Warrell Creek to Nambucca Heads Pacific Highway Upgrade

Commonwealth Approval EPBC 2013/7101 Annual Compliance Report February 2020 – February 2021

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Terms and Abbreviations

BOS	Biodiversity Offset Strategy
CEMP	Construction Environmental Management Plan
Clear Milkvine	Marsdenia longiloba
Cryptic Forest Twiner	Tylophora Woollsii
DoEE	Federal Department of Environment and Energy
DPIE	State Department of Planning and Environment
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
FFMP	Flora and Fauna Management Plan
GBF	Giant Barred Frog
GBFMP	Giant Barred Frog Management Plan
Geolink	Geolink – Project Ecologist for WC2NH Project
GHFF	Grey-headed Flying-fox
Pacifico	Acciona Ferrovial Joint Venture (the TfNSW's road construction contractor for the project).
STQ	Spotted-Tail Quoll
TFMP	Threatened Flora Management Plan
WC2NH	Warrell Creek to Nambucca Heads Pacific Highway Upgrade Project

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1. Introduction

1.1. Purpose of this document

The purpose of this document is to facilitate demonstration by Transport for New South Wales (TfNSW) of satisfactory compliance with the Commonwealth approval conditions for the Warrell Creek to Nambucca Heads Pacific Highway Upgrade project (the Project) with particular reference to Condition 19 and 20. This report covers the sixth reporting period from February 2020 to February 2021.

For each condition, one or more actions are identified which, once implemented, will achieve satisfactory compliance with the condition. Where appropriate, the timing for completion of individual actions is identified.

For each action, the minimum relevant documentation to support demonstration of compliance is identified. This documentation would inform any future compliance audit.

Where an approval condition makes reference to information being provided to the Commonwealth Minister for the Environment, the associated action(s) assumes that this information will be provided, in the first instance, to the Commonwealth Department of the Environment.

1.2. Key dates

The timing for compliance with certain approval conditions is linked to specific dates as follows:

- Commonwealth approval: 11 Dec 2014
- Start of construction: 9 Feb 2015
- Scheduled completion of construction: 9th April 2021
- Expiry of Commonwealth approval 31 Dec 2064

1.3. Responsibility for compliance

Responsibility for compliance with all approval conditions sits with TfNSW.

1.4. NSW planning approval

Condition 3 and 4 (of the Commonwealth approval) provides for the use of plans, strategies or reports required under the NSW approval to satisfy the requirements of the Commonwealth approval, subject to provision of a separate document demonstrating how the document addresses the relevant Commonwealth approval requirements.

Specialists in the fields of flora and fauna have been engaged by TfNSW and the construction contractor to undertake various ecology-related management activities with regard to complying with the NSW planning approval and the CEMP.

This document contains actions relevant to compliance with the NSW planning approval that are also considered to satisfy compliance with Commonwealth approval requirements.

1.5. Definitions for action status conditions

TBA	To Be Arranged - Further works required prior to starting action.
In progress	Action initiated but not yet complete.
Ongoing	Action in place but ongoing works required to ensure compliance.
Complete	Action completed.

1.6. Non Compliances with EPBC Conditions

No non-compliances against the approval conditions were identified during the sixth reporting period (February 2020 – February 2021).

2. Compliance Tracking Tables

The following sections provide a compliance status for the reporting period for the 26 conditions of approval. Note: where relevant, the conditions have been amended to reflect the current approval variation.

2.1. Condition 1

The approval holder must not clear more than:

a) 17.80 hectares (ha) of **Slender Marsdenia/Clear Milkvine and Woolls Tylophora/Cryptic Forest Twiner habitat**;

b) 106.6 ha of **Koala habitat**, including 86.50 ha critical to the survival;

c) 106.6 ha of **Grey-headed Flying-fox habitat**, comprised of 103.50 ha of foraging habitat critical to survival and 3.10 ha of roosting habitat critical to survival;

d) 114.1 ha of **Spotted-tail Quoll habitat**;

e) 0.70 ha of **Giant Barred Frog habitat**;

f) 3.40 ha of Australian Painted Snipe (*Rostratula australis*) wetland habitat;

g) 5.3 ha of habitat for the Regent Honeyeater (*Anthochaera phrygia*) and Swift Parrot (*Lathamus discolour*) wintering habitat, comprising dry schlerophyll forests containing Swamp Mahogany; and

h) 26.1 ha of Milky Silkpod (*Parsonsia dorrigoensis*) habitat, comprising Mixed Floodplain Forest, Flooded Gum Open Forest and White Mahogany/Grey Gum/Ironbark Open Forest.

	Action	Timing	Status	Compliance evidence
1.1	Progressive review of area cleared	Regularly during construction	Compliant Ongoing	Record of clearing numbers provided in monthly report from Contractor to TFNSW. Refer to Table 1.1 below for clearing quantities for the reporting period.
1.2	Confirm clearing limitation targets have been met	Post-construction	TBA	As built survey of actual clearing area. Not able to action until after completion of clearing. Memo/short report

Table 1.1: Clearing Quantities for the reporting period.

Habitat Type	Completed Clearing Quantities		
	Limit (ha) as per Condition 1 Approval	Clearing Quantity (ha)	Current Difference showing remaining habitat (ha) under Condition 1 Approval
Slender Marsdenia/Clear milkvine and Woolls Tylophora/Cryptic Forest Twiner habitat	17.80	17.65	0.15
Koala	106.60	83.44	23.16
Koala (Critical Habitat)	86.50	60.18	26.32
Grey-headed Flying-fox	106.60	83.44	23.17
Grey-headed Flying-fox (foraging habitat critical to survival)	103.50	81.33	22.17
Grey-headed Flying-fox (roosting habitat critical to survival)	3.10	2.10	1.00
Giant Barred Frog	0.7	0.64	0.06
Spotted –tail Quoll habitat	114.10	90.28	23.82
Australian Painted Snipe (Rostratula australis)	3.4	2.84	0.56
Regent Honeyeater (Anthochaera phrygia) and Swift Parrot (Lathamus discolour)	5.30	4.34	0.96
Parsonsia dorrigoensis (Milky Silkpod)	26.1	24.11	1.99

NOTE: The above clearing data represents clearing undertaken up to February 2021. Clearing quantities for all habitat types are below the limits as specified in condition one.

It is anticipated that no further clearing will be undertaken as part of the project.

2.2. Condition 2

Within 30 days of the **complete on of construction**, the **approval holder** must:

a) notify the **Minister** in writing of the **completion of construction**; and

b) provide a report (supported by maps) that clearly shows the location of all **threatened species**, including the number of individuals of threatened flora and their **habitat cleared** as a result of **action**, which demonstrates compliance with Condition 1.

	Action	Timing	Status	Compliance evidence
2.1	Prepare works as executed Environmental and Clearing Plans to show extent of clearing.	Apr 2021	Complete	Report & supporting mapping
2.2	Calculate final clearing quantity and include in summary table.	Apr 2021	Complete	Report & supporting mapping
2.3	Provide written notification (letter) of completion of construction and report to Dept. of the Environment	Apr 2021	Complete	This Report Completed document transmittal form or equivalent

Completion of construction works was on 9th April 2021. A report has been produced and Included in Attachment Two that shows TfNSW are compliant with condition one and two.

2.3. Condition 3

The **approval holder** must undertake the **action** and implement all mitigation measures in accordance with the **Koala Management Plan**, **Grey-headed Flying-Fox Management Plan**, **Spotted-tail Quoll Management Plan** and **Giant Barred Frog Management Plan**. These **Plans** must be implemented.

	Action	Timing	Status	Compliance evidence
3.1	Implement the Koala Management Plan	Pre-construction, Construction and Operation	Compliant Ongoing	Sensitive Area Plans Ecological Monitoring Report Roadkill Quarterly Reports Completed Pre-clearing Checklists Fauna Relocation Register Habitat Tree Hollow Register Environmental Work Method Statements (EWMS) for Activities Project Induction Biodiversity Offset Strategy Urban Design and Landscape Plan Fauna Connectivity Report See summary below

3.2	Implement the Grey-Headed Flying Fox Management Plan	Pre-construction, Construction and Operation	Compliant Ongoing	Sensitive Area Plans Ecological Monitoring Report Roadkill Quarterly Reports Completed Pre-clearing Checklists Fauna Relocation Register Habitat Tree Hollow Register Environmental Work Method Statements (EWMS) for Activities Project Induction Biodiversity Offset Strategy Urban Design and Landscape Plan Fauna Connectivity Report See summary below
3.3	Implement the Spotted-tail Quoll Management Plan	Pre-construction, Construction and Operation	Compliant Ongoing	Sensitive Area Plans Ecological Monitoring Report Roadkill Quarterly Reports Completed Pre-clearing Checklists Fauna Relocation Register Habitat Tree Hollow Register Environmental Work Method Statements (EWMS) for Activities Project Induction Biodiversity Offset Strategy Urban Design and Landscape Plan Fauna Connectivity Report See summary below

3.4	Implement the Giant Barred Frog Management Plan	Pre-construction, Construction and Operation	Compliant Ongoing	Sensitive Area Plans Ecological Monitoring Report Roadkill Quarterly Reports Completed Pre-clearing Checklists Fauna Relocation Register Habitat Tree Hollow Register Environmental Work Method Statements (EWMS) for Activities Project Induction Biodiversity Offset Strategy Urban Design and Landscape Plan Fauna Connectivity Report See summary below

Compliance Tracker

Table 3.1: Compliance with the Koala Management Plan

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
Design Phase/Pre-construction	Minimise areas of Koala habitat to be cleared where feasible and reasonable during the detailed design phase.	The Project design has minimised clearing quantities as much as possible by ensuring the construction corridor is as narrow as possible. Ancillary sites have been located in areas where clearing is minimal.	Design Drawings
Pre-construction	All ancillary sites to be located outside of mapped Koala habitat.	Ancillary sites have been located in areas of minimal clearing and have minimised clearing of Koala habitat trees.	Sensitive Area Plans Ancillary Facility Register
Pre-Construction	Prior to any clearing taking place, the	Prior to construction commencing, only minor clearing (<150mm DBH)	Early Works Permits

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
	Project Ecologist will undertake an inspection of vegetation, to be cleared, to determine if work activities do not constitute "Construction" as defined in the planning approval under the NSW EP&A Act and are excluded from the Referral under the Federal EPBC Act.	was undertaken. The Project Ecologist inspected all areas of clearing to ensure no Koala habitat was removed during Pre-construction activities.	
Pre-Construction/ Construction	The limits of clearing are to be clearly marked on all relevant work plans and protective fencing erected to mark these limits (i.e. 'no-go' areas).	The clearing limits have been included on the Sensitive Area Plans and marked in the field using yellow flagging.	Sensitive Area Plans Early Works Permits Pre-clearing and Ground Disturbance Permits
Detailed Design/Pre-construction	Areas for Koala habitat restoration/connectivity are to be identified and included in the detailed design.	Habitat connectivity planting has been included in the Urban Design and Landscape Plan	Urban Design and Landscape Plan
Pre-construction/ Construction	Preparation of an EWMS would be undertaken for all work/construction activities and would include where necessary measures to minimise risk to Koalas.	An EWMS has been prepared for all work activities which includes measures to protect flora and fauna in accordance with the Flora and Fauna Management Plan (FFMP)	EWMS
	Induction of all personnel involved with pre-construction/construction activities would be undertaken to advise on Koala management requirements	Project Induction includes information about identification of Koala's on site.	Project Induction
	For any areas of vegetation to be cleared during the pre-construction stage of the Project, a suitably qualified ecologist will undertake a search for native fauna (including Koalas) in the vicinity of clearing immediately prior to clearing commencing. During the construction stage, pre-	The Project Ecologist undertakes inspections of all areas to be cleared and signs off on the Pre-clearing Inspection Checklist prior to commencement. No Koala's have been identified on site during clearing operations.	Pre-clearing and Ground Disturbance Permit

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
	clearing surveys will be undertaken within 48 hours of any clearing commencing (These are to include spotlighting surveys within suitable habitat on the night prior to clearing operations commencing in a given area.) In the event that a Koala is identified within 50 metres of a works area, works will be rescheduled until the construction stage of the Project. During the construction phase clearing works, the suitably qualified expert or an experienced wildlife handler under the supervision of the suitably qualified expert will be available to retrieve and provide appropriate care of any displaced matters of NES and release the fauna into adjacent habitats safe from construction work. Immediately prior to (within 2 hours) of clearing commencing in a given area, an additional ecologist inspection is to be undertaken to confirm that clearing areas remain free of fauna (including Koalas). Where Koalas are identified no works would be undertaken within 50 metres of the animal and the measures within the Fauna Management Protocol for Koalas (refer to Table 4.1 of Koala Management Plan) would be implemented. Should relocation of Koalas be required, a Koala Relocation Strategy included in Appendix C of the Koala Management Plan would be implemented.		

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
Pre-construction and Construction	Koala Management Protocol to be implemented requiring all personnel to report Koalas (including road kill). An assessment of future road kill risks including adaptive management actions is to be provided by the Project Ecologist where: - A Koala is detected within/near the site, or - Koala road kill is detected. Prior to the construction of fauna passage locations and installation of fauna fence, where continuous lines of jersey barriers are to be installed, gaps are to be provided to allow escape of any animals off the highway. Where gaps cannot be provided, a suitable material will be placed over the barrier to allow Koalas to climb over the barrier.	No Koala roadkill has been identified on the Project during Pre-construction and Construction Phase of the Project. No concrete barriers have been placed through Koala habitat areas.	Roadkill records and quarterly report.
Pre-construction/ Construction/ Operation	Appropriate habitat offsets to be identified by including targeted Koala surveys (GeoLINK 2014) using recognised survey approaches to confirm usage of potential offset properties.	Offset properties set up Koala's identified on Norton Property. Refer to CoA 14 for further details	Monitoring Records
Construction Operation	Progressive rehabilitation of identified areas (refer to Appendix B of the Koala Management Strategy) during the construction stage using collected topsoil and seed at specific sites and to develop different successional stages of rehabilitation. Key rehabilitation measures would include: - Progressive revegetation/rehabilitation during the construction phase using collected topsoil and seed at specific sites and to	Progressive rehabilitation of the site has commenced. The worksite will be rehabilitated in accordance with the Urban Design and Landscape Plan. Landscape rehabilitation is monitored monthly with a quarterly report developed during the third year of construction. Weed management is undertaken in accordance with the Weed and	Urban Design and Landscape Plan Site Inspection Records TFNSW Specification G36 Weed Management Records

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
	develop different successional stages of rehabilitation. - Planting of locally occurring species, including plants representative of groundcover, understorey and canopy strata. - Planting of preferred food trees for native fauna, including appropriate eucalypt species for the Koala. - Plantings are to be undertaken around fauna crossing structures to optimise utilisation of these structures. - Monitoring and maintenance of plantings. - Managing and controlling weeds.	Pathogen Management Plan (WPMP).	
Pre-Construction Detailed Design/ Construction	EPA will be consulted during the detailed design phase on fauna crossing structure specific requirements for fauna furniture and treatments in and around fauna crossing structures. This will include, but not necessarily be limited to requirements for refuge poles and/or horizontal rails, pathways and appropriate plantings and/or \sizing /placement of scour rock & treatment of the substrate e.g. soil and/or mulch over the concrete floor and apron. Advice will be provided by the project ecologist on fauna furniture to be installed within fauna crossing structures.	The EPA/Fisheries have been consulted with and have provided input into the detailed design of the fauna crossing structures including the fauna furniture design. The Fauna Connectivity Report prepared by TFNSW includes detailed information of the consultation process undertaken with the EPA and Fisheries in relation to the fauna crossing structures. The Project has made prototype panels to demonstrate different types of stone pitching that was to be placed in the low flow channel of Butchers Creek. The prototype panels were shown to the EPA and Fisheries to determine the preferred option for frog and	Detailed Design Drawings ERG Minutes Fauna Connectivity Report

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
		fish passage in this waterway. The fauna furniture design has been demonstrated on site using a prototype and shown to the EPA. The EPA are satisfied with the general arrangement. The fauna drop down design has been demonstrated on site using a prototype and shown to the EPA. The EPA are satisfied with the general arrangement.	

Table 3.2: Compliance with Grey Headed Flying Fox Management Plan

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
Pre-construction	Identify exclusion zones and install exclusion fencing or marking. Exclusion fencing or marking is intended to exclude construction activities from occurring in flying-fox habitat.	Orange flagging and no-go zone signage placed prior to the commencement of construction activities. Flagging was removed when confirmation received that the flying foxes were not utilising the roost on site.	Inspection records Sensitive Area Plans
Detailed Design/ Pre-construction	Minimise through detailed design the incidence of clearing vegetation containing Swamp Mahogany, Melaleuca quinquenervia, Banksia integrifolia and Eucalyptus tereticornis that contribute to foraging habitat during known food bottle necks (i.e. winter period).	The width of the road corridor through the flying fox roost area has been minimised. The total quantity of clearing foraging habitat for GHFF has been minimised.	Sensitive Area Plans Detailed Design Drawings
Pre-construction/ Construction	Construction related infrastructure to be planned and sited within cleared or disturbed areas of the ancillary site. Particularly away from water sources and flying-fox movements areas.	Ancillary sites have been located away from the GHFF roost area and potential habitat.	Consistency review documents for Ancillary site facilities.

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
			Ancillary Facility Register
Construction	Pre-clearing and clearing surveys of all vegetation within the clearing footprint conducted as per protocol. Implement contingency plan for moving flying-fox out of the clearing corridor during vegetation clearing/construction, refer to Appendix C of the GHFF Management Plan.	Pre-clearing and ground disturbance permits have been signed off by the Project Ecologist prior to commencing clearing activities. Project Ecologist present during clearing operations in GHFF habitat. No GHFF have been moved from the Project site for clearing operations	Pre-clearing and ground disturbance checklists.
Detailed Design	To minimise the risk of flying-fox vehicle strike during take-off from roosting/foraging, road corridor revegetation and ornamental planting is not to include plants that flower prolifically and produce nectar food sources likely to attract flying-foxes.	The Urban Design and Landscape Plan has considered revegetation that is suitable for the GHFF. Tree species have been located away from the sides of the roadway. Fauna exclusion fencing has been designed for this area.	Urban Design and Landscape Plan Road Furniture Design Package (RF01)
Construction	Exclusion zones fenced off and/or clearly marked. Fencing and marking monitored with breaches repaired.	The clearing limits have been clearly marked with yellow flagging and no-go zone signage. Rural fencing has been installed to prevent access beyond the Project Boundary into the exclusion zone.	Inspection records
Construction	Installation of temporary exclusion fencing around ancillary facilities.	No Ancillary Site Facilities have been placed in the vicinity of GHFF habitat.	Sensitive Area Plans
Construction	Impacts to the flying-fox camp from construction noise, vibration and light would be managed through maintaining exclusion zone buffers and fencing. Only low noise / low disturbance construction activities to occur within the exclusion zone buffer during mid-September to the following April. Inclusion of cross drainage and the provision of a	No GHFF have been detected using the camp since prior to the commencement of construction. The GHFF colony has been detected using an alternative roost location and have not returned to the roost adjacent to the worksite.	GHFF Monitoring Reports

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
	permeable, free draining rock platform in the vicinity of the camp. Implement contingency plan for moving flying-fox out of the clearing corridor and 100 metre buffer during vegetation clearing/ construction, refer to Appendix C of the GHFF Management Plan.	During the last reporting period, the GHFF Management Plan has been updated to permit the project to undertake activities such as haulage through the site buffer zone if the GHFF population returns to the roost site. This update was approved in January 2017.	
Construction	Implement water quality procedures from the CEMP.	Regular inspections of the erosion and sediment controls in the area is ongoing throughout construction. Water quality monitoring is currently ongoing.	Inspection records Water Quality Monitoring Records

Table 3.3: Compliance with Spotted-tail Quoll Management Plan

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
Detailed Design and Construction	Minimise areas of vegetation (STQ habitat) to be cleared where feasible and reasonable during the detailed design and construction phase. Design changes (e.g. additional ancillary facilities, batch plants etc. to avoid clearing of vegetation (STQ habitat)).	The Project design has minimised clearing quantities as much as possible by ensuring the construction corridor is as narrow as possible. Ancillary sites have been located in areas where clearing is minimal and avoids STQ habitat.	Detailed Design Ancillary Facility Register
Pre-construction	All ancillary sites to be located outside of STQ habitat.	Ancillary sites have been located in areas where clearing is minimal and avoids STQ habitat.	Ancillary Site Facility Consistency Reviews Ancillary Facility Register
Pre-construction	Prior to any clearing taking place, the Project Ecologist will undertake an inspection of vegetation to be cleared to determine if work activities do not constitute “Construction” as defined in the planning approval	Prior to construction commencing, only minor clearing (<150mm DBH) was undertaken. The Project Ecologist inspected all areas of clearing to ensure no STQ	Early Works Permits

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
	under the NSW EP&A Act and are excluded from the Referral under the Federal EPBC Act.	habitat was removed during Pre-construction activities.	
Construction	The limits of clearing are to be clearly marked on all relevant work plans and protective fencing erected to mark these limits (i.e. no-go areas). Fauna habitat resources for the STQ to be marked by the ecologist and retained within areas adjacent to the clearing footprint and within the Project boundary where appropriate.	The clearing limits have been included on the Sensitive Area Plans and marked in the field using yellow flagging. Habitat resources are marked by the Project Ecologist where appropriate	Sensitive Area Plans Pre-clearing and Ground Disturbance Permit
Detailed Design	Areas for STQ habitat restoration/connectivity are to be identified and included in the detailed design.	Habitat connectivity planting has been included in the Urban Design and Landscape Plan	Urban Design and Landscape Plan
Construction	Preparation of an EWMS would be undertaken for all work activities and would include where necessary measures to minimise risk to the STQ.	An EWMS has been prepared for all work activities which includes measures to protect flora and fauna in accordance with the Flora and Fauna Management Plan (FFMP).	EWMS
	Induction of all personnel involved with activities would be undertaken to advise of STQ management requirements.	Project Induction includes information about identification of STQ on site.	Project Induction
	For any area of vegetation to be cleared during the pre-construction stage of the project, a suitably qualified ecologist will undertake a search for native fauna (including STQ) in the vicinity of clearing immediately prior to clearing commencing. During construction a suitably qualified ecologist will undertake pre-clearing surveys for threatened fauna species (including STQs) prior to (within 48 hours) any clearing commencing. For the STQ, these would focus on dens, large hollow-bearing	The Project Ecologist undertakes inspections of all areas to be cleared and signs off on the Pre-clearing Inspection Checklist prior to commencement. No STQ have been identified on site during clearing operations.	Pre-clearing and ground disturbance Permit

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
	trees, scats and any other potential habitat features such as rock formations. Immediately prior to (within 2 hours) of clearing commencing within a given clearing area an additional ecologist inspection is to be undertaken to confirm that clearing areas remain free of fauna (including STQs). In the event that a STQ is identified, no works would be undertaken within 200 metres of the animal and the measures within the Fauna Management Protocol for STQs (refer to Table 4.1) would be implemented. For any STQ detected on/near the site the protocol shown in Table 4.1 is to be implemented.		
Construction	STQ Management Protocol (Table 4-1) to be implemented requiring all personnel to report STQs (including road kill). Assessment of future road kill risk including adaptive management actions to be provided by Project Ecologist where STQ road kill is detected.	No STQ roadkill has been identified on the Project.	Roadkill records and quarterly reports
Construction	Progressive rehabilitation of identified areas refer to Appendix C) during the construction stage using collected topsoil and seed at specific sites and to develop different successional stages of rehabilitation. Key rehabilitation measures would include: - Progressive revegetation/rehabilitation during the construction phase using collected topsoil and seed at specific sites and to develop different successional stages of rehabilitation. -Planting of locally occurring species, including plants	Progressive rehabilitation of the site has commenced. The site will be rehabilitated in accordance with the Urban Design and Landscape Plan which includes habitat connectivity planting around the fauna passage structures.	Inspection records Urban Design and Landscape Plan

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
	representative of groundcover, understorey and canopy strata. - Plantings are to be undertaken around fauna crossing structures to optimise utilisation of these structures. - Monitoring and maintenance of plantings. Managing and controlling weeds.		
Detailed Design and Construction	EPA will be consulted during the detailed design phase on fauna crossing structure specific requirements for fauna furniture and treatments in and around fauna crossing structures. This will include, but not necessarily be limited to requirements for refuge poles and/or horizontal rails, pathways and appropriate plantings and/or sizing /placement of scour rock & treatment of the substrate e.g. soil and/or mulch over the concrete floor and apron. Advice will be provided by the project ecologist on fauna furniture to be installed within fauna crossing structures.	The EPA/Fisheries has been consulted with and have provided input into the detailed design of the fauna crossing structures including the fauna furniture design. The fauna furniture design has been demonstrated on site using a prototype and shown to the EPA. The EPA are satisfied with the general arrangement. The fauna drop down design has been demonstrated on site using a prototype and shown to the EPA. The EPA are satisfied with the general arrangement.	Detailed design drawings

Table 3.4 Compliance with the Giant Barred Frog Management Plan

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
Pre-construction	No areas of Giant Barred Frog habitat to be cleared during preconstruction	No areas of GBF were cleared during pre-construction	Early Works Permits
Pre-construction/ Construction	All ancillary sites to be located outside of mapped Giant Barred Frog habitat.	Ancillary sites are located outside of the mapped GBF habitat.	Sensitive Area Plans Ancillary Facility Register

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
Pre-construction/ Construction	Perform field surveys at nominated biodiversity offset sites	Offset properties have been surveyed and area of potential habitat assessed	Shown on draft offset management plans
Construction	Any design changes required during the construction stage would minimise clearing of Giant Barred Frog habitat where feasible and reasonable	The clearing of GBF habitat has been minimised where possible. Only necessary infrastructure has been placed in the GBF habitat area.	Sensitive Area Plans
Construction	Preparation of an EWMS would be undertaken for all construction activities to clearly communicate relevant measures within this plan to work crews Ongoing induction of all personnel involved with construction activities would be undertaken to advise of Giant Barred Frog management requirements Early Works – Establishing Site Controls (Temporary Frog Fencing) (4.4.2) Pre-clearing Survey for Giant Barred Frogs (4.4.3) Clearing Supervision in Giant Barred Frog areas Dewatering Procedures in Giant Barred Frog areas (4.5.5) Permanent Frog Fencing (4.5.6) Unexpected Finds Procedure (4.5.7) (4.5.4) All mitigation measures applied during construction as per Table 5-1	An EWMS has been prepared for all work activities which includes measures to protect flora and fauna in accordance with the Flora and Fauna Management Plan (FFMP). Project Induction includes information about identification of GBF on site. Temporary frog fencing has been installed prior to the commencement of clearing. The Project Ecologist undertakes inspections of all areas to be cleared and signs off on the Pre-clearing Inspection Checklist prior to commencement. The Project Ecologist has supervised the clearing operations in the GBF habitat. Surveys are undertaken with input sought from the Project Ecologist when the frog fencing is reinstated after a flood event.	EWMS Project Induction Pre-clearing and Ground Disturbance Permit Site Inspection Record Urban Design and Landscape Plan
Construction	Giant Barred Frog road kill to be reported to the Project Ecologist during daily/weekly monitoring	No GBF roadkill has been identified on the Project.	Roadkill records and quarterly report.

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
	An assessment of future road kill risks including adaptive management actions is to be provided by the Project Ecologist where: - A Giant Barred Frog is detected within/ near the site; or - Giant Barred Frog road kill is detected		
Construction Operation	Progressive rehabilitation of identified areas (refer to Appendix C of the GBF Management Plan) Key rehabilitation measures will include planting of the northern bank of Upper Warrell Creek on either side of the bridge Progressive revegetation/ rehabilitation during construction Use of locally endemic native species representative of those currently growing along Upper Warrell Creek Monitoring and maintenance of plantings Managing and controlling weeds	Progressive rehabilitation of the site has commenced. The site will be rehabilitated in accordance with the Urban Design and Landscape Plan which considers GBF habitat in the rehabilitation of Upper Warrell Creek.	Urban Design and Landscape Plan

The Ecological Monitoring Annual Report 2020-2021 provided in Attachment 1 contains the results of the monitoring required for the Management Plans during the reporting period.

2.4. Condition 4

To mitigate impacts to **threatened species**, the **approval holder** must submit the Flora and Fauna Management Sub Plan and Construction Environment Management Plan to the **Department** for approval prior to **commencement**. The Plans must include the additional mitigation measures not included in the **management plans** and as described in the **Biodiversity Offset Strategy**. The approved **plans** must be implemented.

	Action	Timing	Status	Compliance evidence
4.1	Submit Flora and Fauna Management Plan and Construction Environment Management Plan to the Department	Prior to commencement	Compliant Complete	The CEMP and FFMP were submitted to DoEE on the 17 & 22 December 2014.
4.2	Plans must include the additional mitigation measures not included in the management plans as described in the Biodiversity Offset Strategy.	Prior to commencement	Compliant Complete	The plans were accepted by DoEE on the 9 January 2015.
4.3	Implement the FFMP and CEMP	Construction	Compliant Ongoing	Compliance with the FFMP and CEMP is continuously monitored on site. The Project has an independent Environmental Representative to monitor compliance with these documents. See summary below.

Compliance with the CEMP and FFMP is reviewed regularly by TfNSW, the independent Environmental Representative (ER) and Pacifico. There were no non-compliances relating to the FFMP. The Project continued to implement the CEMP through the construction phase.

2.5. Condition 5

In the event of any inconsistency, ambiguity or discrepancy between the **management plans** and the Flora and Fauna Management Plan or the Construction Environmental Management Plan, the **management plans** have precedence.

	Action	Timing	Status	Compliance evidence
5.1	Identify discrepancies in the CEMP/FFMP and Management Plans	Construction	Compliant Ongoing	No discrepancies noted

2.6. Condition 6

Prior to commencement, the approval holder must amend the monitoring program proposed in the Threatened Flora Management Plan to:

a) include detailed monitoring methodology designed to monitor the success of the management and mitigation measures proposed for pre-construction, construction and operations; and
b) ensure all performance thresholds, corrective actions and monitoring/timing frequency are specific, measurable, auditable, enforceable and time-bound to monitor the success of the management and mitigation measures proposed.

Action	Timing	Status	Compliance evidence
6.1 Update the TFMP to include detailed monitoring methodology designed to monitor the success of the management and mitigation measures	Prior to commencement	Compliant Complete	The TFMP has been approved by DoEE on the 9 January 2015;
6.2 Update the TFMP to ensure all performance thresholds, corrective actions and monitoring/timing frequency are specific, measurable auditable, enforceable and time-bound	Prior to commencement	Compliant Complete	The TFMP has been approved by DoEE on the 9 January 2015.

2.7. Condition 7

The **approval** holder must not **commence** the **action** until the **Threatened Flora Management Plan** has been approved by the **Minister.** The approved **Threatened Flora Management Plan** must be implemented.

	Action	Timing	Status	Compliance evidence
7.1	The action must not commence until the TFMP is approved by the Minister	Prior to commencement	Compliant Complete	The TFMP was approved by DoEE on the 9 January 2015.
7.2	Implement the TFMP	Construction	Compliant Ongoing	Translocation Annual Report Ecological Monitoring Report

Further details on the monitoring undertaken are provided in the Annual Ecological Monitoring Report in Attachment 1.

2.8. Condition 8

The **approval holder** must monitor all mitigation measures until they are demonstrated to be successful, and with written agreement from the **Department**.

	Action	Timing	Status	Compliance evidence
8.1	Monitor implementation of the mitigation measures	Construction and Operation	Compliant Ongoing	Ecological Monitoring Annual Report This Report
8.2	Obtain written agreement from the Department that all mitigation measures have been demonstrated as successful	Completion of construction and operation	Compliant TBA	Written agreement with the Department

2.9. Condition 9

If **MNES** not previously identified and reported to the **Department**, are found in the **action** area, the **approval holder** must notify the **Department** in writing within five business days of finding the **MNES**, and within a further 30 business days, the **approval holder** must outline in writing how **impacts** to these **MNES** will be avoided, mitigated and/or **offset**.

	Action	Timing	Status	Compliance evidence
9.1	Notify the Department in writing within five business days of finding MNES	Pre-Construction, Construction, Operation	Ongoing	No additional EPBC listed species have been identified during the reporting period.
9.2	Outline in writing within 30 business days how the impacts to MNES will be avoided, mitigated and/or offset	Pre-Construction, Construction, Operation	Ongoing	No additional EPBC listed species have been identified during the reporting period.

2.10. Condition 10

Prior to **commencement**, all **management plans** must be made publicly available on the **approval holder's website**, for 10 years following **commencement**. The monitoring results must also be made available on request for the duration of the **approval**.

	Action	Timing	Status	Compliance evidence
10.1	Upload Management Plans on to the public website	Construction Operation	Compliant Complete	All management plans uploaded to the TFNSW website.
10.2	Monitoring results must be made available on request for the duration of the approval	Construction Operation	Compliant Ongoing	Monitoring results are available on request.

2.11. Condition 11

The **approval** holder must make all monitoring results required by the **management plans** publicly available on the **approval holder's website** within two months of the monitoring event, for 10 years following **commencement**. The monitoring results must also be made available on request for the duration of the **approval.**

	Action	Timing	Status	Compliance evidence
11.1	All monitoring results to be uploaded to the Project website	Construction Operation	Compliant Ongoing	Monitoring data has been published on the project website in accordance with the timeframes at the link at Note 1. Monitoring results are available on request.

https://www.pacifichighway.nsw.gov.au/project-sections/port-macquarie-to-coffs-harbour/warrell-creek-to-nambucca-heads

2.12. Condition 12

To compensate for the loss of threatened species habitat, within 12 months of the approval of the action, the approval holder must submit to the Minister for approval a Biodiversity Offset Package. The Package must:

a) provide known **habitat** and compensate for the residual significant **impacts** on the **threatened species** and their **habitat** in Condition 1a) to e);
b) demonstrate consistency with and meets the requirements of the **EPBC Act Environmental Offsets Policy**;
a) detail the **offset attributes** (including maps in electronic Geographic Information System (GIS) format with accompanying **shapefiles**), site descriptions environmental values relevant to **threatened species** being **offset**, connectivity with other **habitat** and biodiversity corridors;
b) include detailed surveys and quantitative and qualitative descriptions of any proposed **offset areas** which clearly identify **baseline** conditions. This must include:
    i. a **baseline** description (prior to any management activities) of the current **quality** of the **habitat** for each relevant **threatened species** in each **offset area**, including the location of survey points (GPS reference);
    ii. the quantity (in hectares) of suitable **habitat** present within the **offsets areas** for the **threatened species** the **quality** of the **habitat** for the relevant **threatened species** found within the **offset areas**;
    iii. vegetation condition mapping; and
    iv. photo reference points.
c) be prepared by a **suitably qualified ecologist**;
d) include conservation and management measures for long-term protection and adaptive management of the **offsets** to improve **habitat** for **threatened species** within the **offset areas** from **baseline** conditions, including but not limited to:
    i. a map showing **offset areas** to be managed;
    ii. conservation management actions for each **offset area** and the details of methods to be used;
    iii. **offset** management must be consistent with **threat abatement plans** for **threatened species**;
    iv. the timing of management activity for each **offset area** and anticipated timeframes for achieving performance objectives;
    v. clear performance measures and performance indicators for each **offset area** including contingency actions, criteria for triggering contingency actions and a commitment to the implementation of these actions in the event that performance objectives are not met that will enable maintenance and enhancement of **habitat** within the **offset area**, as well as contribute to the better protection of individuals and/or populations of **threatened species** and their **habitat**;
        i. a monitoring program to assess the effectiveness of the management actions measured against the **baseline** condition. This must include, but not be limited to, control sites and periodic ecological surveys to be undertaken by a **suitably qualified ecologist**;
        ii. a risk assessment and a description of the contingency measures that would be implemented to mitigate these risks;

iii. details of the various parties responsible for the management, monitoring and implementing the management activities, including their experience and qualifications and employment or engagement status; and

iv. details of qualifications and experience of persons responsible for undertaking monitoring, review, and implementation of the Biodiversity Offset Package, including the role of the **independent expert** in preparing, reviewing, and implementing the Biodiversity Offset Package; and

a description of protection and funding arrangements or agreements including work programs and responsible entities

Action	Timing	Status	Compliance evidence
12.1 Submit a BOP to Minister of DoEE for approval	Within 12 months of the approved action	Compliant Complete	The action was approved on 11 December 2014. The Biodiversity Offset Package was submitted for approval on 11 December 2015.

2.13. Condition 13

The **approval holder** must implement the approved Biodiversity Offset Package within 24 months of the date of this **approval**.

	Action	Timing	Status	Compliance evidence
13.1	Implement the actions approved under the BOP	Within 24 months off approval	Compliant –	The BOP was approved by DoEE on 5/7/2017 and is currently being implemented. Ecosystem credits from both Norton and Swain will be retired by 30 June 2021. The Norton offset site was secured on 18 February 2019 and the Swain offset site was secured on 22 February 2019.

A revised draft was submitted to DoEE for approval in November 2016. The revised Plan was approved by DoEE on 5 July 2017.

2.14. Condition 14

If an **offset** site proposed as a part of the Offset Package is already required to be protected as a result of a separate **EPBC Act** approval, only the management actions which can be demonstrated to be additional to those required for the separate approval, can be considered as an **offset** for this project. The legal protection of the site and management action required for separate approvals cannot be considered a part of the **offsets**, in accordance with the **Environmental Offsets Policy**.

	Action	Timing	Status	Compliance evidence
14.1	Allocate offsets under the BOP from one section of a designated property. No cross over of allocation to occur.	Pre During and post construction	Compliant	There is no overlap between the WC2NH offset areas and any other project's offset areas.

To comply with the EPBC Act offset policy, TFNSW has allocated separate areas of the Norton property (503 ha in total) to each project as follows:

NH2U: 281 ha (includes 5 ha domestic exclusion area)

WC2NH: 185 ha

OH2K: 37 ha

A map showing the area dedicated to each property was included in the revised draft of WC2NH OMP (submitted for approval November 2016) and the NGOMP for NH2U. This will give DoEE confidence that no doubling or cross over of allocations between the approved projects has or will occur.

To-date in assessing the OH2K OMP and earlier drafts of the NGOMP and WC2NH OMP, DoEE have not raised any concerns with this approach.

2.15. Condition 15

The **approval holder** must, within 36 months of the **approval** of the Biodiversity Offset Package, register a legally binding conservation mechanism to provide long-term protection to the **offsets** approved by the **Minister** in the Biodiversity Offset Package, which prohibits any activities that are not conservation activities from being undertaken in the **offsets.**

Action	Timing	Status	Compliance evidence
15.1 Register within 36 months of the approval of the Biodiversity Offset Package, a legally binding conservation mechanism to provide long-term protection to the offsets approved by the Minister in the Biodiversity Offset Package, which prohibits any activities that are not conservation activities from being undertaken in the offsets	36 months from BOP approval date	Ongoing	The BOP was approved by DoEE on 5 July 2017 and is currently being implemented.

The WC2NH Biodiversity Offset Package was approved by DoEE in July 2017. TFNSW is progressing with securing the offset properties as follows:

Offset property (tenure)	Offset mechanism	Status
Norton (TFNSW)	Bio Banking Agreement (provides a legally binding conservation mechanism under the Threatened Species Conservation Act)	BioBanking Agreement have been executed by OEH and registered on title on 18 February 2019.
Boambee (Forestry Corporation NSW)	Newly declared Flora Reserve which provides a legally binding conservation mechanism under the Forestry Act.	Forestry Corporation NSW has supplied their compensation terms for this site which were approved by TFNSW in April 2018. FCNSW will now undertake the formal gazettal process to create the Flora Reserve but it will be unlikely to be gazetted by 5 July 2018. We anticipate FCNSW finalising the gazettal process by the end of 2019 to declare the new Flora Reserve.
Swain (private)	Bio Banking Agreement.	BioBanking Agreement have been executed by OEH and registered on title on 22 February 2019.

TFNSW sought a variation to this condition, providing detail on the progress with implementing the package and requesting a further 24 months to finalise the protection mechanisms on the 3 offset sites. This variation was approved by DoEE on 25 September 2018

2.16. Condition 16

If within 6 years, after impacts to Grey-headed Flying-fox habitat, the results of the monitoring required in the Grey-headed Flying-fox Management Plan, show that the Macksville Grey-headed Flying-fox Camp is abandoned by the Grey-headed Flying-fox, between September and May for two consecutive years, the approval holder must then offset the entire 23.50 ha roosting habitat critical to survival within 24 months, rather than 3.10 ha required by Condition 1.

Note: The provision of the additional offset, if required, would be additional to the requirements of Condition 13-16.

Action	Timing	Status	Compliance evidence
16.1 Monitoring GHFF camp. From monitoring results, determine if camp unoccupied continually for 2 consecutive years within a 6 year monitoring period. If unoccupied provide for the full 23.50 Ha offset area else provide for the 3.1 Ha.	Completion by 1 May 2023	Ongoing	Monitoring of the Macksville Greyheaded Flying-fox Camp found it to be abandoned by the Grey-headed Flyingfox, between September and May for two consecutive years on 31 May 2017. TfNSW is in the process of investigating suitable offset habitat.

2.17. Condition 17

Within 14 days after the **commencement** of the **action**, the person taking the **action** must advise the **Department** in writing of the actual date of **commencement**.

	Action	Timing	Status	Compliance evidence
17.1	Advice in writing to be provided to DoEE 14 days prior to the commencement of the action.	14 days prior to the commencement of the action	Complete	A letter was provided to DoEE by TFNSW on the 17 February 2015. The Commencement date for the action was the 9 February 2015.

2.18. Condition 18

The **approval holder** must notify the **Department** in writing of potential non-compliance with any condition of this **approval** as soon as practical and within no later than two business days of becoming aware of the non-compliance. The notice provided to the **Department** under this condition must specify:

a) the condition which the **approval holder** has potentially breached;

b) the nature of the non-compliance; and

c) when and how the **approval holder** became aware of the non-compliance.

Further to providing any such notice, the **approval holder** must provide the following information within 10 business days of becoming aware of a potential non-compliance:

a) how the non-compliance will affect the anticipated impacts of the **approved action**, in particular how the non-compliance will affect the impacts on the **MNES**;

b) the measures the **approval holder** will take to address the impacts of the non-compliance on the **MNES** and rectify the non-compliance; and

c) the time by when the **approval holder** will rectify the non-compliance.

	Action	Timing	Status	Compliance evidence
18.1	Details of any non-compliance to be reported to DoEE within 2 business days of being made aware of the non-compliance	Construction	Compliant Ongoing	No non-compliances were reported to the Department during the reporting period.

2.19. Condition 19

Within three months of every 12 month anniversary of the **commencement** of the **action**, the **approval holder** must publish a report on its **website** addressing compliance with each of the conditions of this **approval**, including implementation of any **management plan, package** as specified in the conditions. **Documentary** evidence providing proof of the date of publication must be included in the published **compliance report**. The **compliance report** must remain on the **website**, for 10 years following **commencement**. The monitoring results must also be made available on request for the duration of the **approval**. Reports of any non-compliance must also be included in the annual **compliance report.**

	Action	Timing	Status	Compliance evidence
24.1	Prepare compliance report and upload to project website	By 9 May 2016	Compliant	Report uploaded to project website. Advice provided to Dept. on date of publication.
24.2	Prepare compliance report and upload to project website	By 9 May 2017	Compliant	Report uploaded to project website. Advice provided to Dept. on date of publication.
24.3	Prepare compliance report and upload to project website	By 9 May 2018	Compliant	Report uploaded to project website. Advice provided to Dept. on date of publication.
24.4	Prepare compliance report and upload to project website	By 9 May 2019	Compliant	Report uploaded to project website. Advice provided to Dept. on date of publication.
24.5	Prepare compliance report and upload to project website	By 9 May 2020	Compliant	Report uploaded to project website. Advice provided to Dept. on date of publication.
24.6	Prepare compliance report and upload to project website	By 9 May 2021	Compliant	Report uploaded to project website. Advice provided to Dept. on date of publication.

Compliance reports are published at https://www.pacifichighway.nsw.gov.au/documentlibrary/warrell-creek-to-nambucca-heads-upgrade-epbc-compliance-reports

2.20. Condition 20

The **approval holder** must maintain accurate **compliance records** substantiating all activities associated with or relevant to the conditions of **approval**, including measures taken to implement the **management plans, package** required by this **approval**, and make them available upon request to the **Department**. Such **compliance records** may be subject to audit by the **Department** or an independent auditor in accordance with section 458 of the **EPBC Act**, or used to verify compliance with the conditions of **approval**. Summaries of audits will be posted on the **Department's website**. The results of audits may also be publicised through the general media.

	Action	Timing	Status	Compliance evidence
20.1	Maintain compliance records for the management plans	Construction, operation	Ongoing	Compliance records are maintained on the relevant TFNSW document management systems, available on the Project Website.
20.2	Maintain compliance records for the Biodiversity Offset Strategy	Construction, operation	Ongoing	Throughout the reporting period, TfNSW has undertaken routine property inspections and maintenance of the Norton property. This has included weed control, cattle exclusion and track maintenance. TfNSW reports to the Biodiversity Conservation Trust to demonstrate compliance with the management plan. The Swain property is protected under stewardship agreement management by the Biodiversity Conservation Trust. This involves monitoring and reporting to ensure that the land owner is managing the property in accordance with the management action plan attached to the stewardship agreement.

2.21. Condition 21

Upon the direction of the **Minister**, the **approval holder** must ensure that an independent audit of compliance with the conditions of **approval** is conducted and a report submitted to the **Minister**. The audit must not commence unless and until the **Minister** has approved the independent auditor and audit criteria. The audit report must address the criteria to the satisfaction of the **Minister.**

	Action	Timing	Status	Compliance evidence
21.1	Prepare independent audit of compliance with the conditions of approval if directed by the Minister to do so.	When Directed	TBA	An independent audit of the conditions of approval has not been required during the reporting period.

2.22. Condition 22

If the **approval holder** wishes to carry out any activity otherwise than in accordance with a **management plans, strategy, package** as specified in the conditions, the **approval holder** must submit to the **Department** for the **Minister's** written approval a revised version of that **management plan, package**. The varied activity must not commence until the **Minister** has approved the varied **management plan, package** in writing. The **Minister** will not approve a varied **management plan, package** unless the revised **management plan, package** would result in an equivalent or improved environmental outcome over time. If the **Minister** approves the revised **management plan, package** that **management plan, package** must be implemented in place of the **management plan, package** originally approved.

	Action	Timing	Status	Compliance evidence
22.1	Provide updated management plan or package for approval	Construction Operation	Compliant Ongoing	STQ Management Plan and Koala Management Plan varied on 22 January 2015. STQ Management Plan and Koala Management Plan varied on 3 October 2016. GHFF Management Plan, STQ Management Plan and Koala Management Plan were updated to change the road kill monitoring program prior to the partial opening of Stage 2A. The updated plans were approved by DoEE on 12 of January 2018.

2.23. Condition 23

If the **Minister** believes that it is necessary or convenient for the better protection of **MNES** to do so, the **Minister** may request that the **approval holder** make specified revisions to a **management plan, package** required by the conditions and submit the revised **management plan, package** for the **Minister's** written approval. The **approval holder** must comply with any such request. The revised **management plan, package** must be implemented. Until the **Minister** has approved a revised **management plan, package**, the **approval holder** must continue to implement the previously approved **management plan, package**, as specified in the conditions.

	Action	Timing	Status	Compliance evidence
23.1	Update the Management Plan or Package in response to a direction from the Minister and provide for approval.	As directed	TBA	No updates to the management plans or package have been required.

2.24. Condition 24

If, at any time after five years from the date of this **approval**, the **approval holder** has not **commenced** the **action**, then the **approval holder** must not **commence** the **action** without the written agreement of the **Minister.**

	Action	Timing	Status	Compliance evidence
24.1	Notify the Minister of the commencement of the action	Prior to Commencement	Compliant Complete	TFNSW notified the Minister of the commencement of the action on the 17 February 2015.

2.25. Condition 25

Unless otherwise agreed to in writing by the **Minister**, the **approval holder** must publish the **management plans, package**, monitoring data in these conditions of **approval** on its **website**. Each **management plans, package**, monitoring data must be published on the **website** within one month of being approved (unless otherwise specified in these conditions) or within one month of data collection.

	Action	Timing	Status	Compliance evidence
25.1	Publish management plans on the Project Website	Construction Operation	Complete Compliant	Management Plans uploaded onto the project website
25.2	Publish the Biodiversity Offset Package on the Project Website	Construction Operation	Complete Compliant	The Biodiversity Offset Package has been published on the project website
25.3	Publish monitoring data onto the website	Construction Operation	Complete Compliant	Monitoring data has been published on the project website in accordance with the timeframes.

2.26. Condition 26

The **approval holder** must notify the **Department** within 5 business days of publishing the **management plan, package**, monitoring data on their website and the **management plan, package**, monitoring data must remain on the website for the life of this **approval**.

	Action	Timing	Status	Compliance evidence
26.1	Management plans uploaded on TFNSW website	With 5 days	Compliant	The CEMP TFMP and FFMP were uploaded on the project web site on 17 February 2015. Plan revisions have been uploaded onto the project website with notification provided to DoEE within 5 business days of publication.
26.2	Monitoring data	Within 2 months of receipt	Compliant	TFNSW provides email notification to the Department's 'EPBC Monitoring' mailbox within 5 days of publishing relevant information onto the project website

Attachment 1 Ecological Monitoring Report 2020 - 2021

Transport
Roads & Maritime
Services

Warrell Creek to Nambucca Heads Koala Monitoring Operational phase

Koala Monitoring Interim Report

Year 3 operational phase

Transport for NSW | October 2020

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Disclaimer:
This report has been prepared in accordance with the scope of services described in the contract or agreement between Sandpiper Ecological Surveys (ABN 82 084 096 828) and Transport for NSW. The report relies upon data, surveys and measurement obtained at the times and locations specified herein. The report has been prepared solely for Transport for NSW and Sandpiper Ecological Surveys accepts no responsibility for its use by other parties. Sandpiper Ecological Surveys accepts no responsibility or liability for changes in context, meaning, conclusions or omissions caused by cutting, pasting or editing the report.

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1. Introduction

In 2015, Transport for New South Wales (TfNSW), in conjunction with Acciona Ferrovial Joint Venture (AFJV), commenced the upgrade of the Pacific Highway between Warrell Creek and Nambucca Heads (WC2NH). The WC2NH project was opened to traffic in two stages: stage 2a - 13.5km section from Lower Warrell Creek Bridge to Nambucca Heads opened on 18 December 2017; and stage 2b 6.25km section from the southern end of the project to the Lower Warrell Creek bridge opened in late June 2018.

Approvals for the WC2NH upgrade required monitoring of several species and mitigation measures during the operational phase. Species and mitigation measures targeted include koala, yellow-bellied glider, giant barred frog, green-thighed frog breeding ponds, underpasses, vegetated median, roadkill, exclusion fence, and threatened flora. Sandpiper Ecological Surveys (SES) has been contracted by TfNSW to deliver the WC2NH operational ecological and water quality monitoring program.

The following interim report details the methods and results of spring year three operational phase koala population monitoring. Year one operational phase monitoring was conducted in spring 2018 (Sandpiper 2018). The aim of koala monitoring is to identify changes in resident koala activity (abundance, home range and movements) in response to construction of WC2NH and the effectiveness of koala habitat connectivity mitigation measures (i.e. fauna underpasses and exclusion fencing). The following report focuses on targeted koala surveys on replicate transects and nearby management trails and includes general comment on the effectiveness of mitigation measures. Detailed analysis of koala use of underpasses and a summary of all koala records will be provided in the annual (year 3 operational phase) koala report, which is due in August 2021.

1.1 Background

The impact of the upgrade on koala (*Phascolarctos cinereus*) was assessed in the Project Environmental Assessment (Sinclair Knight Merz [SKM] 2010a, SKM 2010b), and following its listing on the *Environment Protection and Biodiversity Conservation Act 1999*, a supplementary assessment in accordance with the *EPBC Act Policy Statement 1.1 Significant Impact Guidelines* (Geolink 2016). The supplementary assessment found that the Proposal would have negative impacts on koalas utilising the Nambucca State Forest/ Old Coast Road area, mainly through habitat removal and fragmentation.

The Project, with effective implementation of proposed mitigation measures, was found to be unlikely to result in a significant impact to the local koala population. Notwithstanding, as the Project adversely affected habitat that satisfied the SEWPaC (2012) definition of ‘habitat critical to the survival of the species’ (including direct removal of approximately 86.5 ha of vegetation that satisfies this criteria); the Project was considered to constitute a significant impact on the Koala as per the DSEWPaC (2012) and DoE (2013a) guidelines.

Measures implemented to minimise impacts on koalas include:

- Ecological monitoring to determine the effectiveness of mitigation measures undertaken as part of the Project.
- Installation of fauna crossings, and fauna exclusion fencing to allow for safe passage of fauna (including the koala) crossing the Pacific Highway.
- Installation of 'floppy-top' fauna exclusion fencing to minimise road strike

Prior to construction a pre-clearance baseline koala monitoring methodology was prepared and baseline surveys conducted in autumn and spring 2014 (SKM 2014). Construction phase koala monitoring surveys were conducted in spring 2015 (year 1) and spring 2017 (year 3) (Geolink 2017). Operational phase koala monitoring surveys were conducted in spring 2018 (year 1) (Sandpiper Ecological 2018).

1.2 Study area

The WC2NH project covers a total length of 19.75km and extends from Warrell Creek in the south to Nambucca Heads in the north (Figure 1). The alignment bypasses the town of Macksville and the northern section traverses Nambucca State Forest. Koala population monitoring surveys occur within Nambucca State Forest at the northern end of the upgrade.

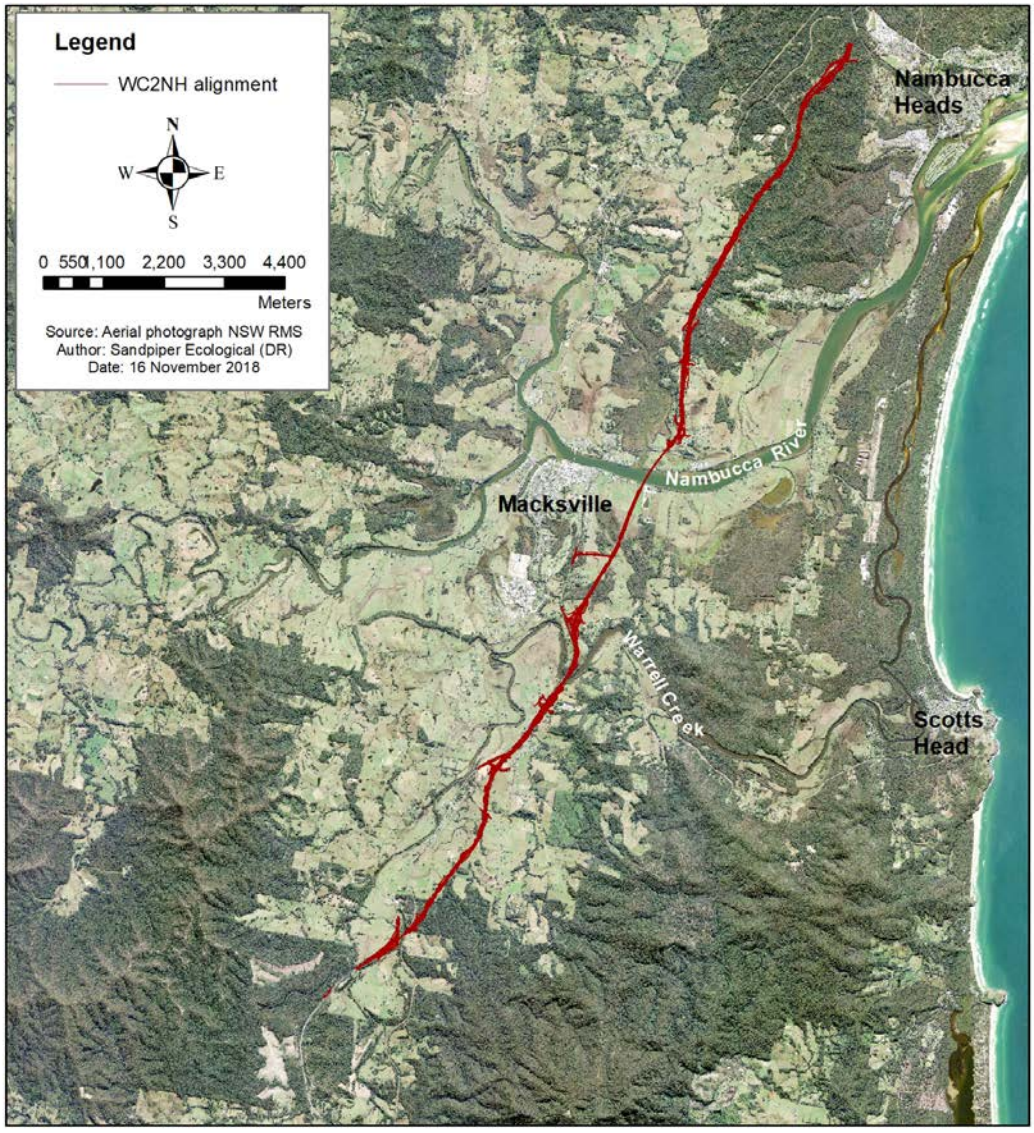

Figure 1: Location of the WC2NH alignment.

2. Methodology

2.1 Transect surveys

Twenty-five paired transects were established perpendicular to the alignment within the Nambucca State Forest/Old Coast Road area between chainages 15600 and 19500. Transects ranged in length from 34m to 500m and were approximately 150m apart (Figure 2). Shorter transects terminated at the forest edge, or at a private property boundary. Each transect was surveyed by one ecologist during the day and night. All surveys were conducted on foot at a speed of 0.5 to 1kph. At night, the male koala call was broadcast for five minutes through a 5-8 watt speaker or megaphone from the approximate centre-point of each

transect. Additional spotlighting was conducted along tracks and roads whilst moving between transects. All nocturnal surveys were conducted using 200+ lumen spotlights.

Four ecologists conducted surveys between 7 and 9 September. Weather conditions during the survey were suitable for sampling koalas with mild to warm temperatures and light winds recorded. Survey time for 500m transects ranged from 26 to 39 minutes/transect.

The following data were collected for each koala detected:

- Location (using global positioning system GPS).
- Distance from transect (GIS).
- Occupied tree species.
- Habitat type.
- Height of occupied tree.
- Diameter at breast height of occupied tree.
- Sex.
- Behaviour.
- Evidence of disease.
- Reproductive status.

2.2 Survey limitations

The survey design has substantial limitations when considered in the context of the monitoring aim. The aim of monitoring is to identify changes in resident koala activity (abundance, home range and movements) in response to construction of WC2NH and the effectiveness of koala habitat connectivity mitigation measures (i.e. fauna underpasses and exclusion fencing). The second part of the aim “the effectiveness of koala habitat connectivity mitigation measures” is addressed in a separate component of the WC2NH operational phase monitoring program and is not a focus of population monitoring. The first part of the aim “to identify changes in resident koala activity (abundance, home range, and movements) in response to construction” is covered by the transect surveys and addressed in this report.

The survey design is unsuitable to obtain information on abundance, home range or movement. As noted by Geolink (2017) the dense mid-storey vegetation present on many transects substantially reduces koala detectability. The detection probability on some transects is likely to be less than 25%. The difficult terrain also means that a substantial amount of time is spent looking at the ground rather than the canopy. In addition, transects are not independent and there is a strong likelihood that the same koala could be recorded on adjoining transects making estimates of abundance difficult. Individuals moving beneath the highway exacerbate this problem.

Detection limitations were noted during previous surveys and sampling along tracks was included to supplement transect surveys (Geolink 2017). However, the lack of well-defined spatial and temporal survey effort for the supplementary surveys introduces another potential bias.

3. Results

3.1 Transect surveys

No koalas were recorded while completing transect surveys during the spring 2020 sample event (Table 1; Figure 2). Koala scats were recorded beneath a tallowwood tree (*Eucalyptus microcorys*) on transects E7, E11, E13, E22, W5, and W16 (Table 2; Figure 2).

3.2 Tracks and easements

One koala was observed inside (i.e. within road corridor) the exclusion fence near E11 during spotlight surveys of tracks and easements on 8/9/2020 (Table 1; Figure 2). The individual was captured and relocated to forest habitat adjacent E11. The male koala was a healthy sub-adult in good condition with no signs of disease. It is likely the individual breached the exclusion fencing via a nearby gate that featured a ~200mm gap between the gate bottom and the ground. The gap was remedied after relocating the individual to the adjoining east forest.

Scats were recorded while surveying the edge of the forest from fence line easements. Scats were detected at three locations near transects E5, E6, and E11. All scat records were beneath tallowwoods.

3.3 Habitat use and distribution

Based on the location of scat records, koala use of adjoining forest was largely evident on ridges and mid-slope within Open Blackbutt Forest. While it is unknown what part of the forest the individual outside the exclusion fence emerged from, it was observed near E11, which is positioned on mid-slope.

The distribution of 2020 records suggest that koalas continue to be distributed quite broadly across the study area albeit at low densities (Figure 2). When combined with underpass crossing records (Sandpiper 2019), evidence of habitat use extends from W5/E5 through to W24/E24. Scat records around E10-E13 show a similar distribution to 2018 scat records. Further, scat records around W5/E5-E7 are consistent with 2018/19 records of nearby underpass use (Figure 2). The combination of scat and underpass records confirms use of both sides of the highway particularly in the vicinity of W11/E11 and W6/E6.

Table 1: Details of koala recorded during the spring 2020 survey. M = male.

Date	Easting	Northing	Time of observation	Closest transect & distance (m)	Survey type	Habitat type	Sex	Behaviour	Reproductive & disease status	Side of carriage way
8/9/2020	496638	6609355	Night	E11; 12m	Track & easement	Open Blackbutt Forest	M	On ground inside exclusion fence	Healthy	East

Table 2: Location of koala scats recorded during spring 2020 transect and track/easement surveys. Datum – GDA 94.

Transect	Evidence	Distance from alignment (m)	Easting	Northing	Date
E5 (fence line nearby)	Old scat beneath tallowwood	fence line	497273	6610075	9/9/2020
E6 (fence line nearby)	Old scat beneath tallowwood	fence line	497131	6609905	9/9/2020
E7	Old scat beneath tallowwood	72	497073	6609803	9/9/2020
E11	Old scat beneath tallowwood	205	496805	6609244	9/9/2020
E11 (fence line nearby)	Old scat beneath tallowwood	fence line	496693	6609399	9/9/2020
E13	Old scat beneath tallowwood	466	496995	6608780	9/9/2020
E22	Old scat beneath tallowwood	32	495923	6607876	9/9/2020
W5	Old scat beneath tallowwood	352	496872	6610275	8/9/2020
W16	Old scat beneath tallowwood	162	496266	6608680	8/9/2020

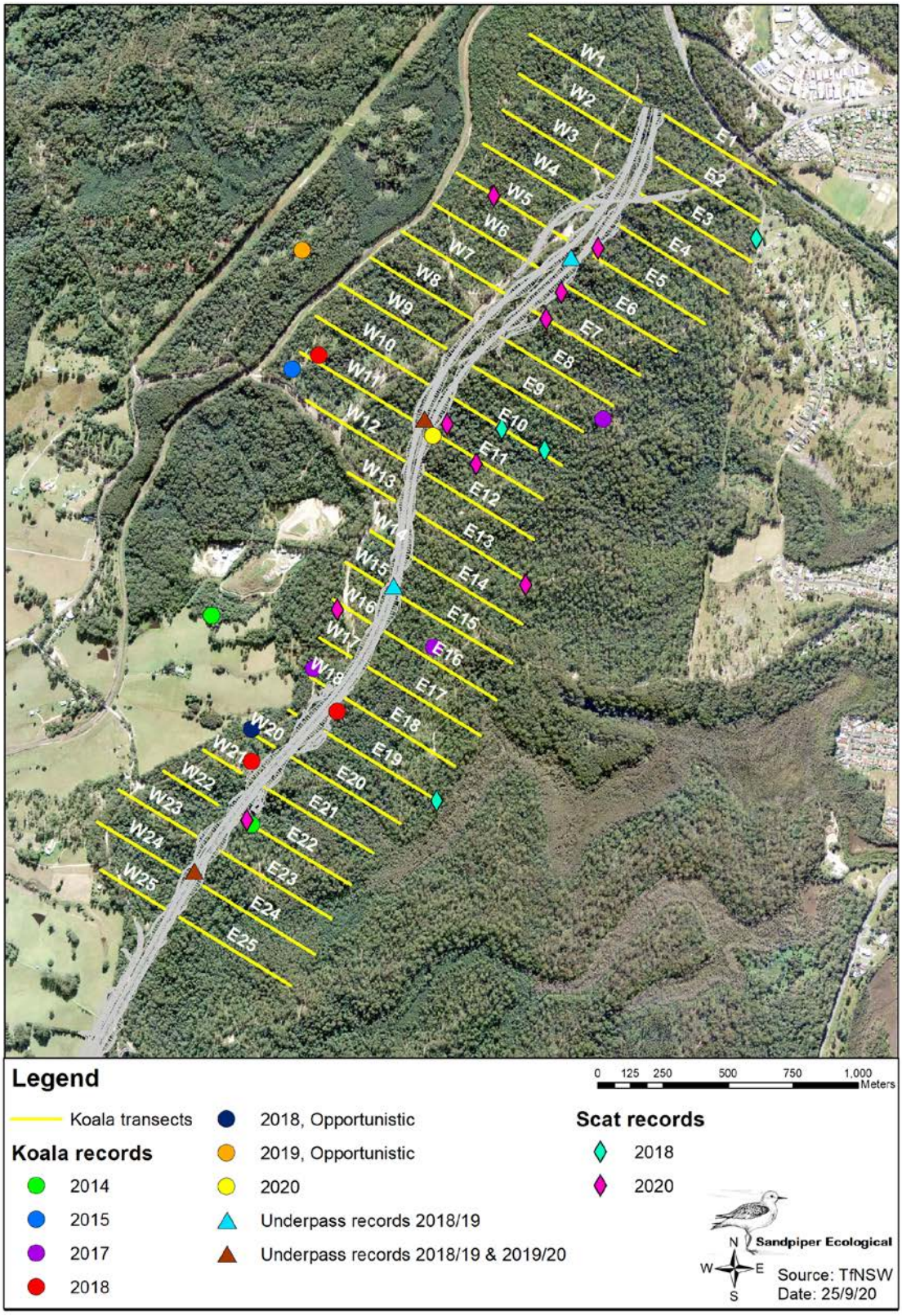

Figure 2: Location of koala observations and scat records between 2014 and 2020.

4. Discussion

4.1 Koala population

Fewer koalas were recorded during current surveys (1 individual) compared to spring 2018 and spring 2017 surveys (3 individuals; Table 3). A single individual was recorded on tracks/easements during baseline surveys and year one of the construction phase (Table 3). However, inconsistencies in survey method, particularly the effort expended on tracks and easements where most koalas have been recorded, precludes a robust assessment of possible changes in koala abundance and whether this is associated with the WC2NH upgrade. Notwithstanding, this report is interim and additional koala data will be collected throughout year 3 whilst conducting underpass and adjacent habitat surveys and yellow-bellied glider surveys. The entire year 3 dataset will enable a more robust analysis of koala abundance in the locality.

Table 3: Comparison of koala records during the baseline, construction, and operational phases of the WC2NH upgrade. * individual recorded on four occasions.

Phase & year	Transect Surveys (diurnal & nocturnal)		Track & Easement Surveys (nocturnal)	Total koalas recorded
	Koalas observed	Koala evidence (scats)	Koalas observed	
Baseline autumn 2014	0	0	1	1
Baseline spring 2014	0	0	1	1
Construction spring 2015	1	1	1	1*
Construction spring 2017	0	2	3	3
Operation spring 2018	1	3	2	3
Operation spring 2020	0	6	1	1

Results of 2017 construction phase surveys and 2018 operation phase showed that at least three koalas were residing within the survey area which was estimated to be approximately 104 ha (Sandpiper Ecological 2019). Home range areas of koalas residing in moderate to high habitat quality habitat on the north coast is reportedly in the range of 23-37 ha (see Lassau *et al.* 2008; Goldingay & Dobner 2014). Home range areas of koalas residing in Nambucca State Forest (NSF) would likely be larger than these estimates due to the lower habitat quality and NSF's forest management history. As such, the study area probably supports few individuals.

Detection of fewer koalas during the current survey may be an artefact of several exogenous factors outside of the control of the upgrade project. Indeed, the broader area has suffered an extended period of drought up until the early part of this year as well as wildfire in the east part of the forest and logging operations in the south-east. While the direct effect of these events is largely unknown, it is expected that they may have adversely affected the local koala population.

Despite fewer koala observations during the current surveys, the detection of scats at nine spatially spread locations suggests there is more than one individual residing in the study area. The distribution of scat records and underpass crossings confirms the findings of 2018/19 monitoring (Sandpiper Ecological 2018, 2019) that some individuals are re-establishing home

ranges to the new forest edge and some home ranges include both sides of the highway. These results also support the notion that the study area supports a low-density koala population (Geolink 2017).

The impact of clearing for the upgrade on the local koala population is difficult to ascertain. As discussed above, clearing impacts are both compounded and confounded by several exogenous factors acting concurrently on the local koala population. Positive signs of koala persistence include the broad distribution of scats across the study area especially adjacent to the upgrade corridor, and the presence of at least one young, healthy individual.

4.2 Habitat use and distribution

It is evident from the distribution of current and 2018/19 monitoring records that koalas are utilising both sides of the highway corridor, particularly in forest areas featuring stands of tallowwood. Encouragingly, koalas have used underpasses to cross the highway corridor at four locations spread along the study area (Figure 2). This suggests that the highway corridor is not a barrier to movement between the forest blocks. The ability to move beneath the highway is particularly important in areas of poor habitat quality or during times of drought or even bushfires when individuals need to extend or shift their home range area.

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Warrell Creek to Nambucca Heads

Interim Giant Barred Frog Monitoring Report – spring year three operational phase

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1. Introduction

In 2015, Roads and Maritime Services (RMS) NSW, in conjunction with Acciona Ferrovial Joint Venture (AFJV), commenced the upgrade of the Pacific Highway between Warrell Creek and Nambucca Heads (WC2NH). The WC2NH project was opened to traffic in two stages:

- Stage 2a - 13.5km section from Lower Warrell Creek Bridge to Nambucca Heads opened on 18 December 2017; and
- Stage 2b - 6.25km section from the southern end of the project to the Lower Warrell Creek bridge opened in late June 2018.

Approvals for the WC2NH upgrade required monitoring of several species and mitigation measures during the operational phase. Species and mitigation measures targeted include koala, yellow-bellied glider, giant barred frog, green-thighed frog ponds, fauna underpasses, vegetated median, road-kill, exclusion fence, and threatened flora. Sandpiper Ecological Surveys (SES) has been contracted by RMS to deliver the WC2NH operational ecological and water quality monitoring program in accordance with the Warrell Creek to Nambucca Heads Operational Ecological and Water Quality Monitoring Brief (the Brief).

The following report details the methods and results of the spring year three operational phase giant barred frog (*Mixophyes iteratus*) population monitoring. The objective of giant barred frog monitoring, as outlined in the Giant Barred Frog Management Strategy (GBFMS), is "to demonstrate through the life of the Project that mitigation has maintained or improved population sizes and habitat of the giant barred frog. The use of preconstruction, during construction and post construction monitoring to measure frog distribution, abundance and habitat quality with defined thresholds will be used to measure the overall performance of the mitigation" (Lewis 2014).

1.1 Background

The giant barred frog is listed as 'Endangered' under both the NSW *Biodiversity Conservation Act 2016* (BC Act) and Federal *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The impact of the upgrade on giant barred frog was assessed in the Project Environmental Assessment (Sinclair Knight Merz [SKM] 2010). Following identification of potential giant barred frog habitat during the Project environmental assessment, Lewis Ecological conducted targeted surveys (in November 2011 and January/February 2013) (Lewis 2014). A population of giant barred frog was subsequently confirmed at Upper Warrell Creek and a management strategy prepared (see Lewis 2014).

Measures proposed to manage impacts on giant barred frogs included: population monitoring, pre-clearing surveys, temporary frog fencing during construction, clearing supervision, dewatering procedures (tadpole surveys) and permanent frog exclusion fence. Population monitoring was recommended to occur within a 1km transect in spring, summer and autumn of Year 1 and 3 of the construction phase using the methods applied during pre-construction baseline surveys.

Pre-construction baseline surveys for giant barred frog were conducted between 20 September 2013 and 2 April 2014. The baseline surveys recorded 47 individuals, including 22 adults (11 females & 11 males), 8 sub-adults, and 8 juveniles. Based on these results the population of giant barred frog at the Upper Warrell Creek site was calculated as 45 adults (with a 1:1 sex ratio), 19 sub-adults, and 16 juveniles (Lewis Ecological 2014b). Geolink (2018) recalculated population size for baseline, year 1 and year 3 construction phase samples and obtained population estimates of 41 (2013/14), 7 (2015/16), and 8 (2017/18) respectively. The results suggest a substantial decline in population between 2013/14 and 2015/16.

During early construction work *Mixophyes* spp. tadpoles were recorded at Butchers Creek (Geolink 2015). There was some conjecture about the identification of tadpoles and targeted surveys for adult frogs and

further consultation with frog specialists was undertaken in an attempt to confirm the identification. The final consensus was that the tadpoles were great barred frog (*Mixophyes fasciolatus*) and the giant barred frog was unlikely to occur at Butchers Creek (see Geolink 2015; Lewis 2015). Nonetheless, a precautionary approach was adopted and the Butchers Creek site was included in population monitoring (Geolink 2016). No giant barred frogs were recorded at Butchers Creek during the construction phase (Geolink 2018).

1.2 Study area

The WC2NH project covers a total length of 19.75km and extends from Warrell Creek in the south to Nambucca Heads in the north (Figure 1). The alignment bypasses the town of Macksville and the northern section traverses Nambucca State Forest.

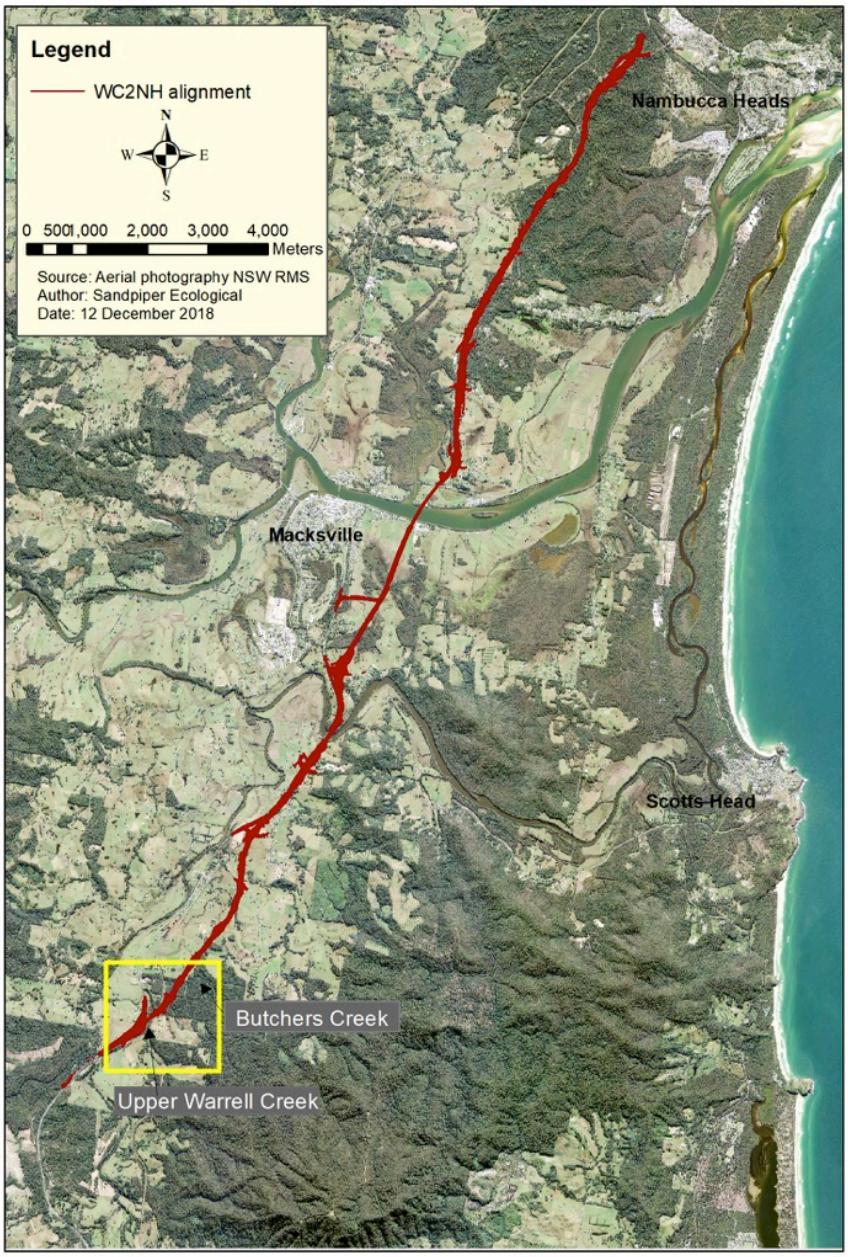

Figure 1: Location of giant barred frog sample sites in relation to the WC2NH alignment.

2. Methodology

2.1 Frog survey

Frog surveys followed the method specified in the Brief and baseline population survey (Lewis 2014). The method involved:

1. Two ecologists conducted a nocturnal meandering foot-based traverse of each 50m survey zone on each side of the watercourse i.e. 40 zones at Upper Warrell Creek (20/side; Figure 2); and 16 zones at Butchers Creek (8/side; Figure 2).
2. Each ecologist was equipped with a 200-lumen spotlight and slowly traversed the riparian zone searching for frogs and listening for calls. Giant barred frog calls were broadcast through a 5-watt megaphone for five minutes within each zone. Both ecologists listened for call responses during and immediately after call broadcast.
3. All captured giant barred frogs were scanned with a Trovan Nanotransponder to determine if that frog had been previously pit-tagged. If the captured individual had not been pit-tagged and was deemed an adult (i.e. >60mm snout-vent length) a tag was inserted beneath the skin on the right side and the insertion hole sealed with vetbond. The insertion point was swabbed with disinfectant prior to the tag being inserted.
4. Data collected on each captured frog included:
    a. Survey zone (20x50m).
    b. Distance from the stream edge measured to the nearest 0.1m.
    c. Position within the microhabitat (i.e. under litter, above litter, exposed, on rock/log).
    d. Sex (male, female, unknown).
    e. Age class (adult=>60mm; sub-adult=40-60mm; juvenile=<40mm).
    f. Snout-vent length (mm).
    g. Weight (grams).
    h. Breeding condition:
        i. males assessed on the colouration of their nuptial pads (i.e. no colour, light, moderate, dark) in accordance with the classification developed by Lewis (2014b);
        ii. females assessed on whether they are gravid (i.e. egg bearing, with the typically adult weighing > 100 grams) or not gravid.
        iii. frogs with a snout vent length of <60 mm were classified as immature.

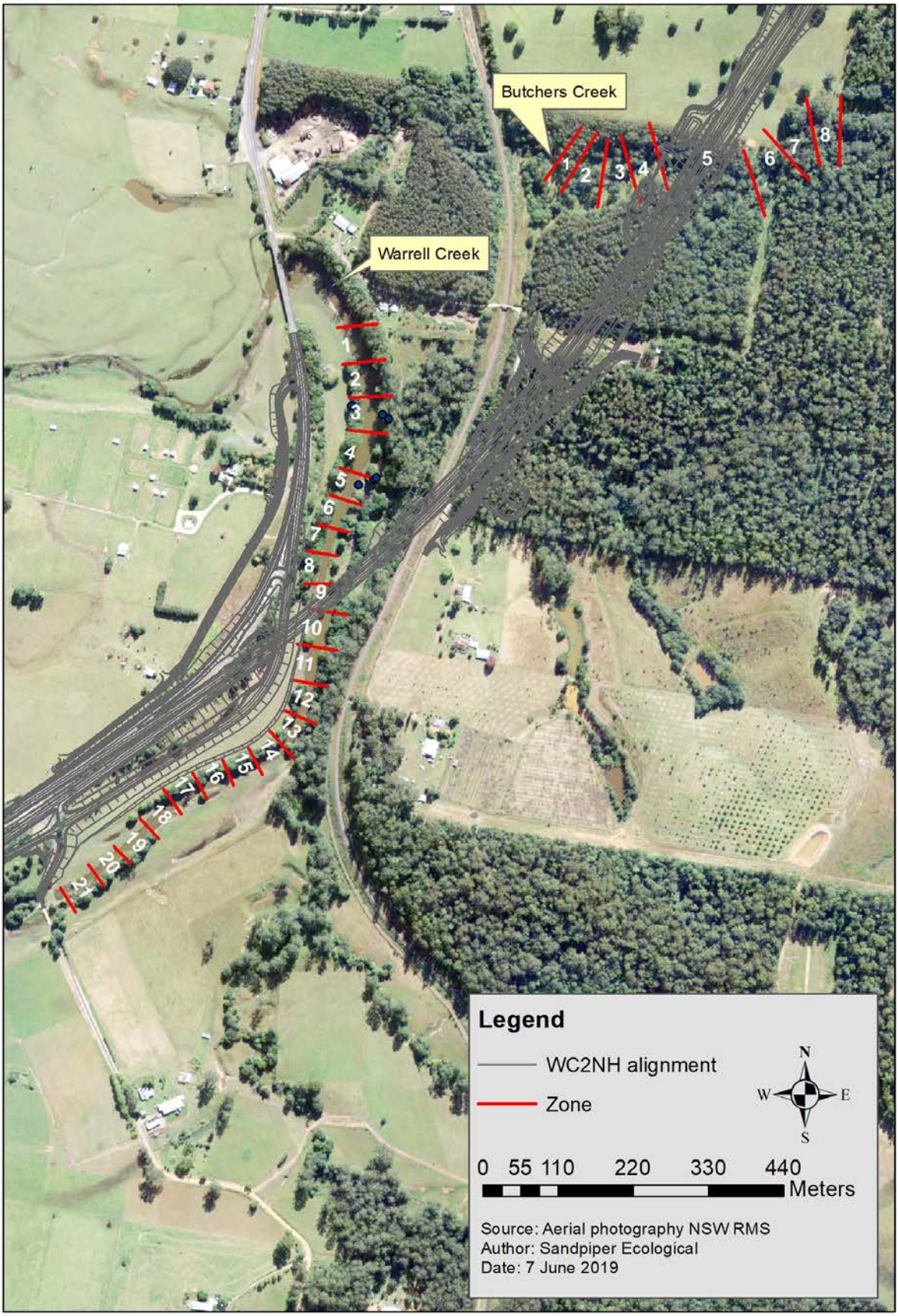

Figure 2: Survey zones within the Upper Warrell creek and Butchers Creek sample site.

2.2 Tadpole survey

Tadpole surveys were undertaken using the following procedure:

1. Dip-netting was undertaken by two ecologists within each survey zone. Dip-netting targeted areas of undercut bank and detritus.
2. One bait trap (~300 mm x 200 mm), baited with bread, was installed within each zone for 2½ -3 hours. This equated to 20 bait traps in Upper Warrell Creek and eight bait traps in Butchers Creek.
3. The following information was collected for each giant barred frog tadpole:
    a. Species
    b. Survey zone (20x50m).
    c. Sex (male, female, unknown).
    d. Weight (grams).

Tadpoles were identified with reference to Anstis (2001, 2017).

2.3 Habitat assessment

Key habitat components in each survey zone are required to be sampled annually (i.e. once/year). Habitat sampling was conducted during the summer sample period. A senior ecologist conducted a meandering traverse of each zone at each site, including both banks. Habitat data recorded in each zone at each site included:

1. Land use: Description of existing land uses e.g. grazing, dairy, horticulture, conservation, private native forestry.
2. Broad vegetation type within the immediate riparian zone (primary stream bank): Riparian Rainforest, Dry Sclerophyll, Wet Sclerophyll, Sedgeland, Grassland or Cleared Land.
3. In stream physical characteristics including stream width and depth(metres), presence of pools and/or riffles, bed composition (sand, clay, rock, organic or other to be specified), and type of emergent vegetation, if present.
4. Stream bank characteristics including bank profile expressed as steep, benched or a gradual incline from the water's edge.
5. Foliage projective cover of overstorey, midstorey and ground layer vegetation on the stream bank.
6. Groundcover expressed as a percentage of vegetation, leaf litter, soil, and exposed rock.
7. Litter depth - Deep (>10 mm); Moderate (20-100 mm); Shallow (>0-20 mm); or Absent (0 mm).

2.4 Water quality

Water samples and field measurements were taken at approximate locations E: 489301 N: 6594447 at Upper Warrell Creek and E: 489642 N: 6594927 at Butchers Creek. Three samples were collected at each site and placed immediately into an esky. One sample was sealed immediately after collection for dissolved oxygen analysis and the other samples were used for hydrocarbons, and general physicochemical parameters (see below). Samples were analysed by the Environmental Analysis Laboratory (EAL), a NATA accredited laboratory, at Southern Cross University. Water quality parameters measured included:

1. Heavy Metals including arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc.
2. Nutrients including Nitrogen (as N), Suspended Solids and Total Phosphorus.
3. Turbidity and dissolved oxygen.

4. Hydrocarbons from the following groups:
    a. Naphthalene group including TRH>C10-C16, TRH>C10-C16 less Naphthalene (F2), TRH>C16-C34, TRH>34-C40, TRH C6-C10 and TRH C6-C10 LESS BTEX (F1).
    b. BTEX group including Benzene, Ethylbenzene, m&p-Xylenes, o-Xylene, Toluene and Xylenes – total.

Field physicochemical measurements including Conductivity, pH, and Temperature, were measured using a Horiba Laqua PC110 portable water quality meter.

3. Results and discussion

3.1 Survey timing, weather conditions and effort

The spring 2020 giant barred frog survey was conducted on 27 and 28 October 2020. Weather conditions were suitable for giant barred frog surveys. Air temperature was between 21 and 23^{0}C with high relative humidity (85-88%) and nil to light wind (Table 1). Rain occurred during the survey on 28/10/20 with up to 57mm recorded in the seven days preceding the surveys. Brief periods of heavy rain on 28/10/20 hampered sampling and may have affected frog activity. A total of 17 person hours were spent conducting nocturnal frog surveys, 12 hours at Upper Warrell Creek and 5 hours at Butchers Creek.

Table 1: Weather conditions and survey effort recorded during the spring 2020 giant barred frog survey. PH = person hours; Wind categories = 0 - no wind, 1 - rustles leaves, 2 - branches moving, 3 - canopy moving

Site	Date	Start/Finish	Observers	PH	Rainfall (present)	Rainfall (prev 24hr)	Rainfall (prev 7 days)	Rainfall (prev 30 days)	RH	Temp	Dew point	Wind
Butchers Creek	27/10/20	2000/2230	BT/NM	5hr	Nil	0	22	28	85	22.9	21.1	0
	28/10/20	2145-2200	DR/LA/NM/BT	1hr	Present	35	57	63	88	21.7	20.9	2
Warrell Creek	27/10/20	2000-2230	DR/LA	5hr	Nil	0	22	28	85	22.9	21.1	0
	28/10/20	1940-2130	DR/LA/NM/BT	7.33	Present	35	57	63	88	21.7	20.9	2

3.2 Frog survey

No giant barred frogs were recorded at Butchers Creek. Three adult giant barred frogs, two male and one female, were recorded at Upper Warrell Creek (Table 2). All individuals were recaptures. Frog 1 was recaptured on 27/10/20 in Zone 6 where it initially responded to playback (Plate 1). The individual was recorded calling from dense leaf litter close to the waters edge on a well vegetated lateral bar. Frog 1 was originally captured and micro-chipped on 6 November 2017 and has been recaptured on three occasions, including spring 2020. All captures of Frog 1 have occurred in Zone 5, with the first capture on the south bank and subsequent captures on the north bank (Figure 3).

Frog 2, an adult female, was recaptured on 27/10/20 in Zone 5. This individual was originally captured and micro-chipped on 5 February 2018 and has been recaptured on three occasions, including spring 2020. All captures have occurred in Zone 5, or on the boundary between 4 and 5 (Figure 3). Both Frogs 1 and 2 are associated with a vegetated lateral deposit that includes a sheltered back channel suitable for breeding.

Table 2: Giant barred frogs captured during the spring 2020 survey at Upper Warrell Creek.

Variable	Frog 1	Frog 2	Frog 3
Capture date	27/10/20	27/10/20	28/10/20
Zone	6	6	20
Creek side	Mid (on island)	North	North
GPS location	489323.6594415	489352.6594444	490654,6597518
Distance from stream edge (nearest 0.1m)	1.2	4	5
Position in micro-habitat*	Beneath ferns, dense leaf litter	On leaf litter - exposed	On leaf litter - exposed
Sex**	M	F	M
Age***	Adult	Adult	Adult
S/V length	83.7	98.7	75.3
Weight	85	141	58
Breeding condition[#]	Moderate	Gravid	Moderate
Microchip ID (new or re-capture)	Re-capture- 00077E8FEF	Re-capture- 00078Abbf2	Re-capture - 991001000620121
Original capture & recapture details	1. 6/11/17; 69gr; 72mm SV 2. 26/2/19; 85gr; 83.8mm SV 3. 20/3/19; 85gr; 81.8mm SV	1. 5/2/18; 152gr; 100mm SV 2. 26/2/19; 141gr; 101.5mm SV 3. 20/3/19; 165gr; 99.5mm SV	1. 19/3/19; 53gr; 75.9mm SV
Capture locations	1. 489302; 6594439 2. 489322, 6594426 3. 489320, 6594428	1. 489327, 6594425 2. 489354, 6594451 3. 489342, 6594424	1. 489323, 6594584

*Microhabitat: under leaf litter, under veg, on leaf litter, exposed, on a log/rock etc.
**Sex: Frogs >78mm were deemed female unless heard calling.
***Age: >60mm = adult, 40-60mm = sub, <40mm = Juv.
[#]Breeding: Males: colour of nuptial pads; light/moderate/dark/no colour. Females: Gravid, typically weighing >100g. Immature: SV length <60mm.

Frog 3, an adult male, was recaptured in Zone 20 on 28/10/20. It was originally captured on 19 March 2019 on the south bank of Zone 3 and has moved 880m upstream and crossed to the north bank where it was recorded in a narrow, degraded area of riparian vegetation with sparse leaf litter. The area is grazed by cattle and lacks good refuge habitat (Figure 3). This represents the first confirmed movement of giant barred frog across the WC2NH alignment.

3.2.1 Frog population

The three frogs recorded in spring 2020 compares favourably with spring 2018 when two individuals were recorded. However, all individuals were recaptures. Whilst it is too early in the year 3 monitoring program to draw conclusions on population size, the absence of new captures is concerning.

Figure 3: Location of frogs captured during the spring 2020 giant barred frog survey and all previous capture locations for these individuals at Upper Warrell Creek.

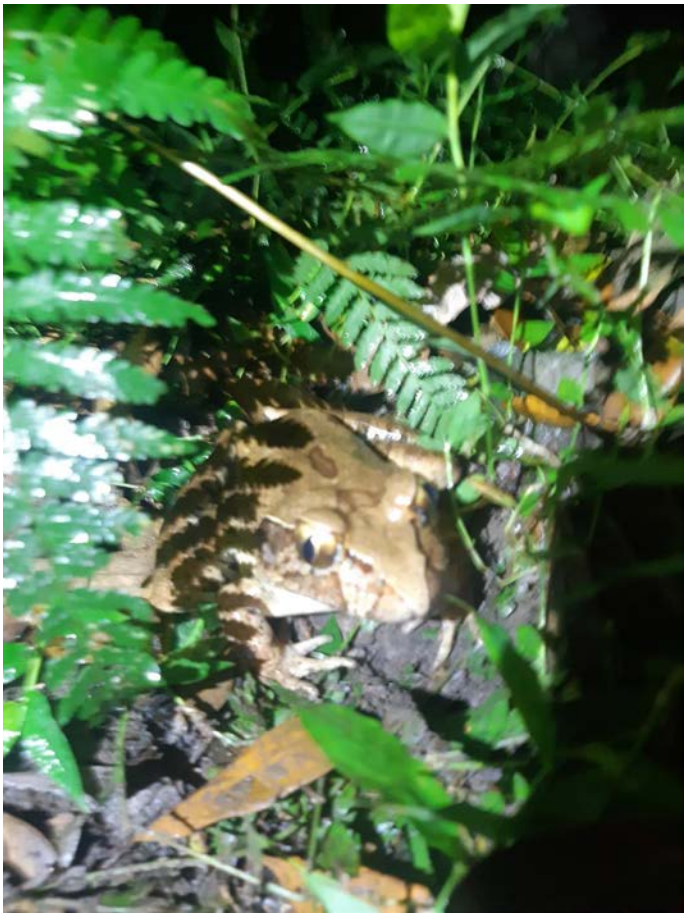

Plate 1: Male (PIT # 00077E8FEF**)** giant barred frog recorded at Upper Warrell Creek during the spring 2020 survey.

3.3 Tadpole survey

No giant barred frog tadpoles were recorded during the spring 2020 survey. At Butchers Creek, 32 great barred frog (*M. fasciolatus*) tadpoles were captured, 22 in bait traps, 17 in Zone 8, and five in Zone 7, and 10 in Zone 3 during dip netting (Plates 2&3). All tadpoles were between development stages 35 to 41 and would have hatched from eggs laid the previous autumn.

Plate 2: Great barred frog tadpoles recorded at Butchers Creek during the spring 2020 survey.

Plate 3: Remnant pool on edge of Zone 8 at Butchers Creek. This pool contained large numbers of well developed (stage 35-41) great barred frog tadpoles and was one of three water bodies within the Butchers Creek sample area during the spring 2020 survey.

3.4 Habitat

3.4.1 Upper Warrell creek

Habitat at Upper Warrell Creek ranged from grassland to moderate quality riparian and wet sclerophyll forest with a dense litter layer (Appendix A). Parts of the Upper Warrell Creek study area contained fragmented riparian forest that is grazed, whilst the remainder consists of a narrow riparian strip bordered by agricultural land. The width of riparian vegetation varied throughout the site but in virtually all zones was restricted to the bank and did not exceed 30m wide. Leaf litter cover ranged from high (>75%) in areas with an intact riparian zone to low (<40%) in cleared and grazed areas. Creek bank topography varies throughout the transect, with a steep bank on both sides downstream of the alignment (i.e. Zones 1-6), and on the north bank upstream of the alignment (zones 11-13), a flatter bank profile occurs on the north bank near the alignment (Zones 7-11), and upstream, Zones 14-18.

One notable aspect of concern was growth of pigeon grass (S*etaria sphacelata*) and broad-leaved paspalum (*Paspalum mandiocanum*) on the north bank in zones 5, 7 and 8. Pigeon grass also dominated the south bank of zones 10, 11, 19, 20 & 21. Whilst giant barred frogs have been recorded in broad-leaved paspalum (Sandpiper Ecological 2019a), dense grass represents a barrier to movement. Geolink (2015, 2018) recorded paspalum and/or pigeon grass in zones 7, 8 and 10, and images presented by Geolink

(2018) show pigeon grass in zones 8 and 10. Based on available information, it seems likely that pigeon grass was present at commencement of construction. It is likely that grazing by stock kept grass under control and the exclusion of stock, particularly on the south bank, has contributed to excess grass growth. Dense grass presently represents a barrier to movement and whilst TfNSW has implemented some work (i.e. slashing & some planting) to reduce grass density in Zones 7 and 8 more intensive work is required.

Review of old aerial photographs from 2010 and 2013 shows a narrow main channel and small back channel with lateral bar (south bank) within and adjoining the alignment (Figure 4). Enlargement of the section within the alignment suggests that the narrow section of creek was linked to the existing back channel situated on the north bank. The extent of riparian habitat is difficult to determine, although the section within the alignment seems to contain fragmented riparian vegetation. Combined, these habitat features likely represented important breeding habitat within the 1km sample area. Further assessment of pre-construction creek morphology will be undertaken for the annual year 3 report.

3.4.2 Butchers Creek

Habitat at Butchers Creek varied substantially between zones. The west side of the alignment was characterised by a narrow degraded riparian zone that was predominantly cleared immediately prior to the spring 2018 survey. In spring 2020, previously cleared areas were dominated by pigeon grass with some regrowth lantana (*Lantana camara*) and small-leaved privet (*Ligustrum sinense*). East of the alignment habitat was characterised by wet sclerophyll forest that extended well beyond the riparian zone. The substrate consisted of rock and gravel with a steep bank and gravel bars. Leaf litter cover varied from 25 to 80% and ground vegetation cover from 10 to 60%. Water was restricted to three small pools.

Habitat at Butchers Creek does not contain the moist micro-climate that is typical of many giant barred frog habitats. The site lacks continuous overhanging riparian vegetation and the thick dense leaf litter and ground vegetation required to create moist ground conditions and in addition the creek is highly ephemeral. Based on surveys in 2018/19 and spring 2020 we conclude that Butchers Creek is unsuitable for giant barred frog. This conclusion is supported by the absence of confirmed records despite regular surveys since 2011 (Lewis 2014; Geolink 2015, 2018; Sandpiper Ecological 2019b). Lewis (2014) surveyed Butchers Creek on two occasions in summer 2011 and on three occasions in spring 2013. No giant barred frogs were recorded during these surveys and Butchers Creek was not included in the WC2NH Giant Barred Frog Management Strategy (Lewis 2014).

During construction, *Mixophyes* tadpoles were captured in Butchers Creek and identified as giant barred frog (Geolink 2015). Subsequently, Lewis (2015) conducted additional nocturnal frog and diurnal tadpole surveys. No giant barred frogs were recorded during these surveys, however, adult and juvenile tadpoles of the great barred frog (*M. fasciolatus*) were recorded. Two tadpoles were retained and grown-out and these were identified as great barred frog. Despite evidence to the contrary, TfNSW adopted a precautionary approach and included Butchers Creek in the Giant barred frog monitoring program. Subsequent population monitoring surveys in 2016, 2017, 2018, 2019 and 2020 (Geolink 2016, 2018; Sandpiper Ecological 2019, this study) have not detected giant barred frog. The overwhelming evidence suggests that Butchers Creek does not support giant barred frog.

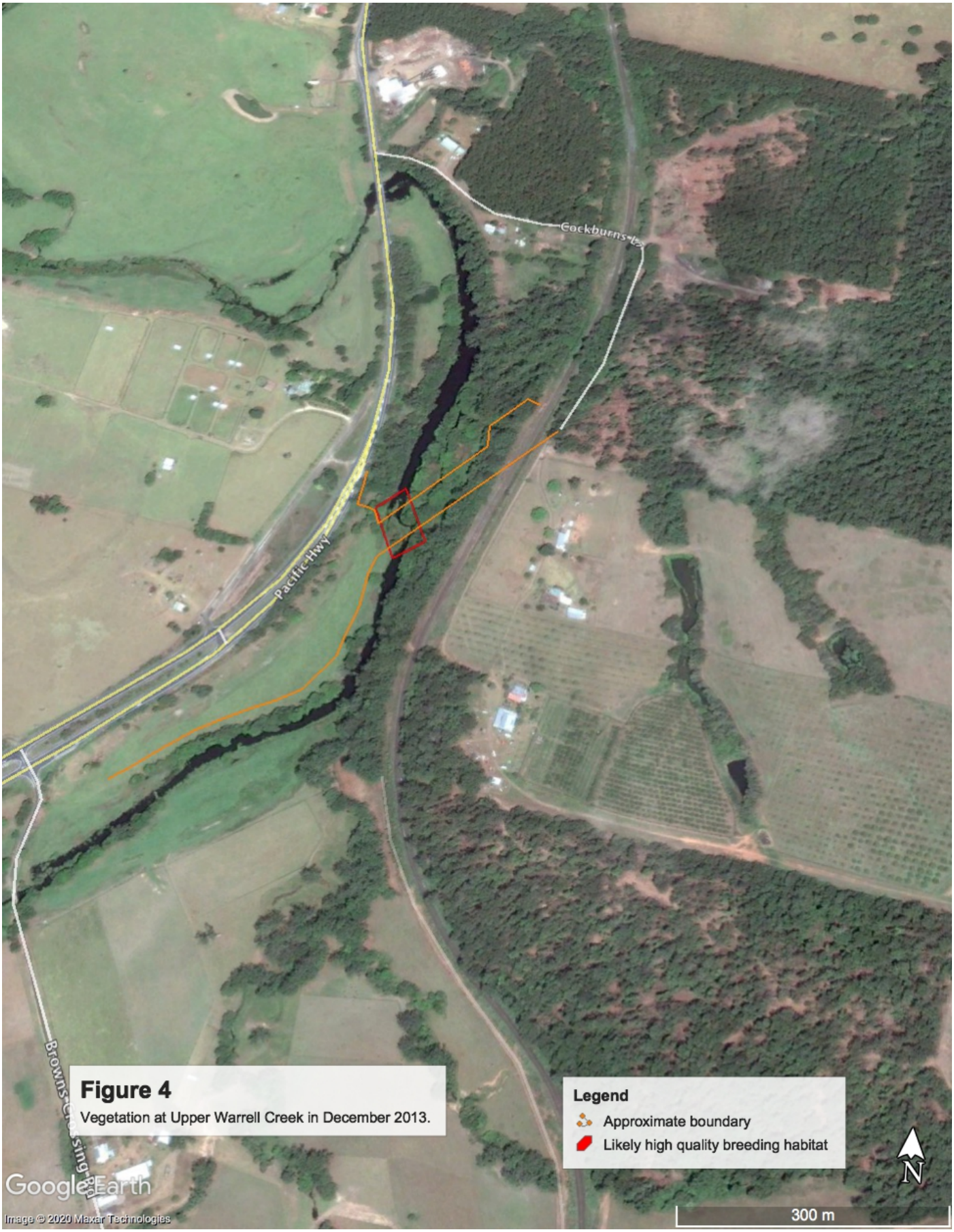

Figure 4: Aerial photograph of the Warrell Creek site from 1 December 2013 with approximate highway boundary and area of important giant barred frog habitat.

3.5 Water quality

Most water quality parameters were within the ANZECC trigger values for freshwater ecosystems in south eastern Australia (Table 2). Exceptions were Total phosphorus and Total nitrogen, which exceeded the ANZECC thresholds for freshwater ecosystems at both sites, and dissolved oxygen, which was substantially lower than the ANZECC trigger value at both sites. Results at Butchers Creek are likely skewed by the absence of stream flow and need to sample in one small stagnant pool. Findings are broadly consistent with the spring 2018 and spring/summer/autumn 2017/18 results (Geolink 2018; Sandpiper Ecological 2018). Elevated nutrients recorded in spring 2020 are attributed to recent run-off from adjoining farmland at Warrell Creek and absence of stream flow at Butchers Creek. The nature of water quality sampling, that is, one-off samples months or years apart, is unlikely to provide data representative of water quality at either site.

Table 3: Results of water sample analysis for Upper Warrell creek and Butchers Creek. ID = insufficient data to derive a reliable trigger value (ANZECC 2000); NS – parameter not sampled.

Parameter	Warrell Creek	Butchers Creek	ANZECC/ARMCANZ Trigger value for freshwater (95% species level of protection)
Temperature (^{0}C)	24.6	19.7	
pH	7.07	6.2	6.5-8.0
Conductivity (us/cm)	0.396	0.212	125-2200
Dissolved oxygen (mg/L O_2)	NS	0.54	9-10.5
Total Suspended Solids (mg/L)	4	4	
Turbidity (NTU)	0.258	0.138	6-50
Total Phosphorus (mg/L P)	0.03	0.03	0.025
Total Nitrogen (mg/L N)	0.37	0.43	0.35
BTEX			
Benzene (µg/L or ppb)	<0.5	<0.5	950
Toluene (µg/L or ppb)	<0.5	<0.5	ID
Ethylbenzene (µg/L or ppb)	<0.5	<0.5	ID
m+p-Xylene (µg/L or ppb)	<1	<1	200
o-Xylene (µg/L or ppb)	<0.5	<0.5	350
Naphthalene (µg/L or ppb)	<0.5	<0.5	16
Total Recoverable Hydrocarbons (TRH)			
C6-C9 Fraction (µg/L or ppb)	NS	NS	ID
C10-C14 Fraction (µg/L or ppb)	<50	<50	ID
C15-C28 Fraction (µg/L or ppb)	<100	<100	ID
C29-C36 Fraction (µg/L or ppb)	<50	<50	ID
C10-C16 Fraction (µg/L or ppb)	<60	<60	ID
C10-C16 less Naphthalene Fraction (µg/L or ppb)	NS	NS	ID
C16-C34 Fraction (µg/L or ppb)	<200	<200	ID
C34-C40 Fraction (µg/L or ppb)	<100	<100	ID
Sum C10-C36 Fraction (µg/L or ppb)	<100	<100	ID
Heavy Metals			
Silver (mg/L)	<0.001	<0.001	0.05
Aluminium (mg/L)	0.099	0.012	55
Arsenic (mg/L)	0.001	<0.001	24
Cadmium (mg/L)	<0.001	<0.001	0.2
Chromium (mg/L)	<0.001	<0.001	1.0
Copper (mg/L)	<0.001	<0.001	1.4

Parameter	Warrell Creek	Butchers Creek	ANZECC/ARMCANZ Trigger value for freshwater (95% species level of protection)
Iron (mg/L)	0.802	0.030	ID
Manganese (mg/L)	0.190	0.009	1900
Nickel (mg/L)	0.001	<0.001	11
Lead (mg/L)	<0.001	<0.001	3.4
Selenium (mg/L)	<0.002	<0.002	11
Zinc (mg/L)	0.003	0.010	8
Mercury (mg/L)	<0.0005	<0.0005	0.6

4. Recommendations

Recommendations are presented in Table 4.

Table 4: Recommendations based on findings of the spring year 3 operational phase giant barred frog monitoring program.

Number	Recommendation	Transport for NSW Response
1.	Continue river bank restoration on the north bank of Zones 7, 8 & 9 at Upper Warrell Creek. Additional planting and maintenance of *Waterhousia floribunda* and understorey shrubs, and control of grass is required to improve connectivity.	The following works are to be undertaken by the WC2NH contractor in zones 7, 8 and 9 - - Works to reduce Pigeon Grass *(Setaria species)* extent and density - Planting of 60 *Waterhousia floribunda* - Plant out wetland plant tubestock to bolster the now established wetland plantings in the area. This scope of works has been developed in consultation with and is endorsed by the EPA. The works are expected to commence in late 2020
2.	Due to the pattern of population decline at UWC detected in construction and operational surveys additional survey effort is recommended at that site for the remaining summer and autumn year 3 operational phase surveys. Further assessment, in accordance with Performance Criteria in the Giant Barred Frog Management Strategy, would be undertaken following population analysis conducted in the annual report, which is due in autumn 2021.	Agree and adopted

5. References

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Appendix A – Habitat data

Table A1: Habitat data collected in 21 zones at Upper Warrell Creek in spring 2020.

Zone	Bank	Landuse (E&W)	Broad veg community (E&W)	In-stream physical characteristics (logs, boulders etc)	Stream width	Stream depth	Presence of pools or riffles	Bed composition	Emergent veg
1	N	Agriculture	Riparian	Rare snags & logs, knotweed & matrush at waters edge, water lily	20-25	1-2m	No	Unknown	Water lily
	S	Agriculture	Riparian	Rare snags & logs, knotweed & matrush at waters edge, water lily	20-25	1-2m	No	Unknown	Water lily
2	N	Agriculture	Riparian	Rare snags & logs, knotweed & matrush at waters edge, water lily	20-25	1-2m	No	Unknown	Water lily
	S	Agriculture	Riparian	Rare snags & logs, knotweed & matrush at waters edge, water lily	20-25	1-2m	No	Unknown	Water lily
3	N	Agriculture	Riparian	Rare snags & logs, knotweed & matrush at waters edge, water lily	20-25	1-2m	No	Unknown	Water lily
	S	Agriculture	Riparian	Rare snags & logs, knotweed & matrush at waters edge, water lily	20-25	1-2m	No	Unknown	Water lily
4	N	Agriculture	Riparian	Tall (Tassal) sedge & knotweed dominate waters edge, water lily	20-25	1-2m	No	Unknown	Water lily
	S	Agriculture	Riparian	Rare snags & logs, knotweed & matrush at waters edge, water lily	20-25	1-2m	No	Unknown	Water lily
5	N	Agriculture	Riparian	Snags, matrush at waters edge, water lily, undercut bank	20	1-2m	No	Unknown	Water lily, occ
	S	Agriculture	Riparian	Snags, matrush at waters edge, water lily, undercut bank	20	1-2m	No	Unknown	Water lily, occ
6	N	Road reserve	Riparian	Logs, snags, water lily, matrush at waters edge	15	1-2m	No	Unknown	Water lily
	S	Agriculture	Riparian	Logs, snags, water lily, matrush at waters edge	15	1-2m	No	Unknown	Water lily
7	N	Road reserve	Riparian	Mostly knot weed & pigeon grass	15	1-2m	No	Unknown	Water lily, knot weed
	S	Agriculture	Riparian	Logs, snags, water lily, matrush at waters edge	15	1-2m	No	Unknown	Water lily
8	N	Road reserve	Grassland	Boulders, logs, waterlily, Juncus, Schoenoplectus (triangle)	8	1m	Yes	Silt& gravel	Water lily, water primrose
	S	Road reserve	Grassland/ riparian	Boulders, logs, waterlily, Juncus, Schoenoplectus (triangle)	8	1m	Yes	Silt& gravel	Water lily, water primrose
9	N	Road reserve	Riparian/cleared	Boulders, logs, waterlily, Juncus, Schoenoplectus (triangle)	8	1m	Yes	Silt& gravel	Water lily, water primrose
	S	Road reserve	Grassland/ riparian	Boulders, logs, waterlily, Juncus, Schoenoplectus (triangle)	8	1m	Yes	Silt& gravel	Water lily, water primrose
10	N	Agriculture	Riparian	Occ logs & snags	15	1-2m	Yes	Unknown	Water lily, water primrose
	S	Road reserve	Grassland	Occ logs & snags	15	1-2m	Yes	Unknown	Water lily, water primrose

11	N	Agriculture	Riparian	Snags, logs, aquatic veg	12	1-2m	No	Unknown	Water lily
	S	Road reserve	Grassland	Snags, logs, aquatic veg	12	1-2m	No	Unknown	Water lily
12	E	Agriculture	Riparian	Occ logs, water lily, snags	15	1-2m	No	Unknown	Water lily
	W	Road reserve	Riparian	Occ logs, water lily, snags	15	1-2m	No	Unknown	Water lily
13	E	Agriculture	Riparian	Occ logs, water lily, snags	13	1-2m	No	Unknown	Water lily
	W	Road reserve	Riparian	Occ logs, water lily, snags	13	1-2m	No	Unknown	Water lily
14	E	Agriculture	Grassland	Occ logs, water lily (cape sis & indica), elodea	13	1m	No	Unknown	Water lily
	W	Road reserve	Riparian	Occ logs, water lily (cape sis & indica), elodea	13	1m	No	Unknown	Water lily
15	E	Agriculture	Grassland	Occ logs, clumps of matrush, water lily, knot weed	11	Unknown	No	Unknown	Water lily
	W	Road reserve	Riparian	Occ logs, clumps of matrush, water lily	11	Unknown	No	Unknown	Water lily
16	E	Agriculture	Grassland	Occ logs, clumps of matrush, water lily, knot weed	11	Unknown	No	Unknown	Water lily
	W	Road reserve	Riparian	Occ logs, clumps of matrush, water lily	11	Unknown	No	Unknown	Water lily
17	E	Agriculture	Grassland	Occ logs, clumps of matrush, water lily	11	Unknown	No	Unknown	Water lily
	W	Road reserve	Riparian	Occ logs, clumps of matrush, water lily	11	Unknown	No	Unknown	Water lily
18	E	Agriculture	Riparian	Occ logs; grass to water level	5	Unknown	No	Unknown	Water lily
	W	Road reserve	Riparian	Occ logs; grass to water level	5	Unknown	No	Unknown	Water lily
19	E	Agriculture	Riparian	Occ logs; grass to water level	9	Unknown	No	Unknown	Water lily
	W	Road reserve	Grassland	Occ logs; grass to water level	9	Unknown	No	Unknown	Water lily
20	E	Agriculture	Riparian	Occ logs; grass to water level	9	Unknown	No	Unknown	Water lily
	W	Road reserve	Grassland	Occ logs; grass to water level	9	Unknown	No	Unknown	Water lily
21	E	Agriculture	Riparian	Occ logs; grass to water level	9	Unknown	No	Unknown	Water lily
	W	Road reserve	Grassland	Occ logs; grass to water level	9	Unknown	No	Unknown	Water lily

Table A2: Habitat data collected in 21 zones at Upper Warrell creek in spring 2020.

Zone	Bank	Stream bank characteristics	Bank profile	Bank vegetation cover	Groundcover composition	Depth of leaf litter	Tadpoles (trap) weight, sex, location.	Tadpoles (dip net) weight, sex, location.
1	N	Intact riparian zone 25m, waterhousia, flooded gum, matrush at waters edge, lantana,	Steep 20m	65.0%	Matrush, lantana, shrubs	40-50mm	0	0
	S	Intact riparian zone 12m wide, waterhousia, flooded gum, camphor laurel, matrush at waters edge,	Undercuts, vertical 0.5m, steep 4m, moderate 5m	80%	Matrush, fishbone fern, vines	75-100mm	0	0
2	N	Intact riparian zone 25m, waterhousia, flooded gum, matrush at waters edge, lantana,	Steep 20m	65.0%	Matrush, lantana, shrubs	40-50mm	0	0
	S	Intact riparian zone 12m wide, waterhousia, flooded gum, camphor laurel, matrush at waters edge,	Undercuts, vertical 0.5m, steep 4m, moderate 5m	80%	Matrush, fishbone fern, vines	75-100mm	0	0
3	N	Intact riparian zone 25m, waterhousia, flooded gum, matrush at waters edge, lantana,	Steep 20m	65.0%	Matrush, Carex , BL paspalum	40-50mm	0	0
	S	Intact riparian zone 12m wide, waterhousia, flooded gum, camphor laurel, matrush at waters edge,	Undercuts, vertical 0.5m, steep 4m, moderate 5m	80%	Matrush, fishbone fern, vines	75-100mm	0	0
4	N	Immediate bank cleared - BL paspalum, pigeon grass, knot weed, tall (Tassal) sedge within 15m of bank, riparian on slope, waterhousia, flooded gum 40m, dense ground cover on immediate bank	Flat for 20m, Steve 40m	25%%	BL paspalum, pigeon grass, occ matrush	50mm	0	0
	S	Intact riparian zone 12m wide, waterhousia, flooded gum, camphor laurel, matrush at waters edge,	Undercuts, vertical 0.5m, steep 4m, moderate 5m	80%	Matrush, fishbone fern, vines	75-100mm	0	0
5	N	Riparian 40m incl side channel, waterhousia, matrush, BL paspalum, SL privet, dense shrub & ground layer	Vertical 2m, moderate 20m	60.0%	Matrush, BL paspalum, lantana	40mm	0	0
	S	Intact riparian zone 15m wide from water to top of bank, waterhousia, some lantana, matrush at waters edge	Vertical 0.5m, steep 13m	55	Matrush, shrubs, lantana,	100mm	0	0
6	N	Riparian 40m incl side channel, waterhousia, matrush, BL paspalum, SL privet, dense shrub & ground layer, contains back channel	Vertical 2m, moderate 20m	60.0%	Matrush, BL paspalum, lantana	40mm	0	0
	S	Established riparian zone 13m, waterhousia, good litter cover	Vertical 0.75m, steep 12m	70.0%	Leaf litter, matrush at waters edge, occ vines & low shrubs	30mm	0	0
7	N	80% pigeon grass & knot weed, 20% Established riparian zone 13m, waterhousia, good litter cover, contains back channel	Vertical 0.75m, steep 12m	80.0%	Leaf litter, matrush at waters edge, occ vines & low shrubs; dense pigeon grass & knot weed in cleared area	30mm	0	0
	S	Established riparian zone 13m, waterhousia, moderate litter cover	Vertical 0.75m, steep 12m	70.0%	Leaf litter, matrush at waters edge, occ vines & low shrubs	30mm	0	0
8	N	20% of bank Scour protection, immediate bank is flat, occ boulders, gravel, sedges, to waters edge, partial revegetation	Flat 20m	50.0%	Knotweed, Schoenoplectus, Juncus, Cyperus spp, Carex, matrush	<10mm	0	0
	S	20% Scour protection - now covered in knot weed, immediate bank is flat, occ boulders, gravel, sedges, to waters edge	Flat 20m	100%%	Knotweed, Schoenoplectus, Juncus, Cyperus spp, Carex	10mm	0	0
9	N	Scour protection, flat bank profile under bridge, 20m riparian zone, waterhousia, matrush at waters edge,	Flat beneath bridge, moderate 20m	55%	Matrush, low shrubs	50mm	0	0
	S	Scour protection, immediate bank is flat, occ boulders, gravel, sedges, to waters edge	Flat 20m	35.0%	Knotweed, Schoenoplectus, Juncus, Cyperus spp, Carex	<10mm	0	0
10	N	Established riparian zone 25m, waterhousia, flooded gum,	Vertical 1m, moderate	80.0%	Matrush, BL paspalum, shrubs	40mm	0	0

		matrush at waters edge, established mid storey	15m, steep 10m					
	S	Scour protection (under bridge), knot weed, pigeon grass, occ waterhousia	Vertical 1.5m, mod slope 3m	90.0%	Knot weed, pigeon grass, BL paspalum	20mm	0	0
11	N	Established riparian zone 25m, waterhousia, flooded gum, matrush at waters edge, established mid storey	Vertical 1m, moderate 15m, steep 10m	80.0%	Matrush, BL paspalum, shrubs	40mm	0	0
	S	Cleared grassland, pigeon grass, knotweed to waters edge, sparse mucronatus.	Flat 3m, vertical 1m	95.0%	Pigeon grass, knot weed	20mm	0	0
12	E	Established riparian zone 25m, waterhousia, flooded gum, matrush at waters edge, established mid storey	Vertical 1m, moderate 15m, steep 10m	80.0%	Matrush, BL paspalum, shrubs	50mm	0	0
	W	Fragmented riparian/grassland, waterhousia, pigeon grass, knotweed & matrush at waters edge	Vertical 1m, steep 2.5m	50%	Pigeon grass, matrush, knotweed to waters edge	50mm	0	0
13	E	Established riparian zone 35m, waterhousia, flooded gum, matrush at waters edge, established mid storey	Vertical 1m, moderate 15m, steep 10m	80.0%	Matrush, BL paspalum, shrubs	50	0	0
	W	Riparian 7m wide, waterhousia, wattles, matrush & knot weed on bank, fallen logs, woody debris	Vertical 1m, steep 2m	75%	Knotweed, matrush, basket grass, BL paspalum	75mm	0	0
14	E	Cleared grassland, knotweed to water level	Steep 0.5m	60.0%	Knotweed	Nil	0	0
	W	Riparian 7m wide, waterhousia, wattles, matrush & knot weed on bank, fallen logs, woody debris	Vertical 1m, steep 2m	75%	Knotweed, matrush, basket grass, BL paspalum	75mm	0	0
15	E	Cleared grassland, knotweed to water level	Vertical 1m	55.0%	Pasture grass, knot weed	Nil	0	0
	W	Riparian, waterhousia, camphor, matrush at water level (clumps)	Vertical 1m, moderate 2.5m	70.0%	Matrush, BL paspalum	75mm	0	0
16	E	Cleared grassland, knotweed to water level	Vertical 1m	55.0%	Pasture grass, knot weed	Nil	0	0
	W	Riparian, waterhousia, matrush at water level	Steep 4m	75.0%	Matrush, BL paspalum, lantana	50	0	0
17	E	Cleared, grassland	Vertical 1m	60.0%	Pasture grass, knot weed	Nil	0	0
	W	8m riparian zone, waterhousia	Steep 4m	65.0%	Matrush, low shrubs	50mm	0	0
18	E	Fragmented, grazed, half cleared, waterhousia, camphor	Moderate slope 2m	40.0%	Knot weed, pigeon grass	10mm	0	0
	W	Fragmented riparian, waterhousia, camphor, pigeon grass & knot weed on immediate bank	Steep, with back channel	90%	Knot weed, pigeon grass	20mm	0	0
19	E	Fragmented riparian veg, waterhousia, flooded gum, grazed, cleared u/S	Sloping, moderate	70%	Sparse matrush, BL paspalum	10mm	0	0
	W	Cleared grassland, dense pigeon grass	Steep, with back channel	90.0%	Pigeon grass	10mm	0	0
20	E	Fragmented riparian veg, waterhousia, flooded gum, grazed, cleared u/S	Sloping, moderate	70%	Sparse matrush, BL paspalum	10mm	0	0
	W	Cleared grassland, dense pigeon grass	Steep, back channel	90.0%	Pigeon grass	10mm	0	0
21	E	Fragmented riparian veg, waterhousia, grazed, cleared u/S	Sloping, moderate	70%	Sparse matrush, BL paspalum	10mm	0	0
	W	Cleared grassland, dense pigeon grass	Steep, back channel	90.0%	Pigeon grass	10mm	0	0

Table A3: Habitat data collected within 8 zones at Butchers Creek in spring 2020.

Zone	Bank	Landuse (E&W)	Broad veg community (E&W)	In-stream physical characteristics (logs, boulders etc)	Stream width	Stream depth	Presence of pools or riffles	Bed composition	Emergent veg
1	N	Agriculture	Camphor forest	Pool/riffle with rocks	3	Nil	Nil	Rock 50%; litter 25%; veg 25%	Mat rush
	S	Agriculture	Shrubs and	Pool/riffle with rocks	3	Nil	Nil	Rock 50%; litter 25%; veg 25%	Mat rush
2	N	Agriculture	Grassland	Pool rifle with rocks, pigeon grass & privet in channel	3.5	Nil	Nil	Rock 20%; litter 30%; grass 50%	Grass
	S	Agriculture	Wet sclerophyll	Pool rifle with rocks	3.5	Nil	Nil	Rock 25%; litter 40%; grass 40%	Grass
3	N	Agriculture	Wet sclerophyll	Pool/riffle with rocks	3	0.5m	Nil	Rock 30%; litter 60%; silt 20%	Mat rush
	S	Agriculture	Disturbed grassland	Pool/riffle with rocks	3	0.5m	Nil	Rock 30%; litter 60%; silt 20%	Mat rush
4	N	Agriculture	Wet sclerophyll	Pool/riffle with rocks	4.5	Nil	Nil	Rock 70%; gravel 10%; silt 10%; organic 10%	Nil
	S	Agriculture	Disturbed grassland	Pool/riffle with rocks	4.5	Nil	Nil	Rock 70%; gravel 10%; silt 10%; organic 10%	Nil
5	N	Agriculture	Wet sclerophyll	Pool/ riffle with rocks	6	Nil	Nil	Rock 60%; litter 40%	Nil
	S	Agriculture	Wet sclerophyll	Pool/ riffle with rocks	6	Nil	Nil	Rock 60%; litter 40%	Nil
6	N	Conservation	Wet sclerophyll	Pool/ riffle with rocks	6	Nil	Nil	Rock 60%; litter 40%	Nil
	S	Conservation	Wet sclerophyll	Pool/ riffle with rocks	6	Nil	Nil	Rock 60%; litter 40%	Nil
7	N	Conservation	Wet sclerophyll	Pool/ riffle with rocks	5	0.7m	Nil	Rock 60%; litter 40%	Nil
	S	Conservation	Wet sclerophyll	Pool/ riffle with rocks	5	0.7m	Nil	Rock 60%; litter 40%	Nil
8	N	Agriculture	Wet sclerophyll	Pool/ riffle with rocks	6-7	0.3m	Nil	Rock 60%; litter 40%	Nil
	S	Conservation	Wet sclerophyll	Pool/ riffle with rocks	6-7	0.3m	Nil	Rock 60%; litter 40%	Nil

Table A4: Habitat data collected within 8 zones at Butchers Creek in spring 2020.

Zone	Bank	Stream bank characteristics	Bank profile	Bank vegetation cover	Groundcover composition	Depth of leaf litter	Tadpoles (trap) weight, sex, location.	Tadpoles (dip net) weight, sex, location.
1	N	Camphor, mat rush, lantana, privet, degraded	Vertical 1.25m	60.0%	Mat rush, Carex, lantana, pigeon grass	25mm		
	S	Mat rush, Lilly pilly, privet, Brown kurrajong degraded	Steep slope 2m	60.0%	Mat rush, BL paspalum, regrowth shrubs, pigeon grass	<10mm		
2	N	No o/S, grass & lantana	Vertical 1m	90%%	Pigeon grass, lantana	20mm		
	S	2m wide, camphor, flooded gum, red ash, degraded	Vertical 2m	60.0%	Mat rush, lantana, BL paspalum, pigeon grass	20mm		
3	N	3m wide, camphor, lantana, privet, highly degraded	Vertical 1.5m	60.0%	Gahnia, mat rush, ferns, BL paspalum, pigeon grass	50mm	Nil	10 M fasciolatus
	S	2m wide riparian zone, catacomb, lantana, degraded	Vertical 1.5m	60%	Matrush, gahnia, lantana, ferns, pigeon grass	25mm		
4	N	5m wide riparian zone, clumps of lomandra & gahnia, degraded	Vertical 2m	75%	Gahnia, mat rush, ferns, BL paspalum	50mm		
	S	2m wide riparian zone, Callicoma, lantana, degraded	Vertical 2m	10.0%	BL paspalum, pigeon grass	25mm		
5	N	Rocky substrate, dense cover of lantana, matrush, BL paspalum	Sloping - steep	75.0%	Matrush, lantana, BL paspalum	30-50mm	Evidence of clearing since initial survey	
	S	Intact riparian zone, water vine, lantana, flooded gum, camphor laurel	Steep	80.0%	Matrush, lantana, BL paspalum	50-100mm		
6	N	5-10m riparian, flooded gum, camphor laurel, dense midstorey	Steep	75	Occasional matrush & ferns	30-50mm		
	S	20m + riparian, various midstorey rainforest species	Moderate slope	80	Occasional matrush & ferns	30-50mm		
7	N	5-10m riparian, flooded gum, camphor laurel, dense midstorey	Steep slope	80.0%	Very sparse, low shrubs	50-75mm		
	S	20m + riparian, various midstorey rainforest species	Steep slope	80%	Very sparse, low shrubs, matrush	50-75	5 M fasciolatus	No dip netting
8	N	5-10m riparian, flooded gum, blackbutt, camphor laurel, dense midstorey	Vertical- 7m	70%	Very sparse, low shrubs	<20mm		
	S	20m + riparian, various midstorey rainforest species laurel	Variable	80%	Matrush, lantana, BL paspalum, saw-sedge	30-50mm	17 M. fasciolatus	No dip netting

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December 2020

Transport
Roads & Maritime
Services

Warrell Creek to Nambucca Heads: interim giant barred frog monitoring report - summer year three operational phase

Transport for New South Wales | March 2021 | Final report

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1. Introduction

In 2015, Transport for New South Wales, in conjunction with Acciona Ferrovial Joint Venture (AFJV), commenced the upgrade of the Pacific Highway between Warrell Creek and Nambucca Heads (WC2NH). The WC2NH project was opened to traffic in two stages:

- Stage 2a - 13.5km section from Lower Warrell Creek Bridge to Nambucca Heads opened on 18 December 2017; and
- Stage 2b - 6.25km section from the southern end of the project to the Lower Warrell Creek bridge opened in late June 2018.

Approvals for the WC2NH upgrade required monitoring of several species and mitigation measures during the operational phase. Species and mitigation measures targeted include koala, yellow-bellied glider, giant barred frog, green-thighed frog ponds, fauna underpasses, vegetated median, road-kill, exclusion fence, and threatened flora. Sandpiper Ecological Surveys (SES) has been contracted by Transport for NSW to deliver the WC2NH operational ecological and water quality monitoring program in accordance with the Warrell Creek to Nambucca Heads Operational Ecological and Water Quality Monitoring Brief (the Brief).

The following report details the methods and results of the summer year three operational phase giant barred frog (*Mixophyes iteratus*) population monitoring. The objective of giant barred frog monitoring, as outlined in the Giant Barred Frog Management Strategy (GBFMS), is "to demonstrate through the life of the Project that mitigation has maintained or improved population sizes and habitat of the giant barred frog. The use of preconstruction, during construction and post construction monitoring to measure frog distribution, abundance and habitat quality with defined thresholds will be used to measure the overall performance of the mitigation" (Lewis 2014).

1.1 Background

The giant barred frog is listed as 'Endangered' under both the NSW *Biodiversity Conservation Act 2016* (BC Act) and Federal *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The impact of the upgrade on giant barred frog was assessed in the Project Environmental Assessment (Sinclair Knight Merz [SKM] 2010). Following identification of potential giant barred frog habitat during the Project environmental assessment, Lewis Ecological conducted targeted surveys (in November 2011 and January/February 2013) (Lewis 2014). A population of giant barred frog was subsequently confirmed at Upper Warrell Creek and a management strategy prepared (see Lewis 2014).

Measures proposed to manage impacts on giant barred frogs included: population monitoring, pre-clearing surveys, temporary frog fencing during construction, clearing supervision, dewatering procedures (tadpole surveys) and permanent frog exclusion fence. Population monitoring was recommended to occur within a 1km transect in spring, summer and autumn of Year 1 and 3 of the construction phase using the methods applied during pre-construction baseline surveys.

Pre-construction baseline surveys for giant barred frog were conducted between 20 September 2013 and 2 April 2014. The baseline surveys recorded 47 individuals, including 22 adults (11 females & 11 males), 8 sub-adults, and 8 juveniles. Based on these results the population of giant barred frog at the Upper Warrell Creek site was calculated as 45 adults (with a 1:1 sex ratio), 19 sub-adults, and 16 juveniles (Lewis Ecological 2014b). Geolink (2018) recalculated population size for baseline, year 1 and year 3 construction phase samples and obtained population estimates of 41 (2013/14), 7 (2015/16), and 8 (2017/18) respectively. The results suggest a substantial decline in population between 2013/14 and 2015/16.

During early construction work *Mixophyes* spp. tadpoles were recorded at Butchers Creek (Geolink 2015). There was some conjecture about the identification of tadpoles and targeted surveys for adult frogs and

further consultation with frog specialists was undertaken in an attempt to confirm the identification. The final consensus was that the tadpoles were great barred frog (*Mixophyes fasciolatus*) and the giant barred frog was unlikely to occur at Butchers Creek (see Geolink 2015; Lewis 2015). Nonetheless, a precautionary approach was adopted and the Butchers Creek site was included in population monitoring (Geolink 2016). No giant barred frogs were recorded at Butchers Creek during the construction phase, or in year one of the operational phase (Geolink 2018; Sandpiper Ecological 2019).

1.2 Study area

The WC2NH project covers a total length of 19.75km and extends from Warrell Creek in the south to Nambucca Heads in the north (Figure 1). The alignment bypasses the town of Macksville and the northern section traverses Nambucca State Forest.

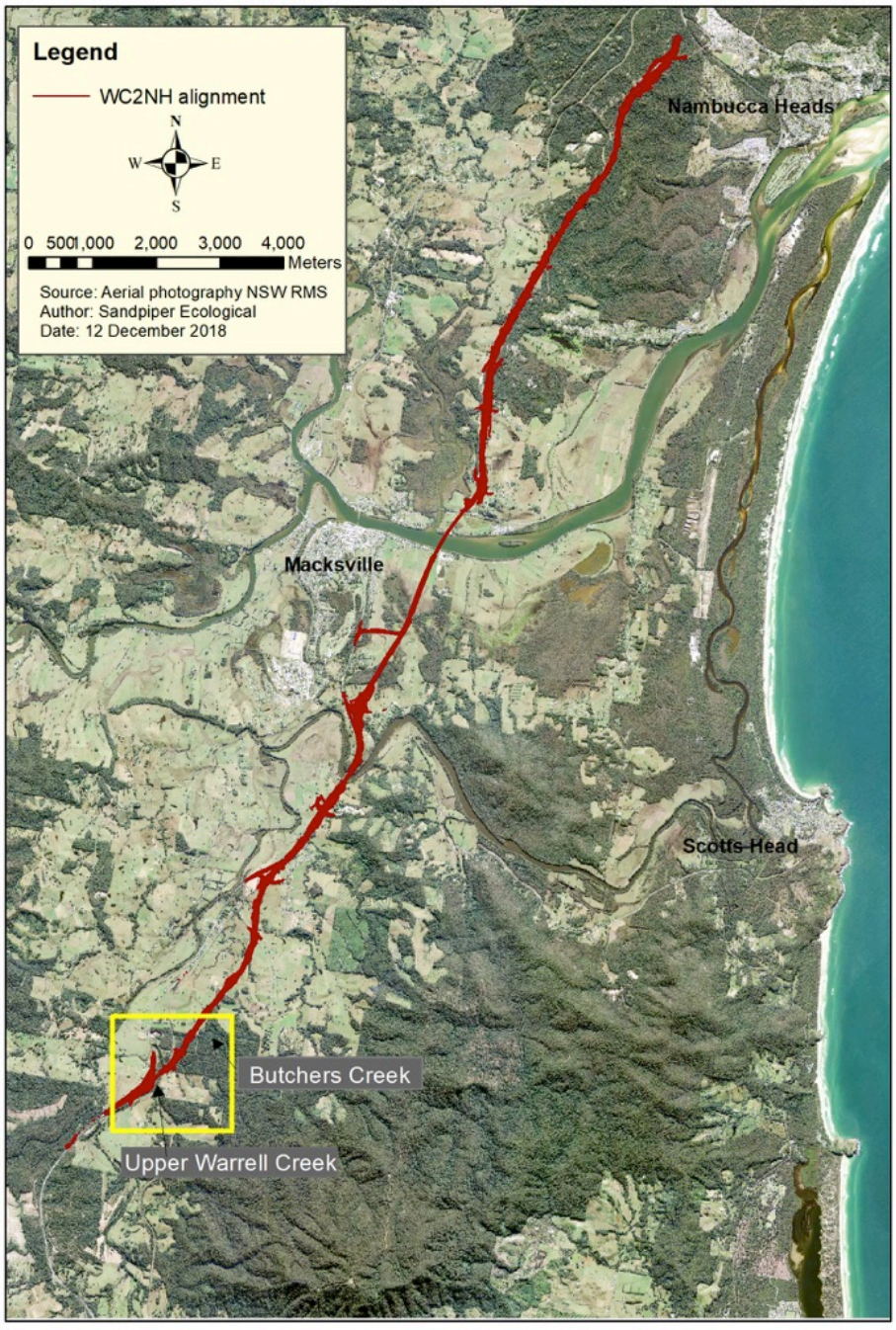

Figure 1: Location of giant barred frog sample sites in relation to the WC2NH alignment.

2. Methodology

2.1 Frog survey

Frog surveys followed the method specified in the Brief and baseline population survey (Lewis 2014), with the inclusion of additional survey effort at Upper Warrell Creek as recommended by Sandpiper Ecological (2020). The method involved:

1. Two ecologists conducted a nocturnal meandering foot-based traverse of each 50m survey zone on each side of the watercourse i.e. 42 zones at Upper Warrell Creek (20/side; Figure 2); and 16 zones at Butchers Creek (8/side; Figure 2).
2. Each ecologist was equipped with a 200-lumen spotlight and slowly traversed the riparian zone searching for frogs and listening for calls. Giant barred frog calls were broadcast through a 5-watt megaphone for 2-3 minutes within each zone. Both ecologists listened for call responses during and immediately after call broadcast.
3. All captured giant barred frogs were scanned with a Trovan Nanotransponder to determine if that frog had been previously pit-tagged. If the captured individual had not been pit-tagged and was deemed an adult (i.e. >60mm snout-vent length) a tag was inserted beneath the skin on the right side and the insertion hole sealed with vetbond. The insertion point was swabbed with disinfectant prior to the tag being inserted.
4. Data collected on each captured frog included:
    a. Survey zone (20x50m).
    b. Distance from the stream edge measured to the nearest 0.1m.
    c. Position within the microhabitat (i.e. under litter, above litter, exposed, on rock/log).
    d. Sex (male, female, unknown).
    e. Age class (adult=>60mm; sub-adult=40-60mm; juvenile=<40mm).
    f. Snout-vent length (mm).
    g. Weight (grams).
    h. Breeding condition:
        i. males assessed on the colouration of their nuptial pads (i.e. no colour, light, moderate, dark) in accordance with the classification developed by Lewis (2014b);
        ii. females assessed on whether they are gravid (i.e. egg bearing, with the typically adult weighing > 100 grams) or not gravid.
        iii. frogs with a snout vent length of <60 mm were classified as immature.

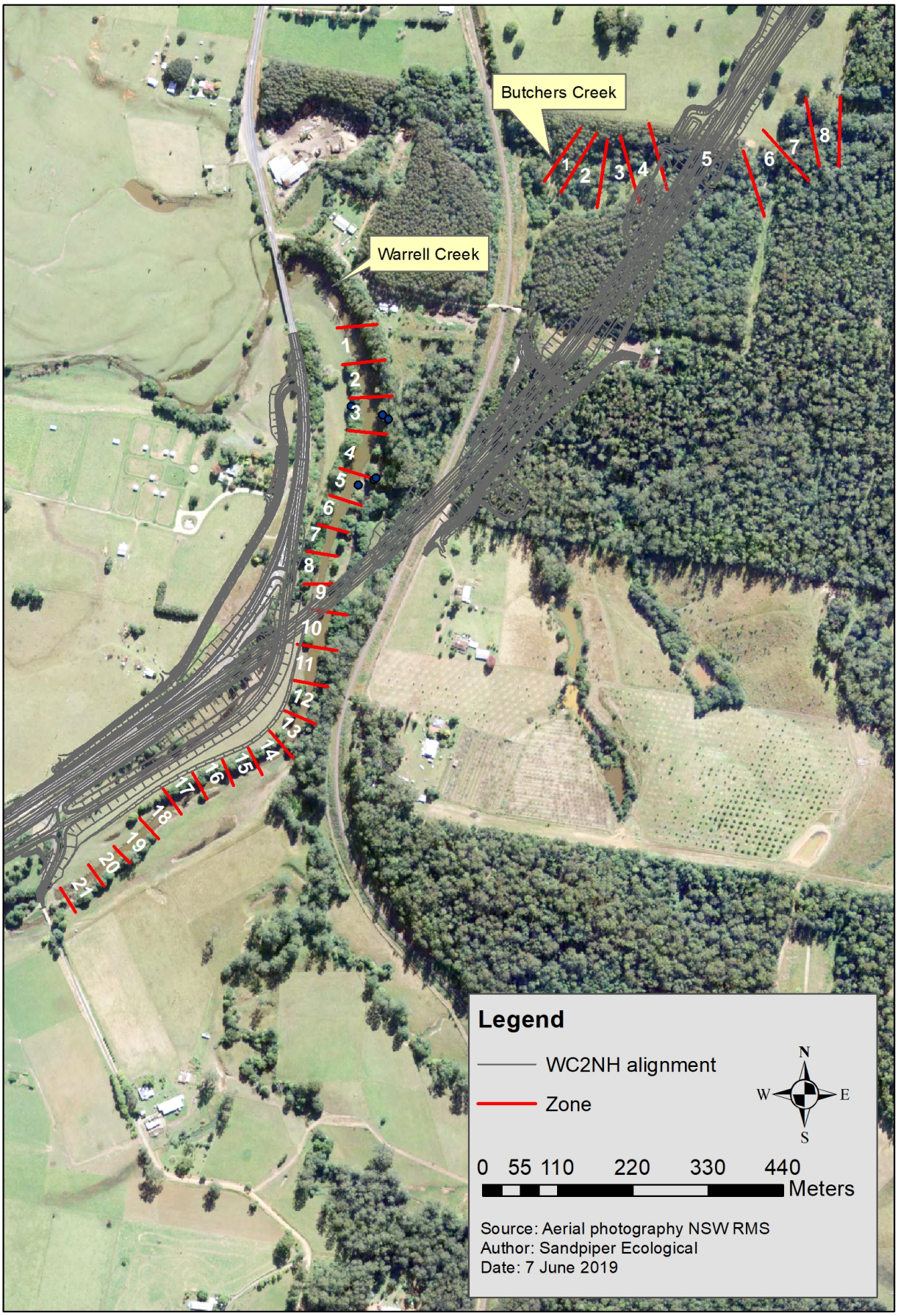

Figure 2: Survey zones within the Upper Warrell Creek and Butchers Creek sample sites.

2.2 Water quality

Water samples and field measurements were taken at approximate locations E: 489301 N: 6594447 at Upper Warrell Creek and E: 489642 N: 6594927 at Butchers Creek. One sample were collected at each site and placed immediately into an esky. Samples were analysed by the Environmental Analysis Laboratory (EAL), a NATA accredited laboratory, at Southern Cross University. Water quality parameters measured included:

1. Heavy Metals including arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc.
2. Nutrients including Nitrogen (as N), Suspended Solids and Total Phosphorus.
3. Turbidity and dissolved oxygen.
4. Hydrocarbons from the following groups:
    a. Naphthalene group including TRH>C10-C16, TRH>C10-C16 less Naphthalene (F2), TRH>C16-C34, TRH>34-C40, TRH C6-C10 and TRH C6-C10 LESS BTEX (F1).
    b. BTEX group including Benzene, Ethylbenzene, m&p-Xylenes, o-Xylene, Toluene and Xylenes – total.

Field physicochemical measurements including Conductivity, pH, and Temperature, were measured using a Horiba portable water quality meter.

3. Results and discussion

3.1 Survey timing, weather conditions and effort

The summer 2021 giant barred frog survey was conducted on 16 and 17 February 2021. Weather conditions were suitable for giant barred frog surveys. Air temperature was between 20.4 and 23.1^{0}C with high relative humidity (84-100%) and nil to light wind (Table 1). Showers occurred throughout the survey with up to 94mm recorded in the seven days preceding the surveys. A total of 17.5 person hours were spent conducting nocturnal frog surveys, 16 hours at Upper Warrell Creek and 1.5 hours at Butchers Creek.

Table 1: Weather conditions and survey effort recorded during the summer 2021 giant barred frog survey. PH = person hours; Wind categories = 0 - no wind, 1 - rustles leaves, 2 - branches moving, 3 - canopy moving

Site	Date	Start/Finish	Observers	PH	Rainfall (present)	Rainfall (prev 24hr)	Rainfall (prev 7 days)	Rainfall (prev 30 days)	RH	Temp	Dew point	Wind
Butchers Creek	17/2/21	2000-2045	DR & LA	1.5	Showers	17mm	60mm	94mm	95	20.4	20.4	1
Warrell Creek	16/2/21	2000-0015	DR & LA	8.5	Showers	16mm	44mm	77mm	84	23.1	20.5	1
	17/2/21	2100-0045	DR & LA	7.5	Showers	17mm	60mm	94mm	100	21.3	20.4	0

3.2 Frog survey

No giant barred frogs were recorded at Butchers Creek. One adult male, three sub-adult (40-60mm S-V length) and two juvenile (<40mm S-V length) giant barred frogs were recorded at Upper Warrell Creek (Table 2). The adult male was recorded calling sporadically from a sheltered location on the south bank in zone 6 (Figure 3). The individual was unable to be captured during the survey. Sub-adult frogs were recorded in zones 8, 16 and 17 on the south bank only, with juvenile frogs recorded in zones 6 and 17 also

on the south bank (Figure 3). Snout-Vent length of juvenile and sub-adult frogs ranged from 36.1 to 51.4mm and none were PIT tagged. Weights ranged from five to 15 grams and distance from the stream edge from 0.2 to 5m (Table 2).

Table 2: Giant barred frogs captured during the spring 2020 survey at Upper Warrell Creek. HC – heard calling; NC – not captured

Variable	Year 3 frog number					
	Frog 4	Frog 5	Frog 6	Frog 7	Frog 8	Frog 9
Capture date	17/2/21	17/2/21	17/2/21	17/2/21	17/2/21	17/2/21
Zone	8	6	6	16	17	17
Creek side	South	South	South	South	South	South
GPS location	489261,6594336	489285,6594410	489283,6594403	489108,6594022	489050,653989	489050,6593989
Distance from stream edge (nearest 0.1m)	0.2	0.5-1m	4	3.5	4.5	5
Position in micro-habitat*	On exposed leaf litter	On bank	On leaf litter exposed	On bare ground/sparse leaf litter	On bare ground/sparse leaf litter	On bare ground/sparse leaf litter
Sex**	Immature	Male - HC	Immature	Immature	Immature	Immature
Age***	Sub-adult		Juvenile	Sub-adult	Sub-adult	Juvenile
S/V length	51.4	NC	36.1	42.6	44.2	39.4
Weight (gr)	15		<5	10	10	6
Breeding condition[#]	N/A	N/A	N/A	N/A	N/A	N/A
Microchip ID (new or re-capture)	N/A	N/A	N/A	N/A	N/A	N/A
Original capture & recapture details	N/A	N/A	N/A	N/A	N/A	N/A

*Microhabitat: under leaf litter, under veg, on leaf litter, exposed, on a log/rock etc.
**Sex: Frogs >78mm were deemed female unless heard calling.
***Age: >60mm = adult, 40-60mm = sub, <40mm = Juv.
[#]Breeding: Males: colour of nuptial pads; light/moderate/dark/no colour. Females: Gravid, typically weighing >100g. Immature: SV length <60mm.

3.2.1 Frog abundance

The number of immature frogs (i.e. frogs with a S-V length <60mm) recorded in summer 2021 exceeded that recorded during year one of the operational phase (1 individual), and years one and three of the construction phase (2 individuals). However, the result is less than during the baseline surveys when 16 immature frogs were recorded (Lewis 2014). The size range of immature frogs recorded in summer 2021 suggests that they would have hatched in summer/autumn 2020. Due to the influence of environmental conditions on growth it is difficult to determine when the subject individuals metamorphed. However, the smaller individuals may have metamorphed in spring 2020. The higher number of immature frogs recorded in summer 2021 is likely to be a direct response to good breeding conditions in 2020. The result highlights the influence that environmental conditions have on frog abundance. The presence of immature frogs shows that breeding is occurring in the locality and is encouraging for the Upper Warrell Creek frog population particularly given the good breeding conditions recorded in 2020/2021.

Whilst reviewing capture records of immature frogs from previous surveys an error with operational phase monitoring methods was identified. During the operational phase the threshold for pit-tagging was set at 60mm S-V length, which is the immature/adult transition point. This contrasts to the baseline and construction phase surveys where the threshold for pit-tagging was set at 40mm S-V length, which is the juvenile/sub-adult transition point. This error has not affected population calculations as immature frogs are not included in the Peterson-Lincoln index, and the effect on detecting movements is limited as only a small number of individuals between 40 and 60mm have been captured during the operational phase. During all future sampling the threshold for pit-tagging will be set at 40mm S-V length.

Figure 3: Location of frogs captured during the summer 2021 giant barred frog survey at Upper Warrell Creek.

3.2.2 Distribution

The distribution of immature frogs provides some insight into potential breeding habitat, and/or suitable tadpole habitat. Zones 16 and 17 contain low quality breeding habitat and no adult frogs have been recorded in those zones during the construction or operation phases. It seems likely that the immature frogs recorded in those zones metamorphed from tadpoles that hatched upstream. Both zones are situated near a small lateral bar that would provide sheltered habitat for tadpoles washed downstream during floods. Similarly, zones 6-8 occur near areas that contain sheltered aquatic habitat. Both the immature frogs recorded during the construction phase were found in zone 6, and six immature frogs were recorded in zones 6 and 8 during the baseline survey.

3.3 Water quality

Most water quality parameters were within the ANZECC trigger values for freshwater ecosystems in south eastern Australia (Table 3). Exceptions were Total phosphorus, which exceeded the ANZECC thresholds for freshwater ecosystems at both sites, dissolved oxygen, which was lower than the ANZECC trigger value at both sites, and turbidity, which exceed the threshold at Butchers Creek. Findings are broadly consistent with spring 2020 and most likely reflect the elevated water level and high rainfall prior to the survey (Sandpiper Ecological 2020). Importantly, all BTEX and Total Recoverable Hydrocarbon levels were below ANZECC trigger levels. Heavy metals were not analysed in summer 2021. The nature of water quality sampling, that is, one-off samples months or years apart, is unlikely to provide data representative of water quality at either site.

Table 3: Results of water sample analysis for Upper Warrell creek and Butchers Creek. ID = insufficient data to derive a reliable trigger value (ANZECC 2000); NS – parameter not sampled.

Parameter	Warrell Creek	Butchers Creek	ANZECC/ARMCANZ Trigger value for freshwater (95% species level of protection)
Temperature (^{0}C)	22.3	21.1	
pH	6.31	6.19	6.5-8.0
Conductivity (us/cm)	0.171	0.108	125-2200
Dissolved oxygen (mg/L O_2)	6.23	6.51	9-10.5
Total Suspended Solids (mg/L)	<1	4	
Turbidity (NTU)	4.7	11.6	6-50
Total Phosphorus (mg/L P)	0.05	0.04	0.025
Total Nitrogen (mg/L N)	0.24	0.10	0.35
BTEX			
Benzene (µg/L or ppb)	<0.5	<0.5	950
Toluene (µg/L or ppb)	<0.5	<0.5	ID
Ethylbenzene (µg/L or ppb)	<0.5	<0.5	ID
m+p-Xylene (µg/L or ppb)	<1	<1	200
o-Xylene (µg/L or ppb)	<0.5	<0.5	350
Naphthalene (µg/L or ppb)	<0.5	<0.5	16
Total Recoverable Hydrocarbons (TRH)			
C6-C9 Fraction (µg/L or ppb)	<40	<40	ID
C10-C14 Fraction (µg/L or ppb)	<50	<50	ID
C15-C28 Fraction (µg/L or ppb)	<100	<100	ID
C29-C36 Fraction (µg/L or ppb)	<50	<50	ID
C10-C16 Fraction (µg/L or ppb)	<60	<60	ID
C10-C16 less Naphthalene Fraction (µg/L or ppb)	NS	NS	ID

Parameter	Warrell Creek	Butchers Creek	ANZECC/ARMCANZ Trigger value for freshwater (95% species level of protection)
C16-C34 Fraction (µg/L or ppb)	<200	<200	ID
C34-C40 Fraction (µg/L or ppb)	<100	<100	ID
Sum C10-C36 Fraction (µg/L or ppb)	<100	<100	ID
Heavy Metals			
Silver (mg/L)	NS	NS	0.05
Aluminium (mg/L)	NS	NS	55
Arsenic (mg/L)	NS	NS	24
Cadmium (mg/L)	NS	NS	0.2
Chromium (mg/L)	NS	NS	1.0
Copper (mg/L)	NS	NS	1.4
Iron (mg/L)	NS	NS	ID
Manganese (mg/L)	NS	NS	1900
Nickel (mg/L)	NS	NS	11
Lead (mg/L)	NS	NS	3.4
Selenium (mg/L)	NS	NS	11
Zinc (mg/L)	NS	NS	8
Mercury (mg/L)	NS	NS	0.6

4. Recommendations

Recommendations are presented in Table 4.

Table 4: Recommendations based on findings of the summer year 3 operational phase giant barred frog monitoring program.

Number	Recommendation	Transport for NSW Response
1.	Continue river bank restoration on the north bank of Zones 7, 8 & 9 at Upper Warrell Creek. Additional planting and maintenance of *Waterhousia floribunda* and understorey shrubs, and control of grass is required to improve connectivity.	The following works are to be undertaken by the WC2NH contractor in zones 7, 8 and 9 - - Works to reduce Pigeon Grass *(Setaria species)* extent and density - Planting of 60 *Waterhousia floribunda* - Plant out wetland plant tubestock to bolster the now established wetland plantings in the area. This scope of works has been developed in consultation with and is endorsed by the EPA. The works were expected to commence in late 2020, however due to numerous high rain events and localised flooding, these works are now expected to commence before July 2021.
2.	Due to the pattern of population decline at UWC additional survey effort is recommended at that site for the remaining autumn year 3 operational phase survey. Further assessment, in accordance with Performance Criteria in the Giant Barred Frog Management Strategy, would be undertaken following population analysis conducted in the year 3 operational phase annual report, which is due in autumn 2021.	Agree and adopted

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Warrell Creek to Nambucca Heads

Annual Underpass Monitoring Report - Operational Phase, Year Two (2019-2020)

Transport for New South Wales | December 2020

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1. Introduction

In 2015, Transport for NSW (TfNSW), in conjunction with Acciona Ferrovial Joint Venture (AFJV), commenced the upgrade of the Pacific Highway between Warrell Creek and Nambucca Heads (WC2NH). The WC2NH project was opened to traffic in two stages:

- Stage 2a - 13.5km section from Lower Warrell Creek Bridge to Nambucca Heads opened on 18 December 2017; and
- Stage 2b - 6.25km section from the southern end of the project to the Lower Warrell Creek bridge opened on 29 June 2018.

Approvals for the WC2NH upgrade required monitoring of several species and mitigation measures during the operational phase. Species and mitigation measures targeted include koala, spotted-tailed quoll, grey-headed flying-red fox, yellow-bellied glider, giant barred frog, green-thighed frog ponds, fauna underpasses, vegetated median, road-kill, exclusion fencing, and threatened flora. Sandpiper Ecological Surveys (Sandpiper) was contracted by TfNSW to deliver the WC2NH operational ecological and water quality monitoring program.

The objective of fauna underpass monitoring is "to assess use of underpasses by threatened and common fauna and to assess the effect of exclusion fencing on movement of small mammals, reptiles and frogs" (RMS 2018). Effectiveness of exclusion fence is also assessed in the annual road-kill report (see Sandpiper Ecological 2018, 2019).

The following annual report presents methods and results of the year two operational phase underpass and adjacent habitat surveys. The results are discussed in relation to the potential indicators of success detailed in the WC2NH Ecological Monitoring Program (RMS 2018) and recommendations regarding future monitoring are provided. The potential indicators of success used to assess the performance of the WC2NH underpasses include:

1. Low rates of use of fauna underpasses and adjacent habitats by feral predators;
2. High levels of fauna underpass use by a wide variety of native fauna species;
3. No change to densities, distribution, habitat use, and movement patterns compared to baseline population data of target species;
4. Evidence of use by dispersing individuals and different age cohorts;
5. Use by cover-dependent species and species with low mobility;
6. No breaches in fauna exclusion fencing;
7. Low incidences of fauna road strike mortality.

A list of species names for fauna referred to in text and Tables is provided in Appendix A.

1.1 Background

The WC2NH upgrade features 23 fauna underpasses, including 13 box culverts, three pipe culverts and seven bridges. Underpasses targeted for monitoring were specified in the WC2NH Ecological Monitoring Program (EMP; Table 1) and include eleven box culverts and one bridge. Site five includes a dual cell box culvert with one cell designated as a wet passage (for aquatic fauna) and the other as dry passage. The dry cell includes a concrete ledge that provides dry passage for terrestrial fauna. Fauna underpasses were designed to target spotted-tailed quoll (*Dasyurus maculatus*), koala (*Phascolarctos cinereus*) and giant barred frog (*Mixophyes iteratus*). Giant barred frog is known to occur at site 1 (Upper Warrell Creek) only, whilst quoll and koala could occur at sites 2-12. Sites 9/10, and 11/12 consist of corresponding culverts on either side of a vegetated median.

Table 1: Underpasses sampled during operational phase monitoring of the WC2NH upgrade. SQ = spotted-tailed quoll; K = koala; GBF = giant barred frog; * sites consist of dual cells 3x3m box culverts with one cell providing wet passage for aquatic fauna; P/A = presence/absence.

Site	Chainage	Type	Structure	Dimensions	Fauna Furniture (P/A)	Substrate	SQ	K	GBF
1	42500	Combined	Bridge		A	Soil			x
2	55120	Dedicated	Box Culvert	1 x 3000 x 3000	P	Concrete	x	x	
3	56410	Combined	Box Culvert	1 x 2400 x 2400	P	Concrete	x	x	
4	57770	Dedicated	Box Culvert	1 x 3000 x 3000	P	Mulch	x	x	
5 *	58510	Combined	Box Culvert	2 x 3000 x 3000	A	Concrete	x	x	
6	58560	Dedicated	Box Culvert	1 x 3000 x 3000	P	Mulch	x	x	
7	59090	Dedicated	Box Culvert	1 x 3000 x 3000	P	Mulch	x	x	
8	59550	Dedicated	Box Culvert	1 x 3000 x 3000	P	Mulch	x	x	
9	59750 NB	Dedicated	Box Culvert	1 x 2400 x 2400	P	Mulch	x	x	
10	59760 SB	Dedicated	Box Culvert	1 x 2400 x 2400	P	Mulch	x	x	
11	60600 NB	Dedicated	Box Culvert	1 x 2400 x 2400	P	Mulch	x	x	
12	60610 SB	Dedicated	Box Culvert	1 x 2400 x 2400	P	Mulch	x	x	

1.2 Study area

The WC2NH project covers a total length of 19.75km and extends from Warrell Creek in the south to Nambucca Heads in the north (Figure 1). The alignment bypasses the town of Macksville and the northern section traverses Nambucca State Forest. Eleven underpasses are situated north of the Nambucca River and one (Site 1) is situated at Upper Warrell Creek near the southern extent of the project. Sites four to twelve adjoin Nambucca State Forest and sites two and three adjoin remnant vegetation on private land.

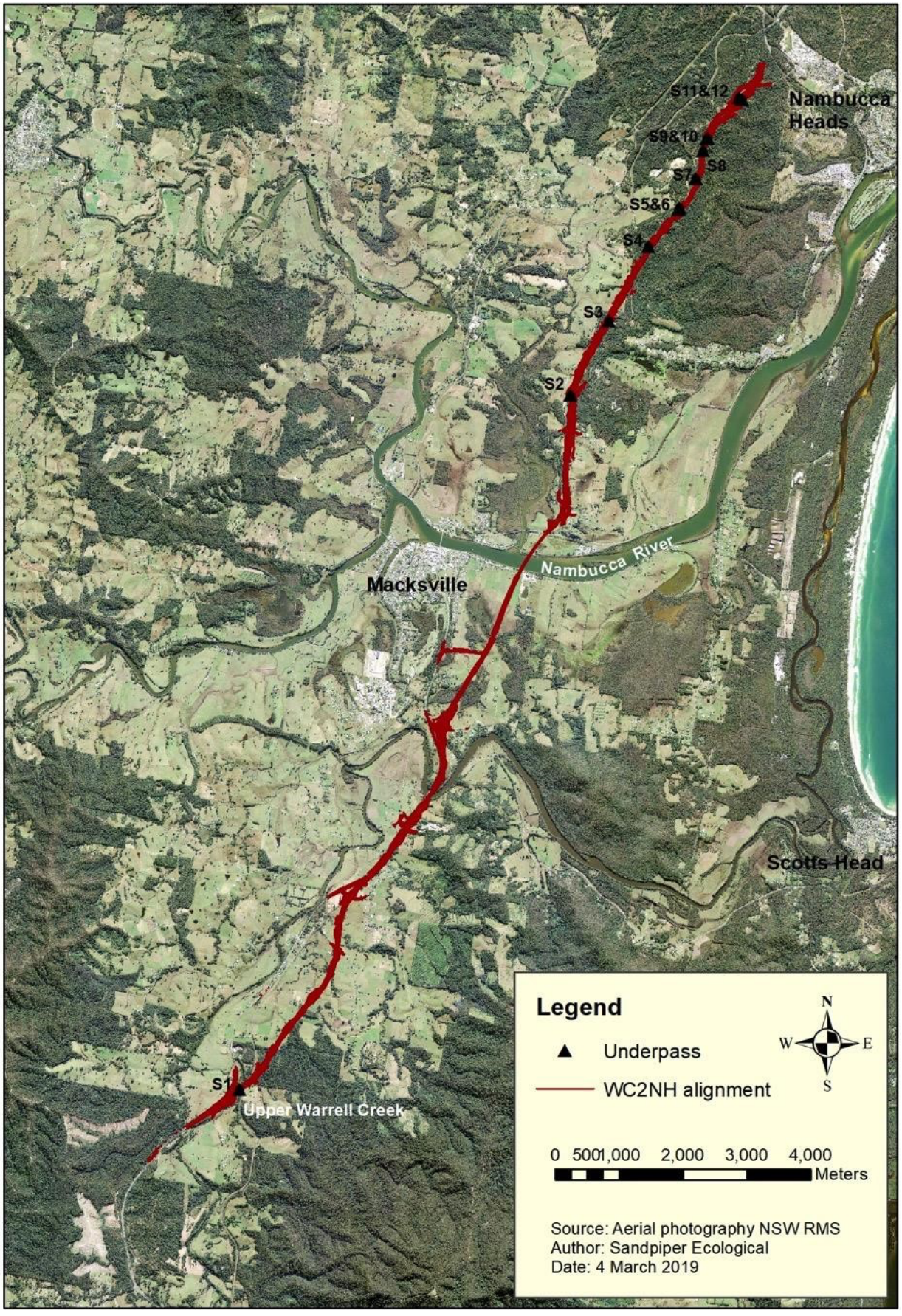

Figure 1: Underpass locations along the WC2NH alignment.

2. Methods

2.1 Timing and weather conditions

Underpass and adjacent habitat surveys were conducted bi-annually between 22 September 2019-28 February 2020 (spring/summer) and 1 June – 1 September 2020 (winter). Dry warm conditions occurred from September 2019 through to January 2020 with a total of 194 mm of rainfall being recorded at the Bureau of Meteorology Bellwood weather station (059150) (Appendix B, Table B1). Warm and wet conditions occurred during February 2020 with the Bellwood station receiving 427 mm (Table 2, Appendix B, Table B1). The winter monitoring period was characterised by cooler and dry conditions (Table 2). Air temperature and relative humidity were collected from Coffs Harbour Airport (station 059151) (Appendix B, Table B1).

Table 2: Summary of weather conditions recorded at Coffs Harbour Airport (station 059151) and Bellwood weather station (059150) during year two operational phase monitoring.

Monitoring period	Total rainfall (mm)	No. rain days	Relative humidity (%)	Max temp range (^{0}C)	Min temp range (^{0}C)
Spring/Summer	665	37	>60% on 90% of days	18.5-35.5	6.7-25
Winter	87	5	>60% on 90% of days	15.9-25.4	2.7-13.3

2.2 Underpasses

2.2.1 Sand pads

Sand pads were installed on 15 October 2019 (spring/summer sample) and 17 June 2020 (winter sample). A 50:50 mix of brickies sand and washed beach sand was used for all sand pads. Two sand pads were installed at each site. In culverts, pads were installed 3-5m from each end, whilst at the bridge (site 1) one pad was installed on each side of Warrell Creek (North and South). Each pad was approximately 50mm deep by 1m wide and extended for the entire culvert width, or for 3m at site 1. At sites with a concrete ledge the pad covered both the floor and ledge (Plate 1). The exception was site 5 where the pad covered the ledge only due to standing water over the culvert floor.

Sand pads were inspected on eight consecutive days across all sites. Rain on 19 June 2020 led to complete or partial wash out of sand pads at sites 3, 5, 8, 9, 10, 11 and 12, with pads reinstalled on 20-21 June. Inspections were conducted by an ecologist and included a systematic scan of each pad searching for fauna tracks. A small torch was used to illuminate the pad, if required. Information recorded included species or fauna group, number of traverses, direction of traverse and pad condition (good, moderate, poor). A complete crossing was recorded when the direction and number of traverses from a species or fauna group was consistent across both pads (east and west) at each site. Incomplete crossings were recorded when the traverse direction and number of track sequences was not consistent across both sand pads. Small fauna exhibit erratic movement making it difficult to accurately determine complete and incomplete crossings. Tracks were identified with reference to Triggs (2004) and advice from senior ecologists. Tracks that could not be identified insitu were photographed and referred to a senior ecologist for identification.

Plate 1. Sand pad being installed in a fauna underpass on the WC2NH upgrade.

2.2.2 Scat and track searches

Each underpass was searched by a senior ecologist and/or ecologist for scats and tracks on two occasions during the spring/summer and winter sample periods. The search involved a slow systematic traverse of each culvert using a hand-held spotlight (Led Lenser P14). Fauna furniture, the culvert floor, and joints were targeted. Areas of accumulated fine sediment were targeted for tracks. Tracks and scats were identified in-situ, with reference to Triggs (2004) and the ecologists experience or photographed and sent to colleagues for identification.

2.2.3 Tile checks

Two roof tiles (300x200) were installed at both ends of underpasses 5m in from the entrance in autumn 2020. These were checked on two occasions during winter sample period.

2.2.4 Cameras

Two motion-activated infra-red cameras (Swift 3C, Swift Enduro or Reconyx HC500) were installed centrally in each culvert, with the exception of site five where one camera was mounted centrally in each cell. At site 1, Reconyx HC500 cameras were initially attached to steel posts, and following theft, were housed in security boxes attached to large boulders. A single camera was installed at approximately 200mm above ground near the water's edge on each side of Upper Warrell Creek (site 1). In total, 24 cameras were installed. In underpasses, both cameras were installed centrally, one on the fauna furniture, and one

approximately 300mm above the culvert floor. Cameras were oriented to the east except for site 1 where cameras were oriented perpendicular to the creek on the north and south banks. Cameras at site 10 were re-oriented to the west following a high incidence of false triggers cause by traffic on the southbound carriageway. Swift cameras were set to take 10 seconds of video with no delay between activation. Reconyx cameras were set on time-lapse mode to take a picture at 1-minute intervals between 8 pm and 6 am each day throughout the spring/summer sample period and 6pm to 6am during the winter sample. Time-lapse mode is better suited to targeting frogs and was used successfully to monitor frog pipes on the Sapphire to Woolgoolga Pacific Highway Upgrade (Sandpiper Ecological 2017a, 2018a). Cameras at site 1 were inundated by floodwater on several occasions in February 2020.

During the spring/summer sample period, cameras at sites 1-12 were installed on 8-9 October. Cameras were inspected during the middle of each session to change batteries and SD cards. Following camera checks between 22 October and 18 November, all cameras at sites 1, 2, 3 and 6 (8 cameras) were stolen. Replacement cameras were reinstalled on 28 November at sites 2, 3, 6 and 22 January at site 1. Cameras from sites 2-12 were retrieved on 18 December 2019 following a total sample period of 70-71 days (Table 3). Cameras at site 1 were retrieved on 28 February following a sample period of 49 days (Table 3). Nine of the 24 cameras were active for less than the 60-day minimum sample period, with eight a result of theft and one (site 11 furniture) due to battery failure. Sampling days were further reduced at site 6 (14 days) and site 1 south (14 days) due to camera malfunction and flooding (Table 3). The remaining 15 cameras were active for 70-71 days (Table 3).

During the winter sample period all cameras were installed between 22 and 25 June, except site 1 north, which was installed on 16 July due to replacement of security housing. Checks were conducted on 28 July and all cameras were retrieved on 1 September. Battery failure and camera malfunction reduced sample periods at sites 11 (furniture), 1 (south) and 12 (floor) with all remaining cameras active for the minimum 60 days (Table 3). Overall, the minimum 120 days annual sample period was achieved for 14 of the 24 cameras. Without theft the minimum sample period would have been achieved by 20 of the 24 cameras. Importantly, the total minimum number of camera days required (2880 days) was exceeded during year two operational monitoring (2917 days) (Table 3). Actions proposed to minimise camera malfunction and battery failure are included in the discussion.

Table 3: Camera survey effort during year two operational phase monitoring**.** * = camera stolen; ^ camera flooded

Site	Cam location	Days active		
		Spr/Sum	Winter	Total
1	North	34*^	47	81
	South	34*^	46	80
2	Furniture	20*	61	81
	Floor	34*	71	105
3	Furniture	34*	71	105
	Floor	34*	71	105
4	Furniture	71	71	142
	Floor	71	71	142
5	North	71	71	142
	South	71	71	142
6	Furniture	14*	72	86
	Floor	14*^	72	86
7	Furniture	71	72	143
	Floor	71	72	143
8	Furniture	71	72	143
	Floor	71	72	143
9	Furniture	70	72	142

	Floor	71	72	143
10	Furniture	71	72	143
	Floor	71	72	143
11	Furniture	48	35	83
	Floor	71	72	143
12	Furniture	71	72	143
	Floor	71	37	108
Totals		1330	1587	2917

Image review

Images were uploaded to a computer and viewed using Windows Photo Viewer ©. A senior ecologist or ecologist reviewed all images, with reference to standard field guides (i.e. Menkhorst & Knight 2004; Pizzey & Knight 2007; Van Dyck *et al.* undated).

Fauna were scored making a complete or incomplete crossing:

- A complete crossing was scored when an animal showed directional movement when detected by the centrally mounted camera.
- An incomplete crossing was scored when an animal showed no directional movement (i.e. remained stationary in front of camera) or passed the camera but returned within 10 minutes.

Crossing definitions are consistent with those used at other Pacific Highway monitoring sites (e.g. Sandpiper Ecological 2017b, 2018b, 2019) and crossing structure research programs (e.g. Soanes *et al.* 2015). Further, it represents a conservative approach to identification of complete crossings. Data recorded for each active image included: site, date, time, species, accuracy (definite 90%+ certainty, probable 75-90% certainty, and possible 60-75% certainty), movement direction (east, west, no directional movement (animal stationary, returned), number of images and image numbers. A hierarchical approach was adopted to species identification that included: species, genus or group. Microbats were recorded as presence only due to their transient nature and none reliance on underpasses for thoroughfare.

Data analysis and interpretation

The adequately assess “use of underpasses” from the EMP operation monitoring aim, complete crossings were used as the standard of measure as it encompasses the purpose of fauna underpasses (i.e. A crossings structure that allows fauna to access habitat that has been fragmented by construction of a road or highway). To account for variations in survey effort between sites and years (1 and 2), complete crossings/week and complete crossings/week/underpass were adopted. Birds and microbats were excluded from analysis as they do not require underpasses for thoroughfare.

As seen in dot point five in the potential indicators (see introduction), fauna with low mobility was not defined within the EMP. As such, fauna with low mobility has been assumed to include animals whose movement is generally limited by their size or behaviour. Hence, fauna that exhibit low mobility/cover dependence has been interpreted as frogs, small reptiles (excluding goanna and water dragon), rodents and bandicoots.

A student’s t-test (assuming equal variances) was conducted to compare feral predator activity (cc/week/underpass) between year 1 and year 2 operational monitoring. Sites 11/12 and 9/10 were averaged as they function as a single site and lack independence if treated separately. Site 5 was removed from the analysis due its proximity to site 6 and presence of permanent water, which limits feral predator use. A square root transformation was performed on all data to achieve normality within the dataset.

2.3 Adjacent habitat

2.3.1 Survey design

A total of 18 sites were sampled at the 12 underpasses as part of adjacent habitat surveys. Sample sites were established on each side of an underpass or underpass pair in the case of sites 5/6, 9/10 and 11/12. Adjacent habitat at sites 5 and 6 was sampled as one site as the underpass entrances were located within 50m of each other. Survey effort was reduced at site 3 due to concern about disturbing neighbours. No spotlighting or arboreal Elliott trapping occurred on the west side at site 3 and the diurnal active search was restricted to a small (100m x 30m) triangular shaped remnant of vegetation in the road reserve.

2.3.2 Trapping

Trapping methods applied during the survey included: cage traps, ground Elliott traps (Type A), arboreal Elliott traps (Type B), pitfall traps, and hair funnels. Trapping occurred within a 1ha area immediately adjacent to each culvert entrance and was conducted over three nights at each site. A maximum of 10 sites were sampled concurrently and trapping was conducted between 14 and 20 November 2019 during the spring/summer and 15-21 June during the winter.

Traps were set in a “X” formation with five ground and five arboreal traps set at 20m intervals on one axis and two cage traps and two hair funnels set at 50m spacing on the other axis (Plate 2). A line of three pitfall traps with drift fence was set at the intersection of both lines (Plate 2). Pitfall traps typically followed the contour and were set near fallen logs and dense ground cover. Trap effort is summarised in Table 4.

Plate 2: Example of a pitfall trap line installed during adjacent habitat surveys (L). Setting up traps in adjacent habitat at site 1 (R).

Arboreal traps and ground Elliott traps were baited with a peanut butter, honey and oats mixture. Arboreal traps were installed 1.8m above ground and attached to a bracket. Honey water was sprayed on the trunk above each arboreal trap, and bait was replaced as required. A plastic bag was placed over the end of each trap to provide cover, and a small amount of leaf litter was placed inside the trap. In spring/summer, arboreal traps were set on the western side of trees to provide shelter from the morning sun. Cage traps were set in a sheltered location and alternately baited with either peanut butter, honey and oats, or sardines. A tuna oil and water mix was sprayed around the entrance to cage traps baited with sardines. All traps were checked within four hours of sunrise. In spring/summer cage and Elliott traps were closed following the morning inspection and re-opened in the late afternoon. Pitfall traps were checked in the morning and again in mid-afternoon.

Captured fauna were identified to species or genus, and, where possible, sexed and aged. Fauna were identified with reference to standard field guides (Van Dyck *et al.* 2013; Menkhorst & Knight 2004; Wilson & Swan 2010). Fauna were not marked as the aim of sampling was to determine the range of species present in adjacent habitat.

2.3.3 Diurnal active search

Diurnal active searches were conducted by one or two ecologists and involved a meandering traverse of habitat within 100m of the underpass entrance at each sample site. Surveys involved searching leaf litter, rolling logs, observing reptile habitat (i.e. log piles, rocks, dense leaf litter) and looking for fauna signs such as scats and tracks. Each site was sampled twice during each sample period for a minimum of 30 person minutes/sample. Spring/summer diurnal active searches were conducted between 22 September-21 October 2019 and winter search between 1 June-16 June. A total of 1080 person minutes were spent conducting diurnal active searches (Table 4).

2.3.4 Nocturnal active search

Nocturnal surveys were conducted on each side of each underpass on two non-consecutive nights during the spring/summer and winter sample periods. One or two ecologists conducted spotlight surveys for 60 person minutes per underpass side/sample period (Table 4). Surveys were conducted using hand-held Led Lenser P14 spotlights and involved a meandering traverse of habitat within 200m of the culvert entrance. Fauna were detected by sight and call and identified to species or genus where possible. Spring/summer surveys were conducted between 3 October and 28 November 2019 and winter surveys between 15-17 June. A total of 1080 person minutes were spent conducting nocturnal active searches (Table 4).

2.3.5 Opportunistic records

Opportunistic observations of fauna near culvert entrances made whilst doing other monitoring activities such as koala, giant barred frog and yellow-bellied glider monitoring were recorded. All fauna observed whilst setting up equipment, with exception of birds, were also recorded.

Table 4: Survey effort for sampling adjacent habitat on the WC2NH upgrade. S/S = spring/summer, W = winter, UP = Underpass.

Component	Method / culvert side	No Samples	Total effort
Arboreal Elliott traps	5 x traps @ 20m spacing	3 nights/site	510 trap nights
Ground Elliott traps	5 x Type A Elliott traps @ 20m spacing	3 nights/site	540 trap nights
Cage traps	2 @ 50m spacing	3 nights/site	216 trap nights
Pitfall traps	1 x line of 3 pits with drift fence	3 nights/site	324 trap nights
Hair funnels	2 @ 50m spacing	14 nights/site	504 trap nights
Active diurnal search	30 person minute search at UP entrance	2 sample/site	1080 person minutes
Active nocturnal search	30 person minute search at UP entrance	2 samples/site	1080 person minutes

2.4 Exclusion fence

Two people traversed the entire length of the fauna exclusion fence on foot on 17 June 2020. Sections of exclusion fence inspected included: type 1 chainmesh fence with floppy top feature (18.03km), Type 3 frog fence combined with floppy top (1.32 km) and Type 4 flying-fox fence (1km) fence. The exclusion fence was assessed in relation to condition, structural integrity, overhanging vegetation and vine growth. Any issues were recorded on a datasheet, and the location logged using a hand-held GPS along with a written description of the issue and location.

3. Results

3.1 Underpasses

3.1.1 Camera monitoring

Species diversity and native fauna use

Twenty species and seven fauna groups were confirmed using underpasses during camera monitoring (Table 5). The highest fauna diversity was recorded at site 7 with eighteen species/groups, followed by sites 4, 5 and 10 with fourteen species/groups (Table 5). The lowest diversity was recorded at site 1 with five species/groups (Table 5). Remaining sites recorded between nine and 13 fauna species/groups (Table 5). Six introduced species were recorded including cat, dog, red fox, black rat, house mouse and European hare (Table 5).

Native species were recorded making complete crossings (cc) at all underpass sites (Figure 2). Sites 2, 7 and 8 featured the highest use by native species averaging 4.25cc/week, 3.5cc/week and 2.8cc/week respectively (Figure 2). Swamp wallaby (2.3cc/week) and bandicoots (0.95cc/week) were frequently recorded at site 2 while short-eared brushtail possum contributed to the majority of complete crossings at sites 7 (1.71cc/week) and 8 (1.47cc/week) (Table 5). Sites 11 and 12 exhibited the lowest use by native species recording 0.15cc/week and 0.30cc/week (Figure 2).

Macropodidae (swamp wallaby, red-neck wallaby, eastern grey kangaroo, wallaby spp.) was the most frequently recorded native fauna group at a rate of 0.55 cc/week/underpass with detections (herein detections refer to complete crossings) at all sites (Figure 6, Table 5). Of the Macropodidae group swamp wallaby exhibited the highest use of underpasses (complete crossings) followed by red-necked wallaby and eastern grey kangaroo (Table 5). *Trichosurus* spp. (short-eared brushtail possum and common brushtail possum) was recorded at a rate of 0.35cc/week/underpass, Bandicoot spp 0.20cc/week/underpass, reptile (eastern water dragon and lace monitor) 0.19 cc/week/underpass, *Antechinus* spp 0.07cc/week/underpass and Koala 0.02 cc/week/underpass (Figure 6).

Koala was the only threatened species recorded, with complete crossings using the culvert floor recorded at sites 4, 9, and 10 (Table 5 and Figure 2). Koala made seven complete crossings (four east, three west) at site 4 during spring/summer and two complete crossings (one east, one west) during winter (Plate 3). An individual was also recorded making a complete crossing (heading west) through 9 and 10 (split median) during spring/summer (Figure 2, see appendix C Table 1)

Native species use increased from 1.04 ± 1.29 cc/week/underpass during year 1 monitoring to 1.49 ± 2.67 cc/week/underpass during year 2 (Figure 3). Further, in contrast to year 1 native species (1.49 cc/week/underpass) exceeded feral predator use (1.35cc/week/underpass) (Figure 3). Increases in use by Macropodidae spp and Peramelidae spp (Northern brown bandicoot, Long-nosed bandicoot and bandicoot spp.) and *Antechinus* spp largely contributed to increased use of underpasses by native species in year two (Figure 6).

Plate 3: Koala recorded at Site 4, moving west on 1 August 2020.

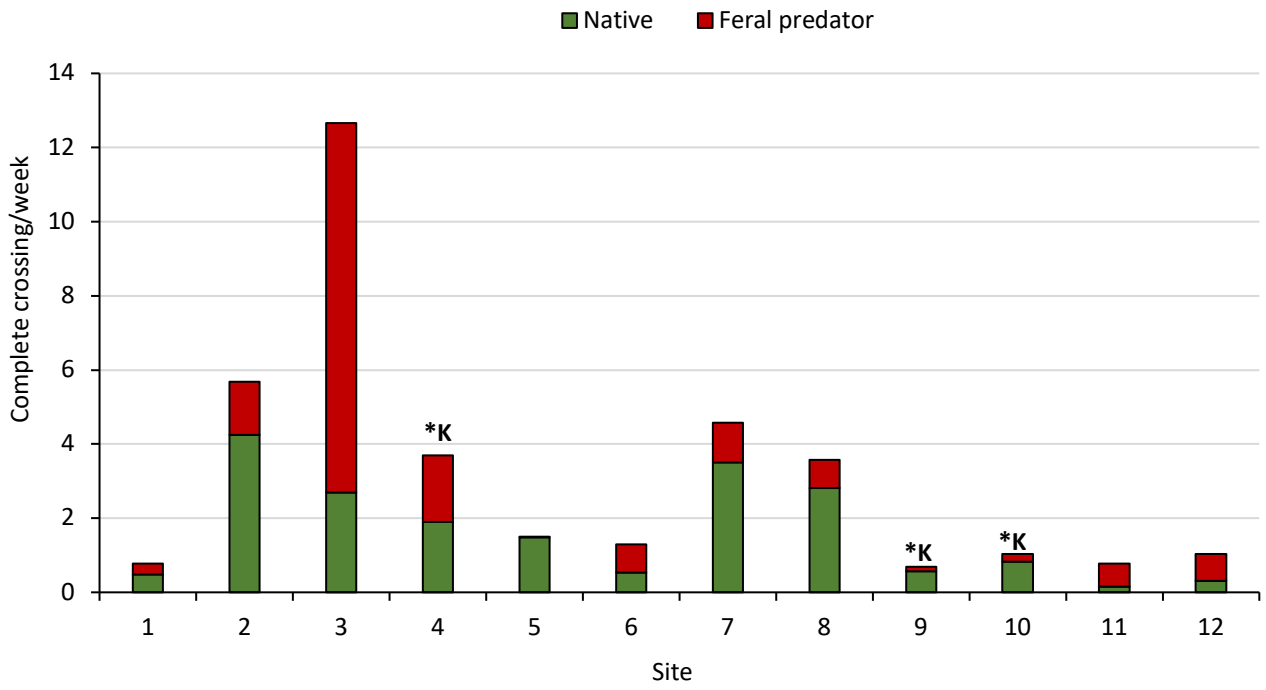

Table 5: *Survey effort for sampling adjacent habitat on the WC2NH upgrade* *K = indicates complete crossing by koala.

Table 6: Complete crossings/week made by each species/group at each of the 12 underpasses monitored on the WC2NH upgrade during year 2 operational monitoring. Sites 1 and 5 did not contain fauna furniture. [I] = introduced species, Fl = Floor, G = ground (culvert floor). See appendix C, Table C1 for all data.

Species/groups	Site and camera location																							
	1		2		3		4		5		6		7		8		9		10		11		12	
	N	S	FF	G	FF	G	FF	G	N	S	FF	G	FF	G	FF	G	FF	G	FF	G	FF	G	FF	G
Short-beaked echidna				0.19										0.05										
Antechinus spp			0.23				0.3				0.16		0.17											
Northern brown bandicoot				0.08																0.02				0.11
Long-nosed bandicoot				0.04				0.02	0.02			0.04		0.02				0.02						
Peramelidae spp. (bandicoot)				0.94		0.03		0.39				0.08		0.02				0.07		0.22		0.09		0.14
Koala								0.22										0.02		0.02				
Common brushtail possum								0.02																
Short-eared brushtail possum										0.1	0.04		1.71	0.07	1.47	0.12		0.1		0.07				
Trichosurus spp						0.03		0.05					0.02	0.02	0.24					0.02				
Eastern grey kangaroo						0.17																		
Swamp wallaby	0.3			2.3		0.67		0.2	0.05	0.17		0.12	0.02	0.05		0.12		0.1		0.12		0.03		0.03
Red-necked wallaby						0.23								0.1						0.05				
Wallaby spp				0.3		0.57		0.02						0.15		0.02		0.07		0.07				
Macropod spp				0.15		0.2								0.49										
House mouse*									0.07	0.02								0.02						0.08
Faun-footed melomys							0.02						0.02											
Swamp rat				0.04						0.02														
Bush rat										0.02														
Water rat									0.02	0.79														
Black rat*			0.04				0.02	0.07	0.79	1.6		0.08	0.02	0.02	0.07			0.07		0.12	0.03			0.67
Rodent spp									0.07	0.32	0.04			0.05	0.42						0.03			
Small mammal										0.02				0.02										
Dog*				0.26		1.37		0.12						0.05						0.02		0.09		0.11
Red fox*	0.04	0.04		1.09		0.3		1.13		0.02		0.49		0.91		0.54		0.1		0.07		0.15		0.25
Cat*	0.09	0.13		0.08	0.13	8.17	0.02	0.49				0.28		0.12	0.02	0.2		0.02		0.1	0.03	0.34		0.36
European hare*												0.04				0.07								
Eastern water dragon									0.02	0.07										0.02		0.03		0.03
Lace monitor								0.69		0.07	0.04	0.04		0.17		0.81	0.02	0.1		0.2				
Australian brush turkey																		0.02						
Purple swamphen	0.09	0.04																						
White-browed treecreeper																	0.02							
Welcome swallow					0.73	0.07																		
White faced Heron	0.04																							
Wood duck										0.1														
Species Richness	**5**	**3**	**2**	**11**	**2**	**11**	**4**	**12**	**7**	**13**	**4**	**8**	**6**	**16**	**5**	**7**	**2**	**12**	**0**	**14**	**3**	**6**	**0**	**9**

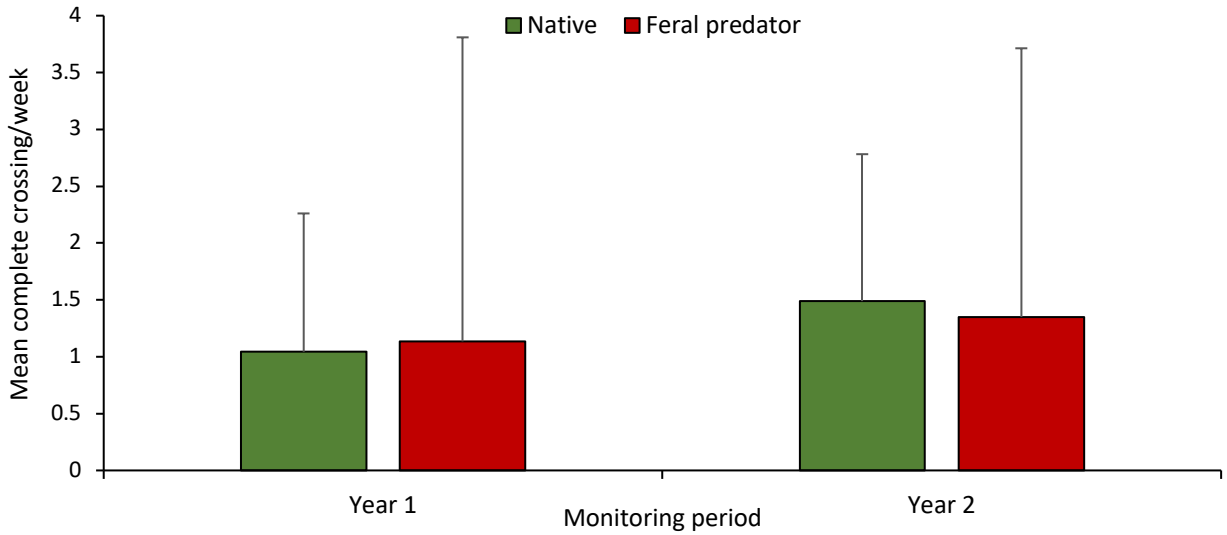

Figure 2: Mean number of complete crossing/week/underpass (+SD) for native and introduced species during year 1 and year 2 monitoring periods (operational).

Feral predator activity

Complete crossings by feral predators were recorded at all sites at an overall rate of 1.34 ± 2.67 cc/week/underpass. This equates to 47% of all complete crossings excluding rodents during year 2 (Figure 2, Figure 3). Feral predator activity was highest at sites 2, 3 and 4 and lowest at sites 5, 9 and 10 (Figure 4). Red fox was recorded at a rate of 0.41 ± 0.39 cc/week/underpass with detections in all underpasses (Figures 5 and 4). Cat (*Felis catus*) recorded 0.84 ± 2.2 cc/week/underpass with detections at all sites except site 5 (Figures 4 and 5). Dog (*Canis lupus familiaris*) exhibited 0.1 ± 0.15 cc/week/underpass and was detected at seven sites (2, 3, 4, 10, 11, 12) (Figures 5 and 4). High use at site 3 can largely be attributed to frequent cat crossings (8.3 cc/week, Figure 4) a majority of which were by 1-2 (distinctive) individuals (Plate 4). Red fox was frequently detected at sites 2 (1.1cc/week), 4 (1.13cc/week) and 7 (0.9cc/week) while dog detections were highest at sites 2 (0.26cc/week) and 3 (1.37cc/week) largely due to two domestic dogs (Figure 4, Plate 4). No instances of predation were recorded in underpasses, although cats carrying prey (rodents) were recorded moving through site 3 on two occasions (see appendix C. Table C1)).

Feral predator use increased from 1.13 ± 2.36 cc/week/underpass during year 1 monitoring to 1.34 ± 2.67 cc/week/underpass during year 2 (Figure 5). While use by cat has remained relatively constant, red fox increased from 0.24 ± 0.45 to 0.41 ± 0.39 cc/week/underpass while dog was recorded at a rate 0.1 ± 0.39 cc/week/underpass with no detections during year 1 monitoring (Figure 5).

Students t-Test comparing mean cc/week/underpass between year 1 and 2 for introduced predators ($P = 0.48$, $n = 12$), foxes ($P = 0.29$, $n = 12$), and cats ($P = 0.85$, $n = 12$) did not identify any statistically significant differences.

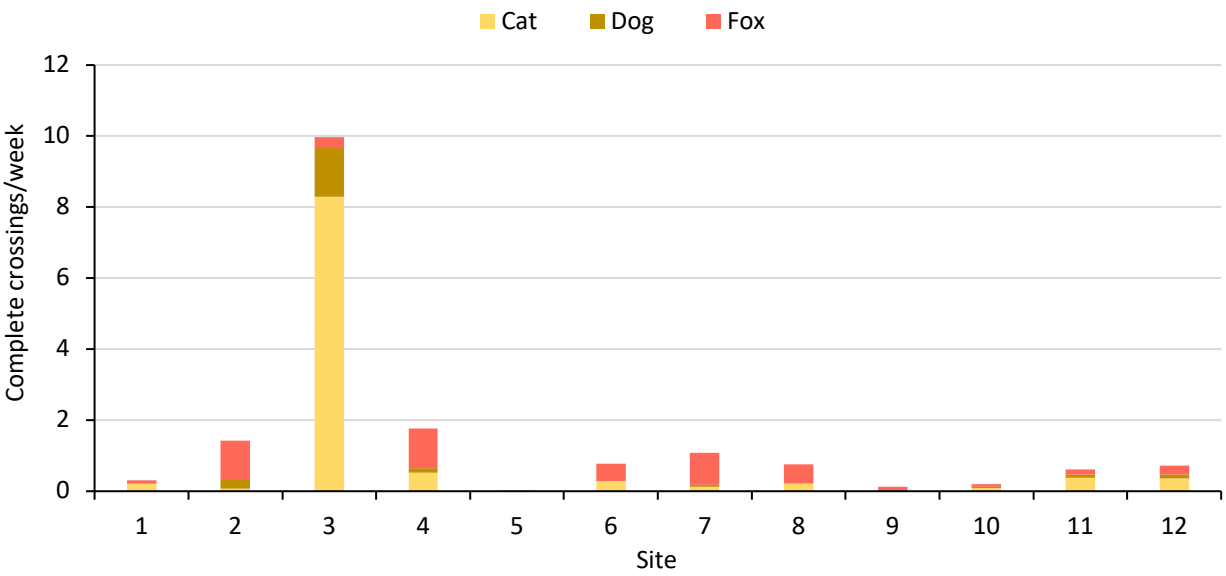

Figure 3: Complete crossings/week by feral predators (cat, red fox, dog) in underpasses during year 2 operational monitoring.

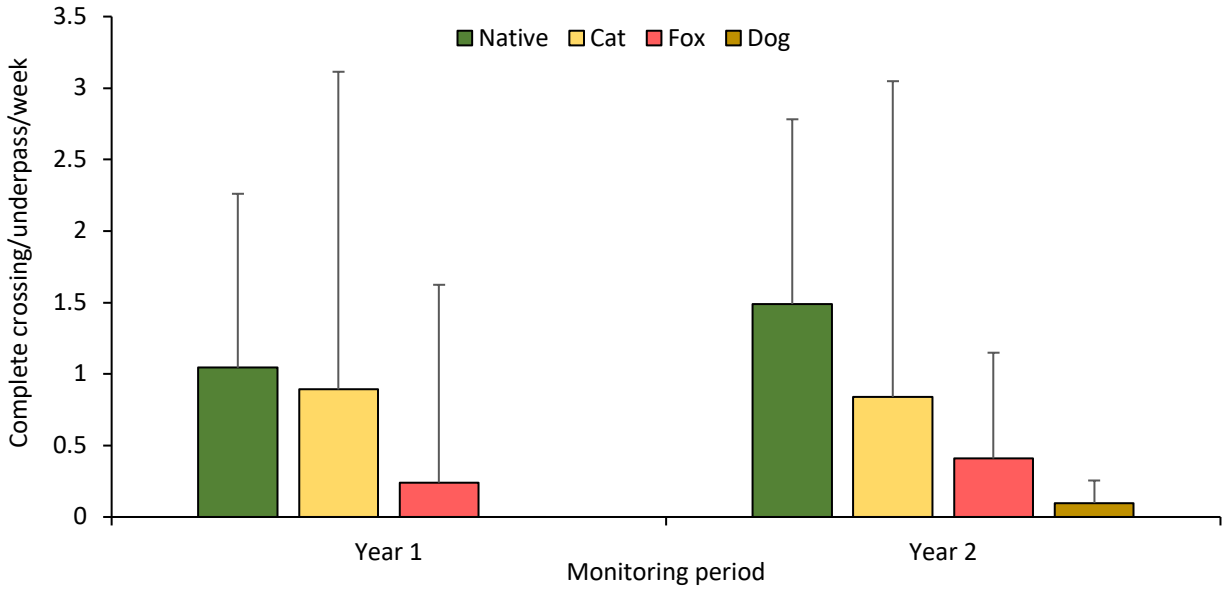

Figure 4. Mean (+SD) number of complete crossing/week/underpass for feral predator species (Cat, Dog, Red fox) during year 1 and year 2 monitoring periods.

Plate 4: Cat individual frequently recorded at site 3 (Top left). Dogs recorded at site 3 (Top right). Feral cat making a complete crossing east at site 7 (Bottom left). Feral dog making a complete crossing east at site 4 (Bottom right).

Use by cover dependent species with low mobility

Fauna with low mobility (see classification in methods) were recorded across all sites with the exception of site 1 (Table 5). In order of use, rodent spp were detected at a rate of 0.43cc/week/underpass, bandicoots 0.20cc/week/underpass and *Antechinus* spp 0.07cc/week/underpass (Figure 6). Rodent species were the most commonly recorded group with confirmed records of introduced black rat (sites 2 and 4-11) house mouse (site 5 and 9), swamp rat (sites 2 and 5), fauna-footed melomys (sites 4 and 7), bush rat (site 5) and water rat (site 5) (Table 5). Bandicoot use was prevalent at site 2 (0.94cc/week) while *Antechinus* spp records were relatively low with complete crossings made on furniture at sites 2, 4, 6 and 7 (Table 5). No cover dependent reptiles or frogs were recorded using underpasses during camera monitoring.

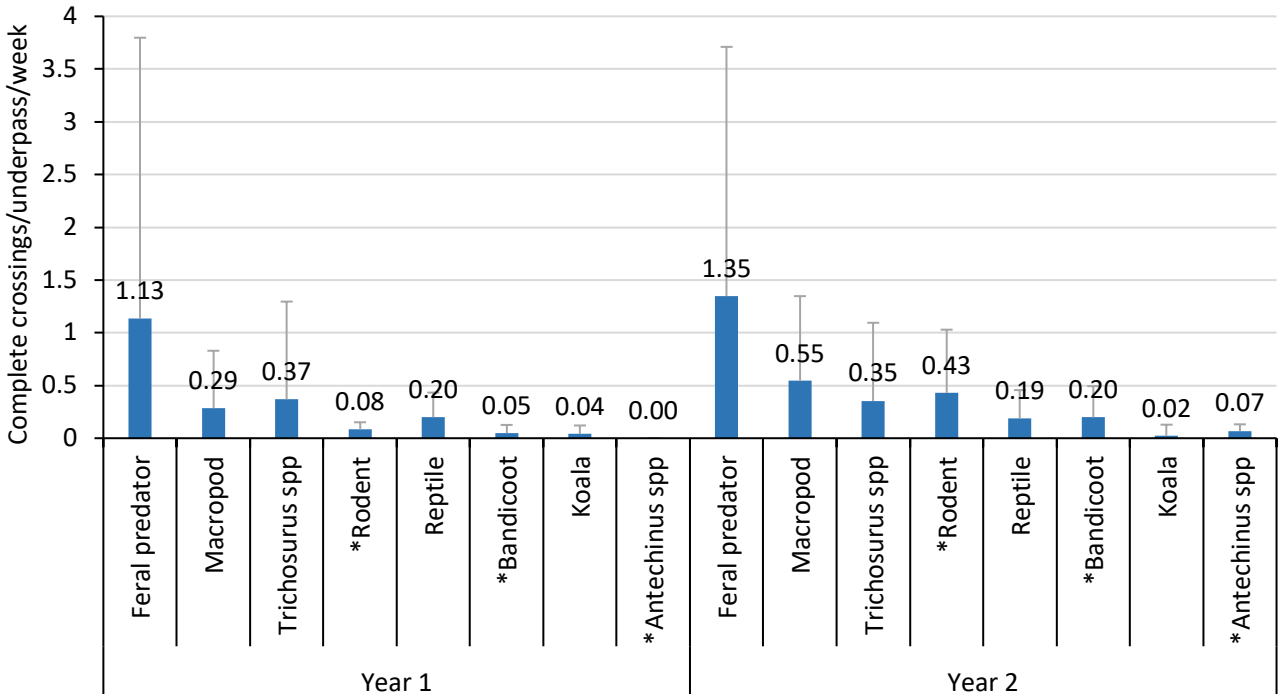

Figure 5: Mean (+SD) number of complete crossings/week/underpass for fauna groups during year 1 and year 2 operational monitoring. *Denotes cover dependent/low mobility species.

Furniture vs Floor

Fauna was recorded using both the culvert floor and furniture during operation phase monitoring (Figure 7). No fauna were recorded using fauna furniture at sites 10 and 12, and sites 1 and 5 did not contain furniture (Table 5). Use of the underpass floor was greater than use of furniture for natives, introduced rodents and feral predators (Figure 7). Furniture use was very low by feral predators, with complete crossings recorded by cat (none for dog or fox) at a rate of 0.02cc/week/underpass (1.2% of all cc by feral predators) (Figure 7, Table 5). Comparatively, 1/3 (31%) of native fauna crossings were completed on fauna furniture at a rate of 0.46cc/week/underpass and the remaining 69% on the culvert floor at a rate of 1cc/week/underpass during year 2 operation (Figure 7). *Trichosurus* spp and *Antechinus* spp, demonstrated preferential use of the fauna furniture accounting for a majority of crossings by native species on the furniture (Table 5, Plate 5). Koalas were recorded using the floor only (Table 5).

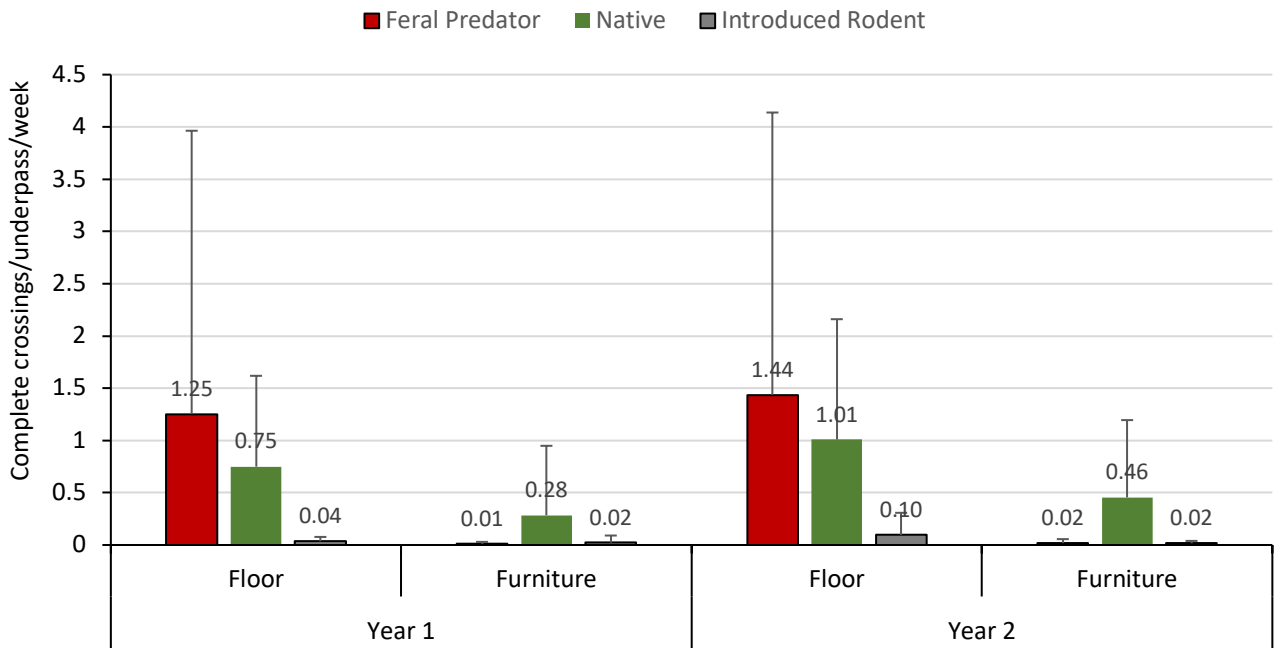

Figure 6: Mean (+SD) number of complete crossings/week/underpass for fauna groups using the culvert floor and furniture during year 1 and year 2 operational monitoring.

Plate 5: Antechinus making a complete crossing west using the fauna furniture at site 6 (Left). Short-eared brushtail possum utilising the fauna furniture at site 8.

3.1.2 Sand pads

Fauna recorded on sand pads largely complimented trends in the underpass camera data. Ten species and fauna groups were recorded on sand pads during monitoring (Appendix C, Table C3). As seen in camera data, species diversity was found to be highest at site 7 (10 species/groups). Rodent spp. was the most commonly recorded fauna group with tracks (incomplete and complete crossings) identified in all underpasses except sites 1 and 8. Koala was recorded making a complete crossing on two occasions at site 4 (Plate 6). Of the smaller fauna groups (small mammals, reptiles and amphibians), a small lizard was reported on one occasion at site 11 and *Antechinus* spp. was reported making three complete crossings at site 2. Sand pad records of feral predators were similar to camera data with cat, dog and red fox confirmed using the underpasses.

Plate 6: Koala tracks (L) recorded on sand pads at Site 4 and Brushtail possum tracks (R) recorded during spring/summer monitoring.

3.1.3 Scat and track searches and tile checks

Ten species, and ten fauna groups were recorded during scat and track surveys during year two monitoring (Appendix C. Table C2). Site 7 and 8 reported the highest diversity of fauna species with ten and nine fauna groups/species respectively (Table 6). Consistent to camera monitoring, sites 1, 11 and 12 report lower fauna diversity with six fauna groups/species or less (Appendix C, Table C2). Tracks or scats of rodents were found in eleven of the twelve culverts and was the most commonly recorded fauna across all sites (Table 6).

Native species/fauna groups were found to be using all culverts (Table 6). Wallaby spp. was recorded at ten sites with lace monitor at seven sites during spring/summer and bandicoot species reported at seven sites each (Table 6). Records of small fauna visitations to the underpasses included *Antechinus* spp. at sites 2,4,6,7, 10, 11 and 12, small and medium reptiles at sites 2, 3, 5 and 8, and a green-tree frog (*Litoria* spp.) scat was recorded at site 10 (Table 6, Appendix C, Table C3). Notably, koala tracks were recorded at site 4 on 28 November and at site 9/10 on 3 October (Appendix C, Table C3).

No fauna was recorded using tiles placed in underpasses.

3.2 Adjacent habitat

Thirty-four species and a further nine fauna groups were recorded in habitat adjoining underpasses (Table 6). The majority of species/groups (28 in total) were detected by diurnal and nocturnal active searches (Table 6, appendix C. Table C4&5). During

trapping surveys, a total of 14 species were identified while hair funnels reported a total of seven fauna groups and species (Appendix C, Table C6). Hair funnel analysis identified 6 species/groups using the adjacent habitat (Appendix C, Table C7). Several threatened species were recorded during spotlight surveys of adjacent habitat, including grey-headed flying fox (*Pteropus poliocephalus*) on 17 occasions, koala on the eastern side of site 4 and giant barred frog at site 1 (Appendix C, Table C5).

A total of 66 individuals were captured during the spring/summer survey and 85 individuals during winter (Appendix C, Table C6). Sugar glider, fawn-footed melomys and black rat were captured in arboreal Elliott traps (Plates 7 & 8). Eight species, two mammals, seven reptiles and two frogs were captured in pitfall traps, and five species including brown antechinus, sugar glider, fawn-footed melomys, bush rat and black rat were captured in ground Elliott traps.

During spring/summer trapping, fawn-footed melomys was the most commonly captured species, with 22 individuals, followed by brown antechinus (10 individuals); black rat (five individuals) and bush rat (three individuals). Remaining species and groups reported two individuals or less. Winter capture rates were highest for black rat (21 individuals), fawn-footed melomys (20 individuals), brown antechinus (16 individuals) and bush rat (10) (Appendix C. Table C6).

Table 7: Species of vertebrate recorded during surveys of adjacent habitat in spring/summer 2019. SS = Spring/Summer, W = Winter. * = Threatened species. $_E$= Endangered species. ⋆ denotes threatened species; $_I$ = Introduced species.

Species	Active Search		Spotlight		Ground Elliott trap		Arboreal Elliott trap		Cage trap		Pitfall trap		Hair funnel	
	SS	W	SS	W	SS	W	SS	W	SS	W	SS	WW	SS	W
Mammals														
Short-beaked echidna	*			*										
Brown antechinus					*						*			*
Antechinus spp.						*						*	*	
Northern brown bandicoot			*						*	*			*	
Long-nosed bandicoot			*										*	
Peramelidae spp. (bandicoot)	*	*	*											
Sugar glider			*	*	*		*	*						
Acrobates spp				*										
Koala*		*	*											
Short-eared brushtail possum									*	*				
Common brushtail possum														*
Trichosurus spp.													*	*
Common ringtail possum				*										
Wallaby spp.	*	*		*										
Swamp wallaby			*										*	
Macropodidae spp.			*											
Grey-headed flying red fox *			*	*										
Pteropus spp.			*											
Fawn-footed melomys					*	*	*	*				*	*	
Bush rat					*	*							*	*
House mouse $_I$						*					*			*
Black rat $_I$					*	*	*	*		*			*	*
Red fox $_I$	*	*												
Dog		*												
Cat $_I$		*	*											

Reptiles														
Burton's legless lizard	*													
Eastern water dragon	*	*	*											
Agamid spp.	*													
Ctenotus spp.		*												
Calyptotis ruficauda		*									*			
Lampropholis delicata											*			
Lampropholis spp.	*	*												
Yellow-faced whipsnake	*													
Dwarf Crowned Snake											*			
Swamp snake														
Blackish blind snake											*			
Black-bellied swamp snake	*										*			
Bandy-bandy			*											
Frogs														
Litoria fallax			*											
Litoria peronii			*											
Litoria tyleri														
Adelotus brevis	*		*											
Limnodynastes peronii			*									*		
Mixophyes iteratus [E]			*											
Crinia signifera		*	*	*										
Pseudophryne coriacea			*								*	*		
Total Nº. Species/groups	**11**	**11**	**20**	**7**	**5**	**5**	**3**	**3**	**2**	**3**	**8**	**4**	**7**	**6**

Plate 7: *Calyptotis ruficauda* captured in a pitfall trap (L) and a sugar glider (L) captured in an arboreal Elliott.

Plate 8: A short-eared brushtail possum captured in a cage trap (L) and a fawn-footed melomys captured in a ground Elliot (R) during adjacent habitat trapping.

3.2.1 Species recorded in underpasses and adjacent habitat

During year two monitoring 46 species and fauna groups were recorded in adjacent habitat and 34 in underpasses. Due to duplication between species and fauna groups (e.g. Macropodidae and wallaby spp. includes both red-necked and swamp wallaby) only confirmed species and unique genera have been included in the comparison between underpasses and adjacent habitat. Species that don't rely on underpasses to cross the alignment such as birds, flying-foxes and gliders have also been excluded. With the above exclusions 34 species and genera were confirmed using adjacent habitat and 22 species and genera were recorded using underpasses (Table 7). Red-necked wallaby, swamp rat, water rat, lace monitor, green tree frog were recorded in underpasses only (Table 7). If these species are assumed to also reside in adjacent habitat, the proportion of species in adjacent habitat that utilised underpasses in year two was 56% (Table 7). The proportion of mammals recorded in both adjacent habitat and underpasses was 90%. Green tree frog was the only species of amphibian reported using underpasses, while seven frog species were reported in adjacent habitat (Table 7). Further, of the 14 reptile species/families recorded during monitoring, only two (lace monitor and eastern water dragon) were confirmed using underpasses (Table 7).

Table 8: Species and genera recorded using underpasses and in adjacent habitat during year two monitoring. * denotes threatened species. $_E$= Endangered species; + = species assumed to occur based on presence in underpass.

Species	Adjacent habitat	Underpass
Mammals		
Short-beaked echidna	*	*
Brown antechinus	*	
Antechinus spp.	*	*
Northern brown bandicoot	*	*
Long-nosed bandicoot	*	*
Koala*	*	*
Short-eared brushtail possum	*	*
Common brushtail possum	*	*
Common ringtail possum	*	
Swamp wallaby	*	*
Red-neck wallaby	*	*
Fawn-footed melomys	*	*
Rodent spp.	*	*
Swamp rat	*	*
Water rat	*	*
Bush rat	*	*
House mouse [I]	*	*
Black rat [I]	*	*
Dog [I]	*	*
Red fox [I]	*	*
Cat [I]	*	*
Sub-total mammals	**21**	**19**
Retiles		
Burton's legless lizard	*	
Lace monitor	+	*
Eastern water dragon	*	*
Calyptotis ruficauda	*	
Lampropholis delicata	*	
Ctenotus spp	*	
Yellow-faced whipsnake	*	
Dwarf Crowned Snake	*	
Swamp Snake	*	
Blackish blind snake	*	
Black-bellied swamp snake	*	
Bandy-bandy	*	
Frogs		
Litoria fallax	*	
Litoria peronii	*	
Adelotus brevis	*	
Limnodynastes peronii	*	
Mixophyes iteratus [E]	*	
Crinia signifera	*	
Pseudophryne coriacea	*	
Green tree frog	+	*
Total No. Species/genus	**34**	**22**

3.3 Fauna fence and road strike

A total of 30 exclusion fence defects were recorded during the winter fence traverse (see appendix C, Table C8). Fifteen issues were considered minor priority, ten medium priority and four high priority (excluding gate which has since been closed). Minor issues included gaps where drains intersect the fence (8 issues) compromising the function of the exclusion fence and potentially enable fauna to breach the fence. Medium priority issues include instances where branches or trees are overhanging the exclusion fence. Four high priority issues identified included breach underneath the frog fence, substantial vegetation

growth over 100m of exclusion fence, a hole dug under the fence and above site 7 where a car had crashed into the exclusion fence (Appendix C, Table C8). An unlocked gate was also found at site 1 which was closed and locked.

No road-kill hot spots were identified adjacent to the underpasses or in sections with exclusion fencing (see road-kill report Sandpiper 2019e). In 2019, nine road-kills were recorded in the fenced area between sites 2 and 12, 66% of which were birds. Three road-kills were reported as small to medium mammals, which should have been excluded by the fence.

4. Discussion

4.1 Low rates of use of fauna underpasses and adjacent habitats by feral predators

Feral predators (combined cat, red fox and dog) recorded complete crossings in underpasses at an overall rate of 1.34 ± 2.67 cc/week/underpass. While what constitutes "low use" is not specified within the WC2NH EMP (RMS 2018), feral predators accounted for 47% of complete crossings with marginally lower rates than recorded for native species (1.49cc/week/underpass). This suggests that feral predators are readily using underpasses to transverse the alignment at a rate that is similar to native fauna.

Introduced predators are commonly encountered during underpass monitoring though their impact on use by native species remains equivocal (e.g. Fitzgerald 2005; Chambers & Bencini 2014; Taylor & Goldingay 2014). It is unknown if feral predators are capturing prey near underpass entrances or simply using underpasses to move through their home range. Given that no instances of predation were recorded, evidence suggests that feral predators are using underpasses to access habitat on both sides of the Pacific Highway. While no instances of predation were observed on camera footage, it is possible that either predation of or avoidance by native species is occurring at monitored underpasses.

Rates of feral predator underpass usage were not consistent throughout the study area. The high usage recorded at site 3 was due to complete crossings by one or two distinctive cats. Previous trapping has failed to capture the individuals, which are likely to be domestic cats from a neighbouring property. Site 2 also recorded relatively high use by fox and cat, which is attributed to the surrounding fragmented agricultural landscape and proximity to site 3. Records of fox were still recorded at all sites (highest at 2, 4, 6, 7, 8) cat 11 sites (highest at 3, 4, 11 and 12) and dog eight sites (highest at 2, 4, 6, 11 and 12). Use of site 4 by dog is of particular concern due to consistent records of koala during both spring/summer and winter 2019/20 and 2018/19 (Sandpiper Ecological 2019).

Despite the absence of statistically significant differences feral predator use increased from a mean of 1.13 ± 2.36 cc/week/underpass in year 1 to 1.34 ± 2.67 cc/week/underpass in year 2. While use by cat has remained relatively constant, red fox increased from 0.24 ± 0.45 to 0.41 ± 0.39 cc/week/underpass (63% increase) and dog increased from nil in year 1 to 0.1 ± 0.39 cc/week/underpass in year 2. These findings suggest that action may be warranted to prevent further increase in feral predator activity, in particular fox and dog. Due to the limited temporal coverage of sampling confirmation of increased activity in year 3 is warranted before control measures are implemented.

4.2 High levels of fauna underpass use by a variety of native species

Native species frequented underpasses at a rate of 1.49cc/week/underpass. A total of 16 native species/genera were recorded making complete crossings. Of the 39 species/genera (includes species recorded in underpasses only) recorded in the adjacent habitat 56% (22 species/genera) were recorded using underpasses. This result is broadly consistent with findings at Sapphire to Woolgoolga (23% to 50%) and slightly higher than the 38% and 42% recorded at NH2U in 2018 and 2019 (Sandpiper Ecological 2018a; 2019d, 2020).

Fauna furniture accounted for 31% of native fauna crossings at a rate of 0.46cc/week/underpass with the remaining 69% on the culvert floor at a rate of 1cc/week/underpass during year 2. *Trichosurus* spp and *Antechinus* spp, demonstrated preferential use of the fauna furniture accounting for the majority of crossings by native species on the furniture. In contrast, feral predators

tended to use the culvert floor with only limited use of furniture by cat. Despite no evidence of predation occurring in the underpasses, the furniture is likely to act as a refuge for native fauna, alleviating predation risk and encouraging underpass crossings by native species. These findings demonstrate that fauna furniture is an important feature in underpasses to facilitate complete crossings by some native species and highlight its importance in providing refuge from feral predators. Results are consistent with the findings of Goldingay *et al.* (2017).

Use of underpasses by koalas was consistent across years one and two sampling. Year one monitoring revealed rapid use of underpasses by koalas, with individuals recorded in five culverts. The number of culverts used in year two declined to three with a peak of 0.22 cc/week recorded at Site 4. Koala use of underpasses at WC2NH was quicker than recorded at other nearby sites. The speed of uptake is likely associated with the location of underpasses in relation to home ranges and importance of adjoining habitat.

The results obtained at WC2NH are encouraging and the number of species and frequency of use of the underpasses will likely increase over time (Gagnon *et al.* 2011). Increase in the use of underpasses by macropods, bandicoots and antechinus between year 1 and year 2 monitoring was apparent. However, this may be due to improved conditions during year 2 as year 1 was characterised by drought. Improved vegetation cover will be critical in attracting species with small home ranges, such as the common garden skink, eastern crevice skink and red-tailed skink that were reported using the adjacent habitat. Recent landscape plantings near the entrance of several underpasses will assist in providing such cover. Further, a reduction in the number of feral predators is likely to alleviate predation pressure and lead to increase use of underpasses by native species. To achieve this targeted control may be warranted, particularly at sites regularly used by koalas.

4.3 No change to densities, distribution, habitat use, and movement patterns compared to baseline population data of target species.

The target species for underpass monitoring, as outlined in the project brief, are spotted-tailed quoll, koala and giant barred frog. No spotted-tailed quolls were detected during year two, consistent with baseline monitoring (GeoLink 2014). Spotted-tailed quolls occur in low densities in northern NSW and the absence of records in underpasses is not unexpected.

Koalas occur in low densities in Nambucca State Forest and small numbers of individuals were recorded near the alignment during baseline (1 individual), construction phase (3 individuals), and year one operational phase (3 individuals) surveys (GeoLink 2014; Geolink 2017; Sandpiper Ecological 2019b).

Koalas were recorded using underpasses at sites 4, 9 and 10 during both sand pad and camera monitoring. However, there is no substantive baseline data to confirm if changes in habitat use and movement patterns have occurred. Results to date are encouraging as they suggest that koalas continue to maintain territory on both sides of the alignment.

Giant barred frogs were detected in adjacent habitat at site 1 but not recorded on underpass cameras. Riparian vegetation partially obstructed the camera field of view at site 1 in winter and new camera locations will be selected for year 3 monitoring. Notwithstanding, movement by giant barred frogs at site 1 is likely limited by the sparse riparian vegetation, and low activity in winter. Indeed, sampling giant barred frogs in winter is unlikely to provide useful data. Improved habitat connectivity beneath the Warrell Creek Bridge in conjunction with significant rainfall events and reduced human disturbance may increase giant barred frog movement beneath the highway. Further monitoring is required to confirm if the species can rebound to previous population levels (Sandpiper Ecological 2019c).

4.4 Evidence of use by dispersing individuals and different age cohorts

Accurately confirming age of individuals using underpasses is difficult using surveys methods outlined in the EMP. However, immature short-eared brushtail possums and juvenile swamp wallaby were regularly recorded making complete crossings at sites 2, 7, and 8. Other methods such mark-release-recapture would likely be required to provide definitive proof of use by dispersing individuals and different age cohorts. Such a survey would be expensive and is not warranted.

4.5 Use by cover-dependent species with low mobility

Several cover-dependent species (typically small mammals, small reptiles and frogs) were recorded in adjacent habitat, including eight frog species, three native mammals (brown antechinus, fawn-footed melomys and bush rat) and ten reptile species. Of these, only four (small reptile, antechinus, fawn-footed melomys and bush rat) were recorded using underpasses. Additional, cover dependent, small mammal species recorded in underpasses only were swamp rat, and water rat. Consistent with previous surveys there were limited records of reptiles and amphibians in underpasses. Low occurrence of frogs and reptiles is most likely due to the inability of cameras to detect these species as opposed to avoidance. This shortfall is assisted by the use of sand pads and scat and tracks searches to detect smaller fauna. Sand pads captured tracks of a small reptile at site 12 and scat searches recorded frog scat at Site 10. Further, while the floor tiles installed during winter monitoring did not increase detection of cover dependent species, activity of reptiles and frogs is typically low during winter and improved detection may occur during spring/summer monitoring.

Whilst frogs and reptiles are consistently recorded using underpasses at a low frequency there is substantial evidence that this is due to sampling method and revegetation of culvert entrances rather than avoidance. For example, Sandpiper Ecological (2018c) using time lapse photography recorded four species of frog and eight species of reptile using pipe culverts on the S2W upgrade and both *Litoria barringtonensis* and *L. gracilenta* have been recorded in culverts at Butchers Creek on the WC2Nh upgrade. Use of underpasses by cover dependent species, such as antechinus, is likely to improve as landscape plantings at culvert entrances grow to provide cover between the forest edge and culvert entrance.

4.6 No breaches in fauna exclusion fencing; Low incidences of fauna road strike mortality.

A total of 30 exclusion fence defects were recorded during the winter fence traverse. Gaps were commonly identified where drains intersect the fence (8 issues) compromising the function of the exclusion fence and potentially enabling fauna to breach the fence. Vegetation (vines) was identified on one occasion growing up the fence (Appendix C, Table C8). An unlocked gate was found and subsequently closed upon inspection. Gates have been implicated as a potential cause in the road-kill deaths of koalas on Nambucca Heads to Urunga upgrade (NH2U) and Section 11 of the Woolgoolga to Ballina (W2B) upgrade. In general, the exclusion fence was in good condition. A recent observation of a koala within the road corridor suggests that fauna may push under loose wire beneath gates. This finding suggests that a koala actively seeking to move through the exclusion fence could breach a gate that may appear secure. In that instance TfNSW immediately repaired the loose wire.

No road-kill hot spots were identified adjacent to the underpasses or in sections with exclusion fencing (see Sandpiper 2019e). Nine road-kills were recorded between sites 2 and 12 during 2019, 66% of which were birds. Three were reported as small to medium mammals, which should have been excluded by the fence. Access for these individuals may have been via drains where the metal screen was blocked by sticks.

4.7 Underpass survey effort and methods

Underpass survey effort was compromised due to theft of all cameras at sites 1, 2, 3 and 6 during the spring/summer sample. Battery failure and camera malfunction reduced effort during the winter sample at a small number of sites. Removal of defective cameras and changing camera orientation will be applied to reduce the incidence of false triggers in year three sampling. To reduce the incidence of malfunction and maximise monitoring days, camera operation will in future be checked opportunistically while conducting other work nearby. This will involve checking the infrared flash when passing through the underpasses. Any cameras that do not show an active infrared flash will be inspected more closely.

Records from sand pad checks largely complimented UP camera data. Discerning tracks on sand pads contributes substantially to the inclusion of broad groups such as small reptile and macropod spp. However, sand pads may better detect smaller fauna groups, which can evade camera activation. For instance, a small reptile (site 11) and *Antechinus* spp (site 2) were recorded using the culvert floor without being recorded by the cameras. Further, sand pads have demonstrated moderate persistence in

underpass allowing for longer-term monitoring of tracks. This is beneficial when conducting scat and tracks surveys and noting opportunistic records (crossings) that may occur outside of camera or sand pad monitoring periods.

5. Contingency Measures and Recommendations

5.1 Contingency Measures

Contingency measures are summarised in Table 8.

Table 9: Potential problems outlined in the EMP and possible contingency measures. Mitigation measures applicable to the project are addressed in bold text in table below.

Problem	Contingency/Corrective Action	Proposed action
High rates of feral predator activity;	Control program	• Consider need for control programs targeting fox and dog (in particular at site 4). • Discuss alternative methods of cat capture/removal at site 3 with TfNSW
Low levels of native fauna movement and species diversity in underpasses;	Modify habitat structure near underpass entrances and/or modify underpass fauna furniture	Revegetation work has already occurred – no further action required.
No use of underpasses by cover-dependent species or species with low mobility or target threatened species	Modify or add potential groundcover resources	Continue with monitoring of tiles leading into year 3-spring/summer sample.
High rates of fauna road mortality.	Modify exclusion fencing design, location or extent depending on the species and location of mortalities	At this stage of monitoring no modifications to exclusion fence design or extent is recommended.

5.2 Recommendations

Recommendations are summarised in Table 9.

Table 10: Recommendations based on findings from year two operational phase monitoring and response from TfNSW.

Number	Recommendation	Transport for NSW Response
1.	Assess options to control canids at sites regularly used by koalas. The spring/summer year 3 sample should be used to confirm if canid use of underpasses remains high. If monitoring shows high canid activity at key sites (i.e. those used regularly by koala) then TfNSW should consult Local Land Services to identify opportunities to link with other control programs in the locality.	With the assistance of Local Land Services (LLS), TfNSW commenced targeted feral dog baiting and cat trapping in May 2019. Further meetings with LLS have resulted in TfNSW being included as a participant in co-ordinated predator pest baiting programs,

		where LLS has the option to place baits in culverts as part of wider baiting efforts involving other stakeholders. Baiting programs are proposed to take place twice per year at peak predator pest activity times. LLS are aiming to have all stakeholders bait at the same time to maximise impact on predator species including feral dogs, foxes and cats.
2.	Sandpiper Ecological to investigate alternative methods to control cats at sites 2 and 3	Agree and adopted
3.	Continue monitoring of tiles in underpasses during year 3	Agree and adopted
4.	At site 1 (Upper Warrell Creek), undertake an additional 6-8 weeks of camera monitoring in autumn (March/April), commencing in autumn year 3 (2021).	Agree and adopted

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Appendix A – Species list

Table A1: Common and scientific names for all species recorded during year two monitoring at WC2NH. ^ = Threatened species.

Common Name	Scientific Name
Koala^	*Phascolarctos cinereus*
Swamp wallaby	*Wallabia bicolor*
Red-necked wallaby	*Macropus rufogriseus*
Wallaby spp.	
Eastern grey kangaroo	*Macropus giganteus*
	Macropodidae spp.
Short-beaked echidna	*Tachyglossus aculeatus*
Yellow-bellied glider^	*Petaurus australis*
Sugar glider	*Petaurus breviceps*
	Petaurus spp.
Feathertail glider	*Acrobates pygmaeus*
Short-eared brushtail possum	*Trichosurus caninus*
Common brushtail possum	*Trichosurus vulpecula*
Brushtail possum spp.	*Trichosurus spp.*
Common ringtail possum	*Pseudocheirus peregrinus*
Northern brown bandicoot	*Isoodon macrourus*
Long-nosed bandicoot	*Perameles nasuta*
Bandicoot species	*Peramelidae spp.*
Fawn-footed melomys	*Melomys cervinnipes*
	Melomys spp.
Water rat	*Hydromys chrysogaster*
Bush rat	*Rattus fuscipes*
Murid spp.	*Muridae spp.*
Brown antechinus	*Antechinus stuartii*
	Antechinus spp.
Long-nosed potoroo^	*Potorous tridactylus*
Grey-headed flying red fox^	*Pteropus poliocephalus*
Flying red fox spp.	*Pteropus spp.*
Bent-wing spp.	*Miniopterus spp.*
Small mammal spp.	
	Dasyuridae spp.
Eastern crevice skink	*Egernia mcpheii*
Garden skink	*Lampropholis delicata*
Grass skink	*Lampropholis guichenoti*
	Lampropholis spp.
Red-tailed calyptotis	*Calyptotis ruficauda*
Eastern water-skink	*Eulamprus quoyii*
Three-toed skink	*Saiphos equalis*
Skink spp.	*Scincidae spp.*
Coastal carpet python	*Morelia spilota*
Red-bellied black snake	*Pseudechis porphyriacus*
Yellow-faced whipsnake	*Demansia psammophis*
Black-bellied swamp snake	*Hemiaspis signata*
Blackish blind snake	*Anilios nigrescens*
Bandy bandy	*Vermicella annulata*
Coastal carpet python	*Morelia spilota*
Burton's legless lizard	*Lialis burtonis*
Lace monitor	*Varanus varius*
Eastern water dragon	*Intellagama lesueurii*

	Agamid spp.
Freshwater turtle spp.	*Chelidae spp.*
Medium reptile spp.	
Small reptile spp.	
Small snake spp.	
Pacific black duck	*Anas superciliosa*
Pheasant coucal	*Centropus phasianinus*
Intermediate egret	*Ardea intermedia*
Tawny frogmouth	*Podargus strigoides*
Owlet-nightjar	*Aegotheles*
Common Name	Scientific Name
Little eagle^	*Hieraaetus morphnoides*
Eastern osprey^	*Pandion haliaetus*
Glossy Black Cockatoo^	*Calyptorhynchus lathami*
White-throated treecreeper	*Cormobates leucophaea*
Green catbird	*Ailuroedus crassirostris*
Eastern yellow robin	*Eopsaltria australis*
Eastern whipbird	*Psophodes olivaceus*
Water bird spp.	
Medium bird spp.	
Small bird spp.	
Eastern dwarf tree frog	*Litoria fallax*
Tyler's tree frog	*Litoria tyleri*
Red-eyed tree frog	*Litoria chloris*
Green tree frog	*Litoria cerulea*
Dusky toadlet	*Uperolia fusca*
	Uperolia spp.
Tusked frog	*Adelotus brevis*
Common eastern froglet	*Crinia signifera*
Great barred frog	*Mixophyes fasciolatus*
Giant barred frog^	*Mixophyes iteratus*
Striped marsh frog	*Limnodynastes peronii*
Red-backed toadlet	*Pseudophryne coriacea*
Medium frog spp.	
Frog spp.	
Cat	*Felis catus*
Red red fox	*Vulpes vulpes*
Black rat	*Rattus rattus*
European hare	*Lepus europaeus*
House mouse	*Mus musculus*

Appendix B – Weather and climatic conditions

Table B1: Weather during the year 2 monitoring period. Rainfall taken from the BOM weather station at Bellwood (059150). Air temperature, wind and relative humidity collected from Coffs Harbour Airport (station 059151).

Date	MINIMUM Air Temperature (°C)	MAXIMUM Air Temperature (°C)	TOTAL Rain Gauge (mm)	AVERAGE Wind Direction DESCRIPTION	MAXIMUM Wind Speed (km/h)	9am Relative Humidity (%)
22/09/2019	18	26.7	0	SE		64
23/09/2019	16	22	4	SE	26	90
24/09/2019	11.2	20.7	0	SW	30	58
25/09/2019	11.8	22	0	NE	39	61
26/09/2019	14.1	22.7	0	NE	54	89
27/09/2019	10.9	25.3	0	NNE	37	72
28/09/2019	10.4	28.3	0	SSW	57	32
29/09/2019	9.7	21.5	0	NE	35	62
30/09/2019	11.8	22	0	SE	41	73
1/10/2019	13.9	20.7	4	SSE	31	81
2/10/2019	12.1	22.3	0	NE	41	54
3/10/2019	14.2	24.1	0	NE	46	54
4/10/2019	11.7	25.5	0	NE	46	44
5/10/2019	16.7	21.7	0	SW	48	76
6/10/2019	16.6	23.5	0			73
7/10/2019	15.7	28.4	0	NE	41	63
8/10/2019	14.3	22.3	0	SSW	46	96
9/10/2019	9.1	21	0	SSE	50	43
10/10/2019	12.4	20.9	0	SW	44	54
11/10/2019	10.4	19.3	0	ESE	31	82
12/10/2019	11.5	18.5	14	SW	31	83
13/10/2019	12.7	21	6	SW	43	77
14/10/2019	10.2	22.2	7	NE	37	64
15/10/2019	14.7	25.4	0	NE	46	77
16/10/2019	15.3	26.6	0	S	69	65
17/10/2019	18.3	32.8	7	NNW	50	73
18/10/2019	12.1	23.2	0	SSW	31	32
19/10/2019	13	25	0	NNE	33	60
20/10/2019	14.7	22.6	0	SW	54	59
21/10/2019	10.9	22.1	0	SE	28	62
22/10/2019	10	22.8	0	ESE	26	59
23/10/2019	12	24.3	0	NE	44	68

24/10/2019	13.8	25.2	0	NNE	54	57
25/10/2019	14.1	26.3	0	NE	56	56
26/10/2019	18.4	28.7	0	NNE	63	44
27/10/2019	16.5	23.9	0	SW	37	55
28/10/2019	12.5	24.3	0	ESE	28	67

Date	MINIMUM Air Temperature (°C)	MAXIMUM Air Temperature (°C)	TOTAL Rain Gauge (mm)	AVERAGE Wind Direction DESCRIPTION	MAXIMUM Wind Speed (km/h)	9am Relative Humidity (%)
29/10/2019	12.7	24.4	0	NE	44	60
30/10/2019	17.4	26	0	NNE	54	63
31/10/2019	15.9	25	0	NNE	52	61
1/11/2019	17.1	24.9	0	NE	48	58
2/11/2019	17.4	25.4	0	NNE	54	62
3/11/2019	18.9	27.8	0	NNE	72	60
4/11/2019	19.1	28.8	2	N	33	59
5/11/2019	13.9	22	0	S	65	71
6/11/2019	12.4	24.4	3	N	35	48
7/11/2019	10.9	30.2	0	NE	48	34
8/11/2019	12	34.3	0	WSW	44	19
9/11/2019	17.3	22.4	0	S	63	52
10/11/2019	6.7	24.9	0	ENE	33	31
11/11/2019	10.6	23.8	0	NE	41	66
12/11/2019	16.1	30.3	0	NE	54	55
13/11/2019	13.4	23.1	0	S	57	66
14/11/2019	13.3	24.1	0	SE	22	68
15/11/2019	14.7	26.3	0	NNE	48	69
16/11/2019	11.2	24.8	0	SW	41	57
17/11/2019	15.1	24.4	0	WSW	54	73
18/11/2019	14.5	24.4	0	NE	44	69
19/11/2019	16.7	26.5	0	N	39	54
20/11/2019	16.2	25.7	0	SSW	37	57
21/11/2019	17.7	27.6	0	NNE	70	68
22/11/2019	20.6	32	0	NNE	70	42
23/11/2019	20.5	26.1	0	NNE	61	65

24/11/2019	17.7	25.8	0	NNE	37	75
25/11/2019	20.7	27.3	0	NNE	67	67
26/11/2019	17.7	31.2	0	NNE	61	59
27/11/2019	18.2	24.2	1	S	48	43
28/11/2019	14.6	25.6	0	NE	50	65
29/11/2019	21	27.7	0	NE	61	81
30/11/2019	21.4	30.3	0	SW	72	74
1/12/2019	19.9	27.5	16	NE	35	78
2/12/2019	18.7	31.2	6	WSW	65	56
3/12/2019	12.6	25.8	0	NNE	54	27
4/12/2019	10.5	27.4	0	NNE	43	31
5/12/2019	11.8	30	0	NE	30	44
6/12/2019	11.8	34.1	0	NNE	43	26
7/12/2019	14.3	26.2	0	S	41	55
8/12/2019	13.8	26.8	0	ESE	28	67

Date	MINIMUM Air Temperature (°C)	MAXIMUM Air Temperature (°C)	TOTAL Rain Gauge (mm)	AVERAGE Wind Direction DESCRIPTION	MAXIMUM Wind Speed (km/h)	9am Relative Humidity (%)
9/12/2019	16.4	27.7	0	NE	50	67
10/12/2019	23.3	29.5	0	NNE	57	66
11/12/2019	21.8	24	0	N	54	86
12/12/2019	21	25.8	0	SSW	35	79
13/12/2019	19.3	24	7	SSE	35	95
14/12/2019	19.3	27.2	0	WSW	30	77
15/12/2019	19.2	28.4	0	NNE	37	74
16/12/2019	17.6	28.6	0	S	61	50
17/12/2019	18.3	25.6	0	SW	37	60
18/12/2019	16	25.7	0	ENE	35	56
19/12/2019	19.1	28.7	0	NNE	63	54
20/12/2019	18.8	27.2	0	WSW	35	72
21/12/2019	17.9	27.6	0	NNE	56	67
22/12/2019	21.9	25.5	0	S	57	85
23/12/2019	19.5	27.3	0	WSW	39	65
24/12/2019	21.7	27.4	1	NE	48	79

25/12/2019	20.7	25.9	8	ESE	33	81
26/12/2019	16.9	26.4	4	E	28	93
27/12/2019	16.9	27.4	0	E	31	58
28/12/2019	15	27.8	0	NE	43	53
29/12/2019	18.3	29.3	0	NE	54	55
30/12/2019	20.9	28.8	0	NNE	59	58
31/12/2019	21.6	30	0	NNE	69	55
1/01/2020	22	28.3	0	NNE	67	64
2/01/2020	20.9	28.3	0	NE	46	67
3/01/2020	21.9	28	0	NNE	54	65
4/01/2020	21.5	29.2	0	NNE	63	57
5/01/2020	21.5	28	0	SSW	57	68
6/01/2020	21.5	28.1	0	SSW	35	69
7/01/2020	22.6	29.4	0	NE	44	71
8/01/2020	22.7	30.7	0	NE	56	59
9/01/2020	20.5	30	0	ENE	37	61
10/01/2020	20.1	30.1	0	NNE	67	63
11/01/2020	25	34.5	0	SSE	54	61
12/01/2020	19.2	26.2	3	SSE	41	92
13/01/2020	18.2	27.3	0	S	31	66
14/01/2020	19.2	26.4	0	SW	28	74
15/01/2020	20.5	28.5	0	ENE	26	83
16/01/2020	23.6	30.5	0	NE	54	67
17/01/2020	20.7	24.9	4	NNE	35	83
18/01/2020	20.7	24.4	12	WSW	26	91

Date	MINIMUM Air Temperature (°C)	MAXIMUM Air Temperature (°C)	TOTAL Rain Gauge (mm)	AVERAGE Wind Direction DESCRIPTION	MAXIMUM Wind Speed (km/h)	9am Relative Humidity (%)
19/01/2020	20.5	28.9	85	NNE	41	87
20/01/2020	22.9	33	0	NW	61	66
21/01/2020	22.6	30.7	0	NE	48	62
22/01/2020	21.5	29.7	0	NNE	41	71
23/01/2020	23.6	33.6	0	NNE	63	69
24/01/2020	23.5	31.2	0	NNE	48	80

25/01/2020	21	30.4	0	N	39	77
26/01/2020	23.6	29	0	NNE	59	70
27/01/2020	24.2	29.3	0	NNE	48	65
28/01/2020	23.6	29.6	0	NNE	57	65
29/01/2020	21.3	28.7	0	S	37	76
30/01/2020	23.6	28.8	0	NNE	31	76
31/01/2020	24.6	30	0	NNE	54	63
1/02/2020	23.6	30.8	0	NNE	63	63
2/02/2020	24.1	33.3	0	NE	59	65
3/02/2020	21.5	35.3	10	S	81	73
4/02/2020	20.2	21.8	3	SSW	61	74
5/02/2020	18.9	24.2	0	WSW	26	72
6/02/2020	19.1	25.4	2	E	48	92
7/02/2020	19.3	28.1	69	ENE	43	85
8/02/2020	21.1	25.9	6	SSE	30	92
9/02/2020	21.1	24.3	95	ENE	52	95
10/02/2020	21	28.7	59	NNE	50	88
11/02/2020	20.5	27.1	35	ENE	41	92
12/02/2020	20.6	25.4	32	NE	41	93
13/02/2020	21.5	26.6	42	ESE	35	94
14/02/2020	21	27.2	6	SSW	39	93
15/02/2020	18.6	29	0	NE	28	71
16/02/2020	22.2	26.5	1	S	33	89
17/02/2020	22.4	29.5	0	SW	63	93
18/02/2020	19.1	31.4	13	NE	50	70
19/02/2020	24.4	35.5	0	SSW	39	73
20/02/2020	21	27.8	3	SSE	31	58
21/02/2020	19.9	26.7	0	ESE	28	71
22/02/2020	19.6	25.5	3	WSW	28	92
23/02/2020	18.4	24.6	13	S	22	88
24/02/2020	19.2	24.5	58	SSW	22	95
25/02/2020	19.8	27.7	20	ENE	30	81
26/02/2020	19.7	30.3	0	NNE	44	69

27/02/2020	18.7	28.7	1	SSW	41	76
28/02/2020	19.2	28.6	0	SSW	43	78

Appendix C – Field data

Table C 1: Underpass camera data recorded during spring/summer and winter of year two operational monitoring WC2NH, 2020.

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
12 (west)	G	10/10/2019	0139	Black Rat	Complete	E	Pr	17	
12 (west)	G	10/10/2019	0438	Cat	Complete	W	D	19-20	black cat
12 (west)	G	12/10/2019	2217	house mouse	Complete	E	Pr	28	
12 (west)	G	13/10/2019	2153	Cat	Complete	E	D	29-30	tabby
12 (west)	G	15/10/2019	0201	Black Rat	Complete	E	Pr	42	
12 (west)	G	15/10/2019	2006	Black Rat	Complete	W	D	86	
12 (west)	G	18/10/2019	0306	house mouse	Complete	E	Pr	111	
12 (west)	G	18/10/2019	2332	Black Rat	Complete	E	D	152-153	
12 (west)	G	20/10/2019	1946	Black Rat	Complete	W	D	165	
12 (west)	G	22/10/2019	2327	Black Rat	Complete	E	D	13	
12 (west)	G	5/11/2019	2350	Black Rat	Complete	E	D	23	
12 (west)	G	6/11/2019	1948	Black Rat	Complete	W	D	28	
12 (west)	G	7/11/2019	0047	Cat	Complete	E	D	29	
12 (west)	G	7/11/2019	0447	Black Rat	Complete	E	D	30	
12 (west)	G	7/11/2019	1946	Black Rat	Complete	W	D	35	
12 (west)	G	11/11/2019	2140	Black Rat	Complete	W	Pr	52	
12 (west)	G	12/11/2019	1006	EW dragon	Complete	W	D	53	
12 (west)	G	12/11/2019	1956	Black Rat	Complete	W	D	55	
12 (west)	G	13/11/2019	0022	Black Rat	Complete	E	D	56	
12 (west)	G	17/11/2019	0103	Black Rat	Complete	E	Pr	63	
12 (west)	G	17/11/2019	2200	Black Rat	Complete	W	D	64	
12 (west)	G	17/11/2019	2259	Black Rat	Complete	E	D	65	
12 (west)	G	18/11/2019	2010	Black Rat	Complete	W	D	66	
12 (west)	G	19/11/2019	0148	Black Rat	Complete	E	D	67	
12 (west)	G	26/11/2019	2308	Black Rat	Complete	E	D	9	
12 (west)	G	2/12/2019	0015	Black Rat	Complete	E	D	20	
12 (west)	G	2/12/2019	2049	Black Rat	Complete	E	D	24	
12 (west)	G	6/12/2019	0144	Black Rat	Complete	E	D	34	
12 (west)	G	7/12/2019	0123	Black Rat	Complete	E	D	37-38	
12 (west)	G	14/12/2019	0158	Black Rat	Complete	E	D	45	
12 (west)	G	14/12/2019	2252	Northern brown bandicoot	Complete	E	Pr	46-47	
12 (west)	G	21/06/2020	2103	Cat	Complete	E	D	9-10	Tabby

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
12 (west)	G	24/06/2020	0303	Fox	Incomplete	W-E	D	16-18	
12 (west)	G	25/06/2020	2218	Cat	Complete	E	D	23	Tabby (likely same individual)
12 (west)	G	4/07/2020	2151	Fox	Complete	E	D	24	
12 (west)	G	6/07/2020	0532	Swamp wallaby	Complete	E	D	25	
12 (west)	G	15/07/2020	0042	Fox	Complete	E	D	30	
12 (west)	G	16/07/2020	2204	Bandicoot	Complete	E	D	32	
12 (west)	G	18/07/2020	1928	Cat	Complete	W	D	35	Black cat
12 (west)	G	20/07/2020	0118	Cat	Complete	W	D	36	Tabby
12 (west)	G	16/07/2020	2204	Northern brown bandicoot	Complete	E	D	32	
12 (west)	G	25/07/2020	0032	Bandicoot spp	Complete	E	D	56	
12 (west)	G	26/07/2020	0013	Cat	Complete	W	D	57	black cat
12 (west)	G	26/07/2020	0133	Fox	Complete	W	D	58	
12 (west)	G	28/07/2020	2152	house mouse	Complete	E	D	13	
12 (west)	G	29/07/2020	1906	Cat	Complete	E	D	14	Tabby
12 (west)	G	30/07/2020	1247	Fox	Complete	W	D	15	
12 (west)	G	9/08/2020	2041	Cat	Complete	E	D	16	Tabby
12 (west)	G	12/08/2020	1215	Dog	Incomplete	E-W	D	18-19	Dark Brown
12 (west)	G	12/08/2020	2254	Cat	Complete	W	D	22	Tabby
12 (west)	G	13/08/2020	1009	Dog	Complete	E	D	23	Dark Brown
12 (west)	G	14/08/2020	2317	Northern brown bandicoot	Complete	W	D	26	
12 (west)	G	14/08/2020	2332	Cat	Complete	W	D	27	Black Cat
12 (west)	G	15/08/2020	0158	Northern brown bandicoot	Complete	E	D	28	
12 (west)	G	16/08/2020	2205	Bandicoot spp	Complete	E	D	30	
12 (west)	G	17/08/2020	1942	Bandicoot spp	Complete	W	D	31	
12 (west)	G	17/08/2020	2048	Bandicoot spp	Complete	E	D	32	
12 (west)	G	19/08/2020	0759	Dog	Complete	E	D	33	
12 (west)	G	24/08/2020	1102	Dog	Complete	E	D	34	
12 (west)	G	27/08/2020	2119	Fox	Complete	W	D	40	
12 (west)	G	27/08/2020	2202	Cat	Complete	E	D	41	
12 (west)	G	29/08/2020	0245	Fox	Complete	E	D	43	
12 (west)	G	31/08/2020	0537	Fox	Complete	E	D	44	
12 (west)	G	1/09/2020	0345	Fox	Complete	W	D	45	
11 (East)	FF	17/12/2019	0041	Black Rat	Complete	E	D	61	
11 (East)	FF	24/06/2020	2357	Rodent spp	Complete	E	D	11-23	Several crossings back and forth
11 (East)	FF	26/10/19	0433	Cat	Complete	E	D	69	tabby
11 (East)	G	20/11/2019	nil						
11 (East)	G	10/10/2019	0435	Cat	Complete	W	D	29	black cat

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
11 (East)	G	13/10/2019	2155	Cat	Complete	E	D	32	tabby
11 (East)	G	26/10/2019	0430	Cat	Complete	W	D	37	
11 (East)	G	7/11/2019	0049	Cat	Complete	E	D	84-85	
11 (East)	G	8/11/2019	1545	EW Dragon	Complete	E	Pr	105	
11 (East)	G	29/07/2020	1909	Cat	Complete	E	D	10	Tabby
11 (East)	G	30/07/2020	0246	Fox	Complete	E	D	11	
11 (East)	G	4/08/2020	2033	Cat	Complete	E	D	12-13	Tabby
11 (East)	G	4/08/2020	2039	Cat	Complete	E	D	14	Tabby
11 (East)	G	9/08/2020	2045	Cat	Complete	E	D	16	Tabby
11 (East)	G	12/08/2020	2251	Cat	Complete	E	D	30	Tabby
11 (East)	G	13/08/2020	1010	Dog	Complete	E	D	31	Dark Brown
11 (East)	G	14/08/2020	2318	Cat	Complete	E	D	33	Black Cat
11 (East)	G	15/08/2020	0158	Bandicoot	Complete	E	D	34	
11 (East)	G	16/08/2020	2206	Bandicoot	Complete	E	D	36	
11 (East)	G	17/08/2020	2049	Bandicoot	Complete	E	D	38	
11 (East)	G	19/08/2020	0800	Dog	Complete	E	D	39	Dark Brown
11 (East)	G	24/08/2020	1143	Dog	Complete	E	D	41	Dark Brown
11 (East)	G	27/08/2020	2118	Fox	Complete	W	D	51	
11 (East)	G	27/08/2020	2205	Cat	Complete	E	D	52-54	Tabby
11 (East)	G	29/08/2020	0246	Fox	Complete	E	D	59	
11 (East)	G	31/08/2020	0431	Swamp wallaby	Complete	E	D	61	
11 (East)	G	31/08/2020	0537	Fox	Complete	E	D	62	
11 (East)	G	1/09/2020	0344	Fox	Complete	W	D	63	
10 (west)	FF			Nil (Summer)					
10 (west)	G	26/10/2019	2219	SEBtP	Incomplete	E-W	Pr	41,43-44	
10 (west)	G	27/10/2019	2055	Black Rat	Complete	W	D	45	
10 (west)	G	7/11/2019	0109	SEBtP	Complete	W	Pr	75	
10 (west)	G	25/11/2019	2220	Black Rat	Incomplete	EXM	D	11-14, 16	
10 (west)	G	13/10/2019	2219	cat	Complete	E	D	19	tabby
10 (west)	G	21/10/2019	1314	EW Dragon	Complete	E	Pr	142	
10 (west)	G	21/10/2019	1457	Lace Monitor	Complete	E	D	11	
10 (west)	G	22/10/2019	1321	Lace Monitor	Complete	W	D	24	
10 (west)	G	24/10/2019	2233	Bandicoot spp.	Incomplete	W-E	D	31-32	
10 (west)	G	25/10/2019	1443	Lace Monitor	Complete	E	D	40	
10 (west)	G	28/10/2019	0220	Bandicoot spp	Complete	W	D	42	
10 (west)	G	31/10/2019	0446	Black Rat	Complete	E	D	46	
10 (west)	G	31/10/2019	1254	Lace Monitor	Complete	E	D	47	
10 (west)	G	1/11/2019	2329	Btposs spp	Complete	W	D	49	

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
10 (west)	G	7/11/2019	0255	Northern brown bandicoot	Complete	W	Pr	55	
10 (west)	G	8/11/2019	0159	Bandicoot spp	Complete	W	D	58	
10 (west)	G	9/11/2019	0404	Cat	Complete	W	D	61	tabby
10 (west)	G	9/11/2019	2242	Koala	Complete	W	D	63	
10 (west)	G	12/11/2019	0311	Bandicoot spp	Complete	W	D	67	
10 (west)	G	13/11/2019	0139	Bandicoot spp	Complete	W	D	77	
10 (west)	G	16/11/2019	0106	Bandicoot spp	Complete	W	D	80	
10 (west)	G	18/11/2019	1158	Lace Monitor	Complete	W	D	93	
10 (west)	G	19/11/2019	0210	Bandicoot spp	Complete	W	D	94	
10 (west)	G	22/11/2019	0149	Bandicoot spp.	Complete	W	D	15	
10 (west)	G	22/11/2019	0216	Black Rat	Complete	W	D	16	
10 (west)	G	22/11/2019	1559	Lace Monitor	Complete	E	D	19	
10 (west)	G	23/11/2019	0003	Bandicoot spp.	Complete	W	Pr	20	
10 (west)	G	25/11/2019	2252	Black Rat	Complete	EXM	D	31	
10 (west)	G	28/11/2019	1403	Lace Monitor	Complete	E	D	46	
10 (west)	G	4/12/2019	0055	Swamp wallaby	Complete	E	D	110	
10 (west)	G	4/12/2019	0539	Swamp wallaby	Complete	W	Pr	111	
10 (west)	G	4/12/2019	2350	SEBtP	Complete	W	D	112	
10 (west)	G	6/12/2019	1535	Lace Monitor	Complete	E	D	118	
10 (west)	G	22/06/2020	2023	Wallaby spp (probable red-neck)	Complete	W	D	10	
10 (west)	G	23/06/2020	2024	Wallaby spp (probable swamp wallaby)	Complete	W	D	11	
10 (west)	G	24/06/2020	0651	Wallaby spp (probable swamp wallaby)	Complete	E	D	12	
10 (west)	G	24/06/2020	2058	Fox	Complete	E	D	17	
10 (west)	G	28/06/2020	1855	Swamp wallaby	Complete	W	D	18	
10 (west)	G	3/07/2020	1707	Wallaby spp	Complete	E	D	19	
10 (west)	G	5/07/2020	0357	Fox	Complete	E	D	20	
10 (west)	G	5/07/2020	1816	Fox	Incomplete	W-E	D	20	
10 (west)	G	21/07/2020	2316	Cat	Complete	W	D	43	
10 (west)	G	30/07/2020	2228	Red neck Wallaby	Complete	E	D	20	
10 (west)	G	1/08/2020	0643	Wallaby spp	Complete	W	D	21	
10 (west)	G	6/08/2020	2025	Cat	Complete	E	D	23	Tabby
10 (west)	G	16/08/2020	0557	Wallaby spp	Complete	W	D	29	
10 (west)	G	19/08/2020	1741	Dog	Complete	W	D	31	
9 (East)	FF	17/12/2019	1049	Lace Monitor	Complete	W	D	187	
9 (East)	FF	4/12/2019	0653	Treecreeper spp.	Complete	E	Pr	176	
9 (East)	FF			Nil winter part 1					

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
9 (East)	G	17/12/2019	0659	Australian bushturkey	Incomplete	NDM	D	318	
9 (East)	G	13/10/2019	0447	Black Rat	Complete	W	Pr	8	
9 (East)	G	14/10/2019	2049	Black Rat	Complete	E	Pr	24	
9 (East)	G	21/10/2019	1459	Lace Monitor	Complete	E	D	128	
9 (East)	G	22/10/2019	1159	Lace Monitor	Complete	W	D	4-5	
9 (East)	G	22/10/2019	1315	Lace Monitor	Complete	W	D	6	
9 (East)	G	23/10/2019	2306	SEBtP	Complete	E	Pr	9	
9 (East)	G	24/10/2019	2229	Long-nosed bandicoot	Complete	W	Pr	10	
9 (East)	G	24/10/2019	2336	Bandicoot spp	Complete	E	D	11	
9 (East)	G	25/10/2019	0157	SEBtP	Complete	E	D	13-16	
9 (East)	G	29/10/2019	0229	SEBtP	Incomplete	W-E	Pr	19-23	
9 (East)	G	1/11/2019	2101	Bandicoot spp	Complete	E	D	26	
9 (East)	G	9/11/2019	2239	Koala	Complete	W	D	43	
9 (East)	G	21/11/2019	2150	Bandicoot spp.	Complete	E	D	4	
9 (East)	G	22/11/2019	0019	SEBtP	Incomplete	EXM	D	5	
9 (East)	G	2/12/2019	0116	Black Rat	Complete	E	D	40	
9 (East)	G	4/12/2019	0054	Swamp wallaby	Complete	E	Pr	67	
9 (East)	G	4/12/2019	0535	Swamp wallaby	Complete	W	D	68	
9 (East)	G	6/12/2019	1536	Lace Monitor	Complete	E	D	97	MB present
9 (East)	G	21/06/2020	2213	House mouse	Complete	E	D	3	
9 (East)	G	22/06/2020	2024	Wallaby spp	Complete	E	D	11	
9 (East)	G	24/06/2020	2055	Fox	Complete	W	D	18-20	
9 (East)	G	28/06/2020	1855	Wallaby spp.	Complete	E	D	21	
9 (East)	G	3/07/2020	1705	Swamp wallaby	Complete	W	D	29-31	
9 (East)	G	5/07/2020	0356	Fox	Complete	W	D	32	
9 (East)	G	5/07/2020	1814	Fox	Complete	W	D	33	
9 (East)	G	14/07/2020	0140	Cat	Complete	W	D	34-35	Tabby
9 (East)	G	26/07/2020	2036	Fox	Incomplete	W-E	D	131	
9 (East)	G	7/08/2020	1751	Swamp wallaby	Complete	E	D	9	
9 (East)	G	7/08/2020	0158	Wallaby spp	Complete	W	D	10	
8	FF	9/12/2019	0331	cat	Complete	E	D	115	Tabby
8	FF	9/10/2019	0407	SEBtP	Complete	E	Pr	3	
8	FF	9/10/2019	1955	SEBtP	Complete	W	D	14	
8	FF	10/10/2019	0317	2 x SEBtP	Complete	E	Pr	15	2 individuals
8	FF	10/10/2019	0349	SEBtP	Complete	W	D	16	
8	FF	12/10/2019	0445	SEBtP	Complete	E	Pr	28	
8	FF	12/10/2019	2149	SEBtP	Complete	W	D	29	
8	FF	13/10/2019	0235	2 x SEBtP	Complete	E	D	30	2 individuals

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
8	FF	13/10/2019	0401	SEBtP	Complete	E	D	31	
8	FF	13/10/2019	2018	SEBtP	Complete	E	Pr	33	
8	FF	14/10/2019	0027	SEBtP	Complete	W	D	34	
8	FF	14/10/2019	0514	SEBtP	Complete	E	Pr	36	
8	FF	14/10/2019	2022	SEBtP	Complete	W	D	44	
8	FF	15/10/2019	2107	SEBtP	Complete	E	D	57	
8	FF	17/10/2019	0419	SEBtP	Complete	E	D	62	
8	FF	18/10/2019	2055	SEBtP	Complete	E	D	73	
8	FF	19/10/2019	0119	2 x SEBtP	Complete	E	D	74	2 individuals
8	FF	21/10/2019	0046	SEBtP	Complete	E	D	92	
8	FF	21/10/2019	0329	2 x SEBtP	Complete	E	D	93	2 individuals
8	FF	21/10/2019	1927	SEBtP	Complete	E	Pr	101	
8	FF	22/10/2019	2345	SEBtP	Complete	W	D	3	
8	FF	24/10/2019	0133	SEBtP	Complete	W	Pr	6	
8	FF	24/10/2019	0243	SEBtP	Complete	W	Pr	7	
8	FF	24/10/2019	1933	SEBtP	Complete	E	Pr	9	
8	FF	24/10/2019	2232	SEBtP	Complete	E	D	12	
8	FF	25/10/2019	0129	SEBtP	Complete	W	D	13	
8	FF	25/10/2019	0249	2 x SEBtP	Complete	E	D	14	2 individuals
8	FF	27/10/2019	2306	SEBtP	Incomplete	E-W	Pr	21-22	
8	FF	28/10/2019	0118	SEBtP	Complete	W	D	24	
8	FF	30/10/2019	0141	2 x SEBtP	Complete	E	D	30	2 individuals (mother and young)
8	FF	31/10/2019	2348	SEBtP	Complete	E	D	32	
8	FF	1/11/2019	0215	2 x SEBtP	Complete	E	Pr	33	2 individuals (mother and young)
8	FF	1/11/2019	2141	SEBtP	Complete	W	Pr	35	
8	FF	2/11/2019	0004	SEBtP	Complete	W	D	37	
8	FF	4/11/2019	0333	2 x SEBtP	Complete	E	Pr	40	2 individuals (mother and young)
8	FF	6/11/2019	0126	SEBtP	Complete	W	D	43	
8	FF	6/11/2019	0231	2 x SEBtP	Complete	E	D	44	2 individuals (mother and young)
8	FF	10/11/2019	0144	SEBtP	Complete	E	D	51	
8	FF	11/11/2019	0146	2 x SEBtP	Complete	E	D	55	2 individuals (mother and young)
8	FF	14/11/2019	0244	2 x SEBtP	Complete	E	D	61	3 individuals (mother and young)
8	FF	15/11/2019	0127	SEBtP	Complete	E	Pr	62	

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
8	FF	15/11/2019	2053	SEBtP	Complete	W	D	66	
8	FF	18/11/2019	0214	2 x SEBtP	Complete	E	D	70	2 individuals (mother and young)
8	FF	19/11/2019	2229	SEBtP	Complete	E	D	76	
8	FF	22/11/2019	0126	2 x SEBtP	Complete	E	D	2	2 individuals (mother and young)
8	FF	22/11/20191	2230	2 x SEBtP	Complete	W	D	5	2 individuals (mother and young)
8	FF	25/11/2019	0335	2 x SEBtP	Complete	E	D	9	2 individuals (mother and young)
8	FF	27/11/2019	0111	SEBtP	Complete	E	D	12	
8	FF	27/11/2019	2218	SEBtP	Complete	E	D	18	
8	FF	28/11/2019	0204	2 x SEBtP	Complete	E	D	19	2 individuals (mother and young)
8	FF	28/11/2019	2244	BtPoss spp	Complete	W	D	24	
8	FF	30/11/2019	0339	2 x SEBtP	Complete	E	D	25	2 individuals (mother and young)
8	FF	30/11/2019	2140	BtPoss spp	Complete	W	D	27	
8	FF	1/12/2019	2311	BtPoss spp	Complete	W	D	30	
8	FF	2/12/2019	0208	SEBtP	Complete	E	D	31-33	
8	FF	4/12/2019	0021	SEBtP	Complete	E	D	52	
8	FF	4/12/2019	0124	BtPoss spp	Complete	W	D	53	
8	FF	5/12/2019	1106	Small bird	Incomplete	NDM	Pr	66	
8	FF	6/12/2019	2155	SEBtP	Complete	E	Pr	73	
8	FF	7/12/2019	0151	SEBtP	Complete	E	D	74	
8	FF	9/12/2019	0250	BtPoss spp	Complete	W	D	84	
8	FF	10/12/2019	0204	BtPoss spp	Complete	W	D	89	
8	FF	10/12/2019	2318	BtPoss spp	Complete	W	Pr	95	
8	FF	11/12/2019	0025	SEBtP	Complete	E	D	96	
8	FF	12/12/2019	2333	SEBtP	Complete	E	D	100	
8	FF	13/12/2019	0218	BtPoss spp	Complete	W	D	101	
8	FF	14/12/2019	2354	SEBtP	Incomplete	W-E	D	102-104	
8	FF	15/12/2019	2337	BtPoss spp	Complete	W	Pr	106	
8	FF	16/12/2019	2329	SEBtP	Complete	E	D	110	
8	FF	17/12/2019	0244	BtPoss spp	Complete	W	Pr	111	
8	FF	17/12/2019	2355	SEBtP	Complete	E	Pr	116	
8	FF	28/06/2020	0209	Black Rat	Complete	E	D	9	
8	FF	28/06/2020	0337	Black Rat	Complete	W	D	10	
8	FF	28/06/2020	2310	Rodent spp	Complete	E	D	11	

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
8	FF	29/06/2020	0130	Rodent spp	Complete	E	D	12	Only capture tail
8	FF	29/06/2020	2316	Rodent spp	Complete	E	D	13	
8	FF	30/06/2020	2308	Rodent spp	Complete	E	D	15	
8	FF	3/07/2020	0241	Rodent spp	Complete	E	D	17	
8	FF	4/07/2020	0209	Rodent spp	Complete	E	D	19	
8	FF	4/07/2020	0508	Black Rat	Complete	W	D	20	
8	FF	6/07/2020	0407	Rodent spp	Complete	E	D	22	
8	FF	6/07/2020	1814	Rodent spp	Complete	E	D	24	
8	FF	7/07/2020	1802	Rodent spp	Complete	E	D	26	
8	FF	10/07/2020	1800	Rodent spp	Complete	E	D	30	
8	FF	11/07/2020	2215	Rodent spp	Complete	E	D	32	
8	FF	12/07/2020	2333	Rodent spp	Complete	E	D	34	
8	FF	14/07/2020	2131	Rodent spp	Complete	E	D	36	
8	FF	15/07/2020	2232	Rodent spp	Complete	E	D	38	
8	FF	17/07/2020	0304	Rodent spp	Complete	E	D	43	
8	FF	25/07/2020	2258	Rodent spp	Complete	E	D	52	
8	FF	27/07/2020	0402	Rodent spp	Complete	E	D	54	
8	G	18/12/2019	0039	SEBtP	Complete	E	D	118	MB present
8	G	9/10/2019	1336	Lace Monitor	Complete	E	D	11	
8	G	10/10/2019	2356	SEBtP	Complete	W	Pr	45	
8	G	17/10/2019	2038	SEBtP	Complete	E	D	93	
8	G	19/10/2019	0038	SEBtP	Complete	W	D	101	
8	G	19/10/2019	1224	Lace Monitor	Complete	W	D	108	
8	G	20/10/2019	2245	Cat	Complete	E	D	115	tabby
8	G	21/10/2019	0045	SEBtP	Complete	E	Pr	116	
8	G	22/10/2019	0437	Swamp wallaby	Complete	E	D	126	
8	G	23/10/2019	1037	Lace Monitor	Complete	W	D	7	
8	G	23/10/2019	1452	Lace Monitor	Complete	E	D	8	
8	G	27/10/2019	1324	Lace Monitor	Complete	W	D	28	
8	G	27/10/2019	1524	Lace Monitor	Complete	E	D	30	
8	G	27/10/2019	1612	Lace Monitor	Complete	E	D	31	
8	G	28/10/2019	1128	Lace Monitor	Complete	W	D	40	
8	G	28/10/2019	1504	Lace Monitor	Complete	W	D	41	
8	G	29/10/2019	1002	Lace Monitor	Complete	W	D	48	
8	G	1/11/2019	1010	Lace Monitor	Complete	W	D	58	
8	G	1/11/2019	1450	Lace Monitor	Complete	E	D	60	
8	G	4/11/2019	1425	Lace Monitor	Complete	W	D	69	
8	G	6/11/2019	0956	Lace Monitor	Complete	W	D	75	

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
8	G	6/11/2019	1317	Lace Monitor	Incomplete	E-W	D	77-78	
8	G	6/11/2019	1413	Lace Monitor	Complete	E	D	79	
8	G	7/11/2019	1531	Lace Monitor	Complete	E	D	87	
8	G	12/11/2019	1936	Wallaby spp.	Complete	E	D	130	
8	G	13/11/2019	1328	Lace Monitor	Complete	W	D	134	
8	G	15/11/2019	1125	Lace Monitor	Complete	W	D	150	
8	G	15/11/2019	1523	Lace Monitor	Complete	E	D	152	
8	G	17/11/2019	1052	Lace Monitor	Complete	E	D	167-169	
8	G	18/11/2019	1214	Lace Monitor	Complete	W	Pr	182	
8	G	25/11/2019	0606	Swamp wallaby	Complete	W	D	23-24	
8	G	28/11/2019	1148	Lace Monitor	Complete	E	D	41	
8	G	30/11/2019	1014	Lace Monitor	Complete	W	D	56	
8	G	2/12/2019	1155	Lace Monitor	Complete	W	D	62	
8	G	3/12/2019	1450	Lace Monitor	Complete	W	D	72	
8	G	4/12/2019	1148	Lace Monitor	Complete	W	D	82	
8	G	7/12/2019	1316	Lace Monitor	Complete	W	D	152	
8	G	8/12/2019	1115	Lace Monitor	Complete	W	D	159	
8	G	8/12/2019	1439	Lace Monitor	Complete	E	Pr	160	
8	G	9/12/2019	0645	Swamp wallaby	Complete	E	Pr	167	
8	G	9/12/2019	0750	Swamp wallaby	Complete	W	D	173	
8	G	12/12/2019	1445	Lace Monitor	Complete	W	D	181	
8	G	15/12/2019	1141	Lace Monitor	Complete	E	Pr	185	
8	G	17/12/2019	0609	Swamp wallaby	Complete	E	D	208	
8	G	23/06/2020	2245	Fox	Complete	E	D	13	
8	G	24/06/2020	2049	Fox	Complete	E	D	20	
8	G	25/06/2020	2147	Fox	Complete	W	D	22	
8	G	26/06/2020	2244	Fox	Complete	W	D	24	
8	G	27/06/2020	2009	Fox	Incomplete	E-W	D	25	
8	G	27/06/2020	2227	Fox	Complete	E	D	26	
8	G	28/06/2020	0342	Fox	Complete	E	D	27	Injured hind leg
8	G	28/06/2020	2225	Fox	Complete	W	D	28	
8	G	2/07/2020	2219	European Hare	Incomplete	E-W	D	30	
8	G	3/07/2020	0148	European Hare	Complete	E	D	31	
8	G	3/07/2020	0250	European Hare	Complete	W	D	32	
8	G	5/07/2020	0532	Fox	Complete	E	D	33	
8	G	10/07/2020	0136	Fox	Complete	W	D	35	Black socks
8	G	14/07/2020	2345	Fox	Complete	W	D	41	Black socks
8	G	15/07/2020	2206	Fox	Complete	W	D	42	Black socks

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
8	G	21/07/2020	2323	Fox	Complete	W	D	52	Black socks
8	G	24/07/2020	0020	Fox	Complete	E	D	68	
8	G	26/07/2020	0227	Fox	Complete	E	D	69	
8	G	30/07/2020	0253	Cat	Complete	W	D	4	Tabby
8	G	30/07.2020	0329	Fox	Complete	E	D	5	
8	G	31/07/2020	0103	Fox	Complete	W	D	6	
8	G	3/08/2020	0348	Fox	Complete	E	D	7	
8	G	3/08/2020	1857	Cat	Complete	W	D	8	Black Cat
8	G	7/08/2020	0551	Cat	Complete	E	D	9	Black Cat
8	G	7/08/2020	1508	Cat	Complete	W	D	10	Black Cat
8	G	9/08/2020	0328	Fox	Complete	E	D	11	
8	G	12/08/2020	2036	Cat	Complete	E	D	20	Black Cat
8	G	14/08/2020	0755	Cat	Complete	E	D	21	Tabby
8	G	14/08/2020	0759	Cat	Complete	W	D	22	Tabby
8	G	17/08/2020	1849	Fox	Complete	W	D	25	
8	G	18/08/2020	1321	Lace Monitor	Complete	W	D	26	
8	G	20/08/2020	0015	Fox	Complete	E	D	27	
8	G	21/08/2020	0240	Fox	Complete	E	D	28	
7	FF	17/12/2019	1644	Swamp wallaby	Complete	W	D	212-213	
7	FF	9/10/2019	2056	SEBtP	Incomplete	W-E	D	35-39	
7	FF	9/10/2019	2217	SEBtP	Complete	W	D	40-43	
7	FF	9/10/2019	2316	SEBtP	Complete	W	D	44-45	
7	FF	10/10/2019	0116	SEBtP	Complete	E	D	46-47	
7	FF	12/10/2019	2122	2 x SEBtP	Complete	W	D	60	2 individuals (mother and joey)
7	FF	13/10/2019	0305	SEBtP	Incomplete	E-W	D	61-64	
7	FF	20/10/2019	0154	SEBtP	Incomplete	E-W	D	109-108	
7	FF	20/10/2019	0814	SEBtP	Complete	E	D	110	
7	FF	20/10/2019	1942	SEBtP	Incomplete	E-W	D	117-118	
7	FF	20/10/2019	2358	2 x SEBtP	Complete	W	D	119	2 individuals (mother and joey)
7	FF	21/10/2019	0121	SEBtP	Complete	W	D	121	
7	FF	22/10/2019	0133	SEBtP	Complete	W	D	130	
7	FF	22/10/2019	2104	SEBtP	Complete	E	D	2	
7	FF	22/10/2019	2247	SEBtP	Complete	W	D	3	
7	FF	23/10/2019	0021	2 x SEBtP	Complete	E	D	5	2 individuals (mother and joey)
7	FF	23/10/2019	0249	SEBtP	Complete	E	D	7	
7	FF	23/10/2019	1959	SEBtP	Complete	E	D	10	

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
7	FF	23/10/2019	2126	SEBtP	Complete	E	D	11	
7	FF	24/10/2019	0419	SEBtP	Complete	W	D	12	
7	FF	24/10/2019	2204	SEBtP	Complete	E	D	13	
7	FF	24/10/2019	2240	SEBtP	Complete	W	D	14	
7	FF	25/10/2019	2253	SEBtP	Complete	E	D	15	
7	FF	27/10/2019	0031	SEBtP	Complete	E	D	16	
7	FF	27/10/2019	0219	2 x SEBtP	Complete	E	D	17	2 individuals (mother and joey)
7	FF	27/10/2019	2047	SEBtP	Complete	E	D	18	
7	FF	27/10/2019	2303	SEBtP	Complete	E	D	19	
7	FF	29/10/2019	2135	SEBtP	Complete	E	D	22	
7	FF	30/10/2019	2109	Antechinus spp	Complete	E	D	25	
7	FF	30/10/2019	2317	2 x SEBtP	Complete	W	D	27	2 individuals (mother and joey)
7	FF	31/10/2019	0107	Antechinus spp	Complete	E	D	28	
7	FF	1/11/2019	0442	Antechinus spp	Complete	E	D	31	
7	FF	2/11/2019	0051	Antechinus spp	Complete	E	D	38	
7	FF	3/11/2019	0035	Antechinus spp	Complete	E	D	42-44	
7	FF	4/11/2019	0208	Black Rat	Complete	E	D	52-53	
7	FF	5/11/2019	0036	2 x SEBtP	Complete	W	D	54	2 individuals (mother and joey)
7	FF	5/11/2019	2102	SEBtP	Complete	E	D	56	
7	FF	6/11/2019	2238	2 x SEBtP	Complete	W	D	58	2 individuals (mother and joey)
7	FF	7/11/2019	0331	Antechinus spp	Complete	E	D	59	
7	FF	8/11/2019	0227	SEBtP	Complete	W	D	64	
7	FF	11/11/2019	2140	SEBtP	Complete	E	D	69	
7	FF	12/11/2019	0055	2 x SEBtP	Complete	W	D	70	2 individuals (mother and joey)
7	FF	13/11/2019	2253	SEBtP	Complete	E	D	77	
7	FF	18/11/2019	2320	2 x SEBtP	Complete	W	D	82	2 individuals (mother and joey)
7	FF	20/11/2019	0111	SEBtP	Complete	E	D	88	
7	FF	20/11/2019	0230	SEBtP	Complete	W	D	89	
7	FF	25/11/2019	2323	2 x SEBtP	Complete	W	D	5	2 individuals (mother and joey)
7	FF	27/11/2019	0339	SEBtP	Complete	E	D	6-7	
7	FF	27/11/2019	2111	SEBtP	Complete	W	D	8	
7	FF	28/11/2019	0124	SEBtP	Complete	W	D	9	

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
7	FF	28/11/2019	2034	SEBtP	Complete	E	D	20	
7	FF	28/11/2019	2034	SEBtP	Complete	E	D	21	
7	FF	28/11/2019	2154	SEBtP	Complete	W	D	24-25	
7	FF	28/11/2019	2309	SEBtP	Complete	W	D	27-28	
7	FF	1/12/2019	2107	SEBtP	Complete	E	D	29	
7	FF	6/12/2019	0156	SEBtP	Complete	E	D	47	
7	FF	6/12/2019	2223	SEBtP	Complete	W	D	51	
7	FF	9/12/2019	0338	SEBtP	Complete	E	D	58-59	
7	FF	9/12/2019	2140	SEBtP	Complete	W	D	60	
7	FF	9/12/2019	2231	SEBtP	Complete	E	D	61-62	
7	FF	10/12/2019	0438	SEBtP	Complete	E	D	63	
7	FF	10/12/2019	2303	SEBtP	Complete	W	D	69	
7	FF	11/12/2019	0332	SEBtP	Complete	E	D	70	
7	FF	11/12/2019	2046	SEBtP	Complete	W	Pr	72	
7	FF	13/12/2019	0423	SEBtP	Complete	E	D	76	
7	FF	13/12/2019	2354	BtPoss spp	Complete	W	D	77	
7	FF	14/12/2019	0429	SEBtP	Complete	W	D	78	
7	FF	14/12/2019	2139	SEBtP	Complete	W	D	80	
7	FF	15/12/2019	0431	SEBtP	Complete	E	D	82	
7	FF	12/07/2020	2127	Antechinus spp	Complete	E	D	11	
7	FF	13/07/2020	2022	Short-eared brushtail possum	Incomplete	W	D	12-13	
7	FF	19/07/2020	2148	Short-eared brushtail possum	Complete	E	D	18-19	
7	FF	20/07/2020	006	Short-eared brushtail possum	Complete	E	D	20	
7	FF	1/08/2020	2110	Short-eared brushtail possum	Complete	E	D	9-11	
7	FF	1/08/2020	2214	Short-eared brushtail possum	Complete	W	D	12-13	
7	FF	9/08/2020	2214	Short-eared brushtail possum	Complete	E	D	14-15	
7	FF	15/08/2020	0536	FF Melomys	Complete	E	Pr		
7	FF	18/08/2020	2104	Short-eared brushtail possum	Complete	W	D	18	
7	FF	27/08/2020	2028	Short-eared brushtail possum	Complete	E	D	23-24	
7	FF	1/09/2020	0113	Short-eared brushtail possum	Complete	W	D	25	
7	G	15/12/2019	2132	SEBtP	Complete	W	D	85	
7	G	9/10/2019	1046	Lace Monitor	Complete	W	Pr	12	
7	G	9/10/2019	2053	SEBtP	Complete	E	D	23	
7	G	10/10/2019	0702	Macropod spp	Complete	E	D	25	
7	G	10/10/2019	2233	Wallaby spp	Complete	W	D	31	
7	G	14/10/2019	0618	Macropod spp	Complete	E	D	34	
7	G	17/101/19	0616	Macropod spp	Complete	E	D	35	
7	G	17/10/2019	1147	Brush turkey	Complete	E	Pr	55	

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
7	G	18/10/2019	0017	Red-necked wallaby	Complete	W	Pr	63	
7	G	19/10/2019	2237	Red-necked wallaby	Complete	W	Pr	79	
7	G	20/10/2019	1947	SEBtP	Complete	E	Pr	90	
7	G	21/10/2019	0015	Fox	Complete	E	Pr	91	
7	G	22/10/2019	0333	Macropod spp	Complete	E	Pr	97	
7	G	2210/19	0423	Macropod spp	Complete	E	D	98	
7	G	22/10/2019	1821	Echidna	Complete	W	D	5	
7	G	22/10/2019	2139	Macropod spp	Complete	W	D	6	
7	G	29/10/2019	0513	Macropod spp	Complete	E	Pr	24	
7	G	30/10/2019	0025	Red-necked wallaby	Complete	W	D	25-27	
7	G	1/11/2019	2037	BtPoss spp	Complete	E	D	28	
7	G	3/11/2019	0956	Macropod spp	Complete	E	D	29	
7	G	6/11/2019	0719	Macropod spp	Complete	E	D	32	
7	G	6/11/2019	1201	Lace Monitor	Complete	W	Pr	33	
7	G	7/11/2019	2038	Red-necked wallaby	Complete	W	D	36	
7	G	8/11/2019	2031	Macropod spp	Complete	E	D	46	
7	G	10/11/2019	0521	Macropod spp	Complete	E	D	48	
7	G	13/11/2019	0431	Macropod spp	Complete	E	D	56	
7	G	15/11/2019	0508	Macropod spp	Complete	E	D	61	
7	G	18/11/2019	0328	Macropod spp	Complete	E	D	72	
7	G	21/11/2019	0557	Wallaby spp.	Complete	E	D	7	
7	G	22/11/2019	2248	Black Rat	Incomplete	EXM	D	10-13	
7	G	23/11/2019	0131	Echidna	Complete	W	D	14	
7	G	23/11/2019	0525	Macropod spp	Complete	E	D	15	
7	G	26/11/2019	0002	Bandicoot spp.	Complete	W	D	19	
7	G	26/11/2019	0855	Macropod spp	Complete	E	D	20	
7	G	27/11/2019	0624	Macropod spp	Complete	E	D	22	
7	G	27/11/2019	1126	Lace Monitor	Complete	W	D	26	
7	G	28/11/2019	0820	Macropod spp	Complete	E	D	29	
7	G	29/11/2019	1414	Lace Monitor	Complete	W	D	36	
7	G	2/12/2019	0503	Macropod spp	Complete	E	Pr	40	
7	G	3/12/2019	0044	Long-nosed bandicoot	Complete	E	D	52	
7	G	4/12/2019	0921	Lace Monitor	Complete	E	D	62	
7	G	8/12/2019	0528	Macropod spp	Complete	E	D	101	
7	G	8/12/2019	0955	Lace Monitor	Complete	E	D	103	
7	G	15/12/2019	2213	Swamp wallaby	Complete	W	D	128	
7	G	17/12/2019	0015	Cat	Complete	E	Pr	139	tabby
7	G	22/06/2020	2212	Short-eared brushtail possum	Complete	E	D	6	

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
7	G	23/06/2020	0001	Short-eared brushtail possum	Complete	E	D	7	
7	G	23/06/2020	2139	Short-eared brushtail possum	Complete	E	D	9	
7	G	26/06/2020	2031	Fox	Complete	E	D	16	
7	G	27/06/2020	0300	Fox	Complete	E	D	17	
7	G	28/06/2020	0039	Fox	Complete	E	D	19	
7	G	28/06/2020	0653	Fox	Complete	E	D	20	
7	G	29/06/2020	0143	Fox	Complete	E	D	23	
7	G	29/06/2020	0620	Fox	Complete	E	D	25	
7	G	30/06/2020	0310	Fox	Complete	W	D	26	x2
7	G	4/07/2020	0053	Fox	Complete	W	Pr	28	
7	G	4/07/2020	0150	Short-eared brushtail possum	Complete	W	Pr	29	
7	G	5/07/2020	0103	wallaby spp	Complete	E	D	30	
7	G	5/07/2020	1859	Fox	Complete	E	D	32	
7	G	6/07/2020	0459	Fox	Complete	E	D	33	
7	G	7/07/2020	2217	Fox	Complete	W	D	34	
7	G	10/07/2020	0001	Fox	Complete	E	D	35	
7	G	13/07/2020	0304	fox	Complete	e	d	38	
7	G	15/07/2020	2222	Fox	Complete	E	D	43	
7	G	17/07/2020	2317	Cat	Complete	E	D	45	
7	G	19/07/2020	2249	Short-eared brushtail possum	Complete	W	D	47	
7	G	25/07/2020	2238	Rodent spp	Complete	E	D	49	
7	G	26/07/2020	2324	Fox	Complete	E	D	51	
7	G	27/07/2020	1633	Wallaby spp	Complete	W	D	52	
7	G	27/07/2020	1634	Wallaby spp	Complete	W	D	53	
7	G	27/07/2020	1712	Wallaby spp	Complete	E	D	54	
7	G	27/07/2020	2247	Fox	Complete	E	D	55	
7	G	29/07/2020	1208	Fox	Complete	E	D	5	
7	G	29/07/2020	2207	Cat	Complete	E	D	6	Tabby
7	G	31/07/2020	2056	Cat	Complete	E	D	7	Tabby
7	G	1/08/2020	05050	Fox	Complete	E	D	9	
7	G	5/08/2020	05050	Fox	Complete	E	D	10	
7	G	6/08/2020	0138	Cat	Complete	E	D	11	
7	G	7/08/2020	0027	Dog	Complete	E	D	12	
7	G	8/08/2020	1807	Fox	Complete	E	D	13	
7	G	11/08/2020	1253	Dog	Complete	W	D	15	
7	G	15/08/2020	1933	Fox	Complete	E	D	16	
7	G	15/08/2020	2344	Rodent spp	Complete	E	D	17	
7	G	16/08/2020	1938	Fox	Complete	E	D	18	

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
7	G	17/08/2020	0108	Fox	Complete	E	D	19	
7	G	19/08/2020	1409	Fox	Complete	W	D	20-21	
7	G	19/08/2020	1758	Fox	Complete	E	D	22	
7	G	21/08/2020	0050	Fox	Complete	E	D	22	
7	G	22/08/2020	1338	Fox	Complete	E	D	25	
7	G	23/08/2020	1712	Swamp wallaby	Incomplete	E-W	D	30-31	
7	G	24/08/2020	0524	Fox	Complete	E	D	32	
7	G	25/08/2020	0652	Fox	Complete	E	D	35	
7	G	25/08/2020	1822	Fox	Complete	E	D	36	
7	G	26/08/2020	0123	Fox	Complete	E	D	37	
7	G	26/08/2020	1206	Lace Monitor	Complete	E	D	39	
7	G	28/08/2020	2341	Fox	Complete	E	D	40	
7	G	29/08/2020	0208	Short-eared brushtail possum	Complete	W	D	41	
7	G	29/08/2020	1055	Fox	Complete	E	D	42	
7	G	29/08/2020	1125	Fox	Complete	E	D	42	
7	G	31/08/2020	00167	Fox	Complete	E	D	43	
7	G	31/08/2020	0417	Small mammal	Complete	E	D	44	
6	FF	17/12/2019	0218	SEBtP	Complete	W	D	140	
6	FF	19/10/2019	1233	Lace Monitor	Complete	E		136-139	
6	FF	13/07/2020	0819	Rodent spp	Incomplete	NDM	D	59-63	
6	FF	4/08/2020	1936	Microbat spp	Present	NDM	D	97-98	Microbat sitting on furniture
6	FF	28/08/1010	0118	Antechinus spp	Complete	E	D	115-123	
6	FF	30/08/2020	1831	Antechinus spp	Complete	E	D	130-131	
6	FF	31/08/2020	1950	Antechinus spp	Complete	E	D	133-134	
6	FF	31/08/2020	2016	Antechinus spp	Complete	E	D	135-136	
6	FF								
6	FF								
6	G	20/10/2019	No fauna photos taken, only photos of camera retrieval - maybe camera malfunction				Pr		
6	G	14/10/2019	0421	Swamp wallaby	Incomplete	E-W	D	47	
6	G	19/10/2019	1115	Lace Monitor	Complete	EXM	D	106-167	

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
6	G	19/10/2019	2146	Black Rat	Complete	E	Pr	173	
6	G	21/10/2019	2317	Black Rat	Complete	W		180	
6	G	23/06/2020	0559	Fox	Complete	E	D	7-9	
6	G	25/06/2020	0457	Fox	Complete	E	D	28-30	
6	G	25/06/2020	0829	Fox	Complete	E	D	31-33	
6	G	27/06/2020	2223	Fox	Complete	E	D	58-60	
6	G	30/06/2020	1143	Cat	Complete	E	D	112-114	x 2
6	G	5/07/2020	0631	Fox	Complete	E	D	160-162	
6	G	6/07/2020	0013	Swamp wallaby	Complete	W	D	169-178	
6	G	6/07/2020	0851	cat	Complete	E	D	181-183	
6	G	16/07/2020	0907	Fox	Complete	E	D	220-222	
6	G	17/07/2020	0600	Fox	Complete	W	D	223-224	
6	G	17/07/2020	0625	Swamp Wallaby	Complete	W	D	226-228	
6	G	19/07/2020	2208	Cat	Complete	E	D	229-231	Kitten
6	G	21/07/2020	0941	Cat	Complete	E	D	238-240	Kitten
6	G	26/07/2020	0829	Cat	Complete	E	D	247-249	Tabby
6	G	27/07/2020	0203	Bandicoot spp	Complete	E	D	250-252	
6	G	28/07/2020	0534	Fox	Complete	E	D	253-255	
6	G	28/07/2020	1734	Fox	Complete	W	D	235-237	
6	G	2/08/2020	0023	European Hare	Complete	E	D	238-242	
6	G	10/08/2020	1825	Fox	complete	w	d	265-267	
6	G	10/08/2020	2153	bandicoot spp	Complete	E	D	268-270	
6	G	10/08/2020	2238	Long-nosed bandicoot	Complete	W	D	270-273	
6	G	13/08/2020	0249	Cat	Complete	E	D	275-279	Tabby
6	G	18/08/2020	0507	Fox	Complete	E	D	292-294	
6	G	31/08/2020	0244	Fox	Complete	E	D	328-331	
5	North	20/10/2019	No photos taken - camera malfunction				D		
5	North	9/10/2019	2033	Black Rat	Complete	E	Pr	22	
5	North	17/10/2019	1956	house mouse	Complete	E	D	48	
5	North	21/10/2019	2112	Black Rat	Incomplete	NDM	D	60	
5	North	22/10/2019	2035	Rodent spp	Complete	E	Pr	4	
5	North	23/10/2019	2102	Black Rat	Complete	E	D	11	
5	North	23/10/2019	2158	Rodent spp	Complete	E	Pr	14	
5	North	23/10/2019	2224	Black Rat	Complete	E	D	16	
5	North	24/10/2019	0302	Rodent spp	Complete	E	Pr	18	
5	North	24/10/2019	2122	Black Rat	Complete	E	Pr	21	

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
5	North	24/10/2019	2159	Black Rat	Incomplete	E-W	Pr	22	
5	North	25/10/2019	1503	EW dragon	Complete	W	D	26	
5	North	25/10/2019	2130	Black Rat	Incomplete	NDM	Pr	29	
5	North	25/10/2019	2148	Black Rat	Complete	E	D	32	
5	North	26/10/2019	2037	Black Rat	Incomplete	EXM	D	37,39	
5	North	26/10/2019	2119	Black Rat	Complete	W	D	40	
5	North	29/10/2019	2312	Black Rat	Complete	E	Pr	67	
5	North	1/11/2019	2019	Black Rat	Complete	E	D	73	
5	North	1/11/2019	2043	Black Rat	Complete	E	D	75	
5	North	1/11/2019	2249	Black Rat	Complete	W-E	Pr	79-81	
5	North	2/11/2019	2004	Black Rat	Complete	E	Pr	83	
5	North	4/11/2019	0254	Black Rat	Complete	E	D	88	
5	North	4/11/2019	0414	Black Rat	Complete	W	D	89	
5	North	4/11/2019	0441	Black Rat	Complete	E	D	90	
5	North	12/11/2019	1327	Swamp wallaby	Incomplete	NDM	D	137	
5	North	13/11/2019	0241	Swamp wallaby	Complete	E	Pr	138	
5	North	14/11/2019	2137	Black Rat	Incomplete	NDM	D	149	
5	North	16/11/2019	2035	Black Rat	Complete	E	D	175-176	
5	North	18/11/2019	2045	Black Rat	Complete	E	D	227-228	
5	North	22/11/2019	0303	Black Rat	Complete	E	D	36	
5	North	23/11/2019	0026	Long-nosed bandicoot	Complete	W	D	48	
5	North	23/11/2019	2058	Black Rat	Complete	E	Pr	62	
5	North	26/11/2019	2354	Black Rat	Complete	E	D	79	
5	North	15/12/2019	2307	Black Rat	Complete	E	D	336	
5	North	15/12/2019	2327	Black Rat	Complete	W	D	338	
5	North	16/12/2019	0044	Black Rat	Complete	E	D	339	
5	North	16/12/2019	0240	Black Rat	Complete	E	Pr	341	
5	North	16/12/2019	0503	Black Rat	Complete	E	D	343	
5	North	16/12/2019	0518	house mouse	Complete	E	Pr	345	
5	North	16/12/2019	2116	Black Rat	Complete	E	D	364	
5	North	16/12/2019	2310	house mouse	Complete	E	D	366	
5	North	17/12/2019	2149	Black Rat	Complete	E	D	391	
5	North	14/07/2020	2103	Black Rat	Incomplete	E-W	D	19-20	
5	North	26/07/2020	2341	Water Rat	Complete	E	D	22	
5	South	18/12/2019	0125	Black Rat	Complete	W	D	393	
5	South	8/10/2019	2055	Black Rat	Complete	E	D	16	
5	South	8/10/2019	2236	Black Rat	Complete	W	Pr	17	
5	South	8/10/2019	2326	Black Rat	Complete	E	Pr	18	

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
5	South	9/10/2019	2021	Black Rat	Complete	E	D	63, 65	
5	South	10/10/2019	2131	Black Rat	Complete	E	Pr	76	
5	South	12/10/2019	0008	Water rat	Complete	E	Pr	88	
5	South	12/10/2019	2257	Water rat	Complete	E	D	93	
5	South	14/10/2019	2208	Water rat	Complete	W	D	105	
5	South	14/10/2019	2307	Water rat	Complete	E	D	106	
5	South	15/10/2019	0150	Water rat	Complete	E	D	107	
5	South	16/10/2019	2333	Water rat	Complete	E	Pr	117	
5	South	20/10/2019	0009	Black Rat	Complete	E	D	138	
5	South	20/10/2019	0243	Fox	Incomplete	E-W	D	139-140	
5	South	21/10/2019	2118	Black Rat	Incomplete	E-W	D	177-178	
5	South	21/10/2019	2135	Black Rat	Complete	W	D	179	
5	South	21/10/2019	2138	Black Rat	Incomplete	EXM	D	180-183	
5	South	21/10/2019	2153	Black Rat	Complete	E	D	184	
5	South	22/10/2019	2025	Black Rat	Incomplete	E-W	Pr	9-10	
5	South	23/10/2019	0211	Black Rat	Complete	E	Pr	11	
5	South	24/10/2019	0116	Black Rat	Complete	E	Pr	17	
5	South	24/10/2019	1958	Black Rat	Complete	E	D	18	
5	South	25/10/2019	0034	Black Rat	Complete	E	Pr	20	
5	South	25/10/2019	2036	Black Rat	Complete	E	D	26	
5	South	25/10/2019	2154	Rodent spp	Complete	E	D	27	
5	South	25/10/2019	2314	Rodent spp	Complete	E	Pr	29	
5	South	26/10/2019	0128	Black Rat	Complete	E	Pr	30	
5	South	26/10/2019	0204	Black Rat	Incomplete	E-W	Pr	31-32	
5	South	26/10/2019	2105	Black Rat	Complete	E	Pr	35	
5	South	26/10/2019	2242	Black Rat	Incomplete	NDM	D	36	
5	South	26/10/2019	2359	Water rat	Complete	E	Pr	39	
5	South	27/10/2019	0458	Black Rat	Complete	E	Pr	40	
5	South	27/10/2019	2012	Black Rat	Complete	E	D	46	
5	South	27/10/2019	2051	Rodent spp	Complete	E	Pr	48	
5	South	27/10/2019	2158	Black Rat	Complete	E	Pr	49	
5	South	28/10/2019	0507	Black Rat	Incomplete	NDM	Pr	50	
5	South	28/10/2019	1936	Black Rat	Complete	E	Pr	60	
5	South	28/10/2019	2341	Water rat	Complete	W	D	62	
5	South	29/10/2019	0141	Black Rat	Complete	W	Pr	63-64	
5	South	29/10/2019	2109	Black Rat	Complete	E	D	81	
5	South	29/10/2019	2250	Black Rat	Complete	W	D	82	
5	South	30/10/2019	0039	Rodent spp	Complete	E	Pr	84	

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
5	South	30/10/2019	0149	Black Rat	Complete	E	Pr	86	
5	South	30/10/2019	2027	Black Rat	Complete	E	Pr	96	
5	South	30/10/2019	2134	Black Rat	Complete	E	Pr	97	
5	South	31/10/2019	2158	Black Rat	Complete	E	D	116	
5	South	1/11/2019	0308	Black Rat	Complete	W	Pr	117	
5	South	1/11/2019	2143	Black Rat	Complete	E	D	126	
5	South	1/11/2019	2301	Black Rat	Complete	W	D	128	
5	South	2/11/2019	0354	Rodent spp	Complete	E	D	129	
5	South	3/11/2019	0244	Rodent spp	Complete	E	D	137	
5	South	3/11/2019	2233	Water rat	Complete	W	D	139	
5	South	4/11/2019	0346	Rodent spp	Complete	E	D	140	
5	South	4/11/2019	1445	EW dragon	Incomplete	NDM	Pr	147	
5	South	4/11/2019	2322	Black Rat	Complete	E	D	148	
5	South	4/11/2019	2342	Black Rat	Complete	W	D	149	
5	South	6/11/2019	0025	Rodent spp	Complete	E	Pr	157	
5	South	6/11/2019	2045	SEBtP x 2	Complete	E	Pr	165	Mother and joey
5	South	6/11/2019	2112	SEBtP x 3	Complete	W	D	166	Mother and joey
5	South	6/11/2019	2250	Black Rat	Complete	W	D	167	
5	South	6/11/2019	2314	Black Rat	Complete	E	D	168	
5	South	7/11/2019	0242	Rodent spp	Complete	E	D	169	
5	South	8/11/2019	0025	Black Rat	Complete	E	D	182	
5	South	8/11/2019	0445	Black Rat	Complete	W	D	183	
5	South	8/11/2019	2052	Black Rat	Complete	W	Pr	197	
5	South	9/11/2019	0054	Black Rat	Complete	E	D	199	
5	South	9/11/2019	0133	Black Rat	Incomplete	W-E	Pr	200,202	
5	South	9/11/2019	0433	Black Rat	Complete	W	D	203	
5	South	10/11/2019	0124	Rodent spp	Complete	E	Pr	209-210	
5	South	11/11/2019	0248	Black Rat	Complete	W	Pr	230	
5	South	11/11/2019	0440	Black Rat	Complete	W	D	231	
5	South	12/11/2019	0427	Rodent spp	Complete	E	Pr	232	
5	South	12/11/2019	0801	Swamp wallaby	Complete	E	D	234	
5	South	12/11/2019	1239	Lace Monitor	Complete	W	D	237	
5	South	12/11/2019	1748	Swamp wallaby	Complete	E	D	239-242	
5	South	14/11/2019	1506	Swamp wallaby	Complete	W	D	261-262	
5	South	15/11/2019	1401	Lace Monitor	Complete	E	Pr	277	
5	South	15/11/2019	1705	Swamp wallaby	Incomplete	E-W	D	278-279	
5	South	15/11/2019	2047	Rodent spp	Complete	E	D	280	
5	South	15/11/2019	2201	Black Rat	Complete	W	D	281	

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
5	South	15/11/2019	2319	Black Rat	Complete	W	D	282	
5	South	17/11/2019	2109	Small mammal	Complete	E	Pr	306	
5	South	17/11/2019	2342	Black Rat	Complete	E	Pr	307	
5	South	18/11/2019	0532	Swamp wallaby	Complete	E	D	310	
5	South	19/11/2019	1142	Lace Monitor	Complete	W	Pr	368	
5	South	19/11/2019	1945	Black Rat	Complete	E	Pr	369	
5	South	20/11/2019	0028	Black Rat	Complete	E	Pr	371	
5	South	20/11/2019	1951	Black Rat	Complete	E	D	8	
5	South	21/11/2019	1131	EW dragon	Complete	W	D	29	
5	South	21/11/2019	2327	Black Rat	Complete	W	D	30	
5	South	22/11/2019	0414	Black Rat	Complete	W	D	31	
5	South	22/11/2019	2121	Black Rat	Complete	E	D	71	
5	South	22/11/2019	2211	Black Rat	Incomplete	EXM	D	72-75	
5	South	24/11/2019	0153	Black Rat	Incomplete	W	Po	90	
5	South	24/11/2019	2306	Swamp rat	Complete	E	Pr	109	
5	South	25/11/2019	2246	Black Rat	Complete	E	D	120	
5	South	26/11/2019	2318	Black Rat	Complete	W	D	147	
5	South	27/11/2019	0001	Black Rat	Complete	E	D	148	
5	South	27/11/2019	0204	Black Rat	Complete	W	D	149-150	
5	South	2/12/2019	0052	Black Rat	Incomplete	E-W	D	231-233	
5	South	3/12/2019	1427	EW dragon	Complete	E	D	280	
5	South	9/12/2019	0039	Bush rat	Complete	W	Pr	394	
5	South	9/12/2019	0523	Swamp wallaby	Complete	E	Pr	395	
5	South	9/12/2019	0728	Swamp wallaby	Complete	E	Po	407	
5	South	11/12/2019	0422	Water rat	Complete	E	D	422	
5	South	16/12/2019	0120	house mouse	Incomplete	EXM	D	443-444	
5	South	17/12/2019	2217	Black Rat	Complete	W	D	473	
5	South	5/06/2020	2211	Water Rat	Complete	E	D	20	
5	South	10/06/2020	0315	Water Rat	Complete	E	D	21-22	
5	South	10/06/2020	0411	Water Rat	Incomplete	E-W	D	23-26	
5	South	15/06/2020	2007	Water Rat	Complete	E	D	27	
5	South	16/06/2020	0323	Water Rat	Complete	E	D	29-31	
5	South	17/06/2020	0406	Water Rat	Complete	W	D	32	
5	South	18/06/2020	0350	Water Rat	Complete	W	D	33	
5	South	18/06/2020	2011	Water Rat	Incomplete	EXM	D	35	
5	South	19/06/2020	0354	Water Rat	Complete	W	D	36-37	
5	South	20/06/2020	2307	Water Rat	Complete	E	D	38-40	
5	South	21/06/2020	0408	Water Rat	Complete	W	D	41	

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
5	South	21/06/2020	1855	Water Rat	Complete	E	D	42	
5	South	22/06/2020	0325	Water Rat	Complete	W	D	44	
5	South	23/06/2020	2218	Water Rat	Complete	E	D	45	
5	South	24/06/2020	2156	Water Rat	Complete	W	D	46	
5	South	1/07/2020	2209	Water Rat	Complete	W	D	47	
5	South	7/07/2020	0606	Wood duck	Complete	W	D	7	x 2
5	South	7/07/2020	0716	Wood duck	Complete	E	D	8-10	
5	South	8/07/2020	1019	Wood duck	Complete	E	D	11-13	x 2
5	South	9/07/2020	1732	Water rat	Complete	E	D	14	
5	South	11/07/2020	0315	Water rat	Complete	E	D	15	
5	South	14/0/2020	0417	Water rat	Complete	E	D	16	
5	South	16/07/2020	0447	Water rat	Complete	E	D	17	
5	South	17/07/2020	1458	Rodent spp	Complete	E	D	18	
5	South	24/07/2020	0343	Water rat	Complete	E	D	19	
5	South	26/02/2020	1811	Water rat	Complete	E	D	22	
5	South	26/07/2020	2257	Microbat spp	Present	NDM	D	23-25	
4	FF	18/12/2019	0437	Black Rat	Complete	W	D	474-475	
4	FF	1/07/2020	0625	Microbat spp	Present	NDM	D	6	
4	FF	1/07/2020	2338	Cat	Complete	W	D	9	
4	FF	13/07/2020	0625	Microbat spp	Present	NDM	D	11	
4	FF	17/07/2020	2104	Antechinus spp	Complete	E	D	12-14	
4	FF	23/07/2020	2104	Antechinus spp	Complete	E	D	16	
4	FF	29/07/2020	2336	Antechinus spp	Complete	E	D	9	
4	FF	3/08/2020	1836	Antechinus spp	Complete	E	D	10	
4	FF	9/08/2020	2339	Antechinus spp	Complete	E	D	11	
4	FF	10/08/2020	1821	Antechinus spp	Complete	E	D	12	
4	FF	11/08/2020	1823	Antechinus spp	Complete	E	D	14	
4	FF	14/08/2020	0254	Antechinus spp	Complete	E	D	16	
4	FF	14/08/2020	2055	Antechinus spp	Complete	E	D	17	
4	FF	17/08/2020	0045	Antechinus spp	Complete	E	D	19	
4	FF	17/08/2020	1910	Antechinus spp	Complete	E	D	19	
4	FF	18/08/2020	2334	Antechinus spp	Complete	E	D	22	
4	FF	24/08/2020	0114	Rodent spp (probable FF)	Complete	E	D	23	
4	G	11/12/2019	1028	Lace Monitor	Complete	E	D	39	MB present
4	G	14/10/12019	0145	cat	Complete	E	D	33	Tabby
4	G	14/10/2019	0200	Fox	Complete	E	D	34	
4	G	16/10/2019	2253	Black Rat	Complete	E	D	48	
4	G	19/10/2019	0234	Koala	Complete	E	D	68	

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
4	G	20/10/2019	1242	Lace Monitor	Complete	W	D	90	
4	G	21/10/2019	2227	Koala	Complete	W	D	95	
4	G	22/10/2019	2055	cat	Complete	W	D	4	tabby
4	G	23/10/2019	1217	Lace Monitor	Complete	E	D	6	
4	G	25/10/2019	1113	Lace Monitor	Complete	E	D	12	
4	G	28/10/2019	1203	Lace Monitor	Complete	W	D	17	
4	G	29/10/2019	1156	Lace Monitor	Complete	E	D	18	
4	G	29/10/2019	2227	Black Rat	Complete	E	D	19	
4	G	30/10/2019	1227	Lace Monitor	Complete	W	D	20	
4	G	1/11/2019	0956	Lace Monitor	Complete	E	D	21	
4	G	1/11/2019	1521	Lace Monitor	Complete	W	D	23	
4	G	3/11/2019	1007	Lace Monitor	Complete	E	D	27	
4	G	3/11/2019	1354	Lace Monitor	Complete	W	D	30	
4	G	9/11/2019	0959	Lace Monitor	Complete	E	D	47	
4	G	9/11/2019	1505	Lace Monitor	Complete	W	D	48	
4	G	13/11/2019	0825	Cat	Complete	E	D	65	
4	G	13/11/2019	1944	Cat	Complete	W	D	66	
4	G	15/11/2019	0104	Koala	Complete	E	D	67	
4	G	15/11/2019	1255	Lace Monitor	Complete	E	D	73-74	
4	G	16/11/2019	1402	Lace Monitor	Complete	E	D	77	
4	G	18/11/2019	1223	Lace Monitor	Complete	W	Pr	85	
4	G	19/11/2019	0431	Swamp wallaby	Complete	W	D	86-87	
4	G	19/11/2019	1052	Lace Monitor	Complete	E	D	89	
4	G	20/11/2019	0502	Cat	Complete	E		91	
4	G	20/11/2019 to 18/12/2019 period (Camera date record malfunction)					D		
4	G	21/11/2019	1925	cat	Complete	E	D	5	Tabby
4	G	6/01/2015	2152	Koala	Complete	E	D	6	
4	G	7/01/2015	1121	Lace Monitor	Complete	W	D	10	
4	G	10/01/2015	2017	Koala	Complete	W	D	12	
4	G	10/01/2015	2052	cat	Complete	E	Pr	13	
4	G	11/01/2015	1853	Black Rat	Complete	E	D	16	
4	G	12/01/2015	1854	Koala	Complete	E	D	20	
4	G	14/01/2015	1003	Lace Monitor	Complete	W	D	37	
4	G	18/01/2015	0616	Lace Monitor	Complete	W	D	45	
4	G	20/01/2015	0514	Lace Monitor	Complete	E	D	53	

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
4	G	20/01/2015	0624	Lace Monitor	Complete	W	Pr	54	
4	G	23/01/2015	0936	Lace Monitor	Complete	W	D	88	
4	G	26/01/2015	1056	Lace Monitor	Complete	W	D	93	
4	G	27/01/2015	1014	Lace Monitor	Complete	W	D	99	
4	G	29/01/2015	1945	Cat	Complete	E	D	106	Tabby
4	G	30/01/2015	2130	Koala	Complete	W	D	107	
4	G	31/01/2015	0414	cat	Complete	E	D	108	Tabby
4	G	31/01/2015	0918	Lace Monitor	Complete	W	D	118	
4	G	22/06/2020	2040	Fox	Complete	W	D	3-7	Eats chicken thighs left
4	G	23/06/2020	0541	Fox	Complete	E	D	8	
4	G	24/06/2020	0103	Fox	Complete	W	D	9	
4	G	24/06/2020	0443	Fox	Complete	E	D	10-12	
4	G	25/06/2020	0206	Fox	Complete	E	D	17	
4	G	25/05/2020	2138	Fox	Complete	W	D	18	
4	G	26/05/2020	2037	Fox	Complete	E	D	20	Running
4	G	26/05/2020	2057	Fox	Complete	W	D	21	Running
4	G	27/05/2020	0006	Fox	Complete	E	D	23	Running
4	G	27/05/2020	0457	Fox	Complete	E	D	25	
4	G	27/05/2020	1026	Fox	Complete	W	D	26	
4	G	27/05/2020	1126	Fox	Complete	E	D	27	
4	G	27/06/2020	1926	Cat	Complete	W	D	28	Spotted
4	G	28/06/2020	0529	Fox	Complete	E	D	29	
4	G	29/06/2020	0444	Cat	Complete	E	D	30	Dark paws and tail
4	G	30/06/2020	0134	Cat	Complete	W	D	32	Spotted
4	G	30/06/2020	2217	Cat	Complete	E	D	35	
4	G	1/07/2020	0448	Fox	Complete	E	D	36	
4	G	1/07/2020	1941	Fox	Complete	E	D	39	
4	G	1/07/2020	2338	Cat	Complete	E	D	40	Dark paws and tail
4	G	3/07/2020	0731	Dog	Complete	E	D	42-45	
4	G	3/07/2020	1754	Fox	Complete	W	D	46	
4	G	3/07/2020	1828	Fox	Complete	W	D	47	
4	G	6/07/2020	1756	Bandicoot spp	Complete	E	D	49	
4	G	7/07/2020	0304	Fox	Complete	E	D	51	
4	G	7/07/2020	2023	Fox	Complete	E	D	52	
4	G	10/07/2020	1915	Cat	Complete	W	D	53	Spotted
4	G	11/07/2020	1949	Bandicoot spp	Complete	E	D	54	
4	G	12/07/2020	0422	Fox	Complete	W	D	55	
4	G	14/07/2020	0456	Fox	Complete	E	D	56	

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
4	G	14/07/2020	0553	Fox	Complete	W	D	57	
4	G	14/07/2020	1800	Fox	Complete	W	D	59	
4	G	15/07/2020	0615	Fox	Complete	E	D	60	
4	G	17/07/2020	0616	Fox	Complete	E	D	62	
4	G	17/07/2020	0616	Fox	Complete	W	D	62	
4	G	18/07/2020	0520	Cat	Complete	E	D	64	
4	G	20/07/2020	2142	Bandicoot spp.	Complete	E	D	66	
4	G	21/07/2020	1920	Bandicoot spp.	Complete	E	D	67	
4	G	24/07/2020	0741	Fox	Complete	E	D	68	
4	G	25/07/2020	0000	Bandicoot spp.	Complete	E	D	69	
4	G	26/07/2020	2314	Bandicoot spp.	Complete	E	D	71	
4	G	27/07/2020	2113	Bandicoot spp.	Complete	E	D	72	
4	G	29/07/2020	0049	cat	Complete	E	D	9	
4	G	29/07/2020	1800	Fox	Complete	E	D	10	
4	G	29/07/2020	2156	Bandicoot spp	C	E	D	11	
4	G	30/07/2020	0539	Cat	Complete	E	D	12	
4	G	30/07/2020	1540	Dog	C	E	D	13	
4	G	30/07/2020	1636	Fox	Complete	W	D	14	
4	G	30/07/2020	2317	Bandicoot	C	E	D	16	
4	G	1/08/2020	0102	Koala	Complete	W	D	17	
4	G	1/08/2020	0342	Koala	Complete	E	D	18	
4	G	1/08/2020	1751	Bandicoot spp	Complete	E	D	19	
4	G	1/08/2020	1916	Fox	Complete	E	D	20	
4	G	1/08/2020	1934	Fox	Complete	E	D	21	
4	G	2/08/2020	1816	Fox	Complete	E	D	22	
4	G	3/08/2020	1704	Fox	Complete	E	D	23	
4	G	4/08/2020	1816	Bandicoot spp	Complete	E	D	24	
4	G	4/08/2020	2022	Cat	Complete	E	D	25	
4	G	5/08/2020	1819	Fox	Complete	W	D	26	
4	G	7/08/2020	1817	Fox	Complete	W	D	27	
4	G	9/08/2020	1841	Fox	Complete	W	D	28	
4	G	9/08/2020	2149	Common brushtail possum	Complete	E	D	29	
4	G	10/08/2020	1950	Bandicoot spp	C	E	D	31	
4	G	11/08/2020	2025	Bandicoot spp	C	E	D	32	
4	G	11/08/2020	2035	Long nosed bandicoot	C	W	D	33	
4	G	13/08/2020	1825	Fox	C	W	D	36	
4	G	13/08/2020	1939	Bandicoot spp	C	E	D	37	
4	G	14/08/2020	1836	Bandicoot spp	C	E	D	38	

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
4	G	14/08/2020	218	Bandicoot spp	C	E	D	40	
4	G	15/08/2020	2046	Cat	C	W	D	44	
4	G	16/08/2002	2030	Fox	C	W	D	45	
4	G	16/08/2020	2038	Fox	C	W	D	46	
4	G	16/08/2020	2110	Fox	C	E	D	47	
4	G	17/08/2020	0251	Fox	C	W	D	48	
4	G	18/08/2020	0252	Fox	C	W	D	50	
4	G	22/08/2020	1359	Dog	C	E	D	51	Black white on chest
4	G	22/08/2020	1400	Dog	C	W	D	53	Black white on chest
4	G	25/08/2020	2207	BtPoss spp	C	E	D	59	
4	G	25/08/2020	2225	BtPoss spp	C	E	D	60	
4	G	25/08/2020	2302	Swamp Wallaby	C	W	D	61	
4	G	25/08/2020	2302	Swamp Wallaby	C	W	D	62	
4	G	26/08/2020	1227	Lace Monitor	C	W	D	63	
4	G	26/08/2020	1925	Swamp Wallaby	C	W	D	65	
4	G	27/08/2020	0537	Swamp Wallaby	C	E	D	68	
4	G	27/08/2020	0551	Swamp Wallaby	C	E	D	69	
4	G	29/08/2020	1446	Lace Monitor	C	E	D	70	
4	G	29/08/2020	1813	Fox	C	W	D	71	
4	G	29/08/2020	1907	Wallaby spp.	C	W	D	72	
4	G	30/08/3030	1917	Dog	C	E	D	74	Black
4	G	31/08/2020	1245	Fox	C	W	D	75	
4	G	31/08/2020	1824	Fox	C	E	D	76	
4	G	1/09/2020	0443	Swamp Wallaby	C	W	D	77	
4	G	1/09/2020	0453	Swamp Wallaby	C	W	D	79	
3	FF	31/01/2015	1617	cat	Complete	W	D	119	Tabby
3	FF	9/10/2019	1013	Welcome swallow	Incomplete	EXM	Pr	8-10	2 individuals
3	FF	9/10/2019	1147	Welcome swallow	Incomplete	EXM	D	13	
3	FF	14/10/2019	0417	Cat	Complete	W	Pr	22	Black, white paws
3	FF	14/10/2019	1002	Welcome swallow	Incomplete	EXM	D	24-26	
3	FF	15/10/2019	1059	Welcome swallow	Incomplete	EXM	Pr	32-33	2 individuals
3	FF	16/10/2019	0952	Welcome swallow	Incomplete	EXM	Pr	49-50	
3	FF	16/10/2019	1052	Welcome swallow	Incomplete	EXM	Pr	51-52	
3	FF	17/10/2019	0817	Welcome swallow	Incomplete	EXM	Pr	70	2 individuals
3	FF	17/10/2019	1026	Welcome swallow	Incomplete	EXM	Pr	81	
3	FF	17/10/2019	1251	Welcome swallow	Incomplete	EXM	Pr	91	
3	FF	17/10/2019	1426	Welcome swallow	Incomplete	EXM	Pr	95, 97	
3	FF	17/10/2019	1527	Welcome swallow	Incomplete	EXM	Pr	103	

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
3	FF	17/10/2019	1705	Welcome swallow	Incomplete	EXM	Pr	108	
3	FF	18/10/2019	1604	Welcome swallow	Incomplete	EXM	Pr	133	
3	FF	18/10/2019	1350	Welcome swallow	Incomplete	EXM	Pr	144	
3	FF	19/10/2019	1408	Welcome swallow	Incomplete	EXM	Pr	146	
3	FF	21/10/2019	1020	Welcome swallow	Incomplete	EXM	Pr	157-159	2 individuals
3	FF	29/11/2019	1048	Welcome swallow	Incomplete	EXM	D	10-11	
3	FF	1/12/2019	1453	cat	Complete	E	Pr	18	Black, white paws
3	FF	1/12/2019	1826	Welcome swallow	Incomplete	EXM	D	20	
3	FF	25/06/2020	2336	Microbat spp	Present	EXM	D	8	
3	FF	28/06/2020	2012	Cat	Incomplete	E-W	D	19-20	White socks - Grey
3	G	5/12/2019	0705	cat	Complete	E	D	52	Black, white paws
3	G	9/10/2019	0529	Cat	Complete	E	D	55	Black, white paws
3	G	10/10/2019	0146	Cat	Complete	W	D	65-69	Black, white paws
3	G	10/10/2019	0542	Cat	Complete	W	D	71	Black, white paws
3	G	10/10/2019	0722	Cat	Complete	E	Pr	72	Black, white paws
3	G	10/10/2019	2037	Fox	Complete	E	Pr	76	
3	G	11/10/2019	0547	Wallaby spp.	Complete	E	Pr	77	
3	G	11/10/2019	0623	Wallaby spp.	Complete	E	D	78	
3	G	11/10/2019	0834	Wallaby spp.	Complete	W	D	80	
3	G	11/10/2019	1331	Cat	Complete	W	D	81	Black, white paws
3	G	11/10/2019	1401	Cat	Complete	E	D	82	Black, white paws (With killed rodent spp.)
3	G	12/10/2019	0412	Cat	Complete	W	D	83	Black, white paws
3	G	12/10/2019	0442	Cat	Complete	E	D	84	Black, white paws
3	G	12/10/2019	0545	Cat	Complete	W	D	85	Black, white paws
3	G	12/10/2019	0629	Cat	Complete	E	D	86	Black, white paws
3	G	12/10/2019	1351	Cat	Complete	W	D	87	Black, white paws
3	G	12/10/2019	1438	Cat	Complete	W	D	88	Black, white paws
3	G	12/10/2019	1542	Cat	Complete	E	D	89	Black, white paws
3	G	12/10/2019	1545	Cat	Complete	E	D	90	Black, white paws
3	G	13/10/2019	0410	Cat	Complete	W	D	91	Black, white paws
3	G	13/10/2019	0607	Cat	Complete	E	Po	92	Black, white paws
3	G	13/10/2019	0930	Macropod	Complete	W	D	93	
3	G	13/10/2019	2232	Fox	Complete	E	D	94	
3	G	13/10/2019	2322	Cat	Complete	W	D	95	Black, white paws
3	G	14/10/2019	0542	Cat	Complete	W	D	97	Black, white paws
3	G	14/10/2019	0633	Cat	Complete	E	D	102	Black, white paws (With killed rodent

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
									spp.)
3	G	14/10/2019	0658	Cat	Complete	E	D	103	Black, white paws
3	G	14/10/2019	1828	EG kangaroo	Complete	W	D	104-106	
3	G	14/10/2019	2035	Cat	Complete	W	D	107	Black, white paws
3	G	14/10/2019	2227	Cat	Complete	E	D	108	Black, white paws
3	G	15/10/2019	0103	Cat	Complete	W	D	109	Black, white paws
3	G	15/10/2019	0143	Cat	Complete	E	D	110	Black, white paws
3	G	15/10/2019	0228	Cat	Complete	W	D	111-115	Black, white paws, and throat
3	G	15/10/2019	0320	Cat	Complete	E	D	116	Black, white paws
3	G	15/10/2019	0436	Fox	Complete	W	Pr	118-120	
3	G	15/10/2019	0453	EG kangaroo	Complete	E	D	121	
3	G	15/10/2019	0553	Cat	Complete	W	D	122	
3	G	15/10/2019	0605	Fox	Complete	E	Pr	123	
3	G	15/10/2019	0625	EG kangaroo	Complete	E	D	124-125	
3	G	15/10/2019	0629	Cat	Complete	E	Pr	126	Black, white paws
3	G	15/10/2019	2020	Wallaby spp.	Complete	W	D	131-132	
3	G	16/10/2019	0458	Cat	Complete	W	Pr	136	Black, white paws
3	G	16/10/2019	0533	EG kangaroo	Complete	E	Pr	137-138	
3	G	16/10/2019	0537	EG kangaroo	Complete	W	D	139	
3	G	17/10/2019	0207	Fox	Complete	W	D	145	
3	G	17/10/2019	1413	Cat	Complete	W	D	156-159	Black, white paws, and throat
3	G	17/10/2019	1454	Cat	Complete	E	D	160	
3	G	17/10/2019	1538	Cat	Complete	W	D	161	
3	G	17/10/2019	1542	Cat	Complete	E	D	163	
3	G	17/10/2019	1549	Cat	Complete	E	D	164	
3	G	18/10/2019	0522	Fox	Complete	E	D	165	
3	G	18/10/2019	1012	Cat	Incomplete	NDM	Pr	177-178	
3	G	18/10/2019	1138	Welcome swallow	Incomplete	EXM	D	187-189	
3	G	18/10/2019	1209	Welcome swallow	Incomplete	EXM	Pr	192-193	
3	G	18/10/2019	1911	Swamp wallaby	Complete	W	D	202-206	
3	G	18/10/2019	2053	Cat	Complete	W	D	210	Black, white paws
3	G	19/10/2019	0142	Fox	Complete	W	D	211	
3	G	19/10/2019	0222	Fox	Complete	E	D	212	
3	G	19/10/2019	0331	Cat	Complete	W	D	213	Black, white paws, and throat
3	G	19/10/2019	0356	Cat	Complete	W	D	214	Black, white paws
3	G	19/10/2019	0401	Cat	Complete	E	D	215	Black, white paws

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
3	G	19/10/2019	0415	Cat	Complete	W	Pr	216	Black, white paws
3	G	19/10/2019	0508	Swamp wallaby	Complete	E	D	217-219	
3	G	19/10/2019	0618	Cat	Complete	E	Pr	221	Black, white paws
3	G	19/10/2019	2001	Wallaby spp.	Complete	W	D	230	
3	G	20/10/2019	0511	Macropod spp.	Complete	E	Pr	231	
3	G	20/10/2019	1752	Swamp wallaby	Complete	W	D	240-241	
3	G	20/10/2019	2202	Cat	Complete	W	D	242	Black, white paws
3	G	21/10/2019	0514	Swamp wallaby	Complete	E	D	243-245	
3	G	21/10/2019	0519	Cat	Complete	E	D	246	Black, white paws
3	G	21/10/2019	0804	Cat	Complete	W	D	247	Black, white paws
3	G	21/10/2019	0814	Cat	Complete	E	D	248	Black, white paws, (with killed rodent spp.)
3	G	21/10/2019	1302	Cat	Complete	W	D	249	Black, white paws, and throat
3	G	21/10/2019	1307	Cat	Complete	E	D	250	Black, white paws
3	G	21/10/2019	1331	Cat	Complete	W	D	251	Black, white paws, and throat
3	G	21/10/2019	1558	Cat	Complete	E	D	252	Black, white paws
3	G	21/10/2019	2313	Cat	Complete	E	D	257	Black, white paws
3	G	22/10/2019	0446	Cat	Complete	W	D	258	Black, white paws, and throat
3	G	22/10/2019	0644	Cat	Complete	E	D	259	Black, white paws
3	G	22/10/2019	0704	Macropod spp.	Complete	E	D	260	
3	G	22/10/2019	0836	Cat	Complete	E	D	262	Black, white paws
3	G	22/10/2019	1107	Cat	Complete	W	D	265	Black, white paws, and throat
3	G	22/10/2019	1146	Cat	Complete	E	D	266	Black, white paws
3	G	28/11/2019	2018	Cat	Complete	E	D	12	Black, white paws
3	G	30/11/2019	2240	Cat	Complete	EXM	Po	22-30	Black, white paws
3	G	1/12/2019	0435	Fox	Complete	W	D	33	
3	G	1/12/2019	0507	Wallaby spp.	Complete	E	Pr	34	
3	G	1/12/2019	1231	Cat	Complete	W	Pr	38	
3	G	1/12/2019	2302	Swamp wallaby	Complete	W	D	40-41	
3	G	2/12/2019	2121	Cat	Complete	E	D	43-51	Tabby
3	G	2/12/2019	2250	Cat	Complete	W	D	52-54	Black, white paws
3	G	3/12/2019	0347	Cat	Complete	EXM	Pr	55-58	
3	G	3/12/2019	0517	Wallaby spp.	Complete	E	D	61	
3	G	3/12/2019	2041	Swamp wallaby	Complete	W	D	78	

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
3	G	4/12/2019	0101	Cat	Complete	W	D	79	Black, white paws
3	G	4/12/2019	0517	Wallaby spp.	Complete	E	D	81	
3	G	4/12/2019	1831	Cat	Complete	E	D	94	Black, white paws
3	G	5/12/2019	0308	Cat	Complete	W	D	95	Black, white paws, and throat
3	G	6/12/2019	0235	Cat	Complete	W	D	103-104	Black, white paws, and throat
3	G	6/12/2019	2237	Swamp wallaby	Complete	W	Po	135	
3	G	7/12/2019	0227	Cat	Complete	W	D	136	Tabby
3	G	7/12/2019	0530	Cat	Complete	E	Pr	138	Black, white paws
3	G	8/12/2019	0450	Macropod spp.	Complete	E	D	150	
3	G	8/12/2019	0613	Cat	Complete	EXM	Po	153-154	Black, white paws, and throat
3	G	8/12/2019	1700	Swamp wallaby	Complete	E	Po	156	
3	G	9/12/2019	0508	Macropod spp.	Complete	E	Pr	158	
3	G	9/12/2019	1728	Swamp wallaby	Complete	E	D	161	
3	G	9/12/2019	2227	Cat	Complete	E	D	162-163	
3	G	10/12/2019	0648	Swamp wallaby	Complete	E	D	165	
3	G	10/12/2019	0743	Swamp wallaby	Complete	W	D	166	
3	G	10/12/2019	2224	Macropod spp.	Complete	E	D	176	
3	G	11/12/2019	1701	Swamp wallaby	Complete	E	D	177	
3	G	12/12/2019	0109	Cat	Complete	E	D	178	Black, white paws, and throat
3	G	12/12/2019	2130	Cat	Complete	W	D	179-181	Black, white paws, and throat
3	G	12/12/2019	2351	Cat	Complete	W	D	182	Black, white paws, and throat
3	G	13/12/2019	0054	Swamp wallaby	Complete	W	Pr	183	
3	G	13/12/2019	0622	Wallaby spp.	Complete	W	Pr	184	
3	G	13/12/2019	0645	Wallaby spp.	Complete	E	Pr	185	
3	G	14/12/2019	2017	Wallaby spp.	Complete	E	D	187	
3	G	14/12/2019	2210	Cat	Complete	W	D	188	Black, white paws, and throat
3	G	15/12/2019	0043	Cat	Complete	E	D	189	Black, white paws
3	G	17/12/2019	2112	Swamp wallaby	Complete	W	Pr	194-195	
3	G	18/12/2019	0228	Cat	Complete	W	D	196	
3	G	18/12/2019	0451	Cat	Complete	E	D	197	
3	G	21/06/2020	1837	Cat	Complete	W	D	5-6	Larger Grey - white socks

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
3	G	21/06/2020	1904	Cat	Complete	W	D	7	Smaller grey - white socks
3	G	21/06/2020	1837	Cat	Complete	E	D	8	Larger Grey - white socks carrying Prey (probable Rodent)
3	G	21/06/2020	2026	Cat	Complete	E	D	9	Tabby
3	G	21/06/2020	1904	Cat	Complete	W	D	10-11	Smaller grey - white socks investigates cage
3	G	22/06/2020	0355	Red-necked wallaby	Complete	E	D	12-13	
3	G	22/06/2020	1838	Cat	Complete	W	D	22-25	White socks - Grey
3	G	23/06/2020	1839	Cat	Complete	E	D	26-77	White socks - Grey feeding on drumsticks
3	G	23/06/2020	0522	Wallaby spp.	Complete	E	D	78	
3	G	23/06/2020	0658	Dogs	Incomplete	W-E	D	79-94	x 2 (kelpie crosses - collars)
3	G	23/06/2020	1842	Cat	Complete	E	D	96-97	
3	G	23/06/2020	1853	Red-necked wallaby	Complete	W	D	98-100	
3	G	23/06/2020	1930	Cat	Complete	W	D	101	
3	G	23/06/2020	2022	Cat	Complete	W	D	102-105	
3	G	23/06/2020	2024	Cat	Complete	E	D	106	
3	G	23/06/2020	2149	Cat	Complete	E	D	107	
3	G	23/06/2020	2301	Cat	Complete	W	D	108	
3	G	24/06/2020	0017	Cat	Complete	W	D	109	
3	G	24/06/2020	0442	Cat	Complete	E	D	112	
3	G	24/06/2020	1528	Cat	Complete	E	D	116	
3	G	24/06/2020	1609	Red-necked wallaby	Complete	W	D	117	
3	G	24/06/2020	1652	Cat	Complete	E	D	118	
3	G	24/06/2020	1923	Cat	Complete	E	D	119	
3	G	24/06/2020	2243	Cat	Complete	E	D	121	
3	G	24/06/2020	0029	Cat	Complete	E	D	121	Carrying prey (Probable Large Rodent)
3	G	25/06/2020	0630	Dog	Complete	W	D	124-129	x 2 (kelpie crosses - collars)
3	G	25/06/2020	1226	Cat	Complete	W	D	138	
3	G	25/06/2020	1324	Cat	Complete	E	D	139	
3	G	25/06/2020	2343	Cat	Complete	E	D	144	
3	G	26/06/2020	0621	Dog	Complete	W	D	145-146	x 2 (kelpie crosses - collars)

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
3	G	26/06/2020	0634	Dog	Complete	E	D	148	x 2 (kelpie crosses - collars)
3	G	26/06/2020	0719	Dog	Complete	W	D	149	x 2 (kelpie crosses - collars)
3	G	26/06/2020	0727	Dog	Complete	E	D	150	x 2 (kelpie crosses - collars)
3	G	27/06/2020	1918	Cat	Complete	W	D	157	
3	G	27/06/2020	1918	Cat	Complete	W	D	158	
3	G	27/06/2020	2105	Cat	Complete	E	D	157	
3	G	27/06/2020	0258	Cat	Complete	E	D	158	
3	G	27/06/2020	2231	Cat	Complete	E	D	164	
3	G	27/06/2020	2256	Cat	Complete	E	D	165	Carry prey
3	G	28/06/2020	0630	Dog	Complete	W	D	166	x 2 (kelpie crosses - collars)
3	G	28/06/2020	0641	Dog	Complete	E	D	166	
3	G	28/06/2020	2217	Cat	Complete	W	D	170	
3	G	29/06/2020	0046	Cat	C	E	D	171	
3	G	29/06/2020	0451	Cat	C	E	D	173	
3	G	29/06/2020	1409	Cat	C	E	D	178	
3	G	29/06/2020	1704	Cat	C	E	D	178	
3	G	28/07/2020	1904	Cat	Complete	W	D	5	Fat tabby or ginger
3	G	28/07/2020	1914	Cat	Complete	W	D	6	Black with white socks
3	G	28/07/2020	2041	Cat	Complete	E	D	7-8	Black with white socks
3	G	28/07/2020	2102	Cat	Complete	W	D	9	Black with white socks
3	G	28/07/2020	2117	Cat	Complete	W	D	10	Fat tabby or ginger
3	G	28/07/2020	2208	Cat	Complete	E	D	11	Fat tabby or ginger
3	G	28/07/2020	2317	Cat	Complete	W	D	12	Fat tabby or ginger
3	G	29/07/2020	0036	Cat	Complete	E	D	13	Fat tabby or ginger
3	G	29/07/2020	0059	Cat	Complete	W	D	14	Fat tabby or ginger
3	G	29/07/2020	0135	Cat	Complete	E	D	15-16	Black with white socks
3	G	29/07/2020	0446	Cat	Complete	E	D	17	Fat tabby or ginger
3	G	29/07/2020	1105	Cat	Complete	W	D	18	Black with white socks
3	G	29/07/2020	1719	Cat	Complete	E	D	20	Black with white socks
3	G	29/07/2020	1845	Cat	Complete	E	D	21	Black with white socks
3	G	29/07/2020	1922	Cat	Complete	W	D	22	
3	G	29/07/2020	2113	Cat	Complete	E	D	23	Fat tabby or ginger
3	G	30/07/2020	0048	Cat	Complete	W	D	24	Fat tabby or ginger
3	G	30/07/2020	0241	Cat	Complete	W	D	25	Black with white socks
3	G	30/07/2020	0336	Cat	Complete	E	D	26	Fat tabby or ginger

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
3	G	30/07/2020	1733	Cat	Complete	E	D	27	Black with white socks
3	G	30/07/2020	2236	Cat	Incomplete	WE	D	28-29	
3	G	31/07/2020	0130	Cat	Complete	W	D	30	Black with white socks
3	G	31/07/2020	0149	Cat	Complete	E	D	31	Black with white socks
3	G	31/07/2020	0443	Cat	Complete	E	D	35	Fat tabby or ginger
3	G	31/07/2020	0829	Cat	Complete	E	D	36	Black with white socks
3	G	31/07/2020	1332	Cat	Complete	W	D	37	Black with white socks
3	G	31/07/2020	1620	Cat	Complete	E	D	38	Black with white socks
3	G	31/07/2020	2030	Cat	Complete	E	D	40	Black with white socks
3	G	1/08/2020	0124	Cat	Complete	W	D	41	
3	G	1/08/2020	0357	Cat	Complete	W	D	42	Black with white socks
3	G	1/08/2020	0409	Cat	Incomplete	EW	D	43-45	Black with white socks
3	G	1/08/2020	0433	Cat	Complete	E	D	46	Black with white socks
3	G	1/08/2020	0501	Cat	Incomplete	WE	D	47-48	Black with white socks
3	G	1/08/2020	0644	Dog	Incomplete	EXM	D	50	
3	G	1/08/2020	1744	Swamp wallaby	Complete	W	D	52	
3	G	1/08/2020	1843	Cat	Complete	E	D	54	Black with white socks
3	G	2/08/2020	0234	Cat	Incomplete	WE	D	55-56	Black with white socks
3	G	2/08/2020	0356	Swamp wallaby	Complete	E	D	57	
3	G	2/08/2020	0705	Dogs	Incomplete	WE	D	58-59	2 x kelpies
3	G	2/08/2020	1206	Cat	Complete	W	D	60	Black with white socks
3	G	2/08/2020	2157	Cat	Complete	E	D	61	Black with white socks
3	G	3/08/2020	0538	Cat	Complete	E	D	62	Black with white socks
3	G	3/08/2020	2353	Cat	Complete	W	D	63	Black with white socks
3	G	4/08/2020	0648	Dogs	Incomplete	WE	D	64-67	2 x kelpies
3	G	4/08/2020	0801	Cat	Complete	E	D	68	Black with white socks
3	G	5/08/2020	0003	Cat	Complete	W	D	69	Black with white socks
3	G	5/08/2020	0434	Cat	Complete	E	D	70-72	Black with white socks
3	G	5/08/2020	0704	Dogs	Incomplete	WE	D	74-75	2 x kelpies
3	G	5/08/2020	0749	Cat	Complete	E	D	77	Black with white socks
3	G	5/08/2020	1538	Cat	Complete	W	D	78	Black with white socks
3	G	5/08/2020	1708	Cat	Complete	E	D	79	Black with white socks
3	G	5/08/2020	1730	Cat	Complete	W	D	80	
3	G	5/08/2020	2152	Cat	Complete	E	D	84	Black with white socks
3	G	6/08/2020	0639	Dogs	Incomplete	EW	D	85-86	2 x kelpies
3	G	6/08/2020	0823	Cat	Complete	E	D	87	Black with white socks
3	G	6/08/2020	1202	Cat	Complete	W	D	88	Black with white socks
3	G	6/08/2020	1603	Cat	Complete	E	D	89-91	Black with white socks

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
3	G	6/08/2020	1657	Cat	Complete	E	D	92	Black with white socks
3	G	6/08/2020	1812	Cat	Complete	E	D	93	Black with white socks
3	G	6/08/2020	1949	Cat	Complete	E	D	94	
3	G	6/08/2020	2255	Cat	Complete	E	D	97	
3	G	7/08/2020	0739	Dogs	Incomplete	EW	D	98-100	2 x kelpies
3	G	7/08/2020	1043	Cat	Incomplete	EW	D	102-103	Black with white socks
3	G	7/08/2020	1357	Cat	Complete	E	D	104	Black with white socks
3	G	7/08/2020	1923	Cat	Complete	W	D	105	
3	G	7/08/2020	1939	Cat	Complete	E	D	107	Black with white socks
3	G	7/08/2020	2136	Cat	Complete	E	D	108	Black with white socks
3	G	8/08/2020	0654	Dogs	Incomplete	WE	D	109-112	2 x kelpies
3	G	8/08/2020	1503	Swamp wallaby	Complete	W	Pr	113	
3	G	8/08/2020	2120	Cat	Complete	W	D	115	
3	G	8/08/2020	2301	Cat	Complete	E	D	116	
3	G	8/08/2020	2327	Wallaby spp.	Complete	E	D	117	
3	G	9/08/2020	0003	Cat	Complete	W	D	118	
3	G	9/08/2020	0409	Wallaby spp.	Complete	W	D	119	
3	G	9/08/2020	0658	Dogs	Incomplete	WE	D	120-121	2 x kelpies
3	G	9/08/2020	0708	Cat	Complete	E	D	122	
3	G	9/08/2020	1855	Cat	Complete	W	D	123	
3	G	9/08/2020	1959	Cat	Complete	E	D	124	
3	G	9/08/2020	2331	Cat	Complete	E	D	125	
3	G	10/08/2020	2001	Cat	Complete	W	D	126	
3	G	10/08/2020	2148	Cat	Complete	E	D	127	
3	G	11/08/2020	1357	Cat	Complete	W	D	128	
3	G	11/08/2020	1441	Cat	Complete	E	D	129	
3	G	11/08/2020	1856	Bandicoot spp	Complete	E	Pr	130	
3	G	12/08/2020	1946	Cat	Complete	W	D	131	
3	G	13/08/2020	0130	Cat	Complete	E	D	132	
3	G	14/08/2020	0025	BtPoss spp	Complete	E	D	133	
3	G	14/08/2020	0510	Cat	Complete	E	D	135	
3	G	15/08/2020	0504	Cat	Complete	W	D	136	
3	G	15/08/2020	0719	Cat	Complete	E	D	137	
3	G	15/08/2020	1845	Cat	Complete	W	Pr	138	
3	G	15/08/2020	1906	Cat	Complete	W	D	139	
3	G	15/08/2020	1944	Cat	Complete	E	D	140	
3	G	15/08/2020	2041	Cat	Complete	E	D	141-145	
3	G	15/08/2020	2340	Cat	Complete	W	D	146	

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
3	G	16/08/2020	0144	Cat	Complete	W	D	147	
3	G	16/08/2020	0508	Cat	Complete	E	D	148-149	
3	G	16/08/2020	0546	Cat	Complete	W	D	150	
3	G	16/08/2020	0709	Dogs	Incomplete	WE	D	151-153	2 x kelpies
3	G	16/08/2020	1719	Cat	Complete	E	D	154	
3	G	16/08/2020	1922	Cat	Complete	W	D	156	
3	G	16/08/2020	2228	Cat	Complete	E	D	157	
3	G	16/08/2020	2302	Cat	Complete	W	D	158	
3	G	17/08/2020	0040	Cat	Complete	W	D	159	
3	G	17/08/2020	0202	Cat	Complete	E	D	160	
3	G	17/08/2020	0340	Wallaby spp.	Complete	E	D	161	
3	G	17/08/2020	0438	Wallaby spp.	Complete	E	D	162	
3	G	17/08/2020	0532	Cat	Complete	E	D	163	
3	G	17/08/2020	0846	Cat	Complete	W	D	164	
3	G	17/08/2020	1809	Cat	Complete	E	D	165	
3	G	17/08/2020	2139	Cat	Complete	W	D	166	
3	G	17/08/2020	2254	Cat	Incomplete	WE	D	167-68	
3	G	18/08/2020	0254	Red-necked wallaby	Complete	W	D	169-170	
3	G	18/08/2020	0936	Cat	Incomplete	EW	D	171-72	
3	G	18/08/2020	1631	Cat	Complete	E	D	173	
3	G	18/08/2020	1959	Cat	Complete	W	D	174	
3	G	18/08/2020	2142	Cat	Complete	E	D	175	
3	G	19/08/2020	0604	Dogs	Incomplete	WE	D	176-178	2 x kelpies
3	G	20/08/2020	0152	Cat	Complete	W	D	179	
3	G	20/08/2020	0306	Cat	Complete	E	D	180	
3	G	20/08/2020	0624	Cat	Complete	W	D	181	
3	G	20/08/2020	0646	Cat	Complete	E	D	182	
3	G	20/08/2020	2111	Cat	Complete	E	D	184	
3	G	21/08/2020	0713	Dogs	Incomplete	WE	D	186-187	2 x kelpies
3	G	21/08/2020	0727	Cat	Complete	E	D	188	
3	G	21/08/2020	0906	Cat	Complete	E	D	190	
3	G	21/08/2020	1510	Cat	Incomplete	WE	D	192-3	
3	G	21/08/2020	1709	Cat	Complete	E	D	194	
3	G	21/08/2020	2138	Cat	Complete	E	D	196	
3	G	22/08/2020	0522	Wallaby spp.	Complete	E	D	197	
3	G	22/08/2020	0533	Cat	Complete	W	D	198	
3	G	22/08/2020	1341	Dog	Complete	W	D	200	
3	G	22/08/2020	1532	Cat	Complete	E	D	201	Black with white socks

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
3	G	22/08/2020	2352	Cat	Complete	W	D	202	Fat tabby or ginger
3	G	23/08/2020	0015	Cat	Complete	E	D	203	Fat tabby or ginger
3	G	23/08/2020	0537	Cat	Complete	E	D	204	Black with white socks
3	G	23/08/2020	0713	Red-necked wallaby	Complete	E	Pr	206	Joey in pouch
3	G	23/08/2020	0723	Dogs	Complete	W	D	207,209-211	2 x kelpies
3	G	23/08/2020	1415	Cat	Complete	W	D	212	Black with white socks
3	G	23/08/2020	1804	Cat	Complete	E	D	213	Black with white socks
3	G	23/08/2020	1837	Red-necked wallaby	Complete	W	D	214	Joey in pouch
3	G	23/08/2020	1900	Swamp wallaby	Complete	W	D	215-216	
3	G	24/08/2020	0116	Swamp wallaby	Complete	E	Pr	217	
3	G	25/08/2020	0207	Cat	Complete	W	D	230	
3	G	25/08/2020	0645	Cat	Complete	E	D	232	Black with white socks
3	G	25/08/2020	1209	Cat	Incomplete	WE	D	234-235	Black with white socks
3	G	27/08/2020	1322	Cat	Incomplete	WE	D	236-237	Black with white socks
3	G	28/08/2020	1236	Cat	Complete	W	D	238	
3	G	28/08/2020	1623	Cat	Complete	E	D	239	
3	G	29/08/2020	0021	Swamp wallaby	Complete	E	D	241	
3	G	29/08/2020	0631	Cat	Complete	W	D	242-243	
3	G	29/08/2020	1538	Cat	Complete	W	D	244	
3	G	29/08/2020	1833	Cat	Complete	E	D	245	
3	G	29/08/2020	2254	Red-necked wallaby	Complete	E	D	246	
3	G	30/08/2020	1010	Cat	Complete	W	D	249	
3	G	30/08/2020	1032	Cat	Complete	E	D	250	
3	G	30/08/2020	2304	Cat	Complete	W	D	251	
3	G	30/08/2020	2329	Cat	Incomplete	EW	D	252-253	
3	G	31/08/2020	0405	Cat	Incomplete	WE	D	254-255	
3	G	31/08/2020	0657	Dogs	Incomplete	WE	D	256-258	2 x kelpies
3	G	31/08/2020	0804	Cat	Complete	E	D	259	
3	G	31/08/2020	1138	Cat	Complete	W	D	260	
3	G	31/08/2020	1824	Cat	Complete	E	D	261	
3	G	1/09/2020	0205	Cat	Complete	W	D	262	
3	G	1/09/2020	0359	Cat	Complete	E	D	263	
2	FF	18/12/2019	0458	Macropod spp.	Complete	E		198	
2	FF	24/06/2020	0301	Black Rat	Complete	W	D	10-15	
2	FF	11/07/2020	0813	Antechinus spp	Complete	E	D	76-106	
2	FF	21/08/2020	0321	Antechinus spp	C	E	D	22-33	
2	FF	24/08/2020	2321	Antechinus spp	C	W	D	34-35	
2	FF	27/08/2020	0132	Antechinus spp	C	W	D	43-45	

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
2	FF	28/08/2020	0321	Antechinus spp	Incomplete	E-W	D	51-52	
2	FF	28/08/2020	2047	Antechinus spp	C	W	D	59-63	
2	FF	No pics							MB present
2	G	28/11/2019	Nil fauna				D		
2	G	8/10/2019	1943	Fox	Complete	W	D	2	
2	G	8/10/2019	2021	Cat	Complete	E	Pr	3	Black, white paws
2	G	9/10/2019	0431	Wallaby spp.	Complete	W	Pr	4	
2	G	10/10/2019	0102	Swamp wallaby	Complete	W	D	11	
2	G	10/10/2019	0312	Swamp wallaby	Complete	E	D	12	
2	G	10/10/2019	0329	Swamp wallaby	Complete	E	D	13-14	
2	G	10/10/2019	0343	Swamp wallaby	Complete	E	D	15-16	
2	G	13/10/2019	0154	Fox	Complete	E	D	27	
2	G	13/10/2019	2244	Fox	Incomplete	E-W	D	29-31	
2	G	14/10/2019	0358	Fox	Complete	E	D	33	
2	G	14/10/2019	1937	Fox	Complete	W	D	34	
2	G	15/10/2019	0002	Fox	Complete	W	D	35	
2	G	15/10/2019	0102	Fox	Complete	E	Po	36	
2	G	15/10/2019	1936	Swamp rat	Complete	E	D	41	
2	G	16/10/2019	2246	Fox	Incomplete	W-E	D	45-47	
2	G	17/10/2019	0342	Fox	Complete	E	D	48	
2	G	17/10/2019	2040	Fox	Complete	W	D	52	
2	G	18/10/2019	2353	Fox	Complete	E	D	60	
2	G	19/10/2019	0245	Fox	Complete	E	D	63	
2	G	19/10/2019	0456	Fox	Complete	E	D	64	
2	G	19/10/2019	2016	Fox	Complete	E-W	D	73	
2	G	19/10/2019	2028	Fox	Complete	W	D	74	
2	G	19/10/2019	2102	Fox	Complete	W	D	75	
2	G	20/10/2019	0322	Fox	Complete	E	D	76	
2	G	20/10/2019	2118	Fox	Incomplete	W-E	D	84-86	
2	G	21/10/2019	0330	Fox	Complete	W	D	87	
2	G	21/10/2019	0517	Fox	Complete	E	D	89	
2	G	21/10/2019	1927	Swamp wallaby	Complete	W	D	94	
2	G	21/10/2019	2014	Fox	Complete	W	D	96	
2	G	21/10/2019	2101	Fox	Complete	W	D	97	
2	G	22/10/2019	0417	Fox	Complete	E	D	99	
2	G	22/10/2019	0450	Swamp wallaby	Complete	E	Pr	100	
2	G	22/10/2019	0521	Fox	Complete	E	D	101	
2	G	22/10/2019	0544	Swamp wallaby	Complete	E	D	102	

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
2	G	30/11/2019	0422	Macropod spp.	Complete	E	D	84	
2	G	1/12/2019	0249	Fox	Complete	E	D	90	
2	G	1/12/2019	0800	Macropod spp.	Complete	E	D	91	
2	G	2/12/2019	2353	Fox	Complete	E	Pr	138	
2	G	4/12/2019	2021	Swamp wallaby	Complete	E	D	236	
2	G	4/12/2019	2032	Swamp wallaby	Complete	W	D	237	
2	G	5/12/2019	0508	Swamp wallaby	Complete	E	D	238	
2	G	6/12/2019	0407	Swamp wallaby	Complete	E	D	313	
2	G	7/12/2019	0326	Swamp wallaby	Complete	E	D	416	
2	G	7/12/2019	2130	Swamp wallaby	Complete	E	D	441	
2	G	8/12/2019	0009	Fox	Complete	E	D	442	
2	G	8/12/2019	1624	Dog	Complete	E	D	465	No collar visible, relatively skinny
2	G	8/12/2019	2005	Macropod spp.	Incomplete	W-E	Pr	467	
2	G	9/12/2019	0409	Swamp wallaby	Complete	E	Pr	468	
2	G	10/12/2019	2028	Swamp wallaby	Complete	E	D	589	
2	G	11/12/2019	0453	Echidna	Complete	E	Po	591	
2	G	12/12/2019	0050	Swamp wallaby	Complete	E	D	674	
2	G	12/12/2019	0233	Swamp wallaby	Complete	E	D	676	
2	G	12/12/2019	2139	Swamp wallaby	Complete	E	D	733	
2	G	13/12/2019	0346	Swamp wallaby	Complete	E	Pr	735-737, 739	
2	G	14/12/2019	2021	Swamp wallaby	Complete	E	D	765	
2	G	15/12/2019	0035	Dog	Complete	E	D	769	
2	G	15/12/2019	0159	Swamp wallaby	Complete	E	D	770	
2	G	15/12/2019	0407	Swamp wallaby	Complete	W	D	771-772	
2	G	16/12/2019	2315	Fox	Complete	E	D	850	
2	G	23/06/2020	0428	Swamp Wallaby	Complete	E	D	43	
2	G	23/06/2020	0527	Swamp wallaby	Complete	E	D	44	
2	G	23/06/2020	1916	Swamp wallaby	Complete	E	D	114-117	
2	G	23/06/2020	1931	Wallaby	Incomplete	E-W	D	119	
2	G	23/06/2020	2139	Swamp wallaby	Incomplete	NDM	D	124-127	
2	G	23/06/2020	2152	Swamp wallaby	Complete	W	D	128-129	
2	G	26/06/2020	220	Fox	Complete	E	D	220	
2	G	28/06/2020	275	Swamp Wallaby	Complete	E	D	275	
2	G	28/06/2020	2343	Bandicoot spp	Complete	E	D	295	
2	G	29/06/2020	0725	Wallaby spp.	Complete	E	D	297	
2	G	29/06/2020	1457	Swamp wallaby	C	W	D	316-317	
2	G	30/06/2020	0527	Wallaby spp.	C	E	D	320	
2	G	30/06/2020	0613	Swamp Wallaby	C	E	D	321	

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
2	G	1/07/2020	1926	Swamp Wallaby	C	W	D	400	
2	G	2/07/2020	0051	Swamp Wallaby	C	E	D	404	
2	G	3/07/2020	0516	Wallaby spp.	C	E	D	444	
2	G	5/07/2020	0043	Wallaby spp.	Incomplete	E	D	497	
2	G	29/07/2020	0547	Swamp wallaby	C	E	D	25	
2	G	29/07/2020	0613	Swamp wallaby	C	W	D	26	
2	G	30/07/2020	0713	Cat	C	E	D	47	Grey white socks
2	G	31/07/2020	0444	Swamp wallaby	C	E	D	80	
2	G	31/07/2020	0558	Swamp wallaby	C	E	D	81	
2	G	1/08/2020	0500	Swamp wallaby	C	E	D	82	
2	G	1/08/2020	0500	Dog	C	E	D	83	Kelpie from site 3
2	G	1/08/2020	1837	Swamp Wallaby	C	W	D	141	Carrying young
2	G	2/08/2020	1804	Bandicoot spp.	C	E	D	181	
2	G	3/08/2020	0416	Swamp wallaby	C	E	D	183	
2	G	3/08/2020	0529	Swamp wallaby	C	E	D	184	
2	G	3/08/2020	1536	Dog	C	E	D	202	Black Dog white chest
2	G	3/08/2020	1544	Dog	C	E	D	205	
2	G	3/08/2020	1900	Bandicoot spp.	C	E	D	208	
2	G	3/08/2020	1910	Northern brown bandicoot	C	E	D	209	
2	G	4/08/2020	1805	Wallaby spp.	C	W	D	235	
2	G	5/08/2020	0552	Swamp wallaby	C	E	D	239	
2	G	9/08/2020	0546	Swamp Wallaby	C	E	D	366	
2	G	9/08/2020	1752	Swamp Wallaby	C	E	D	393	
2	G	10/08/2020	0510	Swamp wallaby	C	E	D	395	x 2
2	G	10/08/2020	1850	Bandicoot spp.	C	E	D	414	
2	G	10/08/2020	1958	Bandicoot spp.	C	E	D	416	
2	G	11/08/2020	0024	Echidna	C	E	D	417	
2	G	11/08/2020	1800	Swamp wallaby	C	E	D	452	
2	G	12/08/2020	0522	Swamp wallaby	C	E	D	454	
2	G	12/08/2020	0524	Swamp wallaby	C	E	D	455	
2	G	12/08/2020	1757	Bandicoot spp.	c	e	d	478	
2	G	12/08/2020	2220	Bandicoot spp.	C	E	D	481	
2	G	13/08/2020	0559	Swamp Wallaby	C	E	D	482	
2	G	13/08/2020	2337	Swamp wallaby	C	E	D	521	
2	G	14/08/2020	0435	Swamp Wallaby	Incomplete	E-W	D	522	X 2
2	G	14/08/2020	0450	Swamp Wallaby	Complete	E-W	D	522	X 2
2	G	14/08/2020	1748	Bandicoot spp.	C	E	D	541	
2	G	14/08/2020	1821	Bandicoot spp.	C	E	D	542	

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
2	G	14/08/2020	2103	Bandicoot spp.	C	E	D	546	
2	G	14/08/2020	2321	Bandicoot spp.	C	E	D	549	
2	G	15/08/2020	0606	Swamp Wallaby	C	E	D	551	
2	G	15/08/2020	12:08	Dog	C	W	D	552	Black white chest
2	G	15/08/2020	1705	Dog	C	E	D	579	Black white chest
2	G	15/08/2020	1749	Long-nosed bandicoot	C	E	D	580	
2	G	15/08/2020	1916	Bandicoot spp.	C	E	D	584	
2	G	16/08/2020	0343	Swamp wallaby	C	E	D	590	
2	G	16/08/2020	1755	Bandicoot spp.	C	E	D	623	
2	G	16/08/2020	1806	Bandicoot spp	C	E	D	624	
2	G	16/08/2020	1911	Bandicoot spp	C	E	D	629	
2	G	16/08/2020	1922	Bandicoot spp	C	E	D	630	
2	G	16/08/2020	1922	Bandicoot spp	C	E	D	633	
2	G	16/08/2002	2230	Bandicoot spp	C	E	D	635	
2	G	17/08/2020	0012	Northern brown bandicoot	C	E	D	638-639	
2	G	17/08/2020	0219	Bandicoot spp	C	E	D	641	
2	G	17/08/2020	1757	Bandicoot spp	C	E	D	682	
2	G	17/08/2020	1929	Bandicoot spp	C	E	D	686	
2	G	17/08/2020	2227	Echidna	C	W	D	687	
2	G	18/08/2020	0242	Swamp wallaby	C	E	D	689	x 2 with juvenile
2	G	18/08/2020	0355	Bandicoot	C	E	D	690	
2	G	18/08/2020	1752	Bandicoot spp	C	E	D	725	
2	G	19/08/2020	0428	Swamp Wallaby	C	E	D	730	
2	G	19/08/2020	1849	Bandicoot spp	C	E	D	783	
2	G	20/08/2020	1850	Bandicoot spp	C	E	D	784	
2	G	20/08/2020	0301	Echidna	C	W	D	789	
2	G	20/08/2020	0301	Echidna	C	E	D	789	
2	G	20/08/2020	2228	Swamp wallaby	C	E	D	835	
2	G	21/08/2020	0238	Wallaby spp.	C	E	D	838	
2	G	21/08/2020	0239	Swamp wallaby	C	E	D	839	
1	North	18/12/2019	0112	Cat	Incomplete	W-E	D	922-923	Tabby
1	North	27/02/2020	0611	Swamp Wallaby	Complete	W	D	2740-2778	
1	North	8/02/2020	0555	White faced Heron	Complete	E	D	9337-9339	
1	North	8/02/2020	0916	Purple Swamp-hen	Incomplete	W-E	D	9340-9348	
1	North	17/02/2020	0759	Purple Swamp-hen x 3	Incomplete	E-W		4228-4252	1 complete in background
1	North	7/08/2020	0403	Swamp wallaby	Complete	W	D	7652	

Site	Side	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Pic/vid No.	Comments
1	North	12/08/2020	0223	Swamp wallaby	C	E	D	1294-1296	
1	North	12/08/2020	0624	Cat	C	W	D	1538-1539	Black cat
1	North	17/07/2020	1007	Swamp wallaby	C	E	D	1254-1258	
1	North	20/07/2020	1217	Fox	C	E	D	3070	
1	North	16/08/2020	0106	Swamp wallaby	C	E	D	4343-4355	
1	North	16/08/2020	0409	Swamp wallaby	C	W	D	4554-4557	
1	North	18/08/2020	0455	Swamp Wallaby	C	E	D	6165-6167	
1	South	22/10/2019	Nil fauna				D		Camera stolen replaced in Jan 20
1	South	22/10/2019	Nil fauna						Camera stolen replaced in Jan 20
1	South	5/07/2020	0714	Cat	Complete	E	E	8035-8039	
1	South	6/07/2020	0322	Cat	Complete	E	E	8534-835	
1	South	9/08/2020	0913	Cat	Complete	E	D	9434-9441	
1	South	9/07/2020	0703	Purple Swamp-hen	Complete	W	D	11093	
1	South	5/07/2020	1201	Fox	Complete	W	D	15358	

Table C 2: Scat and track data recorded during spring/summer (ss) and winter (w) during year two of operational phase monitoring WC2NH, 2020.

5pecies/Group	Site																							
	1		2		3		4		5		6		7		8		9		10		11		12	
	SS	W	SS	W	SS	W	SS	W	SS	W	SS	W	SS	W	SS	W	SS	W	SS	W	SS	W	SS	W
Short-beaked echidna															*									
Antechinus spp.			*				*				*		*						*		*		*	
Peramelidae spp. (bandicoot)			*	*				*	*				*		*		*		*				*	
Koala*							*										*		*					
Trichosurus spp.				*									*	*										
Swamp wallaby													*											
Wallaby spp.	*		*	*	*	*	*		*	*	*		*		*			*		*				
Macropod spp.	*			*											*									
Microbat spp.							*																	
House mouse		*												*				*						

Rodent spp.		*	*		*	*	*	*	*	*	*	*	*	*	*		*	*	*	*				*
Dog				*							*	*					*							
Red fox [I]	*		*	*	*	*		*	*	*	*	*	*	*		*		*		*		*		*
Cat [I]			*		*	*		*	*				*			*			*			*	*	*
Lace monitor					*		*				*		*		*		*		*					
Medium lizard			*						*						*									
Small reptile					*				*															
Litoria spp.																			*					
Welcome swallow					*																			
Bird spp.																	*							
Total no. Species/groups	3	2	7	6	7	4	6	4	7	3	6	3	9	4	7	2	6	4	7	3	1	2	3	3

Table C 3: Sand pad data recorded over 8 nights during spring/summer (ss) and winter (w) during year two of operational phase monitoring WC2NH, 2020.

Species/group	1		2		3		4		5		6		7		8		9		10		11		12	
	SS	W	SS	W	SS	W	SS	W	SS	W	SS	W	SS	W	SS	W	SS	W	SS	W	SS	W	SS	W
Short-beaked echidna			*										*											
Antechinus spp.			*																					
Peramelidae spp. (bandicoot)				*			*	*							*									
Koala*							*																	
Trichosurus spp.			*	*									*	*	*		*							
Swamp wallaby													*											
Red neck wallaby					*																			
Wallaby spp.			*	*	*	*				*			*							*				
Macropod spp.	*			*																				

House mouse[I]		*												*				*						
Rodent spp.		*	*	*		*	*	*	*	*	*	*		*			*	*	*	*	*		*	*
Dog[I]											*	*				*								
Red fox [I]	*		*	*	*	*		*		*				*		*		*		*		*		*
Cat [I]		*			*	*	*	*					*		*	*						*		
Lace monitor											*		*		*		*		*					
Waterbird spp.	*																							
Lampropholis spp.																					*			
Medium reptile							*		*		*						*							
Australian brush turkey													*											
Total species/group	3	3	6	6	4	4	5	4	2	3	4	2	7	4	4	3	4	4	2	3	2	2	1	2

Table C 4: Nocturnal (spotlighting) adjacent habitat surveys conducted during spring/summer and winter during year two of operational phase monitoring WC2NH, 2020.

Location	Side	Date	Obs. No.	Observers	Start Time	Finish Time	Species	Wind	Rain	Visibility	Air Temp	Humidity	Comment
11&12	E	15/06/20	1	LA	1859	1929	Wallaby spp (Heard)	Nil	Nil	Good	13.2	91	
	W	15/06/20	1	LA	1933	2003	SuG Sm	Nil	Nil	Good	13.2	91	
	E	17/06/20	2	DR	1750	1820	Nil	MSB	Nil	Good	14	77	
	W	17/06/20	2	LA	1750	1820	Nil	MSB	Nil	Good	14	77	
9&10	E	15/06/2020	1	BT	1908	1938	Common ringtail possum	Nil	Nil	Good	17	70	
	W	15/06/2021	1	DR	1908	1938	GHFF	Nil	Nil	Good	17	70	
	E	17/6/20	2	BT	1903	1932	ONj	MSB	NIL	GOOD	11.5	84	
	W	17/6/20	2	BT	1829	1900	Nil	MSB	NIL	GOOD	11.5	84	
8	E	15/06/2020	1	BT	1945	2015	Nil	Nil	Nil	Good	17	70	
	W	15/06/2021	1	DR	1945	2015		Nil	Nil	Good	17	70	
	E	17/6/20	2	BT	2009	2040	Nil	MSB	NIL	GOOD	10.6	89	
	W	17/6/20	2	BT	1936	2005	Nil	MSB	NIL	GOOD	10.6	89	
7	E	15/06/20	1	LA	2006	2036	Crinia signifera	Nil	Nil	Good	12.8	93	
	W	15/06/20	1	LA	2037	2107	Nil	Nil	Nil	Good	12.8	93	
	E	17/06/20	2	DR	1824	1854	Nil	MSB	Nil	Good	14	77	
	W	17/06/20	2	LA	1824	1854	Nil	MSB	Nil	Good	14	77	
5&6	E	15/06/2020	1	BT	2020	2050	Nil	Nil	Nil	Good	17	70	
	W	15/06/2020	1	DR	2020	2050	Crinia signifera	Nil	Nil	Good	17	70	
	E	17/06/2020	2	DR	1917	1947	Nil	MSB	Nil	Good	12.8	79	
	W	17/06/2020	2	LA	1917	1947	Nil	MSB	Nil	Good	12.8	79	
4	E	16/06/2020	1	BT	1836	1906	FtG	Nil	Nil	Good	13.8	84	
	W	16/06/2020	1	LA	1836	1906	nil	Nil	Nil	Good	13.8	84	
	E	19/06/20	2	DR	1832	1902	nil	MSB	NIL	Good	11.5	84	
	W	19/06/20	2	LA	1832	1902	nil	MSB	NIL	Good	11.5	84	
3 (E only)	E	15/06/20	1	LA	2112	2142	Nil	Nil	Nil	Good	12.8	93	
	E	17/06/2020	2	DR/LA	2008	2038	Wallaby (bouncing)	MSB	Nil	Good	12.8	79	
2	E	15/06/20	1	DR	2105	2140	Sb echidna, Cr. signifera, GHFF	Nil	Nil	Good	17	70	

	W	15/06/20	1	BT	2105	2140	SuG, Cr. signifera	Nil	Nil	Good	17	70	
	E	17/06/20	2	LA	2046	2116	GhFF	MSB	Nil	Good	14	77	
	W	17/06/20	2	DR	2046	2116	nil	MSB	Nil	Good	14	15	
1	E	16/06/2020	1	BT	1745	1815	nil	Nil	Nil	Good	14.9	84	
	W	16/06/2020	1	LA	1745	1815	nil	Nil	Nil	Good	14.9	84	
	E	19/06/20	2	DR	1748	1818	Nil	Nil	Nil	Good	15.6	68	
	W	19/06/20	2	LA	1748	1818	Crinia signifera	Nil	Nil	Good	15.6	68	
11&12	E	3/10/19	1	NM/BT	2210	2225	GHFF, P. coriacea	Nil	Nil	Good	14.9	84	
	W	3/10/19	1	NM/BT	2152	2207	GHFF	Nil	Nil	Good	14.9	84	
	E	27/11/19	2	LA	2120	2150	GHFF, A. brevis						
	W	27/11/19	2	DR	2120	2150	GHFF, SuG,						
9&10	E	3/10/19	1	NM/BT	2110	2125	GHFF, P.coriacea, A.brevis	Nil	Nil	Good	16.1	79	
	W	3/10/19	1	NM/BT	2128	2143	P.coriacea, GHFF	Nil	Nil	Good	16.1	79	
	E	27/11/19	2	LA	2200	2230	Swamp wallaby, GHFF						
	W	27/11/19	2	DR	2200	2230	GHFF						
8	E	21/10/19	1	NM/LA	2142	2157	GHFF	Nil	Nil	Good	14.2	83	
	W	21/10/19	1	NM/LA	2125	2140	GHFF	Nil	Nil	Good	14.2	83	
	E	28/11/19	2	LA	2000	2030	GHFF						
	W	28/11/19	2	DR	2000	2030	GHFF						
7	E	21/10/19	1	NM/LA	2045	2100	A.brevis, C.signifera, Limnodynastes peronii, GHFF	Nil	Nil	Good	14.2	83	
	W	21/10/19	1	NM/LA	2102	2117	A. Brevis, SuG SE, prob bandicoot HM, GHFF	Nil	Nil	Good	14.2	83	
	E	28/11/19	2	LA	2040	2110	Bandy bandy, GHFF, Adelotus brevis	Nil					
	W	28/11/19	2	DR	2040	2110	GHFF	Nil					
5&6	E	18/10/19	1	NP/NM	2025	2040	GHFF, Lit. peronii, Lit. fallax, A brevis	Nil	Nil	Good	16.2	65	
	W	18/10/19	1	NP/NM	2040	2055	Lit. tyleri, P. Coriacea	Nil	Nil	Good	16.2	65	
	E	28/11/19	2	LA	2120	2150	Lit. fallax, Lit. peroni, Lim. peroni, GHFF	Nil	V. Light	Good	22	77	
	W	28/11/19	2	DR	2120	2150	GHFF, Sw. Wallaby, Lit. peroni	Nil					
4	E	21/10/19	1	NM/LA	2005	2020	GHFF, Limnodynastes peronii	Nil	Nil	Good	16.4	71	
	W	21/10/19	1	NM/LA	2021	2036	GHFF, SuG hc	Nil	Nil	Good	16.4	71	

	E	28/11/19	2	LA	2200	2230	GHFF, koala (sub-adult)	Nil	V. Light	Mod	22	78	
	W	28/11/19	2	DR	2200	2230	GHFF						
3 (E only)	E	18/10/19	1	NP/NM	2005	2020	Cat, LN Bandicoot, Macropod spp.	Nil	Nil	Good	16.5	60	
	E	21/10/19	2	NM/LA	1935	1950	GHFF, Frog spp, cat, Wallaby spp	Nil	Nil	Good	16.4	71	
	E	28/11/19	3	DR/LA	1050	1105	Nil	Nil	Light	Mod	22	78	
2	E	18/10/19	1	NP/NM	1930	1945	C. signifera	Nil	Nil	Good	16.7	56	
	W	18/10/19	1	NP/NM	1945	2000	Nil	Nil	Nil	Good	16.7	56	
	E	28/11/19	2	LA	2315	2345	Nil	Nil	Light	Mod	22	80	
	W	28/11/19	2	DR	2315	2345	GHFF						
1	E	16/10/19	1	NP/NM	2015	2030	Lit fallax						
	W	16/10/19	1	NP/NM	2000	2015	M iteratus, water dragon, small mammal spp., ad brevis						
	E	27/11/19	2	LA	2018	2048	Lit fllax, ff sp						
	W	27/11/19	2	DR	2018	2048	Ad brevis , lit fallax, northern brown, ff sp, swamp wallaby						

Table C 5: Diurnal adjacent habitat surveys conducted during spring/summer and winter during year two of operational phase monitoring WC2NH, 2020.

Site	Date	Side	Survey No.	Observers	Start Time	Finish Time	Wind	Rain	Visibility	Air Temp	Humidity	Species (no. of individuals / behaviour)	Signs (scats/tracks etc)	Comments
11&12	1/06/20	W	1	LA	11:50	0:20	Nil	Nil	Good	20.8	59	Lampropholis spp		
	1/06/20	E	1	LA	1221	1251	Nil	Nil	Good	20.8	59	Wallaby (scat)		
	16/6/20	W	2	BT	958	1027	MSB	Nil	Good	17.6	71	Lampropholis spp.		
	16/6/20	E	2	BT	1031	1100	MSB	Nil	Good	18.1	68	Lampropholis spp.; Saiphos equalis	B'coot diggings	
9&10	1/06/20	W	1	LA	1255	1325	Nil	Nil	Good	22.1	59	Wallaby (scat)		
	1/06/20	E	1	LA	1330	14:00	Nil	Nil	Good	23.8	53	Wallaby (scat)		
	16/6/20	W	2	BT	1120	1150	MSB	Nil	Good	19.1	64	Nil	B'coot diggings	
	16/6/20	E	2	BT	1154	1223	MSB	Nil	Good	19.1	64	Lampropholis spp.		
8	1/06/20	W	1	LA	1406	1446	Nil	Nil	Good	23.8	53	Bandicoot diggings		
	1/06/20	E	1	LA	1448	1516	Nil	Nil	Good	23.8	53	Cat (tracks), Lampropholis x1, Wallaby scat,		
	16/6/20	W	2	BT	1245	1315	MSB	Nil	Good	19	67	Nil		
	16/6/20	E	2	BT	1318	1347	MSB	Nil	Good	19	67	Nil		
7	5/06/20	W	1	LA	11:15	11:45	Nil	Light	Good	19.2	54	Wallaby (scat), Old koala scat		
	1/06/19	E	1	LA	1523	1553	Nil	Nil	Good	21.9	53	Calyptotis ruficauda, Bandicoot diggings		
	16/6/20	W	2	BT/LA	1356	1411	MSB	Nil	Good	19.6	70	Nil		
	16/6/20	E	2	BT/LA	1415	1430	MSB	Nil	Good	19.6	70	L.delicata		
5&6		W	1	LA	11:51	12:21	Nil	Light	Good	19.2	54	Calyptotis ruficauda, Bandicoot diggings		
		E	1	LA	12:24	12:54	Nil	Light	Good	19.2	54	Bandicoot diggings		
	16/6/20	W	2	BT/LA	1436	1451	MSB	Nil	Good	19.6	70	Nil		
	16/6/20	E	2	BT/LA	1453	1509	MSB	Nil	Good	19.6	70	Nil		
4		W	1	LA	13:04	13:34	Nil	Light	Good	19.2	54	Calyptotis ruficauda		
		E	1	LA	13:35	14:05	Nil	Light	Good	19.2	54	Nil		
	17/6/20	W	2	BT	1436	1451	MSB	Nil	Good	19.1	62	Nil	B'coot diggings	
	17/6/20	E	2	LA	1140	1210	MSB	Nil	Good	19.1	62	Rodent scats		
3	17/6/20	E	1	DR	1010	1040	MSB	Nil	Good	NR	NR	Nil		
	17/6/20	W	1	DR	945	1005	MSB	Nil	Good	NR	NR	Nil		
	20/6/20	E	2	LA	1115	1145	Nil	Nil	Good	18	60	Nil		
	20/6/20	W	2	DR	1115	1145	Nil	Nil	Good	18	60	Crinia signifera		
2	16/6/20	E	1	DR	1430	1500	MSB	Nil	Good	19.6	70	C. ruficauda x1, Lampropholis spp. x1, Ctenotus spp x1,	Swamp wallaby (scat)	
	16/6/20	W	1	DR	1505	1530	MSB	Nil	Good	19.6	70	Nil		
	20/06/2020	E	2	LA	1121	1151	Nil	Nil	Good	17.7	58	Crinia signifera, Lampropholis spp.		
	20/06/2020	W	2	DR	1121	1151	Nil	Nil	Good	17.7	58	Nil		
1	1/06/20	W	1	LA	1003	1033	Nil	Nil	Good	18.1	63	EW dragon x2, Lampropholis spp x 1, Btp (scat), Wallaby (track)		

	1/06/20	E	1	LA	1035	1105	Nil	Nil	Good	18.1	63	Lampropholis spp., Fox (scat), Dog (tracks)		
	20/06/2020	E	2	DR	1035	1105	Nil	Nil	Good	17.7	58	Nil		
	20/06/2020	W	2	LA	1035	1105	Nil	Nil	Good	17.7	58	Water dragon, Crinia signifera		
11&12	22/9/19	W	D1	NM	845	915	Msb	Nil	Good	19	82	Lampropholis spp.	OBS	
	22/9/19	E	D1	NM/NP	915	930	MSB	Nil	Good	19	82	Lampropholis spp., A. brevis, Wallaby scat, bandicoot diggings	Obs	
	1/10/19	W	D2	NP	1445	1515	Nil	Nil	Good	21	79	Wallaby scat		
	1/10/19	E	D2	NP	1515	1545	Nil	Nil	Good	21	79	Lampropholis spp., Wallaby scat		
9&10	3/10/19	W	D1	NP	11:00	11:30	RL	Nil	Good	21.5	68	Lampropholis spp., small mammal nest (melomys?), Bandicoot diggings		
	3/10/19	E	D1	NP	11:30	12:00	RL	Nil	Good	21.5	68	Echidna diggings		
	15/10/19	W	D2	Nm/La	9:30	9:45	Nil	Nil	Good	22.1	75	Lampropholis spp		
	15/10/19	E	D2	Nm/La	9:50	10:05	Nil	Nil	Good	22.1	75	Bandicoot diggings, Lampropholis spp, Wallaby scat		
8	3/10/19	W	D1	NP	12:05	1235	RL	Nil	Good	23	65	Lampropholis spp, Echidna diggings, Wallaby scat		
	3/10/19	E	D1	NP	1235	1305	RL	Nil	Good	23	65	Lampropholis spp.		
	Incidental											Swamp snake		
	15/10/19	W	D2	NM/LA	1010	1025	Nil	Nil	Good	22.7	75	Lampropholis spp, bearded dragon		
	15/10/19	E	D2	NM/LA	1030	1045	Nil	Nil	Good	22.7	75	Lampropholis spp, Wallaby scat		
	16/10/19	W	D3	LA	12:02	1232	Msb	Nil	Good	25.8	67	Yellow faced whipsnake, lace Monitor, Lampropholis spp, Bandicoot diggings		
	16/10/19	E	D3	LA			Msb	Nil	Good	25.8	67	Wallaby scat		
7	4/10/19	W	D1	NP	945	1015	RL	Nil	Good	23	61	Wallaby scat, bandicoot diggings		
	4/10/19	E	D1	NP	1015	1045	RL	Nil	Good	23	61	Echidna diggings, Wallaby scat		
	16/10/19	W	D2	LA	1245	1300	Msb	Nil	Good	24.9	69	Lampropholis spp multiple		
	16/10/19	E	D2	LA	1315	1330	Msb	Nil	Good	24.9	69	Lampropholis spp multiple, bandicoot diggings, Wallaby scat		
5&6	Incidental											Burtons legless lizard		
	16/10/19	W	D1	NP/NM	1025	1040	Nil	Nil	Good	29	49	Lampropholis spp, Wallaby scat, bandicoot digging		
	16/10/19	E	D1	NP/NM	1040	1055	Nil	Nil	Good	29	49	Lampropholis spp., Wallaby scat, bandicoot & echidna diggings		
	18/10/19	W	D2	NM	1200	1230	MSB	Nil	Good	22	27	Lampropholis spp multiple, bandicoot diggings		
	18/10/19	E	D2	NM	1235	1305	MSB	Nil	Good	22	27	Wallaby scat, Lampropholis spp multiple		
4	16/10/19	W	D1	NM	1105	1135	Nil	Nil	Good	25.5	66	Lampropholis spp., Wallaby scat, bandicoot & echidna diggings		
	16/10/19	E	D1	NP	1105	1135	Nil	Nil	Good	25.5	66	Lampropholis spp., Wallaby scat,		

												bandicoot & echidna diggings		
	18/10/19	W	D2	NM	1305	1335	MSB	Nil	Good	25.7	16	Med lizard, Wallaby scat		
	21/10/19	E	D2	NM	1035	1105	Nil	Nil	Good	21.8	62	Bandicoot diggings, Wallaby scat, Lampropholis spp		
3	16/10/19	W	D1	NM	1145	1215	Nil	Nil	Good	25.4	67	Wallaby scat, bandicoot diggings		
	16/10/19	E	D1	NP	1145	1215	Nil	Nil	Good	25.4	67	Lampropholis spp., Bandicoot scat, water dragon scat, echidna diggings, Wallaby scat		
	18/10/19	W	D2	NP/NM	1000	1015	Nil	Nil	Good	22.3	31	Wallaby scat, bandicoot diggings		
	18/10/19	E	D2	NP/NM	1015	1030	Nil	Nil	Good	22.3	31	Lampropholis spp., Bandicoot scat, water dragon scat, echidna diggings, Wallaby scat		
2	16/10/19	W	D1	LA	14:30	1500	Nil	Nil	Good	25.4	67	Echidna & bandicoot diggings, Wallaby scat, Lampropholis spp		
	15/10/19	E	D1	LA				nil		25.4	67			
	21/10/19	W	D2	NM	1110	1140	Nil	Nil	Good	25.5	22	Lampropholis spp, Wallaby scat		
	21/10/19	E	D2	NM	1145	1215	Nil	Nil	Good	25.5	22	Wallaby scat, lace Monitor scat, Lampropholis spp		
1	16/10/19	W	D1	LA	1055	1125	RL	Nil	Good	25	65	EW dragon x2, Lampropholis spp x 1		
	16/10/19	E	D1	LA	1130	1200	RL	Nil	Good	25	65	EW dragon x3, Lampropholis spp x2, Fox scat		
	21/10/19	W	D2	NM	1307	1337	Nil	Nil	Good	28	17	EW dragon x 2, wallaby scat, Fox scat, bandicoot diggings		
	21/10/19	E	D2	NM	1235	1305	Nil	Nil	Good	26.6	16	Lampropholis spp		

Table C 6: Fauna captured during adjacent habitat trapping surveys during spring/summer and winter of year two operational monitoring WC2NH, 2020.

Site	Season	Date	Trap type	Species	Sex	Weight	Comments
11&12 west	Winter	16/06/20	Large Elliot	sugar glider	M	125	
11&12 west	Winter	16/06/20	Large Elliot	sugar glider	F	105	
11&12 west	Winter	16/06/20	Pitfall	3X Redbank toadlet			
9/10 east	Winter	16/06/20	Ground Elliot	Brown antechinus	M	40	
9/10West	Winter	16/06/20	Ground Elliot	FF Melomys	F	80	
11&12 East	Winter	17/06/2020	Ground Elliot	FF Melomys	M	76	
11&12 East	Winter	17/06/2020	Ground Elliot	FF Melomys	F	62	
11&12 west	Winter	17/06/2020	Cage trap	Black rat	N/A	N/A	Escaped
9/10 east	Winter	17/06/2020	Ground Elliot	Brown antechinus	M	47	
9/10West	Winter	17/06/2020	Ground Elliot	FF Melomys	F	46	Grey in colour, distinct mosaic tail pattern
9/10West	Winter	17/06/2020	Ground Elliot	FF Melomys	F	63	
11&12 west	Winter	18/06/2020	Large Elliot	sugar glider	M	127	
11&12 west	Winter	18/06/2020	Large Elliot	sugar glider	F	110	
8 west	Winter	18/06/2020	Pitfall	2x FF Melomys	M	NR	Deceased
2 west	Winter	19/06/2020	Ground Elliot	Black rat	M	139	Euthanised
2 west	Winter	19/06/2020	Ground Elliot	Black rat	F	155g	Euthanised
2 west	Winter	19/06/2020	Ground Elliot	Brown Antechinus	F	290g	
2 west	Winter	19/06/2020	Cage trap	Black rat			Escaped
2 east	Winter	19/06/2020	Ground Elliot	FF Melomys	F	73g	
2 east	Winter	19/06/2020	Ground Elliot	FF Melomys	F	54g	
2 East	Winter	19/06/2020	Pitfall	Limnodynastes peronii			
1 West	Winter	19/06/2020	Ground Elliot	Black rat	F	130g	
1 west	Winter	19/06/2020	Cage trap	Black rat	M		Escaped
3 east	Winter	20/06/2020	Ground Elliot	House mouse	M	17 grams	
3east	Winter	20/06/2020	Ground Elliot	Black rat	M	103 grams	
2 East	Winter	20/06/2020	Ground Elliot	FF Melomys	M	79g	
1 West	Winter	20/06/2020	Cage trap	SeBtP	F	-	Carrying young in pouch
1 west	Winter	20/06/2020	Ground Elliot	Black rat	F	136g	
2 East	Winter	21/06/2020	Pitfall	Limnodynastes peronii			
2 East	Winter	21/06/2020	Large Elliot	FF Melomys	F	63g	
1 east	Winter	21/06/2020	Cage trap	SeBtP	F	-	
1 east	Winter	21/06/2020	Ground Elliot	Black rat	-	-	
3 East	Winter	21/06/2020	Ground Elliot	Brown Antechinus	M	42g	
5/6 east	Winter	16/6/20	Ground Elliot	FF Melomys	F	52g	
5/6 west	Winter	16/6/20	Ground Elliot	Bush rat	F	94g	
5/6 west	Winter	16/6/20	Ground Elliot	Bush rat	F	90g	
7 west	Winter	16/6/20	Ground Elliot	FF Melomys	F	72g	
7 west	Winter	16/6/20	Ground Elliot	Brown Antechinus	M	54g	
5/6 west	Winter	17/6/20	Ground Elliot	Bush rat	F	60g	
7 east	Winter	17/6/20	Ground Elliot	Brown Antechinus	F	32g	
7 west	Winter	17/6/20	Ground Elliot	FF Melomys	F	90g	
7 west	Winter	17/6/20	Cage trap	SeBtP	NR	NR	
8 west	Winter	17/6/20	Ground Elliot	Brown Antechinus	M	36g	
8 west	Winter	17/6/20	Ground Elliot	FF Melomys	F	58g	
5/6 west	Winter	18/6/20	Ground Elliot	Brown Antechinus	M	NR	
5/6 west	Winter	18/6/20	Ground Elliot	Bush rat	M	NR	
5/6 west	Winter	18/6/20	Ground Elliot	Black rat	F	NR	euthanised
5/6 west	Winter	18/6/20	Ground Elliot	Brown Antechinus	M	NR	
7 west	Winter	18/6/20	Ground Elliot	FF Melomys	F	NR	
7 east	Winter	18/6/20	Arboreal Elliot	FF Melomys	F	NR	
7 east	Winter	18/6/20	Ground Elliot	Brown Antechinus	M	NR	
8 west	Winter	18/6/20	Ground Elliot	Brown Antechinus	M	NR	
8 west	Winter	18/6/20	Ground Elliot	Brown Antechinus	M	43g	
3 west	Winter	19/6/20	Ground Elliot	FF Melomys	F	54g	
3 west	Winter	19/6/20	Ground Elliot	House mouse	F	15g	Euthanised
3 west	Winter	19/6/20	Ground Elliot	Black rat	F	120g	Euthanised
4 west	Winter	19/6/20	Ground Elliot	FF Melomys	F	54g	
4 west	Winter	19/6/20	Ground Elliot	Bush rat	F	138g	
4 west	Winter	19/6/20	Arboreal Elliot	Brown Antechinus	F	17g	
4 west	Winter	19/6/20	Ground Elliot	Bush rat	M	146g	

2 west	Winter	20/2/20	Ground Elliot	Black rat	M	118g	Euthanised
2 west	Winter	20/2/20	Ground Elliot	Black rat	F	148g	Euthanised
4 west	Winter	20/2/20	Ground Elliot	FF Melomys	F	76g	
4 west	Winter	20/2/20	Ground Elliot	FF Melomys	F	56g	
4 west	Winter	20/2/20	Ground Elliot	Bush rat	F	136g	
4 west	Winter	20/2/20	Ground Elliot	Bush rat	M	128g	
4 west	Winter	20/2/20	Ground Elliot	Brown Antechinus	M	42g	
1 west	Winter	20/6/20	Cage trap	Black rat	NR	NR	
1 west	Winter	20/6/20	Pitfall	Striped marsh frog	N/A	N/A	
3 west	Winter	21/6/20	Ground Elliot	House mouse	M	8g	Euthanised
3 west	Winter	21/6/20	Ground Elliot	House mouse	M	7g	Euthanised
3 west	Winter	21/6/20	Pitfall	House mouse	M	7g	Euthanised
2 west	Winter	21/6/20	Ground Elliot	Brown Antechinus	M	28g	
2 west	Winter	21/6/20	Arboreal Elliot	Black rat	F	87g	Euthanised
2 west	Winter	21/6/20	Ground Elliot	Black rat	F	156g	Euthanised
2 west	Winter	21/6/20	Cage trap	Black rat	NR	NR	
2 west	Winter	21/6/20	Cage trap	Black rat	NR	NR	
1 west	Winter	21/6/20	Cage trap	Black rat	NR	NR	
1 west	Winter	21/6/20	Ground Elliot	House mouse	F	13g	Euthanised
1 west	Winter	21/6/20	Ground Elliot	Black rat	F	92g	Euthanised
4 west	Winter	21/6/20	Arboreal Elliot	Brown Antechinus	F	38g	
4 west	Winter	21/6/20	Ground Elliot	Black rat	F	138g	Euthanised
4 west	Winter	21/6/20	Ground Elliot	Bush rat	F	122g	
4 west	Winter	21/6/20	Ground Elliot	FF Melomys	F	46g	
4 west	Winter	21/6/20	Ground Elliot	Bush rat	M	138g	
5/6 west	Spring/summer	15/10/19	Pit	Calyptotis ruficauda	UK	NA	
5/6 west	Spring/summer	15/10/19	Small Elliot	Bush Rat	UK	UK	Escaped before processing
5/6 west	Spring/summer	15/10/19	Small Elliot	Brown Antechinus	F	26g	Parous, 6 pouch young.
5/6 east	Spring/summer	15/10/19	Pit	Calyptotis ruficauda	UK	NA	
5/6 east	Spring/summer	15/10/19	Small Elliot	FF Melomys	M	56g?	Weight may not be accurate
5/6 east	Spring/summer	15/10/19	Small Elliot	Brown Antechinus	F	27g	Parous, 5 pouch young.
8 east	Spring/summer	15/10/19	Small Elliot	FF Melomys	M	74g	
9/10 west	Spring/summer	15/10/19	Small Elliot	FF Melomys	M	54g	
9/10 west	Spring/summer	15/10/19	Small Elliot	FF Melomys	M	77g	
9/10 west	Spring/summer	15/10/19	Cage	SEBtP	F	NA	Young adult
11/12 east	Spring/summer	15/10/19	Small Elliot	FF melomys	M	80	
11/12 west	Spring/summer	15/10/19	Large Elliot	Sugar Glider	F	100	
11/12 west	Spring/summer	15/10/19	Pitfall	Lampropholis delicata x 4	UK	UK	
5/6 west	Spring/summer	16/10/19	Pit	Blackish blind snake	NA	Na	
5/6 west	Spring/summer	16/10/19	Pit	S Dwarf Crowned Snake	NA	NA	
5/6 west	Spring/summer	16/10/19	Pit	Brown Antechinus	F		Parous
5/6 east	Spring/summer	16/10/19	Small Elliot	FF Melomys		70g	
8 west	Spring/summer	16/10/19	Small Elliot	FF Melomys	M	96g	
9/10 east	Spring/summer	16/10/19	Cage	SEBtP	M	NA	
9/10 west	Spring/summer	16/10/19	Small Elliot	Black Rat	F	90g	
11/12 east	Spring/summer	16/10/19	Pitfall	P. Coriacea	UK	UK	
5/6 west	Spring/summer	17/10/19	Small Elliot	Brown Antechinus	F	26g	Parous, 7 pouch young
5/6 east	Spring/summer	17/10/19	Small Elliot	Black Rat	M	NA	Euthanised
5/6 east	Spring/summer	17/10/19	Small Elliot	FF Melomys	M	77g	
8 east	Spring/summer	17/10/19	Small Elliot	FF Melomys	M	82g	
8 east	Spring/summer	17/10/19	Large Elliot	FF Melomys	M	64g	
8 west	Spring/summer	17/10/19	Small Elliot	Brown Antechinus	F	33	Parous
8 west	Spring/summer	17/10/19	Small Elliot	FF Melomys	F	64g	
1 west	Spring/summer	18/10/19	Large Elliot	Black Rat	M	NA	Euthanised
2 west	Spring/summer	18/10/19	Pit	Swamp snake	NA	NA	
2 east	Spring/summer	18/10/19	Small Elliot	FF Melomys			
2 east	Spring/summer	18/10/19	Small Elliot	FF Melomys			
2 east	Spring/summer	18/10/19	Small Elliot	Brown Antechinus	F		
2 west	Spring/summer	18/10/19	Pit	L delicata x 5			
3 west	Spring/summer	18/10/19	Pit	P. coriacea	NA	NA	
7 west	Spring/summer	18/10/19	Small Elliot	Sugar Glider	M	120	
7 west	Spring/summer	18/10/19	Pitfall	House mouse	F	30	
7West	Spring/summer	18/10/19	Small Elliot	Brown Antechinus	F	30	With 7 young
7West	Spring/summer	18/10/19	Small Elliot	FF melomys	M	80	
4 west	Spring/summer	18/10/19	Small Elliot	FF melomys	F	65	
4 west	Spring/summer	18/10/19	Large Elliot	FF melomys	M	85	

4 east	Spring/summer	18/10/19	Small Elliot	FF melomys	M	65	
2 east	Spring/summer	18/10/19	Small Elliot	Brown Antechinus			
3 east	Spring/summer	18/10/19	Pit	Swamp snake			
1 west	Spring/summer	19/10/19	Small Elliot	Yellow-throated scrubwren			
2 west	Spring/summer	19/10/19	Small Elliot	Bush Rat	M	149	
2 east	Spring/summer	19/10/19	Small Elliot	Brown Antechinus	F	20	Parous with 2 young
2 east	Spring/summer	19/10/19	Small Elliot	FF Melomys	M	49	
3 east	Spring/summer	19/10/19	Pit	Red-backed toadlet			
7 west	Spring/summer	19/10/19	Small Elliot	FF melomys	M	85	
4West	Spring/summer	19/10/19	Small Elliot	Black Rat	F	95	
4 west	Spring/summer	19/10/19	Small Elliot	Black Rat			Escaped
4East	Spring/summer	19/10/19	Cage	Northern brown bandicoot	Na	Na	Minor injuries
3West	Spring/summer	19/10/19	Pitfall	Lampropholis delicata			
3West	Spring/summer	19/10/19	Cage	Northern brown bandicoot			Escaped
1 east	Spring/summer	20/10/19	Small Elliot	Brown Antechinus	F	31g	Parous with 8 pouch young
1 west	Spring/summer	20/10/19	Cage	SEBtP x 2	F		Mother and back young
2 east	Spring/summer	20/10/19	Small Elliot	Brown Antechinus	F		Parous with 7 young
2 east	Spring/summer	20/10/19	Small Elliot	Bush Rat		146g	
2 east	Spring/summer	20/10/19	Cage	Northern brown bandicoot			
2 east	Spring/summer	20/10/19	Pit	C. ruficauda			Check ID
7 west	Spring/summer	21/10/19	Cage	SEBtPoss	M		
7 west	Spring/summer	21/10/19	Small Elliot	Brown Antechinus	F		With young
7 west	Spring/summer	21/10/19	Small Elliot	FF melomys	NA	85	
4 west	Spring/summer	21/10/19	Large Elliot	FF melomys	NA		
4 east	Spring/summer	21/10/19	Small Elliot	FF melomys	NA		

Table C 7: Results from adjacent habitat hair-funnel analysis (14 days) during spring/summer and winter during year two of operational phase monitoring WC2NH, 2020.

Site	Side and bait (O=oats S=Sardines)	Winter 2020		
		Install Date	Collect date	Fauna
1	E-O	15/06/2020	22/06/2020	*Trichosurus sp.*
	E-S	15/06/2020	22/06/2020	
	W-O	15/06/2020	22/06/2020	*Trichosurus vulpecula, Mus musculous*

Site	Side and bait (O=oats S=Sardines)	Winter 2020		
		Install Date	Collect date	Fauna
	W-S	15/06/2020	22/06/2020	
2	E-O	15/06/2020	22/06/2020	*Antechinus spp, Vulpes vulpes*
	E-S	15/06/2020	22/06/2020	
	W-O	15/06/2020	22/06/2020	Rattus sp.
	W-S	15/06/2020	22/06/2020	*Rattus sp.*
3	E-O	15/06/2020	22/06/2020	
	E-S	15/06/2020	22/06/2020	
	W-O	15/06/2020	22/06/2020	Mus musculus
	W-S	15/06/2020	22/06/2020	
4	E-O	15/06/2020	22/06/2020	*Rattus sp.*
	E-S	15/06/2020	22/06/2020	
	W-O	15/06/2020	22/06/2020	*Rattus fuscipes(probable)*
	W-S	15/06/2020	22/06/2020	*Rattus sp.*
6	E-O	15/06/2020	22/06/2020	
	E-S	15/06/2020	22/06/2020	
	W-O	15/06/2020	22/06/2020	
	W-S	15/06/2020	22/06/2020	
7	E-O	15/06/2020	22/06/2020	*Antechinus spp*
	E-S	15/06/2020	22/06/2020	
	W-O	15/06/2020	22/06/2020	Antechinus sp., Rattus sp.
	W-S	15/06/2020	22/06/2020	
8	E-O	15/06/2020	22/06/2020	Trichosurus vulpecula, Rattus sp.
	E-S	15/06/2020	22/06/2020	
	W-O	15/06/2020	22/06/2020	Mus musculus
	W-S	15/06/2020	22/06/2020	
9/10	E-O	15/06/2020	22/06/2020	Trichosurus vulpecula, Antechinus sp.
	E-S	15/06/2020	22/06/2020	*Trichosurus sp.*
	W-O	15/06/2020	22/06/2020	*Rattus sp.*
	W-S	15/06/2020	22/06/2020	
11/12	E-O	15/06/2020	22/06/2020	*Mus musculus*
	E-S	15/06/2020	22/06/2020	
	W-O	15/06/2020	22/06/2020	*Mus musculus*
	W-S	15/06/2020	22/06/2020	
1	E-1	14/11/2019	28/11/2019	*Trichosurus sp.* (Brush-tail Possum)
	E-2	14/11/2019	28/11/2019	
	W-1	14/11/2019	28/11/2019	*Trichosurus sp.* (Brush-tail Possum)
	W-2	14/11/2019	28/11/2019	
2	E-1	14/11/2019	28/11/2019	*Antechinus* sp. Melomys cervinipes (Fawn-footed Melomys)
	E-2	14/11/2019	28/11/2019	
	W-1	14/11/2019	28/11/2019	
	W-2	14/11/2019	28/11/2019	*Rattus fuscipes* (Southern Bush-rat)
3	E-1	14/11/2019	28/11/2019	*Wallabia bicolor* (Swamp Wallaby)
	E-2	14/11/2019	28/11/2019	
	W-1	14/11/2019	28/11/2019	
	W-2	14/11/2019	28/11/2019	*Perameles nasuta* (Long-nosed Bandicoot)
4	E-1	14/11/2019	28/11/2019	*Isoodon macrourus* (Northern Brown Bandicoot)
	E-2	14/11/2019	28/11/2019	
	W-1	14/11/2019	28/11/2019	*Rattus fuscipes* (Southern Bush-rat) Isoodon obesulus (Southern Brown Bandicoot)
	W-2	14/11/2019	28/11/2019	*Rattus fuscipes* (Southern Bush-rat)
6	E-1	14/11/2019	28/11/2019	*Melomys cervinipes* (Fawn-footed Melomys)
	E-2	14/11/2019	28/11/2019	
	W-1	14/11/2019	28/11/2019	*Rattus fuscipes* (Southern Bush-rat)
	W-2	14/11/2019	28/11/2019	*Rattus fuscipes* (Southern Bush-rat)
7	E-1	14/11/2019	28/11/2019	*Melomys cervinipes* (Fawn-footed Melomys)
	E-2	14/11/2019	28/11/2019	
	W-1	14/11/2019	28/11/2019	

Site	Side and bait (O=oats S=Sardines)	Winter 2020		
		Install Date	Collect date	Fauna
	W-2	14/11/2019	28/11/2019	*Perameles nasuta* (Long-nosed Bandicoot)
8	E-1	14/11/2019	28/11/2019	
	E-2	14/11/2019	28/11/2019	*Trichosurus sp.* (Brush-tail Possum)
	W-1	14/11/2019	28/11/2019	
	W-2	14/11/2019	28/11/2019	*Trichosurus sp.* (Brush-tail Possum)
9/10	E-1	14/11/2019	28/11/2019	
	E-2	14/11/2019	28/11/2019	*Trichosurus sp.* (Brush-tail Possum)
	W-1	14/11/2019	28/11/2019	*Rattus* sp.
	W-2	14/11/2019	28/11/2019	*Trichosurus sp.* (Brush-tail Possum) Rattus rattus (Black Rat)
11/12	E-1	14/11/2019	28/11/2019	*Melomys cervinipes* (Fawn-footed Melomys)
	E-2	14/11/2019	28/11/2019	
	W-1	14/11/2019	28/11/2019	*Rattus rattus* (Black Rat)
	W-2	14/11/2019	28/11/2019	

Table C 8: Exclusion fence inspection data collected during winter 2020.

Date	Issue number	Observer	Side	Issue identified	Easting	Northing	Priority	Comments
17/06/2020	1	OT	W	Flap not lining up/minor gaps	494429	6604870	Low	
17/06/2020	2	OT	W	Flap not lining up/minor gaps	494478	6605344	Low	
17/06/2020	3	OT	W	Flap not lining up/minor gaps	494478	6605963	Low	
17/06/2020	4	OT	W	Flap not lining up/minor gaps	494740	6605963	Low	
17/06/2020	5	OT	W	Tree overhanging	494828	6606124	Medium	

17/06/2020	6	OT	W	Flap	495539	6607023	Low	
17/06/2020	7	OT	W	Tree overhanging	495330	6607430	Medium	
17/06/2020	8	OT	W	Vine growing over fence	496079	6608187	Medium	
17/06/2020	9	OT	W	Tree leaning over	496150	6608288	Medium	
17/06/2020	10	OT	W	Gap at drop down	496152	6608299	Medium	
17/06/2020	11	OT	W	Gap at gate	496450	6680788	Medium	
17/06/2020	12	OT	W	Branch on fence	496463	6608842	Medium	
17/06/2020	13	OT	W	Fence base not secure	496517	6609031	Low	
17/06/2020	14	OT	W	gate gap	496517	6609225	Medium	
17/06/2020	15	OT	W	Gaps around drain/dropdown	496562	6609436	Low	
17/06/2020	16	OT	W	Gap around drain	496574	6609461	Low	
17/06/2020	17	OT	W	Unlocked gate under bridge	492218	6598858	High	Gate closed
17/06/2020	18	SR	E	small gap under drain flap	494568	6605414	Low	
17/06/2020	19	SR	E	small tree over fence	494798	6605926	Low	
17/06/2020	20	SR	E	gap around drain flap	494798	6605926	Low	
17/06/2020	21	SR	E	small holes in fence either site of pipe	495236	6606743	Low	
17/06/2020	22	SR	E	tree overhanging fence	495585	6607311	Medium	
17/06/2020	23	SR	E	small gap next to drain flap	495598	6607408	Low	
17/06/2020	24	SR	E	small gap under gate	495651	6607507	Low	
17/06/2020	25	SR	E	Frog fence not in contact with ground	495859	6607825	High	
17/06/2020	26	SR	E	Substantial regrowth from point going 100m north	496069	6608159	High	
17/06/2020	27	SR	E	Gap between gates	496194	6608159	Low	
17/06/2020	28	SR	E	Fence above C7 damaged due to car crash	496501	66087211	High	
17/06/2020	29	SR	E	Hole dug under fence	493338	6601774	High	
17/06/2020	30	SR	E	small tree over fence	492482	6599196	Medium	

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Warrell Creek to Nambucca Heads

Interim Underpass Monitoring Report - Operational Phase, Year Three (2020-2021)

Transport for New South Wales | April 2021

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1. Introduction

In 2015, Transport for NSW (TfNSW), in conjunction with Acciona Ferrovial Joint Venture (AFJV), commenced the upgrade of the Pacific Highway between Warrell Creek and Nambucca Heads (WC2NH). The WC2NH project was opened to traffic in two stages:

- Stage 2a - 13.5km section from Lower Warrell Creek Bridge to Nambucca Heads opened on 18 December 2017; and
- Stage 2b - 6.25km section from the southern end of the project to the Lower Warrell Creek bridge opened on 29 June 2018.

The Ministerial Conditions of Approval (MCoA) for the WC2NH upgrade included a requirement (MCoA B10) to prepare an Ecological Monitoring Program (EMP). The EMP was developed and approved in 2014 and later amended in 2018 (RMS 2018). Species and mitigation measures targeted in the EMP include koala, spotted-tailed quoll, grey-headed flying-red fox, yellow-bellied glider, giant barred frog, green-thighed frog ponds, vegetated median, road-kill, exclusion fencing, threatened flora and fauna underpasses.

As part of the projects approval (MCoA B1, B2, B3) fauna underpasses have been installed at WC2NH "to maintain the viability of local terrestrial fauna populations by facilitating wildlife movement between proximate areas of habitat either side of the upgrade corridor and to accommodate use by several threatened fauna species including the spotted-tailed quoll, koala and giant barred frog" (RMS 2018). To assess the effectiveness of the of the fauna underpasses the EMP specifies operational monitoring to take place bi-annually (i.e spring/summer and autumn/winter for 5 years) in order to align with the breeding and dispersal periods of targeted threatened species (koala, spotted-tailed quoll and giant barred frog).

The following interim report presents methods and results of the year three spring/summer operational phase underpass and adjacent habitat monitoring. The objective of fauna underpass monitoring is "to assess use of underpasses by threatened and common fauna and to assess the effect of exclusion fencing on movement of small mammals, reptiles and frogs" (RMS 2018). Effectiveness of exclusion fence is also assessed in the annual road-kill report (see Sandpiper Ecological 2020b). The results are discussed in relation to the potential indicators of success detailed in the WC2NH EMP (RMS 2018) and recommendations regarding future monitoring are provided. The potential indicators of success used to assess the performance of the WC2NH underpasses include:

1. Low rates of use of fauna underpasses and adjacent habitats by feral predators;
2. High levels of fauna underpass use by a wide variety of native fauna species;
3. No change to densities, distribution, habitat use, and movement patterns compared to baseline population data of target species;
4. Evidence of use by dispersing individuals and different age cohorts;
5. Use by cover-dependent species and species with low mobility;
6. No breaches in fauna exclusion fencing;
7. Low incidences of fauna road strike mortality.

A list of species names for fauna referred to in text and Tables is provided in Appendix A.

2. Methods

2.1 Study area

The WC2NH project covers a total length of 19.75km and extends from Warrell Creek in the south to Nambucca Heads in the north (Figure 1). The alignment bypasses the town of Macksville and the northern section traverses Nambucca State Forest. The WC2NH upgrade features 23 fauna underpasses, including 13 box culverts, three pipe culverts and seven bridges. Underpasses targeted for monitoring were specified in the WC2NH EMP and include eleven box culverts and one bridge (RMS 2018; Table 1). Eleven underpasses are situated north of the Nambucca River and one (Site 1) is situated at Upper Warrell Creek near the southern extent of the project (Figure 1). Sites four to twelve adjoin Nambucca State Forest and sites two and three adjoin remnant vegetation on private land (Figure 1). Site five includes a dual cell box culvert with one cell designated as a wet passage (for aquatic fauna) and the other as dry passage (Plate 1). The dry cell includes a concrete ledge that provides dry passage for terrestrial fauna. Sites 9/10, and 11/12 consist of corresponding culverts on either side of a vegetated median (Plate 1). Fauna underpasses were designed to target spotted-tailed quoll (*Dasyurus maculatus*), koala (*Phascolarctos cinereus*) and giant barred frog (*Mixophyes iteratus*). Giant barred frog is known to occur at site 1 (Upper Warrell Creek) only, whilst quoll and koala could occur at sites 2-12.

Table 1: Underpasses sampled during operational phase monitoring of the WC2NH upgrade. SQ = spotted-tailed quoll; K = koala; GBF = giant barred frog; * sites consist of dual cells 3x3m box culverts with one cell providing wet passage for aquatic fauna; P/A = presence/absence.

Site	Chainage	Type	Structure	Dimensions	Fauna Furniture (P/A)	Substrate	SQ	K	GBF
1	42500	Combined	Bridge		A	Soil			x
2	55120	Dedicated	Box Culvert	1 x 3000 x 3000	P	Concrete	x	x	
3	56410	Combined	Box Culvert	1 x 2400 x 2400	P	Concrete	x	x	
4	57770	Dedicated	Box Culvert	1 x 3000 x 3000	P	Mulch	x	x	
5 *	58510	Combined	Box Culvert	2 x 3000 x 3000	A	Concrete	x	x	
6	58560	Dedicated	Box Culvert	1 x 3000 x 3000	P	Mulch	x	x	
7	59090	Dedicated	Box Culvert	1 x 3000 x 3000	P	Mulch	x	x	
8	59550	Dedicated	Box Culvert	1 x 3000 x 3000	P	Mulch	x	x	
9	59750 NB	Dedicated	Box Culvert	1 x 2400 x 2400	P	Mulch	x	x	
10	59760 SB	Dedicated	Box Culvert	1 x 2400 x 2400	P	Mulch	x	x	
11	60600 NB	Dedicated	Box Culvert	1 x 2400 x 2400	P	Mulch	x	x	
12	60610 SB	Dedicated	Box Culvert	1 x 2400 x 2400	P	Mulch	x	x	

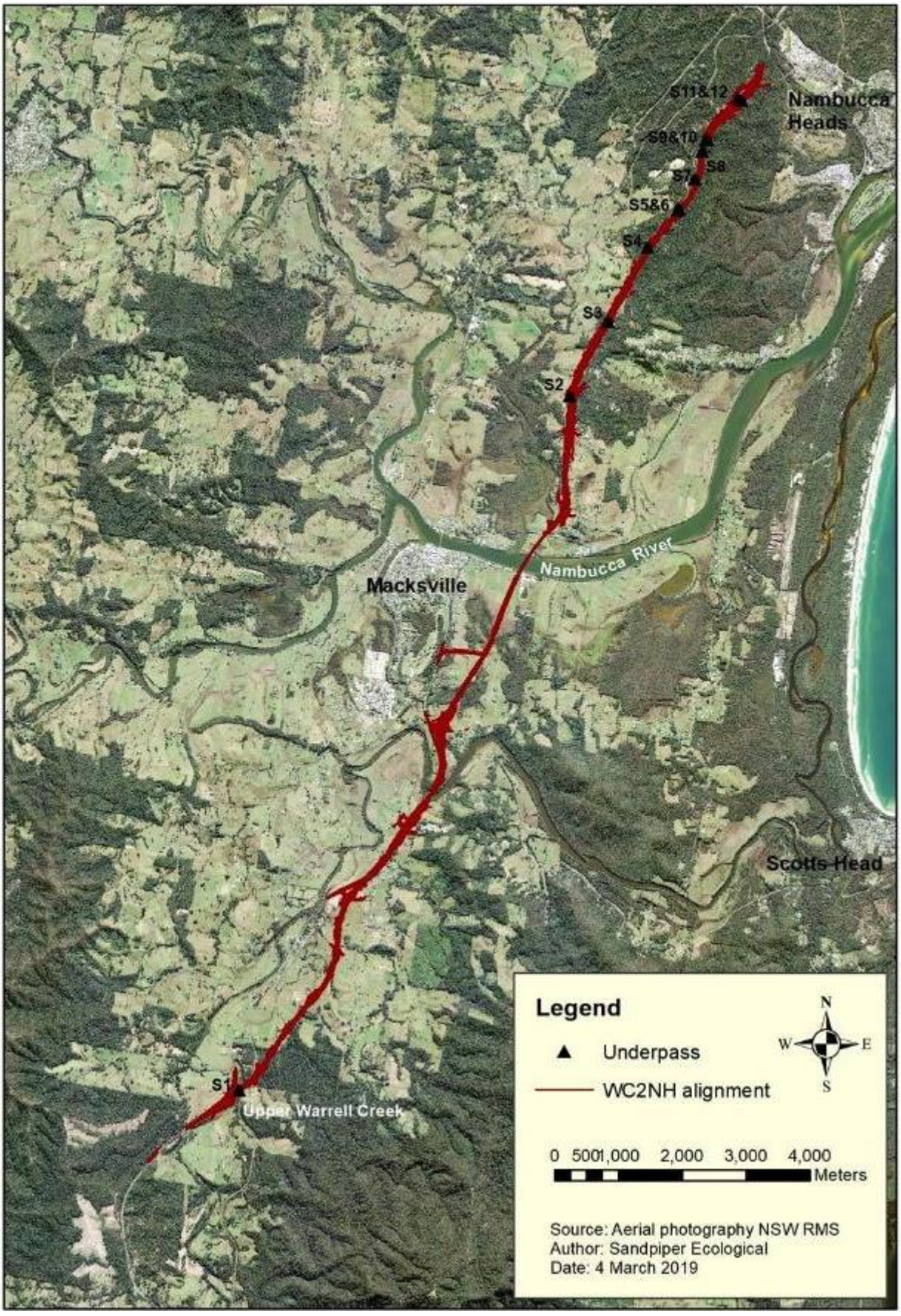

Figure 1: Underpass locations along the WC2NH alignment.

Plate 1. Dual box culverts with designated wet passage at site 5 (top left). Split median box culverts at site 9 and 10 (top right). Fauna furniture entering (bottom left) and exiting site 8 (bottom right).

2.2 Timing and weather conditions

Year 3 operational phase underpass and adjacent habitat surveys were conducted between 12 October 2020 and 04 January 2021 (spring/summer). Dry warm conditions occurred from October 2020 through to November 2020 with a total of 115 mm of rainfall being recorded at the Bureau of Meteorology Bellwood weather station (059150) (Appendix B, Table B1). Warm and wet conditions occurred during December 2020 and early January 2021 with the Bellwood station receiving 704.6mm (Table 2, Appendix B, Table B1). Conditions in December and January were conducive for the movement of amphibians through underpasses.

Table 2: Summary of weather conditions recorded at Coffs Harbour Airport (station 059151) and Bellwood weather station (rainfall only, 059150) during year three spring/summer operational phase monitoring.

Monitoring period	Total rainfall (mm)	No. rain days	Relative humidity (%)	Max temp range (^{0}C)	Min temp range (^{0}C)
Spring/Summer	665	37	>60% on 90% of days	21.7-32.1	6.7-25

2.3 Underpass monitoring

2.2.1 Sand pads

Sand pads were installed on 28 October 2020 (spring/summer sample). A 50:50 mix of brickies sand and washed beach sand was used for all sand pads. Two sand pads were installed at each site. In culverts, pads were installed 3-5m from each end, whilst at the bridge (site 1) two pads were installed on the northern side of Warrell Creek. Each pad was approximately 50mm deep by 1m wide and extended for the entire culvert width, or for 3-4m at site 1. At sites with a concrete ledge the pad covered both the floor and ledge (Plate 1). The exception was site 5 where the pad covered the ledge only due to standing water over the culvert floor on the eastern end.

Sand pads were inspected on eight consecutive days across all sites. Rain on 28 October 2020 led to complete or partial wash out of sand pads at sites 3, 2,and 12, with pads reinstalled on 29 October. Inspections were conducted by an ecologist and included a systematic scan of each pad searching for fauna tracks. A small torch was used to illuminate the pad, if required. Information recorded included species or fauna group, number of traverses, direction of traverse and pad condition (good, moderate, poor). Tracks were identified with reference to Triggs (2004) and advice from senior ecologists. Tracks that could not be identified insitu were photographed and referred to a senior ecologist for identification.

Plate 2. Sand pad being installed in a fauna underpass (Site 3) on the WC2NH upgrade.

2.2.2 Scat and track searches

Each underpass was searched by a senior ecologist and/or ecologist for scats and tracks on two occasions during the spring/summer and winter sample periods. The search involved a slow systematic traverse of each culvert using a hand-held spotlight (Led Lenser P14). Fauna furniture, the culvert floor, and joints were targeted. Areas of accumulated fine sediment were targeted for tracks. Tracks and scats were identified in-situ, with reference to Triggs (2004) and the ecologists experience or photographed and sent to colleagues for identification.

2.2.3 Tile checks

In autumn 2020 two roof tiles (300x200) were installed at both ends of underpasses 5m in from the entrance to target small mammals, reptiles and frogs. These were checked on two occasions during the spring/summer sample period.

2.2.4 Cameras

Two motion-activated infra-red cameras (Swift 3C, Swift Enduro or Reconyx HC500) were installed centrally in each culvert, with the exception of site five where one camera was mounted centrally in each cell. At site 1, Reconyx HC500 cameras were initially attached to steel posts, and following theft, were housed in security boxes attached to concrete posts. A single camera was installed at approximately 200mm above ground near the water's edge on each side of Upper Warrell Creek (site 1). In total, 24 cameras were installed. In underpasses, both cameras were installed centrally, one on the fauna furniture, and one approximately 300mm above the culvert floor. Cameras were oriented to the east except for site 1 where cameras were oriented perpendicular to the creek on the north and south banks. Cameras at site 10 were re-oriented to the west following a high incidence of false triggers cause by traffic on the southbound carriageway. Swift cameras were set to take 10 seconds of video with no delay between activation. Reconyx cameras were set on time-lapse mode to take a picture at 1-minute intervals between 8 pm and 6 am each day throughout the spring/summer sample period. Time-lapse mode is better suited to targeting frogs and was used successfully to monitor frog pipes on the Sapphire to Woolgoolga Pacific Highway Upgrade (Sandpiper Ecological 2017a, 2018a). Cameras at site 1 were inundated by floodwater on several occasions in December 2020.

During the spring/summer sample period, cameras at sites 1-12 were installed on 30-31 October 2020 and were inspected during the middle of each session to change batteries and SD cards. Cameras at sites 2-12 were retrieved on 4 January 2021 following a total sample period of 95 days (Table 3). Cameras at site 1 were retrieved on 23 December 2021 February following a sample period of 77 days (Table 3). Three of the 24 cameras were active for less than the 60-day minimum sample period with two a result of camera malfunction/battery failure and one due to flooding at site 1 south (Table 3). Overall, cameras were active for a period of 2024 days with all underpasses having at least one camera active for >60 days (Table 3). The total number of camera monitoring days achieved in spring/summer year 3 (i.e. 2024) exceeds the effort required by the EMP of 1440 days.

Table 3: Camera survey effort during year three operational phase monitoring**.** * = malfunction/battery failure ^ camera flooded.

Site	Cam location	Days active		
		Spr/Sum	Winter	Total
1	North	77		
	South	53^		
2	Furniture	74		
	Floor	95		
3	Furniture	95		
	Floor	95		
4	Furniture	95		
	Floor	48*		
5	North	95		
	South	30*		

Site	Cam location	Days active		
		Spr/Sum	Winter	Total
6	Furniture	95		
	Floor	95		
7	Furniture	95		
	Floor	95		
8	Furniture	61		
	Floor	95		
9	Furniture	95		
	Floor	95		
10	Furniture	95		
	Floor	95		
11	Furniture	95		
	Floor	95		
12	Furniture	95		
	Floor	66		
Totals		2024		

Image review

Images were uploaded to a computer and viewed using Windows Photo Viewer ©. A senior ecologist or ecologist reviewed all images, with reference to standard field guides (i.e. Menkhorst & Knight 2004; Pizzey & Knight 2007; Van Dyck *et al.* undated).

Fauna were scored making a complete or incomplete crossing:

- A complete crossing was scored when an animal showed directional movement when detected by the centrally mounted camera.
- An incomplete crossing was scored when an animal showed no directional movement (i.e. remained stationary in front of camera) or passed the camera but returned within 10 minutes.

Crossing definitions are consistent with those used at other Pacific Highway monitoring sites (e.g. Sandpiper Ecological 2017b, 2018b, 2019) and crossing structure research programs (e.g. Soanes *et al.* 2015). Further, it represents a conservative approach to identification of complete crossings. Data recorded for each active image included: site, date, time, species, accuracy (definite 90%+ certainty, probable 75-90% certainty, and possible 60-75% certainty), movement direction (east, west, no directional movement (animal stationary, returned), number of images and image numbers. A hierarchical approach was adopted to species identification that included: species, genus or group. Microbats were recorded as presence only due to their transient nature and none reliance on underpasses for thoroughfare.

Data analysis and interpretation

The adequately assess "use of underpasses" as per the EMP operation monitoring aim, complete crossings were used as the standard of measure as it encompasses the purpose of fauna underpasses (i.e. A structure that allows fauna to access habitat that has been fragmented by construction of a road or highway). To account for variations in survey effort between sites complete crossings/week and complete crossings/week/underpass were adopted. Birds and microbats were excluded from analysis as they do not require underpasses for thoroughfare.

As seen in dot point five in the potential indicators of success (see introduction), fauna with low mobility was not defined within the EMP. As such, fauna with low mobility has been assumed to include animals whose movement is generally limited by their size or behaviour. Hence, fauna that exhibit low mobility/cover dependence has been interpreted as frogs, small reptiles

(excluding goanna and water dragon), rodents and bandicoots. Rodent spp were considered to be “undefined” in relation to whether they were introduced or native given the presence of black rats, bush rats and fauna-footed melomys.

2.3 Adjacent habitat survey

2.3.1 Survey design

A total of 18 sites were sampled at the 12 underpasses as part of adjacent habitat surveys. Sample sites were established on each side of an underpass or underpass pair in the case of sites 5/6, 9/10 and 11/12. Adjacent habitat at sites 5 and 6 was sampled as one site as the underpass entrances were located within 50m of each other. Survey effort was reduced at site 3 due to concern about disturbing neighbours. No spotlighting or arboreal Elliott trapping occurred on the west side at site 3 and the diurnal active search was restricted to a small (100m x 30m) triangular shaped remnant of vegetation in the road reserve.

2.3.2 Trapping

Trapping methods applied during the survey included: cage traps, ground Elliott traps (Type A), arboreal Elliott traps (Type B), pitfall traps, and hair funnels. Trapping occurred within a 1ha area immediately adjacent to each culvert entrance and was conducted over three nights at each site. All sites were sampled concurrently and trapping was conducted between 20 and 26 October 2020.

Traps were set in a “X” formation with five ground and five arboreal traps set at 20m intervals on one axis and two cage traps and two hair funnels set at 50m spacing on the other axis (Plate 2). A line of three pitfall traps with drift fence was set at the intersection of both lines (Plate 2). Pitfall traps typically followed the contour and were set near fallen logs and dense ground cover. Trap effort is summarised in Table 4.

Plate 3: Example of a pitfall trap line installed during adjacent habitat surveys (L). Setting up traps in adjacent habitat at site 1 (R).

Arboreal traps and ground Elliott traps were baited with a peanut butter, honey and oats mixture. Arboreal traps were installed 1.8m above ground and attached to a bracket. Honey water was sprayed on the trunk above each arboreal trap, and bait was replaced as required. A plastic bag was placed over the end of each trap to provide cover, and a small amount of leaf litter was placed inside the trap. In spring/summer, arboreal traps were set on the western side of trees to provide shelter from the morning sun. Cage traps were set in a sheltered location and alternately baited with either peanut butter, honey and oats, or

sardines. A tuna oil and water mix was sprayed around the entrance to cage traps baited with sardines. All traps were checked within four hours of sunrise. In spring/summer cage and Elliott traps were closed following the morning inspection and re-opened in the late afternoon. Pitfall traps were checked in the morning and again in mid-afternoon.

Captured fauna were identified to species or genus, and, where possible, sexed and aged. Fauna were identified with reference to standard field guides (Van Dyck *et al.* 2013; Menkhorst & Knight 2004; Wilson & Swan 2010). Fauna were not marked as the aim of sampling was to determine the range of species present in adjacent habitat.

2.3.3 Diurnal active search

Diurnal active searches were conducted by one or two ecologists and involved a meandering traverse of habitat within 100m of the underpass entrance at each sample site. Surveys involved searching leaf litter, rolling logs, observing reptile habitat (i.e. log piles, rocks, dense leaf litter) and looking for fauna signs such as scats and tracks. Each site was sampled twice during each sample period for a minimum of 30 person minutes/sample. Spring/summer diurnal active searches were conducted between 13 and 16 October. A total of 1080 person minutes were spent conducting diurnal active searches during the spring/summer period (Table 4).

2.3.4 Nocturnal active search

Nocturnal surveys were conducted on each side of each underpass on two non-consecutive nights during the spring/summer sample period. One or two ecologists conducted spotlight surveys for 60 person minutes per underpass side/sample period (Table 4). Surveys were conducted using hand-held Led Lenser P14 spotlights and involved a meandering traverse of habitat within 200m of the culvert entrance. Fauna were detected by sight and call and identified to species or genus where possible. Spring/summer surveys were conducted between 13 and 29 October 2020. A total of 1080 person minutes were spent conducting nocturnal active searches (Table 4).

2.3.5 Opportunistic records

Opportunistic observations of fauna near culvert entrances made whilst doing other monitoring activities such as koala, giant barred frog and yellow-bellied glider monitoring were recorded. All fauna observed whilst setting up equipment, with exception of birds, were also recorded.

Table 4: Survey effort for sampling adjacent habitat on the WC2NH upgrade.

Component	Method / culvert side	No Samples	Total effort
Arboreal Elliott traps	5 x traps @ 20m spacing	3 nights/site	510 trap nights
Ground Elliott traps	5 x Type A Elliott traps @ 20m spacing	3 nights/site	540 trap nights
Cage traps	2 @ 50m spacing	3 nights/site	216 trap nights
Pitfall traps	1 x line of 3 pits with drift fence	3 nights/site	324 trap nights
Hair funnels	2 @ 50m spacing	14 nights/site	504 trap nights
Active diurnal search	30 person minute search at UP entrance	2 sample/site	1080 person minutes
Active nocturnal search	30 person minute search at UP entrance	2 samples/site	1080 person minutes

2.4 Exclusion fence

Inspection of the fauna exclusion fence is conducted in the winter sample period only.

3. Results

3.1 Underpasses

3.1.1 Camera monitoring

Species diversity and native fauna use

Eighteen species and six fauna groups were confirmed using (complete crossings) underpasses during camera monitoring (Table 5). The highest fauna diversity was recorded at site 4 and 7 with thirteen species/groups (combined ground and furniture), followed by sites 6 and 12 with eleven species/groups (Table 5). The lowest diversity was recorded at site 1 with only one species (swamp wallaby) being recorded (Table 5). Remaining sites recorded between 6 and 10 fauna species/groups (Table 5). Five introduced species were recorded including cat, dog, red fox, black rat and house mouse (Table 5).

The majority (91-94%) of fauna detections in underpasses were recorded as complete crossings (cc). Overall native species exhibited a higher rate of crossing completions in comparison to introduced species (Figure 2). Complete crossings by native species were recorded in all underpasses at an average rate of 2.12 ± 1.78cc/week/underpass (Figure 2, 3). Sites 4, 11 and 12 featured the highest use by native species with 5.09cc/week, 3.13cc/week and 2.68cc/week respectively (Figure 2). Sites 1 and 9 exhibited the lowest use by native species recording 0.1cc/week and 0.29cc/week (Figure 2).

Swamp wallaby was the most frequently recorded native species with a total of 6.22 cc/week across all sites (Plate 4, Table 5). This was followed by bandicoot spp. (5.49cc/week), lace monitor (3.14cc/week) and *Trichosurus* spp. (2.87cc/week) (Plate 4). Koala was the only threatened species recorded, with complete crossings using the culvert floor recorded at sites 4 and 8 (Table 5). Koala made six complete crossings (three east, three west) at site 4 and one complete crossing (west) at site 8 (see appendix C Table 1). Koala was also recorded making incomplete crossings at site 12 and 10 (Plate 4, Appendix C Table 1).

Use by cover dependent species with low mobility

Fauna with low mobility (see classification in methods) were recorded across all sites, except for site 1 (Table 5). In order of use, bandicoot spp (including long-nosed and northern brown bandicoots) recorded a total of 5.49 cc/week followed by black rat 3.94 cc/week and rodent spp. 2.32 cc/week (see total Table 5). Confirmed rodent species recorded were the introduced black rat (sites 2,4,5,7,8,9,10,12) and house mouse (site 3 and 12) with a probable record of native fawn-footed melomys (site 11) and water rat (site 5) (Table 5). *Antechinus* spp records were relatively scarce with complete crossings made on furniture at sites 2 (Plate 4), 7, 8, 10 and 11 (Table 5). *Egernia* spp. was the only cover dependent reptile recorded, with one complete crossing using furniture at site 9 (Plate 4, Table 5). No frogs were recorded using underpasses during camera monitoring.

Furniture vs Floor

Fauna was recorded using both the culvert floor and furniture during operation phase monitoring (Table 5). Use of the underpass floor was greater than use of furniture for natives, introduced rodents and feral predators (Table 5). Furniture use by feral predators was very low, with two complete crossings recorded by cat at sites 3 and 11 (Table 5, see Appendix C). *Trichosurus* spp and *Antechinus* spp, demonstrated preferential use of the fauna furniture, with *Trichosurus* spp accounting for the majority of crossings by native species on the furniture at sites 3 and 4 (Table 5). Use of furniture by black rats was recorded at sites 2,7,8 and 12 (Table 5). Koalas were recorded using the floor only (Table 5).

Plate 4: *Egernia* spp recorded on furniture at site 9 (Top left). Long-nosed bandicoot heading east at site 6 (Top right). Swamp wallaby travelling west at site 2 (Middle left). Koala recorded making an incomplete crossing at site 10 (Middle right). *Antechinus* spp recorded on fauna furniture at site 2 (Bottom left). Lace monitor recorded on fauna furniture at site 6 (Bottom right).

Table 5: Complete crossings/week made by each species/group at each of the 12 underpasses monitored on the WC2NH upgrade during year 3 spring/summer operational monitoring. Sites 1 and 5 did not contain fauna furniture. Species in bold denote threatened species, * = introduced species, FF= fauna furniture and G = ground (culvert floor). See appendix C, Table C1 for all data.

Species/groups	Site and camera location																								Total
	1		2		3		4		5		6		7		8		9		10		11		12		
	S	N	FF	G	FF	G	FF	G	N	S	FF	G	FF	G	FF	G	FF	G	FF	G	FF	G	FF	G	
Short-beaked echidna										0.06				0.11						0.04					0.20
Antechinus spp.			0.12										0.04		0.13				0.15		0.04				0.48
Northern brown bandicoot								0.10				0.07												0.13	0.30
Long-nosed bandicoot						0.15		0.05				0.04		0.04						0.07					0.34
Peramelidae spp (bandicoot)				0.41		0.18		1.47				0.18		0.07		0.09		0.07		0.22		0.88		1.26	4.85
Koala								0.34								0.04									0.39
Common brushtail possum																		0.07		0.04					0.11
Short-eared brushtail possum						0.04	1.22	0.10				0.15	0.04												1.54
Trichosurus spp					0.90	0.07		0.05		0.06		0.04	0.07	0.04											1.22
Eastern grey kangaroo						0.04																			0.04
Red-necked wallaby						0.15																			0.15
Swamp wallaby	0.11			0.75		1.14		0.93				0.04		0.33		0.04						1.40		1.48	6.22
Wallaby spp.												0.04						0.04							0.07
House mouse*						0.04																		0.04	0.08
Fawn-footed melomys																						0.04			0.04
Water rat									0.06	0.11															0.17
Rodent spp.							0.05	0.20	0.17	0.06			0.11	0.29						0.04	0.70			0.04	1.65
Black rat*			0.04					0.05	0.11	0.11			1.40	0.18	0.22			0.07		0.04			0.09		2.32
Dog*				0.54		0.29		0.49	0.06			0.11		0.29		0.13		0.59		0.59		0.41		0.43	3.94
Fox*				0.04				0.64	0.11			0.44		0.96		0.31		0.18		0.15		0.92		0.91	4.67
Cat*					0.04	2.43						0.11		0.04		0.22		0.26		0.18	0.04	0.11		0.17	3.60
Lace monitor							0.10	0.49	0.11	0.11	0.04	0.29		0.52		0.90		0.07				0.29		0.22	3.14
Eastern water dragon					0.04	0.11		0.24														0.04		0.04	0.47
Egernia spp																	0.04								0.04
Species/group richness	**1**	**0**	**2**	**4**	**3**	**12**	**3**	**13**	**6**	**6**	**1**	**11**	**5**	**11**	**2**	**7**	**1**	**8**	**1**	**9**	**3**	**8**	**1**	**10**	**24**

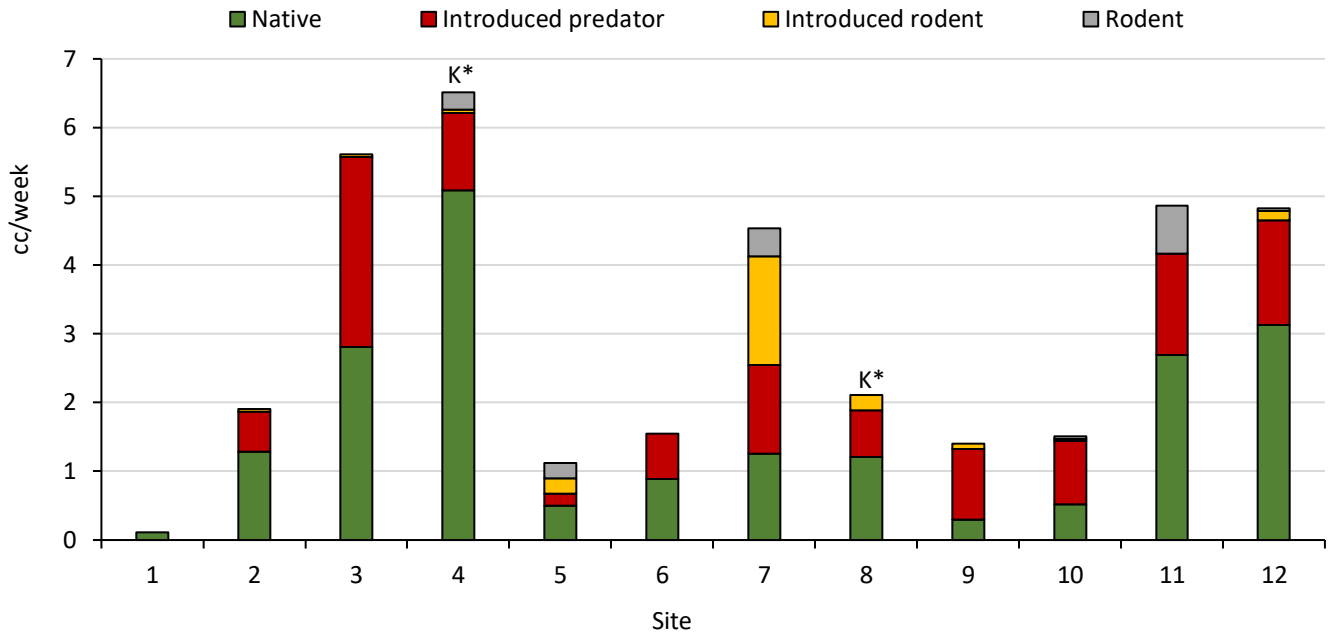

Figure 2: Complete crossings/week for native species, feral predators (combined cat, dog, red fox) introduced rodents (combined black rat and house mouse) and rodents at each underpass during year three spring/summer monitoring. *K = indicates complete crossing by koala.

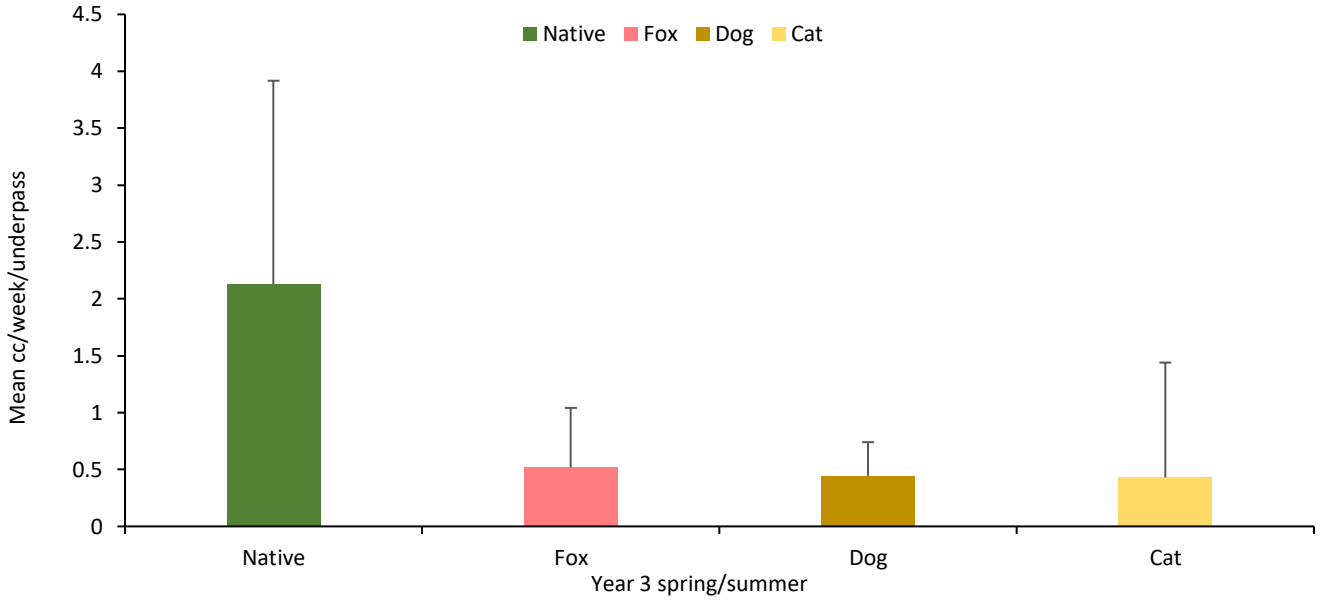

Figure 3: Mean number of complete crossing/week/underpass (+SD) for all native species and introduced predators (Fox, Dog, cat) during year 3 spring/summer operational monitoring.

Feral predator activity

Complete crossings by feral predators were recorded at all sites at an overall rate of 1.39 ± 0.67 cc/week/underpass (Figure 3). Feral predator activity was highest at sites 3, 11/12, 7 and lowest at sites 5, 2, 6 and 8 (Figure 4). Red fox was recorded at a rate of 0.52 ± 0.52 cc/week/underpass with detections in all underpasses aside from sites 1 and 3 (Figure 3 and 4). Dog (*Canis lupus*

familiaris) exhibited 0.44 ± 0.29 cc/week/underpass and was detected at 11 of the 12 sites (Figures 3 and 4). Cat (*Felis catus*) recorded 0.43 ± 1 cc/week/underpass with detections at all sites except 4 and 5 (Figures 3 and 4). High use at site 3 can largely be attributed to frequent crossings (3.09 cc/week, Figure 4) by a distinctive resident individual (Plate 5). Red fox was frequently detected at sites 7 (1.03cc/week), 11/12 (0.91cc/week), and 4 (0.64cc/week) while dog detections were highest at sites 2 (0.54cc/week) and 4 (0.54cc/week) with one distinctive individual frequently detected at sites 4, 9, 10, 11 & 12 (Plate 5). No instances of predation were recorded in underpasses, although cats carrying prey (rodents) were recorded moving through site 3 on two occasions (see appendix C. Table C1).

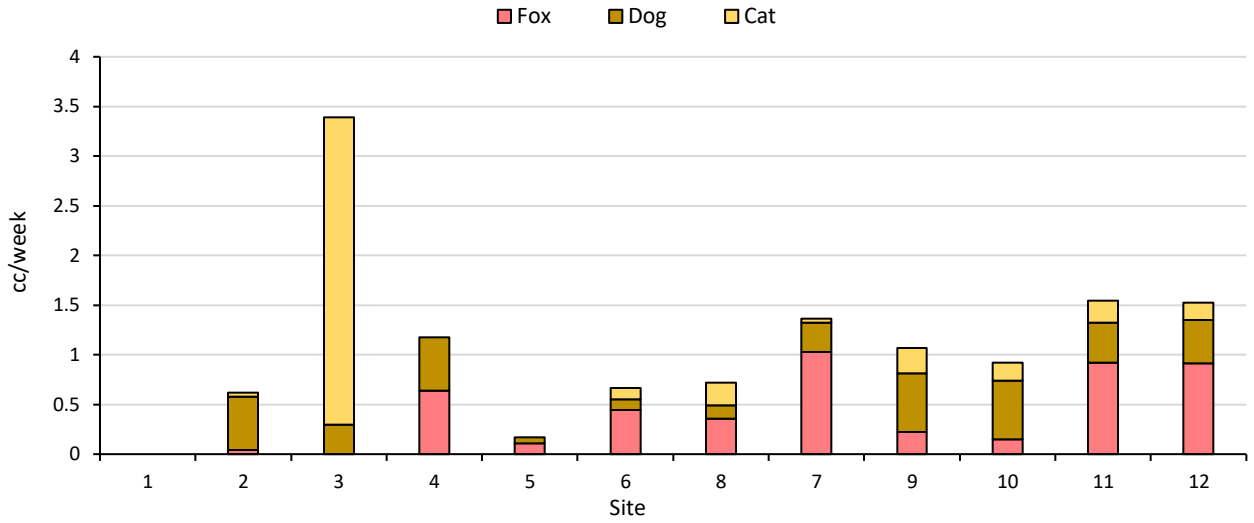

Figure 4: Complete crossings/week by feral predators (cat, red fox, dog) in underpasses during year 3 spring/summer operational monitoring at WC2NH.

Plate 5: Cat frequently recorded at site 3 (Left) and dog frequently recorded at sites 4, 9,10,11,12 (Right).

3.1.2 Sand pads

Fifteen species and fauna groups were recorded on sand pads during monitoring (Appendix C, Table C2). Species diversity was found to be highest at site 4 (six species/groups). Of the native species, bandicoot spp was the most commonly recorded fauna group with tracks identified at sites 2, 4, 6, 9, 11 and 12 (Plate 6, Appendix C, Table C2). *Trichosurus* spp were recorded using the

culvert floor at site 4 (Plate 6). Of the smaller fauna groups (small mammals, reptiles and amphibians), probable *Antechinus* spp. was reported at sites 5, 10 and 11 (Appendix C, Table 2). Sand pad records of feral predators were similar to camera data with cat, dog and red fox confirmed using the underpasses at most sites.

Plate 6: Bandicoot tracks recorded alongside cat tracks at site 8 during spring/summer monitoring. *Trichosurus* spp heading east at site 4 (right)

3.1.2 Scat and track searches and tile checks

Five species, and six fauna groups were recorded during scat and track surveys during year three spring/summer monitoring (Appendix C. Table C3). As seen in camera data, sites 4 and 7 reported the highest diversity of fauna species with five and six fauna groups/species respectively. Native species/fauna groups were found to be using all culverts. Bandicoot spp was recorded at six sites with lace monitor at five sites during spring/summer. Records of small fauna included tracks and scats from *Antechinus* spp. at sites 6, 11 and 12. No fauna was recorded using tiles placed in underpasses.

3.2 Adjacent habitat

Thirty-one species and a further five fauna groups likely to use underpasses (species that don't rely on underpasses to cross the alignment such as birds, flying-foxes and gliders have been excluded) were recorded in habitat adjoining underpasses (Table 6. The majority of species/groups (20 in total) were detected by diurnal and nocturnal active searches (Table 6, appendix C. Table C4&5). During trapping surveys, a total of 12 species were recorded. Hair funnels recording five species (including one record of common ringtail possum) and two groups (Table 6). Several threatened species were recorded during spotlight surveys of adjacent habitat, including grey-headed flying fox, koala on the western side of site 7 and yellow-bellied glider on the west side at site 5/6 (Appendix C, Table C5). Koala scat was also recorded on the eastern side of 9/10 during diurnal surveys (Appendix C, Table 4).

During spring/summer trapping, fawn-footed melomys was the most frequently captured species, with 16 individuals, followed by bush rat (13 individuals); *Lampropholis delicata* (seven individuals), brown antechinus (six individuals; Plate 7) and black rat (4 individuals) (Appendix C, Table 6). Other species captured were red-tailed skink (*Calyptotis rudificauda)* dwarf-crowned snake, northern brown bandicoot, lace monitor, sugar glider, short-eared brushtail possum, and red-backed toadlet (*Pseudophryne coriacea)* (Plate 7).

Plate 7. Brown antechinus captured in a ground Elliot on the west side of site 8 (Left), and *Pseudophryne coriacea* found in a pitfall trap on the east side of site 2 (Right).

Table 6: Vertebrate species that require underpasses to cross the alignment recorded during surveys of adjacent habitat at WC2NH in spring/summer, 2020/2021. SS = Spring/Summer, W = Winter. * = Threatened species.; [I] = Introduced species.

Species	Active Search		Spotlight		Trapping		Hair funnel		Opportunistic records	
	SS	W	SS	W	SS	W	SS	W	SS	W
Mammals										
Short-beaked echidna	*									
Brown antechinus					*					
Antechinus spp							*			
Northern brown bandicoot					*		*			
Long-nosed bandicoot			*							
Peramelidae spp. (bandicoot)	*									
Koala*	*		*							
Common brushtail possum							*			
Short-eared brushtail possum			*		*					
Common ringtail possum							*			
Trichosurus spp.	*									
Swamp wallaby	*		*				*			
Wallaby spp.	*		*							
Fawn-footed melomys					*					
Bush rat					*		*			
House mouse [I]					*					
Black rat [I]					*					
Rattus spp.							*			
Red fox [I]	*									

Species	Active Search		Spotlight		Trapping		Hair funnel		Opportunistic records	
	SS	W	SS	W	SS	W	SS	W	SS	W
Dog	*									
Cat [I]	*									
Reptiles										
Common scaly-foot			*							
Lace monitor					*					
Blue-tongued skink									*	
Southern angle-headed dragon									*	
Calyptotis ruficauda	*				*					
Lampropholis delicata	*				*					
Lampropholis spp.	*									
Yellow-faced whipsnake									*	
Dwarf Crowned Snake					*					
Frogs										
Litoria gracilenta			*							
Litoria fallax			*							
Litoria peronii			*							
Litoria tyleri			*							
Adelotus brevis	*									
Pseudophryne coriacea					*					
Total Nº. Species/groups	**13**		**10**		**12**		**7**		**3**	

3.2.1 Species recorded in underpasses and adjacent habitat

Due to duplication between species and fauna groups (e.g. wallaby spp. includes both red-necked and swamp wallaby) only confirmed species and unique genera have been included in the comparison between underpasses and adjacent habitat (Table 7. Species that do not rely on underpasses to cross the alignment such as birds, flying-foxes and gliders have also been excluded (Table 7). With the above exclusions 33 species and genera were confirmed using adjacent habitat and 21 species and genera were recorded using underpasses (Table 7). Red-necked wallaby, water rat, eastern-water dragon and *Egernia* spp were recorded in underpasses only and are assumed to reside in adjacent habitat (Table 7). With this assumption the proportion of species in adjacent habitat that utilised underpasses during spring/summer monitoring was 64% (Table 7). The proportion of mammals recorded in both adjacent habitat and underpasses was 94% with the common ringtail possum being the only species not recorded using underpasses. No species of frog were recorded using underpasses, while five frog species were reported in adjacent habitat (Table 7). Further, of the nine reptile species/families recorded during monitoring, only three (lace monitor, eastern water dragon & *Egernia* spp.) were confirmed using underpasses (Table 7).

Table 7: Species and genera recorded using underpasses and in adjacent habitat during year three monitoring. * denotes threatened species. + = species designation assumed based on frequent capture of only brown antechinus in adjacent habitat.

Species	Adjacent habitat	Underpass
Mammals		
Short-beaked echidna	*	*
Brown antechinus	*	+
Northern brown bandicoot	*	*
Long-nosed bandicoot	*	*
Koala*	*	*
Short-eared brushtail possum	*	*
Common brushtail possum	*	*
Common ringtail possum	*	
Swamp wallaby	*	*
Red-neck wallaby	+	*
Fawn-footed melomys	*	*

Species	Adjacent habitat	Underpass
Water rat	+	*
Bush rat	*	*
House mouse [I]	*	*
Black rat [I]	*	*
Dog [I]	*	*
Red fox [I]	*	*
Cat [I]	*	*
Sub-total mammals	**19**	**18**
Reptiles		
Lace monitor	*	*
Eastern water dragon	+	*
Blue-tongued skink	*	
Southern angle-headed dragon	*	
Calyptotis ruficauda	*	
Lampropholis delicata	*	
Egernia spp	+	*
Yellow-faced whipsnake	*	
Dwarf Crowned Snake	*	
Sub-total reptiles	**9**	**3**
Frogs		
Litoria gracilenta	*	
Litoria fallax	*	
Litoria peronii	*	
Adelotus brevis	*	
Pseudophryne coriacea	*	
Sub-total frogs	**5**	**0**
Total Nº. Species/genus	**33**	**21**

4. Discussion

4.1 Low rates of use of fauna underpasses and adjacent habitats by feral predators

Feral predators (combined cat, red fox and dog) recorded complete crossings in underpasses at an overall rate of 1.39 ± 0.67 cc/week/underpass. While what constitutes “low use” is not specified within the WC2NH EMP (RMS 2018), feral predators accounted for 40% of complete crossings (excluding unknown and introduced rodents) with lower rates than recorded for native species (2.12 ± 1.78cc/week/underpass). This suggests that feral predators are readily using underpasses to transverse the alignment at a rate that is similar to native fauna. No feral predators were recorded in adjacent habitat. Fox crossing the alignment was recorded at 10 sites (highest at 4, 6, and 11/12), Dog 11 sites (highest at 2,4, 9/10 and 11/12) and cat at eight sites (highest at 3).

As mentioned in response to the previous year 2 annual operational underpass monitoring report (Sandpiper, 2020c), Local Land Services in co-ordination with Transport for New South Wales have the option to place bait in culverts. Moving forward this may be a practical option given that the extent of dog activity has increased with records of complete crossings now at 11 of the 12 sites (previously recorded in 6 sites, Sandpiper, 2020c). Further, the rate of dog activity has increased from 0.1 ± 0.15 cc/week/underpass in year two (Sandpiper 2020c) to 0.44 ± 0.29 cc/week/underpass during the recent spring/summer monitoring period. Of particular concern is the level of use recorded at sites with known koala activity (i.e. sites 4, 8, 9/10 and 11/12). One individual dog has been identified frequently using underpasses 4-12 (Plate 4). The removal of this individual via targeted baiting in culverts (4, 8, 9/10 and 11/12), would decrease the predation risk to koala and other native fauna. Recently, the Forestry Corporation have implemented a wild dog and cat trapping program in the adjoining Nambucca State Forest with the deployment of 1080 baits and traps between 17 November 2020 to May 2021. A collaborative approach to feral predator

control between Local Land Services, Transport for New South Wales and the Forestry Corporation would improve the success of future control programs.

The cat individual from site 3 (records in year 1, 2 and 3) continues to be frequently recorded crossing the alignment. Options for control include continued trapping, shooting and poisoning. Given that the cat is a domestic individual from a neighbouring property, shooting and poisoning have been deemed inappropriate, with trapping considered the best approach. During the winter surveys alternative baits and the 'free feeding' approach will be adopted as part of cage trapping. Free feeding involves leaving bait outside the trap for a number of days allowing the cat to become familiar with the trap before setting it up for capture.

4.2 High levels of fauna underpass use by a variety of native species

Native species frequented underpasses at a rate of 2.12 cc/week/underpass. A total of 15 native species/genera were recorded making complete crossings. Of the 27 native species/genera (includes species recorded in underpasses only) recorded in the adjacent habitat 59% (16 species/genera) were recorded using underpasses. This result is broadly consistent with findings at Sapphire to Woolgoolga (23% to 50%) and slightly higher than the 38% and 42% recorded at NH2U in 2018 and 2019 (Sandpiper Ecological 2018a; 2019d, 2020).

Fauna furniture was regularly used by native fauna to cross the alignment, with *Trichosurus* spp and *Antechinus* spp, demonstrating preferential use of the fauna furniture. In contrast, feral predators tended to use the culvert floor with only limited use of furniture by cat. Despite no evidence of predation occurring in the underpasses, the furniture is likely to act as a refuge for native fauna, alleviating predation risk and encouraging underpass crossings. Continued monitoring during the winter period (Year 3) will enable a comparison with previous years monitoring to assess its importance in providing refuge from feral predators. Use of underpasses by koalas was consistent with years one and two sampling (Sandpiper, 2019f and 2020c).

4.3 No change to densities, distribution, habitat use, and movement patterns compared to baseline population data of target species.

The target species for underpass monitoring, as outlined in the project brief, are spotted-tailed quoll, koala and giant barred frog. No spotted-tailed quolls have been detected to date, consistent with baseline monitoring (GeoLink 2014), and population monitoring of giant barred frogs at Upper Warrell creek is reported elsewhere.

In spring year 3, koalas were recorded using underpasses (complete crossings) at sites 4 and 8 with records of entering (incomplete crossings) at sites 10 and 12. Whilst there is no substantive baseline data to confirm if changes in habitat use and movement patterns have occurred monitoring suggests there is a temporal decline in the number of sites used by koala. Results also show that koalas continue to maintain territory on both sides of the alignment.

4.4 Evidence of use by dispersing individuals and different age cohorts

Accurately confirming age of individuals using underpasses is difficult using the survey methods outlined in the EMP. However, immature short-eared brushtail possums and juvenile swamp wallaby were regularly recorded making complete crossings at sites 2, 7, and 8. Other methods such as mark-release-recapture would likely be required to provide definitive proof of use by dispersing individuals and different age cohorts. Such a survey would be expensive and is not warranted.

4.5 Use by cover-dependent species with low mobility

Several cover-dependent species (typically small mammals, small reptiles and frogs) were recorded in adjacent habitat, including five frog species, three native mammals (brown antechinus, fawn-footed melomys and bush rat) and seven reptile species (excluding lace monitor). Of these, only two (*Antechinus* spp, fawn-footed melomys) were recorded using underpasses. Additional, cover dependent, species recorded in underpasses only were water rat and *Egernia spp*. Consistent with previous surveys there were limited records of reptiles and amphibians in underpasses. Low occurrence of frogs and reptiles is most likely due to the inability of cameras to detect these species as opposed to avoidance. This shortfall is assisted by the use of sand pads

and scat and tracks searches to detect smaller fauna. Sand pads captured tracks of a probable *Antechinus* spp at sites 5, 11 and 12.

5. Contingency Measures and Recommendations

5.1 Contingency Measures

Contingency measures are summarised in Table 8.

Table 8: Potential problems outlined in the EMP and possible contingency measures. Mitigation measures applicable to the project are addressed in bold text in table below.

Problem	Contingency/Corrective Action	Proposed action
High rates of feral predator activity;	Control program	Implement a control programs targeting dogs at sites 4-12.
Low levels of native fauna movement and species diversity in underpasses;	Modify habitat structure near underpass entrances and/or modify underpass fauna furniture	Revegetation work has already occurred – no further action required.
No use of underpasses by cover-dependent species or species with low mobility or target threatened species	Modify or add potential groundcover resources	Continue with monitoring of tiles during winter survey with an increase in frequency of inspections.
High rates of fauna road mortality.	Modify exclusion fencing design, location or extent depending on the species and location of mortalities	Issues relating to road mortality are addressed in the quarterly and annual road-kill reports. At this stage no modifications to the location or extent of exclusion fence is proposed. No mortality of target species has been recorded during the monitoring program.

5.2 Recommendations

Recommendations are summarised in Table 9.

Table 9: Recommendations based on findings from year three spring/summer operational phase monitoring and response from TfNSW.

Number	Recommendation	Transport for NSW Response
1.	Contact Forestry Corporation to determine the extent of the trapping and baiting program being conducted in NSF. If the program does not cover sites 4, 8, 9/10 and 11/12 canid control should be implemented in autumn 2021.	TfNSW has contacted both Local Land Services (LLS) and Forestry Corporation to discuss options for canid control at the identified sites. Onsite inspections at relevant underpasses with LLS are planned for April 21 to determine if trapping is a viable option, and also to initiate risk assessments for potential baiting control later in 2021 / early 2022.
2.	Sandpiper Ecological to trial different trapping methods during the winter 2021 survey to capture the cat at site 3.	Agree and adopted
3.	Continue monitoring of tiles in underpasses during year 3 winter with an increase in effort (inspections to align with sand pad inspections = 8 inspections).	Agree and adopted

4.	At site 1 (Upper Warrell Creek), undertake an additional 6-8 weeks of camera monitoring in autumn (March/April), commencing in March 2021.	Agree and adopted
5.	Reduce sand pad sampling to one sand pad installed centrally within each culvert. This would minimise the risk of wash out and therefore improve the consistency of data collected.	Agree to be adopted.

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Appendix A – Species list

Table A1: Common and scientific names for all species recorded during year two and three operational monitoring at WC2NH. ^ = Threatened species.

Common Name	Scientific Name
Koala^	*Phascolarctos cinereus*
Swamp wallaby	*Wallabia bicolor*
Red-necked wallaby	*Macropus rufogriseus*
Wallaby spp.	
Short-beaked echidna	*Tachyglossus aculeatus*
Yellow-bellied glider^	*Petaurus australis*
Sugar glider	*Petaurus breviceps*
	Petaurus spp.
Short-eared brushtail possum	*Trichosurus caninus*
Common brushtail possum	*Trichosurus vulpecula*
Brushtail possum spp.	*Trichosurus spp.*
Common ringtail possum	*Pseudocheirus peregrinus*
Northern brown bandicoot	*Isoodon macrourus*
Long-nosed bandicoot	*Perameles nasuta*
Bandicoot species	*Peramelidae spp.*
Fawn-footed melomys	*Melomys cervinnipes*
	Melomys spp.
Water rat	*Hydromys chrysogaster*
Bush rat	*Rattus fuscipes*
Brown antechinus	*Antechinus stuartii*
	Antechinus spp.
Grey-headed flying red fox^	*Pteropus poliocephalus*
Flying red fox spp.	*Pteropus spp.*
Bent-wing spp.	*Miniopterus spp.*
Small mammal spp.	
	Dasyuridae spp.
Eastern crevice skink	*Egernia mcpheii*
Garden skink	*Lampropholis delicata*
Grass skink	*Lampropholis guichenoti*
	Lampropholis spp.
Red-tailed calyptotis	*Calyptotis ruficauda*
Eastern water-skink	*Eulamprus quoyii*
Three-toed skink	*Saiphos equalis*
Skink spp.	*Scincidae spp.*
Coastal carpet python	*Morelia spilota*
Red-bellied black snake	*Pseudechis porphyriacus*
Yellow-faced whipsnake	*Demansia psammophis*
Black-bellied swamp snake	*Hemiaspis signata*
Blackish blind snake	*Anilios nigrescens*
Bandy bandy	*Vermicella annulata*
Coastal carpet python	*Morelia spilota*
Burton's legless lizard	*Lialis burtonis*
Lace monitor	*Varanus varius*
Eastern water dragon	*Intellagama lesueurii*
	Agamid spp.
Freshwater turtle spp.	*Chelidae spp.*
Medium reptile spp.	
Small reptile spp.	

Eastern dwarf tree frog	*Litoria fallax*
Tyler's tree frog	*Litoria tyleri*
Red-eyed tree frog	*Litoria chloris*
Green tree frog	*Litoria cerulea*
Dusky toadlet	*Uperolia fusca*
Tusked frog	*Adelotus brevis*
Common eastern froglet	*Crinia signifera*
Giant barred frog^	*Mixophyes iteratus*
Striped marsh frog	*Limnodynastes peronii*
Red-backed toadlet	*Pseudophryne coriacea*
Medium frog spp.	
Cat	*Felis catus*
Red red fox	*Vulpes vulpes*
Black rat	*Rattus rattus*
European hare	*Lepus europaeus*
House mouse	*Mus musculus*

Appendix B – Weather and climatic conditions

Table B1: Weather during the year 3 spring/summer operational monitoring period. Rainfall taken from the BOM weather station at Bellwood (059150). Air temperature, wind and relative humidity collected from Coffs Harbour Airport (station 059151).

Date	Minimum temp (°C)	Maximum temp (°C)	Rainfall (mm)	Direction of maximum wind gust	9am relative humidity (%)
1/10/20	13.5	24.9	0	NE	57
2/10/20	9.9	23.2	0	S	63
3/10/20	11.1	24.4	0	NNE	60
4/10/20	15.5	26.6	0	NNE	57
5/10/20	17.6	27.2	0	NE	54
6/10/20	15.4	26	0	S	59
7/10/20	13.9	25.4	3	NE	64
8/10/20	18.1	28.5	1	NNE	60
9/10/20	16.3	25.9	0	S	61
10/10/20	11.3	23.4	0	ESE	50
11/10/20	9.4	24.1	11	NE	72
12/10/20	13.5	25.1	15	NNE	60
13/10/20	15.2	24.3	5	E	71
14/10/20	9.6	23.1	2	S	66
15/10/20	9.3	23.7	0	ENE	63
16/10/20	14.1	27.5	0	S	60
17/10/20	15.2	26	0	NNE	72
18/10/20	19.9	26.5	0	ENE	62
19/10/20	16.3	22.1	0	SSW	84
20/10/20	14.9	22.7	0	S	70
21/10/20	13.4	23	0	ENE	61
22/10/20	16.7	25.3	2	NE	70
23/10/20	16.5	25.4	2	NNE	68
24/10/20	19.5	25.1	0	N	83
25/10/20	19.2	28.3	0	S	68
26/10/20	16.4	23	0	SSW	86
27/10/20	14.5	23.6	0	S	75
28/10/20	15.9	22.8	0	E	82
29/10/20	13.6	22.2	0	SSW	84
30/10/20	11.9	24.7	0	NE	66
31/10/20	19.7	29.3	0	NE	67
1/11/20	12.9	24.5	0	SW	54
2/11/20	16.8	23.9	0	SSW	60
3/11/20	15	23.6	0	S	60
4/11/20	16.1	26.6	0	NE	59
5/11/20	16.3	30.7	0	SSW	52
6/11/20	13.7	24.2	0	SSW	52
7/11/20	11.2	22.7	0	S	63
8/11/20	15.1	22.2	0	SSW	71
9/11/20	15.8	21.7	0	SW	61
10/11/20	11.3	23.3	0	SE	63

Date	Minimum temp (°C)	Maximum temp (°C)	Rainfall (mm)	Direction of maximum wind gust	9am relative humidity (%)
11/11/20	15.1	25.2	0	NNE	56
12/11/20	17.7	27.3	0	NNE	59
13/11/20	20.3	25.1	1	NNE	64
14/11/20	16	27.5	0	N	69
15/11/20	16.1	27.1	0	SE	52
16/11/20	19	31.2	0	NNE	61
17/11/20	22.9	25.1	0	S	72
18/11/20	17.1	24.3	0	SW	65
19/11/20	15.1	25.8	5	NE	56
20/11/20	20.1	28.2	12	NE	61
21/11/20	17.4	27	0	N	62
22/11/20	19.9	27.6	0	NE	56
23/11/20	19.1	30	9	NE	59
24/11/20	20.3	25.4	5	SSW	67
25/11/20	16.9	25.3	5	SE	60
26/11/20	16.3	26.8	1	NE	59
27/11/20	16.4	27.5	0	NNE	64
28/11/20	20.3	29.5	0	NNE	57
29/11/20	18.6	31.2	35	SSW	64
30/11/20	21.2	26.3	22	S	66
1/12/20	19.3	27.2	0	NE	74
2/12/20	21.9	32.1	0	SW	76
3/12/20	19.6	27.6	6	WSW	88
4/12/20	21.1	29.4	8	NW	57
5/12/20	18.4	29.3	0	NE	71
6/12/20	22.7	27.1	3	NNW	82
7/12/20	21.9	27.2	0	SSW	76
8/12/20	19.3	25.2	0	S	68
9/12/20	14.7	25.4	0	SW	52
10/12/20	17.5	28.1	0	NNE	59
11/12/20	17.5	22.1	28	SSE	89
12/12/20	15.3	22.5	300	SE	96
13/12/20	18	24.8	12	SSE	62
14/12/20	18.2	23.1	19	E	89
15/12/20	20	23.7	66	ENE	93
16/12/20	21.3	24.9	138	NNE	92
17/12/20	22.4	27.3	0	NNE	87
18/12/20	21	29.6	↓	NE	71
19/12/20	21.2	27.8	6.02 days	SSW	75
20/12/20	21.4	30.7	5	S	81
21/12/20	22.3	26.7	7	NNE	91
22/12/20	22.3	31.7	9	N	71
23/12/20	21.3	26.4	0	S	49
24/12/20	18.8	25.1	0	SW	66
25/12/20	17.2	26.7	0	SSW	66

Date	Minimum temp (°C)	Maximum temp (°C)	Rainfall (mm)	Direction of maximum wind gust	9am relative humidity (%)
26/12/20	18.1	24.9	0	ENE	92
27/12/20	18	29.1	0	NNE	62
28/12/20	21.3	28.9	0	NE	70
29/12/20	20.2	27.7	0	SSW	75
30/12/20	19.9	25.2	25	SW	93
31/12/20	19	26.4	0.2	SSE	79
1/1/21	20.3	27.7	0	SE	77
2/1/21	20	25.8	68.6	SE	92
3/1/21	19.4	27.5	3.6	NE	82
4/1/21	22.9	27.4	0.4	N	77

Appendix C – Field data

Table C 1: Underpass camera data recorded during spring/summer and winter of year two operational monitoring WC2NH, 2020.

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
12	Furniture	24/10/2020	2339	Black rat	c	w	d	17	
12	Furniture	22/12/2020	2337	Black rat	c	e	d	42	
12	Ground	03/10/2020	0010	Fox	c	w	d	7	
12	Ground	3/10/2020	0427	Fox	c	e	d	8	
12	Ground	5/10/2020	0206	Swamp Wallaby	c	e	d	9	
12	Ground	5/10/2020	1845	Swamp Wallaby	c	e	d	11	
12	Ground	06/10/2020	0425	Fox	c	e	d	12	x2
12	Ground	08/10/2020	0100	Swamp Wallaby	c	w	d	13	
12	Ground	08/10/2020	0208	Swamp Wallaby	c	e	d	14	
12	Ground	08/10/2020	2247	Swamp Wallaby	c	w	d	16	
12	Ground	08/10/2020	2249	Northern Brown Bandicoot	c	e	d	17	
12	Ground	09/10/2020	0016	Northern Brown Bandicoot	c	w	d	18	
12	Ground	09/10/2020	0300	Northern Brown Bandicoot	c	e	d	19	
12	Ground	9/10/2020	0311	Fox	c	w	d	20	
12	Ground	9/10/2020	0407	Swamp Wallaby	c	e	d	21	
12	Ground	9/10/2020	0608	Dog	c	e	d	22	Black Dog
12	Ground	10/10/2020	0349	Swamp Wallaby	c	e	d	25	
12	Ground	10/10/2020	1326	Lace monitor	c	w	d	26	
12	Ground	10/10/2020	2208	Bandicoot spp	c	e	d	27	
12	Ground	11/10/2020	0156	Fox	c	w	d	28	
12	Ground	11/10/2020	2007	Bandicoot spp	c	w	d	30	
12	Ground	11/10/2020	2238	Bandicoot spp	c	e	d	31	

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
12	Ground	12/10/2020	0143	Fox	c	e	d	32	
12	Ground	12/10/2020	0338	Swamp Wallaby	c	e	d	33	
12	Ground	13/10/2020	0311	Swamp Wallaby	c	e	d	45	
12	Ground	13/10/2020	1734	Dog	c	w	d	46	Black Dog
12	Ground	15/10/2020	0132	Cat	c	w	d	54	Tabby Cat
12	Ground	15/10/2020	0349	Swamp Wallaby	c	e	d	55	
12	Ground	16/10/2020	0007	Bandicoot spp	c	e	d	61	
12	Ground	16/10/2020	0019	Bandicoot spp	c	e	d	62	
12	Ground	16/10/2020	0453	Fox	c	e	d	63	
12	Ground	17/10/2020	0418	Fox	c	e	d	64	
12	Ground	17/10/2020	1834	Swamp Wallaby	c	w	d	65	
12	Ground	18/10/2020	0404	Swamp Wallaby	c	e	d	66	
12	Ground	19/10/2020	0138	Bandicoot spp	c	e	d	69	
12	Ground	19/10/2020	0330	Swamp Wallaby	c	e	d	70	
12	Ground	19/10/2020	2259	Swamp Wallaby	c	e	d	71	
12	Ground	20/10/2020	0046	Swamp Wallaby	c	e	d	72	
12	Ground	20/10/2020	0221	Swamp Wallaby	i	e	d	73-74	
12	Ground	20/10/2020	2359	Bandicoot spp	c	e	d	75	
12	Ground	22/10/2020	0407	Swamp Wallaby	c	e	d	78	
12	Ground	22/10/2020	2313	Bandicoot spp	c	e	d	80	
12	Ground	23/10/2020	0304	Swamp Wallaby	c	e	d	82	
12	Ground	23/10/2020	0200	Swamp Wallaby	c	e	d	83-87	
12	Ground	24/10/2020	0102	Fox	c	e	d	89	
12	Ground	24/10/2020	0421	Swamp Wallaby	c	e	d	90	
12	Ground	24/10/2020	2332	Rodent spp	c	e	d	92	
12	Ground	25/10/2020	0419	Swamp Wallaby	c	e	d	94	
12	Ground	25/10/2020	0954	Water Dragon	c	e	d	95	
12	Ground	28/10/2020	0537	Dog	c	e	d	120	Black Dog
12	Ground	29/10/2020	0304	Bandicoot spp	c	e	d	126	

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
12	Ground	30/10/2020	2337	Cat	c	e	d	7	
12	Ground	31/10/2020	1917	Swamp Wallaby	c	w	d	10	
12	Ground	1/11/2020	0413	Swamp Wallaby	c	e	d	11	
12	Ground	1/11/2020	0537	Dog	c	e	d	12	Black Dog
12	Ground	2/11/2020	1939	Bandicoot spp	c	w	d	22	
12	Ground	2/11/2020	2123	Bandicoot spp	c	e	d	23	
12	Ground	03/11/2020	0142	Fox	c	w	d	24	
12	Ground	03/11/2020	0510	Dog	c	w	d	25	Black Dog
12	Ground	03/11/2020	1945	Swamp Wallaby	c	w	d	26-32	
12	Ground	04/11/2020	0129	Swamp Wallaby	c	e	d	33	
12	Ground	06/11/2020	0131	Bandicoot spp	c	e	d	37	
12	Ground	07/11/2020	1817	Dog	c	w	d	38	
12	Ground	07/11/2020	2303	Bandicoot spp	c	e	d	39	
12	Ground	08/11/2020	0258	Fox	c	e	d	40	
12	Ground	08/11/2020	2158	Bandicoot spp	c	w	d	41	
12	Ground	08/11/2020	2328	Bandicoot spp	c	e	d	42	
12	Ground	10/11/2020	0016	Fox	c	w	d	43	
12	Ground	11/11/2020	1918	House Mouse	c	e	d	44	
12	Ground	13/11/2020	2220	Bandicoot spp	c	e	d	50	
12	Ground	14/11/2020	0223	Fox	c	w	d	51	
12	Ground	14/11/2020	0340	Swamp Wallaby	c	e	d	52	
12	Ground	14/11/2020	0503	Dog	c	e	d	53	
12	Ground	14/11/2020	2037	Bandicoot spp	c	w	d	54	
12	Ground	15/11/2020	0104	Bandicoot spp	c	e	d	56	
12	Ground	15/11/2020	0930	Lace monitor	c	w	d	57	
12	Ground	15/11/2020	1937	Bandicoot spp	c	e	d	58	
12	Ground	15/11/2020	1947	Swamp Wallaby	c	w	d	59	
12	Ground	16/11/2020	0204	Fox	c	w	d	60	

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
12	Ground	16/11/2020	0318	Swamp Wallaby	c	e	d	61	
12	Ground	16/11/2020	338	Fox	c	e	d	62-63	
12	Ground	16/11/2020	1443	Lace monitor	c	e	d	64-65	
12	Ground	16/11/2020	2015	Bandicoot spp	c	w	d	66	
12	Ground	17/11/2020	2300	Bandicoot spp	c	e	d	68	
12	Ground	18/11/2020	0027	Bandicoot spp	c	e	d	69	
12	Ground	18/11/2020	0551	Dog	c	e	d	70	
12	Ground	18/11/2020	2248	Bandicoot spp	c	e	d	72	
12	Ground	19/11/2020	0316	Fox	c	w	d	73-74	
12	Ground	19/11/2020	0341	Fox	c	e	d	75	
12	Ground	19/11/2020	1442	Lace monitor	c	w	d	76	
12	Ground	19/11/2020	1919	Bandicoot spp	c	w	d	77	
12	Ground	19/11/2020	2057	Bandicoot spp	c	w	d	79	
12	Ground	19/11/2020	2222	Bandicoot spp	c	e	d	80	
12	Ground	19/11/2020	2327	Bandicoot spp	c	e	d	81	
12	Ground	20/11/2020	0040	Koala	i	e-w	d	82-83	
12	Ground	20/11/2020	0404	Swamp Wallaby	c	e	d	83	
12	Ground	20/11/2020	1025	Lace monitor	c	e	d	84	
12	Ground	20/11/2020	1901	Dog	c	w	d	86	Black Dog
12	Ground	20/11/2020	2238	Swamp Wallaby	c	w	d	87	
12	Ground	21/11/2020	0203	Fox	c	e	d	88	
12	Ground	21/11/2020	0323	Swamp Wallaby	c	e	d	89	
12	Ground	22/11/2020	0203	Bandicoot spp	c	e	d	92	
12	Ground	22/11/2020	0414	Cat	c	w	d	93	Tabby Cat
12	Ground	24/11/2020	2030	Bandicoot spp	c	e	d	95	
12	Ground	25/11/2020	0343	Fox	c	e	d	96	
12	Ground	25/11/2020	0401	Swamp Wallaby	c	e	d	97	
12	Ground	25/11/2020	0344	Fox	c	e	d	98	

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
12	Ground	25/11/2020	0401	Swamp wallaby	c	e	d	99	
12	Ground	27/11/2020	1901	Swamp wallaby	c	w	d	100	
12	Ground	29/11/2020	2241	Swamp wallaby	c	e	d	101	
12	Ground	30/11/2020	1931	Dog	c	e	d	112	
12	Ground	1/12/2020	0328	Cat	c	w	d	113	
11	Furniture	21/10/2020	1904	Antechinus spp	c	e	d	33	
11	Furniture	16/12/2020	2335	Rodent spp	c	e	d	71	
11	Furniture	17/12/2020	0354	Rodent spp	c	w	d	72	
11	Furniture	18/12/2020	0128	Rodent spp	c	e	d	73	
11	Furniture	18/12/2020	0246	Rodent spp	c	w	d	74	
11	Furniture	19/12/2020	0209	Cat	c	e	d	75	Tabby Cat
11	Furniture	20/12/2020	2041	Rodent spp	c	e	d	76-77	
11	Furniture	20/12/2020	2257	Rodent spp	c	e	d	78-79	
11	Furniture	21/12/2020	2153	Rodent spp	c	e	d	81	
11	Furniture	24/12/2020	2352	Rodent spp	c	e	d	83	
11	Furniture	25/12/2020	0117	Rodent spp	c	e	d	85-86	
11	Furniture	26/12/2020	0017	Rodent spp	c	e	d	87-88	
11	Furniture	27/12/2020	2153	Rodent spp	c	w	d	91	
11	Furniture	28/12/2020	2025	Rodent spp	c	w	d	92	
11	Furniture	29/12/2020	0405	Rodent spp	c	e	d	93	
11	Furniture	29/12/2929	2343	Rodent spp	c	w	d	94	
11	Furniture	30/12/2020	0156	Rodent spp	c	e	d	95	
11	Furniture	30/12/2020	0348	Rodent spp	c	w	d	96	
11	Furniture	30/12/2020	2002	Rodent spp	c	w	d	97	
11	Furniture	31/12/2020	330	Rodent spp	c	e	d	98	
11	Furniture	4/01/2021	0418	Rodent spp	c	e	d	102	
11	Ground	2/10/2020	1630	Fox	c	e	d	7	Times are out
11	Ground	9/10/2020	1353	Swamp wallaby	c	w	d	9	

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
11	Ground	5/10/2020	651	Swamp wallaby	c	e	d	15	
11	Ground	5/10/2020	1626	Fox	c	e	d	16	x2
11	Ground	6/10/2020	1409	Swamp wallaby	c	e	d	18	
11	Ground	7/10/2020	1435	Swamp wallaby	c	e	d	19	
11	Ground	8/10/2020	1611	Swamp wallaby	c	e	d	23	
11	Ground	8/10/2020	1808	Dog	c	e	d	24	
11	Ground	9/10/2020	1553	Swamp wallaby	c	e	d	26	
11	Ground	10/10/2020	1354	Fox	c	w	d	28	
11	Ground	11/10/2020	1344	Fox	c	e	d	32	
11	Ground	11/10/2020	1554	Swamp wallaby	c	e	d	33	
11	Ground	12/10/2020	0317	Swamp wallaby	c	e	d	40	
11	Ground	13/10/2020	0608	Swamp wallaby	c	w	d	42	
11	Ground	13/10/2020	0617	Swamp wallaby	c	w	d	45	
11	Ground	13/10/2020	0640	Swamp wallaby	c	e	d	47	
11	Ground	14/10/2020	1552	Swamp wallaby	c	e	d	48	
11	Ground	15/10/2020	1616	Swamp wallaby	c	e	d	67	
11	Ground	18/10/2020	1558	Swamp wallaby	c	e	d	69	
11	Ground	19/10/2020	1505	Swamp wallaby	c	e	d	72	
11	Ground	23/10/2020	1302	Fox	c	e	d	79	
11	Ground	23/10/2020	1626	Swamp wallaby	c	e	d	80	
11	Ground	24/10/2020	1411	Fox	c	w	d	82	
11	Ground	25/10/2020	1196	Swamp Wallaby	c	e	d	94	
11	Ground	25/10/2020	981	Water Dragon	c	e	d	95	
11	Ground	28/10/2020	766	Dog	c	e	d	111	Black Dog
11	Ground	29/10/2020	551	Bandicoot spp	c	e	d	113	
11	Ground	30/10/2020	2339	Cat	i	e	d	5-6	Tabby Cat
11	Ground	1/11/2020	0413	Swamp Wallaby	c	e	d	10	
11	Ground	1/11/2020	0536	Dog	c	e	d	11-12	Black Dog

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
11	Ground	02/11/2020	2123	Bandicoot spp	c	e	d	19	
11	Ground	03/11/2020	0138	Fox	c	w	d	20	
11	Ground	03/11/2020	0507	Dog	c	w	d	21	Black Dog
11	Ground	04/11/2020	0159	Swamp Wallaby	c	e	d	23	
11	Ground	05/11/2020	2221	Fox	c	w	d	26	
11	Ground	07/11/2020	1815	Dog	c	w	d	32	Black Dog
11	Ground	08/11/2020	0258	Fox	c	e	d	33	
11	Ground	08/11/2020	300	Fox	c	e	d	35	
11	Ground	08/11/2020	306	Fox	c	e	d	36-37	
11	Ground	08/11/2020	2337	Bandicoot spp	c	e	d	39	
11	Ground	10/11/2020	0013	Fox	c	w	d	40	
11	Ground	12/11/2020	0344	Swamp Wallaby	c	e	d	44	
11	Ground	13/11/2020	1135	Dog	c	e	d	48	
11	Ground	13/11/2020	2219	Bandicoot spp	c	e	d	51	
11	Ground	14/11/2020	0220	Fox	c	w	d	52	
11	Ground	14/11/2020	0349	Swamp Wallaby	c	e	d	53	
11	Ground	14/11/2020	0502	Dog	c	e	d	56	
11	Ground	15/11/2020	0103	Bandicoot spp	c	e	d	58	
11	Ground	15/11/2020	0924	Lace monitor	c	w	d	59	
11	Ground	15/11/2020	1540	Lace monitor	c	w	d	60	
11	Ground	15/11/2020	1936	Bandicoot spp	c	e	d	61	
11	Ground	15/11/2020	2111	Bandicoot spp	c	e	d	63	
11	Ground	15/11/2020	2328	FF Melomys	c	e	d	64	
11	Ground	16/11/2020	0334	Swamp Wallaby	c	e	d	65	
11	Ground	16/11/2020	0337	Fox	c	e	d	66-67	
11	Ground	16/11/2020	0951	Lace monitor	c	e	d	68	
11	Ground	17/11/2020	1416	Lace monitor	c	w	d	70	
11	Ground	18/11/2020	0026	Bandicoot spp	c	e	d	71	

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
11	Ground	18/11/2020	0549	Dog	c	e	d	73	
11	Ground	18/11/2020	0901	Lace monitor	c	e	d	74	
11	Ground	18/11/2020	2248	Bandicoot spp	c	e	d	76	
11	Ground	19/11/2020	0312	Fox	c	w	d	77-78	
11	Ground	19/11/2020	0340	Fox	c	e	d	79	
11	Ground	19/11/2020	1416	Lace monitor	c	w	d	80	
11	Ground	19/11/2020	2221	Bandicoot spp	c	e	d	84	
11	Ground	19/11/2020	2327	Bandicoot spp	c	e	d	85	
11	Ground	20/11/2020	0408	Swamp Wallaby	c	e	d	86	
11	Ground	20/11/2020	1857	Dog	c	w	d	89	
11	Ground	21/11/2020	0202	Fox	c	e	d	91	
11	Ground	21/11/2020	0339	Swamp Wallaby	c	e	d	92	
11	Ground	21/11/2020	2029	Bandicoot spp	c	e	d	96	
11	Ground	22/11/2020	0408	Cat	c	w	d	98	Tabby Cat
11	Ground	24/11/2020	0724	Swamp Wallaby	c	e	d	105	
11	Ground	24/11/2020	0817	Swamp wallaby	c	e	d	106	
11	Ground	24/11/2020	2029	Bandicoot spp	c	e	d	108	
11	Ground	25/11/2020	0341	Fox	c	e	d	109	
11	Ground	25/11/2020	0404	Swamp wallaby	c	e	d	110	
11	Ground	27/11/2020	0402	Swamp wallaby	c	e	d	117	
11	Ground	27/11/2020	1902	Swamp wallaby	c	w	d	118	
11	Ground	29/11/2020	2247	Swamp wallaby	c	e	d	129	
11	Ground	30/11/2020	1931	Dog	c	e	d	130	Black Dog
11	Ground	1/12/2020	0328	Cat	c	w	d	132	Tabby Cat
11	Ground	2/12/2020	0422	Swamp wallaby	c	e	d	134	
11	Ground	3/12/2020	1939	Cat	i	w	d	136	Black Cat
11	Ground	3/12/2020	2344	Bandicoot spp	c	e	d	138	
11	Ground	4/12/2020	2134	Bandicoot spp	c	e	d	142	

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
11	Ground	5/12/2020	0223	Fox	c	e	d	143	
11	Ground	6/12/2020	0034	Swamp wallaby	c	e	d	148	
11	Ground	6/12/2020	2202	Bandicoot spp	c	e	d	155	
11	Ground	7/12/2020	2228	Bandicoot spp	c	e	d	159	
11	Ground	8/12/2020	0811	Swamp wallaby	c	w	d	162	
11	Ground	8/12/2020	0845	Swamp wallaby	c	e	d	164	
11	Ground	8/12/2020	2054	Swamp wallaby	c	e	d	167	
11	Ground	9/12/2020	0259	Swamp wallaby	c	w	d	168-169	
11	Ground	10/12/2020	0102	Swamp wallaby	i	e	d	173	
11	Ground	10/12/2020	0200	Swamp wallaby	c	w	d	174	
11	Ground	10/12/2020	1051	Lace monitor	c	w	d	175	
11	Ground	10/12/2020	1442	Lace monitor	c	e	d	176	
11	Ground	10/12/2020	2252	Bandicoot spp	c	e	d	177	
11	Ground	12/12/2020	0717	Dog	c	e	d	179	Black Dog
11	Ground	14/12/2020	2338	Fox	c	e	d	182	
11	Ground	15/12/2020	2132	Bandicoot spp	c	e	d	183	
11	Ground	19/12/2020	0058	Fox	c	w	d	191	
11	Ground	20/12/2020	0349	Fox	c	e	d	192	
11	Ground	20/12/2020	2332	Bandicoot spp	c	e	d	193	
11	Ground	26/12/2020	2155	Swamp wallaby	c	e	d	207	
11	Ground	26/12/2020	2135	Bandicoot spp	c	e	d	209	
11	Ground	27/12/2020	2352	Fox	c	w	d	210	
11	Ground	28/12/2020	0128	Fox	c	e	d	211	
11	Ground	29/12/2020	139	Swamp wallaby	i	e	d	212	
11	Ground	30/12/2020	216	Bandicoot spp	c	e	d	216	
11	Ground	01/01/2021	218	Cat	c	e	d	218	Black Cat
11	Ground	02/01/2021	2118	Bandicoot spp	c	e	d	220	

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
11	Ground	03/01/2021	2030	Bandicoot spp	c	e	d	221	
10	Furniture			Nil recorded for spring/summer					
10	Furniture	25/12/2020	2004	Antechinus spp	c	w	d	43	
10	Furniture	29/12/2020	2158	Antechinus spp	c	e	d	47	
10	Furniture	29/12/2020	2201	Antechinus spp	c	w	d	48	
10	Furniture	31/12/2020	0119	Antechinus spp	c	e	d	51	
10	Ground	6/10/2020	0840	Dog	c	e	d	10	Black Dog
10	Ground	6/10/2020	0933	Dog	c	w	d	11	Black Dog
10	Ground	6/10/2020	1622	Dog	c	e	d	13-14	Black Dog
10	Ground	6/10/2020	1749	Dog	c	w	d	15	Black Dog
10	Ground	6/10/2020	2130	Cat	c	e	d	16	Tabby Cat
10	Ground	7/10/2020	0314	Fox	c	w	d	17	
10	Ground	15/10/2020	2311	Cat	c	w	d	53	Tabby Cat
10	Ground	20/10/2020	0047	Long Nose Bandicoot	c	w	d	55	
10	Ground	20/10/2020	0515	Dog	c	e	d	56	Black Dog
10	Ground	23/10/2020	0009	Black rat	c	w	d	60	
10	Ground	24/10/2020	0017	Fox	c	e	d	61-62	
10	Ground	26/10/2020	0200	Rodent spp	c	w	d	64	
10	Ground	30/10/2020	0013	Dog	c	w	d	109	Black Dog
10	Ground	30/10/2020	0207	Fox	c	w	d	110	
10	Ground	30/10/2020	0958	Dog	c	e	d	5	Black dog white chest
10	Ground	31/10/2020	0653	Dog	c	w	d	6	Black dog white chest
10	Ground	1/11/2020	0654	Dog	c	e	d	7	Black dog white chest
10	Ground	2/11/2020	0655	Dog	c	e	d	8	Black dog white chest

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
10	Ground	6/11/2020	0059	Fox	c	w	d	15	
10	Ground	6/11/2020	1803	Cat	c	e	d	16	
10	Ground	7/11/2020	2125	Cat	c	w	d	17	tabby
10	Ground	9/11/2020	1924	Dog	c	w	d	19	Black dog white chest
10	Ground	12/11/2020	2317	Echidna	c	e	d	21	
10	Ground	14/11/2020	0406	Dog	c	w	d	23	
10	Ground	14/11/2020	0925	**Koala**	I	e	d	25	Sits in front of camera
10	Ground	15/11/2020	2220	Common brushtail possum	c	e	d	26	juvenile x2
10	Ground	19/11/2020	1844	Dog	c	e	d	29	
10	Ground	20/11/2020	0131	Bandicoot spp	c	w	d	30	
10	Ground	23/11/2020	0643	Dog	c	e	d	31	
10	Ground	30/11/2020	0445	Dog	c	w	d	46	
10	Ground	2/12/2020	1756	Dog	c	w	d	49	
10	Ground	3/12/2020	2006	Bandicoot spp	c	w	d	51	
10	Ground	10/12/2020	1936	cat	c	w	d	53	
10	Ground	17/12/2020	2208	Bandicoot spp	c	w	d	59	
10	Ground	18/12/2020	2216	Long-nosed bandicoot	c	w	d	60	
10	Ground	20/12/2020	2146	Bandicoot spp	c	w	d	62	
10	Ground	21/12/2020	2311	Bandicoot spp	c	w	d	64	
10	Ground	2/01/2020	2014	Bandicoot spp	c	w	d	72	
9	Furniture			Nil recorded for spring/summer					Nil
9	Furniture	14/11/2020	1026	Egernia spp	c	e	d	13	Black Dog
9	Ground	6/10/2020	0838	Dog	c	e	d	5	Black Dog
9	Ground	6/10/2020	0930	Dog	c	w	d	6	Black Dog

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
9	Ground	6/10/2020	1620	Dog	c	e	d	7	Black Dog
9	Ground	6/10/2020	1745	Dog	c	w	d	8	Tabby Cat
9	Ground	6/10/2020	2134	Cat	c	e	d	9	
9	Ground	7/10/2020	0310	Fox	c	w	d	10	
9	Ground	8/10/2020	1039	Lace monitor	c	e	d	11-12	
9	Ground	9/10/2020	0952	Lace monitor	c	w	d	15	Tabby Cat
9	Ground	15/10/2020	2305	Cat	c	w	d	39	
9	Ground	17/10/2020	0247	Fox	c	e	d	40	
9	Ground	19/10/2020	0059	Black rat	c	e	d	41	Black Dog
9	Ground	20/10/2020	0512	Dog	c	e	d	42	
9	Ground	25/10/2020	0250	Fox	c	e	d	46	Black Dog
9	Ground	30/10/2020	0009	Dog	c	w	d	84	
9	Ground	30/10/2020	0202	Fox	c	w	d	85	
9	Ground	31/10/2020	0649	Dog	c	w	d	4	
9	Ground	2/11/2020	008	Dog	c	w	d	8	
9	Ground	2/11/2020	2110	Dog	c	e	d	13	
9	Ground	6/11/2020	0057	fox	c	w	d	19	
9	Ground	6/11/2020	1807	Cat	c	e	d	20	
9	Ground	7/11/2020	2044	Cat	c	w	d	21	
9	Ground	9/11/2020	0450	Dog	c	e	d	22	
9	Ground	9/11/2020	1922	Dog	c	w	d	24	
9	Ground	14/11/2020	0404	Dog	c	w	d	29	
9	Ground	15/11/2020	2220	Common brushtail possum	c	e	d	31	x2
9	Ground	18/11/2020	004	Bandicoot spp	c	e	d	33	
9	Ground	19/11/2020	1844	Dog	c	e	d	34	
9	Ground	23/11/2020	0642	Dog	c	e	d	37	
9	Ground	30/11/2020	1949	Dog	c	w	d	52	
9	Ground	2/12/2020	1754	Dog	c	w	d	56	

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
9	Ground	3/12/2020	0303	Fox	I	w	d	58-59	
9	Ground	9/12/2020	0106	Cat	c	e	d	63	
9	Ground	10/12/2020	0241	Wallaby spp	c	e	d	71	
9	Ground	10/12/2020	1917	Cat	c	w	d	72	
9	Ground	20/12/2020	0105	Bandicoot spp	c	e	d	79	
9	Ground	24/12/2020	3037	Black rat	I	w	d	93	
9	Ground	31/12/2020	0235	Cat	c	e	d	96	
9	Ground	2/01/2020	2116	Black rat	c	e	d	97	
8	Furniture	3/10/2020	1913	Antechinus spp	c	e	d	3	Eating a spider
8	Furniture	5/10/2020	1914	Antechinus spp	c	w	d	5	
8	Furniture	5/10/2020	1925	Antechinus spp	c	w	d	6	
8	Furniture	2/11/2020	2017	Black rat	i	w	d	4	
8	Furniture	10/11/2020	2255	Black rat	c	w	d	14	
8	Furniture	10/11/2020	2310	Black rat	c	e	d	15	
8	Furniture	15/11/2020	0237	Black rat	c	w	d	19	
8	Furniture	15/11/2020	0247	Black rat	c	w	d	21	
8	Furniture	17/11/2020	0250	Black rat	c	e	d	22	
8	Ground	3/10/2020	0104	Fox	c	w	d	3	
8	Ground	3/10/2020	0122	Fox	i	ndm	d	4	
8	Ground	3/10/2020	0231	Fox	c	w	d	5-6	
8	Ground	4/10/2020	0927	Lace monitor	c	w	d	8	
8	Ground	04/10/2020	1041	Lace monitor	c	e	d	9	
8	Ground	04/10/2020	1244	Lace monitor	c	e	d	10	
8	Ground	5/10/2020	0358	Fox	c	e	d	12	
8	Ground	5/10/2020	1627	Lace monitor	c	w	d	15	
8	Ground	9/10/2020	0428	Fox	c	e	d	17	Black Dog
8	Ground	9/10/2020	0644	Dog	c	e	d	19	
8	Ground	11/10/2020	0915	Lace monitor	c	w	d	21	
8	Ground	11/10/2020	1431	Lace monitor	c	e	d	22	Black Dog

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
8	Ground	14/10/2020	0501	Dog	c	e	d	29	
8	Ground	15/10/2020	0138	Fox	c	e	d	30	
8	Ground	15/10/2020	0902	Lace monitor	c	w	d	31	
8	Ground	16/10/2020	1216	Lace monitor	c	e	d	41	
8	Ground	17/10/2020	1010	Lace monitor	c	e	d	43	
8	Ground	18/10/2020	0528	**Koala**	c	w	d	44	Tabby Cat
8	Ground	20/10/2020	555	Cat	c	w	d	45	Tabby Cat
8	Ground	20/10/2020	1656	Cat	c	e	d	46	
8	Ground	25/10/2020	2329	Bandicoot spp	c	e	d	49	
8	Ground	30/10/2020	0328	Fox	c	e	d	73	
8	Ground	14/11/2020	0411	Fox	c	e	d	3	
8	Ground	14/11/2020	2334	Cat	c	e	d	4	
8	Ground	15/11/2020	0330	Swamp wallaby	c	w	d	5	
8	Ground	15/11/2020	1055	Lace monitor	c	w	d	6	
8	Ground	16/11/2020	0829	Lace monitor	c	e	d	7	
8	Ground	20/11/2020	2039	Cat	c	e	d	34	
8	Ground	22/11/2020	1259	Lace monitor	c	e	d	37	
8	Ground	23/11/2020	0138	Bandicoot spp	c	e	d	38	
8	Ground	26/11/2020	1033	Lace monitor	c	w	d	48	
8	Ground	26/11/2020	1145	Lace monitor	c	e	d	49	
8	Ground	27/11/2020	1938	Dog	c	w	d	52	
8	Ground	31/10/2020	0905	Lace monitor	c	w	d	2	
8	Ground	31/10/2020	1347	Lace monitor	c	e	d	3	
8	Ground	31/10/2020	1928	Cat	c	e	d	e	
8	Ground	6/11/2020	0929	Lace monitor	c	w	d	14	
8	Ground	6/11/2020	1312	Lace monitor	c	e	d	15	
8	Ground	8/11/2020	1241	Lace monitor	c	e	d	22	
8	Ground	11/11/2020	1046	Lace monitor	c	w	d	24	dates goes until 2/12/2020
7	ground	1/10/2020	1838	Rodent spp	c	w	d	12	
7	ground	2/10/2020	1225	Lace monitor	c	e	d	13	

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
7	ground	3/10/2020	0052	Fox	c	e	d	14	
7	ground	3/10/2020	1224	Lace monitor	c	w	d	15	
7	ground	3/10/2020	2022	Rodent spp	c	w	d	16	
7	ground	4/10/2020	1657	Fox	c	e	d	18	
7	ground	5/10/2020	2121	Dog	c	e	d	19	
7	ground	6/10/2020	1052	Lace monitor	c	e	d	21	
7	ground	8/10/2020	0211	Fox	c	e	d	22	
7	ground	8/10/2020	1044	Lace monitor	c	e	d	23	
7	ground	10/10/2020	0420	Fox	c	e	d	24	
7	ground	11/10/2020	0103	Fox	c	e	d	25	
7	ground	12/10/2020	1311	Lace monitor	c	w	d	27	
7	ground	13/10/2020	1135	Lace monitor	c	e	d	33	
7	ground	13/10/2020	1516	Fox	c	e	d	34	
7	ground	14/10/2020	0258	Fox	c	e	d	38	
7	ground	15/10/2020	1252	Lace monitor	c	w	d	39	
7	ground	16/10/2020	0944	Lace monitor	c	e	d	44	
7	ground	16/10/2020	1950	Bandicoot spp	c	e	d	45	
7	ground	16/10/2020	2349	Fox	c	e	d	46	
7	ground	17/20/2020	0217	Dog	c	w	d	47	
7	ground	20/10/2020	0352	Fox	c	e	d	49	
7	ground	20/10/2020	1604	Fox	c	e	d	51	
7	ground	20/10/2020	2330	Fox	c	e	d	52	
7	ground	21/20/2020	821	Fox	c	e	d	54	
7	ground	21/10/2020	0827	Dog	c	w	d	55	
7	ground	21/10/2020	2228	Fox	c	e	d	57	
7	ground	22/10/2020	0314	Fox	c	w	d	59	
7	ground	22/10/2020	1358	Fox	c	w	d	61	
7	ground	24/10/2020	0131	Rodent spp	c	w	d	62	
7	ground	24/10/2020	1002	Dog	c	w	d	63-131	x2
7	ground	25/10/2020	0011	Black rat	c	e	d	132	
7	ground	25/10/2020	2009	Fox	c	e	d	133	

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
7	ground	26/10/2020	1442	Lace monitor	c	w	d	141	
7	ground	26/10/2020	2126	Fox	c	e	d	142	
7	ground	29/10/2020	1932	Fox	c	e	d	154	
7	ground	31/10/2020	2234	Rodent spp	c	e	d	7	
7	ground	1/11/2020	2013	Fox	c	w	d	9	
7	ground	3/11/2020	0019	Dog	c	w	d	13	
7	ground	6/11/2020	2107	Fox	I	e-w	d	19	
7	ground	6/11/2020	2240	Rodent spp	c	e	d	21	
7	ground	7/11/2020	2218	Brushtail possum spp	c	e-w-3	d	22-24	
7	ground	8/11/2020	2314	Long-nosed bandicoot	c	e	d	25	
7	ground	11/11/2020	0411	Swamp Wallaby	c	e	d	28	
7	ground	12/11/2020	2019	Swamp wallaby	c	w	d	30-31	
7	ground	14/11/2020	1826	Dog	c	w	d	34	
7	ground	15/11/2020	1753	Swamp Wallaby	c	e	d	36	
7	ground	16/11/2020	2117	Black rat	c	w	d	38	
7	ground	16/11/2020	2210	Bandicoot spp	c	e	d	40	
7	ground	17/11/2020	0106	Fox	c	e	d	41	
7	ground	17/11/2020	0127	Fox	c	w	d	42	
7	ground	17/11/2020	0351	Black rat	c	w	d	43	
7	ground	17/11/2020	2021	Swamp wallaby	c	w	d	45	
7	ground	18/11/2020	0327	Rodent spp	c	w	d	46	
7	ground	18/11/2020	0334	Swamp wallaby	c	e	d	47	
7	ground	19/11/2020	1057	Lace monitor	c	w	d	49	
7	ground	20/11/2020	2142	Swamp wallaby	c	w	d	51	
7	ground	21/11/2020	1555	Swamp wallaby	c	e	d	53	
7	ground	22/11/2020	0950	Lace monitor	c	w	d	54	
7	ground	22/11/2020	1239	Lace monitor	c	e	d	55	
7	ground	22/11/2020	2132	Rodent spp	c	e	d	56	

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
7	ground	27/11/2020	2229	Swamp wallaby	c	e	d	59	
7	ground	28/11/2020	0902	Lace monitor	c	w	d	63	
7	ground	29/11/2020	1834	Cat	c	w	d	68	Spotted
7	ground	30/11/2020	0136	Echidna	c	w	d	69	
7	ground	4/12/2020	0115	Fox	c	e	d	76	
7	ground	4/12/2020	0957	Lace monitor	c	e	d	77	
7	ground	5/12/2020	0222	Fox	c	w	d	78	
7	ground	6/12/2020	2159	Fox	c	e	d	82	
7	ground	6/12/2020	2201	Fox	c	w	d	83	
7	ground	8/12/2020	2259	Fox	c	e	d	84	
7	ground	9/12/2020	2135	Swamp wallaby	c	w	d	92	
7	ground	10/12/2020	0210	Rodent spp	c	e	d	93-95	
7	ground	12/12/2020	1923	Dog	c	w	d	101	
7	ground	17/12/2020	0225	Black rat	c	e	d	110	
7	ground	17/12/2020	0313	Fox	i	e	d	111-112	
7	ground	23/12/2020	2128	Echidna	c	e	d	117	
7	ground	23/12/2020	2149	Echidna	c	e	d	118	
7	ground	31/12/2020	2239	Bandicoot spp	i	e-w	d	127	Ran fast back w
7	ground	1/01/2020	2118	Black rat	c	w	d	130	
7	Furniture	1/10/2020	1833	Black rat	c	w	d	10	
7	Furniture	1/10/2020		Black rat	c	e	d	12	
7	Furniture	3/10/2020	213	Rodent spp	c	e	d	13	
7	Furniture	4/10/2020	1927	Black rat	c	w	d	14	
7	Furniture	9/10/2020	2319	Black rat	c	w	d	15	
7	Furniture	10/10/2020	0142	Rodent spp	c	e	d	16	
7	Furniture	10/10/2020	2304	Rodent spp	I	e	d	17-18	
7	Furniture	12/10/2020	2057	Black rat	c	e	d	22	
7	Furniture	12/10/2020	2254	Black rat	c	e	d	24	

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
7	Furniture	15/10/2020	2103	Brushtail possum spp.	c	e	d	28	
7	Furniture	18/10/2020	2108	Black rat	c	w	d	32	
7	Furniture	19/10/2020	1930	Black rat	c	e	d	33	
7	Furniture	22/10/2020	2046	Black rat	c	w	d	35	
7	Furniture	22/10/2020	2317	Black rat	c	e	d	36	
7	Furniture	24/10/2020	2239	Black rat	c	w	d	37-39	
7	Furniture	25/10/2020	0122	Black rat	c	e	d	41	
7	Furniture	25/10/2020	0146	Black rat	c	w	d	42	
7	Furniture	25/10/2020	2000	Black rat	c	w	d	43	
7	Furniture	25/10/2020	2026	Black rat	c	e	d	44	
7	Furniture	25/10/2020	2052	Black rat	c	w	d	45	
7	Furniture	26/10/2020	0314	Black rat	c	w	d	46	
7	Furniture	26/10/2020	2255	Black rat	c	e	d	49	
7	Furniture	27/10/2020	0317	Black rat	c	w	d	50	
7	Furniture	27/10/2020	2332	Black rat	c	w	d	57	
7	Furniture	28/10/2020	0304	Black rat	c	w	d	58	
7	Furniture	28/10/2020	2356	Black rat	c	w	d	62	
7	Furniture	29/10/2020	0303	Black rat	c	w	d	63	
7	Furniture	29/10/2020	0322	Black rat	c	w	d	64	
7	Furniture	29/10/2020	2139	Black rat	c	w	d	72	
7	Furniture	29/10/2020	2352	Black rat	c	e	d	74	
7	Furniture	2/11/2020	2202	Black rat	c	w	d	18	
7	Furniture	2/11/2020	2218	Black rat	c	e	d	19	
7	Furniture	2/11/2020	2218	Black rat	c	w	d	20	
7	Furniture	2/11/2020	2353	Black rat	c	w	d	21	
7	Furniture	4/11/2020	2141	Trichosurus spp	c	e	d	28	
7	Furniture	4/11/2020	2203	Short-eared brushtail possum	c	w	d	30	

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
7	Furniture	7/11/2020	2125	Black rat	c	w	d	34	
7	Furniture	10/11/2020	0049	Black rat	c	w	d	41	
7	Furniture	16/11/2020	2108	Black rat	c	e	d	44	
7	Furniture	16/11/2020	2151	Black rat	c	e	d	45-49	
7	Furniture	18/11/2020	2017	Black rat	c	e	d	50	Feeding on insects
7	Furniture	19/11/2020	2153	Black rat	I	w	d	56-64	
7	Furniture	2/12/2020	0307	Black rat	c	e	d	77	
7	Furniture	4/12/2020	0052	Rodent spp	c	e	d	86	
7	Furniture	4/12/2020	2013	Black rat	c	e	d	87	
7	Furniture	14/12/2020	2327	Black rat	I	e-w	d	91-92	
7	Furniture	25/12/2020	2301	Black rat	I	e-w	d	99-102	
7	Furniture	30/12/2020	0020	Black rat	c	e	d	102-109	
7	Furniture	2/01/2020	2337	Antechinus spp	c	e	d	109	
6	Furniture	4/10/2020	1105	Lace monitor	c	w	d	1624	
6	Ground	2/10/2020	1246	Fox	c	w	d	4	
6	Ground	5/10/2020	0816	Lace monitor	c	w	d	10-13	
6	Ground	9/10/2020	0842	Dog	c	e	d	18	
6	Ground	21/10/2020	1120	Lace monitor	c	w	d	48	
6	Ground	24/10/2020	0238	Long-nosed bandicoot	c	e	d	50-51	
6	Ground	24/10/2020	1959	Short-eared brushtail possum	c	e	d	55	
6	Ground	2/11/2020	1956	Bandicoot spp	c	w	d	16	
6	Ground	3/11/2020	1701	Wallaby spp	c	e	d	21	
6	Ground	4/11/2020	0205	Fox	c	e	d	22	
6	Ground	4/11/2020	1330	Lace monitor	c	e	d	32	
6	Ground	4/11/2020	1754	Swamp wallaby	c	w	d	34	
6	Ground	5/11/2020	1818	Cat	c	w	d	37	

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
6	Ground	5/11/2020	1748	Northern Brown Bandicoot	c	e	d	40	
6	Ground	5/11/2020	0921	Northern Brown Bandicoot	c	e	d	43	
6	Ground	5/11/2020	2319	Bandicoot spp	I	e	d	46-51	
6	Ground	6/11/2020	1145	Lace monitor	c	w	d	53	
6	Ground	9/11/2020	2102	Fox	c	e	d	61	
6	Ground	10/11/2020	0053	Short-eared brushtail possum	c	e	d	65-66	
6	Ground	10/11/2020	0134	Short-eared brushtail possum	c	W	d	67-68	
6	Ground	11/11/2020	2028	Short-eared brushtail possum	C	w	d	70	
6	Ground	14/11/2020	1816	Dog	c	e	d	82	
6	Ground	15/11/2002	1312	Lace monitor	c	e	d	85	
6	Ground	20/11/2020	2151	Cat	c	e	d	88	
6	Ground	21/11/2020	0217	Fox	c	e	d	91	
6	Ground	22/11/2020	0114	Trichsurus spp	c	e	d	94	
6	Ground	25/11/2020	1217	Lace monitor	c	w	d	99	
6	Ground	26/11/2020	0222	Dog	c	e	d	100	
6	Ground	1/12/2020	1053	Lace monitor	c	w	d	105	
6	Ground	2/12/2020	0914	Lace monitor	c	e	d	113	
6	Ground	3/12/2020	1121	Bandicoot spp	c	e	d	0123	
6	Ground	4/12/2020	1115	Bandicoot spp	c	e	d	124	
6	Ground	4/12/2020	2314	Bandicoot spp	c	e	d	125	
6	Ground	8/12/2020	1241	Fox	c	e	d	130	
6	Ground	17/12/2020	0250	Fox	c	e	d	133	
6	Ground	17/12/2020	2204	Fox	c	e	d	138	
6	Ground	19/12/2020	2347	Fox	c	e	d	139	

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
6	Ground	24/12/2020	0152	Fox	c	e	d	148	
6	Ground	24/12/2020	0211	Bandicoot spp	c	e	d	152	
6	Ground	26/12/2020	2154	Fox	c	e	d	157	
6	Ground	28/12/2020	2113	Fox	c	e	d	160	
6	Ground	31/12/2020	1958	Cat	c	e	d	165	
6	Ground	1/01/2020	2132	Fox	c	w	d	166	
5	North	9/10/2020	0821	Dog	c	e	d	9	
5	North	11/10/2020	0646	Fox	c	e	d	10	Moves back and forth
5	North	21/10/2020	0903	Lace monitor	c	e	d	12-16	
5	North	27/10/2020	0855	Lace monitor	c	e	d	17	
5	North	15/11/2020	2039	Black rat	c	w	d	49	
5	North	17/11/2020	0134	Black rat	c	e	d	53	
5	North	23/11/2020	2045	Rodent spp	c	e	d	99	
5	North	23/11/2020	2257	Rodent spp	c	w	d	100	
5	North	6/12/2020	2013	Rodent spp	c	e	d	183	
5	North	17/12/2020	0140	Water rat	c	e	d	253	
5	North	22/12/2020	1733	Fox	c	e	d	254	
5	South	1/10/2020	1954	Short-eared brushtail possum	I	e	d	1-2	
5	South	1/10/2020	2047	Echidna	c	w	d	5	
5	South	11/10/2020	2233	Brushtail possum spp	c	e	d	8	
5	South	18/10/2020	0942	Lace monitor	c	e	d	12	
5	South	18/10/2020	1410	Lace monitor	c	w	d	13	
5	South	22/10/2020	0232	Rodent spp	c	e	d	22	

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
5	South	22/10/20202	2323	Water rat	c	w	d	24	
5	South	23/10/2020	0345	Black rat	c	w	d	25	
5	South	23/10/2020	2222	Black rat	c	w	d	26	
5	South	30/10/2020	0231	Water rat	c	e	d	37	No images session 2
4	Furniture	5/10/2020	1039	Lace monitor	C	w	d	6	
4	Furniture	10/10/2020	2257	Short-eared brushtail possum	c	e	d	11-13	
4	Furniture	31/10/2020	2140	Short-eared brushtail possum	c	e	d	2	
4	Furniture	31/10/2020	2151	Short-eared brushtail possum	c	w	d	2	
4	Furniture	2/11/2020	2122	Short-eared brushtail possum	I	e-w	d	14	
4	Furniture	5/11/2020	2024	Short-eared brushtail possum	I	e-w	d	15-16	
4	Furniture	7/11/2020	2317	Short-eared brushtail possum	c	e	d	24	
4	Furniture	7/11/2020	2323	Short-eared brushtail possum	c	e	d	25	
4	Furniture	7/11/2020	2334	Short-eared brushtail possum	c	w	d	26-30	x2
4	Furniture	8/11/2020	0250	Short-eared brushtail possum	c	w	d	32	
4	Furniture	8/11/2020	0337	Short-eared brushtail possum	c	w	d	33	
4	Furniture	9/11/2020	2012	Short-eared brushtail possum	I	e-w	d	34-35	
4	Furniture	11/11/2020	2146	Short-eared brushtail possum	I	e-w	d	36-37	
4	Furniture	12/11/2020	0106	Short-eared brushtail possum	I	e-w	d	39-40	

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
4	Furniture	12/11/2020	1308	Lace monitor	c	w	d	41	
4	Furniture	12/11/2020	2225	Short-eared brushtail possum	c	e	d	42	x2
4	Furniture	12/11/2020	2240	Short-eared brushtail possum	c	w	d	43	x2
4	Furniture	14/11/2020	2146	Short-eared brushtail possum	c	e	d	51	x2
4	Furniture	14/11/2020	2237	Short-eared brushtail possum	c	w	d	53	x2
4	Furniture	15/11/2020	2117	Short-eared brushtail possum	C	e	d	55	x2
4	Furniture	15/11/2020	2203	Short-eared brushtail possum	c	w	d	56	x2
4	Furniture	15/11/2020	2353	Rodent spp (Bush rat ??)	c	e	d	57	
4	Furniture	18/11/2020	002	Short-eared brushtail possum	c	e	d	59	x2
4	Furniture	18/11/2020	0012	Short-eared brushtail possum	c	e	d	60	x2
4	ground	4/10/2020	1731	Fox	c	W	D	5	
4	ground	5/10/2020	1732	Fox	c	W	D	6	
4	ground	8/10/2020	0211	Bandicoot spp	c	W	D	8	
4	ground	8/10/2020	0212	Eastern water dragon	c	W	D	9	
4	ground	9/10/2020	0244	Fox	c	W	D	10	
4	ground	9/10/2020	0805	Dog	c	W	D	11	
4	ground	9/10/2020	1216	Lace monitor	c	W	D	12	
4	ground	9/10/2020	1551	Dog	c	W	D	13	
4	ground	9/10/2020	2056	Bandicoot spp	c	w	D	14	
4	ground	9/10/2020	2351	Short-eared brushtail possum	c	w	d	15	

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
4	ground	10/10/2020	2352	Short-eared brushtail possum	c	w	d	16	
4	ground	10/10/2020	1802	Swamp wallaby	c	w	d	17	
4	ground	11/10/2020	0021	Swamp wallaby	c	e	d	18	
4	ground	12/10/2020	2056	Bandicoot spp	c	w	D	19	
4	ground	13/10/2020	0032	Dog	c	w	d	21	
4	ground	13/10/2020	1551	Fox	c	w	d	24	
4	ground	15/10/2020	1026	Eastern water dragon	c	e	d	32	
4	ground	15/10/2020	2014	Bandicoot spp	c	e	d	34	
4	ground	17/10/2020	1022	Lace monitor	c	e	d	52	
4	ground	17/10/2002	1940	Bandicoot spp	c	e	d	53	
4	ground	19/10/2002	2036	Bandicoot spp	c	e	d	54	
4	ground	20/10/2020	1624	Fox	c	e	d	56	
4	ground	21/10/2020	1419	Fox	c	e	d	57	
4	ground	22/10/2020	1951	Bandicoot spp	c	e	d	59	
4	ground	24/10/2020	0246	Bandicoot spp	c	e	d	60	
4	ground	24/10/2020	2024	Bandicoot spp	c	e	d	61	
4	ground	26/10/2020	0233	Northern Brown Bandicoot	I	e-w	d	63	
4	ground	31/10/2020	1254	Eastern water dragon	C	e	w	3	
4	ground	31/10/2020	1257	Lace monitor	c	e	d	4	
4	ground	1/11/2020	0158	Fox	c	w	d	6	
4	ground	1/11/2020	2123	Bandicoot spp	c	e	d	12	
4	ground	2/11/2020	2349	Dog	c	e	d	20	Black dog
4	ground	3/11/2020	1518	Eastern water dragon	c	w	d	21	
4	ground	4/11/2020	0228	Fox	c	w	d	22	
4	ground	4/11/2020	1023	Eastern water dragon	c	e	d	28	

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
4	ground	4/11/2020	2031	Bandicoot spp	c	e	d	32	
4	ground	5/11/2020	2024	Bandicoot spp	c	e	d	34	
4	ground	6/11/2020	2041	Bandicoot spp	c	e	d	35	
4	ground	7/11/2020	0001	Bandicoot spp	c	e	d	36	
4	ground	7/11/2020	1858	Bandicoot spp	c	e	d	38	
4	ground	7/11/2020	2006	Bandicoot spp	c	e	d	39	
4	ground	9/11/2020	2027	Bandicoot spp	c	e	d	41	
4	ground	9/11/2020	2121	Fox	c	e	d	42	
4	ground	10/11/2020	1005	Lace monitor	c	e	d	43	
4	ground	10/11/2020	1229	Lace monitor	c	e	d	44	
4	ground	10/11/2020	2232	Swamp wallaby	c	w	d	46	
4	ground	11/11/2020	0359	Swamp wallaby	c	e	d	47	
4	ground	12/11/2020	2248	Swamp wallaby	c	w	d	48	
4	ground	12/11/2020	2252	Swamp wallaby	c	e	d	49	
4	ground	13/11/2020	144	Bandicoot spp	c	w	d	52	
4	ground	13/11/2020	2119	Bandicoot spp	c	e	d	53	
4	ground	14/11/2020	1806	Dog	c	w	d	58	
4	ground	14/11/2020	2327	Koala	c	w	d	59	
4	ground	15/11/2020	100	Swamp wallaby	c	w	d	60	
4	ground	15/11/2020	0346	Swamp wallaby	c	e	d	61	
4	ground	16/11/2020	1359	Lace monitor	c	e	d	64	
4	ground	16/11/2020	1558	Dog	c	w	d	65	
4	ground	18/11/2002	1050	Lace monitor	c	e	d	70	
4	ground	18/11/2002	1823	Dog	l	w-e	d	71-72	White chest
4	ground	19/11/2020	2337	Northern Brown Bandicoot	c	e	d	73	
4	ground	21/11/2020	1908	Dog	c	w-e	d	75	
4	ground	22/11/2002	0055	Dog	c	78	d	78	
4	ground	22/11/2020	0154	Swamp wallaby	c	w	d	79	
4	ground	22/11/2020	0412	Swamp wallaby	c	e	d	80	
4	ground	23/11/2020	0253	Bandicoot spp	c	e	d	84	

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
4	ground	26/11/2020	0314	Bandicoot spp	c	w	d	85	
4	ground	26/11/2020	0314	Long-nosed bandicoot	c	w	d	86	
4	ground	26/11/2020	2112	Bandicoot spp	c	e	d	89	
4	ground	26/11/2002	2238	Bandicoot spp	c	e	d	90	
4	ground	27/11/2020	00017	Dog	c	e	d	91	Black white chest
4	ground	29/11/2020	2338	Bandicoot spp	c	e	d	93	
4	ground	1/12/2020	1928	Bandicoot spp	c	e	d	94	
4	ground	1/12/2020	2049	Swamp wallaby	c	w	d	96	
4	ground	1/12/2002	2052	Swamp wallaby	c	e	d	97	
4	ground	1/12/2020	2134	Swamp wallaby	c	e	d	98	
4	ground	4/12/2020	0146	Fox	c	w	d	101	
4	ground	4/12/2020	2004	Bandicoot spp	c	e	d	102	
4	ground	4/12/2020	2101	Koala	c	e	d	103	
4	ground	5/12/2002	2305	Swamp wallaby	c	e	d	105	
4	ground	5/12/2020	2305	Swamp wallby	c	e	d	106	
4	ground	6/12/2020	2350	Bandicoot spp	c	e	d	108	
4	ground	7/12/2020	0251	Trichsurus spp	c	w	d	110	
4	ground	7/12/2020	2145	Black rat	c	e	d	112	
4	ground	8/12/2020	0102	Fox	c	e	d	113	
4	ground	8/12/2002	1930	Dog	c	e	d	116	
4	ground	8/12/2020	2048	Bandicoot spp	c	e	d	117	
4	ground	9/12/2020	2236	Koala	c	e	d	118	
4	ground	10/12/2002	2134	Swamp wallaby	c	w	d	119	
4	ground	10/12/2020	2146	Bandicoot spp	c	e	d	120	
4	ground	11/12/2020	0401	Swamp ballaby	c	e	d	121	
4	ground	13/12/2020	2356	Fox	c	e	d	125	
4	ground	14/12/2020	0335	Rodent spp	c	e	d	127	
4	ground	14/12/2020	2329	Fox	c	e	d	130	
4	ground	16/12/2020	0050	Northern Brown Bandicoot	c	e	d	132	

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
4	ground	16/12/2020	0123	Koala	c	w	d	133	
4	ground	16/12/2020	2027	Koala	c	e	d	134	
4	ground	19/12/2020	0332	Bandicoot spp	c	e	d	137	
4	ground	22/12/2020	1812	Koala	c	w	d	141	
4	ground	27/12/2020	1225	Lace monitor	c	w	d	147	
4	ground	27/12/2020	1430	Lace monitor	c	e	d	148	
4	ground	29/12/2020	0303	Swamp wallaby	c	w	d	149	
4	ground	29/12/2020	0313	Swamp wallaby	c	e	d	150	
4	ground	30/12/2020	1506	Lace monitor	c	w	d	153	
4	ground	31/12/2020	0029	Rodent spp	c	w	d	154	
4	ground	2/01/2021	2226	Rodent spp	c	w	d	161	
4	ground	3/01/2021	2226	Rodent spp	c	e	d	163	
4	ground	4/01/2021	014	Koala	c	w	d	164	
3	Furniture	29/10/2020	2200	Cat	c	e	d	70	
3	Furniture	5/10/2020	0118	Brushtail possum spp	i	w	d	6-7	
3	Furniture	5/10/2020	2030	Brushtail possum spp	c	e	d	10	
3	Furniture	6/10/2020	1926	Brushtail possum spp	c	e	d	15	
3	Furniture	8/10/2020	0107	Brushtail possum spp	c	w	d	16	
3	Furniture	8/10/2020	0108	Brushtail possum spp	c	e	d	17	
3	Furniture	9/10/2020	1937	Brushtail possum spp	I	e	d	19-20	
3	Furniture	10/10/2020	2027	Brushtail possum spp	C	e	d	21	
3	Furniture	11/10/2020	2306	Brushtail possum spp	C	e	d	25	
3	Furniture	14/10/2020	2301	Brushtail possum	i	w-e	d	32	

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
				spp					
3	Furniture	16/10/2020	2106	Brushtail possum spp	c	w	d	39	
3	Furniture	16/10/2020	2242	Brushtail possum spp	c	e	d	40	
3	Furniture	19/10/2020	2145	Brushtail possum spp	c	e	d	45	
3	Furniture	21/10/2020	0136	Brushtail possum spp	I	w-e	d	46	
3	Furniture	27/10/2020	0830	Eastern water dragon	c	e	d	58	
3	Furniture	28/10/2020	2208	Brushtail possum spp	I	w-e	d	63	
3	Furniture	31/10/2020	1000	Trichosurus spp	c	w	d	2	
3	Furniture	2/11/2020	2209	Trichosurus spp	c	e	d	3	
3	Furniture	4/11/2002	2206	Trichosurus spp	c	w	d	4	
3	Furniture	5/11/2002	0007	Trichosurus spp	c	e	d	6	
3	Furniture	5/11/2020	2107	Trichosurus spp	c	w	d	7	
3	Furniture	6/11/2020	0005	Trichosurus spp	c	e	d	8	
3	Furniture	12/11/2002	2020	Trichosurus spp	c	w	d	10	
3	Furniture	13/11/2002	222	Trichosurus spp	c	w	d	11	
3	Furniture	14/11/2020	1945	Trichosurus spp	c	w	d	12	
3	Furniture	17/11/2020	2015	Trichosurus spp	c	w	d	14	
3	Furniture	19/11/2020	0412	Trichosurus spp	c	e	d	16	
3	Furniture	21/11/2020	0024	Trichosurus spp	c	w	d	17	
3	Furniture	21/11/2020	0205	Trichosurus spp	c	e	d	18	
3	Furniture	11/12/2020	2021	Trichosurus spp	c	w	d	21	
3	Furniture	11/12/2020	2023	Trichosurus spp	c	e	d	23	Active
3	Ground	4/10/2020	0738	Swamp wallaby	c	e	d	7	
3	ground	4/10/2020	1816	Eastern grey	c	w	Pr	10	

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
				kangaroo					
3	Ground	6/10/2020	1026	Swamp wallaby	I	w-e	d	12	
3	ground	6/10/2020	01923	Short-eared brushtail possum	I	e-w	d	15	
3	Ground	7/10/2020	0304	Cat	C	w	d	16	white socks
3	ground	7/10/2020	1951	Cat	C	e	d	16	white socks
3	Ground	8/10/2020	0836	Cat	C	w	d	20	white socks
3	ground	8/10/2020	1512	Bloke holding Machette	i	e-w	d	23	
3	Ground	10/10/2020	0029	cat	c	w	d	24	
3	ground	10/10/2020	2208	Bandicoot spp	c	e	d	26	
3	Ground	11/10/2020	0137	Swamp wallaby	c	e	d	27	
3	ground	11/10/2020	0545	Cat	c	e	d	29	White socks
3	Ground	12/10/2020	0526	Swamp wallaby x 2	c	e	d	31	
3	ground	13/10/2020	2112	Cat	c	w	d	41	Tabby
3	Ground	14/10/2020	0412	Cat	c	e	d	47	White socks
3	ground	15/10/2020	0224	Swamp wallaby	c	e	d	49	
3	Ground	15/10/2020	0613	Dog x2	c	e	d	50	Choc Kelpie
3	ground	15/10/2020	2204	Dog	c	w	d	56	
3	Ground	15/10/2002	2234	Bandicoot spp	c	e	d	57	
3	ground	15/10/2020	2246	Cat	c	e	d	58	
3	Ground	16/10/2002	0523	Swamp wallaby x 2	c	e	d	59	
3	ground	16/10/2020	0527	Cat	c	e	d	60	
3	Ground	17/10/2020	0224	Swamp wallaby	c	e	d	61	
3	ground	17/10/2020	0830	Swamp wallaby x 2	c	e	d	64	
3	Ground	18/10/2020	0154	Cat	c	w	d	65	

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
3	ground	19/10/2020	0239	Cat	c	w	d	67	
3	Ground	19/10/2020	0404	Swamp wallaby	c	e	d	68	
3	ground	19/10/2020	0640	Swamp wallaby x 2	c	e	d	69	
3	Ground	19/10/2020	1900	Cat	c	e	d	70	white socks
3	ground	20/10/2020	0640	Swamp wallaby x 2	c	e	d	75	
3	Ground	20/10/2020	2007	Swamp wallaby	c	w	d	76	
3	ground	20/10/2020	2048	Cat	c	w	d	77	white socks
3	Ground	20/10/2020	2227	Cat	c	e	d	77	
3	ground	21/10/2020	0041	Swamp wallaby	c	e	d	79	
3	Ground	21/10/2020	1601	Eastern water dragon	c	e	d	80-81	
3	ground	21/10/2020	2117	Bandicoot spp	c	e	d	82	
3	Ground	21/10/2020	0252	Cat	c	w	d	83	
3	ground	22/10/2020	1901	Cat	c	e	d	83	
3	Ground	23/10/2020	0618	Cat	c	e	d	85	
3	ground	24/10/2002	2149	Short-eared brushtail possum	c	e	d	87	
3	Ground	25/10/2020	1429	Eastern water dragon x 2	c	e	d	88	
3	ground	25/10/2020	2336	Cat	c	e	d	91	
3	Ground	27/10/2020	0929	Eastern water dragon	l	e-w	d	103-104	
3	ground	27/10/2020	2006	Cat	c	w	d	105	prey in mouth
3	Ground	27/10/2020	2056	Cat	c	e	d	106	
3	ground	27/10/2020	2326	Swamp wallaby	c	e	d	107	
3	Ground	28/10/2020	0115	Cat	c	w	d	115	
3	ground	28/10/2020	1900	Cat	c	e	d	119	
3	Ground	29/10/2020	1913	Cat	c	w	d	125-	

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
								127	
3	ground	29/10/2020	2032	Cat	c	w	d	128	
3	ground	2/11/2020	2120	Swamp Wallaby	c	e	d	4	
3	ground	2/11/2020	2336	Dog	c	w	d	6	Black with white chest
3	ground	3/11/2020	0208	Red necked Wallaby	c	e	d	8-9	
3	ground	3/11/2020	0624	Swamp Wallaby	c	e	d	10	
3	ground	3/11/2020	1804	Swamp Wallaby	i	w	d	12	
3	ground	3/11/2020	1910	Red necked Wallaby	c	w	d	14-15	
3	ground	3/11/2020	2223	Cat	c	w	d	16	Black Cat
3	ground	3/11/2020	2232	Swamp Wallaby	i	e	d	17	
3	ground	4/11/2020	0550	Cat	i	e	d	18	
3	ground	4/11/2020	1432	Swamp Wallaby	i	e	d	23	
3	ground	5/11/2020	2329	Cat	i	e	d	26	
3	ground	6/11/2020	2123	Bandicoot spp	c	e	d	28	
3	ground	7/11/2020	0218	Cat	c	w	d	29	Black Cat
3	ground	7/11/2020	0539	Cat	c	e	d	30	Black Cat
3	ground	8/11/2020	1638	Cat	i	e	d	33-34	Black Cat
3	ground	9/11/2020	0921	Cat	c	w	d	35	Black Cat
3	ground	9/11/2020	1219	Cat	c	w	d	36-37	Black Cat
3	ground	9/11/2020	1534	Cat	i	e	d	38	Black Cat
3	ground	10/11/2020	2146	Bandicoot spp	c	w	d	40-41	
3	ground	11/11/2020	2240	Cat	c	w	d	42	Black Cat
3	ground	12/11/2020	0045	Dog	c	w	d	43	Brown Dog
3	ground	12/11/2020	0526	Cat	i	w	d	46	Black Cat
3	ground	12/11/2020	0754	Cat	c	w	d	47	Black Cat
3	ground	12/11/2020	0811	Cat	i	e	d	48	Black Cat
3	ground	14/11/2020	0236	Cat	c	w	d	49	Black Cat

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
3	ground	14/11/2020	1556	Cat	i	e	d	50	Black Cat
3	ground	15/11/2020	0218	Cat	c	w	d	51	Black Cat
3	ground	15/11/2020	0257	Cat	c	e	d	52	Black Cat
3	ground	18/11/2020	0130	Brush tail possum spp	c	e	d	54	
3	ground	20/11/2020	0231	Dog	c	e	d	57	Brown Dog
3	ground	20/11/2020	0440	Red necked Wallaby x 2	c	e	d	58	
3	ground	20/11/2020	0710	Red necked Wallaby x 2	c	w	d	59-60	
3	ground	20/11/2020	2300	Cat	c	w	d	62	Black Cat
3	ground	21/11/2020	1906	Cat	c	e	d	63	Black Cat
3	ground	22/11/2020	0045	Cat	c	e	d	65	Black Cat
3	ground	23/11/2020	0209	Cat	c	e	d	66-67	Black Cat
3	ground	24/11/2020	0049	Cat	c	w	d	68	Black Cat
3	ground	24/11/2020	0635	Cat	i	e	d	70	Black Cat
3	ground	26/11/2020	0011	Cat	c	w	d	71	Black Cat
3	ground	26/11/2020	0349	Cat	c	e	d	72	Black Cat
3	ground	26/11/2020	2327	Cat	c	w	d	73	Black Cat
3	ground	27/11/2020	0028	Cat	c	e	d	74	Black Cat
3	ground	27/11/2020	2115	Brushtail possum spp	c	e	d	75	
3	ground	28/11/2020	0043	Cat	c	w	d	76	Black Cat
3	ground	28/11/2020	0500	Cat	i	e	d	77	Black Cat
3	ground	1/12/2020	0525	Dog	c	e	d	78	Black Dog
3	ground	3/12/2020	0143	House mouse	c	e	d	80	
3	ground	4/12/2020	2204	Cat	c	w	d	81	Black Cat
3	ground	5/12/2020	0043	Swamp Wallaby	c	e	d	82	
3	ground	5/12/2020	0107	Cat	c	e	d	83	Black Cat

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
3	ground	7/12/2020	0116	Cat	c	w	d	84	Black Cat
3	ground	7/12/2020	1758	Cat	i	e	d	88	Black Cat
3	ground	10/12/2020	0322	Swamp Wallaby	i	e	d	91	
3	ground	10/12/2020	0325	Cat	c	w	d	92	Black Cat
3	ground	10/12/2020	0351	Cat	c	e	d	93	Black Cat
3	ground	12/12/2020	2323	Cat	c	w	d	95	Black Cat
3	ground	13/12/2020	0439	Cat	c	e	d	96	Black Cat
3	ground	13/12/2020	1742	Swamp Wallaby	c	e	d	98-100	
3	ground	15/12/2020	0646	Swamp Wallaby	c	e	d	101	
3	ground	16/12/2020	0143	Cat	c	w	d	103	Black Cat
3	ground	16/12/2020	0337	Cat	i	e	d	104	Black Cat
3	ground	16/12/2020	0608	Swamp Wallaby	c	e	d	105	
3	ground	18/12/2020	0109	Dog	c	w	d	107	Brown Dog
3	ground	18/12/2020	0359	Swamp Wallaby	c	e	d	108	
3	ground	18/12/2020	1345	Water Dragon	i	e	d	109-110	
3	ground	20/12/2020	0603	Swamp Wallaby	c	e	d	138	
3	ground	21/12/2020	0103	Cat	c	w	d	140	Black Cat
3	ground	21/12/2020	0152	Swamp Wallaby	c	e	d	141	
3	ground	21/12/2020	0306	Cat	i	e	d	142	Black Cat
3	ground	22/12/2020	0308	Swamp Wallaby	c	e	d	144	
3	ground	23/12/2020	0528	Red necked Wallaby x 2	c	e	d	145	
3	ground	23/12/2020	1839	Cat	c	e	d	146-147	Black Cat
3	ground	23/12/2020	1856	Red necked Wallaby x 2	c	w	d	148	
3	ground	24/12/2020	0137	Cat	c	e	d	149	Black Cat
3	ground	25/12/2020	0222	Cat	c	w	d	150	Black Cat

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
3	ground	25/12/2020	0357	Cat	c	e	d	151	Black Cat
3	ground	26/12/2020	1410	Swamp Wallaby	c	e	d	152	
3	ground	27/12/2020	0207	Cat	c	w	d	153	Black Cat
3	ground	27/12/2020	0320	Cat	i	e	d	154	Black Cat
3	ground	27/12/2020	1708	Cat	c	w	d	155	Black Cat
3	ground	27/12/2020	1742	Cat	i	e	d	156	Black Cat
3	ground	28/12/2020	0128	Cat	c	w	d	157	Black Cat
3	ground	28/12/2020	1946	Cat	c	e	d	158	Black Cat
3	ground	29/12/2020	0243	Cat	c	w	d	159	Black Cat
3	ground	29/12/2020	0439	Cat	i	e	d	160	Black Cat
3	ground	29/12/2020	1322	Swamp Wallaby	c	w	d	161	
3	ground	30/12/2020	0219	Cat	i	r	d	162	Black Cat
3	ground	30/12/2020	2134	Swamp Wallaby	c	e	d	163	
3	ground	30/12/2020	2315	Kitten	c	w	d	164	Tabby Kitten
3	ground	30/12/2020	2352	Kitten	c	w	d	166-167	Tabby Kitten
3	ground	31/12/2020	0215	Kitten	c	e	d	168	
3	ground	2/01/2021	0538	Swamp Wallaby	i	e	d	170	
3	ground	2/01/2021	2203	Cat	i	w	d	171	Black Cat
3	ground	3/01/2021	0022	Cat	c	e	d	172	Black Cat
2	Furniture	17/10/2020	1018	Eastern water dragon	I	e-w	d	85-112	
2	Furniture	1/12/2020	0130	Black rat	c	e	d	87-93	
2	Furniture	29/12/2020	1126	Antechinus spp	c	e	d	111-123	
2	Furniture	30/12/2020	0302	Black rat	I	w-e	d	128-135	

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
2	Furniture	31/12/2020	2121	Antechinus spp	C	w	d	148-149	
2	Furniture	31/12/2020	2139	Antechinus spp	I	e-w	d	148-149	
2	Furniture	1/01/2021	1939	Antechinus spp	c	e	d	168-172	
2	ground	2/10/2020	2343	Bandicoot spp	c	e	d	67	
2	ground	3/10/2020	0144	Swamp wallaby	c	e	d	68	
2	ground	3/10/2020	0531	Swamp wallaby	c	e	d	69	
2	ground	3/10/2020	0543	Dog	c	w	d	070	
2	ground	4/10/2020	0544	Dog	c	w	d	113	
2	ground	4/10/2020	1956	Swamp wallaby	c	w	d	175	
2	ground	5/10/2020	0019	Swamp wallaby	c	e	d	178	
2	ground	5/10/2020	0020	Dog	c	e	d	179	
2	ground	5/10/2020	0317	Swamp wallaby	c	e	d	180	
2	ground	5/10/2020	215	Bandicoot spp	c	e	d	227	
2	ground	6/10/2020	0305	dog	c	w	d	230	Sandy/cream
2	ground	6/10/2020	1945	Bandicoot spp	c	e	d	304	
2	ground	6/10/2020	2053	Dog	c	e	d	305	Sandy/cream
2	ground	8/10/2020	0345	Swamp wallaby	c	e	d	379	
2	ground	9/10/2020	1910	Dog	c	w	d	519	Sandy/cream
2	ground	10/10/2020	0518	Dog	c	w	d	520	Sandy/cream
2	ground	10/10/2020	0022	Swamp wallaby	c	w	d	572	
2	ground	13/10/2020	1912	Dog	c	e	d	725	Sandy/cream
2	ground	14/10/2020	0453	Dog	c	e	d	727	Sandy/cream
2	ground	14/10/2020	1756	cat	i	e	d	780	Tabby
2	ground	14/10/2020	1916	Bandicoot spp	c	e	d	782	
2	ground	14/10/2020	2252	dog	c	e	d	785	black mottled
2	ground	15/10/2020	0232	dog	c	w	d	786	

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
2	ground	15/10/2020	0319	Bandicoot spp	c	w	d	788	
2	ground	15/10/2020	0408	Swamp wallaby	c	e	d	789	
2	ground	15/10/2020	0548	Dog	c	e	d	791	
2	ground	1/11/2020	0257	Swamp wallaby	c	e	d	62	
2	ground	2/11/2020	0417	Swamp wallaby	c	w	d	102-112	
2	ground	3/11/2020	006	Swamp wallaby	c	e	d	144	
2	ground	3/11/2020	0254	Swamp wallaby	c	e	d	145	
2	ground	4/11/2020	0126	Swamp wallaby	c	e	d	212	
2	ground	6/11/2020	2000	Bandicoot spp	c	c	d	364	
2	ground	7/11/2020	2156	Swamp wallaby	c	w	d	448	
2	ground	8/11/2020	0302	Fox	c	w	d	451	
2	ground	8/11/2020	0431	Swamp wallaby	c	e	d	453	
2	ground	9/11/2020	2206	Bandicoot spp	c	e	d	578	
2	ground	10/11/2020	2155	Bandicoot spp	c	e	d	633	
2	ground	11/11/2020	2105	Swamp wallaby	c	w	d	690	
2	ground	11/11/2020	213	Bandicoot spp	c	e	d	692	
2	ground	12/11/2020	0005	Dog	c	w	d	695	
2	ground	12/11/2020	0417	Swamp wallaby	c	e	d	697	
2	ground	12/01/2020	1940	Bandicoot spp	c	e	d	741	
2	ground	13/11/2020	0235	Swamp wallaby	c	e	d	743	final date 14/11/2020
1	North	Nil	Nil	Nil	Nil	Nil	Nil	Nil	1/10/2020-24/10/2020 recorded nil
1	North	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Regularly inundated
1	South	No images	No images	No images	No images	No images	No images	No images	
1	South	25/11/2020	0127	Swamp wallaby	c	w	d	399	

Site	Cam	Date	Time	Species	Complete or incomplete	Movement	Accuracy	Vid No.	Comments
1	South	25/11/2020	0131	Swamp wallaby	c	e	d	406	

Table C 2: Sand pad data recorded over 8 nights in spring/summer (ss) during year three of operational phase monitoring WC2NH, 2020/2021. + = probable records.

5pecies/Group	Site																							
	1		2		3		4		5		6		7		8		9		10		11		12	
	SS	W	SS	W	SS	W	SS	W	SS	W	SS	W	SS	W	SS	W	SS	W	SS	W	SS	W	SS	W
Short-beaked echidna			*																					
Antechinus spp.									+										+		+			
Peramelidae spp. (bandicoot)			*				*		*		*						*				*		*	
Trichosurus spp.							*																	
Swamp wallaby			*		*																*		*	
Wallaby spp.																								
Rodent spp.			*		*				*				*						*					
Dog							*						*		*		*		*		*		*	
Red fox I							*						*		*		*		*					
Cat I					*								*		*						*		*	
Lace monitor							*		*		*				*									
Eastern water dragon							*				*													
Medium reptile	*																							
Medium frog spp.	*																*							
Bird spp.	*																							
Total no. Species/groups	3		4		3		6		4		3		4		4		4		4		5		4	

Table C 3: Scat and track data recorded during camera monitoring (on two occasions 31 October 2020 and 4 January 2021) in spring/summer (ss) of year 3 operational phase monitoring WC2NH, 2020/2021. + = probable records.

Species/group	1		2		3		4		5		6		7		8		9		10		11		12	
	SS	W	SS	W	SS	W	SS	W	SS	W	SS	W	SS	W	SS	W	SS	W	SS	W	SS	W	SS	W
Antechinus spp.											*										*		*	
Peramelidae spp. (bandicoot)			*				*				*		*				*		*					

Trichosurus spp.	*												*											
Swamp wallaby			*										*											
Wallaby spp.	*				*																*		*	
Rodent spp.							*		*				*											
Dog[l]							*						*				*		*		*		*	
Red fox [l]			*								*				*						*		*	
Cat [l]					*		*								*									
Lace monitor							*						*		*		*		*					
Large reptile					*																			
Total species/group	2		3		4		5		1		3		6		3		3		3		4		4	

Table C 4: Nocturnal (spotlighting) adjacent habitat surveys conducted during spring/summer year three of operational phase monitoring WC2NH, 2020.

Location	Side	Date	Obs. No.	Observers	Start Time	Finish Time	Species	Wind	Rain	Visibility	Air Temp	Humidity	Comment
11&12	E	13/10/20	1	LA	1925	1955	Wallaby spp, Adelotus brevis	Nil	Nil	Good	15.4	75	
	W	13/10/20	1	NM	1925	1955	Nil	Nil	Nil	Good	15.4	75	
	E	15/10/20	2	LA	2235	2305	Nil	ML	Nil	Dark	18	75	
	W	15/10/20	2	NM	2235	2305	Sugar glider	ML	Nil	Dark	18	75	
9&10	E	13/10/20	1	LA	2006	2036	Nil	Nil	Nil	Good	15.4	75	
	W	13/10/20	1	NM	2006	2036	Nil	Nil	Nil	Good	15.4	75	
	E	15/10/20	2	LA	2200	2230	LN bandicoot	Nil	Nil	Good	18.7	69	
	W	15/10/20	2	NM	2200	2230	Swamp wallaby	Nil	Nil	Good	18.7	69	
8	E	13/10/20	1	LA	2045	2115	Wallaby spp,	Nil	Nil	Good	15.4	75	
	W	13/10/20	1	NM	2045	2115	Nil	Nil	Nil	Good	15.4	75	
	E	15/10/20	2	LA	2125	2155	LN bandicoot	Nil	Nil	Good	18.7	69	
	W	15/10/20	2	NM	2125	2155	Swamp wallaby	Nil	Nil	Good	18.7	69	
7	E	13/10/20	1	LA	2122	2152	Wallaby spp	Nil	Nil	Good	13.8	89	
	W	13/10/20	1	NM	2122	2152	GHFF	Nil	Nil	Good	13.8	89	
	E	15/10/20	2	BT	2243	2312	SeBtP (near entrance)	ML	Nil	Dark	18	75	Sitting on refuge pole near entrance
	W	15/10/20	2	BT	2210	2240	**Koala (**M?, twood, 37cm, 496416-6608715)	ML	Nil	Dark	18	75	Prob larger than M rescued near c10 east
5&6	E	13/10/20	1	LA	2200	2230	Litoria peronii, tyleri, flax. Koala Scat, wallaby, GHFF	Nil	Nil	Good	13.8	89	Koala scat under Tallowwood near entrance
	W	13/10/20	1	NM	2200	2230	**YBG,** aAelotus brevis,L. fallax	Nil	Nil	Good	13.8	89	
	E	15/10/20	2	BT	2103	2131	Lit fallax, Lit peroni, Lit tyleri	MSB	Nil	Dark	19	73	
	W	15/10/20	2	BT	2134	2202	Lit fallax, Lit peroni, Lit tyleri, Adelotis	MSB	Nil	Dark	19	73	

Location	Side	Date	Obs. No.	Observers	Start Time	Finish Time	Species	Wind	Rain	Visibility	Air Temp	Humidity	Comment
							brevis						
4	E	13/10/20	1	LA	2234	2304	GHFF, wallaby, Adelotus brevis	Nil	Nil	Good	13.8	89	
	W	13/10/20	1	NM	2234	2304	Nil	Nil	Nil	Good	13.8	89	
	E	15/10/20	2	BT	1954	1923	GHFF, Wallaby sp.	MLB	Nil	Dark	20.1	70	
	W	15/10/20	2	BT	2025	2055	Wallaby sp. Lit peroni	MLB	Nil	Dark	20.1	70	
3 (E only)	E	13/10/20	1	LA/NM	2309	2339	Wallaby	Nil	Good	13.8	89	Nil	
	E	15/10/20	2	LA/NM	1930	2000	Nil	Nil	Nil	Good	18.7	69	
2	E	13/10/20	1	LA/NM	2342	0012	GHFF	Nil	Good	13.8	89	Nil	
	W	13/10/20	1	LA/NM	2342	0012	Nil	Nil	Good	13.8	89	Nil	
	E	15/10/20	2	LA	2030	2100	Nil	Nil	Nil	Good	18.7	69	
	W	15/10/20	2	NM	2030	2100	GHFF, Common scaly foot	Nil	Nil	Good	18.7	69	
1	E	15/10/20	1	LA	1930	2000	GHFF, Swamp wallaby Adelotus, Lit. fallax	Nil	Nil	Good	18.7	69	
	W	15/10/20	1	NM	1930	2000	Adelotus, Lit. fallax	Nil	Nil	Good	18.7	69	
	E	29/10/20	2	NM/BT	1945	2015	Fallax, SeBtp	Nil	Nil	Good	17.4	91	
	W	29/10/20	2	NM/BT	1945	2015	Swamp wallaby, Gracilenta	Nil	Nil	Good	17.4	91	

Table C 5: Diurnal adjacent habitat surveys conducted during spring/summer year three of operational phase monitoring WC2NH, 2020.

Location	Side	Date	Obs. No.	Observers	Start Time	Finish Time	Species	Wind	Rain	Visibility	Air Temp	Humidity	Comment
11&12	E	12/10/20	1	LA	1331	1402	Wallaby spp scat, Calyptotis ruficauda, Fox scat.	MSB	Nil	Great	24.3	59	
	W	12/10/20	1	NM	1331	1402	3 x Lampropholis	MSB	Nil	Great	24.3	59	
	E	14/10/20	2	NM	1632	1702	Wallaby spp, bandicoot diggings, Lampropholis spp x 1	MSB	Nil	Great	21.8	58	
	W	14/10/20	2	NM	1600	1630	Lampropholis spp. X 1	MSB	Nil	Great	21.8	58	
9&10	E	12/10/20	1	LA	1412	1442	Wallaby spp and BtPoss scat	MSB	Nil	Great	24.3	59	
	W	12/10/20	1	NM	1412	1442	Swamp wallaby scat	MSB	Nil	Great	24.3	59	
	E	15/10/20	2	NM	1415	1445	Wallaby spp	MSB	Nil	Great	23	58	
	W	14/10/20	2	NM	1720	1750	Wallaby scat, bandicoot diggings, koala scat @ 496525,6609375	MSB	Nil	Great	21.2	54	
8	E	12/10/20	1	LA	1500	1530	Lace monitor, Swamp wallaby scat	MSB	Nil	Great	24.3	59	
	W	12/10/20	1	NM	1500	1530	Lampropholis delicata, swamp wallaby scat	MSB	Nil	Great	24.3	59	
	E	15/10/20	2	NM	1530	1600	Wallaby spp, Lampropholis spp x 1, bandicoot spp	MSB	Nil	Great	22.5	60	
	W	15/10/20	2	NM	1455	1525	Wallaby spp, bandicoot spp	MSB	Nil	Great	22.5	60	
7	E	12/10/20	1	LA	1542	1612	Lampropholis delicata, Bandicoot diggings. Swamy wallaby	MSB	Nil	Great	24.3	59	

Location	Side	Date	Obs. No.	Observers	Start Time	Finish Time	Species	Wind	Rain	Visibility	Air Temp	Humidity	Comment
	W	12/10/20	1	NM	1542	1612	Lampropholis delicata, swamp wallaby scat, bandicoot diggings	MSB	Nil	Great	24.3	59	
	E	15/10/20	2	NM	1700	1730	Wallaby spp, Lampropholis spp x 1	MSB	Nil	Great	22.6	62	
	W	15/10/20	2	NM	1620	1650	Wallaby spp, bandicoot spp	MSB	Nil	Great	22.6	62	
5&6	E	13/10/20	1	LA	1431	1501	Lace monitor scat, wallaby scat, Lampropholis delicata	MSB	Nil	Great	23.7	58	
	W	13/10/20	1	NM	1431	1501	Lampropholis delicata, swamp wallaby scat, bandicoot diggings	MSB	Nil	Great	23.7	58	
	E	16/10/20	2	LA	1315	1345	No new records	Still	Nil	Good	27.7	37	
	W	15/10/20	2	NM	1735	1805	Swamp wallaby, Adelotus brevis	MSB	Nil	Great	22.6	62	
4	E	13/10/20	1	LA	1521	1551	Wallaby scat, Lampropholis spp	MSB	Nil	Great	23.7	58	
	W	13/10/20	1	NM	1521	1551	Koala scat, bandicoot diggings	MSB	Nil	Great	23.7	58	Photo available Luke's phone
	E	16/10/20	2	LA	1206	1236	Dog tracks	Still	Nil	Good	27.7	37	Dog tracks in mud
	W	16/10/20	2	LA	1237	1307	Swamp wallaby	Still	Nil	Good	27.7	37	Guts found suggesting predation, small mammal
3 (E only)	E	13/10/20	1	LA	1558	1628	Wallaby scat, Lampropholis cat scat	MSB	Nil	Great	23.7	58	
	E	16/10/20	2	LA	1125	1155	Lampropholis spp x2, wallaby scat, bandicoot diggings	Still	Nil	Good	27.7	37	
2	E	13/10/20	1	LA	1634	1704	Wallaby scat, Lampropholis spp	MSB	Nil	Great	23.7	58	
	W	13/10/20	1	NM	1634	1704	Swamp wallaby scat, Lampropholis spp, lace Monitor	MSB	Nil	Great	23.7	58	

Location	Side	Date	Obs. No.	Observers	Start Time	Finish Time	Species	Wind	Rain	Visibility	Air Temp	Humidity	Comment
	E	16/10/20	2	LA	1050	1120	Echidna diggings, Swamp wallaby	Still	Nil	Good	27.4	37	
	W	16/10/20	2	LA	1125	1155	Lampropholis spp x2	Still	Nil	Good	27.7	37	
1	E	13/10/20	1	LA	925	1005	BTP scat, medium lizard, Lampropholis spp	Still	Nil	Good	27.4	37	
	W	13/10/20	1	NM	925	1005	Lampropholis spp, wallaby scat	Still	Nil	Good	27.7	37	
	E	16/10/20	2	LA	1005	1035	Nil new	Still	Nil	Good	27.4	37	
	W	16/10/20	2	NM	1005	1035	Nil new	Still	Nil	Good	27.7	37	

Table C 6: Fauna captured during adjacent habitat trapping surveys during spring/summer of year three operational monitoring WC2NH, 2020.

Site	Side	Date	Trap type	Species	Sex	Weight	Comments
11/12	w	27/10/2020	Pitfalll	Lampropholis delicata			
11/12	w	27/10/2020	Large Elliot	SuG	M	128	
11/12	w	27/10/2020	Large Elliot	SuG	F	153	2X pouch young
11/12	e	27/10/2020	Cage	Lace monitor	Unk	Unk	
9/10	w	27/10/2020	Small Elliot	FF Melomys	Male	70	
9/10	w	27/10/2020	Cage trap	FF Melomys	Unk	Unk	
9/10	w	27/10/2020	Small Elliot	FF Melomys	M	78	
8	e	27/10/2020	Small Elliot	Black rat	M	174	
8 west	w	27/10/2020	Cage trap	Lace monitor			
7 east	e	27/10/2020	Small Elliot	FF Melomys	M	75	
7 east	e	27/10/2020	Small Elliot	FF Melomys	F		Escape
7 east	e	27/10/2020	Small Elliot	FF Melomys	M	65	
7 east	e	27/10/2020	Pitfall	Calyptotis ruficauda			
7 west	w	27/10/2020	Small Elliot	Brown Antechinus	F	27	
7 west	w	27/10/2020	Cage trap	Northern brown	Unk	Unk	
5/6 east	e	27/10/2020	Small Elliot	FF Melomys	F	63	
5/6	w	27/10/2020	Small Elliot	Bush rat	M	113	
5/6	w	27/10/2020	Small Elliot	Bush rat	M	95	
11/12	w	28/10/2020	Small Elliot	House mouse	F	14	
11/12	e	28/10/2020	Cage trap	Lace monitor	Unk	Unk	
9/10	w	28/10/2020	Small Elliot	Bush rat	M	92	
9/10	w	28/10/2020	Small Elliot	Bush rat	M	102	
9/11	w	28/10/2020	Pitfall	Lampropholis delicata			
9/11	E	28/10/2020	Cage trap	Short-eared brushtail possum	F	unk	
7	E	28/10/2020	Small Elliot	FF Melomys	F	68	
5/6	E	28/10/2020	Pitfall	Dwarf crowned snake			
5/6	E	28/10/2020	Small Elliot	FF Melomys	F	71	
5/6	W	28/10/2020	Small Elliot	Bush rat	M	113	
5/6	W	28/10/2020	Small Elliot	Bush rat	M	126	
5/6	W	28/10/2020	Cage trap	Bush rat	unk	unk	
11/12	E	29/10/2020	Small Elliot	FF Melomys	M	84	
11/12	W	29/10/2020	Small Elliot	Black rat	M	91	Euthanised
11/12	W	29/10/2020	Cage trap	Black rat	unk	unk	
11/12	W	29/10/2020	Large Elliot	Sugar glider	F	105	
11/12	W	29/10/2020	Pitfall	Lampropholis spp			
9/10	E	29/10/2020	Pitfall	Calyptotis ruficauda			
9/10	E	29/10/2020	Small elliot	FF Melomys	M	73	
7	W	29/10/2020	Small elliot	Brown Antechinus	F	unk	
7	W	29/10/2020	Small elliot	Brown Antechinus	F	unk	
7	E	29/10/2020	Small elliot	FF Melomys	F	73	
5/6	E	29/10/2020	Small elliot	FF Melomys	F	63	
3	W	27/10/2020	Pitfall	L. delicata x 2	Uk	Uk	
3	E	27/10/2020	Pitfall	L. delicata x 1	Uk	Uk	
3	E	27/10/2020	Pitfall	Pseudophryne coreacia x 2	Uk	Uk	
2	E	27/10/2020	Small elliott	Brown Antechinus	F	26gr	breeding
2	E	27/10/2020	Small elliott	Bush rat	F	123gr	
4	E	27/10/2020	Small elliott	FF Melomys	F	68gr	
4	W	27/10/2020	Small elliott	Bush rat	M	148gr	
4	W	28/10/2020	Cage trap	Bush rat	NR	NR	
4	W	28/10/2020	Pitfall	Pseudophryne coreacia x 2	Uk	Uk	
4	W	28/10/2020	Small elliott	Bush rat	M	148gr	
4	W	28/10/2020	Small elliott	Bush rat	M	149gr	
4	E	28/10/2020	Small elliott	FF Melomys	F	84gr	
3	W	28/10/2020	Pitfall	L. delicata	Uk	Uk	

Site	Side	Date	Trap type	Species	Sex	Weight	Comments
3	E	28/10/2020	Pitfall	Calyptotis ruficauda	Uk	Uk	
2	W	28/10/2020	Pitfall	L. delicata	Uk	Uk	
2	E	28/10/2020	Small elliott	Bush rat	F	132gr	
2	E	28/10/2020	Small elliott	Brown Antechinus	F	29gr	Breeding
1	W	28/10/2020	Pitfall	Dwarf-crowned snake	Uk	Uk	
1	W	28/10/2020	Cage trap	Short-eared brushtail possum	NR	NR	
1	W	28/10/2020	Small elliott	Black rat	F	111gr	Euthanised
2	E	29/10/2020	Small elliott	Brown Antechinus	F	NR	breeding
2	E	29/10/2020	Cage trap	Northern brown bandicoot	NR	NR	
4	E	29/10/2020	Pitfall	House mouse	F	NR	Euthanised
4	E	29/10/2020	Large Elliot	FF Melomys	F	NR	

Table C 7: Results from adjacent habitat hair-funnel analysis (9 days) during spring/summer year three of operational phase monitoring WC2NH, 2020.

Site	Side and bait (1=oats) 2=Sardines)	Spring/Summer 2020		
		Install Date	Collect date	Fauna
1	E-1	26/10/2020	4/11/2020	Trichosurus vulpecula
	E-2	26/10/2020	4/11/2020	
	W-1	26/10/2020	4/11/2020	Trichosurus vulpecula
	W-2	26/10/2020	4/11/2020	
2	E-1	26/10/2020	4/11/2020	
	E-2	26/10/2020	4/11/2020	Rattus fuscipes, Isoodon macrourus
	W-1	26/10/2020	4/11/2020	
	W-2	26/10/2020	4/11/2020	
3	E-1	26/10/2020	4/11/2020	
	E-2	26/10/2020	4/11/2020	
	W-1	26/10/2020	4/11/2020	
	W-2	26/10/2020	4/11/2020	
4	E-1	26/10/2020	4/11/2020	Rattus sp.
	E-2	26/10/2020	4/11/2020	
	W-1	26/10/2020	4/11/2020	Rattus fuscipes
	W-2	26/10/2020	4/11/2020	Rattus fuscipes
5/6	E-1	26/10/2020	4/11/2020	*Trichosurus vulpecula*
	E-2	26/10/2020	4/11/2020	
	W-1	26/10/2020	4/11/2020	Rattus fuscipes
	W-2	26/10/2020	4/11/2020	Rattus sp.
7	E-1	26/10/2020	4/11/2020	
	E-2	26/10/2020	4/11/2020	
	W-1	26/10/2020	4/11/2020	Antechinus sp.

Site	Side and bait (1=oats) 2=Sardines)	Spring/Summer 2020		
		Install Date	Collect date	Fauna
	W-2	26/10/2020	4/11/2020	
8	E-1	26/10/2020	4/11/2020	Trichosurus vulpecula
	E-2	26/10/2020	4/11/2020	
	W-1	26/10/2020	4/11/2020	Pseudocheirus peregrinus(probable)
	W-2	26/10/2020	4/11/2020	
9/10	E-1	26/10/2020	4/11/2020	
	E-2	26/10/2020	4/11/2020	
	W-1	26/10/2020	4/11/2020	*Rattus fuscipes*
	W-2	26/10/2020	4/11/2020	
11/12	E-1	26/10/2020	4/11/2020	
	E-2	26/10/2020	4/11/2020	
	W-1	26/10/2020	4/11/2020	
	W-2	26/10/2020	4/11/2020	Wallabia bicolor

Pacific Highway Upgrade: Warrell Creek to Nambucca Heads

Year 2 Operational phase road-kill monitoring – annual report 2020

Sandpiper Ecological

1/94 Main Street
Alstonville

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1. Introduction

1.1 Background

In 2015, Roads and Maritime Services (RMS) NSW, in conjunction with Acciona Ferrovial Joint Venture (AFJV), commenced the upgrade of the Pacific Highway between Warrell Creek and Nambucca Heads (WC2NH). The WC2NH project was opened to traffic in two stages: stage 2a - 13.5km section from Lower Warrell Creek Bridge to Nambucca Heads opened on 18 December 2017; and stage 2b 6.25km section from the southern end of the project to the Lower Warrell Creek bridge opened in late June 2018.

The upgrade included a number of road-kill mitigation measures to minimise vehicle collisions with native wildlife. The types of structures constructed to mitigate road-kill included:

- Fauna fencing to exclude fauna from the road corridor and to guide fauna towards connectivity structures.
- Fauna Drop Down Structures (escape ramps) along the fauna fencing.
- Fauna connectivity structures, including culverts, bridges, rope bridges and glide poles.

Several fauna fence designs were installed to target threatened species including:

- **Type 1** - Chainmesh fence 1.8 m tall with floppy top feature, which is designed to exclude a range of native mammal species such as macropods, possums, spotted-tail Quoll (*Dasyurus maculatus*) and koala (*Phascolarctos cinereus*). 18.03 km of this fence type occurs at the site.
- **Type 3** - Small gauge mesh fence with sheet metal return angled away from the highway (combined with fauna floppy top fence), which is designed to exclude green-thighed frog (*Litoria brevipalmata*) from the road corridor. 1.32 km of type 3 fauna fence occurs at the site, overlapping with the type 1 fencing.
- **Type 4** - Chainmesh fence 4 m tall through the Macksville Flying-fox camp Paperbark Swamp Forest community designed to discourage grey-headed flying-fox (*Pteropus poliocephalus*) from flying within range of passing traffic when exiting or entering the roost. 1km of type 4 fence occurs at the site.

Sandpiper Ecological Surveys (SES) has been engaged by Transport for NSW (TfNSW) to deliver the WC2NH operational ecological and water quality monitoring program, which includes seasonal road-kill surveys over the entire upgrade length.

Monitoring of road kill is a requirement of the approved WC2NH koala, spotted-tailed quoll and grey-headed flying-fox management plans and the Ecological Monitoring Program (RMS 2018a). Priority species for road-kill surveys are grey-headed flying-fox, koala, spotted-tailed quoll, and giant barred frog (*Mixophyes iteratus*). Monitoring is required for the first five years of operation, and includes weekly surveys for the first 12 weeks of operation and four surveys (at weekly intervals) each season thereafter. Seasonal surveys are scheduled for October, January, April, and July. Due to the staged opening of the project, monitoring of stage 2a commenced in December 2017 with monitoring of stage 2b commencing in July 2018. The 12-week monitoring period for stage 2b ended on 30 September 2018 and Sandpiper Ecological commenced monitoring in October 2018. Previous road-kill monitoring was conducted by Geolink (2018a, b, c, d).

The aim of monitoring is to:

- report on any vertebrate road-kill following opening to traffic; and
- assess the effectiveness of the presence of fauna fencing to prevent fauna being killed by vehicles while attempting to cross the WC2NH Upgrade.

The following report details the methods used to monitor road-kill in 2020 (Year 2 operational phase) and compares road-kill data from 2020 with 2019 (Sandpiper Ecological 2018, 2019a).

1.2 Study area

The WC2NH project covers a total length of 19.75km and extends from Warrell Creek in the south to Nambucca Heads in the North (Figure 1).

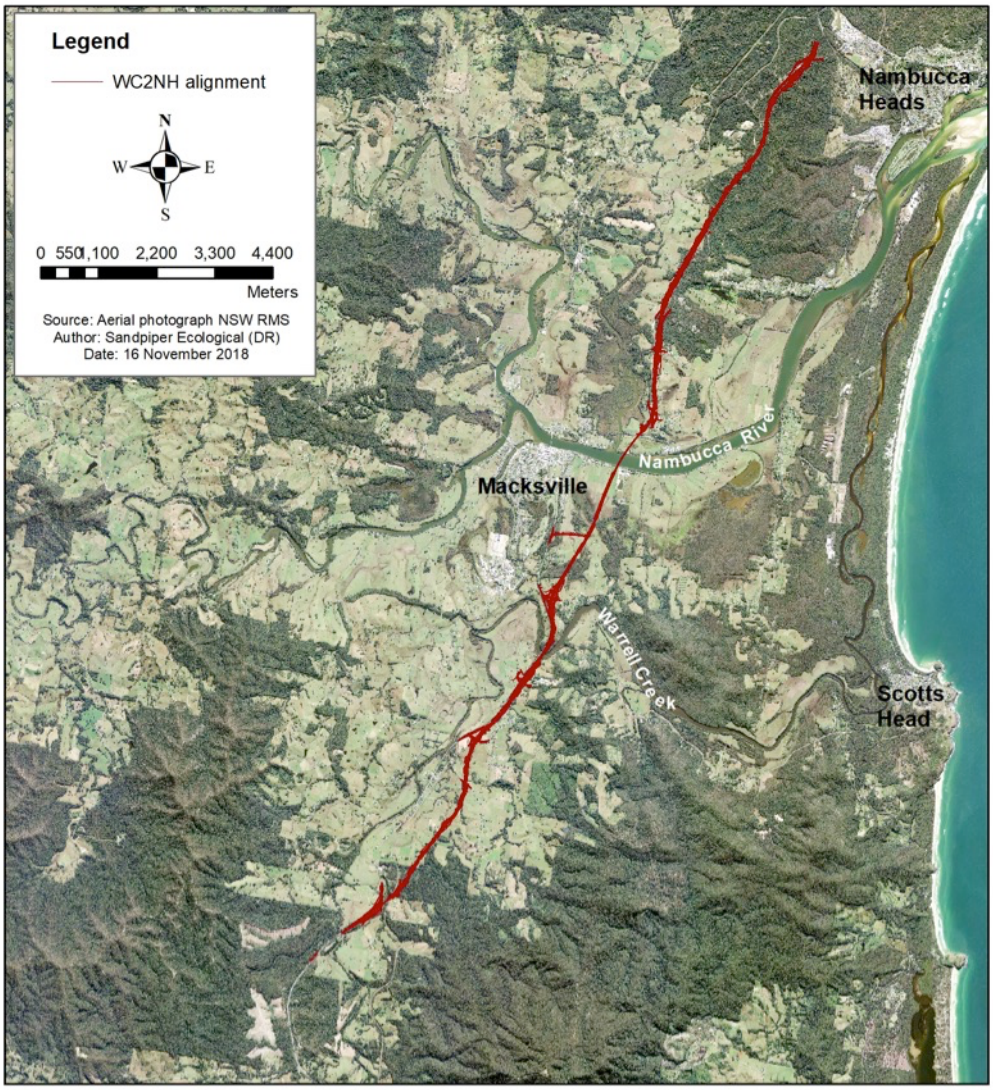

Figure 1: Location of the WC2NH alignment.

2. Methodology

2.1 Road-kill surveys

Surveys were conducted by a two-person team from a vehicle driven at 80-90km/hr in the left lane. The vehicle was equipped with an amber (flashing) light and warning sign (Plate 1). The team consisted of a driver, and ecologist, with experience identifying road-killed fauna. Surveys were undertaken weekly and commenced within three hours of sunrise. During each survey, all personnel scanned the road surface and road shoulder for fauna. When road-killed fauna were detected the vehicle was pulled onto the shoulder/parking bay and the ecologist inspected the subject animal from the closest perpendicular position behind wire rope. Fauna that could not be identified immediately were photographed and images sent to colleagues for assessment. Carcasses were removed from the road surface when safe to do so.

Plate 1: Work vehicle with signage, flashing amber light and indicators.

The April 2020 road-kill survey coincided with government imposed restrictions on social distancing to manage the spread of COVID-19. As part of these restrictions Sandpiper Ecological reviewed its fieldwork practices and initiated a one-person/vehicle restriction unless persons were from the same household. These restrictions meant that one person (an ecologist) conducted the first two road-kill surveys in April 2020, with the second two samples conducted by two operators (including one ecologist) from the same household. Limitations associated with a single operator were overcome by reducing vehicle speed (70-80km/hr) during surveys one and two, and conducting two surveys of the alignment, one immediately after the other, during survey two.

Data collected on each road-kill included (Appendix A1):

- Geographic coordinate
- Presence/absence of fauna exclusion fence
- Species/fauna group
- Date of survey
- Road-kill location – north or southbound carriageway

Data collected for threatened species listed on the Commonwealth *Environment Protection and Biodiversity Conservation Act* (EPBC) *1999* and/or the NSW *Biodiversity Conservation Act* (BC) *2016*, included, where possible: sex and age (juvenile/adult); presence of pouch young if applicable; presence of flightless young (flying-foxes); distance to a fauna connectivity structure; distance to a drop-down structure if applicable; damage to fauna fencing; weather conditions; if the animal was a flying-fox – distance to nearest camp, distance to nearest canopy vegetation, and presence of flowering food trees in median or roadside vegetation. Mammal groups were defined as: small (rodent, small dasyurid, phascogale, small glider etc); medium (possum, bandicoot, quoll, etc); large (wallaby and kangaroo).

All road-kills were cross-referenced with the previous survey results to identify possible duplicates. Using, at a minimum, one team member consistently across all surveys, GPS coordinates of each specimen, looking at carcass age and location on the carriageway, and detailed location description assisted with identification of duplicates. Distance to connectivity structure, and distance to escape structure was determined via GIS. All other data were entered on an iPad in the field.

2.2 Data summary and analysis

Data from the October 2020 survey were uploaded to Microsoft Excel and compared with results from July 2020 to identify duplicate records. The location of October road-kills were then overlaid on the WC2NH alignment to show distribution and compared to road-kills recorded in summer, autumn, and winter 2020 (Table 2). Graphs were produced showing the total number of road-kills in relation to sample periods (years, season and sample weeks), taxonomic groups (i.e. reptile, mammal and bird) and unfenced vs fenced sections of the highway.

2.2.1 Statistical analysis

The primary aim of statistical analysis was to determine if there is a statistical difference in the frequency of road-kill between fenced and unfenced sections of the alignment. Road-kill data were summarised by removing species/groups that would not (under normal circumstances) be stopped by exclusion fence from accessing the road alignment e.g. birds, small reptiles, frogs, small mammals and flying-foxes. Species/groups of fauna likely to be stopped by exclusion fence and therefore included in the analysis are listed in Table 1. Introduced species were included in the analysis. Freshwater turtles were included, as exclusion fence with a ground return should stop this group. Small lace monitors could move through exclusion fence, however, individuals of that size are rarely recorded in open habitats and that species has been included.

The location of each road-kill in relation to exclusion fence was determined by overlaying road-kill records on a plan of exclusion fence extent using ArcGIS. If exclusion fence occurred on one side only the record was classified as “No fence”. Further, road-kill records on bridges were considered unfenced unless exclusion fence extended 100 m beyond both ends of the bridge. Sections of the alignment with a single fence may be included as a separate category in future analysis as sample size increases.

Data were pooled across all samples and divided into “fenced” and “unfenced”. Expected proportions were based on the proportion of highway with fence on both sides (“fenced”) and proportion with a single fence, or no fence (“no fence”). The proportion of fenced verses unfenced was 0.55 to 0.45. Data were analysed using a two-tailed G-test as per the equation of McDonald (2013), and a Kruskal-Wallis test in Systat 13.

Table 1: Fauna groups included in comparison of fenced and unfenced sections of alignment.

Group	Species included
Large Dasyurid	Spotted-tailed quoll
Macropods	Red-necked wallaby, swamp wallaby & eastern grey kangaroo
Bandicoots	Long-nosed & northern brown bandicoots
Possum	Brushtail & ringtail possums
Canid	Fox & dog
Feline	Cat
Leporidae	Hare & rabbits
Freshwater turtles	Long-necked, saw-shelled and Macleay river turtles
Goanna	Lace monitor
Barred frog	Giant barred frog

3. Results

3.1 October 2020 sample

3.1.1 Weather conditions

Weather conditions in the 24hrs preceding each sample were conducive to fauna movement and retention of carcasses on the road surface (Table 2). Light rain (3.8mm) occurred on 23 October prior to the fourth sample with a negligible effect on carcasses retention.

Table 2: Weather conditions in the 24hrs preceding each sample event. Data obtained from BoM Bellwood and Coffs Harbour Weather stations.

Date	Average Relative Humidity (%)	Rainfall (mm)	Max Temperature (^{0}C)	Average Wind Speed (KPH)	Visibility during survey	Rain during survey
2/10/20	63	0.4	23.2	20	Good	Nil
9/10/20	61	0	25.9	15	Good	Nil
16/10/20	60	0	27.5	35	Good	Nil
23/10/20	68	3.8	25.4	56	Good	Nil

3.1.3 Opportunistic road-kill information

No opportunistic road-kill records were obtained during the October 2020 sample period.

3.1.2 Species richness and abundance

A total of 25 road-killed fauna were recorded during the October 2020 sample period. This included twelve native species (two introduced – European hare and goose) and five fauna groups (Table A1, Appendix A). Birds were the most diverse group represented with six species and one group recorded (Table 3). Mammals were the next most diverse group recording three species and three groups (Table 3). Reptile records included two species (eastern-long necked turtle, eastern bearded dragon) and one group (*Chelidae* sp.). A masked owl, listed as vulnerable under the NSW *Biodiversity Conservation (BC) Act* 2016, was recorded north of Upper Warrell Creek. No frogs were recorded during October surveys.

Mammals accounted for 40% of road-kill detections (ten individuals) followed by birds (nine individuals), reptiles (four individuals) and introduced species (two individuals) (Table 3). Wallabies were the most frequently detected group with seven individuals recorded (Table 3). This included three red-necked wallabies, two swamp wallabies and two wallaby spp (Table 3). Degradation, and location of carcasses on the carriageway made identification to species level difficult in some cases (Table 3).

Of the 25 road-kill records, 13 (54%) were individuals that should be blocked by exclusion fence. The remaining 12 records, predominantly birds (8 individuals), were species that readily move through or over exclusion fencing (others included rodent spp and a bearded dragon).

Table 3: Species of vertebrate fauna recorded during seasonal road-kill surveys throughout the operational phase of the WC2NH upgrade. * denotes threatened species; ** = stage 2a only.

Species	Sum 17/18 **	Aut 18 **	Win 18 **	Spr 18	Sum 19	Aut 19	Win 19	Spr 19	Sum 20	Aut 20	Win 20	Spr 20	Total
Birds													
Australian magpie	6	1		1				2	2	1			13
Grey butcherbird			1										1
Magpie-lark	2		1		1		1		1		1	1	8
Australian white ibis			1						1				2
Cattle egret				1						1			2
Little pied cormorant					1								1
Buff-banded rail					1								1
Purple swamphen	3		2	2		1		2	3		1	1	15
White-headed pigeon										1			1
Crested pigeon	2												2
Galah	7				1			3					11
Rainbow lorikeet								1					1
Eastern grass owl*				1									1
Australian boobook			1	1			1				1		4
Masked owl*	1				1		1					1	4
Eastern barn owl			11	3		1	5	2	1				23
Tawny frogmouth	1	3	1	2		6		4		1		1	19
Australian owlet-nightjar					1					1			2
Laughing kookaburra	3		2	1		2		3	1	1	2	1	16
Forest kingfisher	1												1
Australian wood duck	20			2	2		1	2				2	29

Species	Sum 17/18 **	Aut 18 **	Win 18 **	Spr 18	Sum 19	Aut 19	Win 19	Spr 19	Sum 20	Aut 20	Win 20	Spr 20	Total
Pacific black duck	2		1										3
Whistling kite				1									1
Black-shouldered kite					1	1							2
Torresian crow					1								1
Pied currawong				1									1
Black-faced cuckoo-shrike								1					1
Dollarbird					2								1
Green catbird					1								1
Australasian figbird										1			1
Black bittern*						1							1
Eastern yellow robin						1							1
Pheasant coucal							1		1				2
Masked lapwing							1						1
Welcome swallow								1					1
Red-browed finch										1			1
Duck spp.						1				1			2
Tyto spp.										1			1
Small bird								2					2
Medium bird				1	2	2	2	2	6	1	1		16
Unidentifiable bird	5	4	1		3						2	2	17
Total birds	53	8	22	17	18	16	13	25	16	11	8	9	214
Mammals													
Short-beaked echidna				3				2		1	2	1	9

Species	Sum 17/18 **	Aut 18 **	Win 18 **	Spr 18	Sum 19	Aut 19	Win 19	Spr 19	Sum 20	Aut 20	Win 20	Spr 20	Total
Black flying-fox	2	1			7	1	1						11
Grey-headed flying-fox*					8			5	2				15
Pteropus spp.					3	8	1		1	1			14
Common brushtail possum			1	2						1			4
Trichosurus spp.									1	1	1		3
Common ringtail possum					1			1					2
Eastern grey kangaroo				3			1						4
Red-necked wallaby			6		8	2	8	3	7	1	8	3	46
Swamp wallaby	2	1		1		1	1			1	1	2	10
Wallaby spp.						2			3			2	7
Macropod spp.	3		2	1	1					2	1		10
Northern brown bandicoot	1		1		1	1	1	2	2	3	3		15
Bandicoot spp.						1		4				1	6
Chalinolobus spp. (microbat)				1									1
Microbat spp.					1								1
Rodent spp.						2						1	3
Small mammal					2						1		3
Medium mammal				2	4	2	4	5	2	2	2		23
Large mammal				1	1			1			1		4
Unidentified Mammal	1			3									4
Total mammals	10	2	10	17	36	20	17	23	18	13	20	10	196
Reptiles													
Common blue-tongued	1			2	1				2				6

Species	Sum 17/18 **	Aut 18 **	Win 18 **	Spr 18	Sum 19	Aut 19	Win 19	Spr 19	Sum 20	Aut 20	Win 20	Spr 20	Total
skink													
Carpet python	1			2	1	1		1					6
Common tree snake	1	2						1					4
Eastern long-neck turtle	1			6						1		2	10
Macquarie river turtle	5	1					1						7
Unidentified *Chelidae* spp.	6							1				1	8
Red-bellied black snake	1												1
Eastern water dragon	1			1									2
Eastern bearded dragon												1	1
Blackish blind snake						1							1
Yellow-faced whipsnake				1									1
Unidentified reptile								2		1			3
Total reptiles	17	3	0	12	2	2	1	5	2	2	0	4	50
Frogs													
Green tree frog	2												2
Striped marsh frog	3												3
Medium frog				3									3
Large frog				1									1
Total frogs	5	0	0	4	0	0	0	0	0	0	0	0	9
Introduced species													
Cat	1												1
European fox	3	1	1	2	1	1	2						11
European hare	2			1						1		1	5

Species	Sum 17/18 **	Aut 18 **	Win 18 **	Spr 18	Sum 19	Aut 19	Win 19	Spr 19	Sum 20	Aut 20	Win 20	Spr 20	Total
Rabbit	1												1
Black rat	1					1							2
House mouse					1								1
Rock pigeon			1	1									2
Domestic goose				1								1	2
Total introduced species	8	1	2	5	2	2	2	0	0	1	0	2	25
Total	93	14	34	55	57	40	33	53	36	27	28	25	495

The number of road-kill recorded each week in October 2020 varied during the sample period. There was a substantial difference in road-kill abundance between the first two surveys and the third and fourth surveys (Figure 2). Nineteen road-killed fauna were recorded in week one (9 individuals) and two (10 individuals) with the remaining during weeks three and four (three individuals each survey). Week one is not representative of the number of individuals killed in the preceding week as it includes the period between the July and October sample periods.

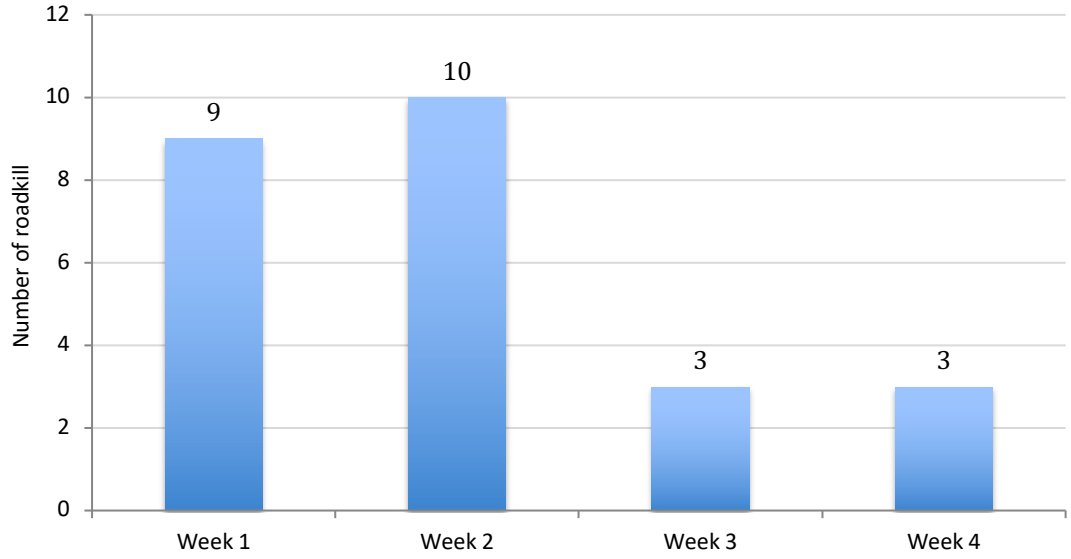

Figure 2: Number of road kills recorded in each sample week during the October (spring) sample period.

The abundance of road-killed fauna in the four vertebrate groups varied over the sample period (Figure 3). The number of road-killed mammals ranged from five in week two to one in week three with detections (>1) occurring throughout the sample period. The number of road-killed birds ranged from four during week two to none during week four. Two reptiles were recorded in week one with single records occurring during weeks two and four (Figure 3).

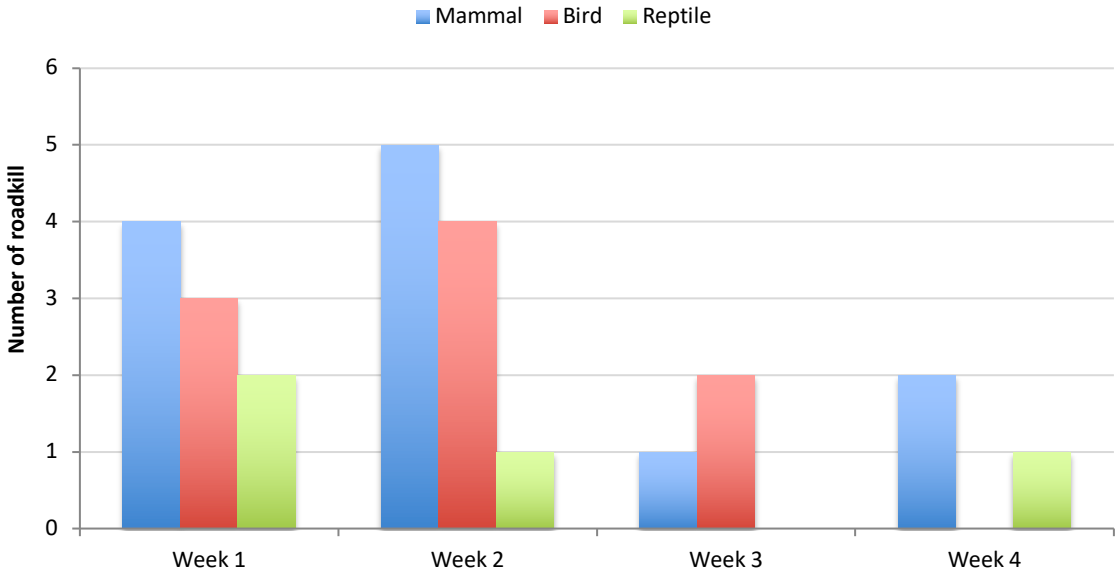

Figure 3: Number of road-killed fauna from four vertebrate classes during each sample week in October 2020.

3.1.4 Distribution of road-kill

In October 2020, road-killed fauna was recorded over the entire WC2NH alignment (Figure 4-8), although the majority of records (68%) occurred south of Mattick Road. Of the eight road-kills recorded north of Mattick Road, 50% were birds. Despite the broad distribution of road-kill a distinct cluster was evident between the Nambucca River and Mattick Road (Five individuals; 2.5 ind/km). Four of the five individuals were wallabies with one bird (domestic goose) recorded (Figure 6 & 7). Clusters of two or more individuals were also recorded to the south of Lower Warrell Creek Bridge and around Nambucca Floodplain Bridge 1 (Figure 5 & 6).

In October 2020, 14 road-kills were recorded in areas with exclusion fence, and 11 were recorded in areas without exclusion fence (Figures 4-8). Road-kills in areas with exclusion fence on one side of the carriageway were classed as fence absent. Five records (or 36%) in sections with fence were species that should have been blocked by the fence (i.e. medium and large mammals and reptiles). In contrast, eight individuals (or 72%) of road-kills in sections without fence were of species that should be blocked by a fence.

Figure 4: Location of road-killed fauna recorded in 2020. Note: only October 2020 records are labeled.

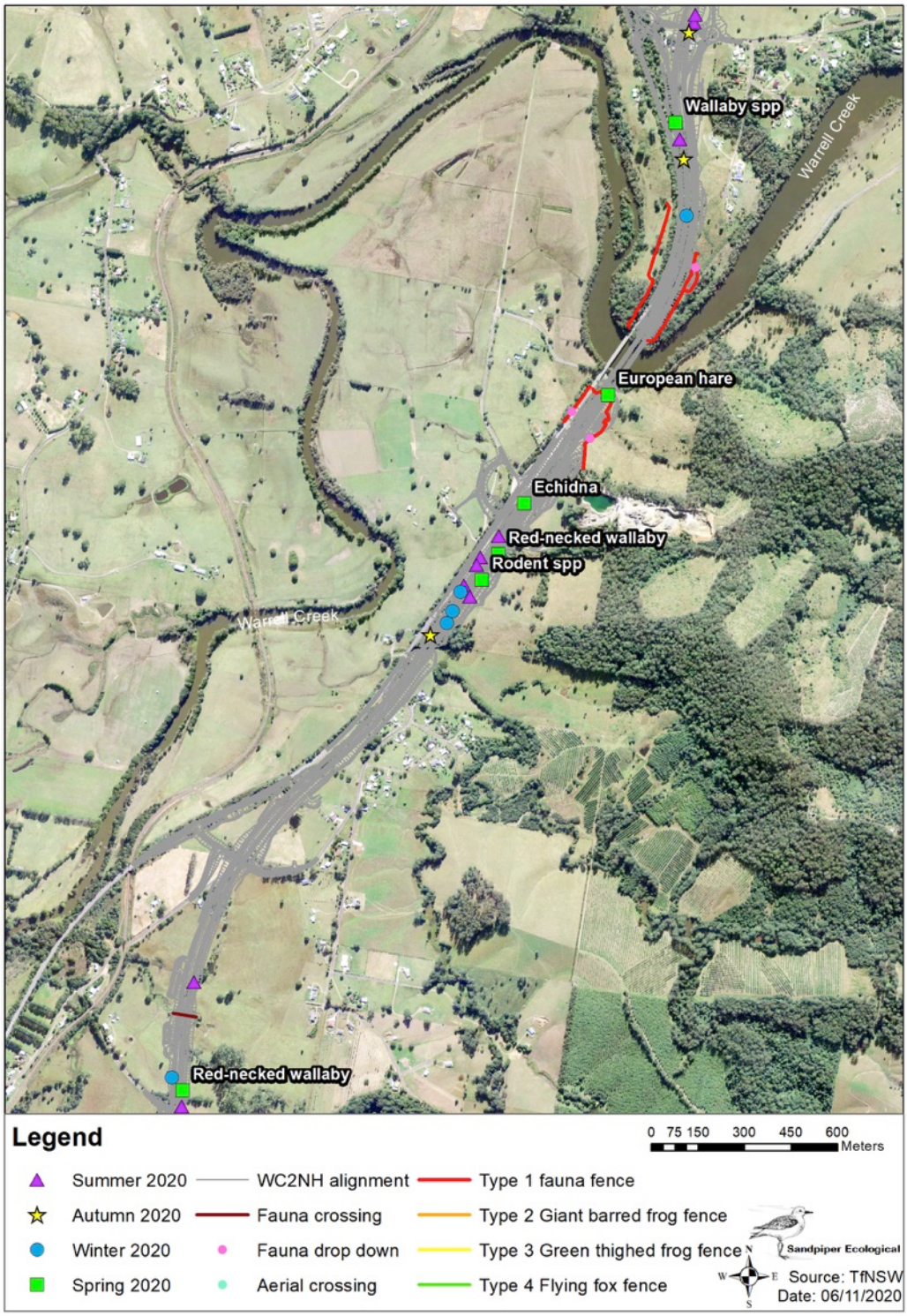

Figure 5: Location of road-killed fauna recorded in 2020. Note: only October 2020 records are labeled

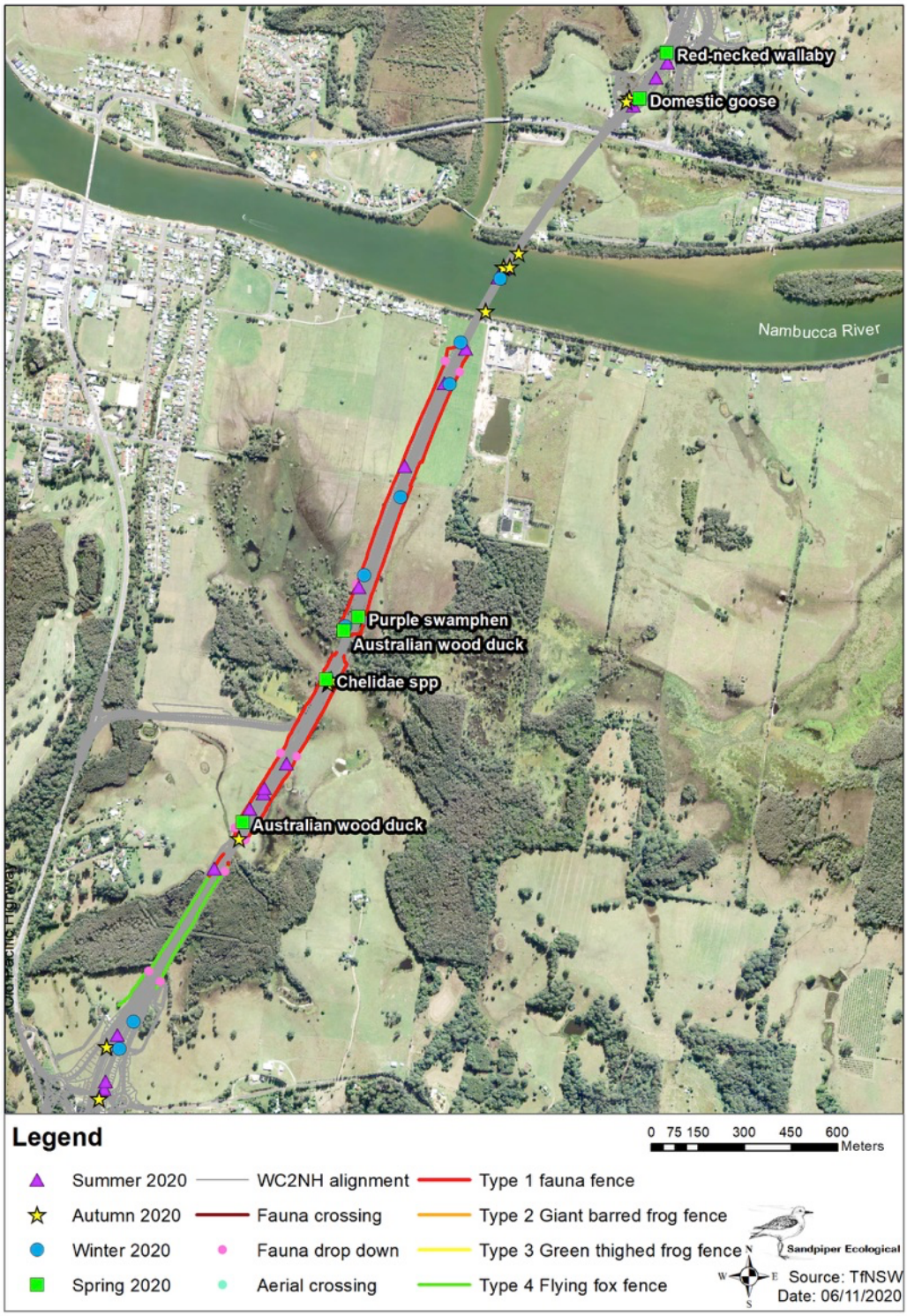

Figure 6: Location of road-killed fauna recorded in 2020. Note: only October 2020 records are labeled.

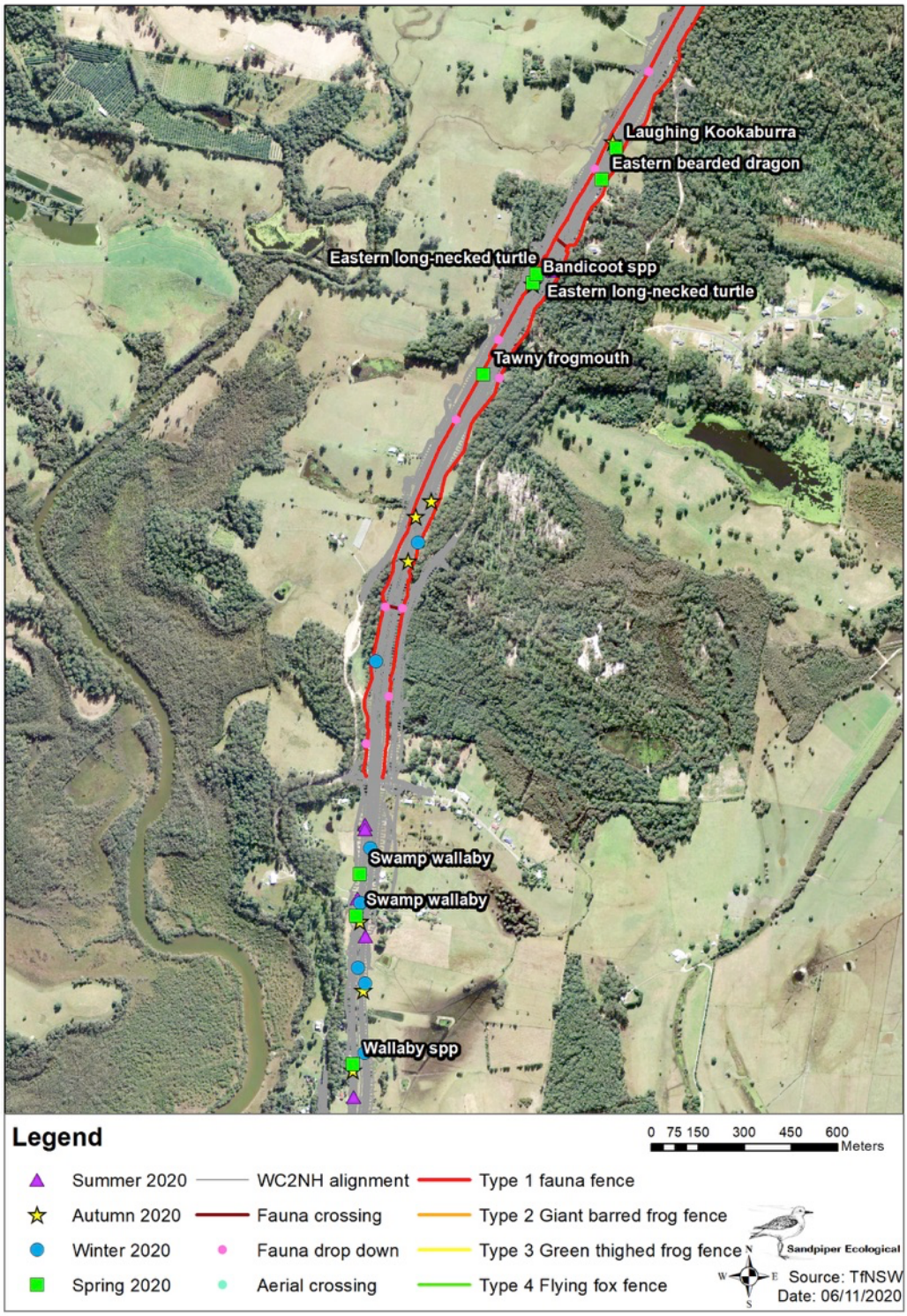

Figure 7: Location of road-killed fauna recorded in 2020. Note: only October 2020 records are labeled.

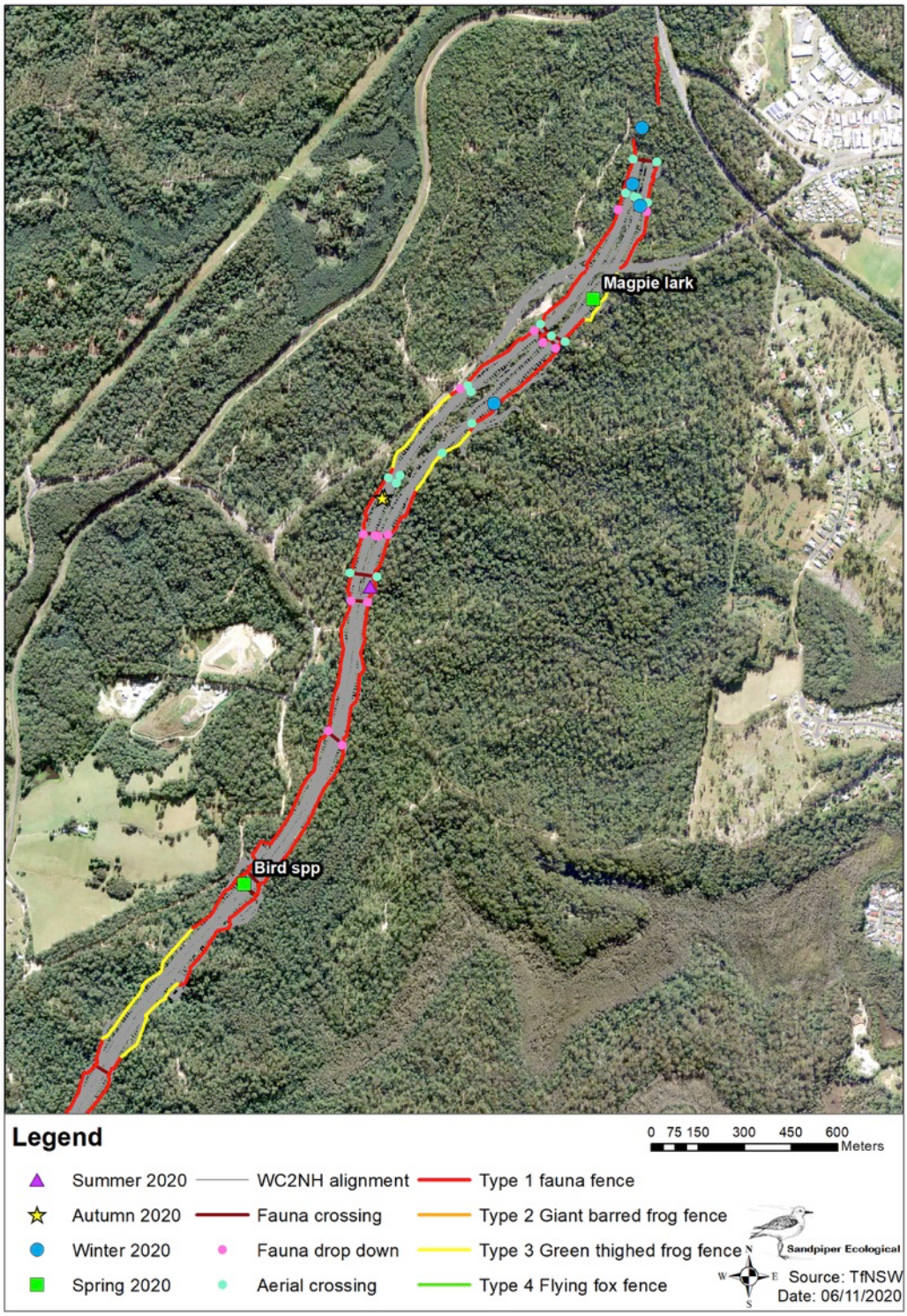

Figure 8: Location of road-killed fauna recorded in 2020. Note: only October 2020 records are labeled.

3.2 Annual results 2020

3.2.1 Species richness and abundance

A total of 30 species and a further 13 fauna groups were recorded during road-kill surveys in 2020, including two threatened species, masked owl and grey-headed flying-fox (Table 3). Both threatened species are listed as vulnerable under the *BC Act* 2016 grey-headed flying-fox is also listed as vulnerable under the Commonwealth *Environment protection and Biodiversity Conservation Act* 1999.

The highest species richness of road-kill was recorded in autumn (14 native species; 5 groups), followed by spring (12 native species; 7 groups), summer (11 native species; five groups) and winter (8 species; 7 groups). The most commonly recorded species were red-necked wallaby (18 records), northern brown bandicoot (8 records), laughing kookaburra (4 records), and swamp wallaby (4 records; Table 3). There were a further six records of medium mammal, which could have been bandicoots or possums.

3.2.2 Temporal comparisons

In 2020 a total of 116 individuals were recorded across the 16 road-kill samples (Table 3). Native mammals were the most commonly recorded group with 61 records, followed by birds (44 records), reptiles (8 records) and introduced mammals (3 records). Road-kill abundance fluctuated between sample weeks (Figure 9). The number of road-kill typically peaked in the first sample week/season (Figure 9) as that sample includes road-kills over a longer period than one week. A more accurate indication of road-kills/week is provided by weeks two, three and four in each sample period.

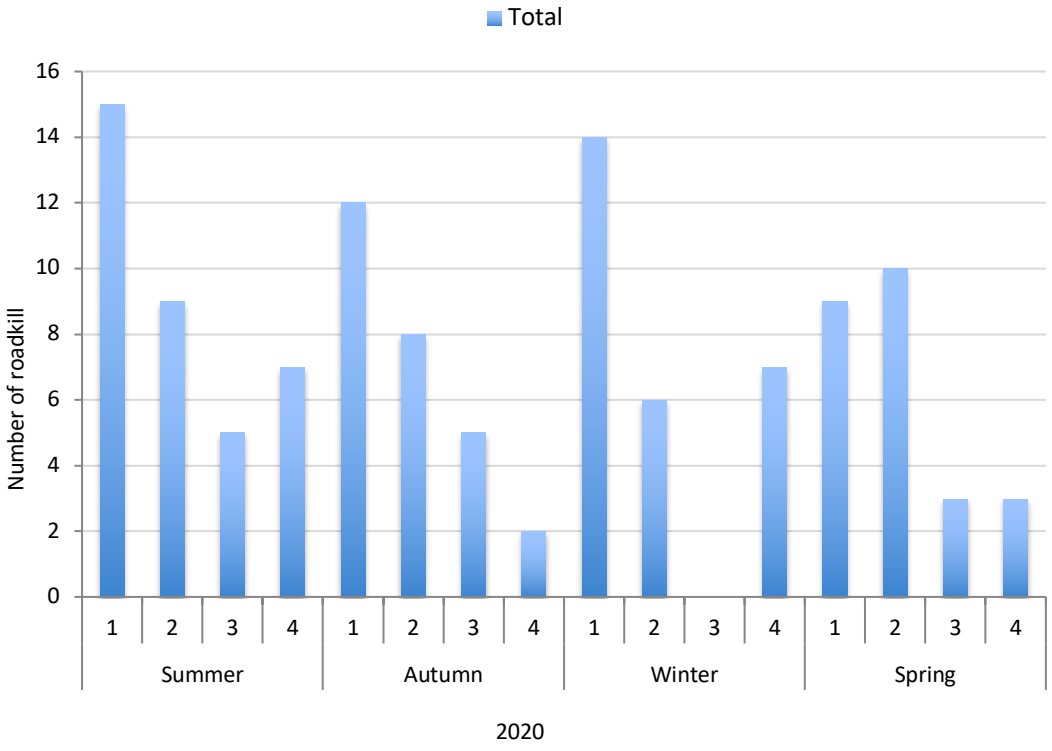

Figure 9: Total number of road-kill recorded each week during 2020.

In comparing the number of road-kills in each sample period (2019 and 2020 combined) the data show a declining trend from spring through summer and autumn to a low in winter (Figure 10). The large standard deviations reflect variations in road-kill numbers between weeks and the higher number recorded in the first week of each sample period.

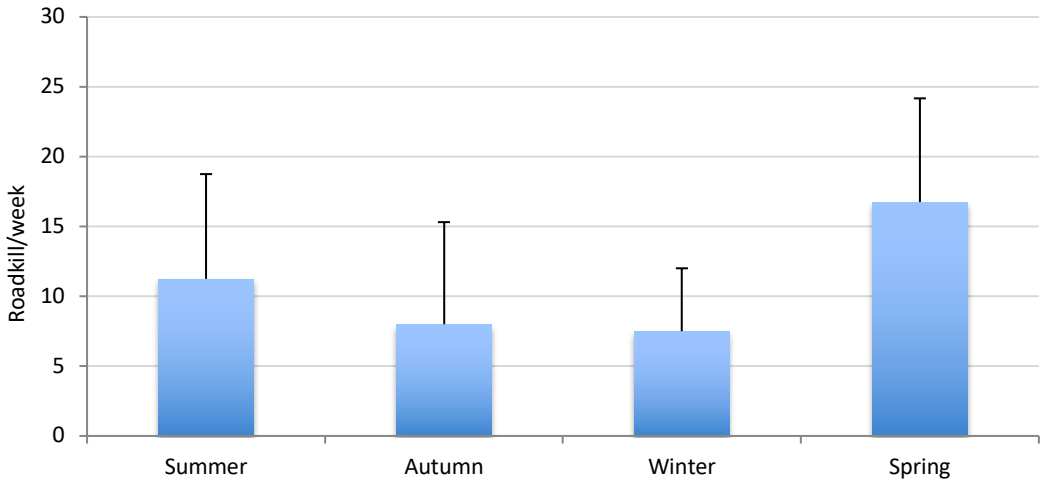

Figure 10: Mean (+SD) number of road-kill per week (n=8) recorded during each sample period (2019 and 2020 combined).

A comparison between 2019 and 2020 data showed a general decline in the number of road-kill (Figure 11). Substantially fewer birds and mammals were recorded in 2020 in comparison to 2019 (Table 4). Whereas the number of introduced individuals also decreased and reptile records remained relatively consistent (Table 4).

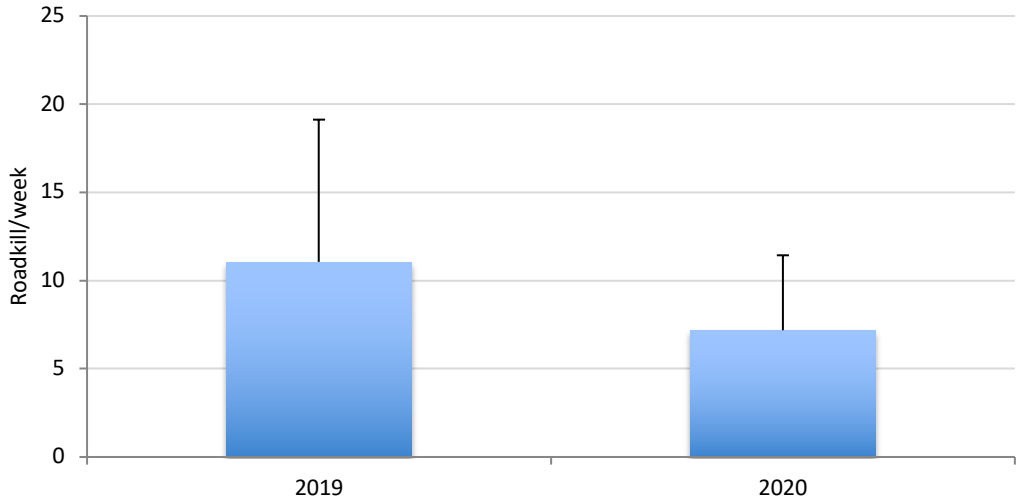

Figure 11: Mean (+SD) number of road-kill per week (n=16) recorded during operational phase monitoring (2019 and 2020).

Table 4: Comparison of road-kill numbers between 2019 and 2020 sample periods.

Year	Total	Birds	Mammals	Reptiles	Amphibians	Introduced
2019	183	72	96	10	0	6
2020	115	45	60	8	0	2

3.2.3 Flying-foxes (*Pteropus* spp.)

Four flying-foxes, including two confirmed as grey-headed flying-fox, were recorded in 2020, with three recorded in summer and one in autumn.

3.2.3 Distribution of road-kill

Road-killed fauna have been recorded over the entire study area (Figures 4-8). There were substantially fewer road-kills in areas with continuous fauna fence north of Mattick Road and the southern extent to just north of Rosewood Road. Road-kill density between the southern extent and just north of Rosewood Road was 3.3 ind/km, which is similar to the 3.57 ind/km recorded north of Mattick Road, but less than the 9.18 ind/km recorded between Warrell Creek and Nambucca river (inc. Gumma floodplain) and 26.7 ind/km on the Nambucca Bridge. Notable road-kill hotspots include:

- Warrell Creek to Nambucca river (inc. the Gumma floodplain) (34 records).
- Nambucca River to Mattick Road (23 records).
- Scotts Head Road to Williamsons Creek (12 records).
- Nambucca River Bridge (8 records).

3.2.4 Fenced vs unfenced

In both 2019 and 2020 the number of road-kills of species that should be blocked by exclusion fence varied between sections of alignment with or without fauna exclusion fence (Figure 12). The number of road-kill was higher in sections where exclusion fence was absent and lower along fenced areas of the alignment (Figure 12). The distribution of species recorded in 2019 and 2020 that should be blocked by the fence is shown on Figures 13 to 20. These figures highlight the clustering of records in areas without fence such as south of Mattick Road (Figure 15), north and south of Bald Hill Road (Figure 17), and between Upper Warrell creek and Warrell creek (Figures 18 & 19).

A G-test was run on two sets of data, 2020, and 2019 + 2020 (Table 5). A statistically significant difference in the number of road-kill between fenced and unfenced areas was recorded for both data sets (Table 5), with a significantly higher number of road-kills in unfenced sections of the alignment. The Kruskal-Wallis test did not record a statistically significant difference between fenced and unfenced sections of the alignment (n=16, df=1, P=0.054), although the result was very close to being significant.

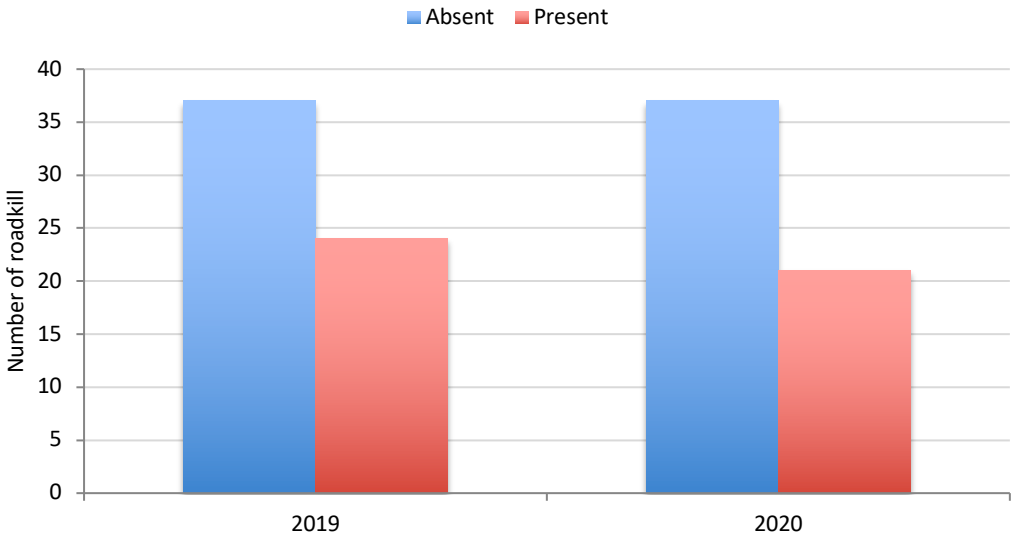

Figure 12: Annual comparison in the number of road-kill reported along the WC2NH alignment where fauna fence is present or absent. Only includes fauna that is likely to be excluded by the fauna fence (see Table 1).

Table 5: Results of G-test on road-kills in fenced and unfenced sections of the alignment.

Group	Category	Nº. road-kill	Expected proportion	Expected Nº.	Df	G statistic	P (2-tail)
All species (2020)	Fence	19	0.55	33.55	1	14.12	0.0001
	No fence	42	0.45	27.45			
All species (20+19)	Fence	40	0.55	68.75	1	26.86	<0.0001
	No fence	85	0.45	56.25			

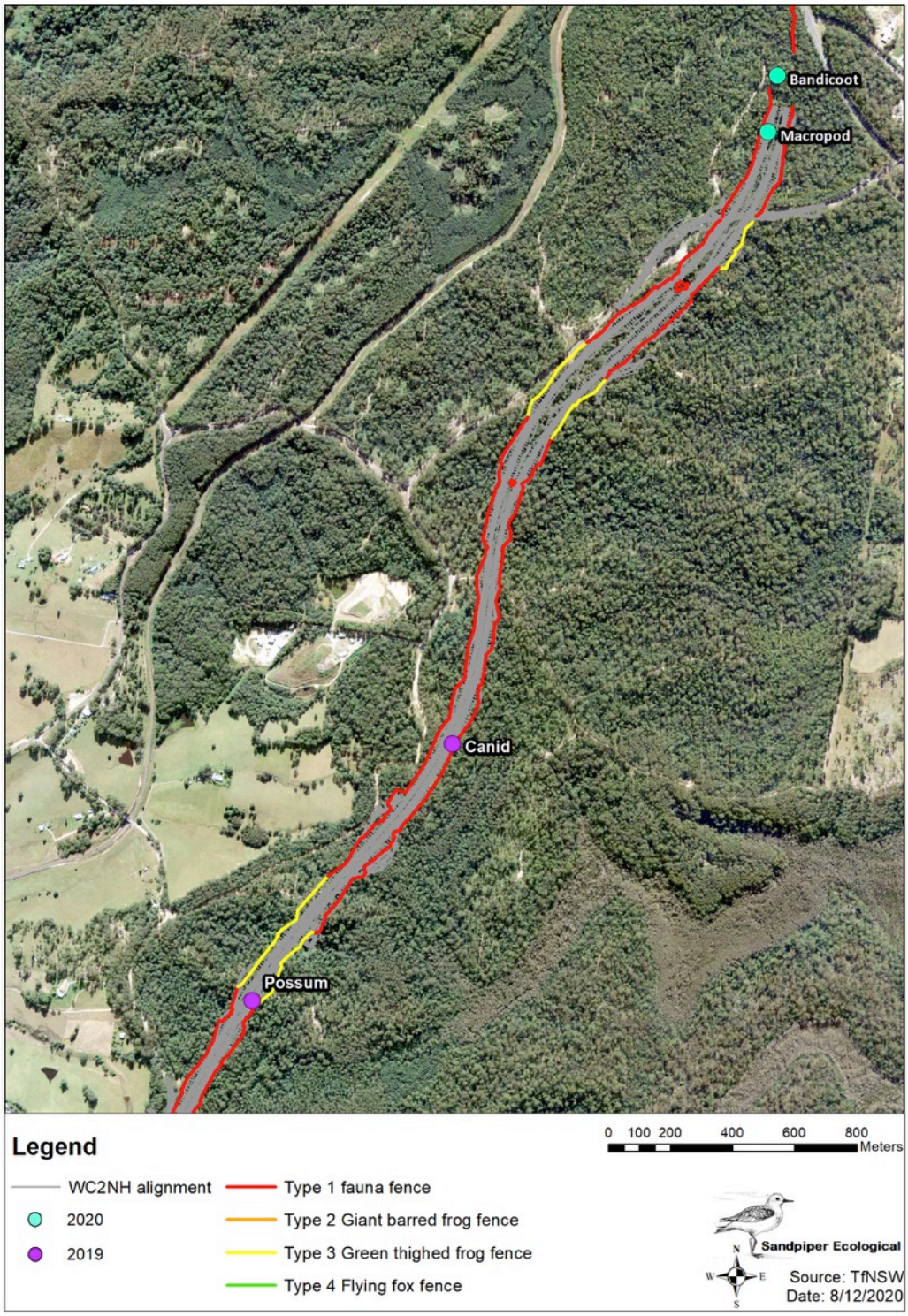

Figure 13: Distribution of fauna groups recorded in 2019 and 2020 that should be blocked by exclusion fence.

Figure 14: Distribution of fauna groups recorded in 2019 and 2020 that should be blocked by exclusion fence.

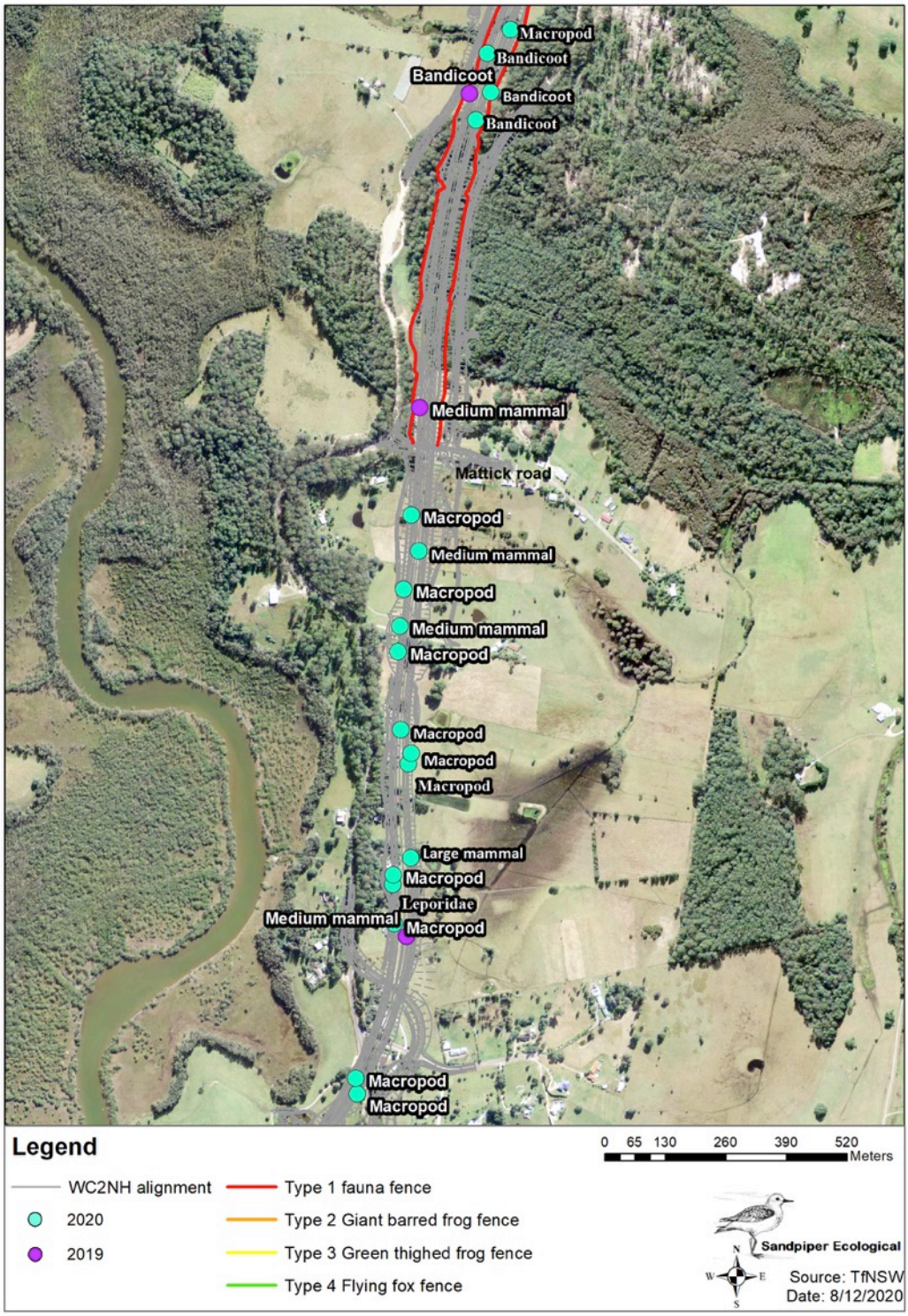

Figure 15: Distribution of fauna groups recorded in 2019 and 2020 that should be blocked by exclusion fence.

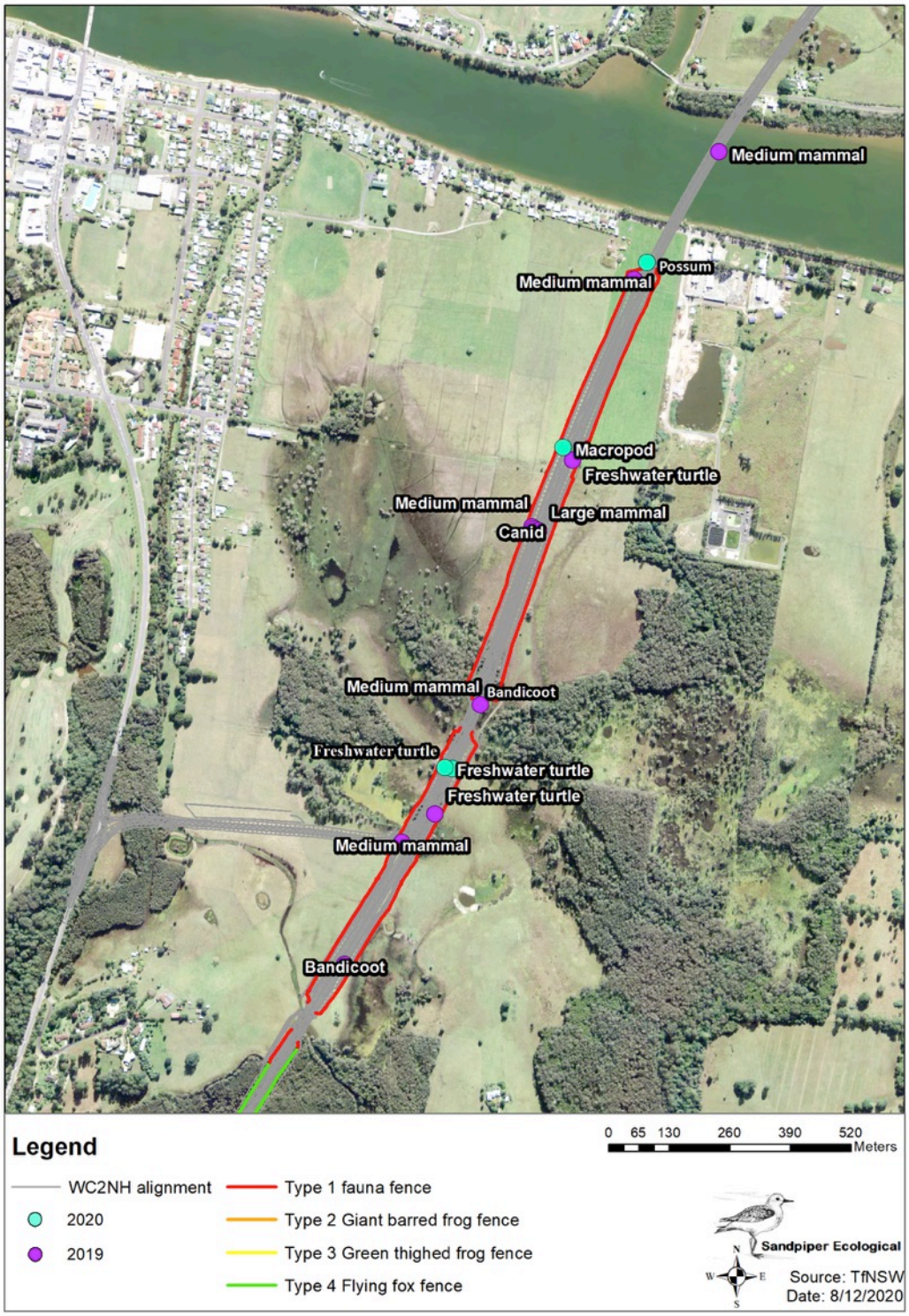

Figure 16: Distribution of fauna groups recorded in 2019 and 2020 that should be blocked by exclusion fence.

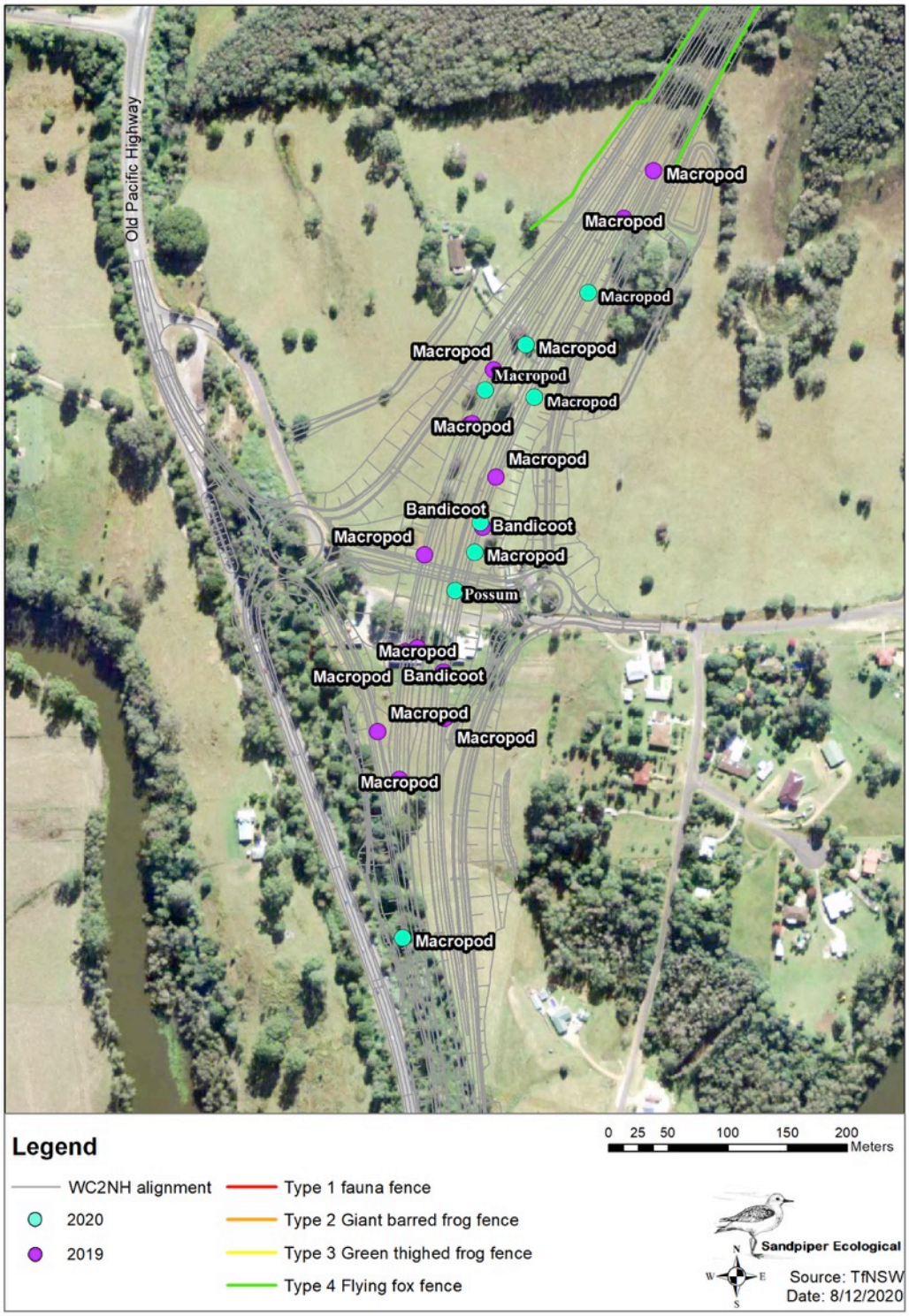

Figure 17: Distribution of fauna groups recorded in 2019 and 2020 that should be blocked by exclusion fence.

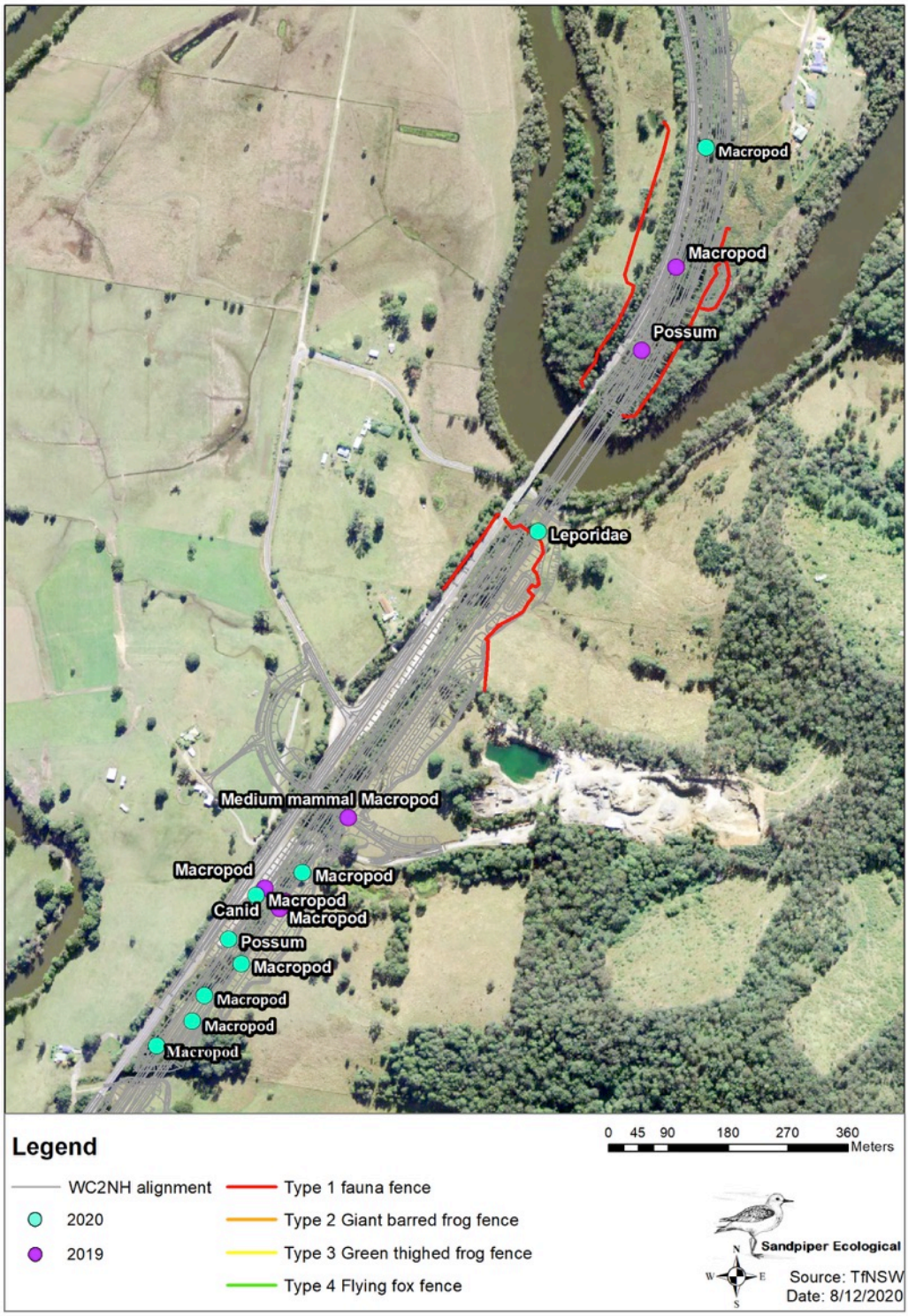

Figure 18: Distribution of fauna groups recorded in 2019 and 2020 that should be blocked by exclusion fence.

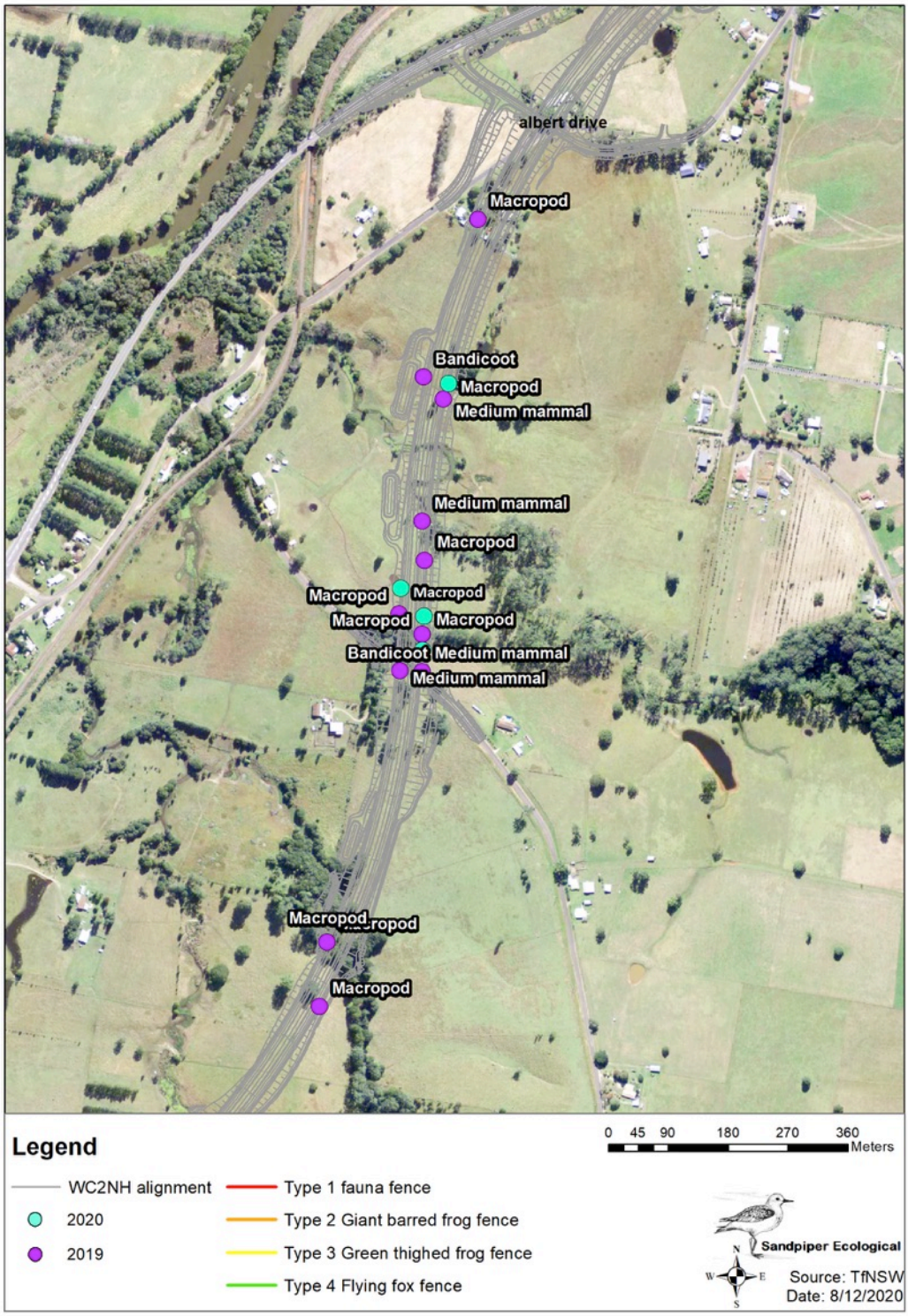

Figure 19: Distribution of fauna groups recorded in 2019 and 2020 that should be blocked by exclusion fence.

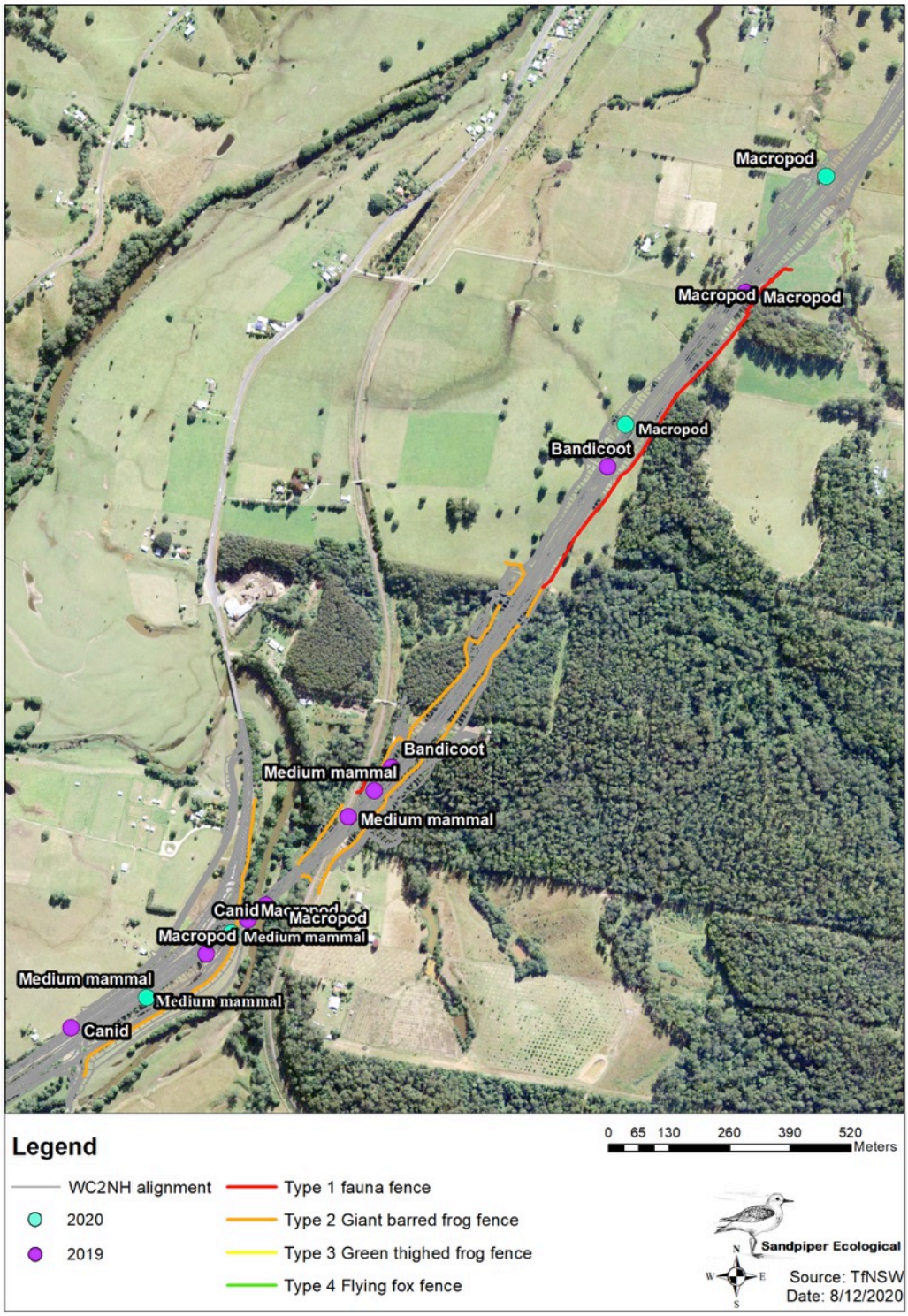

Figure 20: Distribution of fauna groups recorded in 2019 and 2020 that should be blocked by exclusion fence.

4. Discussion

4.1 October 2020

Road-kill monitoring over the entire WC2NH alignment in October 2020 indicated that fauna continue to be killed by vehicles 27 months after the entire alignment was opened to traffic. Road-kill abundance decreased slightly from 28 individuals in winter to 25 individuals in spring (October). Species richness increased from 10 to 15 over the same period. Unlike previous samples the number of road-kill peaked in week two rather than week one. This is contrary to the trend recorded in previous surveys and may be due to a failure to detect some records during the first survey. This likelihood is supported by a noticeable decline in road-kill abundance during weeks two and three.

Monitoring identified a distinct clustering of road-kill consistent with previous samples (see Sandpiper Ecological 2018, 2019a). Sections of alignment between the Nambucca River and Mattick Road, Gumma Floodplain, and between upper and lower Warrell Creeks featured clusters of road-kill. These areas are consistent with most previous quarterly surveys. No amphibians were recorded in October 2020, which is consistent with previous surveys and further emphasises the difficulty identifying road-killed amphibians during vehicle-based surveys.

4.2 Temporal and spatial variation

The distinct seasonal effect recorded in 2018 and 2019 of peaks in spring and summer was less pronounced in 2020 when road-kill abundance peaked in summer (36 individuals) and then remained reasonably consistent in autumn (27), winter (28) and spring (25). The spring/summer peak has been attributed to seasonal changes in breeding cycles and foraging demands (Sandpiper Ecological 2019a). The pattern recorded in 2020 may be influenced by better climatic conditions, which reduced the need for herbivores to forage along the road edge and the need to move larger distances to forage. Further monitoring will assist in determining if the 2020 trend continues.

There have been some notable increases and decreases in abundance of some species between 2018 and 2020. Decreases identified in 2019 for Eastern barn owl, Australian magpie, Australian wood duck, freshwater turtles, and amphibians continued in 2020. Decreases between 2019 and 2020 are evident for carpet python, flying-foxes, European red fox, galah, and tawny frogmouth. These decreases are attributed to a combination of improved climatic conditions from 2018/19 to 2020 (eastern barn owl, amphibians, freshwater turtles, flying-foxes), changes in habitat within the road corridor (Australian wood duck, freshwater turtles), and possibly reduced population size near the alignment (Australian magpie, carpet python). Habituation to the highway is also likely to have influenced road-kill abundance of some species. Introduced species are often the first group to regularly utilise underpasses (Sandpiper Ecological 2015) and it is not surprising to see fox numbers decline and very few cats recorded.

Both short-beaked echidna and bandicoots displayed possible increases in road-kill abundance in 2020. Whilst the abundance of macropods remained high in 2020 (31 road-kills) numbers were consistent with 2019 (27 road-kills). This result is surprising as the 2019 findings were attributed to increased movement and use of the highway corridor for foraging due to drought conditions (Sandpiper Ecological 2019a). A suggestion supported by the findings of Klocker *et al.* (2006), who also recorded elevated road-kill during drought. Continued road-kill at present rates is likely to reduce the abundance of macropods, particularly red-necked wallaby in habitat adjoining the road (Huijser &

Bergers 2000). If macropod road-kill continues at 2019/20 rates in 2021, mitigation measures should be considered at key hotspot sites.

Whilst bandicoots are not grazers they may be attracted to the highway to forage on mulch bunds and batters. Numerous bandicoot diggings have been observed on mulch bunds in some sections of the alignment. Bandicoots are capable of getting through small gaps in fauna fence and it is possible that some road-kill records are due to this. An inspection of the fauna exclusion fence in winter 2020 identified several points where bandicoots could gain access to the alignment (Sandpiper Ecological 2020). TfNSW has commenced repairing these gaps.

Sandpiper Ecological (2018) suggested that the occurrence of birds in road-kill might decline as individuals habituate to the highway. This suggestion is supported by the data with a 30% decline in the number of road-killed birds between 2018 and 2019 and a further 40% decline from 2019 to 2020. It is difficult to determine if the decline in bird abundance is due to population decline or avoidance of the highway. Whilst the highway may represent a population sink for resident territorial species, such as frogmouths, owls, and kookaburras, which may affect populations of some species over time (Loss *et al.* 2014), habituation to the highway cannot be discounted.

4.3 Fenced vs unfenced

The two methods used to compare road-kill abundance between fenced and unfenced sections recorded similar results. The G-test identified a highly statistically significant difference ($P<0.01$) and the Kruskal-Wallis test record a slightly non-significant difference ($P=0.054$). The data suggest an obvious difference with twice the number of road-kills recorded in unfenced or single fence sections, and the disparity between statistical methods may be due to the influence of zero values on the Kruskal-Wallis test. The G-test result suggests that fauna are being killed at a significantly higher frequency in unfenced sections, which is consistent with the hypothesis that exclusion fence reduces road mortality. Results of both methods are consistent with the 2019 findings and both 2020 and 2019 data differ to 2018 when no significant difference between fenced and unfenced was recorded.

The difference between 2019/20 and 2018 is attributed to greater numbers of macropods and bandicoots killed in unfenced sections (in 2019/20), and lower numbers of turtles killed in fenced sections in 2019. Sandpiper Ecological (2018) found that a significantly higher frequency of road-kill occurred in unfenced areas when reptiles were removed from the analysis. Geolink (2018a) attributed the high incidence of road-killed turtles, during Stage 2A monitoring, to individuals trapped on the roadside of the exclusion fence following fence construction. The 2019 and 2020 results support this observation, although it is worth noting that turtles continue to be struck on the Gumma Floodplain, albeit in lower numbers than in 2018.

Despite the higher incidence of road-kill in unfenced areas the results do not show how many individuals are blocked from entering the carriageway by exclusion fence. Exclusion fence corresponds with vegetated areas that have a higher abundance of fauna and without exclusion fence road-kill would be substantially higher in these areas (de Carvalho *et al.* 2014). The lower incidence of mortality through the Nambucca State Forest shows that the exclusion fence is limiting the frequency of road-kill in that area.

At this stage of monitoring no modifications to exclusion fence design or extent is recommended. Due to the likely influence of temporal changes in climate on road-kill further monitoring is recommended to confirm the presence of hotspots and the overall frequency of road-kill within the WC2NH alignment. Bandicoots and macropods stand out as requiring particular scrutiny due to

evidence of increasing road-kill rates. As the road-kill monitoring program extends for five years it may be worth considering corrective actions early in year four should present trends continue in year three.

Data suggest that species likely to be blocked by exclusion fence are killed regardless of whether a drop-down occurs nearby. Whilst the influence of drop-downs on road-kill rate requires further analysis this observation is consistent with drop-down monitoring which showed negligible use by native fauna (Sandpiper Ecological 2019b).

4.4 Threatened fauna

Two threatened species were recorded during road-kill surveys in 2020, grey-headed flying fox (2 individuals), and masked owl (1 individual), with a total of four threatened species recorded since monitoring commenced. Importantly, no additional threatened species were recorded in 2020. Masked owls are susceptible to vehicle strike due to their habitat of foraging along forest edges (see Higgins 1999) and they are likely to be regularly recorded in low numbers. Flying-foxes are also susceptible to vehicle strike when foraging close to traffic or traversing bridges over large waterways. Mortality of flying-foxes on the WC2NH upgrade in 2019 was attributed to both situations, with effects compounded by drought (Sandpiper Ecological 2019a). The substantial decline in flying-fox mortality recorded in 2020 is most likely due to improved foraging conditions associated with higher summer and autumn rainfall and less reliance on road-side vegetation.

Vehicle strike is not identified as a major threat to grey-headed flying foxes (DotEE 2017). Scheelings and Frith (2015) found that 2.4% of individuals presented at clinics in Victoria were due to vehicle strike, and 84.6% of these were euthanised. As noted above vehicle strike may be more prevalent during times of heat and food stress. The suggestion that road-strike at the Nambucca River Bridge could be due to barrier effect (see Sandpiper Ecological 2019a) is not supported by the 2020 survey results.

5. Conclusion and recommendations

Contrary to 2018 and 2019 results the 2020 road-kill monitoring program for the WC2NH upgrade identified a decline in road-kill abundance and no distinct seasonal trend. Easing of drought conditions in 2020 has contributed to lower flying-fox road-kill, although road-kill of macropods and bandicoots remained high, and there is some evidence of increasing incidence of echidna road-kill. Whilst mortality rates for these groups are of concern further monitoring is required to confirm the trend. In 2020 there was notable declines in occurrence of Australian wood duck, freshwater turtles, barn owl, magpies, carpet pythons, fox, and galah, a result attributed to the combined effects of habitat condition, species abundance in adjacent habitat, and habituation. Continued high rates of mortality between the Nambucca River Bridge and Mattick Road, the Gumma Floodplain, and in vicinity of Upper Warrell Creek requires further assessment and future monitoring will assist in determining if mitigation is warranted. Importantly, no spotted-tailed quoll, koala, or giant barred frog was recorded as road-kill during the 2020 sample period. Whilst two grey-headed flying-foxes were confirmed, no individuals were recorded near the former camp, or inside the flying-fox exclusion fence.

Recommendations for future monitoring are presented in Table 6.

Table 6: Recommendations based on findings of the year 2 operational phase road-kill monitoring program.

Number	Recommendation	Transport for NSW Response
1.	Continue seasonal road-kill surveys during year three (2021) of the operational phase using the same methods applied in year one and two	Agree and adopted

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Appendix A – Field Survey Data

Table A1: October 2020 road-kill results. NB = northbound; SB = southbound; C'way = carriageway; Prox = proximity

Date	Obs	Start time	End time	C'way	Species	Sex & age class	Pouch or back young	RK general location	Easting	Northing	Cleared off Rd (Y/N)	Fauna fence P/A & proximity	Fence condition	Prox to xing structure	Proximity to drop-down
2/10/20	LA &SR	730	845	SB	Magpie lark	Adult		100m s old coast road	497311	6610162	No	Present	Good	NA	NA
				SB	Unid bird	Unknown	N/A	300m N Cockburn's lane	489782	6594832	No	Present	Good	NA	NA
				NB	Wallaby spp.	Adult		300 S bald hill Road	492436	6599742	No	Absent	NA	NA	NA
				NB	Eastern long-necked turtle	Adult		100 m south C3	494984	6606393	no	Present	Good	NA	NA
				NB	Wood duck	Adult	N/A	Bridge floodway 1	493269	6601543	no	Present	Good	NA	NA
				NB	Wallaby spp.	Adult	N/A	700 m S Mattick Road	494391	6603844	no	Absent	NA	NA	NA
				NB	Swamp wallaby	Adult		400M s Mattick road	494401	6604324	no	Absent	NA	NA	NA
				NB	Bandicoot spp	Adult		Above C3	494972	6606364	no	Present	Good	161m	215m
				NB	Eastern long-necked turtle	Adult		Above C3	494984	6606393	no	Present	Good	NA	NA
9/10/20	LA/NM			SB	Laughing Kookaburra	Adult		200m North C3	495239	6606798	Yes	Present	Good	NA	NA
				SB	Eastern bearded dragon	Adult		200m North C4	495194	6606697	Yes	Present	Good	NA	NA
				SB	Domestic goose	Adult		North side of Nambucca bridge	494224	6603259	no	Absent	NA	NA	NA
				SB	Purple swamphen	Adult		500m South Nambucca bridge	493317	6601587	no	Present	Good	NA	NA
				SB	Red-necked wallaby	Adult		100m south of Quarry access road	491865	6598351	no	Absent	NA	NA	NA
				SB	Rodent spp	Adult		100m south of Quarry access road	491812	6598268	no	Absent	NA	NA	NA
				SB	Red-necked wallaby	Adult		150 N rosewood road	490846	6596622	no	Absent	NA	NA	NA
				NB	Masked owl	Adult		250m S Rosewood road	490777	6596352	no	Absent	NA	NA	NA
				NB	Red-necked wallaby	Adult		600 m north of Nambucca bridge	494311	6603407	no	Absent	NA	NA	NA
				NB	Swamp wallaby	Adult		150m s Mattick Rd	494413	6604458	no	Absent	NA	NA	NA
16/10/20	LA/KT			SB	European hare	Adult		50m south of Lower Warrell Creek bridge	492219	6598864	no	Absent	NA	NA	NA
				NB	Australia wood duck	Adult		Flood plain bridge 2	492944	6600925	no	Present	Good	NA	NA
				NB	Bird spp	Unknown		Above C5/6	496185	6608276	no	Present	Good	NA	NA
23/10/20	LA/KT			SB	Echidna	Adult		80 n of Quarry access road	491948	6598514	no	Absent	NA	NA	NA
				NB	Chelidae spp.	Adult		Flood plain bridge 1	493212	6601386	no	Present	Good	NA	NA
				NB	Tawny frogmouth	Adult		500 m south C3	494811	6606069	no	Present	Good	NA	NA

Pacific Highway Upgrade Warrell Creek to Nambucca Heads

Operational phase road-kill monitoring – summer 2021.

Sandpiper Ecological

1/101 Main Street
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1. Introduction

1.1 Background

In 2015, Transport for NSW (formerly NSW Roads and Maritime Service), in conjunction with Acciona Ferrovial Joint Venture (AFJV), commenced the upgrade of the Pacific Highway between Warrell Creek and Nambucca Heads (WC2NH). The WC2NH project was opened to traffic in two stages: stage 2a – 13.5km section from Lower Warrell Creek Bridge to Nambucca Heads opened on 18 December 2017; and stage 2b – 6.25km section from the southern end of the project to the Lower Warrell Creek bridge opened in late June 2018.

The upgrade included a number of mitigation measures to minimise vehicle collisions with native wildlife. The types of structures constructed to mitigate road-kill included:

- Fauna fencing to exclude fauna from the road corridor and to guide fauna towards connectivity structures.
- Fauna drop-down structures (escape ramps) along the fauna fencing.
- Fauna connectivity structures, including underpasses, bridges, rope bridges and glide poles.

Several fauna fence designs were installed to target threatened species including:

- **Type 1** - Chainmesh fence 1.8 m tall with floppy top feature which is designed to exclude a range of native mammal species such as macropods, possums, spotted-tail quoll (*Dasyurus maculatus*) and koala (*Phascolarctos cinereus*). A total of 18.03km of this fence type occurs at the site.
- **Type 3** - Small gauge mesh fence with sheet metal return angled away from the highway (combined with fauna floppy top fence) which is designed to exclude green-thighed frog (*Litoria brevipalmata*) and giant barred frog (*Mixophyes iteratus*) from the road corridor. A total of 1.32km of type 3 fauna fence occurs at the site, overlapping with the type 1 fencing.
- **Type 4** - Chainmesh fence 4 m tall through the Macksville Flying-fox camp Paperbark Swamp Forest community designed to discourage grey-headed flying-fox (*Pteropus poliocephalus*) from flying within range of passing traffic when exiting or entering the roost. A total of 1km of type 4 fence occurs at the site.

Sandpiper Ecological Surveys (SES) has been engaged by Transport for NSW (TfNSW) to deliver the WC2NH operational ecological and water quality monitoring program, which includes seasonal road-kill surveys over the entire upgrade length.

Monitoring of road-killed fauna is a requirement of the approved WC2NH koala, spotted-tailed quoll and grey-headed flying-fox management plans and the Ecological Monitoring Program (RMS 2018a). Priority species for road-kill surveys are grey-headed flying-fox, koala, spotted-tailed quoll, and giant barred frog. Monitoring is required for the first five years of operation and includes weekly surveys for the first 12 weeks of operation and four surveys (at weekly intervals) each season thereafter. Due to the staged opening of the project, monitoring of stage 2a commenced in December 2017 with monitoring of stage 2b commencing in July 2018. The 12-week monitoring period for stage 2b ended on 30 September 2018 and Sandpiper Ecological commenced seasonal monitoring in October 2018. Previous road-kill monitoring was conducted by Geolink (2018a, b, c, d).

The aim of road-kill monitoring is to:

- report on any vertebrate road-kill following opening to traffic; and
- assess the effectiveness of fauna fence in preventing fauna being killed by vehicles while attempting to cross the WC2NH upgrade.

The results of monitoring in 2018, 2019 and 2020 have been previously reported on (Sandpiper Ecological 2018, 2019, 2020). The following report covers the summer 2021 monitoring event and includes the entire WC2NH alignment.

1.2 Study area

The WC2NH project covers a total length of 19.75km and extends from Warrell Creek in the south to Nambucca Heads in the north (Figure 1).

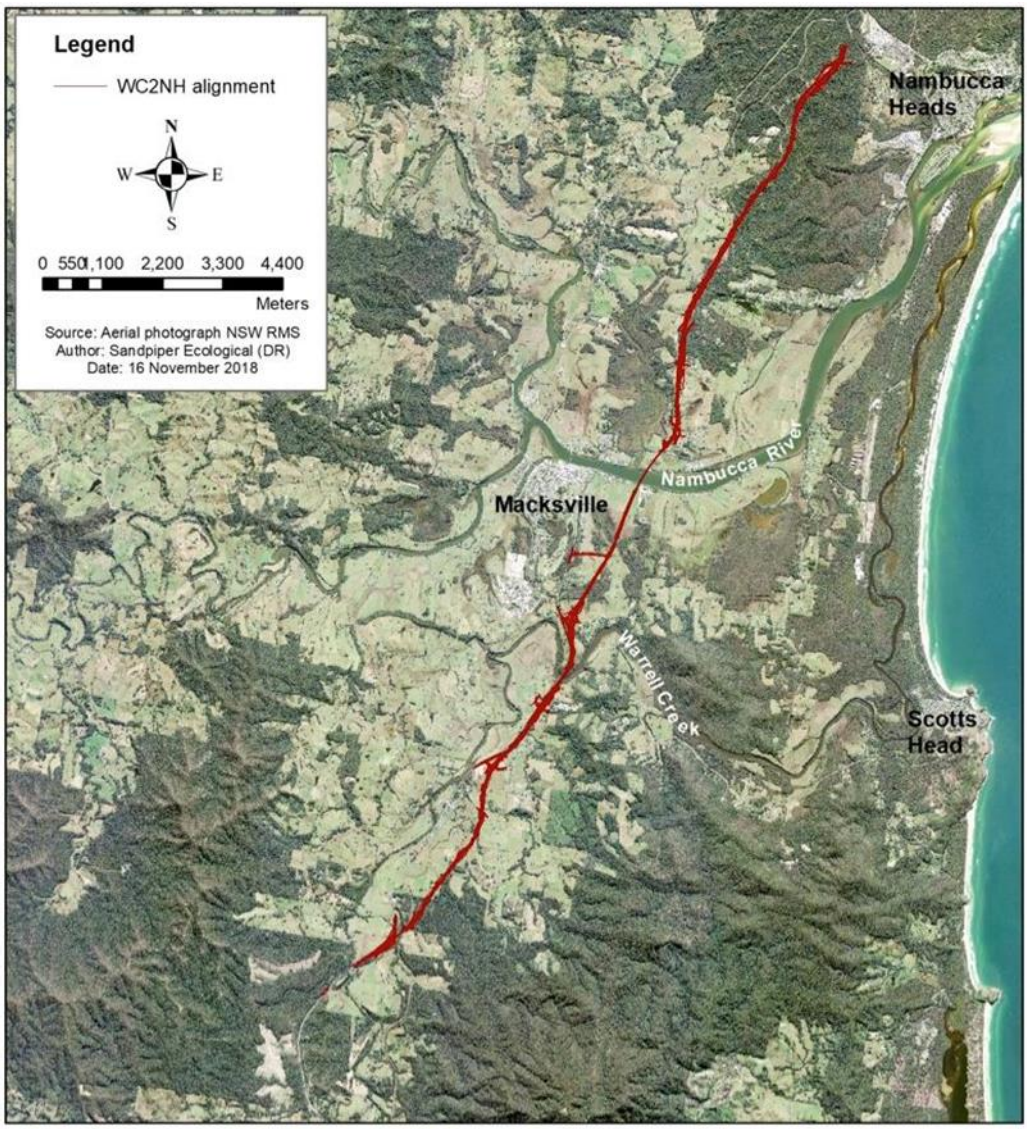

Figure 1: Location of the WC2NH alignment.

2. Methods

2.1 Road-kill surveys

Surveys were conducted by a two-person team from a vehicle driven at 80-90km/hr in the left lane. The vehicle was equipped with an amber (flashing) light and warning sign (Plate 1). The team consisted of a driver and an ecologist passenger with experience identifying road-killed fauna. Surveys were undertaken weekly and commenced within three hours of sunrise. During each survey, the ecologist scanned the road surface and road shoulder for fauna. When road-killed fauna were detected the vehicle would pull onto the shoulder/parking bay and the ecologist would exit the vehicle, move along the roadside behind the wire rope and inspect the subject animal from the closest perpendicular position behind the wire rope. Fauna that could not be identified immediately were photographed and images were sent to colleagues for assessment. Carcasses were removed from the road surface when safe to do so.

Plate 1: Work vehicle with signage, flashing amber light and indicators.

Data collected on each road-kill included:

- Geographic coordinate
- Presence/absence of fauna exclusion fence adjacent the record
- Species/fauna group
- Date of survey
- Road-kill location – north or southbound carriageway

Data collected for threatened species listed on the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* and/or the *Biodiversity Conservation (BC) Act 2016*, included, where possible: sex and age (juvenile/adult); presence of pouch young if applicable; presence of flightless young (flying-foxes); distance to a fauna connectivity structure; distance to a drop-down structure if applicable; damage to fauna fencing; weather conditions; if the animal was a flying-fox – distance to nearest camp, distance to nearest canopy vegetation, and presence of flowering food trees in median or roadside vegetation.

All road-kills were cross referenced with the previous survey data to identify possible duplicates. The consistent use of at least one team member across all surveys, GPS coordinates of each specimen,

detailed carcass descriptions, and detailed location descriptions assisted with identifying duplicates. Distance to connectivity structure, and distance to escape structure was determined via GIS. All other data were uploaded to an iPad in the field.

2.2 Data summary and analysis

Data from the summer 2021 survey were uploaded to Microsoft Excel. The summer data were compared with results from Spring 2020 to further assist in identifying duplicate records. Data were then plotted to show the total number of road-kills in summer 2021 and the number of road-kills in different fauna groups each week of the survey. The location of summer 2021 road-kills was overlaid on the WC2NH alignment to show distribution, and the data compared to road-kills recorded in summer, autumn, winter and spring 2018, 2019 and 2020 (Sandpiper Ecological 2018, 2019, 2020).

3. Results

3.1 Weather conditions

Light rain occurred in the 24-hour period prior to the second and third samples, however no rain occurred during a survey (Table 1). Visibility was good during all surveys (Table 1).

Table 1: Weather conditions during each sample event. *preceding 24 hours. All data was obtained from the Bureau of Meteorology Coffs Harbour weather station except for rainfall data which was obtained from Bellwood station.

Date	Average Relative Humidity (%)	Rainfall (mm)*	Max Temperature (^{0}C)	Max Wind Speed (km/h)	Visibility during survey	Rain during survey
18/1/21	69	0	27.5	54	Good	Nil
22/1/21	62	2	28.0	50	Good	Nil
29/1/21	87	1	27.4	30	Good	Nil
5/2/21	77	0	28.0	30	Good	Nil

3.2 Species richness and abundance

A total of 20 road-killed fauna were recorded during the summer 2021 sample period. Fauna included 12 native species and one introduced species (dog), as well as three fauna groups (Table 2). Birds were the most diverse group represented with seven species and one fauna group. Mammals were represented by five species and one fauna group and reptiles featured two species and one fauna group.

Noisy miner was the most frequently detected species with three records, followed by two records each for Chelidae spp. and wallabies (one swamp wallaby and one red-necked wallaby) (Table 2). Degradation and location of carcasses on the carriageway made identification to species level difficult in some cases (Table 2). No frogs or threatened species were recorded during the summer year 3 surveys.

Of the 20 road-kill records, seven (35%) were species expected to be blocked by exclusion fence (i.e. medium and large mammals). The remaining 13 records, including birds, a small mammal, a common blue-tongued skink and a carpet python are species that readily move through or over exclusion fencing.

Table 2: Species of vertebrate fauna recorded during seasonal road-kill surveys throughout the operational phase of the WC2NH upgrade. * denotes threatened species; ** = stage 2a only; Sum = summer; Aut = autumn; Win = winter; Spr = spring.

Species	Sum 17/18 **	Aut 18 **	Win 18 **	Spr 18	Sum 19	Aut 19	Win 19	Spr 19	Sum 20	Aut 20	Win 20	Spr 20	Sum 21	Total
Birds														
Australian magpie	6	1		1				2	2	1			1	14
Grey butcherbird			1											1
Magpie-lark	2		1		1		1		1		1	1		8
Australian white ibis			1						1					2
Cattle egret				1						1				2
Little pied cormorant					1									1
Buff-banded rail					1									1
Purple swamphen	3		2	2		1		2	3		1	1		15
White-headed pigeon										1				1
Crested pigeon	2													2
Galah	7				1			3						11
Rainbow lorikeet								1						1
Eastern grass owl*				1										1
Australian boobook			1	1			1				1			4
Masked owl*	1				1		1					1		4
Eastern barn owl			11	3		1	5	2	1					23
Tawny frogmouth	1	3	1	2		6		4		1		1	1	20
Australian owlet-nightjar					1					1				2
Laughing kookaburra	3		2	1		2		3	1	1	2	1		16
Forest kingfisher	1													1

Species	Sum 17/18 **	Aut 18 **	Win 18 **	Spr 18	Sum 19	Aut 19	Win 19	Spr 19	Sum 20	Aut 20	Win 20	Spr 20	Sum 21	Total
Australian wood duck	20			2	2		1	2				2	1	30
Pacific black duck	2		1											3
Whistling kite				1										1
Black-shouldered kite					1	1								2
Torresian crow					1								1	2
Pied currawong				1									1	2
Black-faced cuckoo-shrike								1						1
Noisy miner													3	3
Dollarbird					2									1
Green catbird					1								1	2
Australasian figbird										1				1
Black bittern*						1								1
Eastern yellow robin						1								1
Pheasant coucal							1		1					2
Masked lapwing							1							1
Welcome swallow								1						1
Red-browed finch										1				1
Duck spp.						1				1				2
Tyto spp.										1				1
Small bird								2						2
Medium bird				1	2	2	2	2	6	1	1			16
Unidentifiable bird	5	4	1		3						2	2	1	18
Total birds	53	8	22	17	18	16	13	25	16	11	8	9	10	214

Species	Sum 17/18 **	Aut 18 **	Win 18 **	Spr 18	Sum 19	Aut 19	Win 19	Spr 19	Sum 20	Aut 20	Win 20	Spr 20	Sum 21	Total
Mammals														
Short-beaked echidna				3				2		1	2	1		9
Black flying-fox	2	1			7	1	1							11
Grey-headed flying-fox*					8			5	2					15
Pteropus spp.					3	8	1		1	1				14
Short-eared brushtail possum													1	1
Common brushtail possum			1	2						1				4
Trichosurus spp.									1	1	1			3
Common ringtail possum					1			1						2
Eastern grey kangaroo				3			1							4
Red-necked wallaby			6		8	2	8	3	7	1	8	3	1	47
Swamp wallaby	2	1		1		1	1			1	1	2	1	11
Wallaby spp.						2			3			2		7
Macropod spp.	3		2	1	1					2	1			10
Northern brown bandicoot	1		1		1	1	1	2	2	3	3		1	16
Bandicoot spp.						1		4				1		6
Chalinolobus spp. (microbat)				1										1
Microbat spp.					1									1
Rodent spp.						2						1		3
Small mammal					2						1		1	4
Medium mammal				2	4	2	4	5	2	2	2			23
Large mammal				1	1			1			1			4

Species	Sum 17/18 **	Aut 18 **	Win 18 **	Spr 18	Sum 19	Aut 19	Win 19	Spr 19	Sum 20	Aut 20	Win 20	Spr 20	Sum 21	Total
Unidentified Mammal	1			3										4
Total mammals	10	2	10	17	36	20	17	23	18	13	20	10	5	196
Reptiles														
Common blue-tongued skink	1			2	1				2				1	7
Carpet python	1			2	1	1		1					1	7
Common tree snake	1	2						1						4
Eastern long-neck turtle	1			6						1		2		10
Macquarie river turtle	5	1					1							7
Unidentified *Chelidae* spp.	6							1				1	2	10
Red-bellied black snake	1													1
Eastern water dragon	1			1										2
Eastern bearded dragon												1		2
Blackish blind snake						1								1
Yellow-faced whipsnake				1										1
Unidentified reptile								2		1				3
Total reptiles	17	3	0	12	2	2	1	5	2	2	0	4	4	50
Frogs														
Green tree frog	2													2
Striped marsh frog	3													3
Medium frog				3										3
Large frog				1										1
Total frogs	5	0	0	4	0	0	0	0	0	0	0	0	0	9
Introduced species														

Species	Sum 17/18 **	Aut 18 **	Win 18 **	Spr 18	Sum 19	Aut 19	Win 19	Spr 19	Sum 20	Aut 20	Win 20	Spr 20	Sum 21	Total
Cat	1													1
Dog													1	1
European fox	3	1	1	2	1	1	2							11
European hare	2			1						1		1		5
Rabbit	1													1
Black rat	1					1								2
House mouse					1									1
Rock pigeon			1	1										2
Domestic goose				1								1		2
Total introduced species	8	1	2	5	2	2	2	0	0	1	0	2	1	25
Total	93	14	34	55	57	40	33	53	36	27	28	25	20	515

Over the summer 2021 sample period the number of road-kill recorded each week declined from 13 in week one to three in week two, and two in weeks three and four (Figure 2).

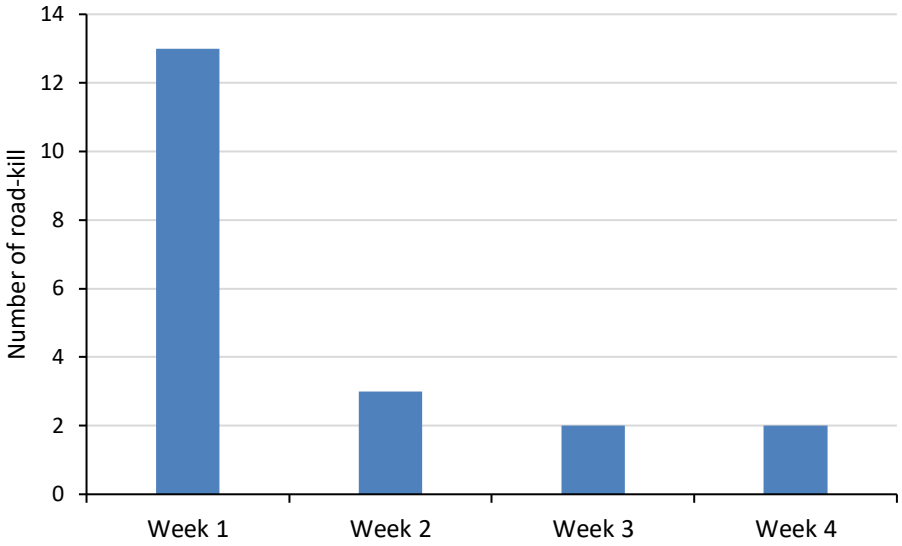

Figure 2: Number of road-kills recorded in each sample week during the summer 2021 sample period.

The abundance of road-killed fauna in the three vertebrate groups varied during the sample period (Figure 3). Birds and mammals were recorded in three weeks, and reptiles in two. The number of road-killed birds decreased from six in week one to three in week two, none in week two and one in week four. The number of road-killed mammals decreased from four in week one to none in week two, and one each in week three and four. The number of road-killed reptiles decreased from three in week one to none in week two, increasing to one in week three, and were absent in week four.

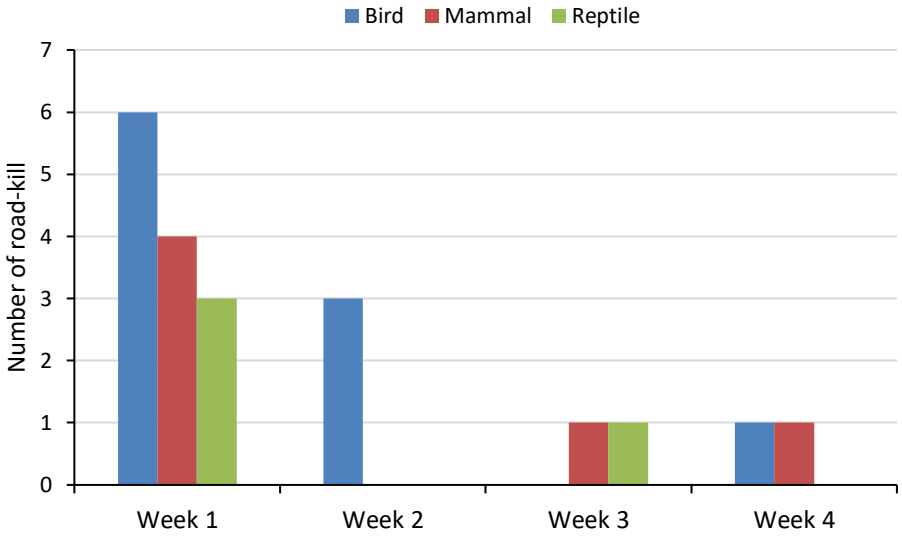

Figure 3: Number of road-killed fauna from three vertebrate classes during each sample week in summer 2021.

The number of road-killed flying-foxes has varied over the monitoring period (Figure 4). Black flying-fox, grey-headed flying-fox and total number of flying-foxes peaked during summer 2019 with seven, eight and 18 road-kills, respectively. Numbers have fluctuated and largely declined since then, with no flying-foxes recorded in winter and spring 2020, and summer 2021 (Figure 4).

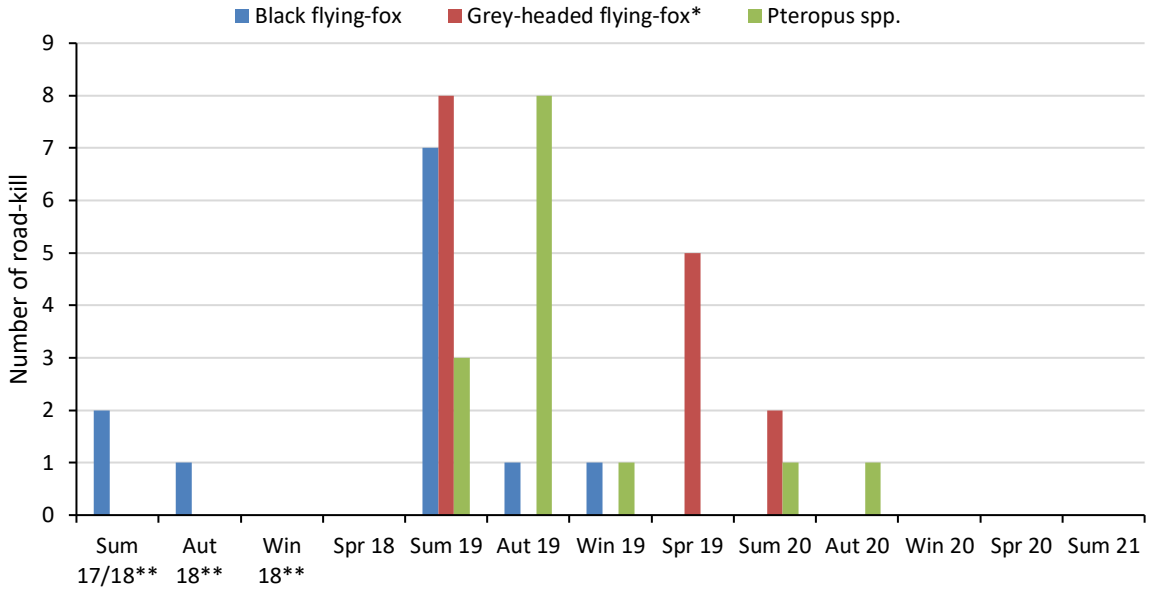

Figure 4: Number of road-killed flying-foxes from all sample periods. * denotes threatened species. **Stage 2a only.

3.3 Opportunistic road-kill information

No opportunistic road-kill was recorded during summer 2021.

3.4 Distribution of road-kill

Fauna road-kills were recorded across the entire WC2NH alignment during summer 2021 (Figures 5-8). Half of the records (50%) were situated between Mattick Road and Bald Hill Road., with the remaining half occurring south of Bald Hill Road (25%), and north of Mattick road (25%) which is entirely fenced with type 1 and 3 exclusion fence. The section between Mattick Road and Bald Hill Road traverses predominantly cleared land and includes the Nambucca River and Gumma floodplain. Approximately 50% of that area is fenced with Type 1 and Type 4 exclusion fence.

During the summer 2021 period, 10 road-kills were recorded in areas without exclusion fence, eight in areas with an exclusion fence and two in an area with an exclusion fence on only one side of the carriageway (Figures 5-8). One of the fenced section records (5% of all records) was a species that was expected to be blocked by the fence (i.e. medium and large mammals). Six records (30% of all records) in sections without fence or with an exclusion fence only on one side, were of species expected to be blocked by an exclusion fence on both sides of the carriageway.

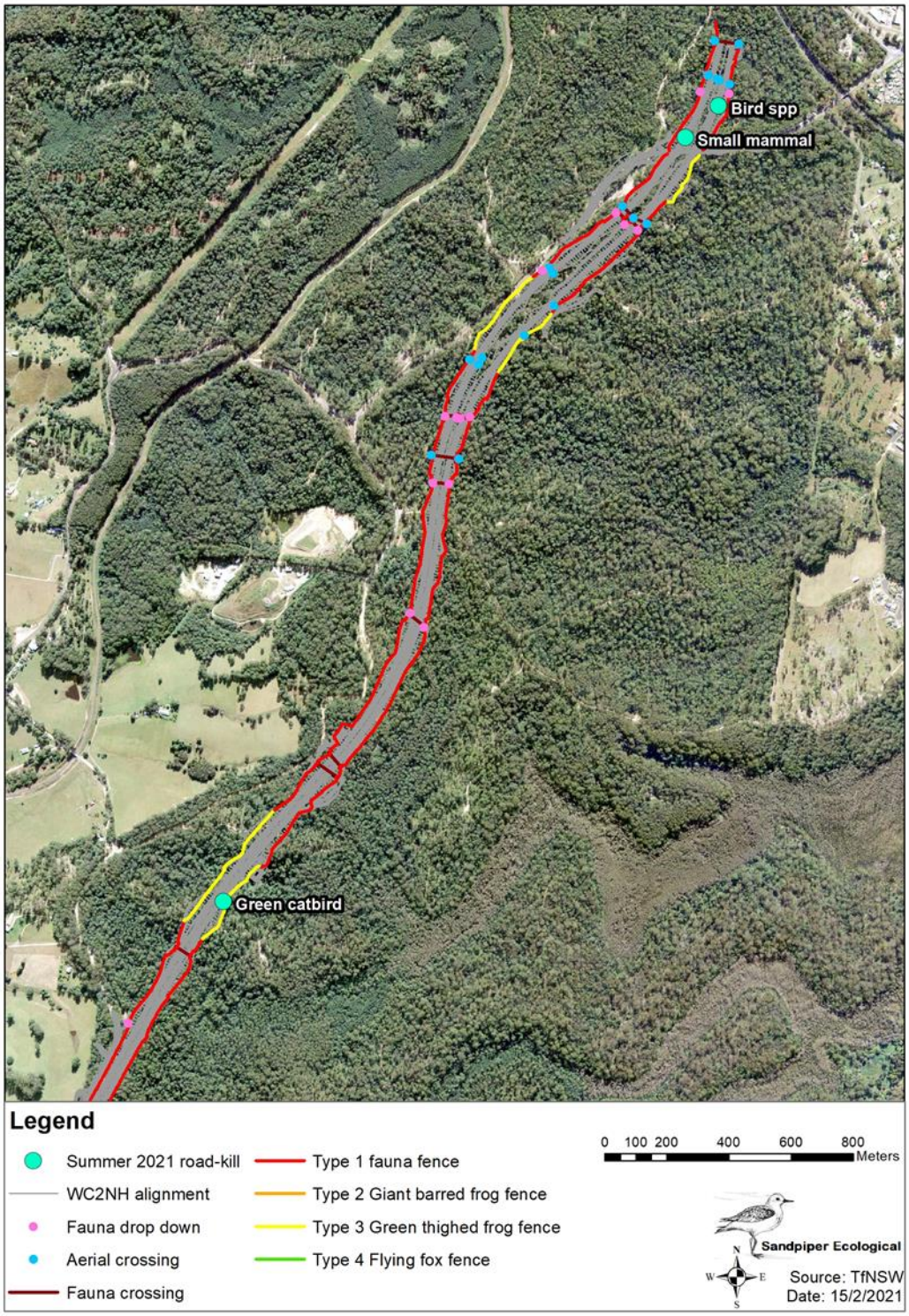

Figure 5: Location of road-killed fauna recorded in summer 2021.

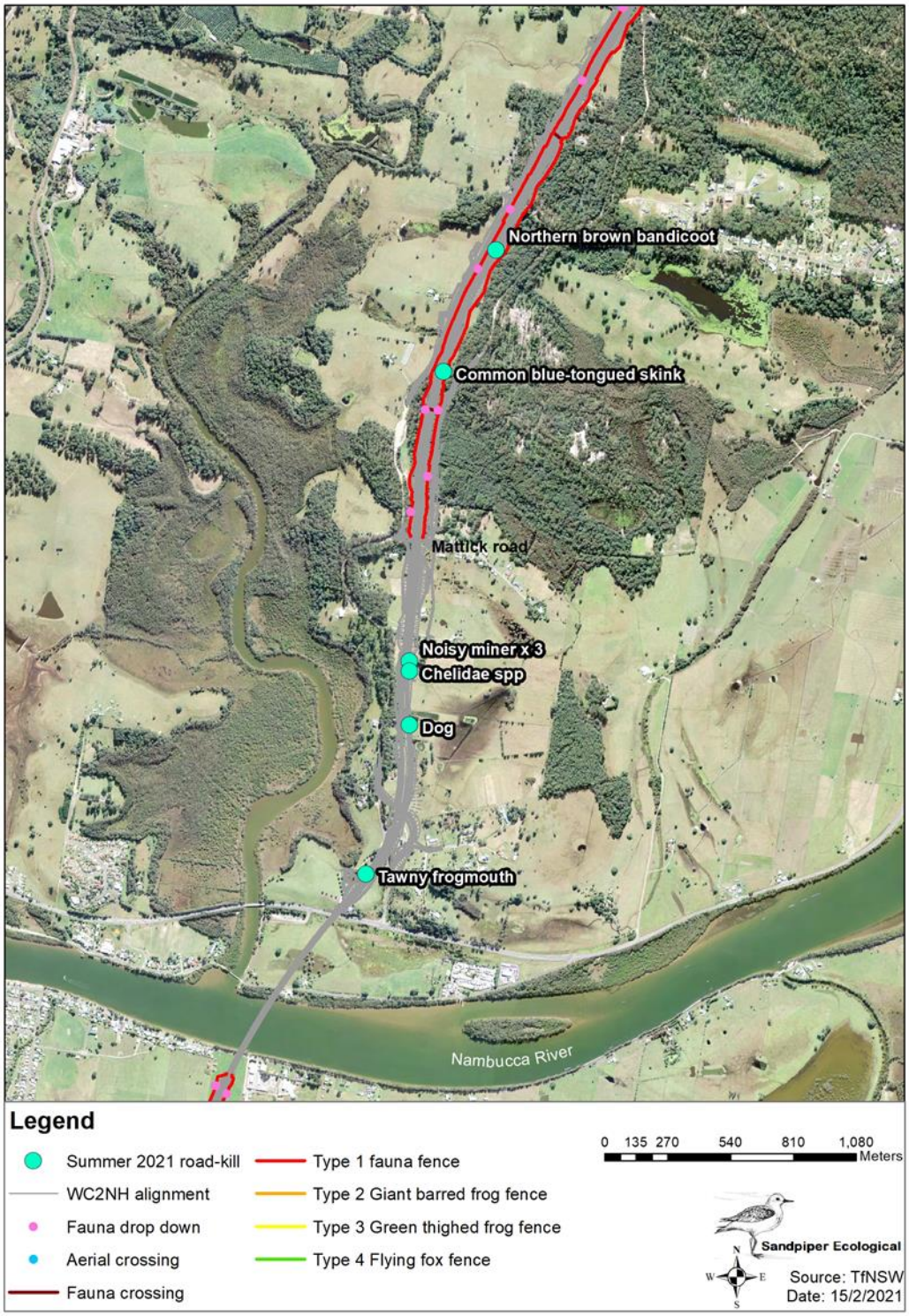

Figure 6: Location of road-killed fauna recorded in summer 2021.

Figure 7: Location of road-killed fauna recorded in summer 2021.

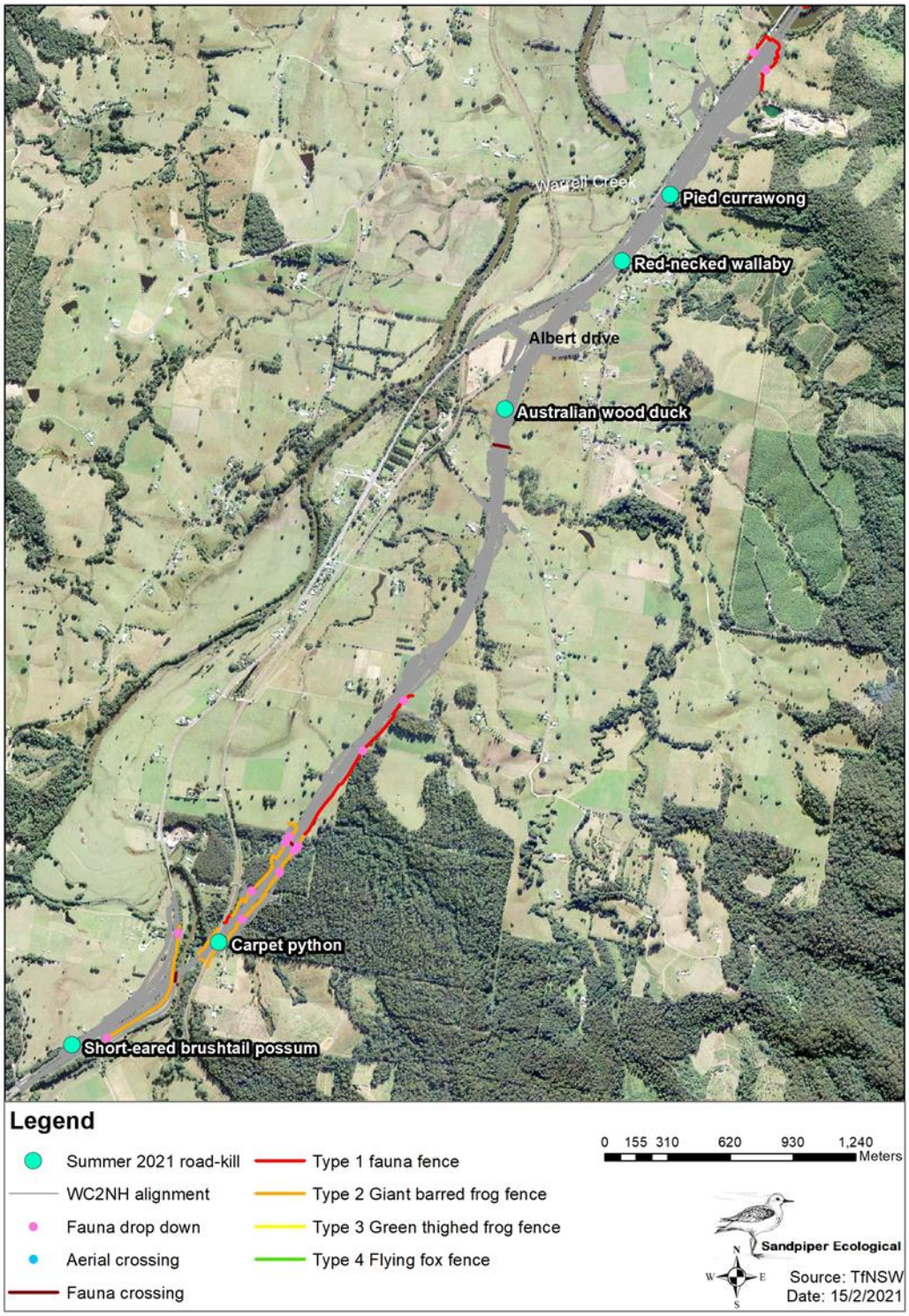

Figure 8: Location of road-killed fauna recorded in summer 2021.

4. Discussion

4.1 Summer 2021

Road-kill monitoring of the WC2NH alignment in summer 2021 indicates that fauna continue to be killed by vehicles 2.5 years after the entire alignment was open to traffic. However, the number of road-kills recorded in summer 2021 is the lowest for any road-kill sample period since seasonal sampling commenced in spring 2018. Indeed, the summer 2021 total was 16 individuals fewer than the summer sample in 2020. Importantly, no threatened species listed under the *EPBC Act 1999*, or the *BC Act 2016* were recorded during the summer 2021 survey.

Unlike 2018 and 2019, the distinct seasonal peaks in spring and summer were not evident during the 2020-2021 period, with 27 individuals recorded in autumn 2020, 28 individuals in winter 2020, 25 individuals in spring 2020, and 20 individuals in summer 2021. Most fauna groups have demonstrated reductions in road-kill numbers. In particular, summer red-necked wallaby road-kill numbers have decreased by six between 2020 and 2021. This is a positive result, as concerns have previously been raised about the effect of road-kill on the local red-necked wallaby population.

The reduction in road-kill numbers may be an artefact of improved local conditions which reduced the need for herbivores, such as red-necked wallabies, to both forage along the road edge and move larger distances to source food. It may also reflect reduced local abundance after a period of protracted drought and bushfires during 2019. While the reduction in road-kill numbers is encouraging, temporal fluctuations in the number and species of road-kill are evident (Sandpiper Ecological 2018, 2019 and 2020). Further monitoring will assist in determining if this trend continues.

As in previous samples, the number of road-kill peaked in week one. This largely reflects the period over which carcasses can accumulate. This trend is likely to occur in seasonal sample periods and it means that the number of road-kills recorded during a month overestimates the actual number of animals killed in that month.

Road-kill hotspots identified in summer 2021 are consistent with previous surveys. The area from Mattick Road to Bald Hill Road (50% of road-kills), which includes the Nambucca River and Gumma Floodplain has consistently recorded a high incidence of road-kill (Sandpiper Ecological 2018, 2019, 2020). Birds and mammals comprised the majority of road-kills in all surveys to date.

4.2 Flying-fox impacts

No road-killed flying-foxes were recorded during summer 2021. This is consistent with the substantial decline in flying-fox road mortality recorded in 2020. It likely reflects the improved foraging conditions during 2020/21 and thereby less reliance on road-side vegetation. It may also reflect a reduction in local population abundance due to the bushfires and extreme drought conditions of 2019.

4.3 Effectiveness of fauna fencing

The spatial pattern of road-kill occurrence is largely consistent with that of previous samples, excluding autumn 2020. The road-kill rate of species expected to be blocked by the fence is lower in areas with exclusion fence than in areas without exclusion fence. Importantly, no mortality of

targeted threatened species was recorded in summer 2021. Monitoring continues to show that where present, exclusion fencing is effective in mitigating road-strike for target species.

5. Recommendations

Recommendations relating to the summer 2021 operational phase road-kill monitoring are summarised in Table 3.

Table 3: Recommendations following the summer 2021 operational phase road-kill monitoring and Transport for NSW response.

Number	Recommendation	Transport for NSW Response
1.	Continue seasonal road-kill surveys using the same methods applied in year one and two	Agreed and adopted.

6. References

Geolink (2018a). *Roadkill monitoring report: WC2NH Stage 2A*. Report prepared for NSW Roads and Maritime Services.

Geolink (2018b). *Roadkill monitoring summary report: autumn (April) 2018*. Letter report prepared for NSW Roads and Maritime Services.

Geolink (2018c). *Roadkill monitoring summary report: winter (July) 2018*. Letter report prepared for NSW Roads and Maritime Services.

Geolink (2018d). *Roadkill monitoring report - initial 12 weeks WC2NH Stage 2B*. Report prepared for NSW Roads and Maritime Services.

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Sandpiper Ecological (2018). *Pacific Highway Upgrade, Warrell Creek to Nambucca Heads: operational phase road-kill monitoring – annual report 2018*. Report prepared for NSW Roads and Maritime Services.

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Sandpiper Ecological (2020). Pacific Highway Upgrade, Warrell Creek to Nambucca Heads: Year 2 operational phase road-kill monitoring- annual report 2020. Report prepared for Transport for NSW.

Appendix A – Field Survey Data

Table A1: Summer 2021 roadkill results. Obs = Observers; LA = Luke Andrews, KT = Katie Stevens, BT = Brendan Taylor; xing = crossing

Date	Observers	Start time	End time	Carriageway	Species	Sex & age class	Presence of pouch or back young	RK general location	Easting	Northing	Cleared off Rd (Y/N)	Fauna fence P/A & proximity	Fence condition	Proximity to xing structure	Proxmity to drop-down	If FlyFox, proximity to camp; prox. to canopy veg, prox. to food
18/1/21	LA/KS	830	930	SB	Bird spp.	Unknown	Nil	100m north of old coast road	497451	6610405	Yes	NA	NA	NA	NA	NA
				SB	Noisy miner x 3	Adult	Nil	200m north of Macksville exit	494429	6604236	Yes	NA	NA	NA	NA	NA
				SB	Chelidae spp.	Unknown	Nil	200m north of Macksville exit	494428	6604193	Yes	Absent	NA	NA	NA	NA
				SB	Dog	Adult	Nil	On Macksville ramp exit	494430	6603962	No	Absent	NA	NA	NA	NA
				SB	Chelidae spp.	Unknown	Nil	On Macksville/Scott's head exit	492649	6600389	No	One side	NA	NA	NA	NA
				SB	Red-necked Wallaby	Sub adult	Nil	100m South of black snake creek	491450	6597779	No	Absent	NA	NA	NA	NA
				SB	Carpet python	Unknown	Nil	Under Upper Warrell creek railway bridge	489459	6594413	No	NA	NA	NA	NA	NA
				NB	Australian wood duck	Adult	Nil	200m South of Albert drive	490873	65970474	No	NA	NA	NA	NA	NA
				NB	Swamp wallaby	Adult	Nil	Macksville on ramp	492623	6600411	No	One side	NA	NA	NA	NA
				NB	Australian magpie	Unknown	Nil	Floodwaters bridge 1	493273	6601534	UK	NA	NA	NA	NA	NA
				NB	Small mammal	Unknown	Nil	50m past old coast road	497343	6610303	No	NA	NA	NA	NA	NA
22/1/21	BT/LA	815	915	SB	Green catbird	Adult	Nil	Above c7	495855	6607840	UK	NA	NA	NA	NA	NA
				SB	Torresian crow	Adult	Nil	100 m north of Gumma floodplain bridge 2	493075	6601108	UK	NA	NA	NA	NA	NA
				NB	Tawny frogmouth	Adult	Nil	100M north NB bridge	492241	6603321	UK	NA	NA	NA	NA	NA
29/1/21	LA/KS	8:30	9:30	SB	Common blue-tongued skink	Adult	Nil	800m North of Mattick Road	494575	6605480	UK	NA	NA	NA	NA	NA
				NB	Short-eared brushtail possum	Adult	Nil	500Ms Upper Warrell creek	488733	6593904	UK	Absent	NA	NA	NA	NA
5/2/21	LA/BT	815	10:00	SB	Northern brown bandicoot	Adult	Nil	1Km north of Mattick Road	494802	6606002	UK	Present	Good	553m	82m	NA
				SB	Pied currawong	Adult	Nil	On Williamson's creek bridge	491688	6598105	UK	NA	NA	NA	NA	NA

Attachment 2: Condition 2 Compliance Report

Commonwealth approval EPBC 2013/7101 Condition Two Compliance

Warrell Creek to Nambucca Heads Pacific Highway Upgrade

February 2021

February 2021 | Version: 1

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Attachments

Attachment 1 Warrell Creek to Nambucca heads EPBC habitat WAE Clearing Maps

Introduction

1.1 Purpose of this document

The purpose of this document is to demonstrate compliance with the Commonwealth approval conditions for the Warrell Creek to Nambucca heads Pacific Highway Upgrade project with particular reference to Condition 2. This requires a report that clearly shows the location of all vegetation and EPBC species habitat cleared as a result of the action, and that demonstrates compliance with the condition.

Condition 2

Within 30 days of the completion of *construction*, the approval holder must:

a) notify the Minister in writing of the completion of construction; and

b) provide a report (supported by mapping) that clearly shows the location of all vegetation and EPBC species habitat cleared as a result of the action, and that demonstrates compliance with Condition 1.

Discussion

EPBC 2013/7101 Condition one states:

The approval holder must not clear more than:

a) *17.80 hectares (ha) of **Slender Marsdenia/Clear Milkvine and Woolls Tylophora/Cryptic Forest Twiner habitat**;*

b) *106.6 ha of **Koala habitat**, including 86.50 ha critical to the survival;*

c) *106.6 ha of **Grey-headed Flying-fox habitat**, comprised of 103.50 ha of foraging habitat critical to survival and 3.10 ha of roosting habitat critical to survival;*

d) *114.1 ha of **Spotted-tail Quoll habitat**;*

e) *0.70 ha of **Giant Barred Frog habitat**;*

f) *3.40 ha of Australian Painted Snipe (Rostratula australis) wetland habitat;*

g) *5.3 ha of habitat for the Regent Honeyeater (Anthochaera phrygia) and Swift Parrot (Lathamus discolour) wintering habitat, comprising dry schlerophyll forests containing Swamp Mahogany; and*

h) *26.1 ha of Milky Silkpod (Parsonsia dorrigoensis) habitat, comprising Mixed Floodplain Forest, Flooded Gum Open Forest and White Mahogany/Grey Gum/Ironbark Open Forest*.

To facilitate compliance with condition one, the WC2NH clearing footprint was overlaid against the vegetation types that make up the different habitat types listed above to determine the total clearing quantity for the project.

Throughout the progression of the design, all the way through to completion of clearing, the total clearing was tracked and compared against the clearing limits to ensure the design was compliant with the approval.

The clearing quantities were tracked through the project through the quarterly compliance tracking meetings and the EPBC annual reports submitted to DoE. Throughout the project, clearing quantities were confirmed to be below those specified in condition one. *Table 1 below* displays the final clearing quantities for the WC2NH Project.

Table 1: Final Clearing Quantities

Final Clearing Quantities (Aerial Survey)			
Habitat Type	**Limit (ha) as per Condition 1 Approval**	**Clearing Quantity (ha)**	**Current Difference showing remaining habitat (ha) under Condition 1 Approval**
Slender Marsdenia/Clear milkvine and Woolls Tylophora/Cryptic Forest Twiner habitat	17.80	17.65	0.15
Koala	106.60	83.44	23.16
Koala (Critical Habitat)	86.50	60.18	26.32
Grey-headed Flying-fox	106.60	83.44	23.17
Grey-headed Flying-fox (foraging habitat critical to survival)	103.50	81.33	22.17
Grey-headed Flying-fox (roosting habitat critical to survival)	3.10	2.10	1.00
Giant Barred Frog	0.7	0.64	0.06
Spotted –tail Quoll habitat	114.10	90.28	23.82
Australian Painted Snipe (Rostratula australis)	3.4	2.84	0.56
Regent Honeyeater (Anthochaera phrygia) and Swift Parrot (Lathamus discolour)	5.30	4.34	0.96
Parsonsia dorrigoensis (Milky Silkpod)	26.1	24.11	1.99

Clearing quantities for all habitat types are below the limits as specified in condition one.

1.1.1.1 Mapping

Condition 2 calls for appropriate mapping to be provided that supports the final clearing quantities as displayed in Table 1. **Attachment 1** shows the final design with the Work as Executed (WAE) clearing boundary. Overlayed with this is the vegetation types that make up the above habitats.

The vegetation types that make up each specific habitat are detailed in Table 2

Table 2: Vegetation types

Vegetation types
Slender Marsdenia/Clear Milkvine and Wooll's Tylophora/Cryptic Forest Twiner habitat consisting of; • Moist open forest -flooded gum and • Moist Open Forest - White Mahogany, Grey Gum and Iron bark
Koala habitat comprising: • Blackbutt Open Forest • Mixed Floodplain Forest • White Mahogany/Grey Gum/Ironbark Moist Open Forest • Flooded Gum Moist Open Forest • Swamp Mahogany/Paperbark Swamp Forest
Grey-headed Flying-fox habitat (foraging habitat critical to survival) comprising: • Blackbutt Open Forest • Mixed Floodplain Forest • White Mahogany/Grey Gum/Ironbark Moist Open Forest • Flooded Gum Moist Open Forest • Swamp Mahogany/Paperbark Swamp Forest
Spotted-tail Quoll habitat comprising: • Blackbutt Open Forest • Mixed Floodplain Forest • White Mahogany/Grey Gum/Ironbark Moist Open Forest • Flooded Gum Moist Open Forest

Vegetation types
• Swamp Mahogany/Paperbark Swamp Forest
• Swamp Forest-Swamp Oak • Freshwater Wetlands • Mangrove Forest • Hardwood Plantation
Parsonsia dorrigoensis (Milky Silkpod) habitat, comprising: • Mixed Floodplain Forest • Flooded Gum Open Forest • White Mahogany/Grey Gum/Ironbark Open Forest

Conclusion

The project, since inception has been committed to reducing the extent of native vegetation clearing to only that specifically required to successfully complete the highway upgrade. Through consistent tracking of the clearing activities, and as shown in the attached mapping and Table 1, all final clearing quantities for each habitat type are compliant with the limits as specified in Condition One.

Warrell Creek to Nambucca Heads Upgrade

Operational Phase Monitoring of Threatened Flora Translocations, In-situ Threatened Plants and Slender Marsdenia and Woolls' Tylophora Habitat Condition

Annual report Year 3 (2020) Ver. 3

Transport for NSW February 2021

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Project team:

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Report prepared for:

Transport for NSW

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Warrell Creek to Nambucca Heads Upgrade

Operational Phase Monitoring of Threatened Flora Translocations, In-situ Threatened Plants and Slender Marsdenia and Woolls' Tylophora Habitat Condition – Year 3 (2020) Ver.3

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Ver. 3

23/4/2021

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Executive Summary

This report describes the results of monitoring (i) threatened flora translocations, (ii) in situ threatened flora and (iii) Slender Marsdenia and Woolls' Tylophora habitat condition, for the Warrell Creek to Nambucca Heads (WC2NH) upgrade of the Pacific Highway. Five threatened and one rare plants species impacted by the WC2NH project were included in the monitoring program: -

- Slender Marsdenia (*Marsdenia longiloba*) (listed as endangered under the *Biodiversity Conservation (BC) Act 2016* and vulnerable under the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*)
- Woolls' Tylophora (Tylophora woollsii) (listed as endangered under the BC Act and the EPBC Act)
- Rusty Plum (*Niemeyera whitei*) (listed as vulnerable under the BC Act)
- Spider Orchid (*Dendrobium melaleucaphilum*) (listed as endangered under the BC Act)
- Floyds Grass (*Alexfloydia repens*) (listed as endangered under the BC Act)
- Koala Bells (*Artanema fimbriatum*) (nationally rare and proposed for State listing).

Monitoring was implemented according to the project threatened flora management plan (RMS 2016 - updated).

To date, three years of construction phase monitoring and two years of operational phase monitoring have been carried out. The third year of operational phase monitoring was conducted by Ecos Environmental in November 2020, making a total of six years since salvage translocations were implemented prior to the start of construction.

Translocated threatened flora

Six years after salvage translocations were implemented, high survival rates were recorded for Slender Marsdenia (68%), Woolls' Tylophora (67%), Spider Orchid (100%), Rusty Plum (86%) and Floyds Grass (well in excess of the donor population). Koala Bells had died out, although this reflects the species' short life cycle and need for open, recently disturbed habitat.

The stem growth response of 164 transplanted Slender Marsdenia was highly variable and included a large percentage of plants that exhibited oscillating stem regrowth. A detailed analysis of stem growth patterns was carried out. Monitoring increased information on the autecology of this species.

In situ threatened flora

The survival rate of in-situ threatened species at the end of Year 6 (Nov 2020) was 100% for Spider Orchid, and Rusty Plum. After declining from 40% in 2018 to <1% in 2019, Maundia recovered to about 20% in 2020 and is likely to regain all its original area as regrowth continues following the end of the 2019 drought. Slender Marsdenia, survival rate was roughly stable although there was evidence that stems had died back and reshot, from the same point or close-by from tuberous roots.

Threatened flora habitat condition

The monitoring plot data found no evidence of declines in Woolls' Tylophora and Slender Marsdenia habitat condition along the edge of clearing next to the new highway.

1 Introduction

The Warrell Creek to Nambucca Heads (WC2NH) project is 19.6 km section of the Pacific Highway upgrade between Warrell Creek and Nambucca Heads on the NSW Mid North Coast (Figure 1). Construction of the WC2NH project began in February 2015 and the new section of highway was opened to traffic (i.e. operational) in July 2018.

A Threatened Flora Management Plan (TFMP) was prepared for threatened plant species impacted by the project (RMS 2016) which included a monitoring program aimed at recording and assessing three components of threatened flora management: (i) threatened flora translocation (ii) in-situ threatened flora populations and (iii) Slender Marsdenia and Woolls' Tylophora habitat condition, to be monitored during construction and operation of the project.

Previous translocation results were recorded for three years during the construction phase (Year 1 - Ecos Environmental 2016a, Year 2 - Ecos Environmental 2017, Year 3 - Ecos Environmental 2018a) and two years during operation (Ecos Environmental 2018b, Ecos Environmental 2019. In November 2020, Ecos Environmental carried out the third year of operational phase monitoring for the present report. Operational phase monitoring is being conducted for four years.

Results are described and analysed in the following sections of this report:

- Section 2: Threatened Flora Translocations
- Section 3: In-situ Threatened Flora Populations
- Section 4: Slender Marsdenia and Woolls' Tylophora Habitat Condition.

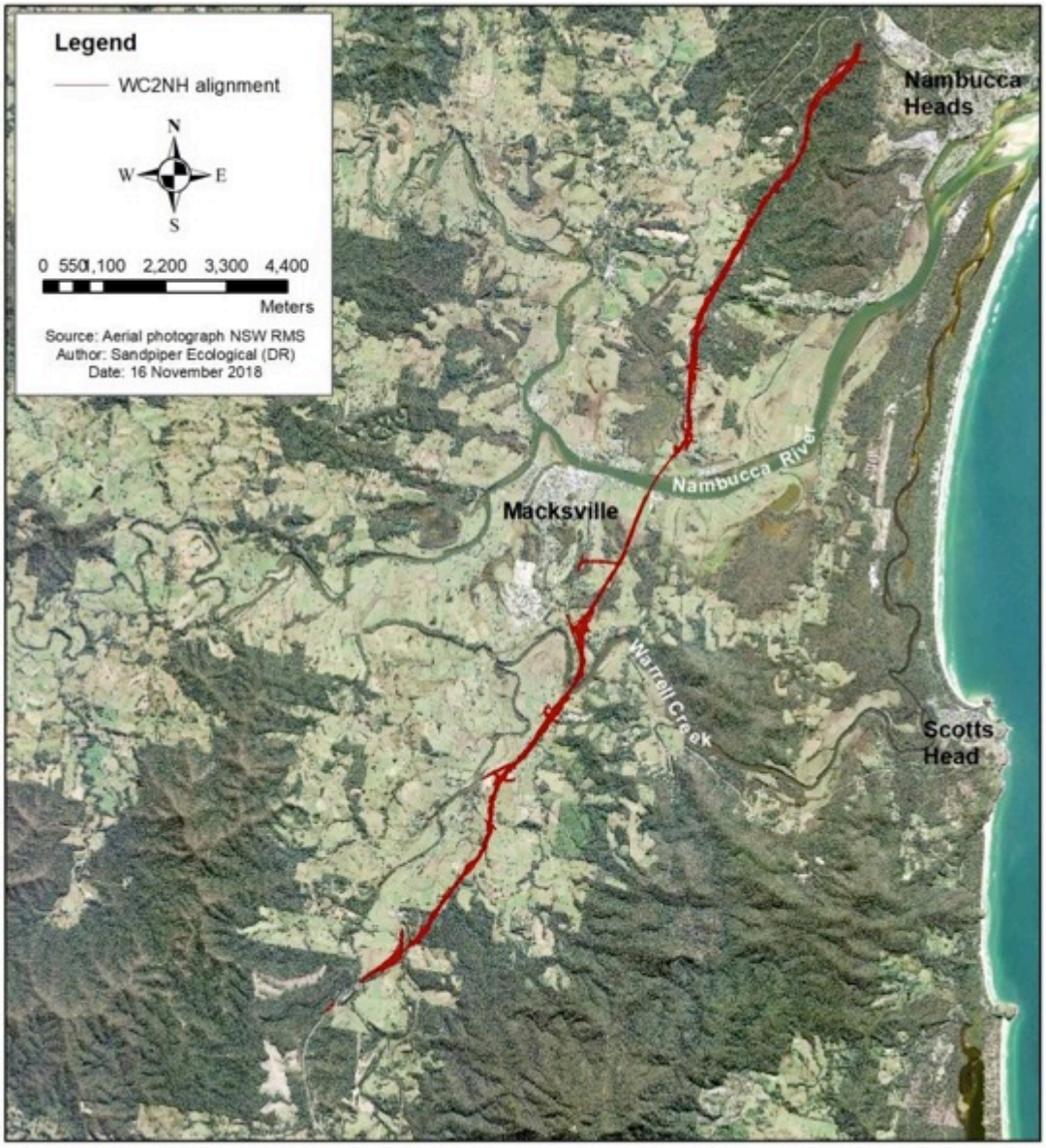

Figure 1: Location of the WC2NH alignment.

2 Threatened Flora Translocation

2.1 Aim and Species Translocated

The translocation component of the TFMP (RMS 2016) was based on guidelines for planning threatened flora translocations by the Australian Network for Plant Conservation (ANPC 2004).

The general aim of translocation was to salvage individuals of threatened species impacted by construction and re-establish them in suitable habitat adjacent to the highway corridor, near the impact sites. Some propagation was also carried out to provide replacements for potential losses during salvage transplanting. The purpose of translocating threatened flora is to maintain population size and avoid loss of numbers occurring in local threatened flora populations during construction. Translocation of each species involved three main actions:

- Salvage transplanting of impacted individuals and re-establishment at receival sites containing habitat closely approximating the impact/donor sites;
- Propagation and introduction of additional individuals as back-up in case of losses; and
- Follow-up maintenance to promote successful establishment and ensure good habitat condition.

Five threatened and one nationally rare plant species were translocated on the WC2NH project:

- Slender Marsdenia (*Marsdenia longiloba*) (listed as endangered under the *BC Act* and vulnerable under the *EPBC Act*)
- Woolls' Tylophora (*Tylophora woollsii*) (listed as endangered under the *BC Act* and the *EPBC Act*)
- Rusty Plum (*Niemeyera whitei*) (listed as vulnerable under the *BC Act*)
- Spider Orchid (*Dendrobium melaleucaphilum*) (listed as endangered under the *BC Act*)
- Floyds Grass (*Alexfloydia repens*) (listed as endangered under the *BC Act*)
- Koala Bells (*Artanema fimbriatum*) (nationally rare and has been proposed for State listing).

2.2 Methods

2.2.1 Receival Sites

Nine receival sites were selected for the species being translocated. All were located in the road reserve (i.e. on RMS property), seven where the highway corridor crosses Nambucca State Forest, one adjacent the new highway bridge at Warrell Creek, and one at the southern end of the upgrade (Table 1 and Figure 2). For further details on receival site selection and a description of each site, refer to any of the construction phase monitoring reports (Ecos Environmental 2016a, 2017 and 2018a).

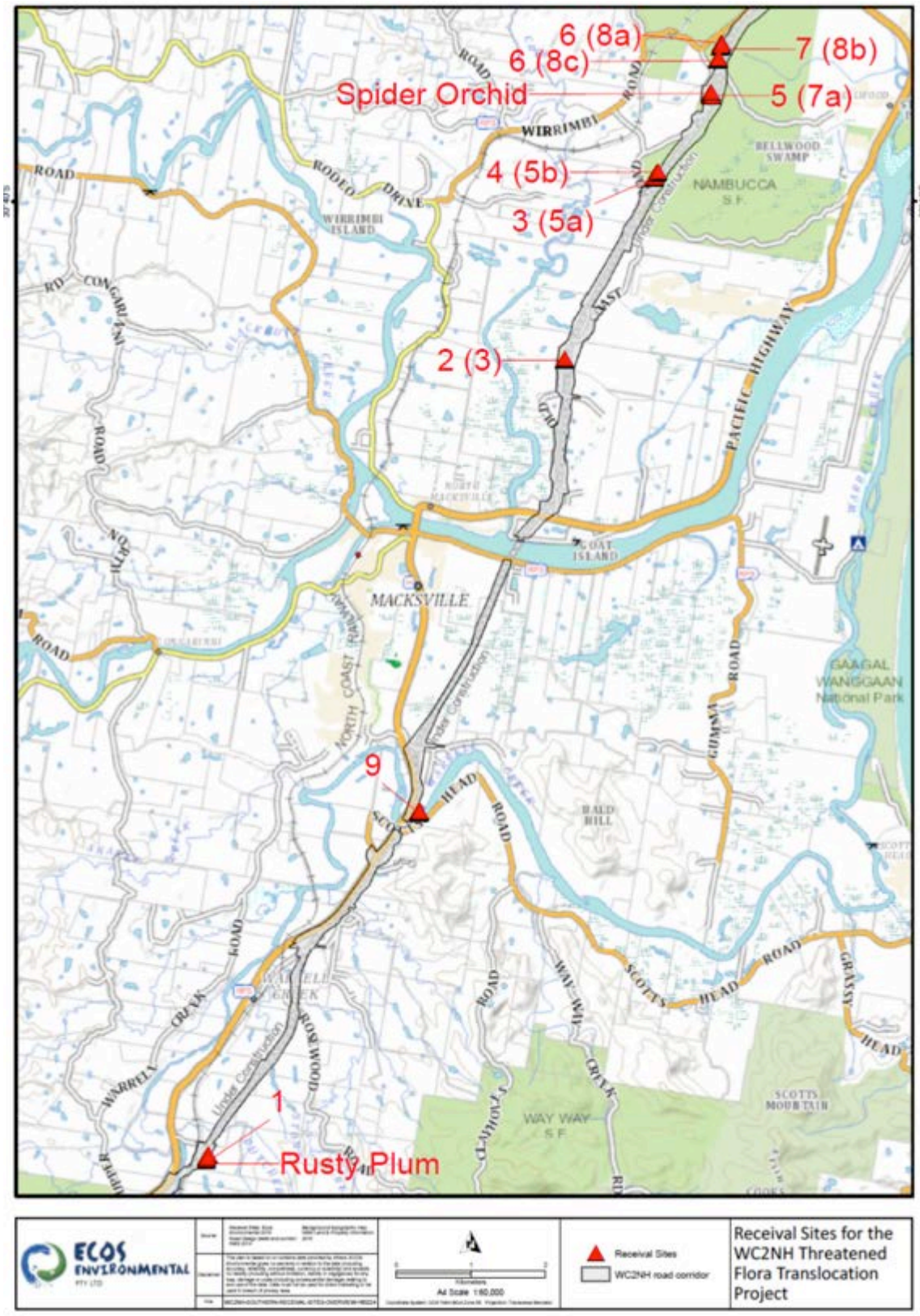

Figure 2: Location of threatened flora translocation receival sites for the WC2NH section of the Pacific Highway upgrade.

Table 1: Translocation receival sites and species translocated. The bracketed identifier is the original number used during selection of the receival sites. A question mark after Woolls' Tylophora indicates that identification is not confirmed (i.e. based on leaves, not flowers).

Receival Site	Species
1 (Cockburns Lane)	Slender Marsdenia, Rusty Plum
2 (3)	Slender Marsdenia
3 (5a)	Slender Marsdenia
4 (5b)	Slender Marsdenia (and Large-flowered Marsdenia)
5 (7a)	Slender Marsdenia, Spider Orchid, Rusty Plum direct seeding, Slender Marsdenia population enhancement.
6 (8a)	Slender Marsdenia, Woolls' Tylophora(?)
7 (8b)	Koala Bells
8 (8c)	Slender Marsdenia
9 (Warrell Creek)	Floyds Grass, Koala Bells population enhancement

2.2.2 Direct Transplanting

Threatened species were translocated from the construction footprint using the direct transplanting method. Direct transplanting involves plant excavation, transport to the receival site and replanting in a single operation, as expeditiously as possible. Trees and saplings are usually dug out with an excavator and small plants with hand tools. The general approach is to excavate each plant with a reduced but partly intact shoot system and root ball, so the plant continues to function physiologically and can regenerate new shoots, leaves and roots. The stem system is pruned back to adjust the root: shoot ratio and reduce evapotranspiration stress, which is the main cause of mortality during transplanting. Regular watering for the first month or so is essential.

Compared to other translocation techniques such as gradual transplanting or propagation from seed or cuttings, direct transplanting can have several advantages:

- Trees and shrubs begin flowering and seed production earlier.
- Less risk of transferring diseases (through handling or from a nursery environment).
- Mycorrhizae and soil microflora are maintained by moving plant and soil together.
- Suitable for large numbers of individuals, large or small.
- Suitable for implementation in rough, forested terrain
- Cost-effectiveness

In a developmental context, some workers prefer translocation by propagating the species from seed or cuttings in a nursery environment followed by introduction to the field. However, Primack (1996) has pointed out the advantages of salvage transplanting: "There are nonetheless ecological advantages to using transplanted plants rather than seeds in reintroduction (translocation) efforts. Plants, particularly adult plants have a higher likelihood of successful establishment than seeds (or seedlings) if they are planted into a suitable site and well-tended. These plants have overcome the most vulnerable stages in their life cycle (seed germination and seedling establishment) so that their chances of surviving in the new habitat are greatly increased. These individuals also have proven genotypes that are free of lethal mutations and adapted to the general environmental conditions. When reintroduction efforts involve reproductively mature adult plants, the new population has the potential to

flower, produce and disperse seeds and create a second generation of plants within a year (or so) of transplantation".

Translocation methods applied to each species on the WC2NH project are described in more detail below.

2.2.3 Slender Marsdenia

2.2.3.1 Salvage Transplanting

Slender Marsdenia was transplanted in February 2015. Seven receival sites were used (Table 6), which were placed near the donor sites to maintain roughly the original population distribution. Stems were moved in blocks of soil about 30 cm wide and 20 cm deep dug out with a spade. This usually meant breaking the plants' tuberous rhizome which grows horizontally in the topsoil. Each salvage point in the TFMP, often included two or more stems (i.e. stem-individuals), sometimes attached to the same rhizome. Stem individuals were generally removed individually as they were not well separated. All stem-individuals were transplanted, including any previously unrecorded ones.

Plants and soil were kept damp during transport and watered as soon as they were planted. The 'stem-individuals' were planted at 5 m intervals along lines to minimise bias in selecting a planting point and to make monitoring easier. Additional plants were translocated in 2016 due to a modification in the road design. In total, 175 stem-individuals were translocated.

The transplants were watered once every two days for the first week then once a week for four weeks. Chicken wire cylinders were installed to prevent animal grazing, to act as a climbing frame and to facilitate monitoring. Flagging tape was attached to the base of each stem just above the ground to make it easier to check if stems that had died back were still alive. Flagging tape with the individual's monitoring number and source code as per the TFMP was attached to each cage. Multiple individuals from the same mapped point were indicated by additional numbers on the source plant code – e.g. ML 46-6, ML46-7.

2.2.3.2 No Fertiliser

Previous translocation work with Slender Marsdenia on the Bonville project found that addition of slow release fertiliser adversely effected the survival of transplanted Slender Marsdenia (although not when grown in pots). Therefore, no fertilisers or mulch were applied to this species during the WC2NH translocation. An experimental comparison of fertiliser and no fertiliser treatments on the NH2U project indicated that even a light application of slow release fertiliser resulted in decreased growth (Ecos Environmental 2016).

2.2.3.3 Propagation of Population Enhancement Plants

Propagation of Slender Marsdenia from rhizome pieces collected during transplanting had poor results. The strike rate of rhizome cuttings was <5% and shoot and root growth was very slow. This was unexpected as the species produces new stems by budding off its rhizome, although these are relatively sparse. A similar low strike rate by propagating from rhizome pieces was recorded on the NH2U project. The few plants propagated were grown-on for two years and planted out in November 2017 at Receival Site 7a.

Searches for Slender Marsdenia pods to propagate from seed were carried out in December 2016, focusing on known large plants on the WC2NH, NH2U and S2W sections of the Pacific highway, but no pods were found. A single pod was found on the WC2NH section in the

summer of 2014/15 during other flora survey work. The pod contained about 100 seeds and nearly all germinated successfully. The seedlings were used on the NH2U project in experimental trials underway at that time (Ecos Environmental 2016).

2.2.4 Woolls' Tylophora

2.2.4.1 Species Identification

Woolls' Tylophora has not been positively identified on the WC2NH project, as no flowering plants have been found. A few plants were tentatively identified as Woolls' Tylophora during TFMP surveys, based on leaf features. Typically, Slender Marsdenia has a more elongated leaf, pinnate venation, cordate leaf base and is glabrous (without hairs). Woolls' Tylophora has a broader leaf with purplish tinges (not always), tends to be more 3-veined at the base and is sparsely hairy (hand lens needed). The two species flower at different times - Woolls' Tylophora from the Bonville project flowered in late August, whereas Slender Marsdenia from NH2U flowered in November and occasionally later (pers. obs.).

Several Slender Marsdenia plants were observed flowering on the WC2NH project, but no Woolls' Tylophora. If Woolls' Tylophora is present, it appears to be rarer than Slender Marsdenia.

2.2.4.2 Salvage Transplanting

Individuals tentatively identified as Woolls' Tylophora were transplanted using the same methods applied to Slender Marsdenia. Both species are vines with tuberous roots. Woolls' Tylophora was translocated to Receival Site 8a, which also received some Slender Marsdenia.

2.2.5 Rusty Plum

2.2.5.1 Salvage Transplanting

All Rusty Plums were salvaged from the Cockburn's Lane section at the southern end of the project and were transplanted into the adjacent road reserve (Receival Site 1). An excavator was used to trench around Rusty Plum trees up to 12 m high, forming a soil-root ball about 1-1.5 m wide and 0.7 m deep. The root ball was undercut, and the tree leaned to the side where the trunk, branches and roots were pruned.

The transplants were watered for the first month. Sugar cane mulch was spread around each plant and hessian barriers erected for shade, as the site was exposed to the afternoon sun. No fertilisers were used.

Several Rusty Plums remained in-situ outside the clearing/construction boundary.

2.2.5.1 Population Enhancement by Direct Seeding

To enhance the population of Rusty Plum on the WC2NH corridor, plants were introduced to one receival site by direct seeding. About 50 fruits were collected in Nambucca State Forest in November 2017. The single large seed were separated from the outer fleshy layer and direct seeded next to Receival Site 7a on the 7th December 2017. The site is in a minor gully supporting wet sclerophyll forest (Flooded Gum) with a rainforest understorey. As trials with direct seeding of Rusty Plum on NH2U had shown the seed is taken by animals and the seedlings grazed (Ecos Environmental 2015), seeds were placed inside metal mesh cylinders. Fourteen cylinders were set out and three or four seeds placed on the soil surface

in each cylinder and covered lightly with leaf litter. The cylinders were tagged for monitoring and locations recorded with a GPS.

2.2.6 Spider Orchid

2.2.6.1 Salvage Transplanting

Two mature Spider Orchid plants were salvaged from Prickly Paperbark (*Melaleuca styphelioides*) trees on the WC2NH footprint. The section of branch supporting the orchid was removed so there was minimal disturbance of the orchid root system growing on the tree bark. The branch with orchid was attached to a small tree in a shaded gully at Receival Site 5 (7a). Apart from keeping plants damp during transport, no watering was carried out.

2.2.6.2 Population Enhancement

The TFMP planned to propagate Spider Orchid plants and introduce them to suitable habitat areas to enhance the local population of this species. Vegetative propagation by division of clumps was not an acceptable option due to the low number of wild plants. Propagation from seed was possible and searches were carried out to try and find seed pods of this species focusing on known locations, but they were unsuccessful.

One seed pod was produced in a translocated population of 55 Spider Orchids on the NH2U project in Spring 2016, but the pod opened between site visits in November 2016 and all the seed were dispersed before they could be collected.

The large Spider Orchid plant translocated on WC2NH flowered each year for six years from 2015 to 2020, but no seed pods were produced (monitoring was carried out in November after flowering in September so it is unlikely pods were missed). An in-situ plant was also monitored but no seed were produced.

2.2.7 Koala Bells

2.2.7.1 Salvage Transplanting

Koala Bells was transplanted in blocks of soil 40 cm wide by 20 cm deep. Plants were pruned and the soil block planted at Receival Site 8b, which was the only site found in the WC2NH road reserve with swamp forest similar to Koala Bells habitat. Wire cylinders were installed around the plants and follow-up watering carried out. No fertilisers were applied.

2.2.7.2 Population Enhancement

Cuttings of Koala Bells were propagated at Ecos Environmental's nursery in summer 2015-2016. The cuttings struck successfully and flowered over summer and autumn, died back in winter then reshot in spring 2016, all while the plants were still in pots. Regrowth in spring 2016 was less vigorous and small adventitious shoots were produced around the edge of the pots. (Vegetative propagation was also observed in some transplants in the field on NH2U.) Twenty plants were introduced to Receival Site 9b, the Floyds Grass translocation site at Warrell Creek in January 2017. This site is on alluvial soil and had an open ground layer with little competition from other ground layer plants, conditions that seem to be preferred by Koala Bells.

2.2.8 Floyds Grass

2.2.8.1 Removal of BLP and topsoil seedbank

Floyds Grass was planted into two 20 m x 20 m areas located on the northern side of Warrell Creek close to the donor site on the edge of the creek. The two areas referred to as Receival Sites 9a & 9b are about 25 m apart. Topographically the site was ideal for Floyds Grass, being on alluvium and close to Warrell Creek but the vegetation was very weedy.

The site was densely covered in Broad-leaved Paspalum (BLP) and Lantana. To prepare the site for introduction of Floyds Grass, a stripping process was carried out, where weeds and the topsoil layer with its weed seedbank were scrapped off using an excavator. As the site was on relatively deep alluvium, there was sufficient depth of well-drained soil left for Floyds Grass to establish after the stripping operation. Killing the BLP and other weeds with herbicide would have left the soil seedbank to contend with and it would not have been impossible to spray weed seedlings without hitting Floyds Grass as it spreads by runners close to ground. Therefore, the strategy was to completely remove BLP and the soil seedbank, then plant Floyds Grass into the weed free site.

Preparation of the site was carried out as follows. First, ground layer vegetation consisting mainly of BLP and Lantana was scrapped off using an excavator bucket. After exposing the soil surface, the top 10 cm of soil was scrapped off and placed on the edge of the site. The soil beneath the uppermost 10 cm was found to have a moderately high clay content, but soil texture and drainage were still suitable for young plant growth. Sed fencing was installed around the site to prevent run-off of soil material to Warrell Creek and to act as a barrier to deter wallaby grazing.

2.2.8.2 Salvage Transplanting

Small clumps of Floyds Grass were dug out with a spade from the bridge site on the edge of Warrell Ck and planted into Receival Site 9a. The plants were watered, and sugar cane mulch (weed free) spread lightly over the soil surface to minimise raindrop compaction. Follow-up watering was carried out as conditions were dry. ‘Seasol’ (seaweed and fish emulsion) fertiliser was applied two weeks after introduction to stimulate growth. As the site was exposed to the afternoon sun, 1 m high shade-cloth fences were erected to provide additional shade (see Plate x).

Although the topsoil seedbank had been removed, some seed germinated from deeper in the soil, notably *Phytolacca octandra* (Ink Weed), a large herbaceous shrub. There was very little BLP germination.

2.2.8.3 Population Enhancement

To increase the size of the salvaged population, approximately 100 additional Floyds Grass were propagated at Ecos Environmental’s nursery and planted in Receival Site 9b in March 2016. Plants were propagated vegetatively from small pieces of runner that broke off during transplanting. As site 9b was more exposed than site 9a, the shade cloth fences had a roof to protect from the overhead sun. Follow-up hand weeding to remove exotic and native species was carried out.

2.2.9 Monitoring and Data Analysis

Monitoring during the construction phase (2015-2018) was conducted quarterly in the first 12 months, biannually in the second 12 months and then annually. Monitoring during the operational phase from 2018 to 2020 was carried out annually.

The following data were recorded to assess survival and growth:

- All species except Spider Orchid: Monitoring Number, Date, Line, Source Label (species translocation plant label), Species (Current ID), Overall Condition (see below), Height (cm), New Shoots (Y/N), Comments, Significant Growth (+) or Significant Dieback (-), Coordinates.

- Spider Orchid: Monitoring Number, Date, Source Label, Species, Number of Pseudobulbs with Leaves, Length of the Longest Pseudobulb, New growth, Overall Condition, Coordinates.

Plant condition was scored on a scale of 0 to 5, where zero = dead and 5 = fully mature, reproductive (Table 2-4). Slender Marsdenia individuals that had died back to the ground were scored as 1 rather than 0 (dead) as stems could reshoot from below ground. Some died back and reshot repeatedly, and some took two years to reshoot. Only plants with above ground stem growth were included in calculation of survival% (i.e. condition score of 2 or greater). Individuals with a condition score of 1 were not included as some of these could have been dead. The survival rate reported is therefore slightly lower than the actual survival rate. The condition-score scale was defined slightly differently for each species, as shown in Tables 2-4 below.

Percent Survival was defined as:
number of individuals in condition classes 2+3+4+5/total *100.

Species height at each monitoring event was averaged for all plants present at the start of monitoring in June 2015, and included plants with zero height that had died back to ground level (i.e. condition class 1 or 0 in the case of Slender Marsdenia).

Table 2: Condition scores applied to Slender Marsdenia and Woolls' Tylophora.

Score	**Condition**
0 – dead	Dead, no sign of reshooting 2 years after dying back
1 –poor	Stem died back to ground level, possibly dead, live stem stub may be present
2 – fair	Plant <75 cm tall, with leaves or leafless, new shoots or active growth present or absent
3 – good	Plant >75 cm tall, stem with leaves, new shoots or active growth present or absent, if stem leafless or leaves discoloured score as 2
4 – advanced	Plant >2.5m tall with >15 leaves
5 – mature	Mature, plant flowering or seeding

Table 3: Condition scores applied to Rusty Plum and Koala Bells.

Score	Condition
0	Dead
1	Leafless and no sign of re-shooting
2	Pruned foliage retained, or small amount of re-shooting after defoliating, or foliage sparse/discoloured (<40 cm tall for Koala Bells)
3	Vigorous re-shooting (>40 cm tall for Koala Bells)
4	Crown recovering, foliage healthy
5	Growing actively, flowering or seeding recorded

Table 4: Condition scores applied to Spider Orchid.

Score	Condition
0	Dead
1	Pseudobulbs discoloured or grazed or withering, no new growth
2	Pseudobulbs healthy in colour, not withering, no new growth
3	Plant small, few healthy pseudobulbs, new growth occurring
4	Several healthy pseudobulbs present, new growth occurring
5	Several good sized, healthy pseudobulbs, flowering or seeding recorded

Pattern of Stem Growth in Slender Marsdenia

Slender Marsdenia showed complex variation in tpattern of stem regrowth after transplanting. Nearly all plants reshot but some plants stayed small and changed little over six years, while others grew tall (>2 m) or maintained steady growth the whole time. Most noticeable were plants that fluctuated in height, reshooting then dying back then reshooting again, sometimes in repeated cycles over six years. After dying back, some plants took more than a year to reshoot, while others died back and reshot twice in one year. The dead stems of these plants were still visible on the wire cage. This variation was perplexing when the volume of soil containing plant and rhizome was initially about the same size (~30 cm x 10 cm x 10 cm), or not greatly different, although the thickness of rhizomes varied (not recorded, but mostly 4-6 mm diameter).

To examine the different pattens of stem growth amongst individuals after transplanting in more detail, 12 categories of stem height change were defined, as shown in Table 5. These were derived by combining stem height data for all individuals in a single spreadsheet for each receival site, then subjectively identifying characteristic syndromes of height change (Table 5). Number of individuals in each category were tallied and expressed as percentages of the total.

Table 5: Categorisation of syndromes of stem height change in Slender Marsdenia over a six-year period after salvage transplanting. Three primary syndromes were recognised – those that died or were probably dead (D), those with relatively little growth that remained small for six years (S), and those that showed relatively vigorous growth (T). Twelve sub-categories were recognised, as defined below.

Sub-categories with "(O)" showed pronounced oscillation in stem growth with cycles of stem dieback and regrowth.

Code	Regrowth response syndromes of transplanted individuals
D	**Dead or possibly dead; all ht = 0 at Nov/2020**
D1	Never reshot
D2	Small shoot then died back to ground, probably dead
D3 (O)	Reshot, reached small to medium height (<1.2 m) then died back to ground, some fluctuated (i.e. dieback-reshoot-dieback)
D4	Reshot, grew tall (~2 m+) then died back to ground, probably dead
S	**Small, growing very slowly, or declining**
S1	Stayed small, mostly less than 10 cm high (occasionally to 50 cm), little change in height in 6 years
S2 (O)	Died back to ground and reshot once or twice, continuously small (mostly <50 cm)
S3	Declining or bell shaped (increase-decrease), some to ~130cm at peak, continuously alive but stem mostly small (<50 cm)
S4 (O)	Fluctuating – e.g. 'small-medium/tall-small'; or 'grew medium/tall then died back to small
T	**Thriving, plant relatively tall, continuing to grow, or maintaining size, healthy**
T1	Tall (1.5 m+), substantial increase in height/number of leaves, or maintained tall height
T2	Moderately tall (0.75 – 1.5 m +), moderate increase in height (δ = 0.5 – 1 m or more), or height constant
T3 (O)	Died back to ground then reshot vigorously (>1 m)
T4	Small for several monitoring events then suddenly grew taller (>1 m)

2.3 Translocation Results

2.3.1 Survival Summary – All Species

Six years after salvage translocation and three years into operational phase monitoring, high survival rates were recorded for all six threatened plant species: Slender Marsdenia 68%, Woolls' Tylophora 67%, Spider Orchid 100%, Rusty Plum 86% and Floyds Grass (see Table 6).

No plants of the rare species Koala Bells were alive after six years. This species appears to be naturally short-lived and requires recently disturbed habitat to recruit new seedlings. Koala Bells can be found on the edge of forest tracks where it grows from seed. As ground layer vegetation become thicker it loses vigour and dies out, but probably persists in the soil seedbank. It grew well at the two receival sites (8b and 9b) for the first 1-2 years and produced seed. Similar results were recorded in other translocations of this species (e.g. NH2U).

Table 6: Survivorship (% alive) of species at six receival sites over 6 years (2015-2020), after salvage translocation.

Species/Receival Site	**No. plants transl.**	**Survival (%)**					
		Aug 2015 (~6 mth)	**Jan 2017 (~2 Yrs)**	**Nov 2017 (~3 Yrs)**	**Nov 2018 (~4 Yrs)**	**Nov 2019 (~5 Yrs)**	**Nov 2020 (~6 Yrs)**
Slender Marsdenia(*Marsdenia longiloba*)							
Receival Site 1 - Cockburns Lane	27	93	75	63	59	59	56
Receival Site 2 (3) – Old Coast Rd	17	91	93	88	88	88	88
Receival Site 3 (5a) – Old Coast Rd	22	81	91	73	77	68	68
*Receival Site 4 (5b) – Old Coast Rd	16	94	81	69	69	50	71
Receival Site 5 (7a) – Old Coast Rd	57	90	72	74	72	56	61
Receival Site 6 (8a) – Old Coast Rd	8	75	75	75	88	86	93
Receival Site 8 (8c) – Old Coast Rd	28	100	86	82	79	70	67
Total/All Sites	164 (175)	91	80	74	74	68	68
Rusty Plum(*Niemeyera whitei*)							
Receival Site 1 - Cockburns Lane	7	100	86	86	86	86	86
Wooll's Tylophora (*Tylophora woollsii* – unconfirmed)							

Species/Receival Site	No. plants transl.	Survival (%)					
		Aug 2015 (~6 mth)	Jan 2017 (~2 Yrs)	Nov 2017 (~3 Yrs)	Nov 2018 (~4 Yrs)	Nov 2019 (~5 Yrs)	Nov 2020 (~6 Yrs)
Receival Site 6 (8a) – Old Coast Rd	6	100	100	83	67	67	67
Spider Orchid (*Dendrobium melaleucaphilum*)							
Receival Site 5 (7a) – Old Coast Rd	2	100	100	100	100	100	100
Floyds Grass (*Alexfloydia repens*)							
Receival Site 9a – Warrell Creek	54 clumps	94	Substantial cover	Substantial cover	Substantial cover	Substantial cover	Fair cover
Receival Site 9b – Warrell Creek	61 clumps	Not planted yet	98	93	70	Reasonable cover	Fair cover
Koala Bells (*Artanema fimbriatum*)							
Receival Site 7 (8b) – Old Coast Rd	16	63	25	13	6	0	0
Receival Site 9 – Warrell Creek	14	Not planted yet	Not yet planted	57	86	75	0
Total	30	63	25	34	43	37	0

* Note – Site 5b included 9 *Marsdenia liisae* and 7 *M. longiloba*. These species had a survival rate of 78% and 71% respectively.

2.3.2 Slender Marsdenia (*Marsdenia longiloba*)

2.3.2.1 Summary

Combining data for all six receival sites, the survival rate of Slender Marsdenia after 6 years was 68%, the same as last year (Table 6). Survivorship per site ranged from 56% to 93%. Overall, two sites had very high survival rates (3, 8a) and four sites had moderately high survival rates (1, 5a. 7a, 8c).

High survival rates were maintained despite the severe drought conditions in 2019. Given the tendency of Slender Marsdenia to die back and reshoot again, some individuals recorded as dead (ie Ht = 0) may still reshoot, so the actual survival rate is probably slightly higher, around 75%.

When observed in November 2019 during drought there was no sign of moisture stress such as wilting and many plants had new shoots, a sign of active growth. This suggests that the tuberous rhizome of Slender Marsdenia stores water as well as photosynthate, which the plant draws on to initiate new growth in spring when conditions on average are dry.

2.3.2.2 Changes in mean height

Mean plant height is a measure of how well Slender Marsdenia regrew and recovered from transplanting at each site. Mean height was calculated by averaging across all individuals including those with zero height, which underestimates the mean height of live plants, but arguably gives a better estimate of overall performance by factoring in mortalities.

Mean stem height of Slender Marsdenia at receival sites after six years ranged from 35.0 cm to 97.6 cm (Table 7), similar to last year.

After the initial period of height increase in Year-1 there was relatively little change in mean height in Year 2 at the six receival sites (Figure x), then in Year 3 mean heights in the receival sites started to diverge more, staying relatively constant in sites 7a, 5a and 1, and increasing in sites 3, 8c and 8a. This difference appeared to reflect the higher mortality of plants in sites 7a, 5a and 1, or greater number of zeros in the data.

Oscillations in mean height at the different receival sites are evident in Figure 3. This is partly due to the tendency of Slender Marsdenia to die back then resprout again (see next section). There is little correspondence between the six sites in the pattern of rises and dips, which suggests that fluctuations are not related to the macro environment (e.g. rainfall pattern) but perhaps to differences in habitat and internal rhythms of plant growth.

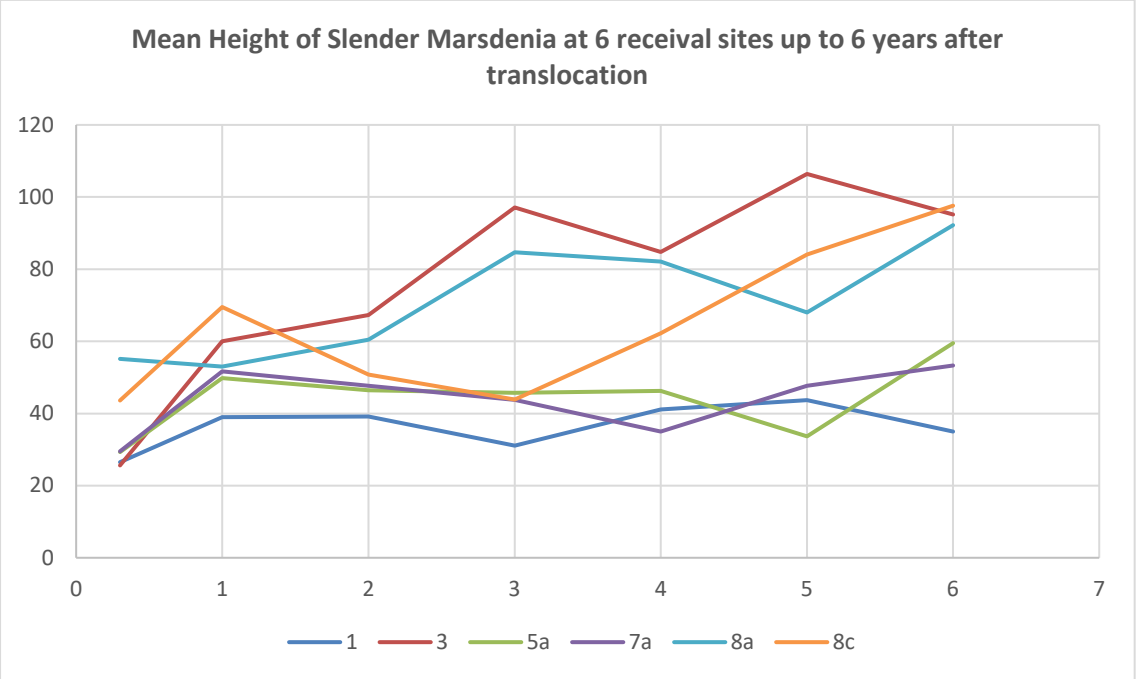

Figure 3: Changes in the mean height Slender Marsdenia at 6 receival sites after during years 1-6 after transplanting. Mean height diverges more from Year 3 onwards, staying relatively flat in sites 7a, 5a and 1, and increasing in sites 3, 8c and 8a. This is due to higher mortality in sites 7a, 5a and 1.

Table 7: Mean height (cm) ± standard error of Slender Marsdenia at 6 receival sites from June 2015 to November 2020 (six years after translocation). This data is plotted in Fig 3.

Receival site	n	June 2015 (6 mths)	Feb 2016 (~1 yr)	Jan 2017 (~2 yrs)	Nov 2017 (~3 yrs)	Nov 2018 (~4 yrs)	Nov 2019 (~5 yrs)	Nov 2020 (~6 yrs)
Receival Site 1	27	26.5±6.5	39.0±10.4	39.2±10.6	31.1±10.3	41.13±9.5	43.7±8.8	35.0±12.0
Receival Site 2 (3)	11	25.6±10.1	60.8±15.5	67.3±13.6	97.1±14.2	84.8±12.7	106.4±13.2	95.2±15.9
Receival Site 3 (5a)	22	29.3±7.5	49.8±11.2	46.4±9.5	45.7±9.3	46.3±10.8	33.7±9.5	59.5±15.0
Receival Site 5 (7a)	57	29.5±3.7	51.7±6.9	47.7±7.6	43.8±8.1	35.0±6.3	47.7±5.7	53.3±10.6
Receival Site 6 (8a)	8	55.1±22.2	53.0±17.9	60.5±17.5	84.7±18.3	82.1±19.1	68.0±17.7	92.2±25.9
Receival Site 8 (8c)	28	43.6±6.3	69.5±9.1	50.8±5.9	43.9±5.4	62.2±10.6	84.1±9.6	97.6±26.1

The averaged height data presented in Figure 3 are informative but do not show what is happening to individual plants. This is examined in the next section.

2.3.2.3 Pattern of stem growth response in transplanted Slender Marsdenia

The stem regrowth response of Slender Marsdenia after transplanting varied greatly both within and between receival sites. Of the three main categories of response taken over six years (D, S and T), D (dead) ranged from 7.1% to 44.4% between receival sites, S (small) ranged from 5.9% to 38.1%, and T (tall or thriving) ranged from 9.1% to 82.4%.

Table 8 shows the percentage of three primary categories and 12 sub-categories of stem regrowth response defined above in Section x which are shown graphically in Figs 3 and 4.

Table 8: Percentage of three primary categories and 12 sub-categories of stem regrowth response after transplanting. Sub-categories with "(O)" showed pronounced oscillation in stem growth with cycles of stem dieback and regrowth.

	Stem Height Growth Syndromes of transplanted individuals – see notes		**Receival sites**					
		1 (Cb)	**2 (3)**	**3 (5a)**	**5 (7a)**	**6 (8a)**	**8 (8c)**	**All**
D	**Dead or possibly dead; all ht = 0 at Nov/2020**							
D1	Never reshot	3.7	0	4.5	5.3	7.1	0	3.0
D2	Small shoot then died back to ground, probably dead	14.8	11.1	9.1	7.0	7.1	3.7	8.5
D3 (O)	Reshot, reached small to medium height (<1.2 m) then died back to ground, some fluctuated (i.e. dieback-reshoot-dieback)	25.9	0	18.2	26.3	0	25.9	20.0
D4	Reshot, grew tall (~2 m+) then died back to ground, probably dead	0	0	9.1	0	0	3.7	0.6
	Sub-total	44.4	11.7	38.1	38.6	7.1	33.3	32.1
S	**Small, growing very slowly, or declining**							
S1	Stayed small, mostly less than 10 cm high (some to 50 cm), little height change in 6 yrs	7.4	5.6	0	7.0	0	7.4	5.5
S2 (O)	Died back to ground and reshot once or twice, continuously small (mostly <50 cm)	11.1	0	4.5	7.0	0	0	5.5
S3	Declining or bell shaped (increase-decrease), some to ~130cm at peak, continuously alive but stem mostly small (<50 cm)	7.4	0	18.2	3.5	0	3.7	4.9
S4 (O)	Fluctuating – e.g. 'small-medium/tall-small'; or 'grew medium/tall then died back to small	11.1	0	9.1	14.0	28.6	7.4	11.5
	Sub-total	33.3	5.9	38.1	31.6	35.7	18.5	27.3
T	**Thriving, plant relatively tall, continuing to grow, or maintaining size, healthy**							
T1	Tall (1.5 m+), substantial increase in height/no. of leaves, or maintained height	3.7	5.6	9.1	5.3	7.0	18.5	7.9
T2	Moderately tall (0.75 – 1.5 m +), moderate increase in height (δ = 0.5 – 1 m or more), or height constant	7.4	66.7	13.6	22.8	50.0	25.9	26.7
T3 (O)	Died back to ground then reshot vigorously (>1 m)	11.1	0	4.5	1.8	0	0	3.0
T4	Small for several monitoring events then suddenly grew taller (>1 m)	0	11.1	0	0	0	3.7	3.0
	Sub-total	22.2	82.4	9.1	29.8	57.1	48.1	40.6
	% Survivorship 6 yrs	55.6	88.2	68.2	61.4	92.9	66.6	67.9
	Total individuals	27	17	22	57	14	27	164

In the D group (Dead or possibly dead, Ht = 0) – 32.1%

- Most of the D group reshot, grew small to medium in size then died back to the ground (Ht = 0), sometimes in two cycles.
- A low 3% out of 164 transplants failed to show any recovery after transplanting (i.e. D1).

In the S group (Small) – 27.3%

- 5.5% remained small (<10 cm high) for 6 years (i.e. S1)
- 5.5% died back and reshot one or more times, but stayed small (i.e. S2)
- 11.5% fluctuated from small to medium or large and then small again (i.e. S4)

In the T group (Tall or Thriving) – 40.6%

- 35% maintained relatively tall height after regrowth in Year 1 (T1 & T2)
- 6% fluctuated dying back then reshooting and growing tall again (T3 and T4)

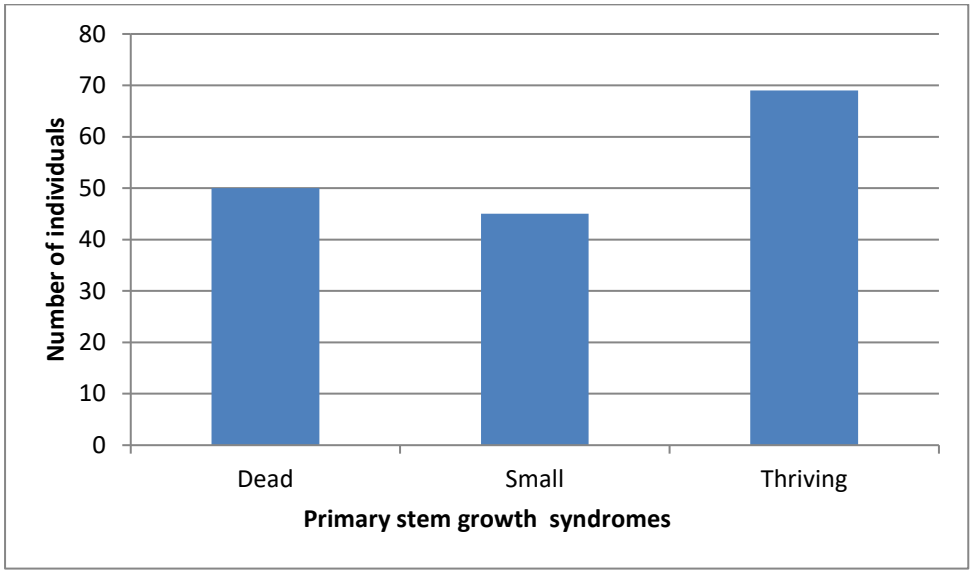

Figure 4: Frequency of the three main regrowth outcomes in transplanted Slender Marsdenia over six years. Data pooled for 6 receival sites.

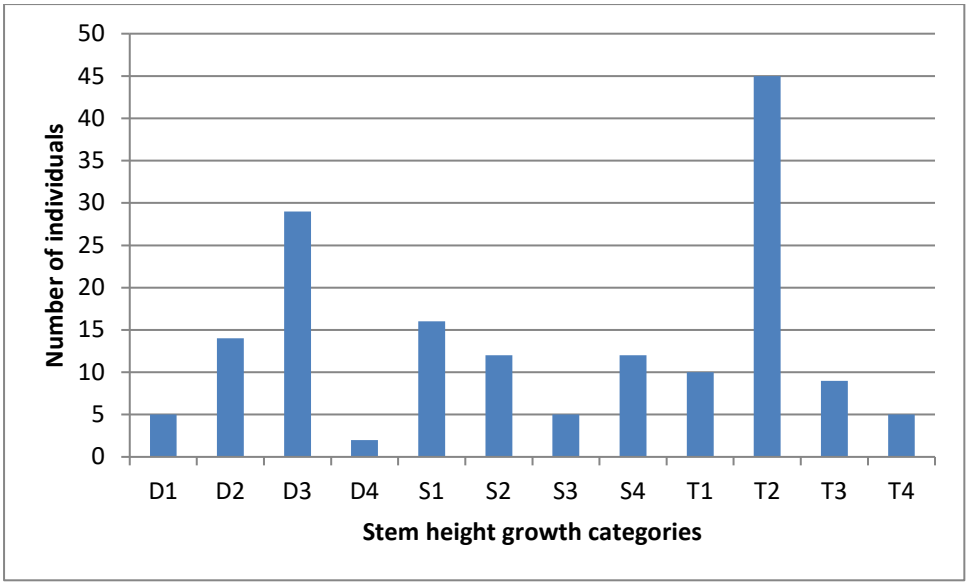

Figure 5: Stem growth pattern of 164 translocated Slender Marsdenia. Data from six receival sites combined. Primary categories: D = dead, S = surviving, T = thriving. See Table 5 for definition of stem height growth sub-categories.

2.3.2.4 Receival site and stem growth

Inspection of Table 8 shows that the 6 receival sites fall into 3 groups with respect to patterns of stem growth: -

> Receival sites 1 and 7a had high D and S and low T; these sites also had a lower incidence of plants with new shoots.
>
> Receival sites 3 and 8a had low D and S and high T; these sites also had a higher incidence of plants with new shoots.
>
> Receival sites 8a and 5 have intermediate values of D, S and T.

At least some individuals at all receival sites reached the T1 or T2 categories (i.e thriving).

There was no obvious factor underlying the variability in stem regrowth response. Two general factors could be involved: -

1. Differences in the quality or vigour of stem individuals transplanted from donor sites to the receival sites. The donor sites for receival sites 1 and 7a included many small, stem-individuals, while receival sites 3 and 8a received larger, more vigorous plants.
2. Habitat differences including soil moisture, soil nutrient availability, associated species and light levels may have affected stem growth. Receival sites 1, 7a and 5a with lower mean height and higher mortality, were in wet sclerophyll with a denser rainforest mid-stratum and lower light levels. Sites 3, 8a and 8 c with higher mean height and lower mortality were more open wet sclerophyll with higher light levels.

2.3.2.5 Incidence of stem height oscillation

Most new shoot growth in Slender Marsdenia is produced from early spring to early summer. Stems often grew ~10 cm to 1 m on the wire mesh cylinders then die back to ground, then produced another stem, sometimes in the same season, or 1 or even 2 years later. Such oscillating or transitory stem growth is common even though some plants maintain roughly constant height or continue to grow. New stems grow from the tuberous rhizomes of Slender Marsdenia, which they appear to produce selectively and in low number.

Several categories of stem height change in Table 5 over 6 years involve stems dying back then new stems being produced again from the same point (i.e. D3, D4, S2, S4, T3). Stem height fluctuation was more common in smaller plants but also recorded occasionally in large plants. Reshooting after dieback generally occurred within 12 months, but sometimes not for 18 months, and in a few cases longer.

Modifying the primary categories of stem height change in Table 8 to emphasise stem height fluctuation (i.e. D3+D4+S2+S4+T3), 39% of transplanted stems exhibited stem height oscillation over the six year monitoring period.

Possible functions underlying stem height fluctuation in Slender Marsdenia include:-

(i) *Seasonal growth response.*To replenish food storage in tuberous roots (the reshooting phase), while minimising consumption of stored food if conditions for photosynthesis decline (the die back phase).

(ii) *Gauging the environment.* Fluctuating small shoots may represent the plant testing microsites for growth potential before committing to expenditure of stored resources by producing stem and leaf growth.

(iii) *Budgeting strategy.* Stem height fluctuation may represent a strategy for budgeting the consumption of limited resources during changing conditions of supply (ie. photosynthate, or raw materials for photosynthesis) and demand (i.e. consumption of photosynthate or raw materials).

(iv) *Exploratory module.* Slender Marsdenia may produce different kinds of exploratory stem with different functions in informing or coordinating the whole plant before attempting growth tall, flowering stem.

The oscillation in stem height recorded during monitoring reflects Slender Marsdenia's habit of producing transitory stems that appear to 'test' the environment, or 'prepare' the plant, before initiation of tall stem growth and possible flowering. Slender Marsdenia has a rhizome network that enables the plant to move the position of stems around its immediate habitat, by extending rhizomes and sending up new exploratory stems that may provide directions to the rhizome on which direction to grow, to reach a favourable light gap and soil niche for example.

2.3.2.6 Comparison of stem height pattern in in-situ plants

Monitoring of in-situ plants of Slender Marsdenia on the WC2NH and NH2U projects indicates that stem height fluctuation is present to much the same extent in naturally occurring in situ populations, and size class distribution is also much the same and not an

artefact of translocation. For example, most plants observed in in situ populations were small stem shoots and these were often short-lived. Large plants (>2.5 m) with foliage in the forest mid-stratum were rare.

2.3.2.7 Reproduction

Flowering

Only one out of 164 transplants flowered in six years, and this plant flowered twice - last year and this year (2019, 2020). In Nov 2020, the plant (Receival Site 3, no. 5) was 2.8 m high and had ~40 leaves, the same measurements being recorded last year. This plant appears to to have reached a size where it can reproduce without growing any larger.

The same very low incidence of flowering was recorded in translocated Slender Marsdenia on the NH2U project (one individual flowered). No flowering was recorded in-situ plants, and flowering is rarely observed in other naturally occurring plants although this could be because the inconspicuous flowers (and pods) are produced higher up in mid-stratum trees where hard to see.

Vegetative reproduction

Some plants appeared to be producing new stem individuals by shooting from rhizomes below ground. It was difficult to distinguish vegetative reproduction from plant regrowth after dying back.

2.3.3 Rusty Plum (*Niemeyera whitei*)

Survival rate of transplanted Rusty Plums at Receival Site 1 remained at 86% after six years. All six had increased in height and were in good condition. It may be another 10 years before the largest individuals reach reproductive maturity.

For the population enhancement component, direct seeded Rusty Plum germinated in 8 out of 14 chicken-wire cylinders in 2017. At least half the seed sown (3 per cylinder) rotted and failed to germinate. This was due to the poor quality of the seed (undersized) produced in drought years.

In November 2020, seedlings were still present in 7 cylinders, the tallest being 25 cm. This represents zero growth since last year, again possibly due to effects of previous drought years. No fertiliser has been added to the plots/cylinders.

2.3.4 Wooll's Tylophora (*Tylophora woollsii* – unconfirmed)

At Receival Site 6 (8a), six transplanted individuals that could be Woolls' Tylophora (identification unconfirmed) were mainly in good condition, showing new shoot growth and maintaining or increasing stem height.

2.3.5 Large-flowered Milk Vine (*Marsdenia*)

Some of the Marsdenia vines salvaged to Receival Site 4 (5b) are *Marsdenia liisae*, not *Marsdenia longiloba* as first thought. Its leaves are larger, thicker and often darker green.

Marsdenia liisae ranges between the Hastings River (Pt Macquarie) and the Nightcap Range in NSW and is considered rare, but not listed as threatened.

The survival rate of 9 *Marsdenia liisae* after six years was 78%, about the same as *Marsdenia longiloba*.

2.3.6 Spider Orchid (*Dendrobium melaleucaphilum*)

The two translocated Spider Orchid plants were in good condition after six years. Both plants continued to flower in spring (August - September) but set no seed (no pods formed), possibly due to absence of pollinators. Flowering was evident in November from persistent raceme axes projecting between the leaves. Some pseudobulbs (stem units) died and new ones were produced demonstrating active growth.

2.3.7 Floyds Grass (*Alexfloydia repens*)

Floyds Grass has persisted in the two areas where it was translocated to in Receival Site 9. Merging of patches and loss of tags due to floods has made monitoring of tagged individuals impractical and has been replaced by an overall assessment of the extent of Floyds Grass and habitat condition in the two sub-areas (9a and 9b).

Area 9a

About half the fenced area comprising Area 9a contained Floyds Grass in Nov/2020, six years after translocation. This is about the same area of coverage as recorded last year, which has been stable for about 3 years. Plants are found in the half of the fenced area closest to Warrell Creek, about 10 m away. The other half has a high percentage of Broad-leaved Paspalum, but it doesn't appear to be spreading any further in the section where Floyds Grass if found. A high density of native Ottochloa grass is present, which Floyds Grass appears to be able to co-exist with. Where there are small shrubs and saplings, Floyds Grass has climbed up above Ottochloa using the shrubs for support and is more visible.

Area 9b

Floyds Grass is still present in reasonable number in this section of the translocation area, although close inspection is required to see it below the Broad-leaved Paspalum that covers most of area 9b. Planted Swamp Oaks are still alive in wire cages but have not been maintained and are heavily grazed, most likely by swamp wallabies.

This area was included in additional maintenance carried out last year. A selective herbicide was applied to this area in an attempt to eradicate Broad-leaved Paspalum while leaving Floyds Grass unharmed. Some yellowing of BLP was observed but it was not killed and this year is as dense as before. Floyds Grass was unharmed by the herbicide.

Habitat Restoration

Considering that (i) BLP poses a medium to long-term threat to the viability of the translocated population; (ii) substantial investment has been made into translocating Floyds Grass to this site; and (iii) this is the southern-most occurrence of the species (which is listed as Endangered – State and Federally), it is recommended that maintenance work using methods originally proposed by Ecos Environmmental be undertaken in 2021, consisting of hand weeding of BLP within the two translocation areas, herbicide spraying in a wide perimeter band around the two areas) and additional planting of Swamp Oak tubestock.

2.3.8 Koala Bells (*Artanema fimbriatum*)

Koala Bells transplanted to Receival Site 7 (8b) has died out, Flowering and seeding occurred for two years so dormant seed may be present in the soil seedbank, allowing for regeneration in future if suitable conditions appear (e.g. after bushfire or track maintenance). Koala Bells appears to be short-lived, so this is a normal pattern of growth in this species.

Propagated Koala Bells was introduced to Receival Site 9b in autumn 2017. The plants were mature and flowering and seeding occurred straight away so that recruitment from seed was recorded a few months later in spring 2017. These plants persisted in spring 2019 but had died out this year (spring 2020). There was no further recruitment. The site has grown over with Broad-leaved Paspalum which inhibits plant growth and seed germination. Koala Bells is short-lived perennial and prefers disturbed areas where there is high light and minimal competition from other plant species. These conditions were created at Receival Site 9b by stripping away the BLP dominated ground layer vegetation.

2.4 Performance Criteria

Table 9: Performance Criteria for Assessing Threatened Translocation Areas

Performance criteria	Yes/No
1. All recorded directly impacted individuals were translocated.	Yes
2. At least 60% of transplant and enhancement individuals are surviving after the first year, 50% after five years and 40% after eight years.	Yes
3. At the end of the monitoring program at least 50% of surviving individuals have a Condition Class of 3.	Not applicable yet
4. Habitat at receival sites in good condition conducive to medium term survival (i.e. 10 years)	Yes for all sites except Receival Site 9 (Floyds Grass) where habitat condition has deteriorated in Area 9b and remains only fair in Area 9a due to dense Broad-leaved Paspalum directly adjoining the site

2.5 Work Schedule for Year 4 (Dec 2020 – May 2022)

Table 10: Work Schedule for Year 4 of operational phase threatened flora management (Dec/2020 – May/2022).

Task	**Time**
Monitoring	
Fourth annual operational phase monitoring	Nov/2021 (to coincide with flowering of Slender Marsdenia and Rusty Plum)
Reporting	
Fourth annual operational phase monitoring report	Dec/2021-Jan/2022
Maintenance of Floyds Grass TA	
Proposed maintenance of Receival Site 9 a & b (Floyds Grass) to remove exotic species, particularly Broad-leaved Paspalum; spray out surrounding exotics, repair/remove shade cloth shelters, maintain planted Swamp Oak, plant more Swamp Oak etc, Steps to be implemented as listed below:-	May/2021- May/2022
1.Weed control/habitat restoration	
Hand weed Broad-leaved Paspalum; set up wick wip test in sub-sample area; spray out 10 m habitat restoration zone	May-June/2021

around Area 1 and 2; remove flood debris etc.	
2.Follow-up tubestock planting and weed removal	
Plant tubestock in habitat restoration zone Swamp Oak, Flooded Gum, Forest Red Gum and install 1.2 m high chicken wire tree guards to prevent wallaby grazing	Aug-Sept/2021
3.Follow-up weed control	3-6 monthly
4.Monitor results of maintenance works (include in WC2NH annual translocation monitoring)	Nov-Dec/2021 (6 months after first treatment)

3 In-Situ Threatened Flora Populations

3.1 Methods

The In-situ Threatened Flora Populations component of the TFMP comprises the following threatened plant species:

- Maundia (*Maundia triglochinoides*)
- Rusty Plum (*Niemeyera whitei*)
- Slender Marsdenia (*Marsdenia longiloba*)
- Spider Orchid (*Dendrobium melaleucaphilum*)
- Woolls' Tylophora (*Tylophora woollsii*).

Individuals of these threatened species were located and tagged before clearing and construction of the WC2NH section of the Pacific Highway began. All individuals occurred within the project boundary but outside the clearing limit (Figures 5-9) and have remained in-situ during the pre-construction, construction and operation phases of the upgrade.

GeoLINK conducted pre-construction and construction monitoring of the in-situ threatened species between January 2015 and October 2017. The following identification and condition data were recorded for each in-situ plant:

- Genus and species
- Plant identification number
- Overall plant condition scored on scale between 0 and 5 (see Tables 2-4)
- Presence of flowers and/or fruit
- Any new growth
- Any recruitment
- Any weed infestations or other impacts.

See *Warrell Creek to Nambucca Heads Monitoring of In-situ Threatened Flora (Annual Report – Spring 2017)* (GeoLINK 2017) for more information.

Ecos Environmental conducted the first yearly operation phase monitoring of the in-situ threatened species in November 2018. All tagged plants were located and the same condition data as recorded by GeoLINK were collected. Additionally, Ecos Environmental recorded the height of each individual to assess plant growth and performance throughout the monitoring program. In November 2020, Ecos Environmental conducted the third yearly operational phase monitoring, which is described in this report.

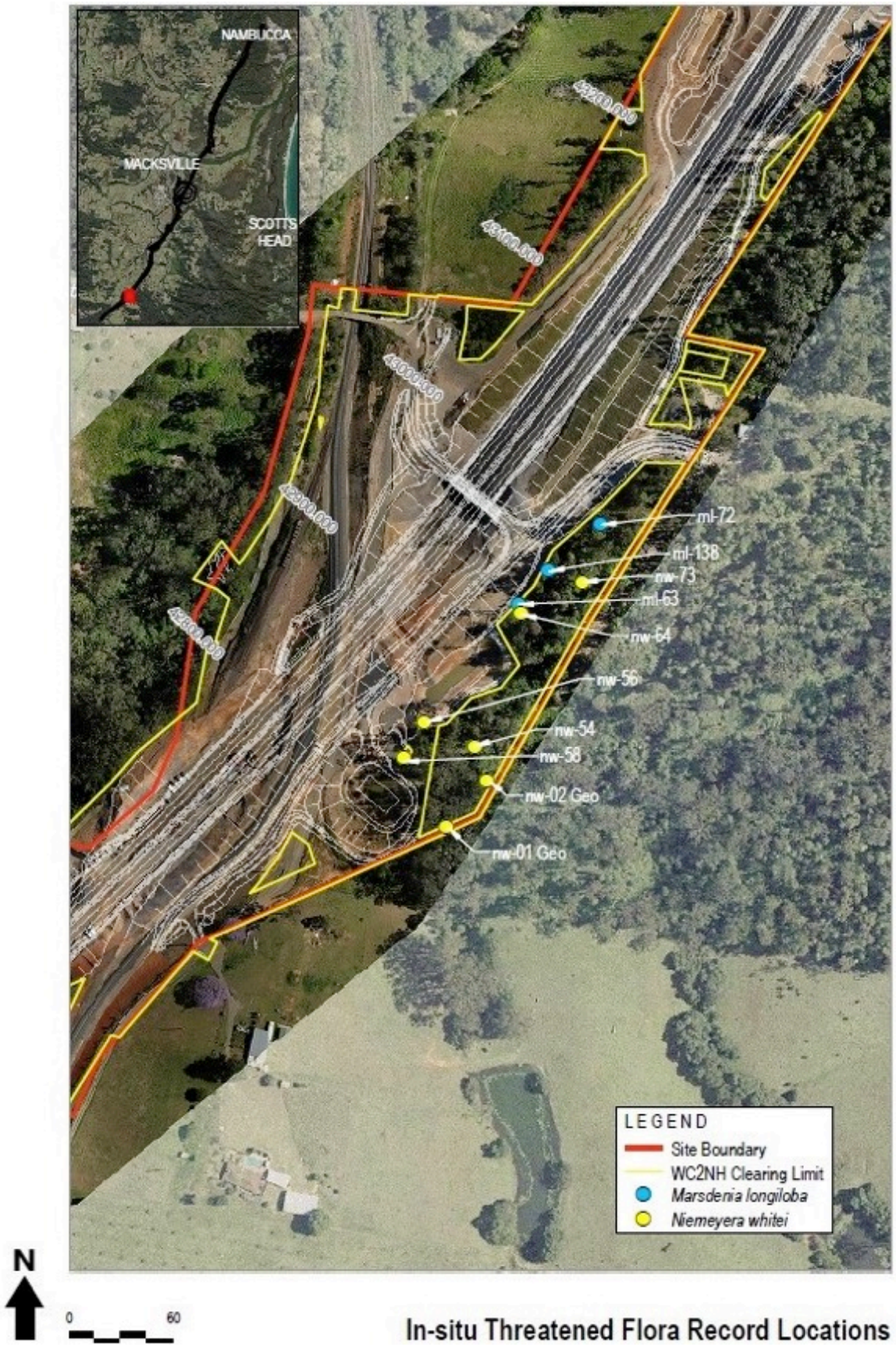

Figure 5: In-situ Slender Marsdenia and Rusty Plum at Cockburns Lane, WC2NH. Map sourced from GeoLINK (2017).

Figure 6: Maundia population at Nambucca Floodplain, WC2NH. Map sourced from GeoLINK (2017).

Figure 7: In-situ Slender Marsdenia, WC2NH. Map sourced from GeoLINK (2017).

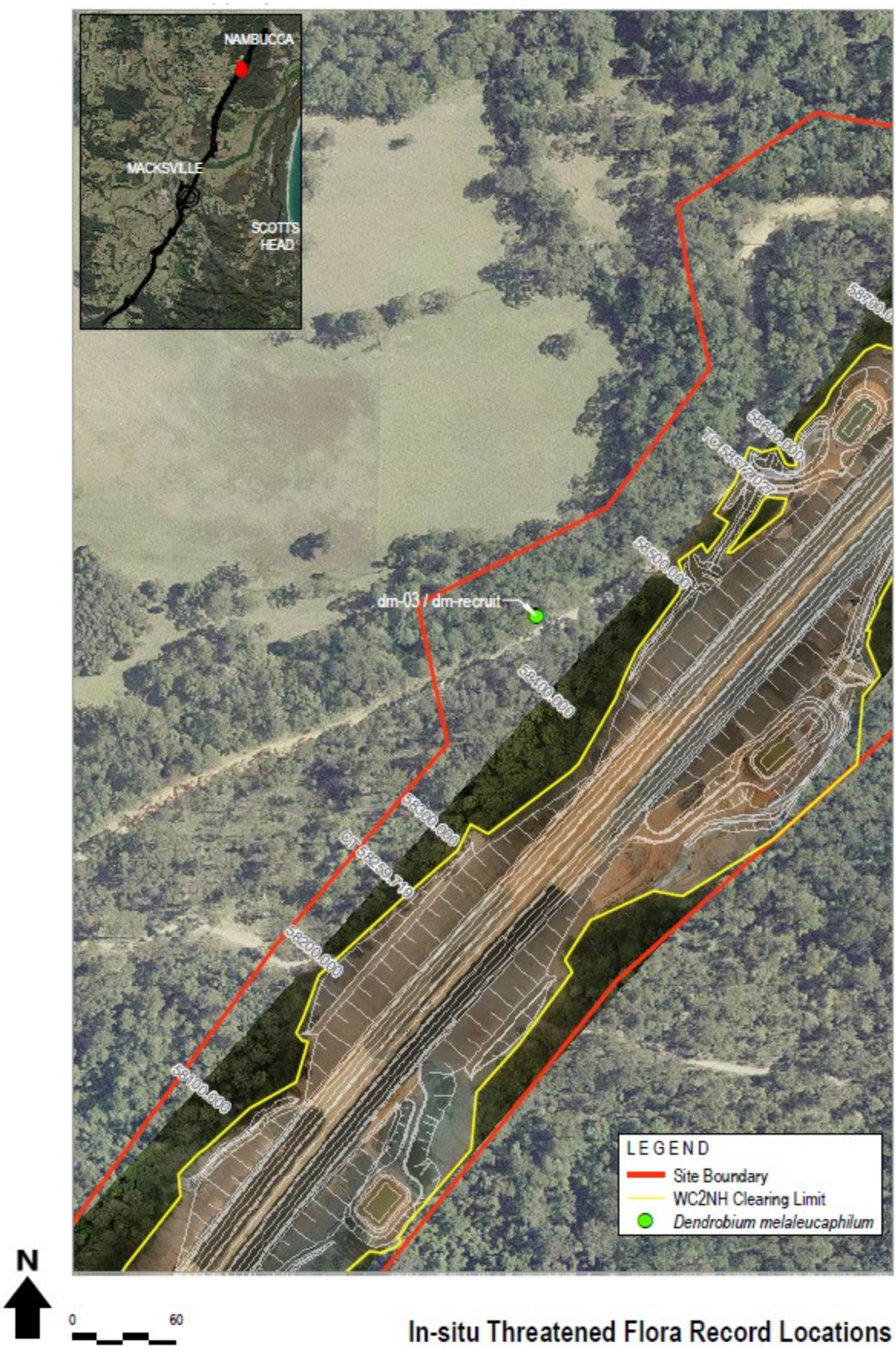

Figure 8: In-situ Spider Orchid, WC2NH. Map sourced from GeoLINK (2017).

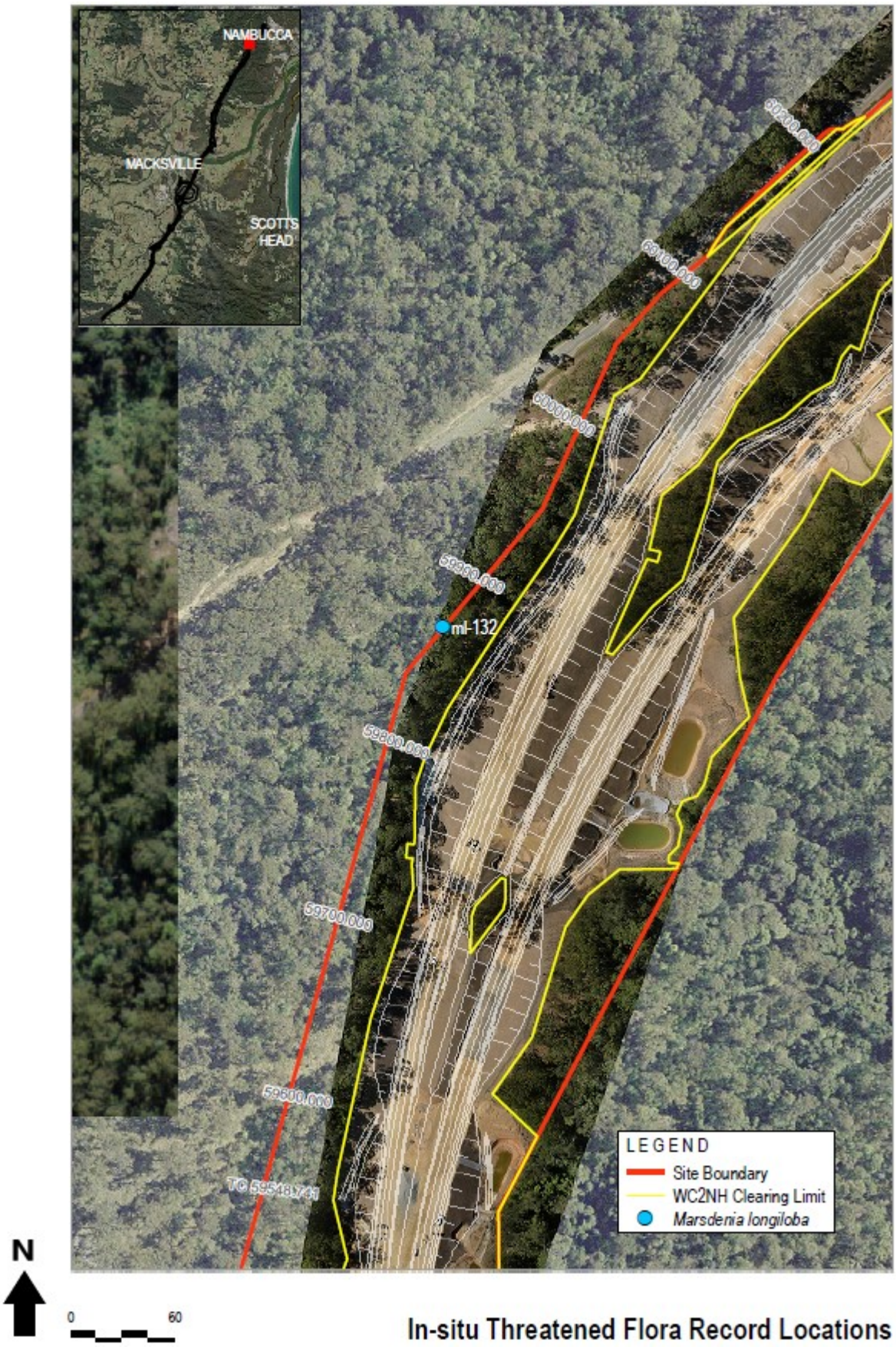

Figure 9: In-situ Slender Marsdenia, WC2NH. Map sourced from GeoLINK (2017).

3.2 Results

See Appendix 2 for photos of the in-situ threatened plant species in November 2020.

3.2.1 Maundia (*Maundia triglochinoides*)

In November 2018, Maundia had a crown cover of 40% within the monitoring plot and extended well beyond the plot, forming a large population. By November 2019, Maundia had almost disappeared from the plot (Table 11) and the surrounding area due to drought conditions. Only a few yellowing leaves were seen. There was no standing water in the swamp and it was dry enough to walk across. The main wetland plant was an *Eleocharis* species, which was unaffected by the dry conditions, as were Ludwigia and several other species. It appears that Maundia requires at least some standing water and a flooded substrate to maintain green growth, otherwise it dies off.

In November 2020, Maundia was again present in the swamp which was 30-50 cm deep and covered in dense aquatic vegetation, including Persicaria strigosa, P. orientalis, Eleocharis sp. and other species. Maundia covered about 20% of the plot and other patches were growing nearby. Several plants were observed with flower spikes.

3.2.2 Spider Orchid (*Dendrobium melaleucaphilum*)

The large Spider Orchid plant (DM03) appeared to have deteriorated. There were more dead pseudobulbs and not many with leaves. Nearly all pseudobulbs had flowered last spring, including dead ones, but no seed pods were formed. This year the plant had 70 pseudobulbs, 8 with leaves and 30 dead pseudobulbs. Sixty pseudobulbs has flowered, but no pods.

3.2.3 Rusty Plum (*Niemeyera whitei*)

All seven in-situ Rusty Plums at Cockburns Lane were alive and in reasonable condition in November 2020 (Table 13). No fruits were observed this year.

Habitat condition at the Cockburns Lane site in November 2020 was generally good. Lantana was scattered throughout the site, but did not appear to be having any negative effects on Rusty Plum or Slender Marsdenia, which also occurs at site.

3.2.4 Slender Marsdenia (*Marsdenia longiloba*)

The monitoring program includes five in-situ Slender Marsdenia occurrences (most with more than one stem including one with 15-30 stems in a small area) across three sites (Table 14). Monitoring Slender Marsdenia through time can be difficult as plants often die back and reshoot and new stems emerge from underground rhizomes away from old stems, making it appear that plants have changed location. This is part of Slender Marsdenia's natural growth pattern and life cycle rather than a response to human-related disturbances.

In November 2020, Slender Marsdenia was actively growing (i.e. green stem and leaves) in all five in-situ locations. In most locations there was more than one stem and so height and plant condition was recorded for the largest stem. The height (of the largest stem) of individuals ranged from 10 cm to 2m cm and condition score ranged from 2 to 4 (Table 14).

The largest in situ Slender Marsdenia occurrence being monitored - ML93 - consists of a clonal patch of small stem-individuals growing across the fence line along Old Coast Road in remnant forest in the road reserve and adjoining property. In November 2020, this patch consisted of about 15 stems within an area approx. 15 m x 10 m, extending from the edge of Old Coast Road to the base of a large Tallowwood (*Eucalyptus microcorys*). All stems were small (<20 cm high) and most were producing new growth (new shoots). No flowering or fruiting was observed. Recruitment in this patch is mostly likely vegetative or asexual by means of production of stems from underground tuberous roots.

At ML132 shoots remained small (<10 cm high). Stems at ml-72, ml-138 and ml-63 occur at Cockburns Lane (same site as in-situ Rusty Plum) were small and one 1.5 m high.

Table 11: In-situ threatened flora monitoring results for Maundia (*Maundia triglochinoides*) recorded by Ecos Environmental 2018 - 2020.

Maundia (*Maundia triglochinoides*)																
Population	Cover-Abundance and (Condition Class Score)			Flower/ Fruit Present			New Growth			Recruitment			Damage/ Disturbance			Site Conditions (Spr 2019)
	Spr 2018	Spr 2019	Spr 2020	Spr 2018	Spr 2019	Spr 2020	Spr 2018	Spr 2019	Spr 2020	Spr 2018	Spr 2019	Spr 2020	Spr 2018	Spr 2019	Spr 2020	
Nambucca Floodplain	40% (5)	<1%	20%	Y	N	Y	Y	Y	Y	Y	N	Y	N	N	N	Canopy height 10-13 m with *Melaleuca quinquenervia* dominant species; ground stratum 100% crown cover; water to 50 cm deep; exotic grass spp. along fauna fenceline with road.

Table 12: In-situ threatened flora monitoring results for Spider Orchid (*Dendrobium melaleucaphilum*) recorded by Ecos Environmental 2018 - 2020.

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Plant ID #	Length of longest pseudobulb (cm)			Leaf Condition			Number of pseudobulbs with leaves			New Growth			Recruitment			Damage/ Disturbance			Site Conditions	GeoLINK notes (PC 2015-Spr 2017)	Ecos Environmental notes (Spr 2019)
	Spr 2018	Spr 2019	Spr 2020	Spr 2018	Spr 2019	Spr 2020	Spr 2018	Spr 2019	Spr 2020	Spr 2018	Spr 2019	Spr 2020	Spr 2018	Spr 2019	Spr 2020	Spr 2018	Spr 2019	Spr 2020			
3	35	35	35	5	5	3	50+	50	8	N	Y	Y	N	N	N	N	N	N	Canopy height 25 m and crown cover approx 90% comprised of Eucalyptus spp.	Very healthy with signs of increased flowering activity.	Fairly healthy, effect of dry conditions evident in many dead and ratty pseudobulbs
DM Recruit	12	12	12	3	3	2	4	4	4	N	N	N	N	N	N	N	N	N		This new recruit was first observed during Spring 2016.	

Table 13: In-situ threatened flora monitoring results for Rusty Plum (*Niemeyera whitei*) recorded by Ecos Environmental 2018 - 2020.

Plant ID #	Height (cm)			Leaf Condition			Flower/ Fruit Present			New Growth			Recruitment			Damage/ Disturbance			Site Conditions (Spr 2020)
	Spr 2018	Spr 2019	Spr 2020	Spr 2018	Spr 2019	Spr 2020	Spr 2018	Spr 2019	Spr 2020	Spr 2018	Spr 2019	Spr 2020	Spr 2018	Spr 2019	Spr 2020	Spr 2018	Spr 2019	Spr 2020	
NW58	800	820	820	4	4	4	N	N	N	Y	Y	Y	N	N	N	N	N	N	Canopy height 20 m with crown cover 70%; some medium to large patches of Lantana scattered throught site.
NW56	120	130	130	4	4	4	N	N	N	Y	Y	Y	N	N	N	N	N	N	
NW73	700	750	750	5	4	4	Y	N	N	N	Y	Y	N	N	N	N	N	N	
NW54	600	640	640	4	4	4	N	N	N	N	Y	Y	N	N	N	N	N	N	
NW64	800	850	850	5	4	4	Y	N	N	N	N	N	N	N	N	N	N	N	
NW01-Geo	450	450	450	4	4	4	N	N	N	N	Y	Y	N	N	N	N	N	N	
NW02-Geo	500	530	530	4	4	4	N	N	N	N	Y	Y	N	N	N	N	N	N	

Table 14: In-situ threatened flora monitoring results for Slender Marsdenia (*Marsdenia longiloba*) recorded by Ecos Environmental 2018 - 2020.

Plant ID	Height (cm)			Leaf Condition			Flower/ Fruit Present			New Growth			Recruitment			Damage/ Disturbance			Site Conditions	GeoLINK notes (PC 2015-Spr 2017)	Ecos Environmental notes (Spr 2018-to Spr 2020)
	Spr 2018	Spr 2019	Spr 2020	Spr 2018	Spr 2019	Spr 2020	PC 2015	Spr 2018	Spr 2020	Spr 2018	Spr 2019	Spr 2020	Spr 2018	Spr 2019	Spr 2020	Spr 2018	Spr 2019	Spr 2020			
ML93	100	130	18	2	3	3	Spr 2018	Spr 2019	N	Y	Y	Y	N	Y	N	N	N	N	Canopy height 20 m; crown cover 100% with Eucalyptus microcorys dominant species.	15 live plants now within 1 m radius of subject plant. All range from 2 – 4 in condition class. Some plants recorded during spring 2016 have died back however new recruits have also been recorded and are now at a count of 23 flagged individual plants.	Clonal patch, no. variable 15-30 individuals in an area 15m x 10 m, from the base of E. microcorys to the edge of O)ld Coast Rd. In 2018, most plants small (<20cm high), a few >1 m high. In 2020, all small.
ML132	8	10	5	2	3	3	N	N	N	Y	Y	Y	N	N	N	N	N	N	Canopy height 25 m; crown cover 80%	During Spring 2016 partially natural die back was recorded. The plant recorded during spring 2017 is fresh, green with new growth indicating possibly a new plant to the one previously recorded.	Most shoots tagged 2018 had died off. Two small shoots (<10 cm tall) in 2020 about 1 m apart
ML72	40	10	10	2	3	3	N	N	N	N	N	N	N	N	N	N	N	N	Canopy height 20 m; crown cover 70%	Natural die back of the stem, possibly live stem bulb. No obvious signs of construction related impacts.	Died back and reshot
Ml138	90	10	10	3	3	3	N	N	N	Y	N	Y	N	N	N	N	N	N		Tall plant with mature leaves some yellowing.	Died back and reshot

ML63	10	300	250	2	4	4	N	N	N	N	Y	Y	N	N	N	N	N	N		Healthy

3.3 Conclusion

The survival rate of in-situ threatened species at the end of Year 6 (spring 2020) was 100% for Spider Orchid, Rusty Plum and Slender Marsdenia. (Table15). Maundia does not occur as discrete individuals but as a sward of stems, so its abundance was measure just as crown cover. The plot crown cover of Maundia had increased from <1% last year to 20% in Nov 2020, due the end of the 2019 drought and above average rainfall in 2020. The survival rate of Slender Marsdenia remained stable although there was evidence that stems had died back and reshot, from the same point or close-by from tuberous roots.

No signs of construction-related impacts were observed in spring 2020. The monitoring results meet the performance criteria – *survival rate at the end of Years 4-8 is >70%* and *of surviving plants at end of each year >75% are in good condition (class 3 or >)* – for Spider Orchid, Rusty Plum and Slender Marsdenia and therefore no corrective actions are required for these species. Note that >75% of in-situ Slender Marsdenia plants do not have a class score of 3 or > as they were not taller than 75 cm, but this is not of concern for this species because of its clonal habit and tendency for stems to dieback and regrow again.

Table 15: Performance measures for In-situ Threatened Flora Populations monitoring.

Species	Survival rate at finish of clearing (October 2015/ Spring 2015) is 100%, no accidental damage due to clearing	Survival rate at end of Years 1-3 is >80%	Survival rate at end of Year 4 (2018)	Survival rate at the end of Years 4-8 is >70%	Of surviving plants at end of each year >75% are in good condition (class 3 or >)			
					Year 2 - 2016	Year 3 - 2017	Year 5 - 2019	Year 6 - 2020
Spider Orchid (*Dendrobium melaleucaphilum*)	Yes - 100% survival No accidental damage due to clearing	Yes - 100% survival	Yes - 100%	Not applicable yet	Yes - 100% in good condition, with new recruit. recorded also in good condition (score 3)	Yes - 100% (including new recruit) in good condition (Score 4)	Yes - 100% with one plant reproductive	Yes - 100% with one plant reproductive
Maundia (*Maundia triglochinoides*)	Yes - 100% survival No accidental damage due to clearing	Yes - 83% survival	No - <1% survival (trace)%	Not applicable yet	Yes - 100% in good condition (score 5)	Yes - 100% of visible plants in good condition (score 3)	No – poor condition (score 1)	Yes – good recovery after the drought, flowering (score 3)
Rusty Plum (*Niemeyera whitei*)	Yes - 100% survival No accidental damage due to clearing	Yes - 100% survival	Yes - 100%	Not applicable yet	Yes - 80% in good condition (score 2 - 5)	Yes - 100% in good condition (score 3 - 5)	Yes - 100% with some plants reproductive	Yes - 100% with some shoot growth
Slender Marsdenia (*Marsdenia longiloba*)	No - 62% of plants were recorded as living But no construction related impacts were recorded	No - 60%	Yes - 100%	Not applicable yet	Yes - 100% (5 of 5 records) recorded scores 3 - 4	No - 60% (3 of 5 records) recorded scores 1 - 4	No - 40% in good condition	Yes - 70% in good condition

4 Slender Marsdenia and Woolls' Tylophora Habitat Condition

4.1 Methodology

This component of the TFMP aims to monitor Slender Marsdenia and Woolls' Tylophora habitat within the indirect impact zone – i.e. within 10 m of the edge of clearing – for potential edge effects and declines in habitat condition. The study design involves ten permanent plots along the edge of clearing in known Slender Marsdenia and Woolls' Tylophora habitat (Figures 10-12). Each plot is 10 m * 20 m with the long axis parallel to the edge of clearing. Within each plot, the following vegetation and landscape attributes are measured:

- Native vegetation structure (according to Native Vegetation Interim Type Standard)
- Level of weed incursion (measured by summing the abundance of all exotic species)
- Microclimate class (Table 16).

The plots were established by GeoLINK on 26 November 2015 around the time that clearing operations in the northern zone of the project were being completed. The plots were again monitored by GeoLINK during autumn and spring 2016 and spring 2017. See GeoLINK (2017) for more information.

Ecos Environmental carried out the first yearly operation phase monitoring of the ten plots in November 2018. The plots were located and data on the above parameters were collected. Native vegetation structure was measured according to Roads and Maritime Services (2018) which states that: "Structure consists of the height, crown cover and dominant species in each vegetation layer and will be recorded according to the current OEH vegetation standard (Native Vegetation Interim Type Standard – http://www.environment.nsw.gov.au/research/VISplot.htm)."- p27.

Ecos Environmental was sent GeoLINK (2017) after the data were collected and when it was read it became apparent that GeoLINK measured native vegetation structure differently to the Interim Type Standard. Specifically, overall crown cover was estimated for each stratum rather than individually for the three most dominant species. As Ecos Environmental followed the Interim Type Standard as per Roads and Maritime Services (2018), our vegetation structure data had to be compared qualitatively rather than quantitatively with GeoLINK's data. Appendix 4 includes GeoLINK (2017) data on vegetation structure.

Ecos Envrionmetal carried out the third yearly operation phase monitoring in November 2020, which is described in this report.

Table 16: Microclimate exposure classes for Slender Marsdenia and Woolls' Tylophora habitat.

Microclimate Class (less exposed to more exposed)	**Microclimate Type**
1	Sheltered aspect (e.g. south) and vegetation understorey slightly more open and exposed than before clearing.
2	Sheltered aspect (e.g. south) and vegetation understorey moderately more open and exposed than before clearing.
3	Sheltered aspect (e.g. south) and vegetation understorey much more open and exposed than before clearing.
4	Exposed aspect (e.g. east, north and west) and vegetation understorey slightly more open and exposed than before clearing.
5	Exposed aspect (e.g. east, north and west) and vegetation understorey moderately more open and exposed than before clearing.
6	Exposed aspect (e.g. east, north and west) and vegetation understorey much more open and exposed than before clearing.

Figure 10: Slender Marsdenia and Woolls' Tylophora Habitat monitoring quadrats 5, 6, 7 and 8, WC2NH. Map sourced from GeoLINK (2017).

Figure 11: Slender Marsdenia and Woolls' Tylophora Habitat monitoring quadrats 9 and 10, WC2NH. Map sourced from GeoLINK (2017).

Figure 12: Slender Marsdenia and Woolls' Tylophora Habitat monitoring quadrats 1, 2, 3 and 4, WC2NH. Map sourced from GeoLINK (2017).

4.2 Results

Comparing (qualitatively) the vegetation structure data recorded by Ecos Enviromental (Table 18) with that recorded by GeoLINK (Appendix 4), no major changes in vegetation structure could be inferred.

It appears that since spring 2015 the level of weed incursion has increased in some plots but decreased in others (Table 17). All changes, however, are minor with weed crown cover remaining far below the performance measure threshold of 25%.

The data also indicate that the microclimate of some plots in spring 2020 differs from previous years. Specifically, that plots 6, 7, 8, 9 and 10 became more exposed. The data, however, should be interpreted cautiously as it were collected by two different observers – GeoLINK from 2015-2017 and Ecos Environmental in 2018-2020 – and therefore likely reflects observer variability. In the field, Ecos Environmental was of the impression that the vegetation understorey of plots was either moderately or much more exposed than before clearing. Consequently, no plots were assigned a microclimate class of 1 or 4 (for different aspects but both meaning only slightly more exposed than before clearing). GeoLINK, on the other hand, assigned plots 6, 7, 8, 9 and 10 either a 1 or 4 depending on their aspect.

Table 17: Weed level and microclimate class of Slender Marsdenia and Woolls' Tylophora habitat plots.

Plot	Weed Level (% crown cover)	Microclimate Class
1	Lantana	
Spring 15 (GeoLINK)	<5%	5
Autumn 16 (GeoLINK)	5	5
Spring 16 (GeoLINK)	5	5
Spring 17 (GeoLINK)	5	5
Spring 18 (Ecos)	<5%	5
Spring 19 (Ecos)	5	5
Spring 20 (Ecos)	5	5
2	Lantana, Whisky Grass	
Spring 15 (GeoLINK)	<5%	5
Autumn 16 (GeoLINK)	5	5
Spring 16 (GeoLINK)	10	5
Spring 17 (GeoLINK)	10	5
Spring 18 (Ecos)	<5%	5
Spring 19 (Ecos)	<5%	5
Spring 20 (Ecos)	5%	5
3	Lantana	
Spring 15 (GeoLINK)	<5%	1
Autumn 16 (GeoLINK)	<5%	1
Spring 16 (GeoLINK)	<5%	1
Spring 17 (GeoLINK)	<5%	1
Spring 18 (Ecos)	<5%	2
Spring 19 (Ecos)	<5%	2
Spring 20 (Ecos)	<5%	3
4	Lantana	
Spring 15 (GeoLINK)	0	2
Autumn 16 (GeoLINK)	0	2
Spring 16 (GeoLINK)	0	2
Spring 17 (GeoLINK)	0	2
Spring 18 (Ecos)	<5%	2
Spring 19 (Ecos)	<5%	2
Spring 20 (Ecos)	<5%	2
5	Lantana, Setaria, Broad-leaved Paspalum	
Spring 15 (GeoLINK)	<5%	5
Autumn 16 (GeoLINK)	<5%	5
Spring 16 (GeoLINK)	<5%	5
Spring 17 (GeoLINK)	<5%	5
Spring 18 (Ecos)	<5%	5

Plot	Weed Level (% crown cover)	Microclimate Class
Spring 19 (Ecos)	<5%	5
Spring 20 (Ecos)	<5%	5
6	Lantana	
Spring 15 (GeoLINK)	5	4
Autumn 16 (GeoLINK)	5	4
Spring 16 (GeoLINK)	5	4
Spring 17 (GeoLINK)	5	4
Spring 18 (Ecos)	<5%	5
Spring 19 (Ecos)	10	5
Spring 20 (Ecos)	10	5
7	Broad-leaved Paspalum	
Spring 15 (GeoLINK)	0	1
Autumn 16 (GeoLINK)	0	1
Spring 16 (GeoLINK)	0	1
Spring 17 (GeoLINK)	0	1
Spring 18 (Ecos)	<5%	2
Spring 19 (Ecos)	0	2
Spring 20 (Ecos)	0	2
8	Lantana	
Spring 15 (GeoLINK)	5	1
Autumn 16 (GeoLINK)	5	1
Spring 16 (GeoLINK)	7	1
Spring 17 (GeoLINK)	5	1
Spring 18 (Ecos)	<5%	2
Spring 19 (Ecos)	<5%	2
Spring 20 (Ecos)	<5%	2
9	Lantana, Broad-leaved Paspalum, Coastal Morning Glory	
Spring 15 (GeoLINK)	5	1
Autumn 16 (GeoLINK)	5	1
Spring 16 (GeoLINK)	<5%	1
Spring 17 (GeoLINK)	<5%	1
Spring 18 (Ecos)	<5%	2
Spring 19 (Ecos)	<5%	2
Spring 20 (Ecos)	<5%	2
10	Lantana, Billygoat Weed, Setaria	
Spring 15 (GeoLINK)	<5%	4
Autumn 16 (GeoLINK)	<5%	4
Spring 16 (GeoLINK)	<5%	4
Spring 17 (GeoLINK)	<5%	4
Spring 18 (Ecos)	<5%	5
Spring 19 (Ecos)	<5%	5
Spring 20 (Ecos)	<5%	5

Table 18: Vegetation structure of ten Slender Marsdenia and Woolls' Tylophora habitat monitoring plots, WC2NH. Data recorded November 2020 by Ecos Environmental.

Stratum	Dominant species	Cover (% crown cover)	For the entire		
Plot 1					
Upper	*Eucalyptus grandis*	10	Upper stratum Height to crown (m) min-mode-max		
Upper	*Syncarpia glomulifera*	20			
Upper			20	20	30
Mid	*Lophostemon confertus*	20	Mid stratum Height to crown (m) min-mode-max		
Mid	*Cissus hypoglauca*	65			
Mid	*Acacia binervata*	15	4	5	10
Lower	*Blechnum cartilagineum*	30	Lower stratum Height to crown (m) min-mode-max		
Lower	*Dodonaea triquetra*	15			
Lower	*Cordyline stricta*	10	0.5	2	4
Plot 2					
Upper	*Syncarpia glomulifera*	50	Upper stratum Height to crown (m) min-mode-max		
Upper	*Eucalyptus microcorys*	20			
Upper	*Allocasurina torolosa*	15	15	24	28
Mid	*Cissus hypoglauca*	40	Mid stratum Height to crown (m) min-mode-max		
Mid	*Calicoma seratifolia*	15			
Mid	*Trochocarpa laurina*	15	2	8	15
Lower	*Blechnum cartilagineum*	20	Lower stratum Height to crown (m) min-mode-max		
Lower	*Morinda jasminoides*	25			
Lower	*Cryptocarya rigida*	30	0.5	1	2
Plot 3					
Upper	*Syncarpia glomulifera*	15	Upper stratum Height to crown (m) min mode max		
Upper	*Eucalyptus grandis*	30			
Upper	*Eucalyptus anchorphylla*	10	28	28	30
Mid	*Cryptocarya rigida*	50	Mid stratum Height to crown (m) min mode max		
Mid	*Callicoma seratofolia*	30			
Mid	*Cissus hypoglauca*	40	4	5	12
Lower	*Blechnum cartilagineum*	30	Lower stratum Height to crown (m) min mode max		
Lower	*Livistonia australis*	30			
Lower	*Ripognum forcetianum*	15	0.5	1	3
Plot 4					
Upper	*Eucalyptus grandis*	30	Upper stratum Height to crown (m) min mode max		
Upper	*Eucalyptus glomulifera*	25			
Upper	*Eucalyptus acmenoides*	10	20	30	30
Mid	*Livistonia australis*	5	Mid stratum Height to crown (m) min mode max		
Mid	*Alphitonia excelsa*	20			
Mid	*Synoum glandulosum*	10	4	5	15
Lower	*Cissus hypoglauca*	50	Lower stratum Height to crown (m) min mode max		
Lower	*Gahnia sieberana*	20			

Stratum	Dominant species	Cover (% crown cover)	For the entire		
Lower	*Lepidosperma laterale*	5	0.5	1	2
Plot 5					
Upper	*Syncarpia glomulifera*	40	Upper stratum Height to crown (m) min mode max		
Upper	*Glochidion ferdinandii*	10			
Upper	*Gmelina leichhardtii*	10	15	18	20
Mid	*Livistonia australis*	15	Mid stratum Height to crown (m) min mode max		
Mid	*Guioa semiglauca*	30			
Mid	*Cissus hypoglauca*	20	7	10	12
Lower	*Cordyline stricta*	20	Lower stratum Height to crown (m) min mode max		
Lower	*Gahnia aspera*	15			
Lower	*Lomandra longifolia*	10	0.8	1	1.5
Plot 6					
Upper	*Eucalyptus pilularis*	40	Upper stratum Height to crown (m) min mode max		
Upper	*Lophostemon confertus*	20			
Upper	*Eucalyptus microcorys*	20	15	22	27
Mid	*Trochocarpa laurina*	15	Mid stratum Height to crown (m) min mode max		
Mid	*Acacia melanoxylum*	15			
Mid	*Tabernaemontana pandacaqui*	20	5	8	12
Lower	*Cordyline stricta*	20	Lower stratum Height to crown (m) min mode max		
Lower	*Livistonia australis*	20			
Lower	*Blechnum cartilagineum*	10	0.5	1	2
Plot 7					
Upper	*Eucalyptus microcorys*	80	Upper stratum Height to crown (m) min mode max		
Upper	*Eucalyptus grandis*	10			
Upper			14	20	22
Mid	*Leptospermum polygalifium*	35	Mid stratum Height to crown (m) min mode max		
Mid	*Archirhodomyrtus beckleri*	10			
Mid	*Glochidion ferdinandi*	10	1.5	3	5
Lower	*Calochlaena dubia*	80	Lower stratum Height to crown (m) min mode max		
Lower	*Lomandra longifolia*	5			
Lower	*Blechnum cartilagineum*	5	0.5	0.7	1
Plot 8					
Upper	*Eucalyptus grandis*	70	Upper stratum Height to crown (m) min mode max		
Upper					
Upper			30	24	18
Mid	*Cissus hypoglauca*	20	Mid stratum Height to crown (m) min mode max		
Mid	*Rubus moluccanus*	20			
Mid	*Guioa semiglauca*	20	12	8	7
Lower	*Blechnum cartilagineum*	25	Lower stratum Height to crown (m) min mode max		
Lower	*Oplismenus imbecilis*	30			
Lower	*Morinda jasminoides*	15	2	1	0.3

Stratum	Dominant species	Cover (% crown cover)	For the entire		
Plot 9					
Upper	*Eucalyptus grandis*	15	Upper stratum Height to crown (m) min mode max		
Upper	*Corymbia intermedia*	30			
Upper	*Eucalyptus microcorys*	10	14	25	32
Mid	*Cryptocarya rigida*	30	Mid stratum Height to crown (m) min mode max		
Mid	*Livistonia australis*	15			
Mid	*Synoum glandulosum*	10	1.5	2.5	7
Lower	*Gahnia siberana*	5	Lower stratum Height to crown (m) min mode max		
Lower	*Lastreopsis* sp.	25			
Lower	*Cordyline stricta*	2	0.1	0.5	1
Plot 10					
Upper	*Eucalyptus grandis*	70	Upper stratum Height to crown (m) min mode max		
Upper					
Upper			20	25	28
Mid	*Melaleuca stypeloides*	10	Mid stratum Height to crown (m) min mode max		
Mid	*Lophostemon confertus*	10			
Mid	*Cissus antarctica*	20	2	8	10
Lower	*Morinda jasminoides*	40	Lower stratum Height to crown (m) min mode max		
Lower	*Opplismenus imbecilis*	40			
Lower	*Cissus antarctica*	20	0.3	1.2	2

4.3 Conclusion

The monitoring plot data suggest that to date there have been no declines in Woolls' Tylophora and Slender Marsdenia habitat condition along the edge of clearing.

Applying the method specified by RMS (2018), different microclimate exposure scores were assigned for some plots than GeoLINK (2017), which most likely reflects observer variability rather than physical changes. Plot crown-cover of exotic species at the end of year 5 ranged from 0 to 10% or well below below the performance threshold of 25%, and vegetation structure appeared to have remained the same. Therefore, no corrective actions are required (Table 19).

Table 19: Performance measures for Slender Marsdenia and Woolls' Tylophora Habitat Condition monitoring.

Performance measure	**Yes/No – comments**
Plot crown-cover of exotic species is no more than 25% at the end of Years-2 to 8.	Yes – plot crown cover of exotic species at the end of year 6 is 0-10%
Baseline vegetation structure (height and crown cover) remains the same or increases in height and crown cover at the end of each year compared to the previous year.	Yes – qualitative assessment of vegetation structure data revealed no major decreases in height and crown cover at the end of year 6 compared to year 5
There is no increase in the microclimate exposure class (e.g. 1 to 2, or 4 to 5) compared to the previous year.	No – the plots 6 and 10 maintained microclimate exposure score of 5 and plots 6-9 increased from 2 to 3, but this most likely reflects observer variability rather than physical changes.

5 Recommendations

The following corrective actions (see Table 20) are recommended in relation to the results of the Floyds Grass translocation (see Section 2.3.7) recorded in Year 3 of the operational phase monitoring.

Table 20: Recommended program of corrective actions to treat decline in habitat condition and vigour of translocated Floyds Grass translocation area at the Warrell Ck TA.

Item No.	Task	Personnel	Time	TfNSW response
1	**Weed control/habitat restoration**			Agree to be adopted.
	Hand weed Broad-leaved Paspalum; set up wick wip test in sub-sample area; spray out 10 m habitat restoration zone around Area 1 and 2; remove flood debris etc.	Plant ecologist and bush regenerator.	May-June 2021	
2	**Follow-up tubestock planting and weed removal**			Agree to be adopted.
	Plant tubestock in habitat restoration zone Swamp Oak, Flooded Gum, Forest Red Gum and install 1.2 m high chicken wire tree guards to prevent wallaby grazing	Bush regenerator	Aug/Sept 2021	
3	**Follow-up weed control**	Bush regenerator	3-6 monthly to May 2022	Agree to be adopted.
4	**Monitoring** (as part of WC2NH annual translocation monitoring)	Plant ecologist	Nov/Dec 2021	Already in place

6 References

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Appendix 1: Photos Translocated Threatened Flora

Plate 1: Transplanted Rusty Plum no. 1 at Receival Site 1 Cockburns Lane showing one dead branch and new tip growth. Nov/2020.

Plate 2: Transplanted Rusty Plum no. 2 at Receival Site 1 Cockburns Lane, 4.1 metres high after 6 years. Original height approx. 8 m with a dbh of 30 cm. New stems and branches resprouted from trunk cut off about 1 m above ground. Nov/2020.

Plate 3: Rusty Plum seedling at Receival Site 7a, directed seeded Dec/2017, approx. 25 cm high Nov 2020. No increase in height in the last 12 months.

Plate 4: Transplanted Spider Orchid at Receival Site 7a. The orchid comprises a tight clump of about 50 slender pseudobulbs, most with a pair of leaves at the end. Small bristles can be seen which are the remains of orchid flower spikes produced in August-September 2020. Nov 2020.

Plate 5: Transplanted Spider Orchid at Receival Site 7a after six years. The original stem supporting the orchid was removed and attached to tree in a gully at the receival site. Nov 2020.

Plates 6 and 7: Floyds Grass translocation area – Receival Site 9, Area 1. Close-up of Floyds Grass and Ottochloa growing together and mounds with Floyds Grass underneath Ottochloa growing on top. Nov/2020.

Plate 8. Floyds Grass translocation area – Receival Site 9, Area 1. Warrell Creek on the left hand side.

Plate 9. Floyds Grass translocation area – Receival Site 9, Area 1. Floyds Grass in the foreground and encroaching Broad-leaved Paspalum. Nov/2020.

Plates 10 and 11. Floyds Grass Receival Site 9, Area 1 showing dense Broad-leaved Paspalum surrounding the translocation area, and wood chipped patches in the background (attempt at habitat restoration).

Plate 12. Floyds Grass Receival Site 9, Area 2 showing dense Broad-leaved Paspalum within the translocation area.

Plate 13. Floyds Grass Receival Site 9, Area 2. There is still a reasonable amount of Floyds Grass growing amongst Broad-leaved Paspalum which would have a much better chance of survival if the site had more maintenance, which it missed out on during the construction period.

Plates 14-16: Receival Site 1 Cockburns Lane. Upper – habitat with in situ and transplanted Slender Marsdenia; Lower – transplanted Slender Marsdenia's no. 1 and 18. Nov 2020.

Plate 17: Receival Site 3. This site was relatively open and unshaded, and usually had a SE breeze blowing through it. Slender Marsdenia transplanted to the site had a high survival rate and high mean height.

Plate 18: Receival Site 3, Slender Marsdenia no. 5. This plant flowered in Nov 2020 and the year before, the only one recorded flowering out of 164 tranplanted.

Plate 19: Receival Site 5a. This receival site had a denser 'rainforest' understory and deeper shade.

Plate 20: Small Slender Marsdenia in Receival Site 5a

Plate 21: Receival Site 7a. The survival rate and mean height of Slender Marsdenia at this site were relatively low . The habitat has a denser understory and deeper shade compared to other sites.

Plate 22: Transplanted Slender Marsdenia in Receival Site 7a. This one has left the wire cylinder and has climbed a small tree.

Plate 25: Receival Site 8a. From top left, Slender Marsdenia nos. 3, 6, 8 and 12. This receival site is relatively open on the edge of clearing and a track. Survival rate and mean height are high.

Plate 26: Receival Site 8c. This receival site was relative open and unshaded. Survival and growth rates of transplanted Slender Marsdenia were relatively high compared to other receival sites.

Plate 27: Receival Site 8c. Slender Marsdenia no. 15. Nov 2020.

Appendix 2: Photos In Situ Threatened Flora

Plate 28: In situ Rusty Plum NW 73 at Cockburns Lane, growing hard against the trunk of a Flooded Gum but in good condition. Nov 2020.

Plate 29: Maundia triglochinoides with the sword shaped leaves at in situ monitoring site on the Nambucca River floodplain. Water in swamp 0.5 m of water after 2019 drought. Nov 2020.

Plate 30: After declining from 40% to <1% crown cover in the 2019 drought (crown cover <1%), Maundia recovered quickly in 2020, which had above average rainfall, refilling the swamp at the monitoring site alongside the new highway. Photo shows Maundia flowering, Nov 2020.

Plate 31: In Situ Slender Marsdenia ML-93, Old Coast Road. Slender Marsdenia growing in a litter mound at the base of a large Tallowwood tree with stem-individuals also extending to the right into the road reserve up to edge of road.

Plate32: Close up of small Slender Marsdenia stem-individuals in photo above.

Plate 33: In Situ Spider Orchid in swampy wet sclerophyll forest on Old Coast Road. The plant had decline since last year, possibly an effect of the 2019 drought. The pseudobulbs were in poor condition. Many were discoloured, partly hollow, possibly grazed by something. Most had flowered in spring. Nov 2020.

Plate 34: In Situ Spider Orchid. Close up of above showing remains of terminal flower racemes.

Attachment 1

Warrell Creek to Nambucca Heads EPBC habitat WAE Clearing Maps

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ADJOINS SHEET 2

Design
Project WAE Clearing (16/6/2019)

Threatened Species Habitat
Giant Barred Frog
Green-thighed frog
Grey-headed Flying Fox

Vegetation
Freshwater wetlands (EEC)
Mixed floodplain forest (EEC)
Regrowth and weeds: moist open forest - White Mahogany, Grey Gum, Swamp Oak, Camphor Laurel
Saltmarsh EEC
Swamp forest - Swamp Mahogany / Paperbark (EEC)
Swamp Oak forest (EEC)

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WARRELL CREET TO NAMBUCCA HEADS

EPBC Habitat Works As Executed (WAE) Clearing

Sheet 1 of 17

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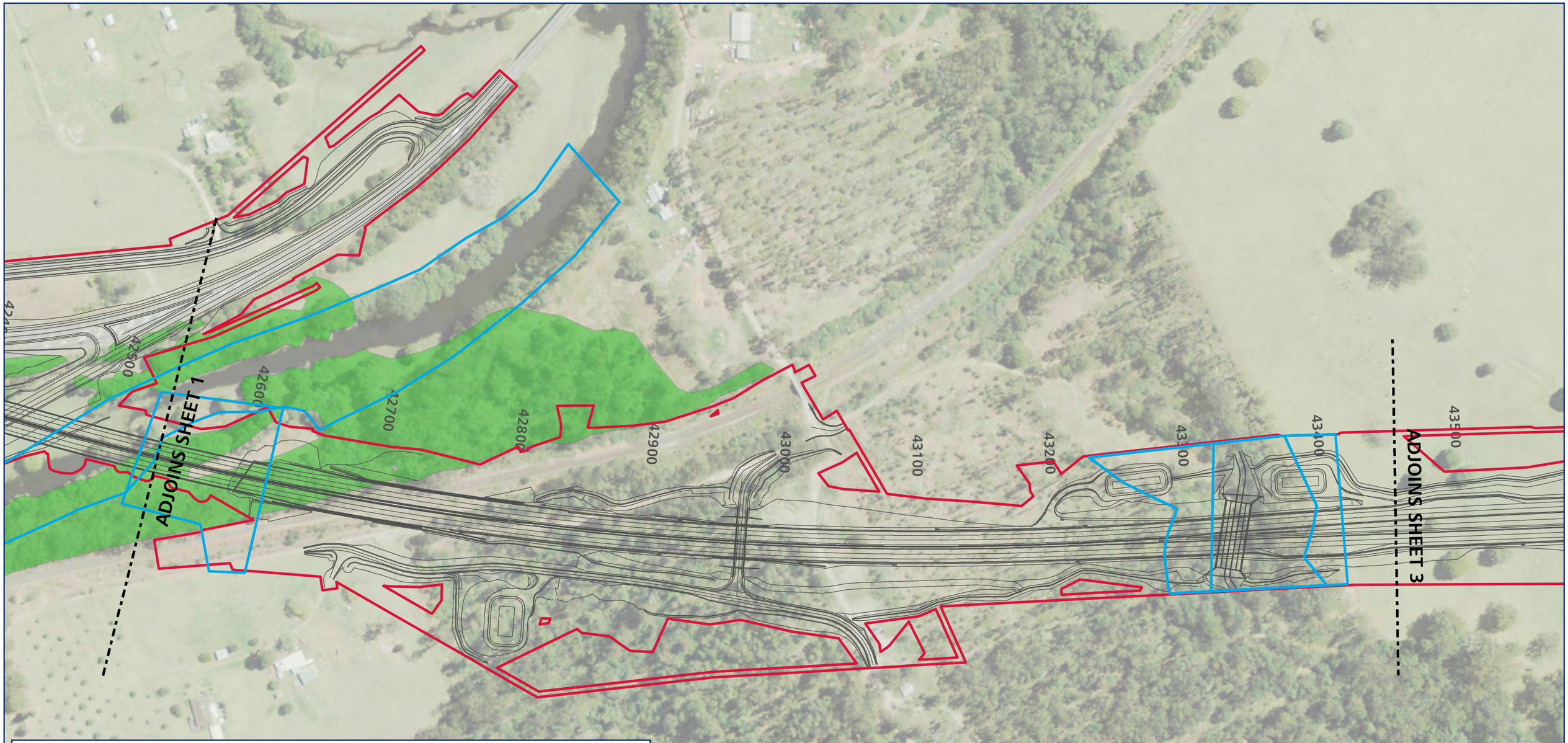

Design
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Threatened Species Habitat
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- Green-thighed frog
- Grey-headed Flying Fox

Vegetation
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Design
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Threatened Species Habitat
Giant Barred Frog
Green-thighed frog
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WARRELL CREET TO NAMBUCCA HEADS

EPBC Habitat Works As Executed (WAE) Clearing

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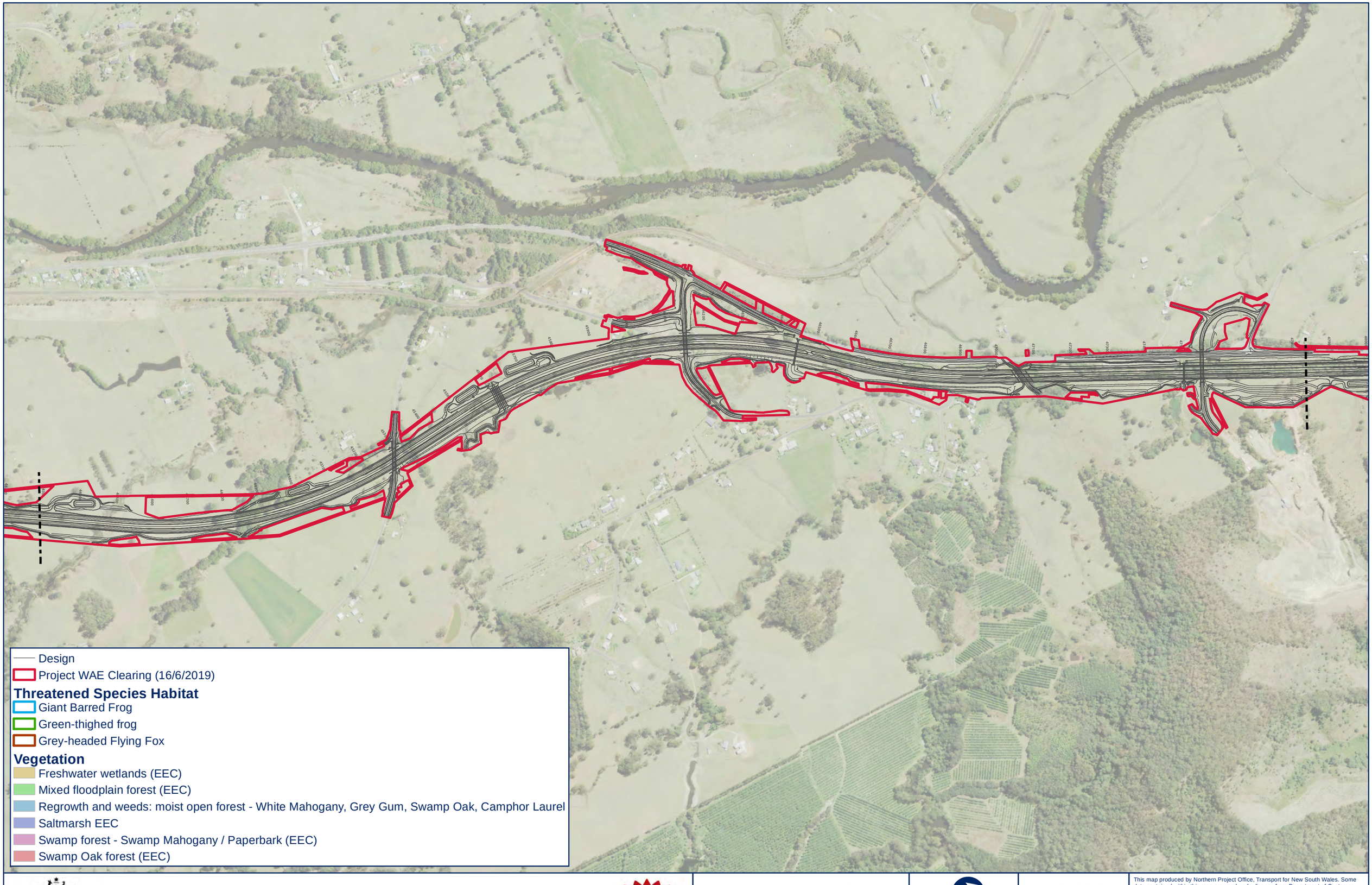

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WARRELL CREET TO NAMBUCCA HEADS

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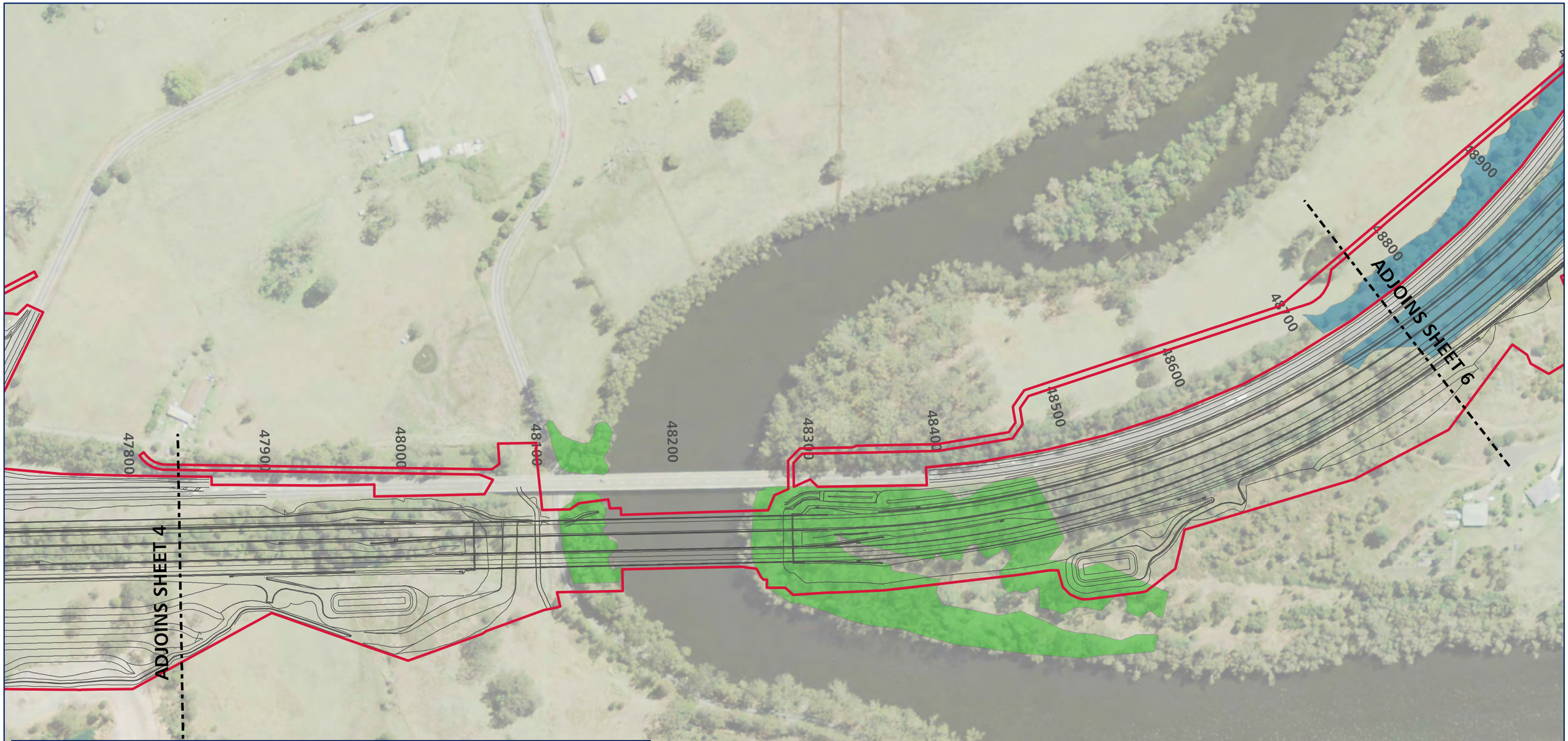

Design
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Threatened Species Habitat
Giant Barred Frog
Green-thighed frog
Grey-headed Flying Fox

Vegetation
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Swamp forest - Swamp Mahogany / Paperbark (EEC)
Swamp Oak forest (EEC)

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WARRELL CREET TO NAMBUCCA HEADS

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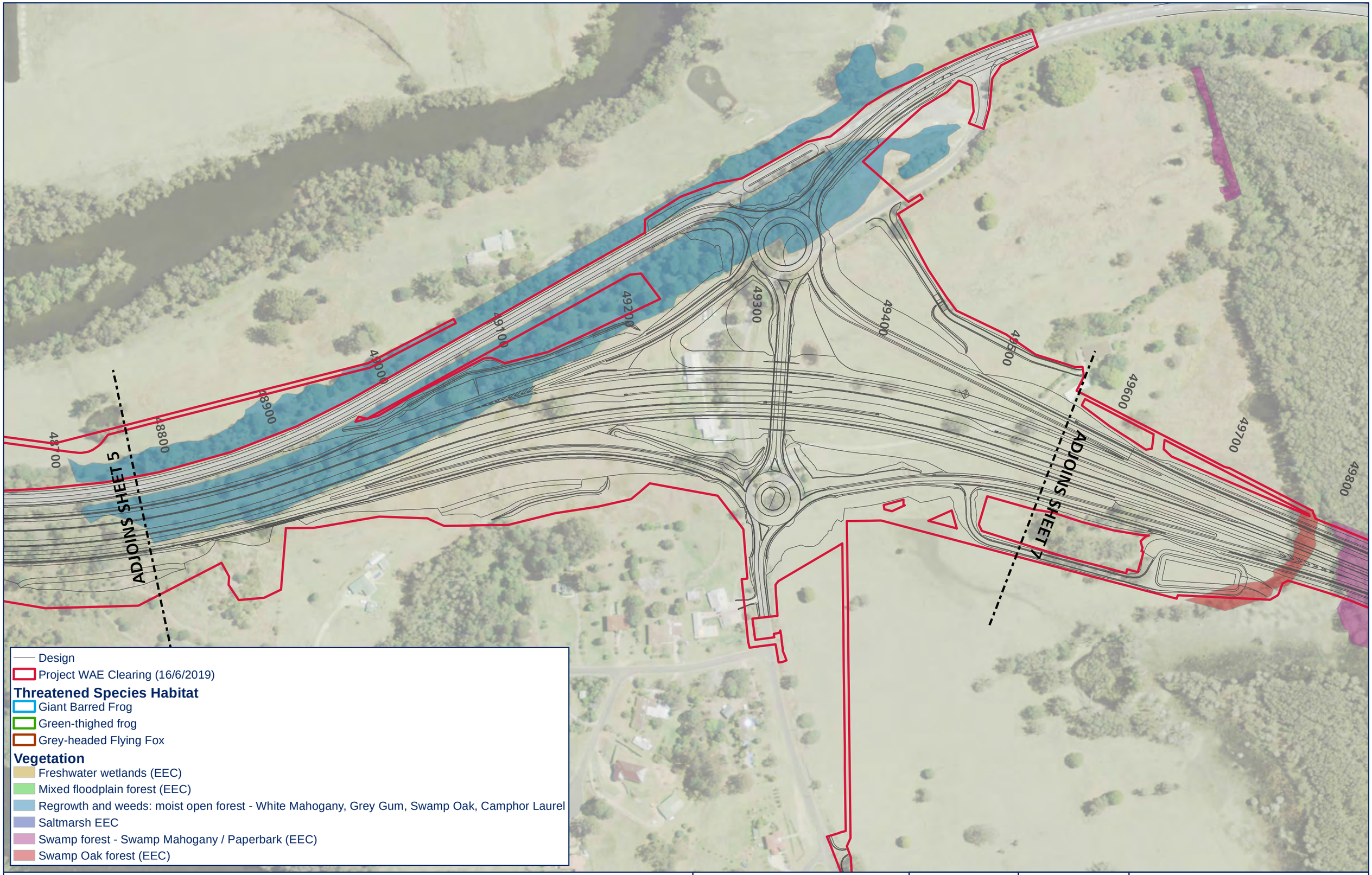

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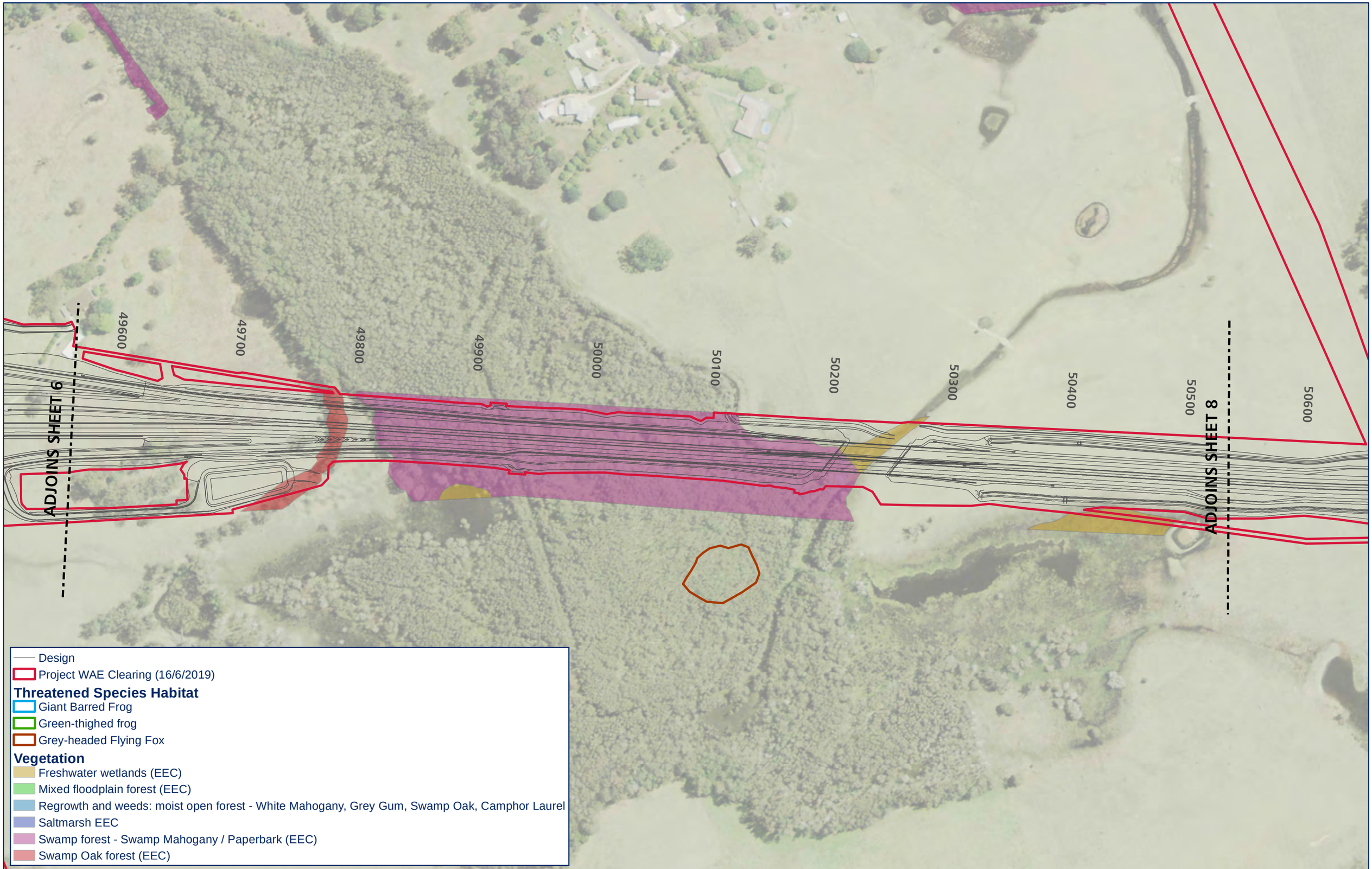

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Threatened Species Habitat

- Giant Barred Frog
- Green-thighed frog
- Grey-headed Flying Fox

Vegetation

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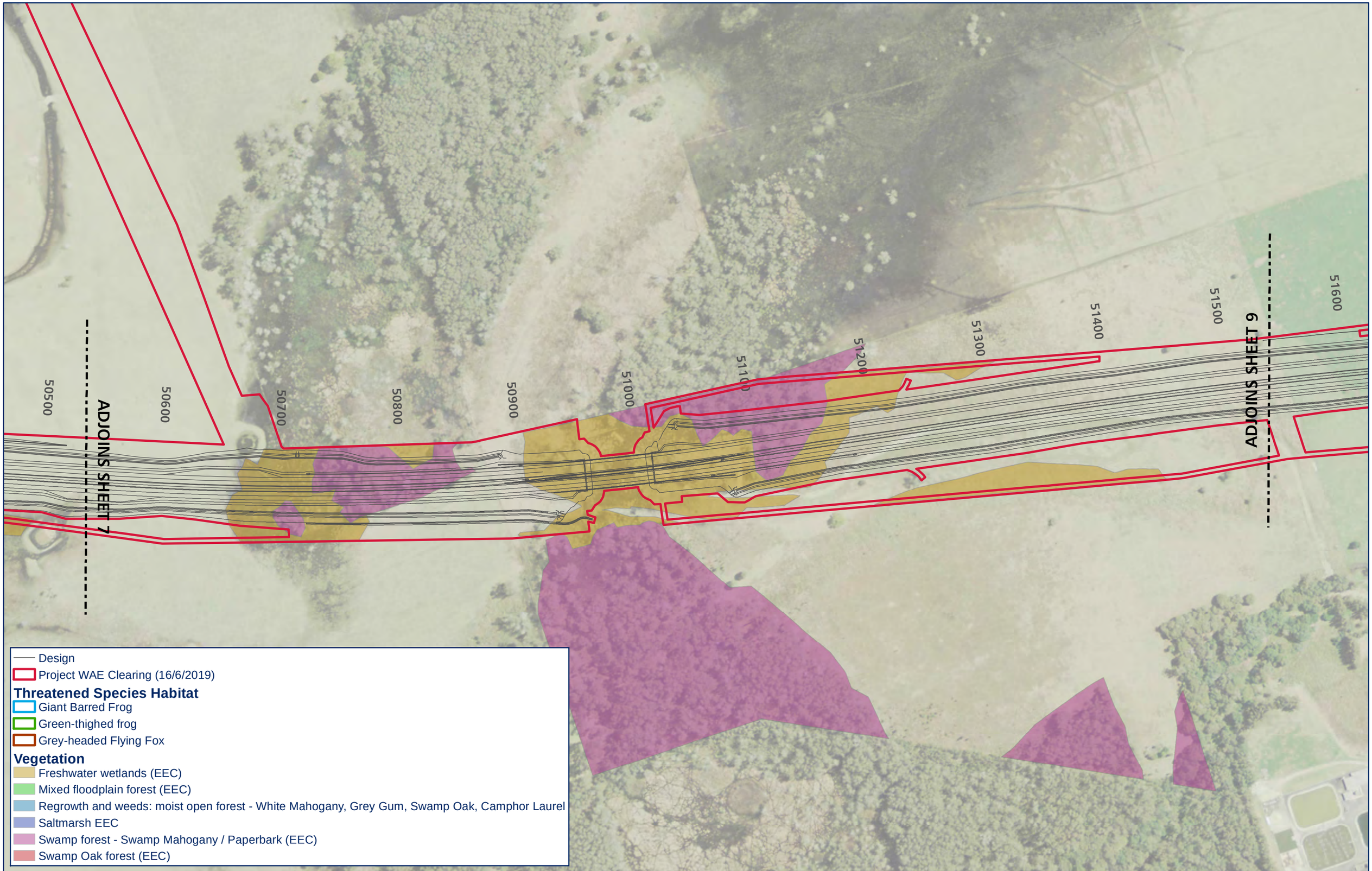

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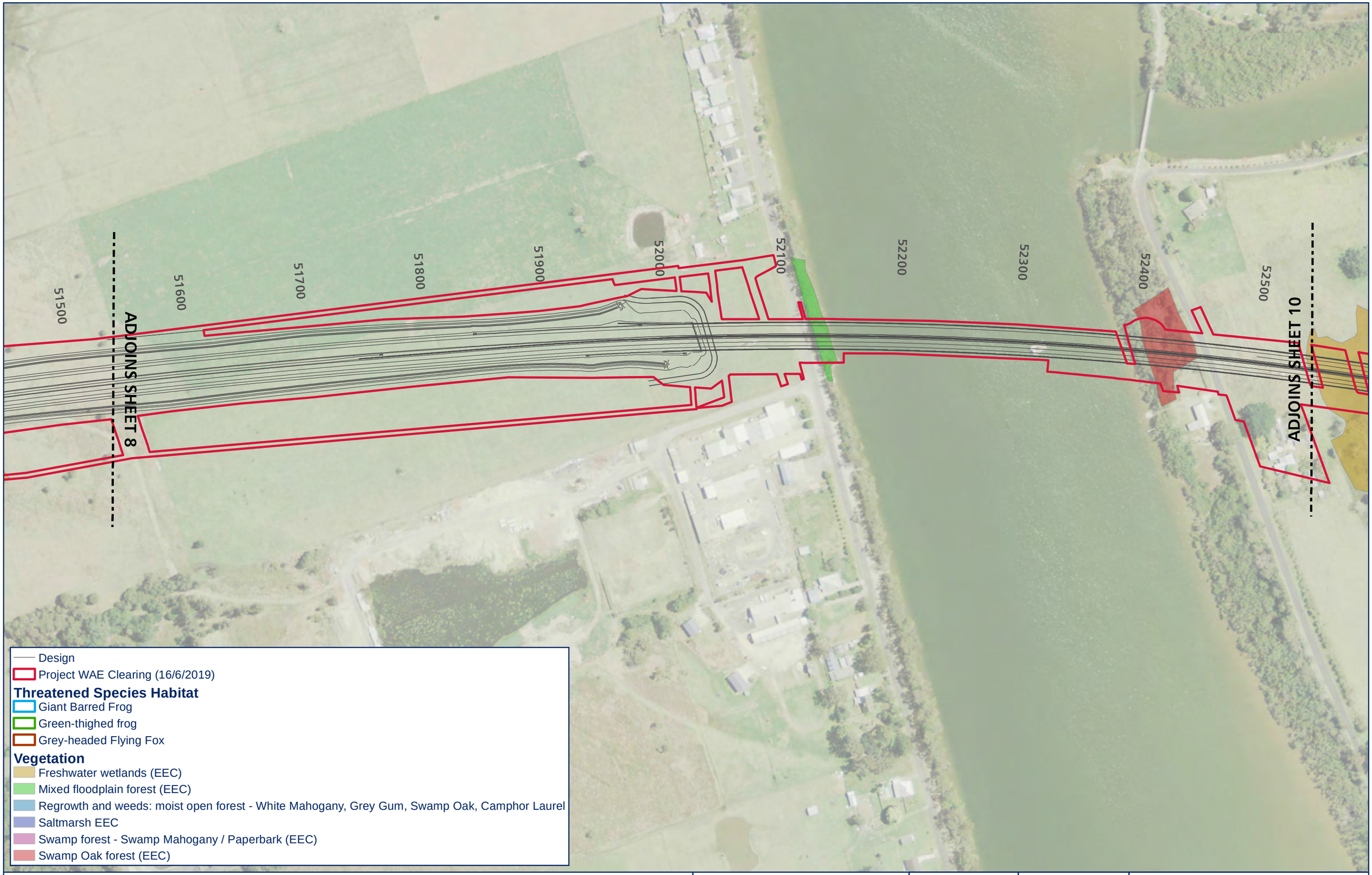

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Threatened Species Habitat
Giant Barred Frog
Green-thighed frog
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Vegetation
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Design

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Threatened Species Habitat

Giant Barred Frog

Green-thighed frog

Grey-headed Flying Fox

Vegetation

Freshwater wetlands (EEC)

Mixed floodplain forest (EEC)

Regrowth and weeds: moist open forest - White Mahogany, Grey Gum, Swamp Oak, Camphor Laurel

Saltmarsh EEC

Swamp forest - Swamp Mahogany / Paperbark (EEC)

Swamp Oak forest (EEC)

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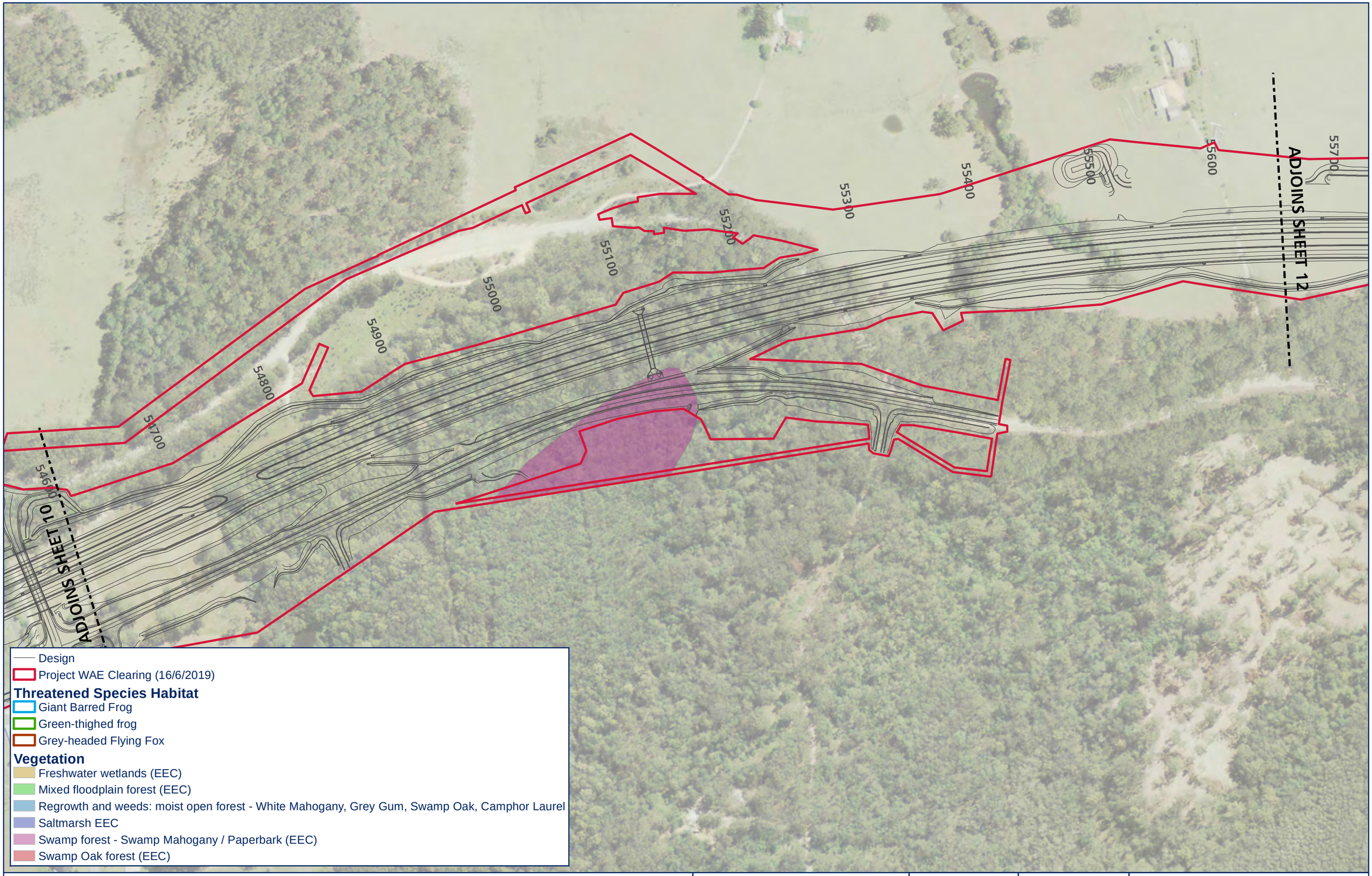

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ADJOINS SHEET 13

Design
Project WAE Clearing (16/6/2019)

Threatened Species Habitat
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Vegetation
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- Design
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WARRELL CREET TO NAMBUCCA HEADS

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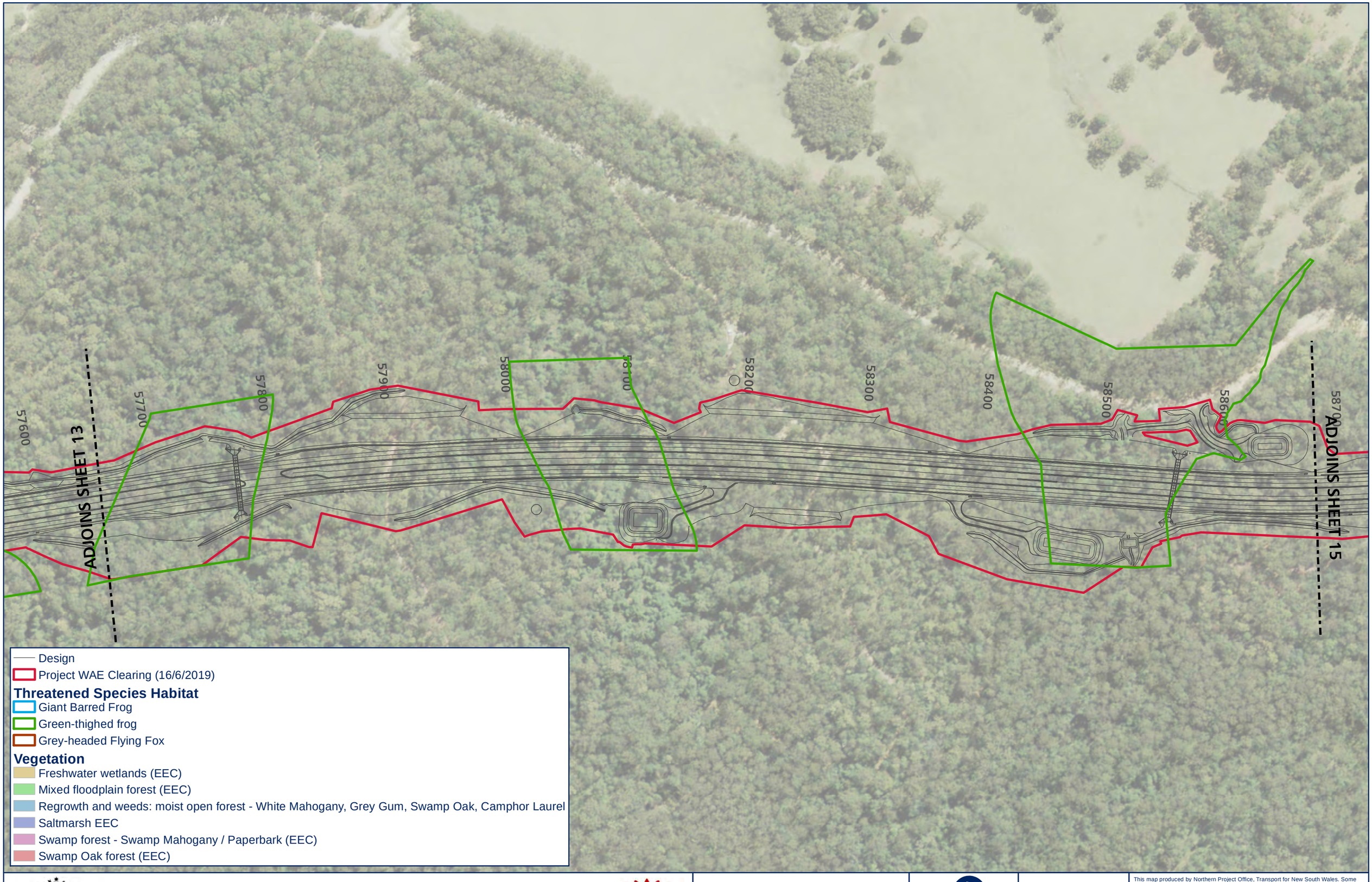

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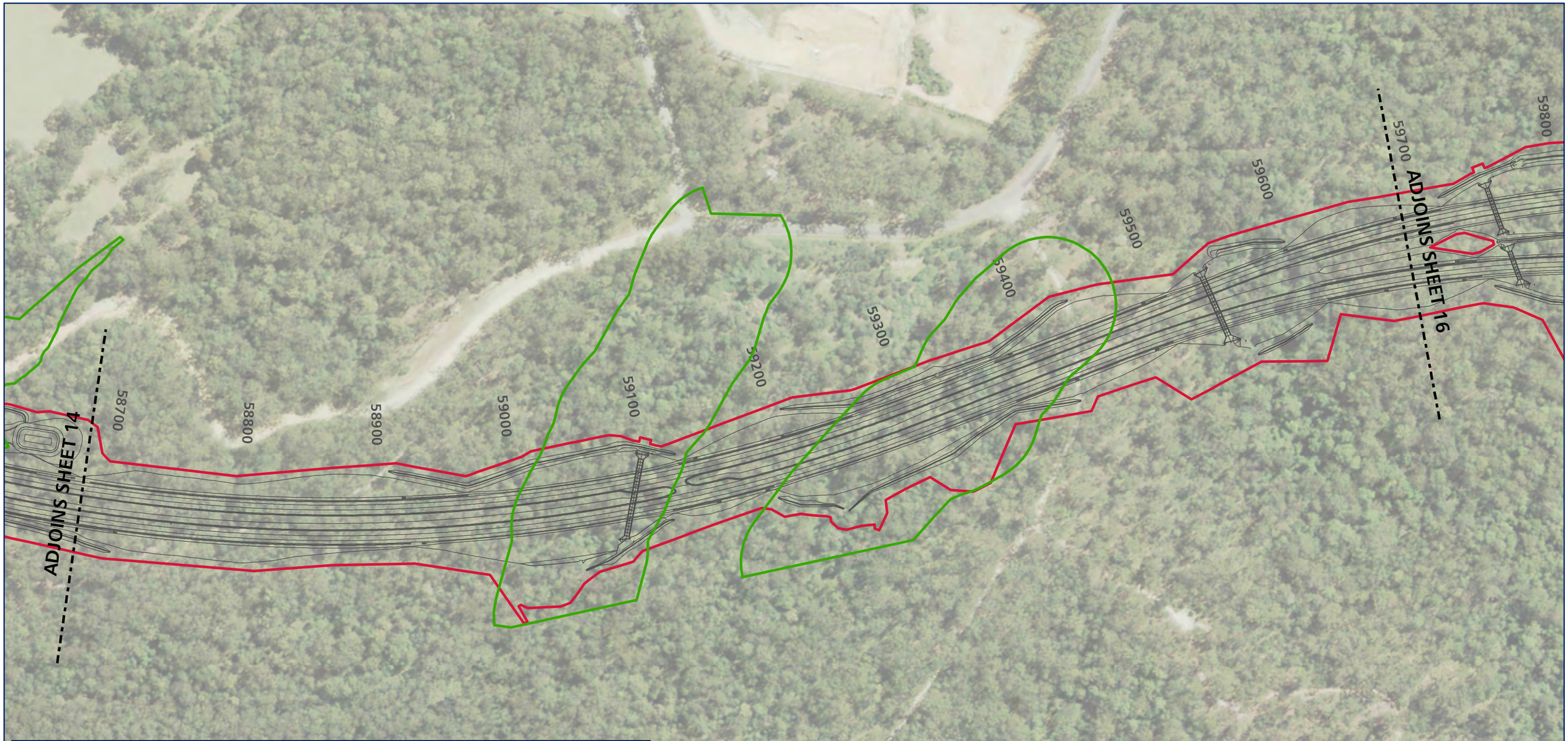

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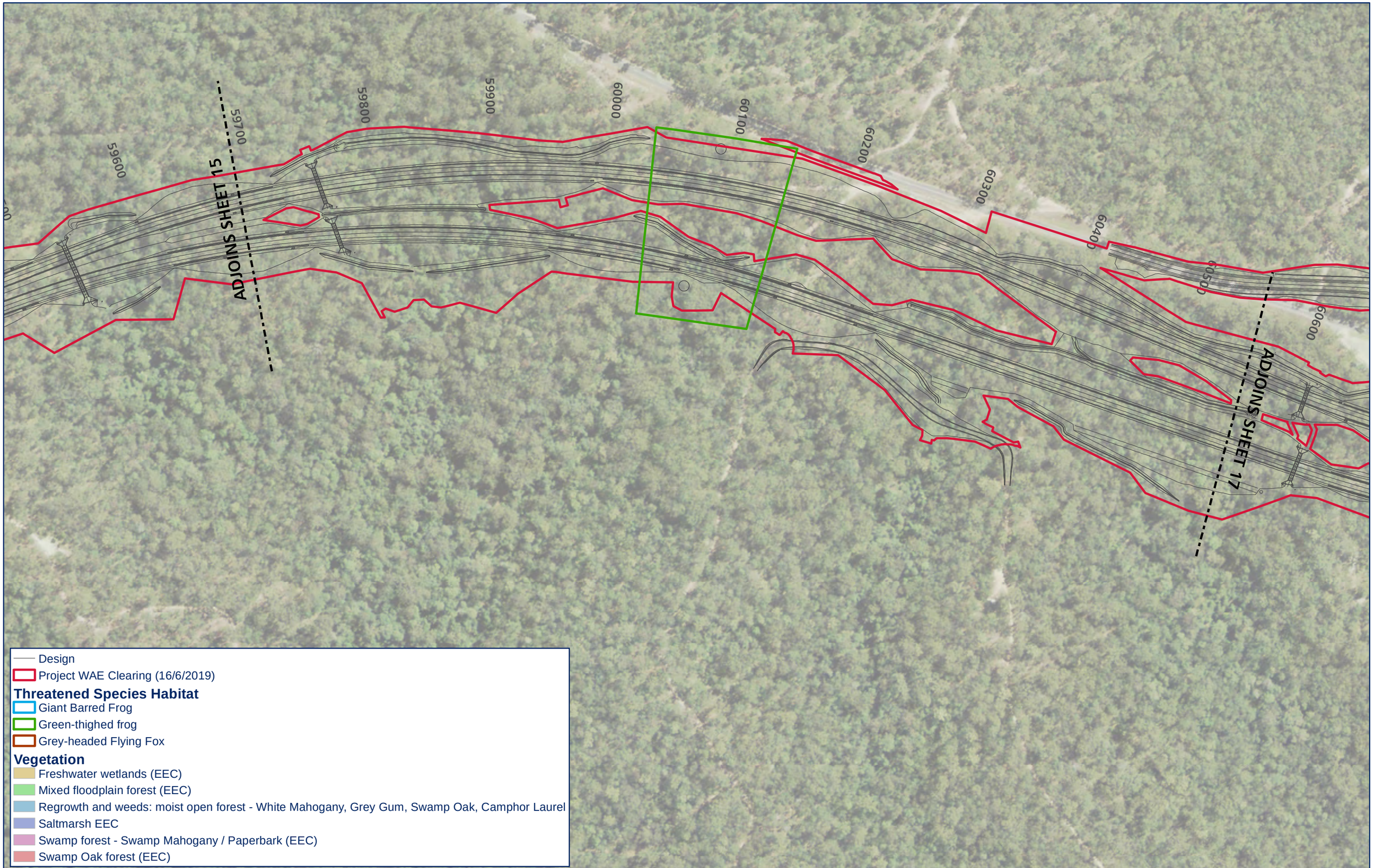

- Design
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Threatened Species Habitat

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- Freshwater wetlands (EEC)
- Mixed floodplain forest (EEC)
- Regrowth and weeds: moist open forest - White Mahogany, Grey Gum, Swamp Oak, Camphor Laurel
- Saltmarsh EEC
- Swamp forest - Swamp Mahogany / Paperbark (EEC)
- Swamp Oak forest (EEC)

Australian Government

BUILDING OUR FUTURE

WARRELL CREET TO NAMBUCCA HEADS

EPBC Habitat Works As Executed (WAE) Clearing

Sheet 16 of 17

NSW GOVERNMENT

Map Published: 8/04/2020

Author: WILSOTH

Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Horizontal Datum: GDA 1994

1:2,800 at A3

25 0 25 50 75 100
Metres

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ADJOINS SHEET 16

60500
60600
60700
60800
60900
61000
61100
61200
61265
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61500
61600
61700

Design
Project WAE Clearing (16/6/2019)

Threatened Species Habitat
Giant Barred Frog
Green-thighed frog
Grey-headed Flying Fox

Vegetation
Freshwater wetlands (EEC)
Mixed floodplain forest (EEC)
Regrowth and weeds: moist open forest - White Mahogany, Grey Gum, Swamp Oak, Camphor Laurel
Saltmarsh EEC
Swamp forest - Swamp Mahogany / Paperbark (EEC)
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