (October 2022) • Summer (January 2023) Current report.	Weekly during October (spring), January (summer) and April (autumn (12 weeks) in Year 4, 5, 6 and 8, or until mitigation measures can be demonstrated to have been effective as defined in the EPBC approval.	Entire length of completed Project

1.1.2 Background data

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

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

- *Giant Barred Frog fencing is to be at least 900 millimetres in height and will comprise of gauze size 30-40 millimetres to prevent frogs from moving through the fence, yet allow for the flow of overland water. The gauze will include a small return of not less than 150 millimetres on the ground.*
- *Green-thighed Frog fencing is to comprise of 500 millimetres high neoprene rubber sheeting (>4 millimetre thickness) including a small rubber return of not less than 100 millimetres on the ground. The fence must consist of a hot dip galvanized pressed sheet metal or powder coated aluminium pressed sheet mounted on a galvanized star picket. This fencing was unsuccessful and has since been replaced. Transport for NSW (TfNSW) removed the neoprene sheeting and replaced it with vermin-proof mesh, as approved on the Pacific Highway Upgrade between Woolgoolga and Ballina. These frog fencing replacement works were completed in November 2018.*
- *Where both frog species occur in association the frog fencing must account for both morphologies.*
- *Phascogale fencing: Phascogale fencing is attached to floppy top fauna fencing. At the base of floppy top fauna fences, a second layer of mesh is installed to 200 millimetres above ground level height, offset from the first layer of mesh to create maximum opening size of 25 millimetres. Above 200 millimetres, 600 millimetre hot dip galvanised pressed steel sheet or powder coated aluminium pressed sheet are affixed to the floppy top fauna fencing.*

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

1.1.3 Purpose of this report

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

1.2 Performance Measures

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

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

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

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

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

1.3 Monitoring Timing

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

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

1.4 Reporting

Annual reporting of monitoring results will outline:

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

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

1.5 Limitations

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

2. Methodology

2.1 Monitoring Sites

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

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

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

2.2 Survey Methods

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

2.2.1 Fauna fence inspections

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

2.2.2 Frog searches

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

Table 2: Threatened frog survey dates and 24 hour rainfall

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

2.2.3 Road kill surveys

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

2.3 Data analysis

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

3. Results

3.1 Fence Inspections

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

3.1.1 Maintenance

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

3.1.2 Possible breaches

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

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

3.2 Threatened Frog Searches

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

3.3 Road Kill Surveys

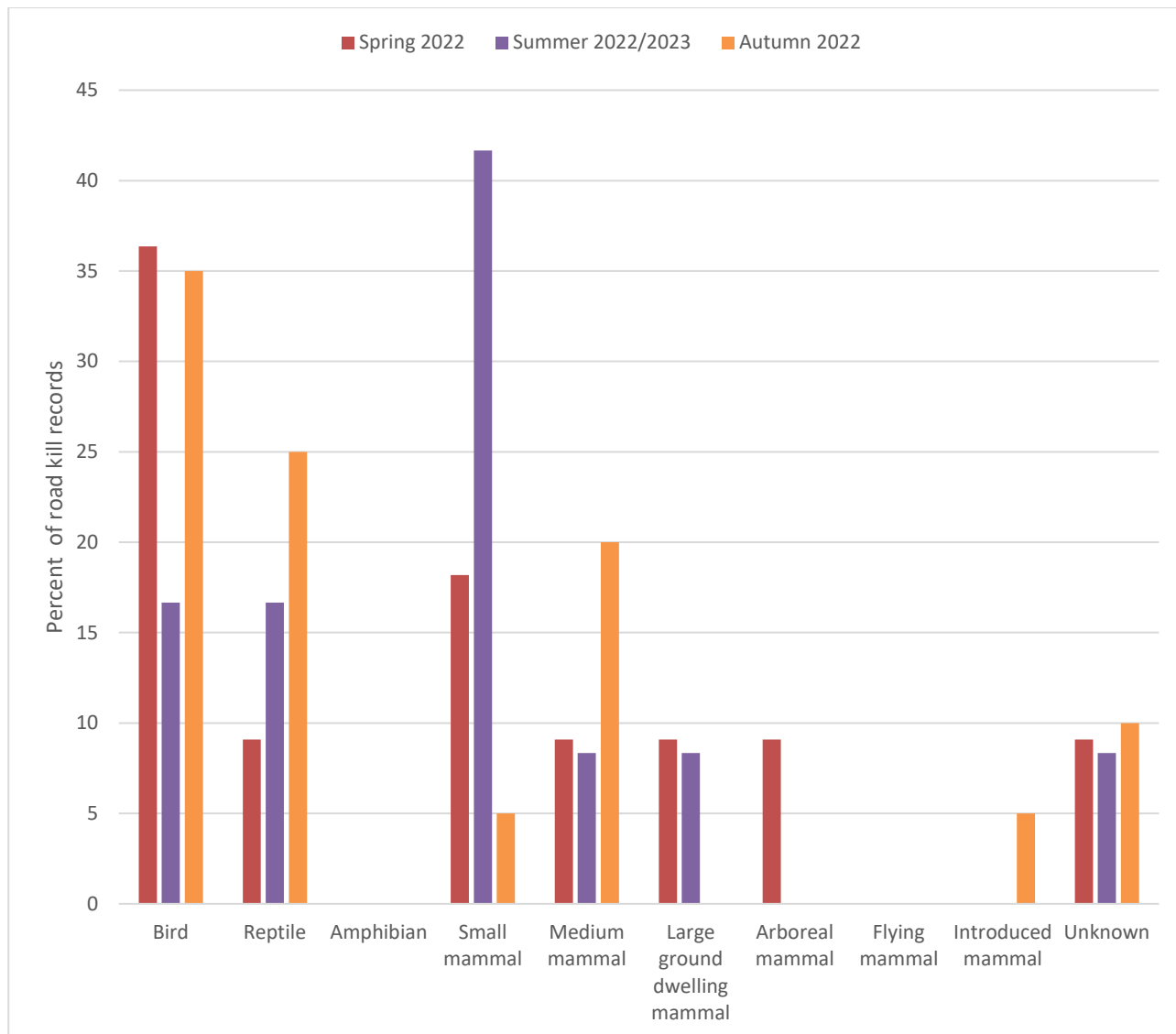
Road kill results are provided in Annex 1. The distribution of road kill records is shown in Figure 1.

3.3.3 Total alignment

Fauna categories for analysis were defined as follows:

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

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



Graph 1: 2022/2023 road kill records

3.3.4 Threatened fauna

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

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

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

Table 3: Threatened species road kill to date

Monitoring type (report)	Monitoring period	Threatened species identified as road kill (number recorded)
Baseline (Lewis 2014)	2013-2014	<ul style="list-style-type: none"> • Koala (1*) • Grey-headed Flying Fox (2)
Clearing (Niche 2015)	2014-2015	<ul style="list-style-type: none"> • Koala (4) • Grey-headed Flying Fox (1) • Masked Owl (2) • Spotted-tail Quoll (1)
Construction (Niche 2016b)	2015-2016	<ul style="list-style-type: none"> • Koala (1)
Construction (Niche 2017b)	2016-2017	<ul style="list-style-type: none"> • Koala (2)
Construction (Niche 2018)	2017-2018	Nil
Operational (Niche 2019)	2018-2019	<ul style="list-style-type: none"> • Koala (1)
Operational (Niche 2020)	2019-2020	<ul style="list-style-type: none"> • Brush-tail Phascogale (1)
Operational (Niche 2021)	2020-2021	<ul style="list-style-type: none"> • Koala (1)

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

3.3.5 Fauna fence

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

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

3.3.6 Fauna crossings

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

Aerial crossings

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

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

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

Underpasses

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

3.3.7 Comparison with baseline and previous monitoring

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

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

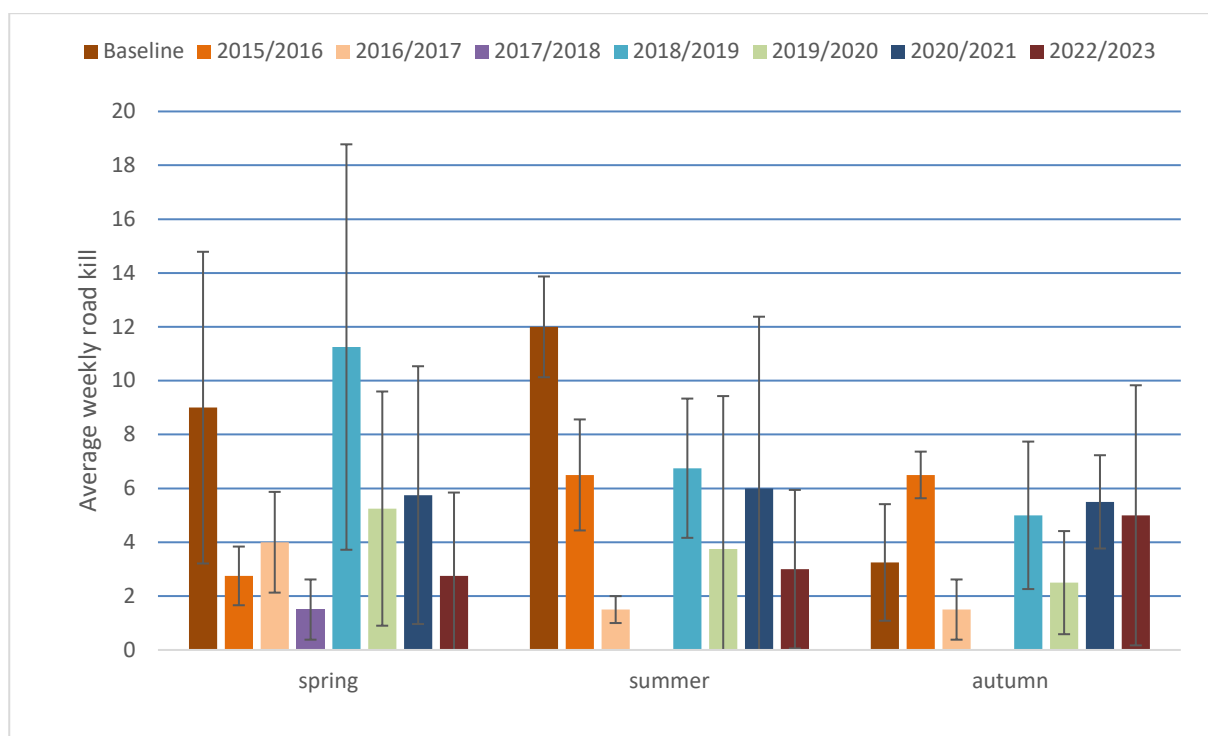
In order to compare the results of the baseline surveys with that of subsequent monitoring periods, the average weekly road kill for the four survey weeks undertaken in each season of the baseline surveys (spring (October), summer (January), autumn (May)), was compared to the same four weeks of each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

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

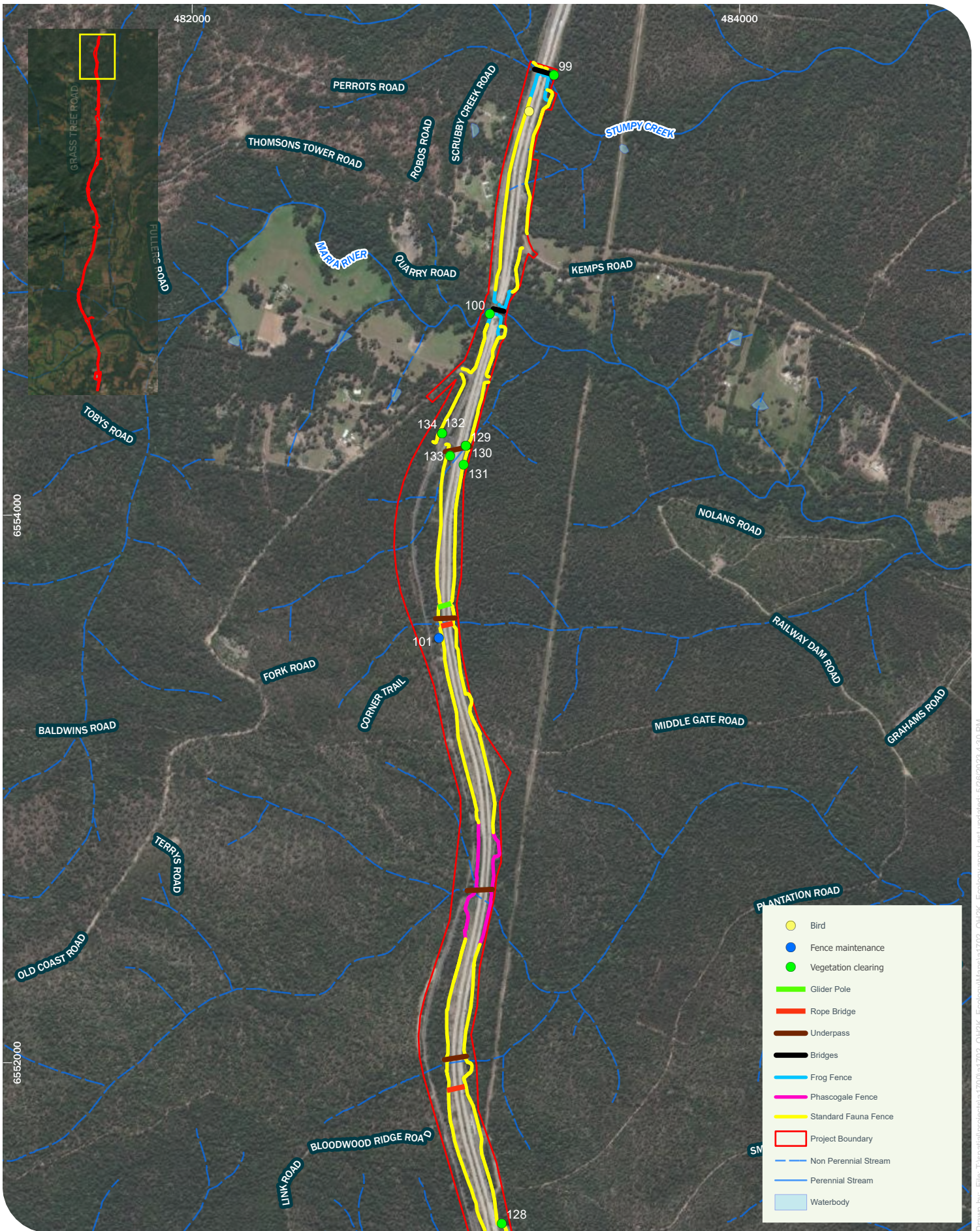
Table 4: Weekly road kill rates for monitoring undertaken along the entire Project alignment

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

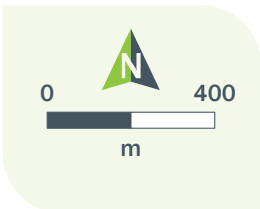
n = number of survey weeks; * = construction partially complete



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



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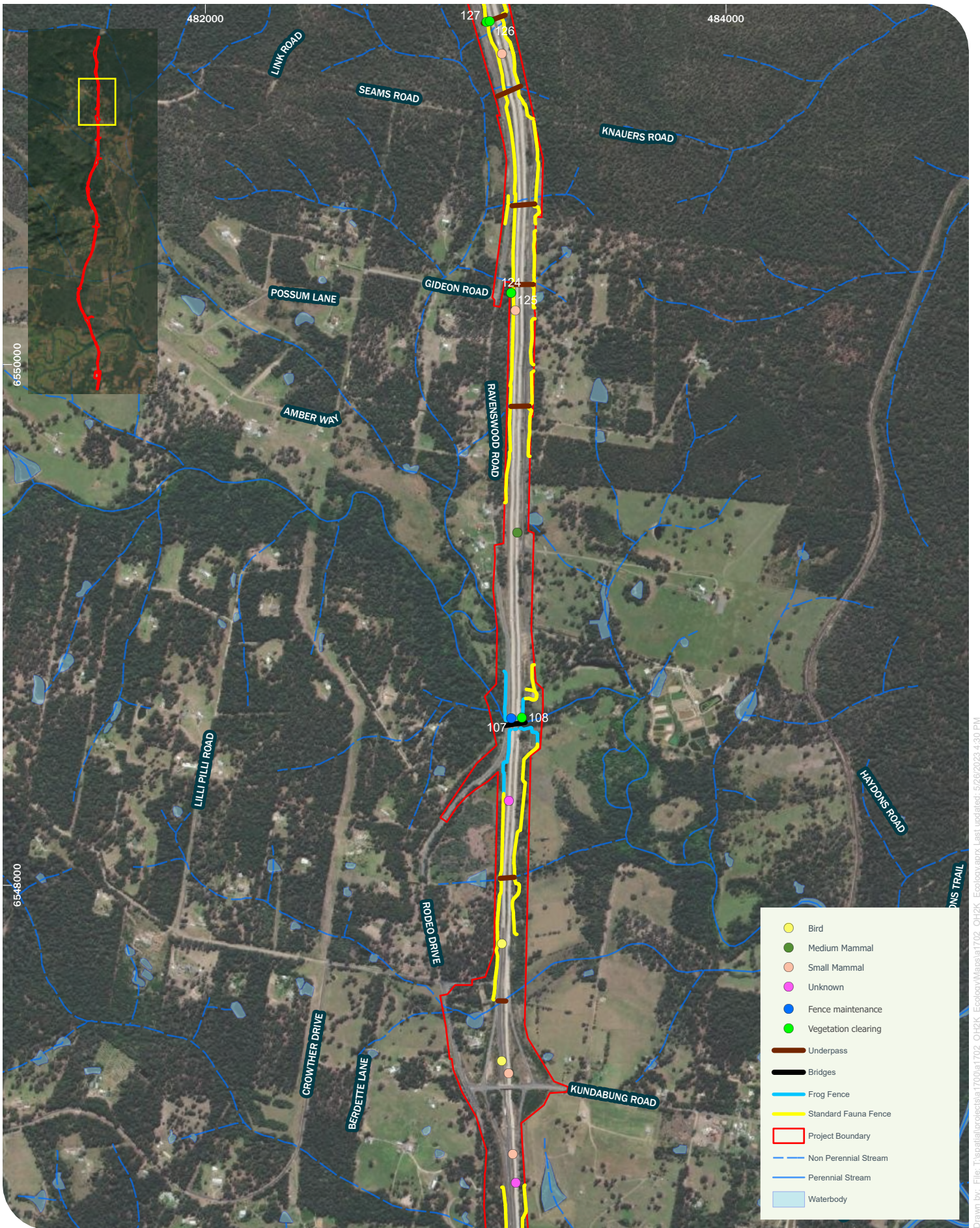


Fauna fence maintenance actions - Summer 2022/2023 1
Oxley Highway to Kempsey Pacific Highway Upgrade

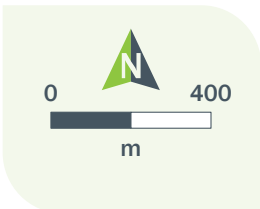
Niche PM: Radika Michniewicz
 Niche Proj. #: 1702 PI 5.11
 Client: TfNSW

Figure 1.1

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



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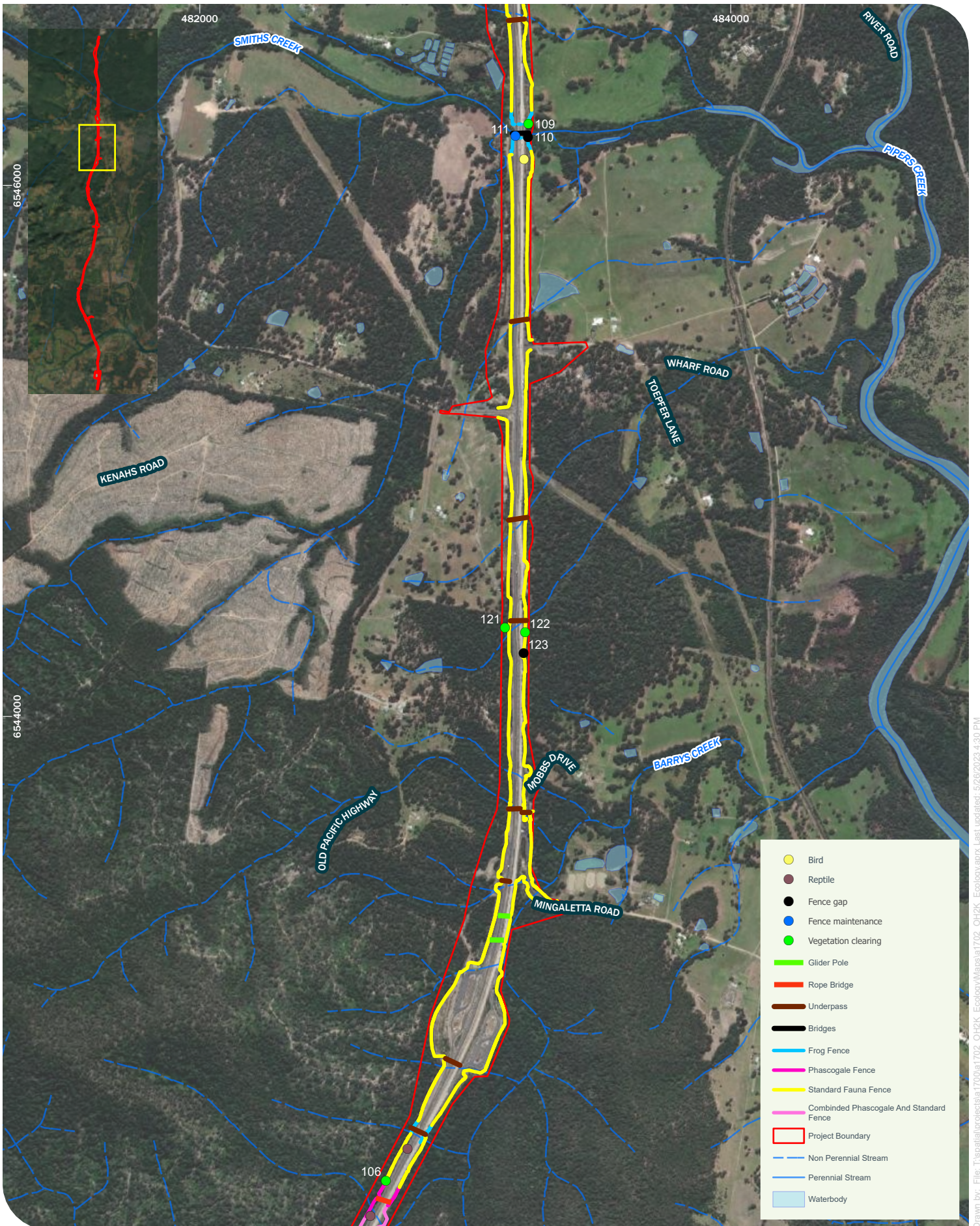


Fauna fence maintenance actions - Summer 2022/2023 2
Oxley Highway to Kempsey Pacific Highway Upgrade

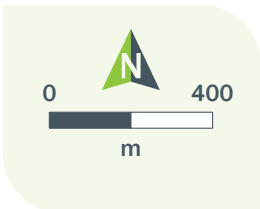
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 Client: TfNSW

Figure 1.2

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



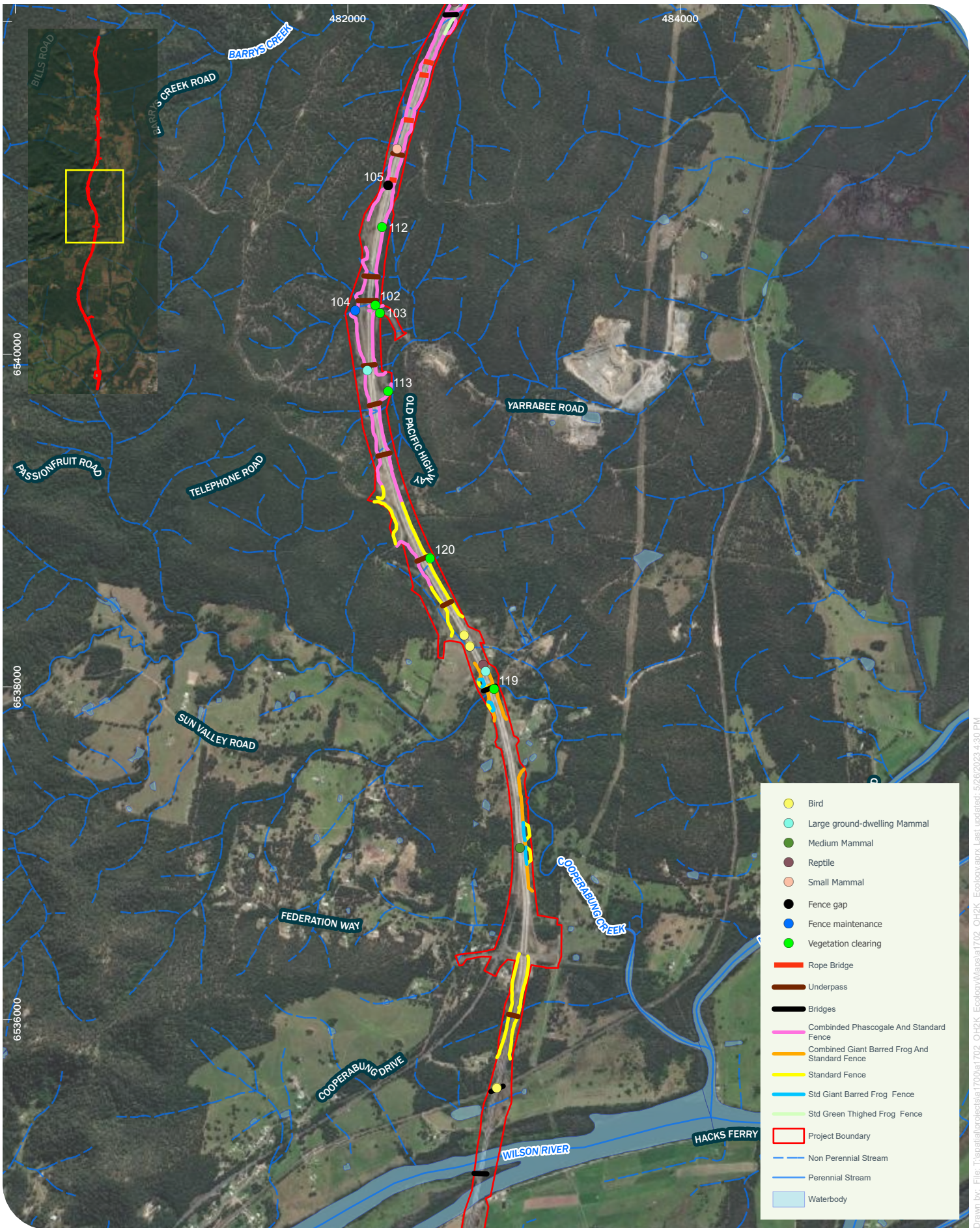
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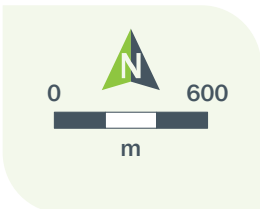
Fauna fence maintenance actions - Summer 2022/2023 3
Oxley Highway to Kempsey Pacific Highway Upgrade

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

Figure 1.3



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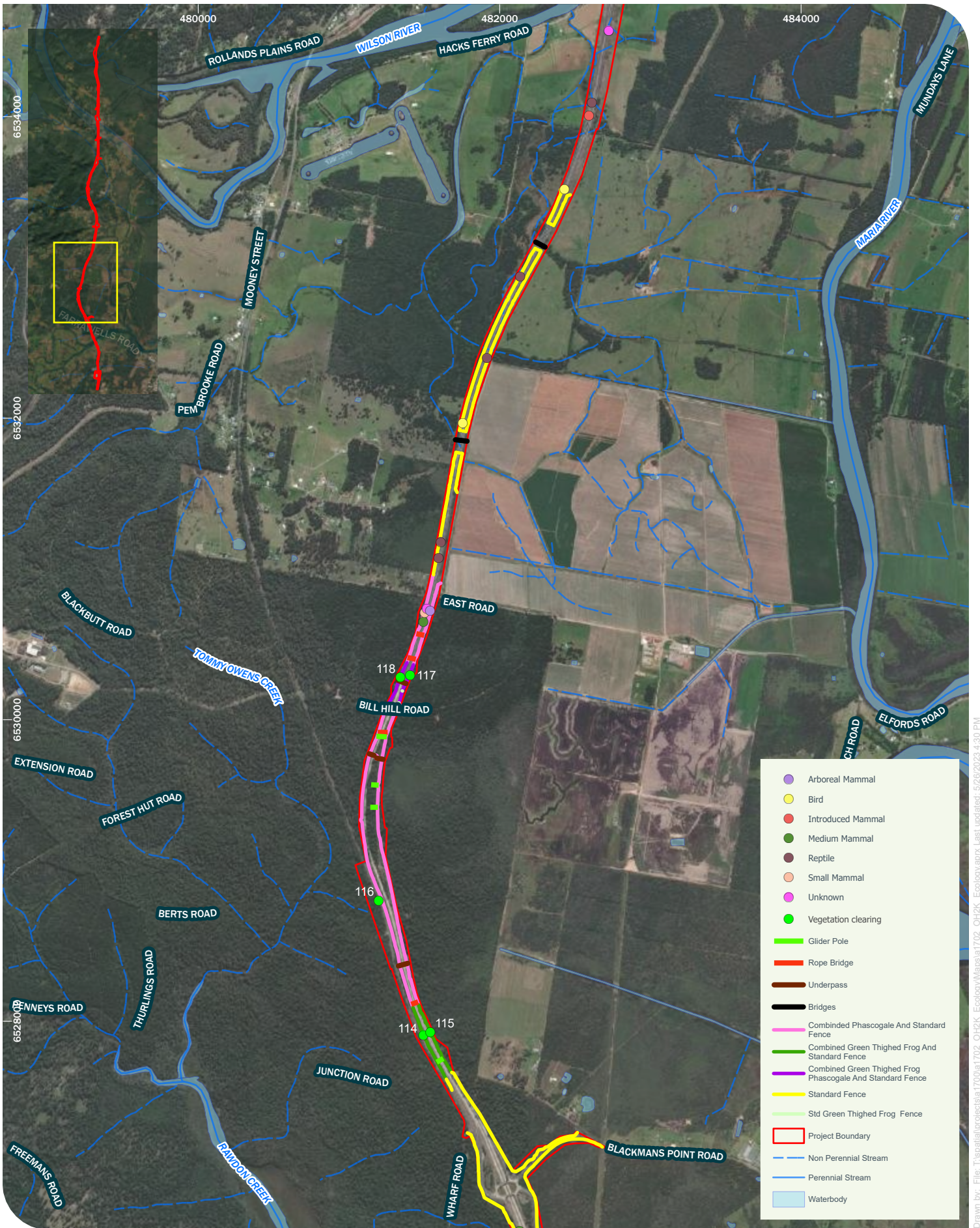


Fauna fence maintenance actions - Summer 2022/2023 4
Oxley Highway to Kempsey Pacific Highway Upgrade

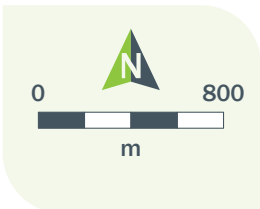
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 Client: TfNSW

Figure 1.4

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



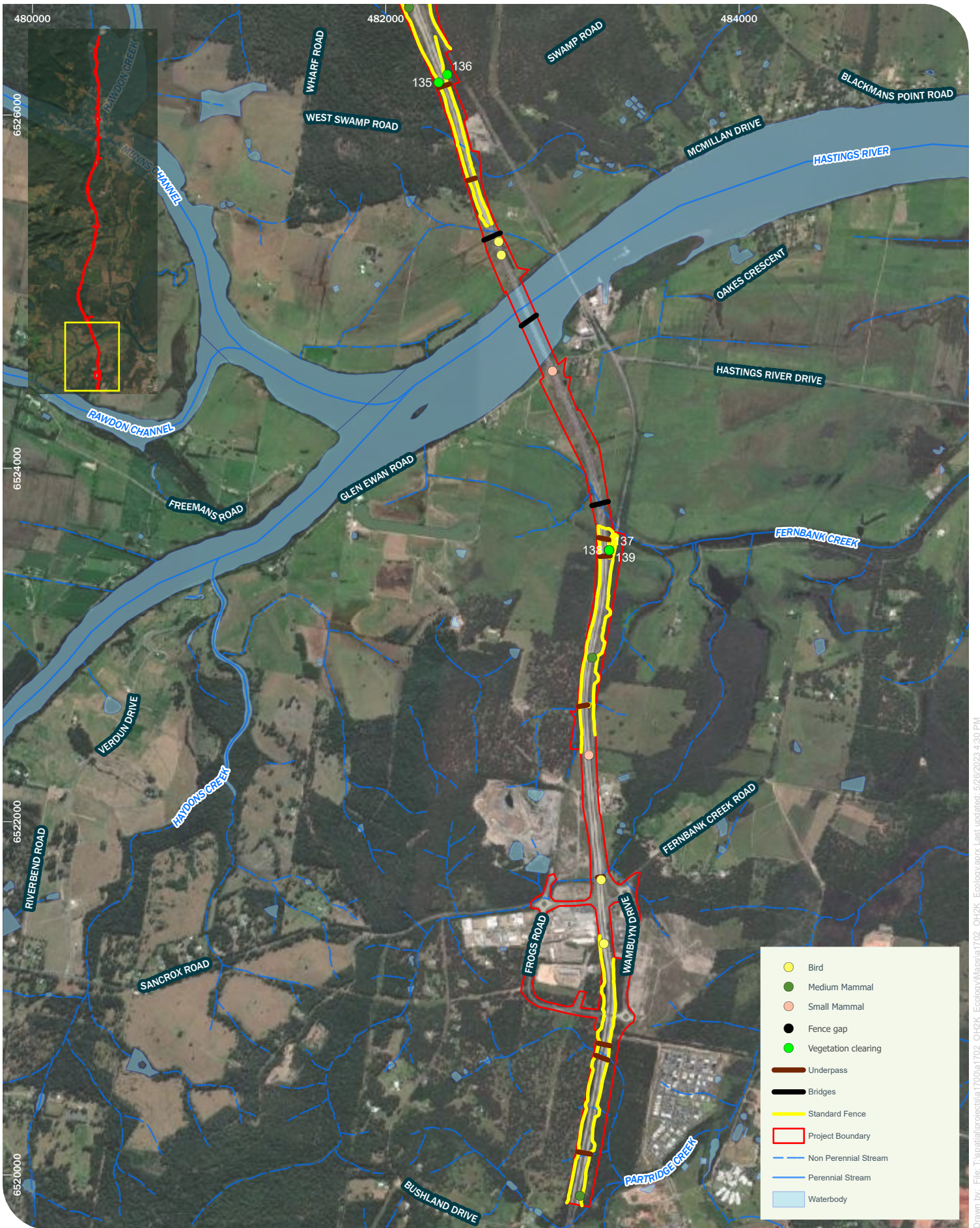
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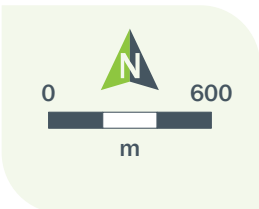
Fauna fence maintenance actions - Summer 2022/2023 5 Oxley Highway to Kempsey Pacific Highway Upgrade

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

Figure 1.5



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Fauna fence maintenance actions - Summer 2022/2023 6
Oxley Highway to Kempsey Pacific Highway Upgrade

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 Client: TfNSW

Figure 1.6

4. Discussion

4.1 Performance Measures

4.1.1 Fauna fence

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

Table 5: Indicators of success for fauna fencing

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

4.1.2 Road kill

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

Table 6: Performance measures for road kill monitoring

Performance measure	Discussion
Lower rates of road kill in proximity (i.e. areas of the main carriageways within areas adjacent to installed fauna fencing, and within 200 m of rope bridges and fauna underpasses) to fauna fencing, rope bridges and fauna underpasses than in sections of the upgrade not near wildlife crossing structures or fauna fences in Year 1 – 6 & 8 monitoring events.	This performance measure has been met. <i>Fauna fence:</i> Of the 30 road kill records (excluding birds) from the 2022/2023 monitoring period, nine (30%) records were within and 21 (70%) records were outside fenced areas. Considering the data with regard to the extent of fencing along the highway, calculation of a road kill per kilometre rate (excluding birds) showed the rate of road kill in unfenced areas (6.4 kilometres; 3.28 records/kilometre) to be substantially higher than the rate in fenced areas (30.6 kilometres; 0.29 records/kilometre). <i>Aerial crossing 200 metre boundary:</i> Of the 43 road kill records, only one arboreal mammal was recorded. The single arboreal mammal was recorded within 200 metres of an aerial crossing. Considering all road kill records, six were recorded within 200 m of an aerial crossing. Calculation of a <i>road kill per kilometre</i> rate therefore showed the rate of road kill within 200 metres of aerial crossings (5.2

Performance measure	Discussion
	<p>kilometres; 1.15 records/kilometre) to be similar to outside this boundary (31.8 kilometres; 1.16 records/kilometre).</p> <p><i>Underpass 200 metre boundary:</i> Of the 30 road kill records (excluding birds) eight occurred within 200 metres of underpasses. The rate of road kill within 200 metres of fauna underpasses/bridges (19.2 kilometres; 0.42 records/kilometre) was lower than the rate outside this boundary (17.8 kilometres; 1.23 records/kilometre).</p>
<p>Reduced incidence of road kill from baseline conditions during monitoring events in Years 1- 6 & 8 and when all monitoring events are considered at Year 8.</p>	<p>This performance measure has been met.</p> <p>The overall average weekly road kill rate for the same three seasons has decreased from baseline values (8.0) to 2018/2019 (7.7), 2019/2020 (3.8), 2020/2021 (5.8) and 2022/2023 (3.6).</p>
<p>Fauna exclusion fencing is installed at a minimum in the locations identified in Schedule 3 of the EPBC approval at Year 4.</p>	<p>This performance measure has been met.</p> <p>TfNSW have advised that all fauna fencing as identified in Schedule 3 of the EPBC approval has been installed.</p>

5. Recommendations

5.1 Contingency Measures and Recommendations

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

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

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

Table 7: Contingency measures for fauna fencing

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

References

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

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

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

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

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

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

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

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

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

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

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

Annex 1 – 2022/2023 road kill survey data

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

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

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