Kundabung to Kempsey

Flora and Fauna Management Plan

Roads and Maritime Services | October 2014

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Revision	Date	Details	Approved by
Report prepared by McDonnell Dowell OHL Joint Venture			
1	04/11/14	Approved for construction DoTE/DP&E	J.Hamilton (JV)
Roads and Maritime Update to report prepared by SMEC Hyder Joint Venture			
2	15/11/16	Update to Appendix B - Ecological Monitoring Program	A. Darlington
3	30/08/19	Update to Appendix B - Ecological Monitoring Program	S. Hardiman

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GLOSSARY/ ABBREVIATIONS

Term/ Abbreviation	Definition
CEMP	Construction Environmental Management Plan
CFFMP	Construction Flora and Fauna Management Plan
CoA	Condition of Approval
DPI	Department of Primary Industries (Fishing and Aquaculture)
EA	Environmental Assessment
EEC	Endangered Ecological Community
EPA	Environment Protection Authority
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPBC Act	*Environmental Protection and Biodiversity Conservation Act 1999*
EWMS	Environmental Work Method Statements
FM Act	*Fisheries Management Act 1994*
GBF	Giant Barred Frog
NPW Act	*National Parks and Wildlife Act 1974*
NW Act	*Noxious Weeds Act 1993*
OEH	NSW Office of Environment and Heritage
Roads and Maritime	Roads and Maritime Services
SoC	Statement of Commitments
TSC Act	*Threatened Species and Conservation Act 1995*

1.0 INTRODUCTION

1.1 CONTEXT

This Construction Flora and Fauna Management Sub Plan (CFFMP or Plan) forms part of the Construction Environmental Management Plan (CEMP) for the upgrade of the Pacific Highway between Kundabung and Kempsey (hereafter referred to as the Project or 'K2K').

This CFFMP has been prepared to address the requirements of the Minister's Conditions of Approval (CoA), the Roads and Maritime Statement of Commitments (SoC), the Commonwealth Department of the Environment Conditions of Approval, the mitigation and management measures listed in the Oxley Highway to Kempsey Environmental Assessment (EA), the Environment Protection and Biodiversity Conservation (EPBC) Act approval conditions and all applicable legislation.

The Plan will be continually updated to reflect any changes that may have effects on flora and fauna management, such as K2K project design adjustments and results of pre-clearing surveys. The project was approved by the Department of the Environment (formerly SEWPaC under section 130(1) and 133 of the EPBC Act on 24 January 2014. EPBC conditions of approval are included in Section 3.4 of this Plan. Additional mitigation measures are contained in Table 5-1.

1.2 BACKGROUND

For the purposes of approvals the project was assessed as Oxley Highway to Kempsey. The McConnell Dowel OHL Joint Venture ('the JV') is delivering the 13.7km K2K section of the Oxley Highway to Kempsey Pacific Highway Upgrade, which this CFFMP covers. The Oxley Highway to Kundabung section is being delivered by others and is not included in this Plan.

The *Oxley Highway to Kempsey – Upgrading the Pacific Highway - Environmental Assessment* (RTA 2010) assessed the impacts of construction and operation of the Project on flora and fauna.

As part of EA development, a detailed flora and fauna assessment was prepared to address the Environmental Assessment Requirements issued by the Department of Planning. The flora and fauna assessment was included in the EA as Volume 2 – Flora and Fauna Working Paper.

The EA concluded that there were unlikely to be significant residual flora and fauna impacts associated with the construction and operation of the Project, following the implementation of the proposed mitigation and management measures identified in the EA.

The Oxley Highway to Kempsey Project was referred to the Commonwealth Department of the Environment (formerly the Department of Sustainability, Environment, Water, Population and Communities) on the 24 August 2012 due to the potential significant impact on a number of species listed under the Environmental Protection and Biodiversity Conservation Act, 1999 (EPBC Act) including the Koala, Grey-headed Flying Fox, Spotted –tail quoll and Giant Barred Frog. The Oxley Highway to Kempsey Project was declared a controlled action on 21 September 2012 and was approved by the Minister for the Environment on 24 January 2014, subject to a number of conditions being met.

1.3 ENVIRONMENTAL MANAGEMENT SYSTEMS OVERVIEW

The overall Environmental Management System for the Project is described in the **Construction Environmental Management Plan (CEMP) (QMS# 025-Y001-2602).**

The CFFMP is part of the JV's environmental management framework for the Project, as described in Section 4 of the CEMP. In accordance with CoA B.31(b), this Plan has been developed in consultation with the Environment Protection Authority (EPA). The Department of Primary Industries (Fishing and Aquaculture) has also been consulted.

Mitigation and management measures identified in this Plan will be incorporated into site or activity specific Environmental Work Method Statements (EWMS).

EWMS will be developed and signed off by environment and management representatives of the JV, RMS and the Project Environmental Representative prior to associated works and construction personnel will be required to undertake works in accordance with the identified mitigation and management measures.

Used together, the CEMP, strategies, procedures and EWMS form management guides that clearly identify required environmental management actions for reference by JV personnel and contractors.

The review and document control processes for this Plan are described in Chapters 9 and 10 of the CEMP.

2.0 PURPOSE AND OBJECTIVES

2.1 PURPOSE

The purpose of this Plan is to describe how construction impacts on ecology will be minimised and managed.

2.2 OBJECTIVES

The key objective of the CFFMP is to ensure that impacts to flora and fauna are minimised. To achieve this objective, the following will be undertaken:

- Ensure appropriate controls and procedures are implemented during construction activities to avoid or minimise potential adverse impacts to flora and fauna along the Project corridor.
- Ensure appropriate measures are implemented to address the relevant CoA and SoC outlined in Table 3-1 and Table 3-2, and the management measures detailed in the EA.
- Ensure appropriate measures are implemented to comply with all relevant legislation and other requirements as described in Section 3.1 and Section 3.4 of this Plan.

2.3 TARGETS AND INDICATORS

The following targets have been established for the management of flora and fauna impacts during the Project:

- Ensure full compliance with the relevant legislative requirements, CoA, SoC and EPBC as well as relevant Roads and Maritime specifications and guidelines.
- No disturbance to flora and fauna outside the proposed construction footprint and associated access tracks and site compounds.
- No increase in distribution of weeds currently existing within the Project areas.
- No new weeds introduced to the Project areas.
- No net loss of significant habitat resources including hollow logs and tree nesting hollows, with materials cleared from the construction area re-used in adjacent areas where possible.
- Effective rehabilitation / revegetation that ensures different successional stages of rehabilitation are achieved.
- No fauna mortality during construction.
- Not facilitate spread of feral animals as a result of construction.
- No pollution or siltation of aquatic ecosystems, wetlands, endangered ecological communities (EECs) or threatened species habitat.
- Provide effective fauna movement and fish passage.
- Ensure full compliance with the relevant legislative requirements, CoA and SoC.
- Meet environmental protection licence water quality discharge parameters for all planned basin discharges (ie those within design capacity).
- Manage downstream water quality impacts attributable to the K2K Project (ie maintain water waterway health by avoiding the introduction of nutrients, sediment and chemicals outside of that permitted by the environmental protection licence and/or Australian and New Zealand guidelines for fresh and marine water quality (ANZECC guidelines).

- Ensure training on best practice soil and water management is provided to all construction personnel through site inductions.

3.0 ENVIRONMENTAL REQUIREMENTS

3.1 RELEVANT LEGISLATION AND GUIDELINES

3.1.1 Legislation

Legislation relevant to flora and fauna management includes:

- *Environmental Planning and Assessment Act 1979* (EP&A Act).
- *National Parks and Wildlife Act 1974* (NPW Act).
- *Threatened Species and Conservation Act 1995* (TSC Act).
- *Fisheries Management Act 1994* (FM Act).
- *Noxious Weeds Act 1993* (NW Act).
- *Pesticides Act 1999.*
- *Animal Research Act 1985*
- *Native Vegetation Act 2003.*
- *Prevention of Cruelty to Animals Act 1979.*
- *Plant Diseases Act 1924.*
- *Environmental Protection and Biodiversity Conservation Act 1999* (Commonwealth) (EPBC Act).

Relevant provisions of the above legislation are explained in the register of legal and other requirements included in Appendix A1 of the CEMP.

3.1.2 Guidelines

The main guidelines, specifications and policy documents relevant to this Plan include:

- Roads and Maritime QA Specification G36 – Environmental Protection (Management System).
- Roads and Maritime QA Specification G40– Clearing and Grubbing.
- Roads and Maritime QA Specification R176 – Native Seed Collection.
- Roads and Maritime QA Specification R178 – Vegetation.
- Roads and Maritime QA Specification R179 – Landscape Planting.
- Roads and Maritime Environmental Direction No.25 - Management of Tannins from Vegetation Mulch (January 2012).
- Roads and Maritime *Practice Note: Clearing and Fauna Management – Pacific Highway Projects* (May 2012).
- Roads and Maritime *Biodiversity Guidelines* (September 2011).
- NSW Department of Primary Industries, *Why Do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings*, Fairfull and Witheridge, 2003;
- *Fishnote – Policy and Guidelines for Fish Friendly Waterway Crossings* – November 2003;
- NSW National Parks & Wildlife Service. 2001. *Policy for the Translocation of Threatened Fauna in NSW: Policy and Procedure Statement No. 9* Threatened Species Unit, Hurstville NSW;
- Australian Network for Plant Conservation. 2004. *Guidelines for the Translocation of Threatened Plants in Australia*, 2nd Edition.
- DECCW 2008. *Hygiene protocol for the control of disease in frogs*.

3.2 MINISTER'S CONDITIONS OF APPROVAL

The CoA relevant to this Plan are listed in Table 3-1 below. A cross reference is also included to indicate where the condition is addressed in this Plan or other Project management documents. Where conditions are not specifically addressed in this Plan, the relevant document is referenced.

Table 3-1 Conditions of Approval relevant to this CFFMP

CoA No.	Condition Requirements	Document Reference
CoA B1	The Proponent shall design (and implement) the fauna and waterway crossings identified in Table 6-2 of Appendix B of the document listed under condition A1 (d), at the locations and in accordance with the minimum design principles identified in Table 6-2, unless otherwise agreed by the Director-General.	Oxley Highway to Kempsey Pacific Highway Kundabung to Kempsey Fauna Connectivity Report (SMEC-Hyder JV)
CoA B2	Investigations into the design of fauna and waterway crossings identified in Table 6-2 of Appendix B of the document listed under condition A1(d) during detailed design shall be undertaken with the input of a suitably qualified and experienced ecologist and in consultation with the EPA and DPI (Fishing and Aquaculture).	Oxley Highway to Kempsey Pacific Highway Kundabung to Kempsey Fauna Connectivity Report (SMEC-Hyder JV)
CoA B3	The Proponent shall prepare a report on the final design of fauna and/or waterway crossings identified in Table 6-2 of Appendix B of the document listed under condition A1(d), where the location of the crossing has changed and/or the crossing does not meet the minimum design principles identified in Table 6-2. The report shall be submitted to the Director-General prior to the commencement of construction of the relevant crossing, and shall demonstrate how the new location and/or design would result in acceptable biodiversity outcomes. The report shall clearly identify how the fauna and/or waterway crossing will work in conjunction with complementary fauna exclusion fencing measures to be implemented for the project. The report shall be accompanied by evidence of consultation with the EPA and DPI (Fishing and Aquaculture) in relation to the suitability of any changes to the location and/or crossing design.	Oxley Highway to Kempsey Pacific Highway Kundabung to Kempsey Fauna Connectivity Report (SMEC-Hyder JV)
CoA B4	The Proponent shall investigate the provision of widened medians (with the aim of retaining existing vegetation in a widened median where feasible and reasonable) as an alternative to the provision of glider poles and rope bridges to facilitate the movement of gliders across the project at the following locations: (a) Cairncross 1 – between station 10000 to 11600; (b) Ballengarra 1b – between station 23200 to 24100; and (c) Maria River 1b – between station 33760 to 34380.	Median Widening Assessment (SMEC Hyder JV)

CoA No.	Condition Requirements	Document Reference
	This investigation shall be undertaken by a suitably qualified and experienced ecologist and in consultation with the EPA and the Forestry Corporation of NSW . The Proponent shall prepare a report on the median widening investigation, including the location and final design of the glider crossing measures and consequential impacts on other ecologically significant elements potentially affected by the widening. The report shall be submitted for the approval of the Director General no later than six months prior to the commencement of work that would result in the disturbance of native vegetation in the median widening investigation areas, or within such period otherwise agreed by the Director General. Work within the median investigation areas shall not commence until written approval has been received from the Director General.	
CoA B5	As part of the investigation into widened medians under condition B4, the Proponent shall investigate and report on the provision of widened medians at Barrys Creek (station 23967) as an alternative fauna crossing design for Koalas and Quolls.	Median Widening Assessment (SMEC Hyder JV)
CoA B6	The Proponent shall, in consultation with the EPA and DPI (Fishing and Aquaculture), ensure that all waterway crossings are designed and constructed consistent with the principles of the Guidelines for Controlled Activities Watercourse Crossings (Department of Water and Energy, February 2008), Policy and Guidelines for Fish Friendly Waterway Crossings (NSW Fisheries, February 2004) and Policy and Guidelines for Design and Construction of Bridges, Roads, Causeways, Culverts and Similar Structures (NSW Fisheries 1999). Where multiple cell culverts are proposed for creek crossings, at least one cell shall be provided for fish passage, with an invert or bed level that mimics creek flows.	Oxley Highway to Kempsey Pacific Highway Kundabung to Kempsey Fauna Connectivity Report (SMEC-Hyder JV)
CoA B7	Prior to the commencement of construction work that would result in the disturbance of native vegetation (or as otherwise agreed by the Director General), the Proponent shall, in consultation with the EPA, prepare and submit for the approval of the Director General a Nest Box Plan to provide replacement hollows for displaced fauna. The Plan shall detail the number and type of nest boxes to be installed which must be justified based on the number and type of hollows removed (based on detailed pre-construction surveys), the density of hollows in the area to be cleared and adjacent forest, and the availability of adjacent food resources. The Plan shall also provide details of maintenance protocols for the nest boxes installed including responsibilities, timing and duration.	Appendix A - Nest Box Plan
CoA B8	The Proponent shall, in consultation with the EPA and DPI (Fishing and Aquaculture), develop a Biodiversity Offset Strategy that identifies the available options for offsetting the biodiversity impacts of the project in perpetuity, with consideration to the Principles for the use of biodiversity offsets in NSW (Office of Environment and Heritage website http://www.environment.nsw.gov.au/biocertification/offsets.htm dated 17 June 2011). Unless	Biodiversity Offset Strategy (Roads and Maritime 2013)

CoA No.	Condition Requirements	Document Reference
	otherwise agreed to by the EPA and DPI (Fishing and Aquaculture), offsets shall be provided on a like-for-like basis and at a minimum ratio of 4:1 for areas of high conservation value (including EEC, salt marsh and poorly conserved vegetation communities identified as being more than 75% cleared in the catchment management area) and 2:1 for the remainder of native vegetation areas (including mangroves, seagrass, and non-EEC riparian vegetation). The Strategy shall include, but not necessarily be limited to: (a) the aims and objectives of the biodiversity offset strategy; (b) confirmation of the vegetation type/ habitat (in hectares) to be cleared and their condition, and the size of offsets required (in hectares); (c) details of the type of available offset measures that have been identified to compensate for the loss of threatened species and vulnerable and endangered ecological communities and/ or their habitats, and native vegetation (including mangroves, seagrasses, salt marsh and riparian vegetation). The measures shall achieve a neutral or net beneficial outcome for all the biodiversity values likely to be impacted directly or indirectly during both the construction and operation of the project; (d) the decision-making framework that would be used to select the final suite of offset measures to achieve the aims and objectives of the Strategy, including the ranking of offset measures; (e) a process for addressing and incorporating offset measures arising from changes in biodiversity impacts (where these changes are generally consistent with the biodiversity impacts identified for the project in the documents listed under condition A1), including: changes to the footprint due to detailed design; changes to predicted impacts as a result of changes to mitigation measures; the identification of additional species/ habitat through pre-clearance surveys and construction; and additional impacts associated with the establishment of ancillary facilities; and (f) options for the securing and management of biodiversity offsets in perpetuity. The Biodiversity Offset Strategy shall be submitted to the Director General for approval no later than 6 weeks prior to the commencement of construction that would result in the disturbance of native vegetation, unless otherwise agreed by the Director General. The Proponent may elect to satisfy the requirements of this condition by identifying a suitable offset strategy which addresses impacts from multiple Pacific Highway Upgrade projects within the North Coast Bio-region. Any such strategy, including an agreement made with the EPA, must be made in consultation with the Department and approved by the Director	

CoA No.	Condition Requirements	Document Reference
	General within a timeframe agreed to by the Director General.	
CoA B9	Within two years of the date of approval of the Biodiversity Offset Strategy, unless otherwise agreed by the Director General, the Proponent shall prepare and submit a Biodiversity Offset Package for the approval of the Director General. The Package shall be developed in consultation with the EPA and DPI (Fishing and Aquaculture), and shall include, but not necessarily be limited to: (a) details of the final suite of the biodiversity offset measures to be implemented for the project demonstrating how it achieves the requirements of the Biodiversity Offset Strategy (including specified offset ratios); (b) the final selected means of securing the biodiversity values of the Package in perpetuity, including ongoing management, maintenance and monitoring requirements; and (c) timing and responsibilities for the implementation of the provisions of the Package over time. The requirements of the Package shall be implemented by the responsible parties according to the timeframes set out in the Package, unless otherwise agreed by the Director General.	Roads and Maritime will prepare a Biodiversity Offset Package for the Project.
CoA B10	The Proponent shall develop an Ecological Monitoring Program to monitor the effectiveness of the biodiversity mitigation measures implemented as part of the project. The program shall be developed by a suitably qualified and experienced ecologist in consultation with the EPA and DPI (Fishing and Aquaculture) and shall include but not necessarily be limited to: (a) an adaptive monitoring program to assess the effectiveness of the mitigation measures identified in conditions B1, B4, B7 and B31(b) and allow amendment to the measures if necessary. The monitoring program shall nominate performance parameters and criteria against which effectiveness will be measured and include operational road kill surveys to assess the effectiveness of fauna crossings and exclusion fencing implemented as part of the project; (b) mechanisms for developing additional monitoring protocols to assess the effectiveness of any additional mitigation measures implemented to address additional impacts in the case of design amendments or unexpected threatened species finds during construction (where these additional impacts are generally consistent with the biodiversity impacts identified for the project in the documents listed under condition A1); (c) monitoring shall be undertaken during construction (for construction-related impacts) and from opening of the project to traffic (for operation/ ongoing impacts) until such time as the effectiveness of mitigation measures can be demonstrated to have been achieved over a minimum of three successive monitoring periods (i.e 6 years) after opening of the	Appendix B - Ecological Monitoring Program

CoA No.	Condition Requirements	Document Reference
	project to traffic, unless otherwise agreed by the Director General. The monitoring period may be reduced with the agreement of the Director General in consultation with the EPA and DPI (Fishing and Aquaculture), depending on the outcomes of the monitoring; (d) provision for the assessment of the data to identify changes to habitat usage and whether this can be directly attributed to the project; (e) details of contingency measures that would be implemented in the event of changes to habitat usage patterns directly attributable to the construction or operation of the project; and (f) provision for annual reporting of monitoring results to the Director General and the EPA and DPI (Fishing and Aquaculture), or as otherwise agreed by those agencies. The Program shall be submitted to the Director General for approval no later than 6 weeks prior to the commencement of construction that would result in the disturbance of native vegetation (unless otherwise agreed by the Director General).	
CoA B31	As part of the Construction Environment Management Plan for the project required under condition B30, the Proponent shall prepare and implement the following sub plan(s): … (b) a Construction Flora and Fauna Management Sub-plan to detail how construction impacts on ecology will be minimised and managed. The sub-plan shall be developed in consultation with the EPA and DPI (Fishing and Aquaculture) and shall include, but not necessarily be limited to: (i) details of pre-construction surveys undertaken to verify the construction boundaries/footprint of the project based on detailed design and to confirm the vegetation to be cleared as part of the project (including tree hollows, threatened flora and fauna species, mangroves, seagrass and riparian vegetation). The surveys shall be undertaken by a suitably qualified and experienced ecologist and include targeted surveys during suitable conditions for Koalas, Green-thighed Frog, Giant Barred Frog and microbats within and in the vicinity of the project corridor;	Section 4.3 Appendix B - Ecological Monitoring Program Appendix C - Giant Barred Frog Management Strategy Appendix D – Green-thighed Frog Management Strategy Appendix E – Microbat Management Strategy ~~Appendix F – Aquatic Vegetation Management Strategy~~ Appendix G – Pre-clearing Checklist
	(ii) updated sensitive area / vegetation maps based on B31(b)(i) above and previous survey work;	Appendix A6 of the CEMP
	(iii) details of general work practices and mitigation measures to be implemented during construction to minimise impacts on native fauna and native vegetation (particularly	Section 5

CoA No.	Condition Requirements	Document Reference
	threatened species and EECs) not proposed to be cleared as part of the project, including, but not necessarily limited to: fencing of sensitive areas, a protocol for the removal and relocation of fauna during clearing, presence of a suitably qualified and experienced ecologist to oversee clearing activities and facilitate fauna rescues and re-location, clearing timing with consideration to breeding periods, measures for maintaining existing habitat features (such as bush rock and tree branches etc), seed harvesting and appropriate topsoil management, construction worker education, weed management (including controls to prevent the introduction or spread of *Phytophthora cinnamomi*), erosion and sediment control and progressive re-vegetation;	Appendix G – Pre-clearing Checklist Appendix H – Working Around Trees Guidelines Appendix I – Fauna Handling and Rescue Procedure Appendix K – Weed and Pathogen Management Plan
	(iv) specific procedures to deal with EEC/threatened species anticipated to be encountered within the project corridor including re-location, translocation and/or management and protection measures;	Section 5 Appendix I – Fauna Handling and Rescue Procedure Appendix J - Unexpected Threatened Flora Find Procedure
	(v) a management strategy for the Green-thighed Frog and Giant Barred Frog in the case that the pre-construction surveys identify the presence of these species or its habitats in the project corridor or its vicinity. The strategy shall include details of the measures to avoid, minimise and mitigate impacts to these species;	Appendix C - Giant Barred Frog Management Strategy Appendix D – Green-thighed Frog Management Strategy
	(vi) a Microbat management strategy in the case that the pre-construction surveys (undertaken at least 12 months in advance of disturbance to potential roosting structures, or as agreed by the Director General) identify the presence of or evidence of microbat roosting in the project corridor or its vicinity. The strategy shall detail measures to avoid, minimise and mitigate impacts to microbats and identified roost sites, including short and long term management measures;	Appendix E - Micro bat Management Strategy
	~~(vii) an aquatic vegetation management strategy for mangroves and seagrass. The strategy shall:~~ ~~i. identify the potential for the translocation of mangroves and/or seagrass impacted by the project;~~ ~~ii. if translocation is feasible, include details of a translocation plan consistent with Policy and Guidelines for Fish Habitat Conservation and Management (NSW Fisheries 1999) including details of ongoing maintenance such as responsibilities, timing and duration;~~	~~Section 5~~ ~~Appendix F - Aquatic Vegetation Management Strategy~~ *Appendix F is not required as project has neither mangroves nor seagrasses within the project area according to EA.*

CoA No.	Condition Requirements	Document Reference
	~~iii. identify a process for incorporating appropriate compensatory habitat for mangroves and/or seagrass impacted by the project in the Biodiversity Offset Strategy referred to in condition B8 of this approval, should the information obtained during the investigation find that translocation is not feasible or where the monitoring undertaken finds that translocation measures have not been successful (as identified through performance criteria); and~~ ~~iv.~~ include detail of the mitigation measures to be implemented during construction ~~to avoid and minimise impacts to areas identified to contain these species, including~~ impacts from the use and storage of construction plant, equipment, materials ~~and entry by personnel;~~	
	(viii) a procedure for dealing with unexpected EEC/threatened species identified during construction including cessation of work and notification of the EPA, determination of appropriate mitigation measures in consultation with the EPA (including relevant re-location measures) and update of ecological monitoring and/or biodiversity offset requirements consistent with conditions B8 and B10; and	Section 5 Appendix I – Fauna Handling and Rescue Procedure Appendix J – Unexpected Threatened Flora Find Procedure
	(ix) mechanism for the monitoring, review and amendment of this sub-plan;	Section 7 Appendix B - Ecological Monitoring Program

3.3 STATEMENT OF COMMITMENTS

Relevant SoC are listed Table 3-2 below. This includes reference to required outcomes, the timing of when the commitment applies, relevant documents or sections of the environmental assessment influencing the outcome and implementation.

Table 3-2 Statement of commitments relevant to this CFFMP

Outcome	Ref #	Commitment	Timing	Reference Document	CFFMP Reference
Minimise impacts on native vegetation, fauna and their habitats.	F1	Detailed design will minimise the area of native vegetation and habitat to be cleared wherever reasonable and feasible.	Detailed design	*RTA QA Specification G36 Environmental Protection (Management System).*	Table 5-1 Mitigation Measure FF6
	F2	The limits of clearing and other native vegetation disturbance will be clearly marked on relevant work plans and on site with temporary fencing installed prior to clearing.	Pre-construction and construction	*RTA QA Specification G36 Environmental Protection (Management System).* *RTA QA Specification B30 - Clearing, Excavation & Backfill for Bridgeworks.* *RTA QA Specification R178 – Vegetation*	Table 5-1 Mitigation Measure FF6
	F3	Rehabilitation and revegetation will be undertaken in stages and as early as practicable to restore and enhance habitat opportunities.	Construction and operation	*RTA QA Specification G36 Environmental Protection (Management System).*	Table 5-1 Mitigation Measure FF10
	F4	Habitat features and resources for native fauna (such as hollow-bearing trees, hollow logs, nest boxes and bush rocks) impacted by the Proposal will be relocated where feasible and reasonable. Such relocation will be undertaken in a manner to limit damage to existing vegetation and will not occur in high condition remnant vegetation.	Pre-construction and construction	*RTA QA Specification G36 Environmental Protection (Management System).*	Table 5-1 Mitigation Measure FF30 Appendix A
	F5	Native and locally indigenous plants will be used in the landscaping and disturbed areas will be progressively revegetated.	Construction and operation	*RTA QA Specification G36 Environmental Protection (Management System).*	Table 5-1 Mitigation Measure FF10 and FF11

Outcome	Ref #	Commitment	Timing	Reference Document	CFFMP Reference
Minimise adverse impacts on aquatic habitat and fish species.	F6	Watercourse crossings will be designed to facilitate fish passage where appropriate and in consultation with relevant government agencies.	Detailed design Pre-construction	*RTA QA Specification G36 Environmental Protection (Management System).* *Fishnote: Policy and Guidelines for Fish Friendly Waterway Crossings.* *Policy and Guidelines for Design and Construction of Bridges, Roads, Causeways, Culverts and Similar Structures.* *Fish Passage Requirements for Waterway Crossings*	Table 5-1 Mitigation Measure FF31
	F7	Water quality control measures will be installed as early as possible in the construction program and will be designed / selected to meet identified receiving water objectives.	Pre-construction Construction	*RTA QA Specification G36 Environmental Protection (Management System).* *RTA QA Specification G38 Soil and Water Management (Soil and Water Management Plan).*	Table 5-1 Mitigation Measure FF32 Construction Soil and Water Management Plan (Appendix B4 of CEMP)
	F8	A weed management strategy would be developed as part of the construction environmental management plan.	Pre-construction	All relevant RTA policies, specifications, guidance notes and environmental directions.	Table 5-1 Mitigation Measure FF13 Appendix K
Manage impacts on threatened plant species where possible.	F9	Threatened plants in proximity to the Proposal that are to be retained will be identified by pre construction surveys and protected during construction through exclusion fencing and education of construction workers through the site induction process.	Pre-construction	*RTA QA Specification G36 Environmental Protection (Management System).*	Table 5-1 Mitigation Measure FF14
	F10	The feasibility of relocating individuals of threatened species to suitable habitat will be investigated.	Pre-construction	*RTA QA Specification G36 Environmental Protection (Management System).* *Australian Network for Plant*	Table 5-1 Mitigation Measure FF15

Outcome	Ref #	Commitment	Timing	Reference Document	CFFMP Reference
				Conservation 2004 guidelines.	
Minimise impacts on native fauna during construction.	F11	Consideration would be given to constructing artificial frog ponds if appropriate.	Detailed design	*RTA QA Specification G36 Environmental Protection (Management System).*	Appendix D
	F12	A suitably qualified ecologist will undertake preclearance surveys. Searches will include nests and large hollow-bearing trees and target habitats of hollow-dwelling species, koalas and frogs. Fauna species found in pre-clearance surveys will be relocated to suitable habitat as close as possible to the area in which they were found.	Pre-construction	*RTA QA Specification G36 Environmental Protection (Management System).*	Table 5-1 Mitigation Measure FF24 Appendix G
	F13	Where feasible and reasonable, removal of frog habitat along drainage lines will not be undertaken during periods of wet weather.	Construction	*RTA QA Specification G36 Environmental Protection (Management System).*	Table 5-1 Mitigation Measure FF23 Appendix C Appendix D
	F14	The construction contractor will maintain contact details for local DECCW officers, WIRES and/or other relevant local wildlife carer groups.	Pre-construction and construction	*RTA QA Specification G36 Environmental Protection (Management System).*	Table 5-1 Mitigation Measure FF33 Appendix I
	F15	Surveys will be undertaken for threatened bat species by a suitably qualified ecologist to identify any roosting bats prior to the demolition of the existing highway bridges. Any bats will be moved and relocated following consultation with DECCW.	Pre-construction and construction	*RTA QA Specification G36 Environmental Protection (Management System).*	Table 5-1 Mitigation Measure FF20 Appendix E
	F16	Development of a nest box strategy will be undertaken.	Pre-construction	*RTA QA Specification G36 Environmental Protection (Management System).*	Table 5-1 Mitigation Measure FF21 Appendix A
Maintain terrestrial	F17	Culverts and bridges identified in the Environmental Assessment as having a potential role in fauna crossing	Detailed design	*RTA QA Specification G36 Environmental Protection (Management*	Table 5-1 Mitigation Measure FF31

Outcome	Ref #	Commitment	Timing	Reference Document	CFFMP Reference
fauna connectivity.		will be designed to facilitate fauna movements where feasible and reasonable.		*System).* *RTA QA Specification B30 - Clearing, Excavation & Backfill for Bridgeworks.*	Oxley Highway to Kempsey Pacific Highway Kundabung to Kempsey Fauna Connectivity Report (SMEC-Hyder JV)
	F18	The feasibility of widening the median will be further investigated in consultation with DECCW during the detailed design.	Detailed design	*RTA QA Specification G36 Environmental Protection (Management System).*	See Median Widening Assessment (SMEC Hyder JV)
Limit opportunities for animals to access the highway.	F19	Fauna exclusion fencing (eg floppy-top fencing) will be erected along the Proposal at appropriate locations to direct fauna movement towards fauna crossing structures.	Pre-construction	*RTA QA Specification G36 Environmental Protection (Management System).*	Table 5-1 Mitigation Measure FF29 Oxley Highway to Kempsey Pacific Highway Kundabung to Kempsey Fauna Connectivity Report (SMEC-Hyder JV)
Offset the residual impacts of the proposal on key habitat.	F20	An agreement will be developed in negotiation with Department of Planning and in consultation with DECCW for habitat offsets.	Pre-construction and construction	*RTA QA Specification G36 Environmental Protection (Management System).* *RTA Compensatory Habitat Policy and Guideline (draft).*	Biodiversity Offset Strategy (Roads and Maritime 2013)
Determine effectiveness of flora and fauna mitigation measures.	F21	A monitoring program will be developed to allow the effectiveness of mitigation and offset measures to be assessed and allow for their modification if necessary. The program will be for a minimum of 12 months after construction completion.	Pre-construction, construction and operation	*RTA QA Specification G36 Environmental Protection (Management System).*	Table 5-1 Mitigation Measure FF5 Appendix B Ecological Monitoring Program

3.4 EPBC ACT APPROVAL CONDITIONS

The EPBC Act approval conditions relevant to this Plan are listed in Table 3-3 below. A cross reference is also included to indicate where the condition is addressed in this Plan or other Project management documents. Where conditions are not specifically addressed in this Plan, the relevant document is referenced.

Table 3-3 EPBC Act Approval Conditions and Management Measures relevant to this CFFMP

EPBC CoA	Related Table 5-1 ID	Management Measure and/or Evidence of Compliance	Performance Indicator/Target	Timeframe	Responsibility
CoA 2	To assist in mitigating the impacts of the proposal on the Koala, Grey-headed Flying-fox, Spotted-tail Quoll and the Giant-Barred Frog during construction, the person taking the action must prepare and submit a Flora and Fauna Management Plan for each stage of the action, for the Minister's written approval prior to commencement of each stage of the action. The Flora and Fauna Management Plan for each stage must be approved by the Minister in writing prior to commencement of the relevant stage. These plans must include:				
a.	Measures to be implemented to avoid, suppress and control the spread of weeds, plant pathogens and invasive species;				
	FF13	Weeds will be managed in accordance with the Weed and Pathogen Management Plan (Appendix K).	**Performance indicator:** As per Weed and Pathogen Management Plan (Appendix K) **Performance target:** Completion of all mitigation measures outlined in the Weed and Pathogen Management Strategy within the prescribed timeframes.	As per Weed and Pathogen Management Plan (Appendix K).	Environmental Manager
	FF37	Washing procedures will be implemented to ensure that insect pests and their eggs/larvae are not present on equipment. The washing procedure will be undertaken in accordance with the process described in Guide 7 of the Roads and Maritime *Biodiversity Guidelines*.	**Performance indicator:** Washing procedures implemented in accordance with Guide 7 of the Roads and Maritime Biodiversity Guidelines. **Performance target:** All plant and equipment is washed in accordance with Guide 7 of the RMS Biodiversity Guidelines prior	Immediately prior to exiting known areas of pathogens.	Environmental Manager Project Ecologist / suitably qualified expert

			to exiting known areas of pathogens		
	FF38	The spread of bacteria, viruses and diseases such as *Phytophthora cinnamomi*, amphibian chytrid fungus, myrtle rust and beak and feather disease will be addressed using the processes described in Weed and Pathogen Management Plan (Appendix K).	**Performance indicator:** As per Weed and Pathogen Management Plan (Appendix K) **Performance target:** Completion of all mitigation measures outlined in the Weed and Pathogen Management Strategy within the prescribed timeframes.	As per Weed and Pathogen Management Plan (Appendix K).	Environmental Manager
b.	Measures to avoid and minimise other indirect impacts that may result from the proposal during and after construction, including erosion and sedimentation;				
	FF10	Revegetation/rehabilitation of all areas disturbed as part of the Project (that do not form part of permanent pavement or structures) will be undertaken progressively during construction to maintain and enhance key habitat areas in order to minimise the impact on Koala, Grey-headed flying fox, Spotted-tail Quoll and Giant Barred Frogs.	**Performance indicator:** Stabilisation of disturbed areas following completion of the works within that area. **Performance Target:** Stabilisation of all disturbed areas within 14 days of completion of the works within that area.	14 days after the completion of works within an area.	Environmental Manager Construction Manager Project/ Site Engineer
	FF9	Native vegetation cleared from the construction footprint will be mulched and used along with retained topsoil for reuse in rehabilitation works and erosion control, as merchantable timber or for fauna habitat where appropriate.	**Performance indicator:** Use of timber as a result of clearing in rehabilitation works and erosion and sediment control (mulch), as merchantable timber or for fauna habitat, where appropriate. **Performance target:** Mulch is utilised for rehabilitation works in all areas nominated in the landscape plans and for erosion and sediment controls.	Daily (or as required).	Environmental Manager Construction Manager Project/ Site Engineer
	SW10	The development of Environmental Work Method Statements (EWMS) to provide detailed guidance on construction methodologies and will meet the requirements of the specifications and Conditions of Approval. They will detail the controls to be implemented, responsibilities, location, timing and details on how to implement controls.	**Performance indicator:** All works carried out in accordance with approved EWMS. AND All high risk EWMS to be developed in consultation with relevant	Prepared and provided to relevant parties10 days prior to commencement of the activity.	Environmental Manager Environmental Manager

			agencies. **Performance target:** 100% of works carried out in accordance with approved EWMS		
			AND Relevant agencies consulted in the development of all high risk EWMS		
	SW17	Works will be programmed to minimise the extent and duration of disturbance to vegetation. This will include leaving clearing (undertaken by manual means) and initial earthworks in intermittent and permanent watercourses until subsequent works are about to commence.	**Performance indicator:** Vegetation retained in intermittent and permanent water courses until immediately before works are scheduled to commence. **Performance target:** 100% of vegetation is retained in intermittent watercourses until immediately prior to construction in those areas.	Immediately prior to works scheduled to commence. As detailed in location specific Progressive Erosion and Sediment Control Plans (PESCPs).	Superintendent Foreman Environmental Advisor
	SW25	Catch drains, contour and diversion drains across exposed areas will be installed immediately (i.e. within 24 hours and prior to forecast rain events) following clearing, and re-established and maintained during topsoil removal and earthwork operations.	**Performance indicator:** Installation of erosion and sediment controls following clearing. **Performance target:** 100% of the erosion and sediment controls on the ERSED plan installed within 24 hours or prior to forecast rain following clearing	Installed within 24 hours of clearing and prior to forecast rain events.	Superintendent Foreman Environmental Advisor
	SW28	Erosion and sediment control structures will remain installed and maintained until sufficient vegetative cover is achieved. (i.e. 70% cover over 90% of the erodible catchment).	**Performance indicator:** All erosion and sediment controls maintained as 'Blue Book' requirements. **Performance target:** 100% of all erosion and sediment controls maintained to the 'blue book' standard.	Weekly inspection until there is 70% cover over 90% of the erodible catchment.	Superintendent Foreman Environmental Advisor
	SW35	Temporary crossings will: • Be used for the shortest time required to complete their	**Performance indicators:** Temporary creek crossing EWMS	EWMS prepared and provided to relevant	Environment Manager

		designed operational function and affected riparian vegetation will be rehabilitated as soon as possible to existing or better condition. • Use material that will not result in fine sediment material entering the waterway. • Where rock crossings are used, the rock will be of suitable size to prevent/reduce the likelihood of the material being washed away in a storm or flood event, with large sized rock on the lower side of crossings where water velocity increases. • Pipes of sufficient size shall be used to provide fish passage in Class 1,2 and 3 waterways. • Hydrocarbon booms shall be placed downstream of platforms and temporary crossings to intercept oil and grease.	to be developed in consultation with relevant agencies AND Temporary Creek Crossing EWMS meets the requirements of SW 35. **Performance targets:** No temporary creek crossing work to commence until relevant agencies have been consulted in development of the Temporary Creek Crossing EWMS. AND Temporary Creek Crossing EWMS contains and meets all the requirements of SW35	agencies at least 10 days prior to construction of temporary creek crossings commencing.	Temporary Works Manager
	SW36	Scour protection will be installed at the base of permanent and temporary drainage outlets, and will be integrated where feasible into current banks to minimise impacts.	**Performance indicator**: Scour protection installed at the base of permanent and temporary drainage outlets. **Performance target:** All permanent and temporary drainage outlets have scour protection installed at the base	Prior to basin commission.	Foreman Environmental Advisor
	SW37	Drainage works will be stabilised against erosion by appropriate selection of channel dimensions, slope and lining, and the inclusion, if necessary, of drop structures and energy dissipaters.	**Performance indicator:** Stabilisation of drainage works where required, by appropriate means. **Performance target:** Where required, all drainage work is stabilised by appropriate means.	Prior to any rainfall (events exceeding 10mm) event.	Foreman Environment Advisor
	SW38	Culverts and permanent stream protection measures will be installed as early as possible in the construction program to facilitate transverse drainage during the early stages of construction.	**Performance indicator:** Installation of culverts and permanent stream protection measures. **Performance target:**	Prior to clearing within that catchment.	Foreman Environment Advisor

			All culverts and permanent stream protection measures are installed during the early stages of construction.		
	SW50	Sediment basins will be retained for a minimum of six months or until a 70% vegetative cover is achieved in its catchment; other satisfactory controls are in place and approved by the EM or the basin is otherwise redundant.	**Performance indicator:** All erosion and sediment controls maintained as 'Blue Book' requirements. **Performance target:** All erosion and sediment controls maintained to the 'blue book' standard.	Weekly inspection until there is 70% cover over 90% of the erodible catchment.	Environmental Manager
	SW65	Erosion and sediment controls will be inspected at least daily (with maintenance and/or modifications made as necessary). Inspections and/or maintenance during wet-weather maybe increased where necessary.	**Performance indicator:** All erosion and sediment controls maintained as per 'Blue Book' requirements. **Performance target:** All erosion and sediment controls maintained to the 'blue book' standard.	Daily Visual Inspection Weekly Environmental Inspection Post Rainfall Inspection (where required)	Foreman Environmental Advisor
	SW67	Watercourse bed and banks to be monitored weekly and post rainfall during construction for indications of instability. Attention to monitoring for channel erosion will be completed during and following higher than normal flow conditions. Protection measures will be installed should increase intensity or erosion be identified. Where increased intensity of erosion is identified that may have an impact on EPBC species or their habitat, these will be rectified within 5 days. If there is an immediate risk of impact on EPBC Act listed species, temporary rectification works will occur within 1 day.	**Performance indicator:** Monitor instability in watercourse beds and banks. **Performance target:** All watercourse beds and banks inspected every week and after all rainfall, . **Performance indicator:** Rectification of identified increased intensity of erosion within watercourse beds and banks that may impact on EPBC species or their habitat. **Performance target:**	Weekly Environmental Inspection Post Rainfall Inspection (where required) Within 5 days or 1 day of identification depending on the risk.	Foreman Environmental Manager

			All areas of increased intensity of erosion within watercourse beds and banks that may impact on EPBC species or their habitat rectified within 5 days or 1 day (immediate risk).		
c.	Measures to manage aquatic habitat on-site to at least maintain habitat values for the Giant Barred Frog;				
	N/A	Measures to manage aquatic habitat on-site will be implemented as per the Giant Barred Frog Management Strategy (App C). These include: **3.2 Management Strategies** 1. Identification and protection of Giant Barred Frog habitat; 2. Pre-clearing Surveys to be implemented in four stages of: a. Early works when establishing site controls (i.e. clearing limits for clearing and grubbing) including ; b. Pre-clearing survey within 5 days of commencing the clearing and grubbing program; i. All Giant Barred Frogs captured will be relocated to the nearest side of the clearing limit: A permit is not required by NSW authorities for relocation of frogs and tadpoles). c. Clearing supervision during the clearing and grubbing program; and d. De-watering procedures within areas identified as Giant Barred Frog habitat (i.e. creek diversions). The dewatering process will be conducted in accordance with an Environmental Work Method Statement (EWMS) and the DECC (2008) Hygiene protocol for the control of disease in frogs Information Circular Number 6 (DECC 2008). All waterways and dams within those areas identified as Giant Barred Frog habitat will be subject to this dewatering process. Environmental Work Method Statement (EWMS) developed for all dewatering activities incorporating all measures outlined in section 3.2.2 iv of the GBF management strategy. Please note that the EWMS is a construction document and will be developed during construction. These will be developed by the environmental manager in consultation with the environmental review group (NSW EPA,	**Performance indicators:** Identify all known GBF habitat AND Implement frog fencing. AND All pre-clearance surveys undertaken by a suitably qualified ecologist as outlined in the definition provided in the EPBC approval. AND All pre-clearing surveys carried out within 5 days and no greater than 48hrs prior to clearing and grubbing activities within known GBF habitat. AND Project Ecologist / suitably qualified expert supervise clearing and grubbing operations in known areas of GBF habitat. AND Dewatering eWMS developed in consultation with the project ERG AND Implement frog fencing around	5 days prior to clearing in known areas of GBF habitat Within 5 days but no later than 48hrs of commencing clearing and grubbing in known areas of GBF habitat Daily in know areas of GBF habitat. 10 days prior to commencement of de-watering activities in known areas of GBF habitat	Environmental Manager Environmental Advisor Foreman Engineer

		fisheries, RMS and the JV) 3. Frog fencing in areas of Giant Barred Frog habitat considered in the context of: a. Temporary frog fencing; and b. Permanent frog fencing. 4. An unexpected finds procedure to address instances where Giant Barred Frogs are detected during routine pre-clearing surveys or at other times during the project. 5. Suitable land is identified within the Biodiversity Offset Package which contains a population of Giant barred Frogs. Note: The criteria for determining offset / compensatory habitat for the GBF will be contained in the Biodiversity Offset Management Plan and will comply with condition 5.	known areas of GBF habitat AND Implement procedure following positive find of GBF AND Identification of suitable land within the Biodiversity Offset Package which contains a population of GBF's. AND As per GBFMP AND As per the Water Quality Monitoring Plan AND Surveys for GBF and habitat carried out.	5 days prior to working in known areas of GBF habitat Immediately after positive finding GBF Prior to implementation of the Biodiversity Offset Package As per GBFMP As per the Water Quality Monitoring Plan Bi-annually during construction	RMS
		Monitoring of the Management Strategies The monitoring program will be limited to Smiths Creek, Pipers Creek and Maria River. Between 1-2 reference sites will also be incorporated into this monitoring program. Alternative reference sites could include upstream locations where Smiths Creek Road crosses Smiths Creek and Old Coast Road where it crosses Pipers Creek. **Frequency of Surveys** The surveys will be undertaken in spring, summer and autumn following operation of the project, between Year 4 and Year 8 (i.e. 5 years; Table 4-1. Year 4 represents the commencement of operation of either stage of the project – Oxley Highway to Kundabung or Kundabung to Kempsey). A baseline survey will be undertaken prior to construction and consist of one survey in spring, summer and autumn (i.e. three surveys). This approach will provide cues on habitat use within and adjacent to the road corridor leading up to construction and provide the basis for comparing the overall performance of the project. The baseline survey and (survey report) is to be completed prior to the commencement of clearing and grubbing within 500 m of Giant	**Performance target:** 100% of the K2K sensitive area plans identify GBF habitat. AND All areas of known GBF habitat fenced at least 5 days prior to clearing commencing. AND All pre-clearing surveys carried out by a suitably qualified ecologists. AND	5 days prior to clearing in known areas of GBF habitat Within 5 days but no later than 48hrs of commencing clearing and grubbing in	Environmental Manager Environmental Advisor

		Barred Frog habitat identified at Smiths Creek, Pipers Creek and Maria River. Baseline monitoring data for the GBF has been included in the updated Ecological Monitoring Program. Refer to App A of the CEMP for detailed maps of GBF habitat and 'no-go' zones. **Frog and Tadpole Surveys** Frog and Tadpole surveys provide an additional means to assess population structure and as to whether frogs are breeding at the site. The survey procedure is outlined in the GBFMP **Habitat Surveys** Habitat surveys provide an opportunity to measure changes in the receiving environment over the life of the monitoring program. Habitat data would initially be collected each year during the spring sampling period and the need for additional habitat monitoring would be subject to review. A water quality monitoring program is in place. Implementation of the program has commenced and will continue for the duration of construction. This program includes water quality monitoring in GBF habitat, specifically Smiths creek, Pipers Creek and Maria River. During construction, habitat and frog survey data would be collected each year biannually.	All pre-clearing surveys carried out within 5 days and no greater than 48hrs prior to clearing and grubbing activities within known GBF habitat. AND All clearing and grubbing activities within known GBF habitat supervised by suitably qualified ecologist AND No dewatering works to commence until ERG is consulted on the Dewatering EWMS. AND Fencing installed around all known areas of GBF habitat at least 5 days prior to commencing work in GBF habitat. AND All unanticipated discoveries of the GBF immediately follow GBF finds procedure AND Biodiversity Offset strategy contains population of GBF or suitable habitat. AND All mitigation measures carried out as specified in the GBFMP AND All mitigation carried out as specified in the Water Quality	known areas of GBF habitat Daily in know areas of GBF habitat. 10 days prior to commencement of de-watering activities in known areas of GBF habitat 5 days prior to working in known areas of GBF habitat Immediately after positive finding GBF Prior to implementation of the Biodiversity Offset Package As per GBFMP	RMS

			Monitoring Plan AND All surveys for GBF and GBF habitat completed bi-annually during construction.	As per the Water Quality Monitoring Plan Bi-annually during construction	
	FF18	The measures identified in the Giant Barred Frog Management Plan will be implemented and include: Surveys will be undertaken 24 hours in advance of clearing to determine the presence of individuals within localised clearing areas in the form of a clearing survey. Frog fencing will be installed at least 5 days prior to the commencement of clearing in Giant Barred Frog Habitat Areas. Dewatering will be undertaken in accordance with the hygiene protocol described in CoA 2(a).	**Performance indicators:** Surveys of GBF habitat undertaken in advance of clearing AND Frog fencing installed prior to the commencement of clearing in suitable areas. AND Dewatering undertaken in accordance with the hygiene protocol described in CoA 2(a). **Performance targets:** All surveys for GBF are completed prior to clearing GBF habitat AND All frog fencing installed around GBF habitat prior to clearing AND All dewatering of known GBF habitat undertaken in accordance with the hygiene protocol described in CoA 2 (a)	24 hours prior to clearing 5 days prior to the commencement of clearing As required	Environmental Manager Project Ecologist / suitably qualified expert
	FF6, FF34	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). Fencing will be installed 5 days prior to vegetation clearing activities occurring. Riparian and aquatic habitat (including known GBF habitat) will be	**Performance indicators:** The limits of clearing clearly marked on all relevant work plans and protective fencing erected to mark these limits.	5 days prior to vegetation clearing activities occurring	Project / Site Engineers Foreman / Leading Hands

		protected from construction works through the installation of protective fencing prior to works commencing in the vicinity.	AND Installation of protective fencing around riparian and aquatic habitat. **Performance targets:** 100% of relevant work plans contain clearing limits, an protective fencing erected along all limits of clearing at least 5 days prior to clearing commencing in that area. AND All riparian and aquatic protection fencing installed at least 5 days prior to construction works commencing within the vicinity.	5 days prior to vegetation clearing activities occurring near riparian and aquatic habitat	Environmental Manager
	FF23	Removal of frog habitat along drainage lines will not be undertaken during wet weather (i.e. during or within 48 hours of rain events exceeding 10 millimeters).	**Performance indicator:** No removal of frog habitat along drainage lines during 'wet weather'. **Performance target:** All frog habitat removal to be completed during dry weather (i.e. not during or within 48 hrs of rain events exceeding 10 millimeters)	During or within 48 hours of rain events exceeding 10 millimetres.	Foreman/ Leading Hands Environmental Manager Project Ecologist / suitably qualified expert
	FF33	Waterways (including known GBF habitat) will be protected from sediment impacts during construction, in accordance with the mitigation measures listed in the CSWMP and included within this table below (denoted by the 'SW' ID reference). Measures designed specifically to protect aquatic flora and fauna may include: • Installation of in stream sediment curtains • Construction of temporary diversions	**Performance indicator:** If required, installation of in stream sediment curtains AND If required, construction of temporary diversions **Performance targets:** Installation of sediment curtains in all streams where prescribed AND	Any time prior to the commencement of in-stream works Any time prior to the commencement of in-stream works	Environmental Manager Project Soil Conservationist Foreman

			Installation of temporary diversions in all waterways, where prescribed		
	FF35	Existing trees, grasses and ground cover will be retained within 15 meters of watercourses (including known GBF habitat) until immediately before construction commences in that area (i.e. 48 hours). All trees in these areas will be felled manually, leaving grasses and small understory species wherever possible.	**Performance indicator:** Retention of trees, grasses and groundcovers within 15 metres of watercourse **Performance target:** All vegetation within 15 metres of a watercourse retained until immediately prior to construction	At least 48hrs prior to clearing operations within 15 meters of a watercourse	Environmental Advisor Foreman
	SW67	Watercourse bed and banks to be monitored weekly and post rainfall during construction for indications of instability. Attention to monitoring for channel erosion will be completed during and following higher than normal flow conditions. Protection measures will be installed should increase intensity or erosion be identified. Where increased intensity of erosion is identified that may have an impact on EPBC species or their habitat, these will be rectified within 5 days. If there is an immediate risk of impact on EPBC Act listed species, temporary rectification works will occur within 1 day.	**Performance indicators:** Completion of Weekly Environmental Inspection and Post Rainfall Inspection as required and following higher than normal flow conditions. AND Rectification of identified increased intensity of erosion within watercourse beds and banks that may have an impact on EPBC species or their habitat. **Performance targets** Completion of Environmental Inspections every week; and after all rain events, in all areas of work in and adjacent to watercourses AND All areas of increased intensity of erosion within watercourse beds and banks that may impact on EPBC species or their habitat	Weekly Environmental Inspection Post Rainfall Inspection (as required). Within 5 days of identification (within one day when there is an immediate risk).	Environmental Advisor Environmental Advisor / Foreman

			rectified within 5 days or 1 day (immediate risk). .		
d.	A detailed description of the pre-clearance surveys to be undertaken by a suitably qualified expert within all areas proposed for disturbance, including: hollow bearing trees, logs, existing culverts and bridges, no earlier than 48 hours prior to the removal of vegetation occurring in that area to ensure that the area is free of the Koala, Giant-Barred Frog, Grey-headed Flying-fox and Spotted-tail Quoll.				
	FF7	Prior to vegetation clearing, a suitably qualified ecologist will survey all areas to be cleared and will mark out any areas of significant vegetation (EECs, threatened species, riparian vegetation and mangroves) to be fenced and protected, in accordance with the methodology outlined in Section 4.3.1.	**Performance indicators:** Completion of Pre-Construction Surveys. AND Completion of Pre-Clearing Surveys. **Performance targets:** Completion of pre-construction surveys in all areas of clearing 20 days prior to clearing. AND Completion of pre-clearing surveys in all areas of clearing at least 24 hours but no greater than 48 hours prior to clearing.	20 days prior to clearing At least 24 hours but no greater than 48 hrs prior to clearing.	Environmental Manager Project Ecologist / suitably qualified expert
	FF24	A suitably qualified expert will undertake pre-clearance surveys for native fauna immediately prior to clearing activities. Searches will be undertaken on, hollow bearing trees, logs, existing culverts and bridges. Searches will take place no earlier than 48 hours prior to the removal of vegetation occurring in that area to ensure that the area is free of the Koala, Giant-Barred Frog, Grey-headed Flying-fox, Spotted-tail Quoll, Little Eagle and other hollow dwelling species.	**Performance indicator:** Completion of Pre-Clearing Surveys **Performance target:** Completion of pre-clearing surveys in all areas of clearing at least 24 hours but no greater than 48 hours prior to clearing.	At least 24 hours but no greater than 48 hrs prior to clearing.	Environmental Manager Project Ecologist / suitably qualified expert
	FF27	A two-stage clearing process will be implemented in all areas supporting identified fauna habitat such as hollow bearing trees, habitat trees and bushrock. • Non-habitat trees will be removed before habitat trees,	**Performance indicator:** Completion of two-stage clearing in identified fauna habitat.	At least 24 hours but no greater than 48 hrs prior to clearing.	Environmental Manager Project Ecologist / suitably

		allowing fauna an opportunity to move from the habitat trees. • Non-habitat trees will be removed at least 48 hours before habitat trees are removed (unless otherwise agreed by the EPA). • Felled (habitat) trees will be left for a short period of time (i.e. at least one hour except in instances approved by the Project Ecologist / suitably qualified expert) on the ground, to give any fauna remaining in the trees an opportunity to escape before further processing of the trees occurs. The Project Ecologist/ suitably qualified expert or wildlife handler will inspect the felled trees for resident species or injured wildlife. These will then be treated or relocated. Relocated wildlife will be moved the shortest possible distance to improve the likelihood of survival given this area is probably within the animals home range.	**Performance target:** Two-stage clearing conducted in all areas of fauna habitat.		qualified expert
e.	Measures to relocate and/or ensure the appropriate care of individuals of the Koala, Giant-Barred Frog, Grey-headed Flying-fox and Spotted-tail Quoll that are identified during searches referred to in condition 2d; and				
	N/A	Procedures shall be implemented to ensure that fauna identified during pre-clearance surveys are treated and handled in an appropriate manner. These procedures are outlined in Appendix I of this CFFMP, the Fauna Handling and Rescue Procedure.	**Performance indicator:** Implementation of the Fauna Handling and Rescue Procedure (Appendix I of this CFFMP). **Performance target:** Implementation of the Fauna Handling and Rescue Procedure in all cases of identified fauna during pre-clearance surveys.	As required	Environmental Manager Project Ecologist / suitably qualified expert
	FF4	A Project ecologist/ suitably qualified expert specific to the known threatened species found on site will be appointed prior to the commencement of construction.	**Performance indicator:** Presence of project ecologist/ suitably qualified expert during construction activities which have the potential to impact upon known locations of GBF. **Performance target:** Project ecologist/suitably expert present during all construction	Appointment prior to the commencement of construction.	Environmental Manager Project Ecologist/ suitably qualified expert

			activities that have the potential to impact upon known locations of GBF		
	FF26	During the proposed clearing works, the Project Ecologist/ suitably qualified expert or an experienced wildlife handler under the supervision of the Project Ecologist / suitably qualified expert will be present to retrieve and provide appropriate care of any displaced fauna and release the fauna into adjacent habitats safe from construction work.	**Performance indicators:** Implementation of the Fauna Handling and Rescue Procedure (Appendix I). AND Presence of suitably qualified individual during clearing activities. **Performance target:** Implementation of the Fauna Handling and Rescue Procedure in all cases of identified fauna during all clearing works AND Suitably qualified individual present during all clearing activities	At all times during clearing activities.	
	FF28	Contact details for the Project Ecologist / suitably qualified expert, FAWNA, the Port Macquarie Koala Hospital and local veterinary hospitals will be maintained and kept at a convenient location on the Construction Site and must be available to the relevant management and supervisory personnel at all locations where clearing is being undertaken, to enable quick contact in the event of a fauna rescue.	**Performance indicators:** Contact details of details for the Project Ecologist / suitably qualified expert, FAWNA, the Port Macquarie Koala Hospital and local veterinary hospitals placed on notice boards in main office and crib sheds. AND Contact details of details for the Project Ecologist / suitably qualified expert, FAWNA, the Port Macquarie Koala Hospital and local veterinary hospitals incorporated in the Clearing and Grubbing EWMS.	Prior to the commencement of construction. Provided to the relevant parties 10 days prior to clearing.	Environmental Manager

			Performance targets: Contact details for the Project Ecologist / suitably qualified expert, FAWNA, the Port Macquarie Koala Hospital and local veterinary hospitals placed on all notice boards in main office and crib sheds prior to clearing. AND Contact details of details for the Project Ecologist / suitably qualified expert, FAWNA, the Port Macquarie Koala Hospital and local veterinary hospitals incorporated in the Clearing and Grubbing EWMS prior to clearing.		
	FF22	Specific measures identified in the Pre-clearing checklist/Fauna Handling and Rescue Procedure will be followed. Specifically: • Clearing will be conducted in two stages (felling of non-habitat trees followed by habitat trees at least 24 hours later). • Felling of habitat trees within koala habitat will only be undertaken in the presence of a suitably qualified koala spotter.	**Performance indicators:** Clearing conducted in two stages (felling of non-habitat trees followed by habitat trees at least 24 hours later). AND Felling of habitat trees within koala habitat undertaken in the presence of a suitably qualified koala spotter. **Performance targets:** All clearing conducted in 2 stages (felling of non-habitat trees followed by habitat trees at least 24hrs later) AND Presence of a suitably qualified koala spotter present for all felling of habitat trees within koala habitat	All clearing activities.	Site Engineers Foreman Environmental Advisor Project Ecologist / suitably qualified expert
f.	Clear key milestones, monitoring, performance indicators, corrective actions and timeframes for the completion of all actions outlined in the plan.				

		Key milestones, monitoring actions, performance indicators and timeframes are identified in this table relating to Conditions 2.a and 2.e inclusive. All nonconformities identified during surveillance, monitoring, inspections and audits must be closed out and signed off within the timeframe agreed with the Principal, the Project Environmental Representative, and relevant Authorities. Written responses to non-conformities identified must be provided to: • The Principal, the Project Environmental Representative and relevant regulatory Authorities within 5 working days; except • Non-conformities identified in audits where a response must be provided within 7 working days.	**Performance indicators:** Compliance with all mitigation measures (including timeframes) outlined within this table and approved Construction Environmental Management Plan. AND All non-conformities be closed out and signed off within the timeframe agreed with the Principal, the Project Environmental Representative, and relevant Authorities **Performance targets:** Compliance with all mitigation measures outlined within this table (including timeframes) and approved CEMP AND All non-conformities closed out within the timeframe agreed with the Principal, the Project Representative and relevant authorities	As outlined in this table.	Environmental Manager RMS Project Environmental Representative
		For each non-conformance identified, a corrective/preventative action (or actions) must be implemented. In addition, any environmental management improvement opportunities can be initiated because of incidents or emergencies, monitoring and measurement, audit findings or other reviews. Improvement opportunities may also result in the implementation of corrective / preventative actions.	**Performance indicator:** Written responses to non-conformities identified provided to: • The Principal, the Project Environmental Representative and relevant regulatory Authorities; except • Non-conformities identified in audits **Performance target:**	Provided to the Principal within 5 working days Non-conformances identified and recorded in Monthly audits.	

			All identified non-conformities responded to in writing and provided to: • The Principal, the Project Environmental Representative and relevant regulatory Authorities; except • Non-conformities identified in audits		
		Corrective / preventative actions and improvement opportunities will be recorded and managed via the Project Commitments Register, or other suitable designated database. Details entered will include detail of the issue, action required and timing and responsibilities. The record will be updated with date of close out and any necessary notes. The database will be reviewed regularly to ensure actions are closed out as required. Procedures for rectifying any non-compliance identified during environmental auditing, review of compliance or incident management are also documented in the Compliance Tracking Program.	**Performance indicators** Up to date project commitments register, or other suitable designated data base. AND Non-compliances documented in the compliance tracking program. **Performance targets:** Project commitments register, or other suitable designated data base kept up to date at all times. AND All non-conformances documented in the compliance tracking program	Quarterly (otherwise as required).	

4.0 ENVIRONMENTAL ASPECTS AND IMPACTS

The following sections summarise existing flora and fauna within and adjacent to the Project area including species, communities and habitats. Identified impacts are then reviewed. The key reference documents are Chapter 15 of the EA and Volume 2 – Flora and Fauna Working Paper of the EA. The Project boundary and relevant ecological data is shown on the Sensitive Area Plans included in Appendix A6 of the CEMP.

4.1 ENVIRONMENTAL ASPECTS

4.1.1 Endangered Ecological Communities

Three EECs listed under the NSW TSC Act have been identified in the K2K project area and are listed below:

- Subtropical Coastal Floodplain Forest of the NSW North Coast Bioregion.
- Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregion.
- Freshwater Wetlands on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregion.

The location of these EECs in relation to the Project is shown on the Sensitive Area Plans included at Appendix A6 of the CEMP.

No Commonwealth EPBC Act listed EECs were identified in the study area.

4.1.2 Threatened Plant Species

Threatened flora species identified in the EA as having the potential to occur within the Project corridor, and their conservation status, are listed in Table 4-1. No threatened flora species listed under the EPBC Act or TSC Act were recorded in the study area during targeted field investigations conducted in 2005 to 2007. However, subsequent surveys have identified *Maundia triglochinoides* to the east of the project boundary in Barrys Creek (Lewis Ecological Surveys, 2012). According to the survey results, the stand was in a constructed dam and was estimated to cover an area of approximately 10m^2.

Table 4-1 Threatened or otherwise significant plant species

Scientific name	Common name	EPBC Act	TSC Act	Occurrence
Acronychia littoralis	Scented acronychia	Endangered	Endangered	Potential
Arthraxon hispidus	Hairy-joint Grass	Vulnerable	Vulnerable	Potential
Maundia triglochinoides	Maundia	-	Vulnerable	Recorded
Melaleuca biconvexa	Biconvex Paperbark	Vulnerable	Vulnerable	Potential
Parsonsia dorrigoensis	Milky Silkpod	Endangered	Vulnerable	Potential
Phaius australis	Southern Swamp Orchid	Endangered	Endangered	Potential
Phaius tankervilleae	Swamp Orchid	Endangered	Endangered	Potential

The location of threatened flora species in relation to the Project is shown on the Sensitive Area Plans included at Appendix A6 of the CEMP.

4.1.3 Fauna Habitats

Key habitat elements identified within the study area include:

- An array of flowering tree and shrub species within the forest, woodland and heathland communities, providing a constant supply of foraging resources for nectarivorous and insectivorous bird, bat and arboreal mammal species.
- Decorticating bark on paperbark trees, providing potential shelter sites for reptiles and microchiropteran bats.
- Paperbarks (Melaleuca sp.) and Swamp Mahogany within the Paperbark Swamp Forest and Swamp Mahogany / Forest Red Gum Swamp Forest stands, providing important autumn / winter foraging resources for nectar-eating birds, bats and arboreal mammals in the study area, including the threatened Grey-headed Flying Fox (Pteropus poliocephalus).
- Hollow-bearing trees of importance to hollow-dependent fauna species, including eight threatened species recorded in the study area (i.e. Eastern Freetail-bat (Mormopterus norfolkensis), Eastern False Pipistrelle (Falsistrellus tasmaniensis)[possible identification only], Southern Myotis (Myotis macropus), Greater Broad-nosed Bat (Scoteanax ruepellii) [probable identification only], Glossy Black Cockatoo (Calyptorhynchus lathamii), Masked Owl (Tyto novaehollandiae), Sooty Owl (Tyto tenebricosa) and Yellow-bellied Glider (Petaurus australis)).
- Preferred Koala feed trees and associated habitat.
- Known foraging habitat for Glossy Black Cockatoo. Two species of preferred feed trees for this species, Black She-oak (Allocasuarina littoralis) and Forest Oak (Allocasuarina torulosa), occur in the study area and are common within the dry ridgetop forest community.
- Grass and sedge species, and dense groundcover within the Swamp Oak Forest and Paperbark Swamp Forest and Swamp Mahogany/Forest Red Gum Swamp Forest communities provide suitable foraging resources for granivorous and herbivorous fauna and a range of reptiles and frogs.
- Areas of dense groundcover vegetation and soft substrate, providing suitable shelter and foraging habitat for a variety of small terrestrial mammals, including bandicoots and native mice and rats.
- Existing bridges and culverts provide roost sites for microchiropteran bats (Appendix E).
- Artificial and natural water bodies provide foraging and breeding habitat for frogs and waterbirds as well as foraging habitat for the Southern Myotis (Myotis macropus).

The fauna habitats in the Project study area were ranked as high, medium or low based on fauna habitat characteristics and evidence of fauna presence.

4.1.4 Threatened Fauna

Threatened fauna species identified during survey (confirmed) and those which were considered highly likely to occur in the study area are listed in Table 4-2 and Table 4-3:.

Table 4-2: Threatened fauna recorded in the study area during field surveys

Common name	Scientific name	EPBC Act	TSC Act
Black-necked Stork	*Ephippiorhynchus asiaticus*	-	Endangered
Eastern Bentwing-bat	*Miniopterus schreibersii*	-	Vulnerable
Eastern False Pipistrelle	*Falsistrellus tasmaniensis*	-	Vulnerable
Eastern Freetail-bat	*Mormopterus norfolkensis*	-	Vulnerable
Giant Barred Frog (GBF)	*Mixophyes iteratus*	Endangered	Endangered
Glossy Black-Cockatoo	*Calyptorhynchus lathami*	-	Vulnerable
Greater Broad-nosed Bat	*Scoteanax rueppellii*	-	Vulnerable
Green-thighed Frog	*Litoria brevipalmata*	-	Vulnerable

Common name	Scientific name	EPBC Act	TSC Act
Grey-headed Flying-fox	*Pteropus poliocephalus*	Vulnerable	Vulnerable
Koala	*Phascolarctos cinereus*	Vulnerable	Vulnerable
Little Bentwing-bat	*Miniopterus australis*	-	Vulnerable
Little Eagle	*Hieraaetus morphnoides*	-	Vulnerable
Little Lorikeet	*Glossopsitta pusilla*	-	Vulnerable
Masked Owl	*Tyto novaehollandiae*	-	Vulnerable
Osprey	*Pandion haliaetus*	Migratory	Vulnerable
Rose-crowned Fruit-dove	*Ptilinopus regina*	-	Vulnerable
Sooty Owl	*Tyto tenebricosa*	-	Vulnerable
Southern Myotis	*Myotis macropus*	-	Vulnerable
Square-tailed Kite	*Lophoictinia isura*	-	Vulnerable
Stephens' Banded Snake	*Hoplocephalus stephensii*	-	Vulnerable
Varied Sitella	*Daphoenositta chrysoptera*	-	Vulnerable
Yellow-bellied Glider	*Petaurus australis*	-	Vulnerable

Table 4-3: Threatened fauna considered highly likely to occur in the study area

Common name	Scientific name	EPBC Act	TSC Act
Brush-tailed Phascogale	*Phascogale tapoatafa*	-	Vulnerable
Common Planigale	*Planigale maculata*	-	Vulnerable
Powerful Owl	*Ninox strenua*	-	Vulnerable
Spotted Harrier	*Circus assimilis*	-	Vulnerable
Spotted-tailed Quoll	*Dasyurus maculatus*	Vulnerable	Vulnerable
Squirrel Glider	*Petaurus norfolcensis*	-	Vulnerable
Wompoo Fruit-dove	*Ptilinopus magnificus*	-	Vulnerable

4.1.5 Aquatic Fauna

Species recorded in freshwater habitats during investigations for the EA are shown in Table 4-4:.

Table 4-4: Aquatic fauna

Habitat	Species
Freshwater Pipers Creek, Smiths Creek, , Maria River	2550 fish were caught from seven species. The most commonly recorded native fish were three species of Gudgeon: the Striped Gudgeon (*Gobimorphus australis*), Firetail Gudgeon (*Hypseleotris galii*) and the Empire Gudgeon (*Hypseleotris compressa*). No state or nationally threatened species were present. One exotic species, the Mosquito Fish (*Gambusia holbrooki*) was identified; this was the most abundant species caught across all sites.

The fisheries habitat classification for each of the waterways in the K2K Project area is provided in Table 4-5:.

Table 4-5: Fisheries habitat classifications

Waterway	Classification #	Description
Barrys Creek	Class 2 – Moderate Fish Habitat	Named permanent or intermittent stream, creek or waterway with clearly defined bed

Waterway	Classification #	Description
		and banks with semi-permanent to permanent waters in pools or in connected wetland areas. Marine or freshwater aquatic vegetation is present. Known fish habitat and/or fish observed inhabiting the area.
Maria River	Class 2 – Moderate Fish Habitat	
Pipers Creek	Class 2 – Moderate Fish Habitat	
Smiths Creek	Class 2 – Moderate Fish Habitat	
Stumpy Creek	Class 2 – Moderate Fish Habitat	

Classification in accordance with NSW DPI Fisheries Guidelines

4.2 CONSTRUCTION ACTIVITIES

Key aspects of the Project that could result in adverse impacts to terrestrial and aquatic flora and fauna include:

- Clearing of native vegetation, including habitat. The EA and subsequent studies identified clearing of approximately 240 hectares of native vegetation, of which 39 hectares are EEC for the whole Pacific Highway Upgrade – Oxley Highway to Kempsey. The K2K section of the project has been allocated 87.42 hectares of native vegetation clearing. The K2K project has also been allocated 2ha for unforeseen temporary works activities. All project clearing will conform with the requirements of EPBC CoA 1.
- Works around and within watercourses.
- Disturbance of soils, consequential erosion and the mobilisation of sediment.
- Use of chemicals/fuels (potential for spills).

Refer also to the Aspects and Impacts Register included in Appendix A2 of the CEMP.

4.3 ECOLOLGICAL IMPACTS

Likely and potential impacts associated with Project are discussed in Chapter 15 of the EA and include:

- Loss of approximately 87.42 hectares of native vegetation including EECs within the K2K section of the alignment.
- Loss of threatened flora species and their habitat.
- Loss of fauna habitat.
- Potential increase in the incidence of mortality of some native fauna, including threatened species.
- Fragmentation of habitats and wildlife corridors.
- Barrier effects on wildlife and riparian corridors (such as the erosion of genetic stock).
- Edge effects (such as weed invasion, pests and disease).
- Disturbance to aquatic and riparian habitats potentially resulting in contamination and siltation of waterways.
- Cumulative impacts in association with the Pacific Highway Upgrade Program as well as other development projects in the Mid-North Coast region.

Notwithstanding the identified impacts, the mitigation and management measures provided in Table 5-1 aim to minimise the above likely and potential impacts on those threatened ecological communities and species identified in Section 4.1, Table 4-1 and Table 4-2.

In the absence of appropriate mitigation measures, there is the potential for significant impacts on those threatened entities identified as occurring within the Project corridor.

4.4 CLEARING AND GRUBBING

4.4.1 Pre-Construction Surveys

As per CoA B31(b)(i) pre-construction surveys will be undertaken for all areas that are to be cleared during the works, including built structures. These surveys will be undertaken by an ecologist/ suitably qualified expert.

Pre-construction surveys will be undertaken at least 20 days in advance of clearing activities. These surveys will be undertaken by an ecologist/ suitably qualified expert

These surveys will be completed at least 20 working days prior to the commencement of clearing and will be limited to the time required to satisfactorily complete these activities.

Pre-construction surveys will include targeted surveys for those species recorded as present, or have been identified as likely to be affected by native vegetation clearing activities.

The pre-construction survey will include the following:

- A survey for threatened fauna and demarcation of trees containing threatened fauna.
- A survey for threatened flora and demarcation on the ground and on a map.
- At least 7 days prior to the commencement of clearing, demarcation of all hollow bearing trees, potential hollow bearing trees and all other fauna containing habitat trees, including trees with nests, dreys and termitaria likely to be occupied by fauna, (by the Project Ecologist / suitably qualified expert).
- In consultation with EPA, identification of approved location for release of any fauna captured during the survey.
- Recommendations on additional survey requirements.
- A check to ensure exclusion zones have been delineated and any biodiversity assets to be retained are marked.
- A check to ensure temporary fencing is in place on the construction boundary prior to clearing commencing.

The outcome of these surveys will be documented by the Project Ecologist / suitably qualified expert and the Sensitive Area Maps will be updated accordingly.

4.4.2 Pre-Clearing Surveys

Clearing will be undertaken using a ‘two stage clearing process’.

1. **Stage One - Non-habitat Tree Removal**

When vegetation is proposed to be removed that may be habitat for native fauna the area shall be surveyed at least 24 hours and no greater than 48 hours prior to removal to establish if native fauna is present.

The Pre-Clearing Survey will include the following:

- A survey of the site to update information on fauna presence.
- Capture and removal of non-mobile fauna such as snakes and key habitat features such as active bird nests and re-location into pre-determined habitat.
- Translocation of fauna, if necessary.

If fauna is present, all fauna that can be physically captured during targeted works (i.e. active searches) will be relocated into areas of suitable habitat adjacent to the Project site (i.e. adjacent to the clearing footprint).

The species, number, sex, age, class and general health of each individual is to be recorded for later reporting. This procedure is outlined in Appendix I, Fauna Handling and Rescue Procedure.

2. **Stage Two – Habitat Tree Removal**

If the survey indicates that native fauna is present, the individual species habitat tree shall be retained for an additional 48 hours before revisiting the site. If individuals still remain after this time, the habitat may only be cleared in the presence of an appropriately qualified and licensed fauna rescue personnel.

Stage Two, must occur at least 24 hours after Stage One (removal of non-habitat trees), unless otherwise agreed with the EPA.

5.0 ENVIRONMENTAL MITIGATION AND MANAGEMENT MEASURES

5.1 FLORA AND FAUNA MITIGATION AND MANAGEMENT MEASURES

A range of environmental requirements and control measures are identified in the various environmental documents, including the EA, Statement of Commitments, Conditions of Approval, EPBC Act conditions of approval and other Roads and Maritime documents and guidelines.

Specific measures and requirements to address impacts on flora and fauna are outlined in Table 5-1. Some soil and water mitigation and management measures specifically relevant to the protection of flora and fauna have also been reproduced and are denoted by the ID reference "SW". These mitigation and management measures are duplicated in the supporting Construction Soil and Water Management Plan that forms part of the overall environmental management system for the project. Note: any changes made to these mitigation measures need to be updated in the Construction Soil and Water Management Plan to avoid administrative non-compliance.

5.2 BIODIVERSITY OFFSETS

Biodiversity offsets are proposed as required by NSW Minister for the Environment CoA B.8 and B.9. These are documented separately in the Biodiversity Offset Strategy (2013) and the Biodiversity Offset Package and Biodiversity Offset Management Plan (to be prepared by Roads and Maritime).

Table 5-1 Flora and fauna management and mitigation measures

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
GENERAL					
FF1	Training will be provided to all Project personnel, including relevant sub-contractors on flora and fauna requirements from this plan through inductions, toolboxes and targeted training. Flora and fauna training requirements will be as per Section 6.2 of this plan.	Training resources such as threatened species fact sheets.	Pre-construction	Environmental Manager	CoA B.31(b)(iii) SoC G36 Sections 6.9 and 6.10
FF2	Any works required outside the construction footprint verified in accordance with CoA B31(b)(i) will be referred to the Environment Manager for advice on further assessment and approval requirements in accordance with Section 7.2 of this plan and Section 3.7 of the CEMP. All construction activities that require the clearing of native vegetation would comply with the requirements of the Department of the Environment Condition of Approval 1.		Construction – prior to any related works commencing	Project / Site Engineers Environmental Manager	CoA B31(b)(i) G36 Section 6.9 DoTE CoA 12
FF3	In the event that threatened species or EECs are unexpectedly identified during construction the Unexpected Threatened Species /EECs Finds Procedure will be followed.		Construction	Environmental Manager Project Ecologist / suitably qualified expert	CoA B31(b)(viii) Appendix I of this CFFMP
FF4	A Project ecologist/ suitably qualified expert specific to the the known threatened species found on site will be appointed prior to the commencement of construction.		Pre-construction	Environmental Manager	B31(b)(iii)
FF5	All construction requirements of the Ecological Monitoring Program will be implemented.		Construction Operation	Environmental Manager	CoA B10 SoC F21 Appendix B of this CFFMP

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
VEGETATION CLEARING, PROTECTION AND MANAGEMENT					
FF6	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). Fencing will be installed prior to vegetation clearing activities occurring. The limits of clearing will be marked in accordance with Guide 2 of the Roads and Maritime *Biodiversity Guidelines*.	Roads and Maritime *Biodiversity Guidelines* Roads and Maritime *Practice Note: Clearing and Fauna Management – Pacific Highway Projects (May 2012)*	Pre-construction	Project / Site Engineers Foreman / Leading Hands Environmental Manager	EA SoC F2 CoA B31(b)(iii) G36 Section 6.9 G40 Section 2.4 DoTE CoA 2b and 2c
FF7	Prior to vegetation clearing, a suitably qualified ecologist will survey all areas to be cleared and will mark out any areas of significant vegetation (EECs, threatened species, riparian vegetation and mangroves) to be fenced and protected, in accordance with the methodology outlined in Section 4.3.1. Areas of weed infestation will also be identified and documented. These works will be limited to the time required to satisfactorily complete these activities.		Pre-construction	Environmental Manager Project Ecologist / suitably qualified expert	CoA B31(b)(iii) DoTE CoA 2d
FF8	Seed will be collected from areas of remnant native vegetation to be affected by the construction footprint. Seed collection will be undertaken prior to and during clearing and seed will be stored for use in revegetation works where feasible. Where sufficient seed cannot be collected for the alignment, local native seed would be purchased for landscaping. Seed will be stored in a cool, dry, vermin		Pre-construction Construction	Environmental Manager	CoA B31(b)(iii)

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	proof, air conditioned storage area at a temperature suitable to minimize deterioration of the seed.				
FF9	Native vegetation cleared from the construction footprint will be mulched and used along with retained topsoil for reuse in rehabilitation works and erosion control, as merchantable timber or for fauna habitat measures where appropriate, and in consultation with the EPA. Mulch and topsoil will not be stockpiled in 'no-go' areas and cleared vegetation will not be pushed into 'no-go' areas.	*Roads and Maritime Environmental Direction No.25 – Management of Tannins from Vegetation Mulch*	Construction	Project / Site Engineers Foreman / Leading Hands Environmental Manager	EA G40 Section 4
FF10	Revegetation/rehabilitation of all areas disturbed as part of the Project that do not form part of permanent pavement or structures will be undertaken progressively during and following construction to maintain and enhance habitat, particularly in identified regional corridors and key habitat areas. Revegetation/rehabilitation will meet the following milestones: • On slopes 3:1 or flatter where earthworks requiring revegetation have been completed over an area exceeding one hectare, revegetation will be carried out within 14 days. • On slopes steeper than 3:1 where earthworks requiring revegetation have been completed over an area exceeding one hectare, revegetation will be carried out within 7 days. • Open drains will be revegetated within 7 days of excavation.		Construction	Project / Site Engineers Foreman / Leading Hands	EA CoA B31(b)(iii) SoC F5

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	Soil and erosion controls for any area will remain in place for six months or until 70% vegetation cover is achieved within the catchment of the controls. Non-compliance with these milestones would be addressed in accordance with the processes outlined in Section 8.6 of the CEMP.				
FF11	Native and locally indigenous plants are to be used in the landscaping and revegetation areas.		Construction	Project / Site Engineers Foreman / Leading Hands Environmental Manager	EA SoC F5
FF12	Revegetation works will consider planting of preferred food trees for native fauna, including appropriate eucalypt species for the Koala and Yellow-bellied Glider, *Allocasuarina* spp. for the Glossy Black-cockatoo, and winter flowering trees for birds and arboreal mammals where feasible.		Construction	Environmental Manager	EA DoTE CoA 2b
FF13	Weeds will be managed in accordance with the Weed and Pathogen Management Plan.		Construction	Project / Site Engineers Foreman / Leading Hands Environmental Manager	EA G36 Section 6.9 CoA B31(b)(iii) SoC F8 Appendix K of this CFFMP DoTE CoA 2a
THREATENED FLORA					
FF14	Any threatened plants identified within and immediately adjacent to the limits of clearing will be located and tagged. Threatened plants in proximity to the footprint that are to be		Pre-construction	Project Ecologist / suitably qualified expert	EA SoC F9 DoTE CoA 2a

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	retained are to be fenced during construction and identified to construction workers during site induction.				
FF15	If reasonable and feasible, threatened plant species that are to be directly impacted will be translocated to suitable habitat prior to vegetation clearing in consultation with EPA.		Pre-construction	Project Ecologist / suitably qualified expert	SoC F10
~~*FF17*~~	~~*[Contractor to develop mitigation or management measures specific to the management of Maundia triglochinoides. Measures should address at a minimum SoC F2, F8, F10 and CoA B31(b)(i).*~~ ~~*An assessment of potential impact on Maundia triglochinoides has been prepared and should be referred to.]*~~		~~*Pre-construction*~~ ~~*Construction*~~	~~Environmental Manager~~ ~~Project Ecologist~~	~~*[To be developed, consider the following*~~ ~~*SoC F2, F9, F10*~~ ~~*CoA B31(b)(i)]*~~
FF17	*Management of Maundia troglochinoides*				
	Pre-construction surveys will be used to identify the current extent of *Maundia* within and close to the clearing limits. These surveys will be performed by a suitably qualified ecologist.		Pre-construction	*Project Ecologist / suitably qualified expert* Environmental Manager	*CoA B31(b)(i)* *SoC F9*
	Identified populations in proximity to the Proposal will be protected during construction via the use of exclusion fencing and education of construction workers through the site induction process.		Pre-construction and construction	*Project Ecologist / suitably qualified expert* Environmental Manager	*SoC F9*
	The feasibility of relocating individual plants into adjacent suitable habitat will be investigated. **Note**. Fruiting bodies may be		Pre-construction and construction	*Project Ecologist / suitably qualified expert*	*SoC F10*

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	harvested and dispensed into adjacent areas as part of this process.			Environmental Manager	
	The location of known *Maundia* plants along with the limits of clearing and other native vegetation disturbance will be clearly marked on relevant work plans.		Pre-construction and construction	Site Engineer Environmental Manager *Project Ecologist / suitably qualified expert*	*SoC F2*
	New locations considered suitable for ongoing monitoring will be forwarded onto the RMS for adoption into the Ecological Monitoring Program		Pre-construction, construction and post construction	Environmental Manager Project Ecologist / suitably qualified expert	Appendix B Ecological Monitoring Program
THREATENED FAUNA					
FF18	The measures identified in the Giant Barred Frog Management Plan will be implemented.		As specified	Environmental Manager Project Ecologist / suitably qualified expert	CoA B31(b)(v) Appendix C of this CFFMP DoTE CoA 2c
FF19	The measures identified in the Green-thighed Frog Management Plan will be implemented.		As specified	Environmental Manager Project Ecologist / suitably qualified expert	CoA B31(b)(v) SoC F11 Appendix D of this CFFMP
FF20	The measures identified in the Microbat Management Strategy will be implemented.		As specified	Environmental Manager Project Ecologist / suitably qualified expert	CoA B31(b)(vi) SoC F15 Appendix E of this CFFMP
FF21	The Nest Box Plan will be implemented.		Pre-construction	Environmental Manager Project Ecologist / suitably qualified expert	EA CoA B7 SoC F16 Appendix A of this CFFMP

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
WILDLIFE PROTECTION					
FF22	Should clearing activities coincide with the Koala breeding season (September to February), specific measures identified in the Pre-clearing checklist/Fauna Handling and Rescue Procedure will be followed.		Pre-construction Construction	Project / Site Engineers Foreman / Leading Hands Environmental Manager Project Ecologist / suitably qualified expert	EA CoA B31(b)(iii) DoTE CoA 2e CoA B31(b)(iii) Appendix G of this CFFMP Appendix J of this CFFMP
FF23	Removal of frog habitat along drainage lines will not be undertaken during wet weather (i.e. during or within 48 hours of rain events exceeding 10 millimeters).		Pre-construction Construction	Foreman / Leading Hands Environmental Manager Project Ecologist / suitably qualified expert	SoC F13 DoTE CoA 2c
FF24	A suitably qualified expert will undertake preclearance surveys for native fauna immediately prior to clearing activities. Searches will be undertaken on , hollow bearing trees, logs, existing culverts and bridges. Searches will take place no earlier than 48 hours prior to the removal of vegetation occurring in that area to ensure that the area is free of the Koala, Giant-Barred Frog, Grey-headed Flying-fox, Spotted-tail Quoll, Little Eagle and other hollow dwelling species.	*Roads and Maritime Practice Note: Clearing and Fauna Management – Pacific Highway Projects (May 2012)*	Pre-construction Construction	Project Ecologist / suitably qualified expert	EA CoA B31(b)(i) Appendix H of this CFFMP DoTE CoA 2d
~~*FF25*~~	~~*[Contractor to develop mitigation or management measures specific to the management of Little Eagle. Measures should address at a minimum SoC F2, F8, F10 and CoA B31(b)(i). An assessment of potential impact on the Little Eagle has been prepared and should be referred to.]*~~		~~*[To be developed]*~~	~~*[To be developed]*~~	~~*[To be developed, consider the following*~~ ~~*SoC F2, F9, F10*~~ ~~*CoA B31(b)(i)]*~~
FF26	During the proposed clearing works, the Project Ecologist/ suitably qualified expert or		Construction	Foreman / Leading Hands	CoA B31(b)(i) DoTE CoA 2d and

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	an experienced wildlife handler under the supervision of the Project Ecologist / suitably qualified expert will be present to retrieve and provide appropriate care of any displaced fauna and release the fauna into adjacent habitats safe from construction work.			Environmental Manager Project Ecologist / suitably qualified expert	2e
FF27	Clearing will be undertaken in accordance with the process described in Guide 4 of the Roads and Maritime *Biodiversity Guidelines*. A two-stage clearing process will be implemented in all areas supporting identified fauna habitat such as hollow bearing trees, habitat trees and bushrock. • Non-habitat trees will be removed before habitat trees, allowing fauna an opportunity to move from the habitat trees. • Non-habitat trees will be removed at least 48 hours before habitat trees are removed (unless otherwise agreed by the EPA). • Felled (habitat) trees will be left for a short period of time (i.e. at least one hour except in instances approved by the Project Ecologist / suitably qualified expert) on the ground, to give any fauna remaining in the trees an opportunity to escape before further processing of the trees occurs. The Project Ecologist/ suitably qualified expert or wildlife handler will inspect the felled trees for resident species or injured wildlife. These will then be treated or relocated. Relocated wildlife will be moved the shortest possible distance to improve the	Roads and Maritime *Biodiversity Guidelines*. Roads and Maritime *Practice Note: Clearing and Fauna Management – Pacific Highway Projects (May 2012)*	Construction	Foreman / Leading Hands Environmental Manager Project Ecologist / suitably qualified expert	EA CoA B31(b)(iii) DoTE CoA 2d

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	likelihood of survival given this area is probably within the animals home range.				
FF28	Contact details for the Project Ecologist / suitably qualified expert FAWNA, the Port Macquarie Koala Hospital and local veterinary hospitals will be maintained and kept at a convenient location on the Construction Site and must be available to the relevant management and supervisory personnel at all locations where clearing is being undertaken, to enable quick contact in the event of a fauna rescue.		Construction	Foreman / Leading Hands Environmental Manager Project Ecologist / suitably qualified expert	SoC F14 DoTE CoA 2e
FF29	Fauna exclusion fencing (e.g. floppy-top fencing) will be erected along the Project corridor at appropriate locations (as identified in Schedule 3 of the Department of the Environment approval) to direct fauna movement towards fauna-crossing structures. Where fencing is installed after traffic is diverted onto the new Pacific Highway, but prior to construction completion, the fencing would be monitored weekly to check for damage and overhanging vegetation. In the operational phase of the project, fauna fence is routinely inspected as part of general road maintenance asset inspection every three months.		Construction Operation (Roads and Maritime Responsibility)	Project / Site Engineers Foreman / Leading Hands Environment Manager	EA SoC F19 DoTE CoA 3
FAUNA HABITATS AND CONNECTIVITY					
FF30	Habitat features and resources for native fauna (such as hollow logs and bush rocks) will be distributed along the route of the Project where feasible and reasonable. Such relocation will be undertaken so as to limit damage to existing vegetation and would not	Roads and Maritime *Biodiversity Guidelines*.	Construction	Foreman / Leading Hands Environmental Manager	EA SoC F4 DoTE CoA 3

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	occur in good condition remnant vegetation. This measure will be implemented consistent with Guide 5 of the Roads and Maritime *Biodiversity Guidelines*.				
FF31	The fauna connectivity measures confirmed during the detailed design (and outlined in the Department of Environment Condition of Approval 3) would be implemented.	Oxley Highway to Kempsey Pacific Highway Kundabung to Kempsey Fauna Connectivity Report (SMEC-Hyder JV)	Construction	Project / Site Engineers Foreman / Leading Hands Environmental Manager	CoA B1, B2, B3, B4 and B5 DoTE CoA 3
AQUATIC HABITATS					
FF32	Permanent Water quality control measures will be installed as early as possible in the construction program, and at least prior to construction completion. Temporary controls will be installed in accordance with SW25 (pg. 41).		Construction	Project / Site Engineers Foreman / Leading Hands	SoC F7 DoTE CoA 2b
FF33	Waterways (including known GBF habitat) will be protected from sediment impacts during construction, in accordance with the mitigation measures listed in the CSWMP and included within this table below (denoted by the 'SW' ID reference). Measures designed specifically to protect aquatic flora and fauna may include: • Installation of in stream sediment curtains. • Construction of temporary diversions.		Construction	Project / Site Engineers Foreman / Leading Hands Environmental Manager	DoTE CoA 2b
FF34	Riparian and aquatic habitat (including known GBF habitat) will be protected from		Construction	Project / Site Engineers	EA

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	construction works through the installation of protective fencing prior to works commencing in the vicinity. Any retained riparian vegetation impacted by construction would be rehabilitated prior to the completion of construction.			Foreman / Leading Hands Environmental Manager	DoTE CoA 2c
FF35	Existing trees, grasses and ground cover will be retained within 15 meters of watercourses (including known GBF habitat) until immediately before construction commences in that area (i.e. 48 hours). All trees in these areas will be felled manually, leaving grasses and small understory species wherever possible.		Construction	Project / Site Engineers Foreman / Leading Hands Environmental Manager	G40 Section 2.4
FF36	Large woody debris within watercourses will be retained where possible.		Construction	Project / Site Engineers Foreman / Leading Hands Environmental Manager	EA
SW1	*The potential for erosion during the construction of the Project will be appropriately managed in accordance with the measures contained within Managing Urban Stormwater: Soils and Construction Volume 1 (Landcom 2004) and Managing Urban Stormwater: Soils and Construction Volume 2D, Main Road Construction (DECC 2008b).*		*Pre-construction* *Construction*	*Construction Manager/Environment Manager*	*G38* *Good practice* *EA 20.3.4* *CoA C17* *CoA 2b, CoA 2c*
SW10	*The following EWMS will be prepared and implemented to manage soil and water impacts. The EWMS is to provide detailed guidance on construction methodologies, with the input of construction personnel, to meet the requirements of the CFFMP, specifically*		*Pre-construction* *Construction*	*Superintendent/Environment Manager/Foreman*	*G38* *SoC SGW4* *CoA 2b*

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	they detail the controls to be implemented, responsibilities, location and timing and detail on how to implement. *EWMS for activities identified as having high environmental risk will undergo a period of consultation with EPA and DPI Fishing and Aquaculture. Those marked with an asterisk below are those likely to be subject to consultation:* • *Working platforms in or adjacent to waterways*.* • *Temporary waterway crossings.* • *Site compound establishment.* • *Public road accesses and managing mud tracking.* • *Batch plant establishment and operation*.* • *Managing runoff from curing processes.* • *Clearing and grubbing.* • *Sediment basin design, construction and management*.* • *Dewatering*.* • *Piling.* • *Blasting.* *Where in stream works are to take place, specific work method statements will be developed in consultation with relevant government agencies.*				
SW17	*Works will be programmed to minimise the extent and duration of disturbance to vegetation. This will include leaving clearing (undertaken by manual means) and initial earthworks in intermittent and permanent watercourses until subsequent works are*		*Pre-construction* *Construction*	*Superintendent/Foreman*	*G38* *SoC VAD4 and F5* *CoA 2b*

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	about to commence.				
SW25	*Catch drains, contour and diversion drains across exposed areas will be installed immediately (ie within 24 hours and prior to forecast rain events) following clearing, and re-established and maintained during topsoil removal and earthwork operations.*		*Construction*	*Superintendent/Foreman*	*G38* *CoA 2b*
SW28	*Erosion and sediment control structures will remain installed and maintained until sufficient vegetative cover is achieved.*		*Construction*	*Superintendent/Foreman*	*CoA 2c* *Good practice*
SW34	*The EWMS for working platforms in or adjacent to waterways identified in SW10 will detail how the works are to be undertaken to reduce erosion and minimise impacts on water quality and riparian fauna and flora. Considerations will include:* • *Ensuring that where possible earth and/or rock platforms for driving piles are constructed to minimise impacts on the direct water channel.* • *Keeping vegetation clearing to a minimum, ie that necessary to complete the works.* • *Constructing rock platforms for driving piles/girder erection only where necessary.* • *Selecting the optimum rock size for platforms/ haul roads to account for all issues including safety and environment.* • *Using larger rock size and grades on the lower side of the works to assist in reducing failure risks.* • *Addressing stormwater overflow design*		*Pre-construction/construction*	*Environment Manager/Superintendent*	*G36* *Good practice* *SoC SGW4* *CoA 2a and 2c*

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	and pipe capacity. • *Enclosing platforms in geotextile fabric and appropriate erosion and sediment controls before clearance commences.* • *Staging for works will occur as far in advance as possible to ensure that platforms are placed in waterways for the minimum time required to carry out the works.* *The EWMS will be prepared in consultation with EPA and DPI (Fisheries Conservation and Aquaculture).*				
SW35	*Where temporary crossings are required, these will be designed, constructed and maintained in accordance with Managing Urban Stormwater Soils and Construction Volumes 2A and 2D Main Road Construction (DECC 2008) and section 5.3.4 of the guideline Managing Urban Stormwater 4th edition March 2004, Volume 1 Soils and Construction and subject to the preparation of an EWMS identified in SW10 and SW34. Temporary crossings will:* • *Be 'fish friendly' with a lower section of the temporary crossing provided to act as an emergency spillway.* • *Be used for the shortest time required to complete their designed operational function and affected riparian vegetation will be rehabilitated as soon as possible to existing or better condition.* • *Use material that will not result in fine sediment material entering the waterway.*		*Construction*	*Environment Manager/Superintendent/Engineers*	*G36* *CoA B31d (iii)* *SoC F17* *CoA 2b and 2c*

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	• *Where rock crossings are used, the rock will be of suitable size to prevent/reduce the likelihood of the material being washed away in a storm or flood event, with large sized rock on the lower side of crossings where water velocity increases.* • *Pipes of sufficient size shall be used to provide fish passage in Class 1,2 and 3 waterways.* • *Hydrocarbon booms shall be placed downstream of platforms and temporary crossings to intercept oil and grease.*				
SW36	*Scour protection will be installed at the base of permanent and temporary drainage outlets, and will be integrated where feasible into current banks to minimise impacts.*		*Construction*	*Engineers*	*G36* *G38* *CoA B21c* *SoC SGW8* *CoA 2b and 2c*
SW37	*Drainage works will be stabilised against erosion by appropriate selection of channel dimensions, slope and lining, and the inclusion, if necessary, of drop structures and energy dissipaters.*		*Construction*	*Engineers*	*G38* *CoA B21c* *CoA 2b*
SW38	*Culverts and permanent stream protection measures will be installed as early as possible in the construction program to facilitate transverse drainage during the early stages of construction.*		*Construction*	*Superintendent/Foreman*	*G38* *SoC F7* *CoA 2b*
SW45	*A number of temporary sedimentation basins for construction phase, will be converted to provide operational phase water quality management.*		*Construction*	*Engineer*	*EA 6.4.15, 13.4.1* *CoA 2b*

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
SW50	*Sediment basins will be retained for a minimum of six months or until a 70% vegetative cover is achieved in its catchment; other satisfactory controls are in place and approved by the EM or the basin is otherwise redundant.*		*Construction/post construction*	*Construction Manager*	*Good practice* *CoA 2b*
SW65	*Erosion and sediment controls will be inspected at least daily (with maintenance and/or modifications made as necessary). Inspections and/or maintenance during wet-weather maybe increased where necessary.*		*Construction*	*Foreman*	*SoC GS1* *Good practice* *CoA 2b*
SW66	*A Project soil conservation specialist will inspect the work areas, assess drainage and riparian conditions, prepare erosion and sediment control plans and provide advice to the Project team to maintain a high standard of erosion and sediment practices on site. Inspections will be undertaken typically on a fortnightly basis, or as required where high-risk activities are proposed, or where sensitive areas have the potential to be affected eg SEPP 14 wetland, heritage sites.*		*Pre-construction/Construction*	*Soil Conservation Specialist* *Environment Manager*	*Good practice* *SoC GS1* *CoA 2b*
SW67	*Watercourse bed and banks to be monitored weekly and post rainfall during construction for indications of instability. Attention to monitoring for channel erosion will be completed during and following higher than normal flow conditions. Protection measures will be installed should increase intensity or erosion be identified.* *Where increased intensity of erosion is identified that may have an impact on EPBC species or their habitat, these will be rectified*		*Pre-construction/Construction*	*Soil Conservation Specialist* *Environment Manager*	*EA 12.4.4* *CoA B30e(ii)* *CoA 2b*

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	within 5 days. If there is an immediate risk of impact on EPBC Act listed species, temporary rectification works will occur within 1 day.				
PESTS AND DISEASES					
FF37	Washing procedures will be implemented to ensure that insect pests and their eggs/larvae are not present on equipment. The washing procedure will be undertaken in accordance with the process described in Guide 7 of the Roads and Maritime *Biodiversity Guidelines*.	RMS *Biodiversity Guidelines*.	Construction	Project / Site Engineers Foreman / Leading Hands Environmental Manager	EA Appendix K of this CFFMP DoTE CoA 2a
FF38	The spread of bacteria, viruses and diseases such as *Phytophthora cinnamomi*, amphibian chytrid fungus, myrtle rust and beak and feather disease will be addressed using the processes described in Appendix K Weed and Pathogen Management Plan and Guide 7 of the Roads and Maritime *Biodiversity Guidelines*.	Roads and Maritime *Biodiversity Guidelines*.	Construction	Project Engineers Foreman / Leading Hands Environment Manager	EA Coa B31(b)(iii) Appendix K of this CFFMP DoTE CoA 2a

6.0 COMPLIANCE MANAGEMENT

6.1 ROLES AND RESPONSIBILITIES

The Project Team's organisational structure and overall roles and responsibilities are outlined in Section 4.2 of the CEMP. Specific responsibilities for the implementation of environmental (flora/fauna) controls are detailed in Chapter 5 of this Plan.

6.2 TRAINING

All employees, contractors and utility staff working on site will undergo site induction training relating to flora and fauna management issues. The induction training will address elements related to flora and fauna management including:

- Existence and requirements of this sub-plan.
- Relevant legislation.
- The requirements of the Department of the Environment approval and the management measures to be implemented to comply with this approval.
- Specific species likely to be affected by the construction works and how these species can be recognised.
- Mulch stockpile location and management measures.
- Fauna rescue requirements.
- Weed control measures.
- General flora and fauna management measures.
- Specific responsibilities for the protection of flora and fauna.

Further details regarding staff induction and training are outlined in Chapter 5 of the CEMP.

6.3 INSPECTIONS AND MONITORING

Inspections of sensitive areas and activities with the potential to impact flora and fauna will occur for the duration of the project.

Requirements and responsibilities in relation to inspections and monitoring are documented in Sections 8.1 and 8.2 of the CEMP and in the Ecological Monitoring Program (Appendix B of this Plan).

6.4 AUDITING

Audits (both internal and external) will be undertaken to assess the effectiveness of environmental controls, compliance with this sub plan, MCoA and other relevant approvals, licenses and guidelines.

Audit requirements are detailed in Section 8.4 of the CEMP.

Any corrective actions or opportunities for improvement will be dealt with through the process outlined in Section 6.8 of the CEMP.

6.5 REPORTING

Reporting requirements and responsibilities are documented in Section 8.5 of the CEMP.

An Ecological Monitoring Program (as required by CoA B10) will assess and report on the effectiveness of mitigation measures implemented as part of the Project. Details of the Ecological Monitoring Program are included in Appendix B of this Plan.

7.0 REVIEW AND IMPROVEMENT

7.1 CONTINUOUS IMPROVEMENT

Continuous improvement of this plan will be achieved by the ongoing evaluation of environmental management performance against environmental policies, objectives and targets for the purpose of identifying opportunities for improvement. This will be achieved through the process documented in Section 9 of the CEMP.

The continuous improvement process will be designed to:

- Identify areas of opportunity for improvement of environmental management and performance.
- Determine the cause or causes of non-conformances and deficiencies.
- Develop and implement a plan of corrective and preventative action to address any non-conformances and deficiencies.
- Verify the effectiveness of the corrective and preventative actions.
- Document any changes in procedures resulting from process improvement.
- Make comparisons with objectives and targets.

7.2 CFFMP UPDATE AND AMENDMENT

The processes described in Chapter 8 and Chapter 9 of the CEMP may result in the need to update or revise this Plan. This will occur as needed.

Any revisions to the CFFMP will be in accordance with the process outlined in Section 1.6 of the CEMP. Where such revisions do not have an equal or better outcome for Koala, Grey-headed Flying-fox, Spotted-tail Quoll and the Giant-Barred Frog, the plan will be provided to the Minister for the Environment for written approval prior to implementation of those changes.

Any changes to soil and water related mitigation measures will need to be replicated within the Construction Soil and Water Management Plan (QMS# 025-Y008-2602). A copy of the updated plan and changes will be distributed to all relevant stakeholders in accordance with the approved document control procedure – refer to Section 10.2 of the CEMP

APPENDIX A – NEST BOX PLAN OF MANAGEMENT

OXLEY HIGHWAY TO KEMPSEY:

NEST BOX PLAN OF MANAGEMENT

JULY 2013

PREPARED FOR THE SMEC-HYDER JOINT VENTURE BY:

LEWIS ECOLOGICAL SURVEYS

Commercial in Confidence

Disclaimer

....
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(Bachelor Applied Science – Hons)

...30th July 2013.........
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Ben Lewis (Lewis Ecological Surveys) – Field surveys, report author and project management.

George Madani (Lewis Ecological Surveys) – Field surveys.

Photography - Lewis Ecological Surveys © else stated

Top Left – Hollow bearing tree 445, a senescent Tallowwood estimated to contain 43 tree hollows of various sizes and configurations located at the north western extent of Barrys Creek riparian fauna corridor.

Top Right – Feather-tail Glider, a species recorded from the project area and likely to be a common inhabitant of tree hollows.

Bottom Left – Squirrel Glider, a species likely to inhabit parts of the Upgrade corridor and a species that will readily use nest boxes.

Bottom Right – Common Ringtail Possum, a species which is likely to be a common inhabitant of moist gully forest types and will readily utilise nest boxes.

Report to be cited as: Lewis, B.D (2013). Oxley Highway to Kempsey: Nest Box Plan of Management. Report prepared for SMEC-Hyder Joint Venture by Lewis Ecological Surveys. ©

Distribution History

Version	Date	Issued To	Position	Name
A	30th May 2013	Hyder Consulting	Environmental Team Leader	Jane Rodd
A	30th May 2013	Hyder Consulting	Environmental Team Leader	Zoe Wood
A	30th May 2013	Hyder Consulting	Environmental Team Leader	Kate Wiggins
A	30th May 2013	Hyder Consulting	Environmental Team Leader	Kevin Radford
B	9th June 2013	Hyder Consulting	Environmental Team Leader	Jane Rodd
B	9th June 2013	Hyder Consulting	Environmental Team Leader	Zoe Wood
B	9th June 2013	Hyder Consulting	Environmental Team Leader	Kate Wiggins
B	9th June 2013	Hyder Consulting	Environmental Team Leader	Kevin Radford
C	30th July 2013	Hyder Consulting	Environmental Team Leader	Jane Rodd
C	30th July 2013	Hyder Consulting	Environmental Team Leader	Zoe Wood
C	30th July 2013	Hyder Consulting	Environmental Team Leader	Kate Wiggins
C	30th July 2013	Hyder Consulting	Environmental Team Leader	Kevin Radford

Revision History

Rev.	Description	Prepared By	Date	Reviewed By
A	Draft for Comment Version File - 2171213cNestBoxPlanVersA	Ben Lewis ta Lewis Ecological Surveys	7th June 2013	Kate Carroll (SMEC-Hyder JV)
A	Draft for Comment Version File - 2171213cNestBoxPlanVersA	Ben Lewis ta Lewis Ecological Surveys	7th June 2013	Zoe Wood (SMEC-Hyder JV)
B	Final Version File - 2171213cNestBoxPlanVersB	Ben Lewis ta Lewis Ecological Surveys	22nd July 2013	Kate Wiggins (SMEC-Hyder JV)
B	Final Version File - 2171213cNestBoxPlanVersB	Ben Lewis ta Lewis Ecological Surveys	22nd July 2013	Aleesha Darlington (RMS)

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1.0 INTRODUCTION

1.1 Background

Lewis Ecological Surveys (LES) has been contracted by the SMEC-Hyder Joint Venture (SHJV) to prepare a nest box plan as part of the Oxley Highway to Kempsey Pacific Highway Upgrade project. This Nest Box Plan of Management (NBPoM) forms part of the overall management of fauna for the Upgrading of the Pacific Highway to a four lane divided carriageway from the existing Oxley Highway Interchange at Port Macquarie, north to the recently completed section of the Kempsey Bypass, South Kempsey by constructing the Oxley Highway to Kempsey Upgrade (the Project). The primary objective of this plan is to implement nest boxes as a compensatory mechanism for the loss of den, roost and nest resources and thereby satisfying Minister Condition of Approval B7 "*prior to the commencement of any construction work that would result in the disturbance of any native vegetation (or as otherwise agreed to by the Director General), the Proponent shall in consultation with OEH prepare and submit for the approval of the Director General a Nest Box Plan to provide replacement hollows for displaced fauna consistent with the requirements of SoC F15. The plan shall detail the number and type of nest boxes to be installed which must be justified based on the number and type of hollows removed (based on detailed pre-construction surveys), the density of hollows in the area to be cleared and adjacent forest, and the availability of adjacent food resources. The plan shall also provide details of maintenance protocols for the nest boxes installed including responsibilities, timing and duration".*

Among those hollow dependant fauna previously recorded in the Oxley Highway to Kempsey area are a number of threatened species including the Yellow-bellied Glider (*Petaurus australis*), Glossy Black Cockatoo (*Calyptorhynchus lathami*), Masked Owl (*Tyto novaehollandiae*) and microchiropteran bats such as the Greater Broad-nosed Bat (*Scoteanax rueppellii*) and Eastern False Pipistrelle (*Falsistrellus tasmaniensis*). The Environmental Assessment prepared by GHD (2010) highlighted a number of ecological impacts including but not limited to the loss of suitable and/or potential foraging habitat and hollow bearing trees (HBTs) which represent potential den, roost or nest sites for the species above.

1.2 Why Provide Nest Boxes

The removal of HBTs has the potential to impact upon the population processes of a species requiring tree hollows. For example, the removal of hollows can expose individuals to greater levels of predation, reduced reproductive success of that species and can increase inter-specific and intra-specific competition for resources (Carbery 2004). For these reasons, the removal of HBTs is currently listed as a key threatening process (KTP) pursuant to the *Threatened Species Conservation* Act (NSW Scientific Committee 2006). The provision of nest boxes can ameliorate these processes, and is the focus of increased research efforts (*see* review in Goldingay and Stevens 2009). Monitoring of nest boxes has shown the uptake of nest boxes by native fauna may be as high as 75% following their first year of installation (Lewis 2013). In this context they have also been useful in providing breeding resources for threatened fauna including the threatened Brush-tailed Phascogale (Lewis 2013).

The Environmental Assessment prepared for the Oxley Highway to Kempsey Upgrade did not provide numbers of HBTs but relied on broad subjective terms to described tree hollow resources. For example, tree hollows of various sizes were present but not abundant in the drier forest communities. Tree hollows of various sizes were more abundant within the riparian and swamp forest communities, particularly at Ballengarra, Cairncross and Maria River State Forests (GHD 2010). Moreover, no assessment was undertaken on the density of HBTs or the potential occupancy rates of these hollows by native fauna.

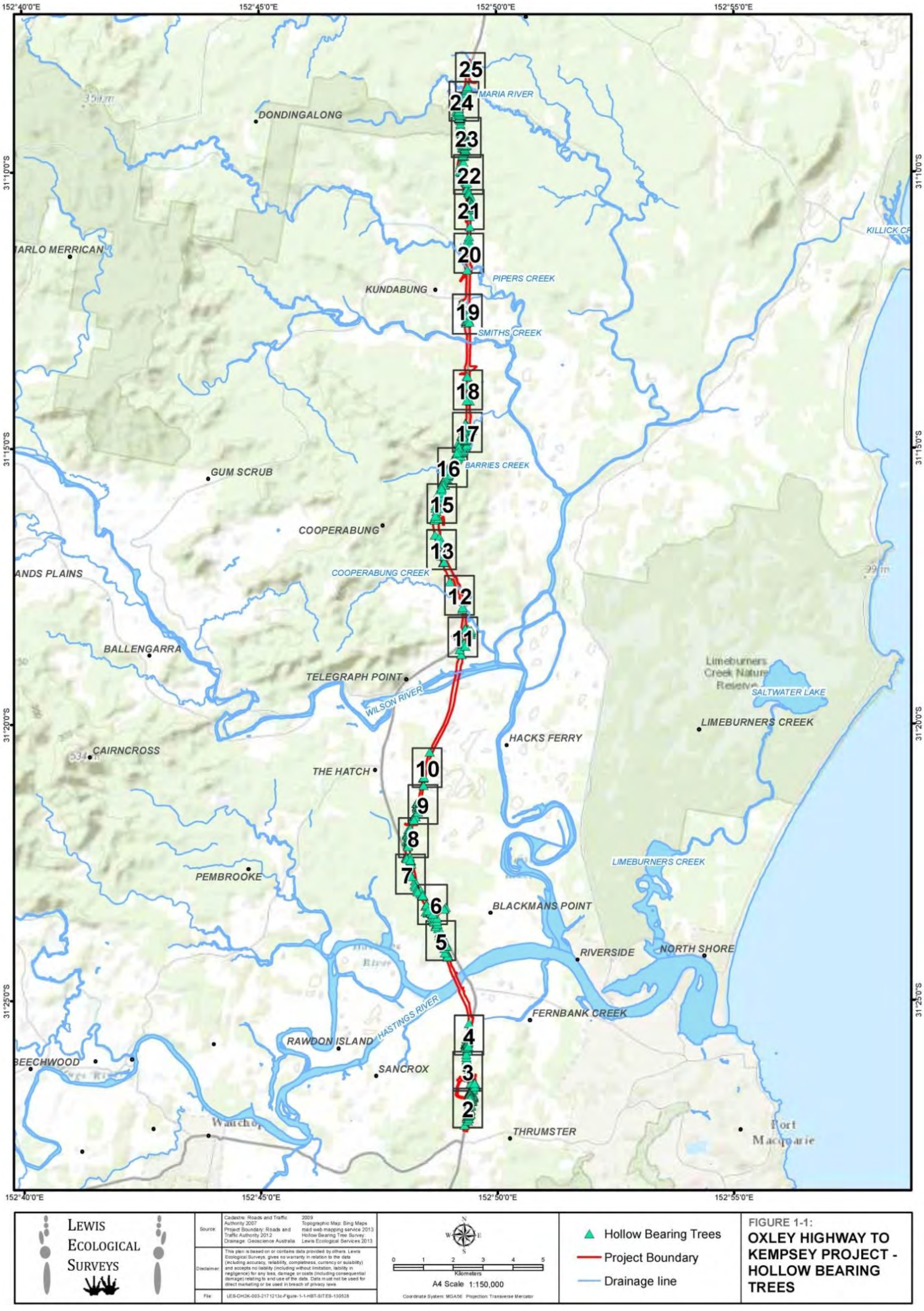

Figure 1-1. Location of project study area and broad distribution of hollow bearing trees.
Note: Numbered insert boxes refer to higher resolution maps in Appendix C and insert box 1 is Figure 1-1.

1.3 Structure of this Plan

This NBPoM identifies the fauna which are likely to utilise tree hollows along the construction/clearing footprint and provides an indication as to the number, type, location, installation heights, aspect and density of nest boxes required to compensate for this whilst addressing the implications of land tenure and maintenance considerations. As part of preparing this plan, a monitoring and maintenance program has also been developed to ensure that nest boxes are functioning appropriately and to assess their effectiveness over the life of this plan (2013-2020). For the purposes of this plan, the term effectiveness refers to whether or not the identified fauna groups outlined in this plan utilise the provided nest boxes. Final concept design and finalisation of detailed design will affect the final project footprint. Any changes to the design affecting impacted areas will need to be assessed and any requirements for further survey will need to be confirmed prior to construction.

2.0 FAUNA SPECIES USING TREE HOLLOWS IN THE LOCALITY

Fifty-one (51) native species of animal that use natural tree hollows for nesting/roosting or as den sites were recorded as part of pre-approval surveys for the Pacific Highway upgrade, notwithstanding a number of other fauna that potentially inhabit the area (GHD 2010). Among those previously recorded fauna were 24 mammals, 27 hollow-dependent birds, five reptiles and five species of hylid frog with nine of these currently listed as threatened fauna pursuant to the NSW *Threatened Species Conservation* Act 1995 (Appendix A). Additional records obtained opportunistically by the author of this plan (BDL) note another five species (i.e. Powerful Owl, Brush-tailed Phascogale, Short-eared Possum, Diamond Python and Graceful Tree Frog) within the project area whilst the undescribed Broad-nosed Bat (*Scotorepens sp.),* Squirrel Glider and Greater Glider almost certainly inhabit parts of the project area. For example, the Squirrel Glider is likely to occur in the northern extent of Cairncross State Forest and immediately east of the proposed widened median area (i.e. ch.11200) whilst further north it is likely to inhabit those areas between Cooperabung Hill and Mingaletta Road. The Greater Glider is likely to occur in the Barrys Creek and Maria River areas where there are sufficient numbers of large tree hollows.

Habitat descriptions including natural tree hollow characteristics for each of these species or species groups is provided in Appendix B.

3.0 DISTRIBUTION, CHARACTERISTICS AND SUITABILITY OF EXISTING TREE HOLLOWS

The use of tree hollows by fauna may depend on a number of factors including hollow characteristics (diameter, height, depth), the number of hollows in a tree, tree health, size, location, density and the resulting thermoregulatory capabilities of the hollows themselves (Gibbons and Lindenmayer 2003). A more detailed discussion of these factors in provided in Section's 4-6 with relevance to the species considered in this plan. This section describes the characteristics of tree hollow resources present within the RMS road corridor during a ground based observation survey between the 20th April 2013 and 20th May 2013. Some additional information has been obtained on the extent of tree hollows in the adjacent landscape, as this information will determine the locations where nest boxes will be installed. These surveys were performed in September 2012 and May 2013.

3.1 Hollow Bearing Trees within the RMS Road Corridor

3.2.1 Distribution

Six hundred and three (603) HBTs[1] providing an estimated 3642 tree hollows have been identified between the Oxley Highway Interchange (south) and Stumpy Creek at South Kempsey (Figure 3-1; Appendix C). Each of these trees have been assigned a designated number for reference (i.e. H01-H628[2]) and marked with pink paint and white flagging tape (Plate 3-1). Apart from the Barrys Creek area (ch. 23000-25300), most of the HBTs tended to occur away from the prominent water courses that flow through the Upgrade. For example, the riparian zones associated with Cooperabung Creek, Smiths Creek, Pipers Creek and Maria River contained large mature eucalypts often dominated by Flooded Gum (*Eucalyptus grandis*). This species of tree tends to only start producing hollows once it reaches an advanced form of senescence which was largely absent from the areas mentioned above. Despite their overall size, the Flooded Gum communities in these areas were still considered relatively young (i.e. <100 years age and often 40-50 years).

In other areas such as Kundabung (i.e. ch. 26000-29000) severe storms in 2010 and 2011 has resulted in a lot of crown damage to some trees but these broken limbs are just that and are not considered likely to start producing hollows in the short or medium term (i.e. 5-15 years).

Plate 3-1. Example of how trees have been marked in the field for identification as hollow bearing trees.

The survey identified a number of areas as containing a high density (>6 hbt/ha) of tree hollow resources. They included:

- 71 HBTs in an areas referred to as Sancrox South (ch.0-2400);
- 34 HBTs in an area largely restricted to the riparian and swamp sclerophyll forest habitats (i.e. EEC) to the south of Fernbank Creek (ch. 3450-4000);
- 11 HBTs clustered in the southern end of Cairncross State Forest (ch. 7400-7600);

[1] Another 32 HBTs were marked in the field with later GIS showing these now occur outside the RMS footprint.
[2] Duplication in numbers between 459-465 in the Ravenswood Road area.

- 12 HBTs to the south of the widened median in Cairncross State Forest (ch. 10100-10350);
- 50 HBTs in the central and northern part of the Cairncross widened median in Cairncross State Forest (ch. 10700-11300);
- 24 HBTs toward the north extent of Cairncross State Forest within an area of Swamp Sclerophyll Forest EEC (ch. 12025-12300);
- 11 HBTs in the upper reaches of Barrys Creek (i.e. 23165-23400);
- 77 HBTs through the middle reaches of Barrys Creek north to Mingaletta which appears to be an important fauna corridor (ch. 24040-25550);
- 19 HBTs in the Kundabung area which provides a localised concentration of tree hollows and probably hollow dependant fauna (ch. 28900-29225);
- 17 HBTs in the southern end of Maria State Forest merging into private lands (ch. 32700-33025);
- 17 HBTs within a drainage line and surrounding lower slopes to the east of Bloodwood Rest Area in Maria River State Forest (ch. 34700-34900); and
- 28 HBTs located on the low ridge and southern slopes to the south of Middle Gate Road in Maria River State Forest (ch. 35035-35300).

Some individual HBTs were seen as locally significant given their characteristics as being senescent trees of more than 200 years in age, the large number of hollows they contained (i.e. >20) and their high likelihood of supporting threatened fauna including large forest owls. Examples included:

- **HBT 154** (Blackmans Point Interchange) which may contain the roost of a large forest owl (i.e. Masked Owl) given the recent signs of discarded prey items, suitability of the tree hollows themselves and the known occurrence of this species using this part of the carriageway;
- **HBT304** (Cooperabung South) which is a senescent Tallowwood estimated to contain 37 tree hollows of various sizes and configurations and contains most of the available tree hollows in this area;
- **HBT373** (Barrys Creek Riparian Corridor) which contains some 38 tree hollows of various sizes and configurations; and
- **HBT445** (Barrys Creek Riparian Corridor) which is a senescent Tallowwood estimated to contain 43 tree hollows of various sizes and configurations.

Other examples have been documented in Section 3.4.

3.2.2 Tree Hollow Characteristics

Of the 3642 identified tree hollows, 654 (18%) were trunk hollows, 2984 (82%) were limb hollows, and four (<1%) were basal trunk hollows (i.e. butt of the tree trunk). The size of each hollow was assigned into three size classes based on their estimated size of their entrance. This approach identified:

- 1768 small hollows (<50 mm);
- 1193 medium hollows (50 – 150 mm);
- 604 large hollows (>150 mm);
- 68 trees had prominent fissures (narrows splits predominantly in tree trunk not the bark of the tree); and
- 4 basal/butt hollows consider likely to be utilised by fauna.

Most of the identified 603 HBTs contained more than one hollow with an average of 6.34 functional hollows per tree (S.D = 5.55). Around 16% of the identified HBTs contained ≥10 tree hollows with up to 43 hollows recorded in a large Tallowwood in the north western part of the Barrys Creek Riparian Corridor (ch. 25325). Sixteen trees were considered significant in the context that they contained more than 20 tree hollows with these being distributed from the Cairncross widened median area north through Cooperabung, Barrys Creek and Kundabung.

3.2.3 Suitability of the Tree Hollow Resources to Fauna

The suitability of each tree hollow to specific fauna groups was assigned primarily on the basis of the entrance size, tree species, status (live, dead), height above the ground and the size of the tree based on an estimated diameter at breast height (DBH). The spatial arrangement of hollows and their location within the landscape was also considered. For example, an isolated paddock tree containing hollows was considered unsuitable for gliders due to the canopy gap being beyond their normal volplane (i.e. gliding) capability. Similarly, a medium to large open hollow in dense vegetation away from water was not considered suitable for hollow nesting ducks (i.e. Maned Duck, *Chenonetta jubata*). The status of hollow using fauna is documented in Appendix A making reference as to whether the species has been previously recorded from or near (i.e. < 1km) the RMS road corridor.

Perusal of Figure 3-2 illustrates:

- Most of the identified habitat trees provide hollows suitable for:
  - Arboreal herpetofauna including *Eulamprus* and *Egernia* skinks, arboreal snakes (i.e. Green Tree Snake) along with most of the hylid tree frogs known from the area, particularly Peron's Tree Frog (*Litoria peronii*), Tyler's Tree Frog (*Litoria tyleri*) and Bleating Tree Frog (*Litoria dentata*).
  - Scansorial mammals such as the Brown Antechinus and threatened Brush-tailed Phascogale (*Phascogale tapoatafa*);
  - Microchiropteran bats;
  - Small gliding marsupials including the Feather-tail Glider (*Acrobates pygmaeus*) and Sugar Glider;
  - Larger Gliders including Greater Glider, Yellow-bellied Glider and Squirrel Glider (*Petaurus norfolcensis*); and
  - Parrots, particularly Scaly-breasted Lorikeet, Rainbow Lorikeet and Eastern Rosella. Also included in this broad group for passerine birds such as the White-throated Treecreeper (*Cormobates leucophaea*).
- Two hundred and seventy-one (271) HBTs provide den resources for possums;
- One hundred and eighty-one (181) HBTs provide suitable retreat and overwintering sites for Lace Monitor;
- Sixty-one (61) HBTs provide suitable nest resources for black cockatoos and Australian King Parrot (*Alisterus scapularis*) which typically utilise a large deep cavity at sufficient heights above the ground;
- One hundred and seventeen (117) HBTs provide potential nest resources for smaller owls such as the Southern Boobook (*Ninox novaehollandiae*) and Barn Owl (*Tyto alba*); and
- Fourteen of the recorded HBTs were considered suitable for large forest owls including Masked Owl (*Tyto novaehollandiae*), Powerful Owl (*Ninox strenua*) and to a limited extent Sooty Owl (*Tyto tenebriscosa*) around the Maria River and Barrys Creek areas and their respective catchments which support more moist forms of sclerophyll forest. The Barking Owl (*Ninox connivens*) was considered as unlikely to inhabit or at least nest in tree hollows found within the RMS footprint.

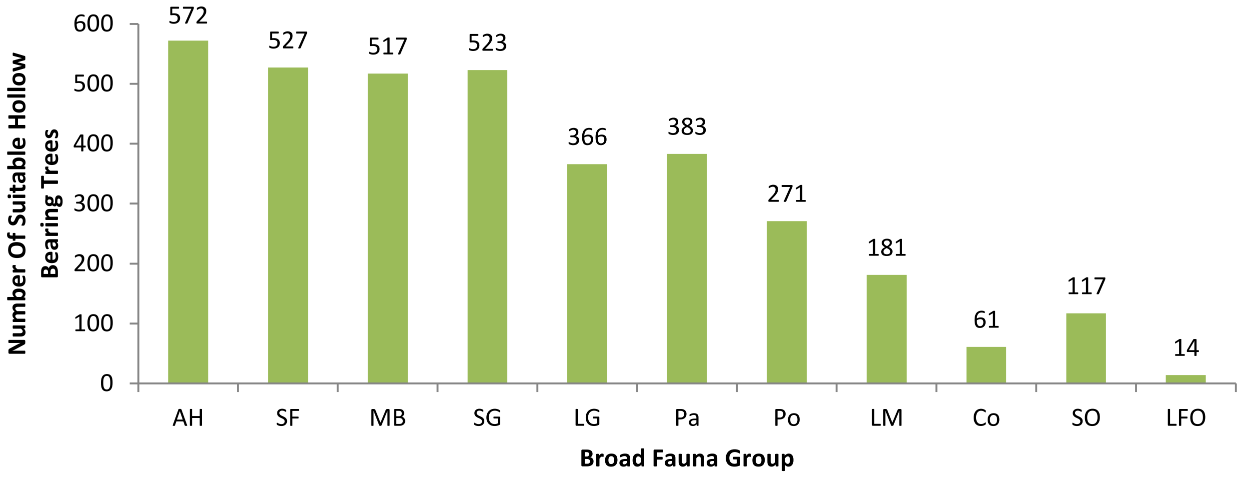

Figure 3-2. Suitability of the identified tree hollows to broad fauna groups from the 603 HBTs identified within the Upgrade corridor.
SF = Scansorial mammals (e.g. Antechinus), MB = Microchiropteran bats, SG = Small gliders (Feather-tail Glider, Sugar Glider), LG = Larger Gliders (Squirrel, Yellow-bellied, Greater), Po = Possums (Common Ring-tail Possum, Common Brushtail Possum and Short-eared Brush-tail Possum), PA = Parrots (i.e. Eastern Rosella, Lorikeets), LP = Large Parrot (i.e. King Parrot), Co = Cockatoos (Sulphur-crested Cockatoo, Yellow-tailed Black Cockatoo, Glossy Black Cockatoo), SO = Smaller Owls (Southern Boobook, Barn Owl), LFO = Large Forest Owl (Powerful Owl, Masked Owl, Sooty Owl), LM = Lace Monitor, AH = Arboreal herpetofauna (*Egernia*, *Eulamprus*, Tree Frogs).

3.2 A Look at Tree Hollow Resources Adjacent to the Clearing Footprint

Field surveys employing 1 hectare quadrats were established at 42 locations immediately adjacent to the road corridor to collect data on the density of HBTs and to estimate the number of functional tree hollows accordingly to the aforementioned size classes (Table 3-1). A range of broad fauna habitats were surveyed including:

- Riparian habitats of Cooperabung Creek, Barrys Creek, Pipers Creek and Maria River;
- Moist Sclerophyll Forests bordering riparian habitats (i.e. Barrys Creek) or within sheltered gullies in Ballengarra State Forest and to a lesser extent Maria River State Forest;
- Swamp Forests on the south eastern side of Sancrox, lands associated with Fernbank Creek and its tributaries. Lands bordering the Cairncross widen median, northern extent of Cairncross State Forest and private lands to the land and gullies and low lying areas in Maria River State Forest; and
- Dry Sclerophyll Forests broadly distributed across the project.

This survey identified most of the forested lands adjacent to the road corridor contain <4 HBTs per hectare. The exceptions were lands adjacent to chainages:

- Eastern side of Sancrox east of the RMS depot at ch. 2350;
- East of the widened median in Cairncross State Forest ch. 11200 and further north at ch. 11700;
- West of the northern extent of Cairncross State Forest ch. 12200 which is likely to support threatened gliders and key foraging resources;
- East and still within the riparian zone of Barrys Creek ch. 24850 and ch. 25300;
- East of southern parts of Maria State Forest at ch. 34200;
- East of Middle Gate Road in Maria River State Forest ch. 35300; and
- North east of Stumpy Creek ch. 38000 (Kempsey South).

These cursory surveys show that clusters of HBTs generally occur in association with forest/habitat types that yield non merchantable timber or are too close to infrastructure and pose a risk during timber harvesting operations. In a number of instances, there is a disproportional density of HBTs within the road corridor when compared to the surrounding environs as these areas have historically been treated as "buffer" zones.
After reviewing the HBT data it was considered necessary to critique other specific tree hollow characteristics in assessing the need for nest boxes within a given area. At those localities where HBTs exceeded 4/ha they were assessed to see whether they contained a:

- High proportional of stags as opposed to senescent trees (i.e. >70%) indicating a reduced life expectancy of hollow resources;
- An adequate amount of tree hollows to accommodate displaced fauna during clearing operations;
- Were in close proximity to specific mitigation devices such as fauna underpasses and vegetated medians adopted for the project; or
- Form part of previously mapped key habitats and corridors linking important coastal lowlands with upland areas (Scotts *et al.* 2000).

With respect to this latter point, the Upgrade passes through nine sub regional and regional corridors identified in the EPA Key Habitats and Corridors Project mapping. These nodal areas provide habitat linkages for a range of lower north coast fauna assigned to the Dry Valleys, Moist Escarpment Foothills, Dry Coastal Foothills and Coastal Complex fauna assemblages. More detailed information can be found within the flora and fauna working paper for the Oxley Highway to Kempsey Environmental Assessment (GHD 2010).

Using the secondary consideration described above it was deemed necessary to provide nest boxes in the vicinity of:

- Within the area defined as the Cairncross Widen Median ch. 11200 given the number of tree hollows that could potentially be removed and the usefulness of this mitigation measure being integrated with the vegetated widened median;
- Northern extent of Cairncross State Forest ch. 12200;
- Barrys Creek around ch. 24850 and ch. 25300 given the habitat connectivity, the riparian nature of the habitats being removed and the extent and types of tree hollows present; and
- Parts of Maria River State Forest (i.e. ch. 35300).

The proposed recipient areas for nest boxes have been presented in Section 6.0 of this plan.

3.3 Opportunities for Retaining Significant Hollow Bearing Trees

Field surveys identified a number of individual HBTs as significant on the basis of the overall number of tree hollows they contained and/or their suitability for particular species such as large forest owls. This section presents those trees and provides some information in relation to opportunities for their retention. They include:

- **HBT 154** (Stag) in the Blackmans Point Interchange may contain the roost of a large forest owl (i.e. Masked Owl) given the recent signs of discarded prey items, suitability of the tree hollows themselves and the known occurrence of this species using this part of the carriageway;
- **HBT 192** (Stag) **HBT196** (Pink Bloodwood) in the proposed Cairncross Widened Median area with each tree providing 26 hollows suitable for a broad range of fauna;
- **HBT 218 (**White Mahogany) also within the Cairncross Widened Median that provides some 30 tree hollows in an area likely to contain the threatened Squirrel Glider;
- **HBT 304** (Cooperabung South) which is a senescent Tallowwood estimated to contain 37 tree hollows of various sizes and configurations and contains most of the available tree hollows in this area (within 0.5 km). This tree occurs within an unformed section of Haydons Wharf Road and does not form part of the main Pacific Highway carriageway;
- **HBT 373** (Stag) and **HBT 402** (White Mahogany) which contains some 38 and 24 tree hollows of various sizes and configurations in the Barrys Creek riparian corridor;
- **HBT445** (Tallowwood) and **HBT 448** (Tallowwood) which contain 23 tree hollows respectively towards the western limit of the RMS project boundary in the Barrys Creek riparian corridor; and
- **HBT 628** (Kundabung) which is a senescent Small-fruited Grey Gum at the edge of the RMS project boundary which doesn't appear to require an extension in this area to accommodate the Upgrade. This tree contains 25 hollows and has the capacity to support those more mobile fauna that could still reside in the area (i.e. Parrots, Possums, small owls, microbats)**.**

All of the quoted HBTs above should be located on the design drawings and relevant environmental constraint maps. The location of HBT154 in relation to the carriageway design will necessitate its removal (*see* Sheet 5 in Appendix C). To reduce impacts to any potential large forest owls using this tree for breeding, additional mitigation strategies are required. They include field surveys that involve stag watching to assess occupancy and breeding activity (i.e. autumn-early winter) of large forest owls with the results of these surveys used to guide additional mitigation options including but not limited to the early installation of large forest owl boxes in areas adjacent to the clearing footprint to promote passive relocation of owls followed by the removal of the tree between September and February (i.e. outside of the breeding season).

The location of HBTs 373, 402, 445 and 448 given the current design will probably necessitate their removal during the construction of the Upgrade. These HBTs should be retained if possible in A-Class construction and alternative mitigation measures should be developed to ameliorate impacts during their removal under future M-Class construction. Examples of alternative mitigation strategies could include additional nest boxes to provide short term resources for the high numbers of displaced fauna expected from these trees combined with a longer waiting period between first (i.e. under scrubbing) and second (felling of habitat trees) stages of clearing.

For HBTs 192, 196 218, 304 and possibly 628 the final design should investigate ways in which these trees can be retained. Beyond this, these areas should be protected from construction related works other than what is considered essential. The locating of access tracks, utilities redistribution, car parking facilities and other ancillary works including topsoil stock piles, lay down areas, wash down bays, site shedding and compound sites should not be located in these areas. This approach will be in accordance with MCoA:

C1. The Proponent shall employ all feasible and reasonable measures to minimise the clearing of native vegetation during the construction of the project

C28 Unless otherwise approved by the Director General in accordance with this condition, the sites for ancillary facilities associated with the construction of the project shall (c) be located in areas of low ecological significance and require minimal clearing of native vegetation (not beyond that already required by the project).

The protection of the identified areas should include the demarcation of clearing limits and signage identifying these areas as 'no go' zones**.**

Table 3-1. Comparison between the numbers of HBTs identified for removal and the extent and characteristics of HBTs in adjacent forested land.
Note – omitted chainages reflect cleared lands or areas where field surveys could not be undertaken (i.e. Nambucca River Floodplain investigation area).
SoC = Side of Carriageway; No. = Number, M = Metres, ha = hectare, S = Small (<50mm), M = Medium (51-150 mm), L = Large (>150 mm), nd = no data, SC = Secondary Consideration as per text on page 7.
* = likely to be an underestimate given tree hollow detection is often difficult and there is likely to be a greater number of hollow bearing trees in the vicinity of ch. 14050

Plot No	Chainage	No HBT Removed from 400 m section of carriageway	SoC	Fauna Habitat	Tree Hollows in Adjacent Forest							Nest Boxes Required	Nest Box Zone (see Table 4-1 for locations)
					No. Stags	No. Senescent Trees	Density ha	Estimated No. Functional Hollows					
								S	M	L	Total		
1	1350	14 east side only	East	Swamp Sclerophyll Forest merging into Dry Sclerophyll Forest	1	2	3	14	9	3	26	Yes	A
2	1350	11 west side only	West	Small area of Swamp Sclerophyll forest merging into Dry Sclerophyll Forest	0	1	1	2	1	0	3	Yes	B
3	2350	12 east side only	East	Dry Sclerophyll Forest	2	3	5	13	8	3	24	No	-
4	3700	15 east side only	East	Swamp Sclerophyll Forest	1	2	3	9	4	1	14	Yes	C
5	3700	12 west side only	West	Predominantly Dry Sclerophyll forest	0	2	2	7	3	0	10	Yes	D
6	4350	1	West	Swamp Sclerophyll Forest	2	2	4	8	2	0	10	No	-
7	6800	7	West	Dry Sclerophyll Forest	1	3	4	11	4	1	16	No	-
8	7500	11	West	Dry Sclerophyll Forest	2	1	3	6	3	0	9	Yes	E
9	8200	14	West	Dry sclerophyll Forest	1	2	3	9	5	1	15	Yes	F
10	9100	10	East	Dry Sclerophyll Forest merging into Swamp Sclerophyll Forest	1	2	3	7	2	2	11	Yes	G
11	10100	7	West	Dry Sclerophyll Forest	0	2	2	5	3	0	8	Yes	H
12	10800	15	West	Dry Sclerophyll Forest	1	1	2	5	2	0	7	Yes	I
13	11200	29	East	Swamp Sclerophyll Forest	2	5	7	18	9	5	32	Yes	I
14	11700	6	East	Swamp Sclerophyll Forest	2	6	8	14	6	6	26	No	-
15	12200	28	West	Swamp Sclerophyll Forest	1	4	5	16	7	2	25	Yes	J
16	12950	4	West	Swamp Sclerophyll Forest	1	9	1	2	1	0	3	Yes	K
17	14050	1*	West	Swamp Sclerophyll Forest	0	0	0	0	0	0	0	Yes	L
18	17700	5	East	Dry Sclerophyll Forest	1	2	3	14	4	2	20	Yes	M
19	18150	10	East	Sub tropical Floodplain Forest	0	2	2	9	5	1	15	Yes	N
20	19000	2	East	Sub tropical Floodplain Forest	2	2	4	7	3	1	11	No	-
21	20700	6	West	Dry Sclerophyll Forest with moist elements	1	1	2	5	1	0	6	Yes	O
22	21000	6	East	Dry Sclerophyll Forest	2	1	3	7	3	1	11	Yes	P
23	21600	1	West	Dry Sclerophyll Forest	1	1	2	6	1	0	7	No	-
24	22100	7	West	Wet Sclerophyll Forest	0	3	3	7	4	2	13	Yes	Q

Plot No	Chainage	No HBT Removed from 400 m section of carriageway	SoC	Fauna Habitat	Tree Hollows in Adjacent Forest							Nest Boxes Required	Nest Box Zone (see Table 4-1 for locations)
					No. Stags	No. Senescent Trees	Density ha	Estimated No. Functional Hollows					
								S	M	L	Total		
25	22800	2	East	Dry Sclerophyll Forest	1	3	4	11	2	4	17	No	-
26	23200	9	West	Dry Sclerophyll Forest	1	1	2	5	2	1	8	Yes	R
27	23800	9	West	Wet Sclerophyll Forest	1	3	4	11	7	3	21	Yes	R
28	24850	15	West	Dry Sclerophyll Forest	3	2	5	13	8	3	24	Yes	S
29	24850	17	East	Wet Sclerophyll Forest	1	2	3	7	6	1	14	Yes	T
30	25300	17	East	Wet Sclerophyll Forest	2	3	5	17	11	4	32	Yes	T
31	25300	9	West	Dry Sclerophyll Forest	1	2	3	11	3	3	17	Yes	U
32	26400	2	West	Dry Sclerophyll Forest	1	1	2	4	1	0	5	No	-
33	29050	18	West	Partly Cleared Dry Sclerophyll Forest	0	2	2	7	2	0	9	Yes	V
34	30700	1	West	Wet Sclerophyll Forest	1	1	2	3	1	0	4	No	-
35	31700	6	West	Dry Sclerophyll Forest	1	2	3	7	4	2	13	Yes	W
36	32900	17	East	Dry Sclerophyll Forest	2	2	4	14	5	5	24	Yes	X
37	34200	9	East	Dry Sclerophyll Forest	3	2	5	11	2	0	13	No	-
38	34800	18	East	Dry Sclerophyll Forest bordering moist forest in drainage line	1	2	3	15	1	1	17	Yes	Y
39	35300	31	East	Dry Sclerophyll Forest	3	2	5	16	8	2	26	Yes	Y
40	36400	10	East	Swamp Sclerophyll Forest	0	3	3	9	3	1	13	Yes	Z
41	36900	5	East	Wet Sclerophyll Forest	0	2	2	6	3	0	9	Yes	AA
42	37800	1	East	Dry Sclerophyll Forest	2	4	6	16	9	5	30	No	-

4.0 NUMBER OF NEST BOXES REQUIRED

This section presents the proposed number of nest boxes required and the types of fauna the nest boxes should accommodate during stage one (ground based tree hollow survey) of a two stage assessment (i.e. recalculation once clearing of detailed design is completed). The final (i.e. second stage) will be an appraisal once the clearing works have been completed and a final tally of the actual numbers of HBTs and tree hollows has been tallied based on the detailed design (numerical data substituted back into the formulas provided below). At this point in time, the nest box plan will be updated to reflect the final number of nest boxes required and re submitted to the EPA for approval.

4.1 The Proposed Number of Nest Boxes Required

A condition for this project's approval was to compensate for the loss of HBTs by using nest boxes, however, it did not provide any scope as to the ratio or what defines when compensation is necessary. In this absence, those areas adjacent to the RMS road corridor that support fewer than 4 HBTs per hectare require nest boxes. Secondary considerations have also resulted in five initially exempt areas (i.e. ch. 11200, ch. 12200, ch. 24850, ch. 25300, ch. 35300) being re classified as areas requiring nest boxes. This approach is consistent with the nest box plan prepared for the Kempsey Bypass project and the Warrell Creek to Urunga Upgrades (Lewis 2010; Lewis 2013b).

At ch. 21600, the loss of a single HBT supporting just three tree hollows was not deemed as requiring a specific compensatory factor given the broader expanse of dry forest found in Ballengarra State Forest. A similar situation also was also found at ch. 26400 and ch. 30700 (Pipers Creek).

In this context, 723 nest boxes of various sizes are required for the Oxley Highway to Kempsey project with:

- 469 nest boxes required for the Oxley highway to Kundabung (ch. 0-24040); and
- 254 nest boxes required for the Kundabung to Kempsey (ch. 24040-37850) Upgrade.

No nest boxes have been proposed as part of the early works for the construction of the Sancrox Interchange although some of the residual vegetated lands may be required to accommodate nest boxes for the southern two nest box zones for the Oxley highway to Kundabung Upgrade.

A two stage formula has been used to derive the number of nest boxes required for each area identified in Table 4-1.

Stage 1:

$$A \times B \times 1.2 = \text{Proposed Number of Nest Boxes Required}$$

Where:

$$\mathbf{A} = \frac{\text{Number of identified HBTs within the clearing footprint of a specified zone}}{\text{Area (ha) of vegetated land identified for removal}} = \text{Density HBT/ha}$$

$$\mathbf{B} = \frac{\text{Total number of tree hollows identified}}{\text{Total number of HBTs within the zone}} = \text{Mean number of functional hollows per HBT}$$

1.2 = 20% error factor built in to accommodate for the difficulties associated with identifying tree hollows in habitat with one or more of the following factors:

- Dense lower or mid stratum;
- Particular tree species (i.e. Broad-leaved Paperbark) that are difficult to accurately critique for tree hollows or the trees themselves have been prone to a lot of termite activity which cannot be fully investigated unless the tree was felled (i.e. White Stringybark around Sancrox and several other locations);
- Adverse weather conditions when surveys had to be completed. For example, more difficult to identify tree hollows on cloudy days as the opportunities to utilise shadowing is not available.

As an example, using this formula at Zone A (eastern side of ch. 1100-1700) can be summarised as follows:

- 3.6 ha has been identified for removal;
- 17 HBTs have been identified within the RMS road corridor; which contain
- 128 functional tree hollows.

Applying the base formula of:
4.72 (A) x 7.53 (B) = 35.54 nest boxes followed by the introduction of the 20% error/compensatory factor: 1.2 x 35.54 = 42.65. This number is then rounded up to the nearest whole number to show 43 nest boxes are required for Zone A. This number is then reviewed in stage 2 and for every cockatoo/owl nest box required within a given zone an additional possum nest box is required to reduce competitive interactions for nesting/denning resources. Four additional possum boxes are required bring this total to 52. Stage 2 below is used to determine the types of nest boxes required.

Stage 2:

Within each zone, the number and specific designs of nest boxes have been tailored to best accommodate for the loss of hollow resources. This has been done on a proportional basis, so if for example 20% of the tree hollows being removed are considered suitable for small gliders, then 20% of the nest boxes should be specifically designed for gliders such as Sugar Glider and Feather-tail Glider. Using the Zone A example again:

- 47 nest boxes are required and these will comprise:
  - 6 microchiropteran bats;
  - 8 scansorial fauna (Antechinus/Phascogale) boxes;
  - 8 small gliders;
  - 5 larger gliders;
  - 7 possums;
  - 5 parrots/lorikeets;
  - 4 cockatoos, larger parrots or small owls with an additional 4 possum boxes to reduce competition.

Some specific fauna groups have been omitted from the nest box schedule given they have generalist habits (i.e. arboreal herpetofauna) which suggest they will utilise most of the current nest box designs or their nesting habits are synonymous with other widely scattered resources found adjacent to the footprint (i.e. termitaria for kingfishers). This approach is also supported following initial monitoring of nest boxes on the Kempsey Bypass project (Lewis 2013a). Moreover, the number of bat nest boxes has been reduced in a number of instances given their highly mobile habits compared to other fauna considered in this plan and the relatively low uptake rates recorded during monitoring for the Kempsey Bypass project (Lewis 2013b). In this context consideration should also be given to amalgamating the numbers of some boxes with those being required for the microbat management strategy developed for this section of the Upgrade (*see* Lewis 2013c). For example, if there are to be bat boxes installed on trees in this zone as a result of offsetting the loss of roost habitats in culverts for bats which also use tree hollows then this should also be considered in the overall tally.

4.2 Type of Nest Boxes to be Supplied

Most of the HBTs identified for removal contain small and medium sized limb and to a lesser extent trunk hollows which are considered suitable for smaller fauna including scansorial marsupials such as *Antechinus*, small gliders including the Feather-tail Glider and Sugar Glider, some larger species of glider (i.e. Squirrel Glider and Yellow-bellied Glider), microchiropteran bats, possums, and smaller hollow dependant birds up to the size of lorikeets and rosella's. It therefore seems appropriate that the nest boxes themselves be designed with these fauna groups in mind. Ultimately, this equates to fewer large nest boxes capable of providing roosting and nesting habitat for cockatoos and owls but they will however, be required for this section of the Upgrade.

Nest boxes considered suitable for the following fauna groups have been proposed:

- Scansorial fauna (*Antechinus*)
- Small gliders (Feather-tail Glider and Sugar Glider);
- Larger gliders (Squirrel Glider, Yellow-bellied Glider, Greater Glider)
- Possums (Common Brushtail Possum, Short-eared Possum and Common Ringtail Possum);

- Microchiropteran bats (fluttering and direct flying species that utilise tree hollows);
- Medium sized parrots/lorikeets;
- Cockatoo (Black Cockatoos);
- Small Owls (Southern Boobook and Barn Owl); and
- Large Forest Owls (Masked Owl, Sooty Owl, Powerful Owl).

No specific nest box designs have been proposed for arboreal herpetofauna given they are considered to have generalist habits and likely to use a number of the designs proposed in this plan. For example, a juvenile python would be capable of using the bat and scansorial fauna nest boxes whilst a larger adult may be more inclined to seek refuge within a possum, cockatoo or small owl nest box.

Microchiropteran bats have been considered here as a single group and include only those species which utilise tree hollows (i.e. cave roosting species such as *Miniopterus spp* not considered). The target species range in size from the small (4 g) Little Forest Bat (*Vespadelus vulturnus*) through to the medium sized bats including the Chocolate Wattled Bat (*Chalinolobus morio*) and Gould's Wattled Bat (*Chalinolobus gouldi*) up to the relatively large Greater Broad-nosed Bat (*Scoteanax rueppellii*) and White-striped Mastiff Bat (*Tadarida australis*) which attain weights of 25-38 g. Whilst these and other species were recorded during the pre-approval field surveys there is no evidence to suggest they actually utilise tree hollows within the clearing footprint which probably forms only a fraction of their home range (*see* Van Dyke and Strahan 2008). Moreover, roost site selection can be highly variable with entrances often larger than what may normally be required. For example, Gould's Wattled Bat is known to use roost sites with entrances of 100 mm whilst Lessor Long-eared Bat (*Nyctophilus geoffroyi*) may also use similarly large roosts as times, even where smaller tree hollows are spatially abundant (Dixon and Lumsden 2008; B. Lewis unpub. data). Given these unknowns and the fact that most of the bats being considered are relatively small (i.e. <20 g; *see* Churchill 2008) they have been considered here as a single group.

When providing nest boxes for microchiropteran bats, an important consideration is the thermoregulatory[3] properties of the nest box as this is thought to be a significant factor in bat roost site selection (Gibbons and Lindenmayer 2002; Lourenco and Palmeirim 2004). Even when the requirements are met for a single species or size guild there may also be seasonal requirements in relation to migratory habits or breeding biology. For example, Bechstein's bats (*Myotis bechsteinii*) in Germany tend to prefer sun-exposed boxes during lactation whereas shaded boxes were preferred pre-lactation (Kerth *et al*. 2001).

Attempting to successfully compensate for the larger more mobile species may also result in a reduction of nest box use or effectiveness of this plan. For example, there is limited evidence to suggest black cockatoos will readily use artificial nest boxes here on in the coastal forest of NSW. Given that both the Yellow-tailed Black Cockatoo and Glossy Black Cockatoo have been recorded in the area on a number of occasions, it is appropriate that an equitable number of nest boxes be constructed for these species. This is partly due to the relatively low number of suitable tree hollows located throughout the adjacent forests, particularly the drier forest assemblages that support merchantable timber in Cairncross State Forest, Ballengarra State Forest and Maria River State Forest and the relatively young age of the forest within some of the recently acquired lands as nature reserves (i.e. Rawdon Creek and Cooperabung Nature Reserves). Whilst herpetofauna have not been specifically accounted for it is expected that at least some of the nest boxes will provide amicable refuge habitat.

In relation to the large forest owls these species typically inhabit tracts of forests in the vicinity of 500-1000 ha so there are a lot of potential nest sites in this area. The surveys in the adjacent forest though suggest there are perhaps a disproportionate number of large senescent trees in close proximity to the existing carriageway and that perhaps some of these may actually form nest sites for this group of fauna. Examples include the southern extent of Cairncross State Forest where a potential nest site for perhaps the Masked Owl was discovered during the course of these field surveys and the frequency of large hollows within parts of the Barrys Creek riparian corridor could be used by Sooty, Masked or Powerful Owls. In any event the number of large forest owl boxes proposed in this nest box management plan relies on ground based observations and this will be updated following the clearing works. At this time there may be an opportunity to amend the number of nest boxes required for these species, should the post clearing survey justify it.

[3] Thermoregulation relates to the ability of an animal to keep its body temperature within certain boundaries, even when the surrounding temperature is very different. This process is one aspect of homeostasis, a dynamic state of stability between an animal's internal environment and its external environment.

Table 4-1. Proposed number of nest boxes for each of the identified nest box zones within the 3 construction project areas.

Note - Flexibility should be permitted to change the placement of nest boxes as currently proposed if landholder agreement is not reached. Contractor's Project Ecologist to perform.

Ha = Hectare, No. = Number, HBT = Hollow Bearing Tree. SoC = Side of Carriageway, RMS = Roads and Maritime Services, SF NSW = State Forests NSW.

Specific Designs: MB = Microchiropteran bats, SF = Scansorial mammals (e.g. Antechinus, Phascogale), SG = Small gliders (Feather-tail Glider, Sugar Glider), Po = Possums (Common Ring-tail Possum, Common Brushtail Possum and Short-eared Brush-tail Possum), P/L = Parrots (i.e. Eastern Rosella, Lorikeets), Co = Cockatoos/Large Parrot (Sulphur-crested Cockatoo, Yellow-tailed Black Cockatoo, Glossy Black Cockatoo, King Parrot), SO = Smaller Owls (Southern Boobook, Barn Owl). C = Cockatoo, S = Small Owls

Add. Poss refers to the number of possum boxes required in the vicinity of Cockatoo/King parrot/Small Owl/Large Forest Owl nest boxes to discourage their uptake of these nest boxes.

* Estimation following review of data from around ch. 14100 where access could not be obtained.

Zone	Chainages	Area removed ha	No. HBT Removed	No. Functional Hollows	No. Nest Boxes required										Position		
						MB	SF	SG	LG	Po	P/L	Co/SO	LFO	Add. Poss	SoC	Tenure	Comment
Sancrox Early Works																	
No required																	
OH2Ku				**Sancrox Early Works**	**0**												
A	1100-1700	3.60	17	128	47	6	8	8	5	7	5	4	0	4	East	Private	Position in association with drainage line running east. Ensure boxes are installed 3 months prior to clearing. If access problems suggest tie in with early works at Sancrox and use northern buffer interface with the RMS depot at ch. 2300.
B	900-1700	3.50	15	121	41	5	9	7	5	6	5	2	0	2	West	Private	Position close to the carriageway on RMS retained land unless an agreement can be reached with neighbouring landholder. An alternative is to install on lands further to the south. If access problems suggest tie in with early works at Sancrox and use northern buffer interface with the RMS depot at ch. 2300 or alternatively liaise with port Macquarie Shire council to install within road reserve of Sancrox Road.
C	3500-4250	3.75	20	96	31	5	4	5	7	5	5	0	0	0	East	Private	Position in Swamp Sclerophyll Forest EEC on RMS land or broker and agreement with landholder to install also in this EEC to the east of ch. 3800
D	3500-4250	2.02	12	69	41	6	8	10	4	6	7	0	0	0	West	Private	Position within the retained vegetated strip of the RMS road corridor or alternatively seek a landholder agreement.
E	7000-8000	9.85	23	102	14	2	2	2	2	2	2	1	0	1	West	Forests NSW	Position close to boundary interface and around western part of ch. 7500
F	8050-8650	13.4	17	81	10	0	2	1	0	2	0	1	2	2	East	Forest NSW	Position east of 8400 and install at least 3 months before clearing and grubbing operations.
G	9000-9600	4.5	13	86	24	4	4	4	4	4	2	1	0	1	East	Forests NSW	Position east of 9150 which ties into the areas requiring conservation for Green-thighed Frog ponds. This also ties in with some important autumn and winter foraging resources for birds and gliders.
H	10000-10800	9.8	16	136	19	1	1	5	5	2	1	2	0	2	Both	RMS + Forests NSW	Position in northern end of section within and in association with key trees identified in the retained vegetated widen median.
I	10800-11450	7.15	43	330	60	5	5	12	15	7	8	4	0	4	Both	RMS + Forests NSW	Position within and adjacent to median ideally around ch.11050-11250. No large forest owl boxes proposed as this will detract from effectiveness of measuring the widen median and its use by arboreal fauna.
J	11650-12350	7.00	35	224	41	4	5	9	10	5	4	2	0	2	Both	RMS + Forests NSW	Position within residual Swamp Sclerophyll Forest and associated low lying drainage areas either within the RMS project boundary or adjacent to it.
K	12550-13150	4.50	4	29	8	2	2	2	0	2	0	0	0	0	West	RMS	Position to the west of ch.13050.
L	13600-14200	2.80	7*	32	14	2	2	5	1	2	2	0	0	0	West	RMS + Private	Install on western side in vicinity of ch.13900-14075.
M	17400-17950	5.50	7	46	11	1	2	2	2	2	0	1	0	1	West	RMS + Private	Install within drainage line and slopes to the north between ch.17700-17800 unless clearing data shows otherwise.
N	18000-18550	5.30	10	96	24	3	4	4	3	4	2	1	1	2	Both	RMS + Port Macquarie Council	Review this data if HBT304 can be retained following the review/design refinement for construction of the unformed section of Haydons Wharf Road. Install required boxes in residual areas of habitat.
O	20550-21200	4.55	7	27	8	1	1	2	2	1	1	0	0	0	West	RMS + OEH Estate	Install within the boundary interface with Cooperabung Nature Reserve and the RMS boundary at 20750.
P	20750-21550	2.95	8	51	22	3	6	4	2	2	3	1	0	1	East	RMS	Install on hill and northern slope of Cooperabung Hill.
Q	22000-22700	8.75	8	44	9	0	2	0	2	1	0	2	0	2	West	RMS + Forests NSW	Install in riparian moist forest to west of ch. 22150. Bat boxes from bat management strategy to be additional items at this location.

Zone	Chainages	Area removed ha	No. HBT Removed	No. Functional Hollows	No. Nest Boxes required										Position		
						MB	SF	SG	LG	Po	P/L	Co/SO	LFO	Add. Poss	SoC	Tenure	Comment
R	23000-24000	4	20	122	45	4	7	4	10	6	6	2	2	4	West	RMS + Forests NSW	Install within moist forest elements retained in the upper Barrys Creek riparian corridor. HBTs with numerous hollows have been identified for retention in this management plan and may change actual number of nest box required.
Ku2K				**OH2Ku Total**	**469**	**54**	**74**	**86**	**79**	**66**	**53**	**24**	**5**	**28**			
S	24100-25100	9.15	29	241	37	2	6	5	7	5	3	3	1	5	West	RMS + Forests NSW	Install in residual habitat or boundary interface with boxes on both north and south facing slopes. Change in the location of north bound rest area would result in fewer boxes required.
T	24600-25450	6.80	34	259	50	6	7	9	9	6	5	2	2	4	East	RMS + Forests NSW	Install along the riparian zone of Barrys Creek. Bat boxes to be installed over water. Cockatoo boxes on the eastern bank away from creek line preferably in ecotonal areas with drier forest.
U	25150-25750	4.80	11	163	46	5	7	8	8	6	4	2	2	4	West	RMS + Forests NSW	Install around RMS boundary at ch. 25300. Install large forest owl boxes in association with other large trees at maximum height possible.
V	28500-29300	7.45	18	121	20	3	5	5	1	3	3	0	0	0	Both	RMS	Both side of highway considered here as most of fauna probably require/occupy this as part of their home range. Install boxes on whichever side is likely to retain the most native vegetation.
W	31300-32250	3.80	9	58	19	3	5	5	0	3	3	0	0	0	Both	RMS	Both side of highway considered here as most of fauna probably require/occupy this as part of their home range. Install boxes on whichever side is likely to retain the most native vegetation.
X	32650-33600	7.60	19	70	15	1	3	3	2	1	1	1	1	2	East	Forests NSW	Install on south western boundary of state forest east of ch. 3000-33150.
Y	34400-35300	9.98	53	164	26	3	3	3	3	3	3	3	1	4	Both	RMS + Forests NSW	Install in two broad areas either side of carriageway. Area one within moist gully forest type and area 2 on south facing slope below Middle Gate Road unless clearing data/fauna rescue suggests otherwise. Sooty Owl recorded using these dry gullies in 2005.
Z	35900-36600	5.60	18	73	17	2	2	4	4	3	2	0	0	0	East	RMS + Forests NSW	Install within residual moist forest along drainage line or alternatively lower reaches which form swamp sclerophyll forest. i.e. ch. 36350-36500.
AA	36700-37000	1.55	7	27	24	4	4	3	4	4	1	1	1	2	East	RMS + Forests NSW	Install on eastern side preferably on south riparian zone area. Install small owl and large forest owl boxes as high as possible with a north easterly aspect facing the Maria River.
				Ku2K Total	**254**	**29**	**42**	**45**	**38**	**34**	**25**	**12**	**8**	**21**			

5.0 DESIGN AND CONSTRUCTION OF NEST BOXES

5.1 Some Design Considerations

The recommended dimensions of nest boxes for fauna known or considered likely to occur in the vicinity of the carriageway has been summarised in Table 5-1. Whilst recognising that different fauna require different nest box dimensions the constructed box should take the following design considerations into account:

- Consideration for the target species or fauna group so that:
    - The entrance hole is no larger than for the intended recipient;
    - The entrance hole is positioned toward the top of the nest box so the area remains dark;
    - Rear entrances may be used for some species, namely gliders and bats to avoid competition from non-target species (see below); and
    - Rough sawn timber to allow animals to grip the exterior of the nest box.
- Should consider the need for anti-competition devices such as:
    - Rear openings for scansorial fauna, bats and gliders to avoid uptake by Common Myna (*Acridotheres tristis*) or common generalist birds such as Rainbow Lorikeets (*Trichoglossus haematodus*);
    - Anti pest devices should be considered. For example, Buffalo Fly ear tags are considered a suitable deterrent for the European Bee (*Apis mellifera*) when positioned close to the nest box entrance.
- Specific furniture needs of the intended recipient fauna such as:
    - Lining the floor with ≥20 mm of non-toxic wood shavings, or in the event they conceal the opening of the nest box, an alternative material such as decayed wood or shredded bark should be selected; and
    - Provision of toe holds to enable young to climb from the nest box.
- A number of weather associated variables including:
    - The use of ≥30 mm thick timber to insulate against heat and cold;
    - All joins and gaps should be sealed with a non-toxic glue;
    - The lid of the nest box should overhang by ≥25 mm like an awning to reduce moisture damage;
    - Small drain holes should be placed in the bottom front section of the nest box; and
    - The exterior should be preferably painted with a dark coloured outdoor water-based acrylic paint or oil, and the internal surfaces left unpainted.
- Whilst considering the above, the thermoregulatory capabilities of the nest box need to be considered, particularly for bats as this is thought to significantly influence roost use (*see* Gibbons and Lindenmayer 2002; Lourenco and Palmeirim 2004). This may be achieved using one or more variables including but not limited to the thickness of the nest box walls, external colour of the box (white versus black or an intermediate colour such as grey) or aspect in its positioning. Whilst this has been the focus of little research effort in Australia several overseas studies support this (*see review in* Goldingay and Stevens 2009). For example, Soprano Pipistrelles (*Pipistrellus pygmaeus*) in Portugal preferred the high temperatures (~40^{o}C) associated with black roost boxes over white or grey coloured boxes (Lourenco and Palmeirim 2004). Seasonally, Bechstein's bats (*Myotis bechsteinii*) in Germany seem to prefer sun-exposed boxes during lactation whereas shaded boxes were preferred pre-lactation (Kerth *et al*. 2001).
- Given that monitoring is often proposed there should be allowances for routine maintenance included in the overall nest box design. For example, a hinged lid to allow visual inspection and maintenance access.
- Where monitoring is proposed, the labelling of the nest boxes should be in such a way so as to easily identify them from other nest boxes. For example, a box number and code for each fauna group be stamped or riveted onto the bottom or side of each nest box to enable easier identification, preferably from the ground.
- There should be no sharp edges such as protruding nails or staples.
- Where nest boxes are being designed specifically for gliders they should have a good landing surface close to the nest box such as a large branch.
- The design of the positioning and fastening mechanism should be sturdy and stable and preferentially with a slight forward lean to assist with drainage whilst allowing for growth in the host tree. It is recommended that bracketing use the Habisure™ system (Hollow Log Homes Pty Ltd) where possible as this has the added advantage of allowing at least one metre growth in the diameter of the host tree before adjustment is required, is non-invasive to the tree and provides the required security (Figure 5-1).

Table 5-1. Summary of specifications for nest boxes targeting specific species or fauna groups (Grant 1997; Franks and Franks 2006; McNabb and Greenwood 2011).

Dimen = Dimension.

1 = Nest boxes are to be installed as close to the canopy as possible, thus in the first instance the upper limit of the height range is to be adopted. The lower limit should only be referred to where a series of constraints are present and be approved by the RMS Project Ecologist or Environment Manager. Note – designs 6 and 7 culminate into the required 25 boxes for cockatoos/owls/larger parrots.

Nest Box Type	Total No Required	Fauna Group	Inner Dimen. (mm)	Depth (mm)	Entrance Width (mm)	Height Above Ground[1] (m)	Comments
1	116	Scansorial mammals (i.e. Antechinus, Brush-tailed Phascogale)	180 x 180	300	35 – 40	5-8	Timber should be at 30 mm thick for insulation. Choose a tree with no side branches for predator avoidance. Flap of carpet over the entrance to prevent a draft. Drill 5 mm drainage holes at the base of the box.
2	83	Microchiropteran bats (fluttering and direct flying species)	200 x 200	400	10 – 30	5-8	Wedge shaped design reduces build up of guano. Entrance should be a slit at the bottom of the box and heavily grooved to promote grip. Note - **Boxes used in the microbat management strategy should form part of the overall number required for the OH2K project.**
3	131	Small Gliders (i.e. Sugar Glider)	200 x 200	300	40-45	5-8	Recent research would suggest 5 m is sufficient positioning height (R. Goldingay pers. comm.).
4	117	Larger Gliders (i.e. Yellow-bellied Glider)	250 x 300	400	70-90	8-10	Use rear entry design to reduce uptake by possum and other non-specific fauna.
5	100	Possums (Brush-tails)	250 x 300	400	85-100	5-8	A ladder of wire mesh or cut steps on the inside will allow the young to climb out.
6	18	Small Owls (Boobook Owl, Barn Owl)	250 x 300	500	100	8-10	Make spout entrance short and horizontal.
7	18	Black Cockatoos/Large Parrots (King Parrot)	300 x 400	1200	200	8-10	A large piece of timber should be attached to the lid for chewing. Layer of sawdust will attract cockatoos and 5mm drainage holes should be placed in base of box. Angled spout entrance. PVC design can also be used.
8	78	Medium-sized Parrots (Lorikeets/Rosellas)	200 x 200	400	65	5-8	Layer of sawdust will attract parrots such as Rosellas. Place 5 mm drainage holes in the base of the box.
9	13	Large forest owls	550 x 550	800	200	12-20	May have to be custom built and installed using an elevated work platform (EWP) or specialist tree climbers.

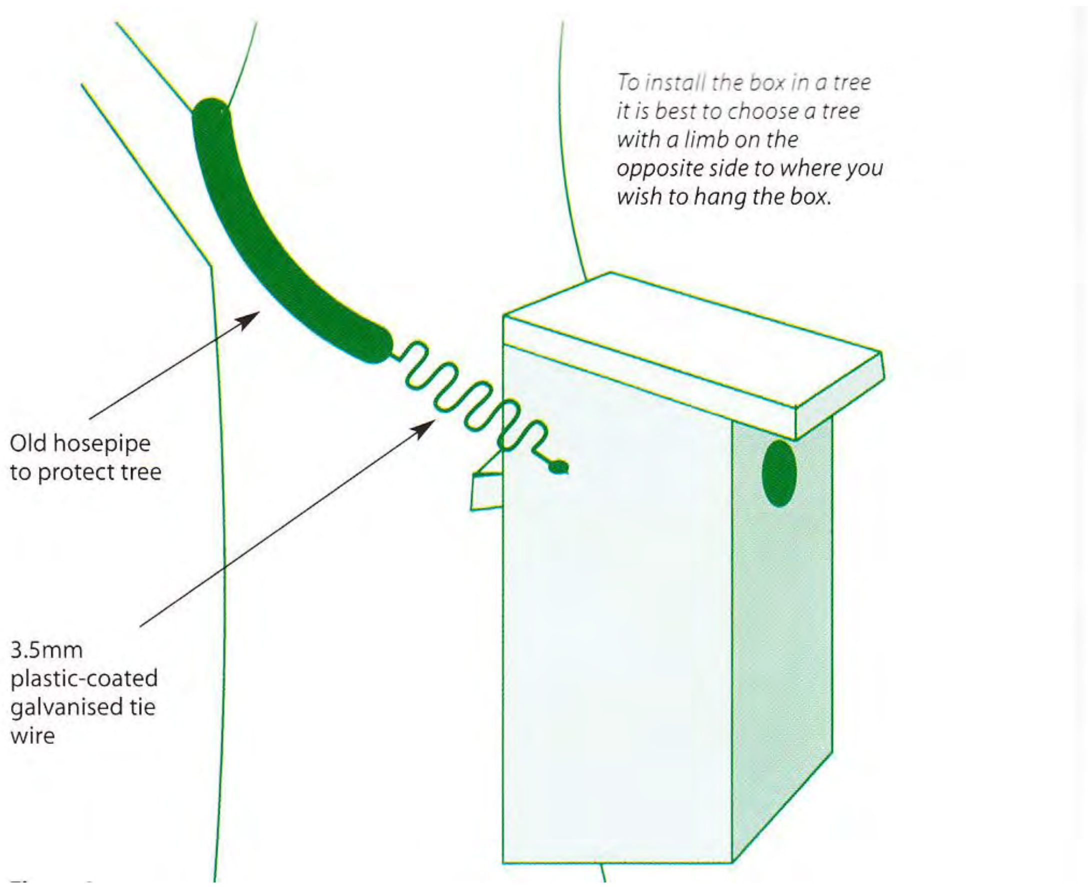

Figure 5-1. Diagrammatic sketch of the Habisure system. Courtesy of Alan and Stacey Franks (Hollow Log Homes ©)

5.2 Dealing with Non Target or Pest Species

A number of pest species both native and exotic are relevant to this plan and are known to utilise both natural hollows and nest boxes. The most relevant ones to this plan are:

- European Bee;
- Exotic birds including Common Myna and Common Starling (*Sturnus vulgaris*); and
- Termites and ants.

These species may construct hives or nests in boxes that exclude the target groups of hollow-dependant fauna. Termites can similarly invade nest boxes and eventually consume them, whilst ants although not known to prevent nest box use, can cause maintenance problems. Natural hollows frequently used by exotic birds can out-compete native species for nesting resources. The introduction of nest boxes may further facilitate habitat availability for exotic birds resulting in an increase of the local population and in some instances may contribute to key threatening processes pursuant to the *TSC* Act. For example, inadvertently providing habitat for European Bees. Therefore, a number of recommendations have been suggested to eliminate pest species from nest boxes including the use of:

- Rear openings for glider and bat boxes to reduce uptake by non-target species;
- Replacement of a perch with a router-grooved ladder. Nest boxes without a visible entrance hole are less likely to be used by birds (Birds Australia 2001);
- Pest strips or Buffalo Fly ear tags attached and passed into the nest box on a long pole when a colony of ants, termites or honeybees are inactive so as to destroy established colonies; and
- Talcum powder, Coupex ® and other domestic agents can be applied to the entrance of a nest box to deter ants.

It is recommended these later strategies form part of the monitoring and maintenance schedule.

6.0 DISTRIBUTION AND POSITION OF NEST BOXES

This section extends on from the discussion in Section 3.0 which set out to determine broad areas where nest boxes were required. The selected location and positioning of nest boxes is a fundamental component of this plan given that it will ultimately determine the effectiveness of this as a mitigation tool. The use of nest boxes may also be affected by the availability of tree hollows in the surrounding area which varies in this context from 0- 8 HBTs per hectare in the measured 1 ha quadrats and estimates of 4-8 HBTs per hectare in the swamp sclerophyll forests which border parts of the widened median in Cairncross State Forest (*see* Table 3-1).

As a general rule nest boxes should be installed on large (>400 mm dbh), mature trees close to or on the main trunk. Taking this into account the proposed locations shown in Table 4-1 have also considered:

- The number of tree hollows identified for removal in that part of the construction corridor;
- The residual number of tree hollows on those lands adjacent to the clearing footprint;
- The suitability of those tree hollows to fauna adjacent to the clearing footprint;
- Availability and suitability of other key life cycle components such as foraging resources for displaced fauna including but not limited to autumn-winter flowering Swamp Mahogany (*Eucalyptus robusta*) and Broad-leaved Paperbark (*Melaleuca quinquenervia*), late winter-spring spring flowering Forest Red Gum (*Eucalyptus tereticornis*) or the presence of *Allocasuarina spp* in the case of the Glossy Black Cockatoo;
- Habitat connectivity in the context to those areas identified for removal and the intended recipient fauna; and
- Other fauna mitigation devices and their locations along the carriageway. For example, fauna underpasses and vegetated medians.

Preference has also been given to:

- Areas that contained mixed aged stands of trees, some of which have started to produce tree hollows albeit in low densities or are likely to in the short-medium term (20-40 yrs); and
- Where preferably within RMS's managed road reserve or have been endorsed by landholders during initial consultations.

In addition to those points raised above, the behavioural ecology of the target species must also be considered along with site specifics including aspect, positioning height above the ground, installation techniques and the spatial arrangement or density of nest boxes. This latter point is required to meet the territorial needs of some species that will vigorously defend a territory, attacking individuals of the same species, and occasionally destroying rival nests. Others species are more gregarious, tolerating overlapping home ranges. Therefore an understanding on the individual territorial requirements of a species' can be used as a guide to the density of nest boxes within any given area. Lindenmayer *et al.* (2003) suggested there is a spatial trend in the occupancy pattern of nest box use where nest boxes used for arboreal marsupials placed in a clump of four had greater occupancy rates over time. This would suggest the occupancy of nest boxes by fauna would depend on the density of other roosting/nesting habitat resources within the localised area. Tables 4-1 and 6-1 have been used as a guide in selecting the location and density of nest boxes within the nominated areas.

The position of the nest box on the host tree has also been considered in the context of predominant weather patterns, along with light and noise disturbances arising from the carriageway. It is proposed that nest boxes be installed with their entrances facing away from the lights of traffic and from a north west to south east position on the tree trunk to provide additional shelter from rain and wind (i.e. dominant rainfall from the south west). If this is not always possible, an alternative, particularly for glider nest boxes is to have the entrance facing into the tree. This would necessitate a maintained gap between the nest box entrance and the tree of around 100 mm.

Another important consideration is the height at which nest boxes are placed in the host tree. It has often been recommended that nest boxes be placed as high as possible to protect the occupants from predation and low enough to allow monitoring and maintenance. After considering the preferred height of nest box placement for each of the fauna groups it is recommended that nest boxes be positioned at heights of 5-8 m and possibly a little higher for specific fauna such as black cockatoos (8-10 m) and higher again for the large forest owl nest boxes. In this later instance it may be preferential to install boxes as high as possible as this group of fauna tend to select hollows found in larger and taller trees. The recommended height has taken into account the surrounding structure of the vegetation where the overstorey ranges from 11-18 m in the Swamp Forest communities to more than 25 m in the taller sclerophyll forest found around throughout the state forests. After considering the heights proposed for the installation of the nest boxes a suitable extension ladder with the necessary safety equipment and training would be sufficient to install and subsequently monitor them or alternatively a portable Elevated Work Platform (EWP). In the cases of the large forest owl nest boxes it may be necessary to have them installed by specialist tree climbers.

Table 6-1. Breeding territory and distance required between nest boxes for native fauna that utilise tree hollows and were either recorded, or considered likely to occur along the carriageway.

Bold type denotes vulnerable fauna pursuant to the NSW *TSC* Act. NS = No nest boxes supplied for these species.

Common Name	Scientific Name	Territorial at any stage of life-cycle? (y/n)	Breeding territory (ha) or distance between nests (m)	Distance between nest boxes (m)	Nest Box Type (see Table 5-1)
Birds					
Australian Wood Duck	*Chenonetta jubata*	Y[1]	unknown[1]	-	NS
Grey Teal	*Anas gracilis*	Y[1]	1 pair per 0.25 ha[1]	-	NS
Chestnut Teal	*Anas castanea*	Y[1]	unknown[1]	-	NS
Glossy Black Cockatoo	***Calyptorhynchus lathami***	**N[2]**	**-**	**-**	**7**
Yellow-tailed Black Cockatoo	*Calyptorhynchus funereus*	N[2]	-	-	7
Galah	*Cacatua roseicapilla*	N[2]	-	-	6
Long-billed Corella	*Cacatua tenuirostris*	N[2]	5 nests per tree[2]	2-3 m	NS
Sulphur-crested Cockatoo	*Cacatua galerita*	N[2]	-	-	7
Rainbow Lorikeet	*Trichoglossus haematodus*	N[2]	Several pairs in same tree[2]	2-3 m	8
Scaly-breasted Lorikeet	*Trichoglossus chlorolepidotus*	N[2]	Several pairs in same tree[2]	2-3 m	8
Musk Lorikeet	*Glossopsitta concinna*	N[2]	Several pairs in same tree[2]	2-3 m	8
Little Lorikeet	***Glossopsitta pusilla***	**N[2]**	**Several multiple species in same tree[2]**	**2-3 m**	**NS**
Australian King Parrot	*Alisterus scapularis*	Y[2]	100 m[2]	100 m	7
Eastern Rosella	*Platycercus eximius*	Y[2]	90 m[2]	90 m	8
Powerful Owl	***Ninox strenua***	**Y[2]**	**300-1500 ha[2]**	**3.8 km**	**9**
Sooty Owl	***Tyto tenebricosa***	**Y[2]**	**200-800 ha[2]**	**2.5 km**	**9**
Masked Owl	***Tyto novaehollandiae***	**Y[2]**	**200-800 ha[2]**	**2.5 km**	**9**
Southern Boobook	*Ninox novaeseelandiae*	Y[2]	37 ha[2]	600 m	6
Barn Owl	*Tyto alba*	Y[2]	300 m[2]	300 m	6
Australian Owlet-Nightjar	*Aegothesles cristatus*	Y[2]	<80 ha[2]	750-900 m	8
Laughing Kookaburra	*Dacelo novaeguineae*	Y[2]	25 ha[2]	500 m	NS
Sacred kingfisher	*Todiramphus sanctus*	Y[2]	4 ha[3]	200 m	NS
Dollarbird	*Eurystomus orientalis*	Y[2]	14 ha[3]	300 m	NS
White-throated Treecreeper	*Cormobates leucophaeus*	Y[3]	3-7 ha[3]	170-250 m	NS
Striated Pardalote	*Pardolotus striatus*	Y[3] immediate area	Pairs up to 100's pairs	2 m	NS
Starling [I]	*Sturnus vulgaris* [I]	Y[4]	2.3 territories/ha	100 m	NS
Common Myna [I]	*Acridotheres tristis* [I]	Y[4]	0.8-2.0 ha	125 m	NS
Reptiles					
Southern Leaf-tailed Gecko	*Phyllurus platurus*	N[5]	-	-	NS
Tree Skink	*Egernia mcpheei*				NS
Lace Monitor	*Varanus varius*	Unknown[5]	-	-	NS
Diamond Python	*Morelia spilota spilota*	Unknown[5]	-	-	NS
Carpet Python	*Morelia spilota*	Unknown[5]	-	-	NS

Common Name	Scientific Name	Territorial at any stage of life-cycle? (y/n)	Breeding territory (ha) or distance between nests (m)	Distance between nest boxes (m)	Nest Box Type (see Table 5-1)
Frogs					
Bleating Tree Frog	*Litoria dentata*	N[6]	-	-	NS
Perons Tree Frog	*Litoria peronii*	N[6]	-	-	NS
Tyler's Tree Frog	*Litoria tyleri*	N[6]	-	-	NS
Mammals					
Brown Antechinus	*Antechinus stuartii*	N[7]	1-2 ha[8]	-	1
Brush-tailed Phascogale	***Phascogale tapofata***	**Y[8]**	**5-60 ha[8]**	**-**	**1**
Mountain Brushtail Possum	*Trichosurus caninus*	Y[8]	0.2-4 ha[8]	100 m	5
Common Brushtail Possum	*Trichosurus vulpecular*	Y[8]	0.2-4 ha[8]	100 m	5
Feather-tail Glider	*Acrobates pygmaeus*	N[9]	0.15-2.1 ha[10]	~2-4[9]	1/2
Sugar Glider	*Petaurus breviceps*	Unknown[11]	0.89-1.54 ha[11]	100-125 m	3
Squirrel Glider	***Petaurus norfolcensis***	**Y[11]**	**3-15 ha**	**125 m**	**3/4**
Yellow-bellied Glider	***Petaurus australis***	**Y[17]**	**30-60 ha**	**125 m**	**4**
Greater Glider	*Petauroides volans*	Y[14]	2-20 ha	125 m	4
Common Ringtail Possum	*Pseudocheirus peregrinus*	Unknown[8]	-	-	5
White-striped Mastiff Bat	*Tadarida australis*	N[15]	-	-	2
Eastern Free-tail Bat	***Mormopterus norfolkensis***	**N[15]**	**-**	**-**	**2**
Gould's Wattled Bat	*Chalinolobus gouldi*	N[15]	-	-	2
Chocolate Wattled Bat	*Chalinolobus morio*	N[15]	-	-	2
Eastern Forest Bat	*Vespadelus pumilus*	N[15]	-	-	2
Little Forest Bat	*Vespadelus vulturnus*	N[15]	-	-	2
Southern Forest Bat	*Vespadelus regulus*	N[15]	-	-	2
Greater Broad-nosed Bat	***Scoteanax rueppellii***	**Y[16]**	**Regional if maternity site**	**-**	**2**
Eastern Broad-nosed Bat	*Scotorepens orion*	N[15]	-	-	2
Lesser Long-eared Bat	*Nyctophilus geoffroyi*	N[15]	-	-	2
Gould's Long-eared Bat	*Nyctophilus gouldi*	N[15]	-	-	2

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7.0 NEST BOX MANAGEMENT

The management of nest boxes forms part of the overall management of fauna for the Upgrading of the Pacific Highway from just north of the Oxley Highway Interchange at Port Macquarie north to Stumpy Creek, South Kempsey.

7.1 When will the Nest Boxes be Installed?

The contractor will install 60% of the nominated nest boxes prior to or during the clearing works with the objective of providing temporal refuge habitat for those hollow dependent fauna displaced during clearing operations. The installation location of these boxes within each of the nominated zones will be in accordance with Table 4-1 and will be installed by the contractors Project Ecologist. The remaining 40% of nest boxes will be installed by the contractor once a final tally of functional tree hollows has been compiled and reviewed as a result of the data collected during the clearing supervision. Occupancy rates of tree hollows during the clearing supervision will also facilitate the final number and types of nest boxes being installed. Ultimately, the Project Ecologist will be responsible for determining these values as they will be performing the clearing supervision.

7.2 Monitoring and Maintenance

Roads and Maritime Services have committed to developing a suitable monitoring and maintenance strategy to evaluate the effectiveness of the nest boxes with this summarised in Table 7-1. As such, it will be important to assign each nest box a number and ensure its location is recorded using a GPS. It is proposed that summer and winter monitoring would take place shortly after the installation period (i.e. Year 3 and 4 of this plan) and this would continue in Year 6 and Year 8. The maintenance program will align with this monitoring program after which a pre-handover maintenance inspection will be undertaken at Year 8 (Table 7-1).

During each monitoring event, the following information should be collected for each nest box using a field proforma:

- Inspection dates, weather conditions (i.e. rain, wind, cloud cover, ambient temperature) and time each box was inspected;
- Nest box number;
- Is the nest box currently occupied by native fauna;
- If yes, what species;
- If no, are there signs of use and can the species be identified or assigned to a group (i.e. bats, birds);
- Has the nest box been used by a pest species (i.e. European Bees, Common Myna, Termites);
- Is there any deterioration of the nest box;
- Is there any maintenance required; and
- Has the surrounding landscape changed (i.e. clearing, partial clearing).

Factors to be considered as part of the maintenance schedule include:

- The need to remove exotic pests species such as Common Mynas, Common Starling and European Bees;
- Replacement of fallen, damaged or degraded nest boxes;
- Repositioning or relocation of dysfunctional[4] nest boxes;
- Checking each box is not holding water or leaking; and
- Removing excess nesting material[5] as this may impede access over time.

[4] Dysfunctional for the purposes of the nest box monitoring program shall mean nest boxes that are showing no signs of use during the latter stages of the monitoring program (i.e. after 3 monitoring episodes).

[5] Build-up of nest material that threatens to block nest box entrance or create management problems as determined by the qualified zoologist undertaking the monitoring program.

Table 7-1. Timing of key actions for this nest box plan of management, responsibilities and documentation requirements.

Management Action/Year Number	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Responsibility	Documentation Requirements
Pre Construction										
Prepare Nest Box Plan	√								RMS	Construction Environmental Management Plan
Construction										
Commission Construction of Nest Boxes	√	√							Contractor	-
Install Nest Boxes		√	√						Contractor	Construction Environmental Management Plan
Monitoring										
Summer			√	√		√		√	Contractor	Yearly reporting
Winter			√	√		√		√	Contractor	Yearly reporting
Maintenance										
Maintenance of boxes			√	√		√		√	Contractor	-
Pre Handover Maintenance Inspection								√	Contractor	Nest Box Reporting

7.3 Performance Measures

The performance of the nest box program would be assessed against the following parameters:

- Use of nest boxes by a wide range of native fauna;
- Use of nest boxes designed for specific species by those species (i.e. Brush-tailed Phascogale nest box being used by this species);
- Low rates of exotic fauna using nest boxes; and
- Reduced maintenance requirements.

7.4 Contingency Measures

A number of contingency measures have been proposed to overcome potential problems associated with using nest boxes as a mitigation device. These have been summarised in Table 7-2.

Table 7-2. Potential problems encountered when using nest boxes as a mitigation tool to offset tree hollow losses.

Problem	Contingency/Correction Action
Poor use of nest box materials resulting in increased maintenance.	Review and change nest box supplier. Investigate the use of alternative materials.
Nest box being used by non-target species.	Review the selection and number of nest box designs.
Nest boxes become occupied by exotic or invasive fauna (i.e. European Bees, Termites).	Review/modify nest box design to exclude undesirable species, treat if applicable (i.e. Buffalo Fly ear tags for bees) or relocate those nest boxes to another location.
Poor uptake/usage rate by native fauna.	Review the types and numbers of nest box designs, their location or positioning (i.e. aspect) within the tree.
Nest boxes deteriorating rapidly and requiring maintenance.	Identify causes of nest box failure, modify design and construct accordingly.

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APPENDIX A

Hollow Dependant Fauna Recorded along the RMS Road Corridor

Table A. Summary of hollow dependant fauna recorded on or near to the Oxley Highway to Kempsey Upgrade.

Bold type denotes species currently listed as vulnerable pursuant to the NSW *Threatened Species Conservation* Act (1995).

* denotes introduced species.

Family Name	Common Name	Scientific Name
FROGS		
HYLIDAE	Common Green Tree Frog	*Litoria caerulea*
HYLIDAE	Bleating tree Frog	*Litoria dentata*
HYLIDAE	Eastern Dwarf Frog	*Litoria fallax*
HYLIDAE	Peron's Tree Frog	*Litoria peronii*
HYLIDAE	Tyler's Tree Frog	*Litoria tyleri*
REPTILES		
GECKONIDAE	Southern Leaf-tailed Gecko	*Saltuarius swaini*
VARANIDAE	Lace Monitor	*Varanus varius*
SCINCIDAE	Tree Skink	*Egernia mcpheei*
SCINCIDAE	Bar-sided Skink	*Eulamprus martini*
COLUBRIDAE	Green Tree Snake	*Dendrelaphis punctulata*
MAMMALS		
DASYURIDAE	Brown Antechinus	*Antechinus stuartii*
DASYURIDAE	Dusky Antechinus	*Antechinus swainsonii*
DASYURIDAE	**Brush-tailed Phascogale**	***Phascogale tapoatafa***
PETAUROIDEA	**Yellow-bellied Glider**	***Petaurus australis***
PETAUROIDEA	Sugar Glider	*Petaurus breviceps*
PSEUDOCHEIRIDAE	Common Ringtail Possum	*Pseudocheirus peregrinus*
ACROBATIDAE	Feather-tail Glider	*Acrobates pygmaeus*
MURIDAE	Bush Rat	*Rattus fuscipes*
MURIDAE	Fawn-footed Melomys	*Melomys cervinipes*
PHALANGERIDAE	Common Brush-tail Possum	*Trichosurus vulpecula*
VESPERTILIONIDAE	Chocolate Wattle Bat	*Chalinolobus morio*
VESPERTILIONIDAE	Gould's Wattled Bat	*Chalinolobus gouldi*
VESPERTILIONIDAE	Eastern Broad-nosed Bat	*Scotorepens orion*
VESPERTILIONIDAE	Eastern Forest Bat	*Vespadelus pumulis*
VESPERTILIONIDAE	Southern Forest Bat	*Vespadelus regulus*
VESPERTILIONIDAE	Southern Forest Bat	*Vespadelus vulturnus*
VESPERTILIONIDAE	**Little Bent-wing Bat**	***Miniopterus australis***
VESPERTILIONIDAE	**Southern Myotis**	***Myotis macropus***
VESPERTILIONIDAE	**Greater Broad-nosed Bat**	***Scoteanax rueppellii***
VESPERTILIONIDAE	**Eastern False Pipistrelle**	***Falsistrellus tasmaniensis***
VESPERTILIONIDAE	Lesser long-eared Bat	*Nyctophilus geoffroyi*
VESPERTILIONIDAE	Gould's Long-eared Bat	*Nyctophilus gouldi*
MOLOSSIDAE	A Free-tail Bat	*Mormopterus sp. 1*
MOLOSSIDAE	Little Free-tail Bat	*Mormopterus sp. 2*
MOLOSSIDAE	White-striped Mastiff Bat	*Tadarida australis*
BIRDS		

Family Name	Common Name	Scientific Name
ANATIDAE	Hardhead	*Aythya australis*
ANATIDAE	Pacific Black Duck	*Anas superciliosa*
ANATIDAE	Wood Duck	*Chenonetta jubata*
ANATIDAE	Grey Teal	*Anas gracilis*
ANATIDAE	Chestnut Teal	*Anas castanea*
CACATUIDAE	**Glossy Black Cockatoo**	***Calyptorhynchus lathami***
CACATUIDAE	Yellow-tailed Black Cockatoo	*Calyptorhynchus funereus*
CACATUIDAE	Galah	*Cacatua rosicapilla*
PSITTACIDAE	Rainbow Lorikeet	*Trichoglossus haematodus*
PSITTACIDAE	Scaly Breasted Lorikeet	*Trichoglossus chlorolepidotus*
PSITTACIDAE	**Little Lorikeet**	***Glossopsitta pusilla***
PSITTACIDAE	Musk Lorikeet	*Glossopsitta concinna*
PSITTACIDAE	Australian King Parrot	*Alisterus scapularis*
PSITTACIDAE	Eastern Rosella	*Platycercus eximius*
STRIGIDAE	Southern Boobook	*Ninox novaeseelandiae*
STRIGIDAE	**Powerful Owl**	***Ninox strenua***
TYTONIDAE	**Masked Owl**	***Tyto novaehollandiae***
TYTONIDAE	**Sooty Owl**	***Tyto tenebricosa***
TYTONIDAE	Barn Owl	*Tyto alba*
AEGOTHELIDAE	Australian Owlet Nightjar	*Aegotheles cristatus*
CAPRIMULGIDAE	White-throated Nightjar	*Eurostopodus mystacalis*
ALCEDINIDAE	Laughing Kookaburra	*Dacelo novaeguineae*
ALCEDINIDAE	Sacred Kingfisher	*Todiramphus sanctus*
ALCEDINIDAE	Forest Kingfisher	*Todiramphus macleayii*
CORACIIDAE	Dollarbird	*Eurystomus orientalis*
CLIMACTERIDAE	White-throated treecreeper	*Cormobates leucophaeus*
PARDALOTIDAE	Striated Pardalote	*Pardolotus striatus*
PARDALOTIDAE	Spotted Pardalote	*Pardolotus punctatus*
STURNIDAE	Common Starling *	*Sturnus vulgaris* *
STURNIDAE	Common Myna *	*Acridotheres tristis* *

APPENDIX B

Ecology of Relevant Hollow Dependant Fauna

Table B. Summary of hollow dependant fauna species known from the lower foothills and coastal plans of the Hastings, Wilson and Maria River Valley.

M = Metres, MM = Millimetre, DBH = Diameter at breast height.

Fauna Group Common Name (Latin Name)	Habitat	Den tree type	Height (m)	Entrance diameter (mm)	Depth (mm)	Density of hollow use within home range	Comment
Mammals							
Scansorial mammals							
Brush-tailed Phascogale (*Phascogale tapoatafa*)	Largely an arboreal inhabitant of dry sclerophyll forests and woodlands with little/sparse ground cover. It uses multiple den sites usually a tree hollow but also known to use rotted stumps and bird nests. Forages on arthropods and small vertebrates over variable home range of 5-100 ha depending on habitat quality (Soderquist and Rhind 2008).	Rough barked trees of ≥250 mm DBH					Large tree cavities with small secure entrances are preferred (Soderquist and Rhind 2008).
Brown Antechinus (*Antechinus stuartii*)	Widespread in a variety of forested and heathland habitats reaching its highest density in habitats with dense groundcover and abundant logs. Nests are constructed in hollow log or tree hollow when young reach 5 weeks old (Crowther and Braithwaite 2008)						Likely to use a range of nest box types.
Small Gliders							
Feather-tail Glider (*Acrobates pygmaeus*)	Widely distributed throughout tall forests and woodlands of eastern Australia with home range of up to 2.1 ha (Ward and Woodside 2008). Normally den in groups of 3-5 individuals with observations of up to 25 individuals.	400-2000 mm DBH	25	120	920		Known for utilising any available enclosed space including tree hollows, telephoneinterchange boxes, bird boxes, old bird nests or abandoned possum drays Ward and Woodside 2008).
Sugar Glider (*Petaurus breviceps*)	Found in variety of habitats including rainforest, sclerophyll forests and woodland habitats of eastern and northern Australia (Suckling 2008). Highest densities tend to occur in open forest habitats where animals have access to dense patches of *Acacia* (Suckling 2008).	>300 mm DBH	8 -31	35-50	60-700	<5	It seems to tolerant some level of habitat fragmentation being often road in linear strips of vegetation and has been successfully introduced in rehabilitated habitats augmented with nest boxes.

Fauna Group Common Name (Latin Name)	Habitat	Den tree type	Height (m)	Entrance diameter (mm)	Depth (mm)	Density of hollow use within home range	Comment
Large Gliders							
Squirrel Glider (*Petaurus norfolcensis*)	Inhabitant of dry sclerophyll forest and woodland but usually absent from dense coastal ranges of NSW. Such habitats tend to have *Eucalyptus*, *Corymbia*, *Angophora* species with a shrubby understorey of Acacia or Banksia with at least one winter flowering species providing an important nectar source (van der Ree and Suckling 2008)	Rough barked trees including Ironbarks and Swamp Mahogany 900mm DBH					Usually select multiple tree hollows with a tight fitting entrance.
Yellow-bellied Glider (*Petaurus australis*)	Generally restricted to tall, mature eucalypt forest and coastal woodlands in high rainfall areas of temperate to sub-tropical eastern Australia (NPWS 2003; Menkhorst and Knight 2003). A family group of two to six individuals usually occupy a home range of 30-60 ha (Goldingay 2008). Tree hollows are used for denning and these are changed periodically throughout the year.	800-2000 mm DBH	44	110 - 140	1300	6 - 13	These gliders require large hollows because family groups share den sites (Gibbons and Lindenmayer 2003).
Greater Glider (*Petauroides volans*)	An inhabitant of Eucalypt, *Corymbia* and *Angophora* dominated habitats from low open forests on the coast to tall closed forest of the coastal ranges and along riparian corridor and woodlands west of the dividing range (McKay 2008).	>1m DBH	11	180		2 - 14	
Possums							
Common Ringtail Possum (*Pseudocheirus peregrinus*)	Occupant of usually dense vegetation types including rainforest where shrubs form dense tangled foliage although inhabitant riparian woodland vegetation west of the dividing range. Spherical nests lined with shredded bark or grass are made in a hollow limb or dense undergrowth (McKay and Ong 2008).	100 - 1430 DBH	4	66-80	> 200	8	Ringtail possums inhabiting areas with dense understorey vegetation are more likely to build drays from sticks and vegetative matters as a shelter in preference to tree hollows (McKay and Ong 2008).
Common Brushtail Possum (*Trichosurus vulpecula*)	Widely distributed throughout Australia, however, sclerophyll forests tend to be the preferred habitat (Kearle and How 2008). Although tree hollows are the usually den location in either tree limb or trunk individuals have been recorded using termite mounds, hollow logs and rabbit warrens (Kearle and How 2008).	550-1150 mm DBH	6	> 100	90-120	4 - 8	The generalist denning habits of this species suggest alternative nesting resources should be an effective substitute for the loss of tree hollow habitat.

Fauna Group **Common Name** **(Latin Name)**	**Habitat**	**Den tree type**	**Height (m)**	**Entrance diameter (mm)**	**Depth (mm)**	**Density of hollow use within home range**	**Comment**
Short-eared Brushtail Possum (*Trichosurus caninus*)	An inhabitant of moist forests north from about Newcastle (How 2008). It reaches its peak density of 1 individual per 10 ha in forest gullies with abundant tree hollows in north eastern NSW (Martin 2008). Den site selection is normally in a live or dead tree although it has been known to utilise epiphytes.	550-1150 mm DBH	6	> 100	90-120	4 - 8	
Flying Mammals							
Microchiropteran bats (i.e. East Coast Free-tail Bat, Greater Broad-nosed Bat, Large-footed Myotis)	No preferred hollow characteristics are apparent among bats and both natural and man-made structures are used. However some species of microchiroptera are partly heterothermic suggesting that their selection of roost sites is strongly influenced by microclimatic conditions (Gibbons and Lindenmayer 2003). Bat species have been known to show fidelity to a roost area, rather than a single roost (Gibbons and Lindenmayer 2003) which may indicate the substitution of natural hollows with nest boxes will not greatly influence local populations of this fauna group.	Mature, senescent or dead trees > 800 mm DBH.					Been recorded using roost trees as small as 25 mm.
Birds							
Ducks							
Australian Wood Duck (*Chenonetta jubata*)	An inhabitant of grasslands, open woodlands, wetlands, flooded pastures and coastal inlets and bays. Also common on farmland with dams, as well as around rice fields, sewage ponds and in urban parks. Often be found around deeper lakes that may be unsuitable for other waterbirds, as it prefers to forage on land (Pizzey and Knight 2008).	Live or dead tress above or near water	3		400		Often re-using the same site.
Grey Teal (*Anas gracilis*)	Common inhabitant of all sheltered watered areas ranging from freshwater to saltwater. It preferred habitat tends to be timbered pools and river systems of the inland areas, where large aggregations numbers thousands are not uncommon (Marchant and Higgins 1993).	Usually tall tree along watercourse	3.5		1300		Rarely on ground, under shrubs or bushes.

Fauna Group **Common Name** **(Latin Name)**	**Habitat**	**Den tree type**	**Height (m)**	**Entrance diameter (mm)**	**Depth (mm)**	**Density of hollow use within home range**	**Comment**
Chestnut Teal (*Anas castanea*)	Inhabitant of wetlands and estuaries in coastal regions, and is one of the few ducks able to tolerate hyper saline waters, although it still needs fresh water for drinking. It will also use open freshwater lakes, reservoirs and sewage ponds during dry seasons. It mainly breeds in coastal areas, needing hollow trees in water or short grasslands near water for nesting, and it will readily take to suitably constructed nest boxes (Marchant and Higgins 1993; Pizzey and Knight 2008).	Close to water	1-10.5				Nest sites tend to be lower in mangrove communities
Cockatoos							
Glossy Black Cockatoo (*Calyptorhynchus lathami*)	In coastal parts of NSW the preferred habitat for Glossy Black Cockatoo is dry open forest or woodland with a plentiful supply of *Allocasuarina* species for foraging, and large hollows for nesting (Pepper *et al.* 2000). Glossy Black Cockatoos are selective in their choice of foraging sites and chose stands that produce the highest seed to cone ratio (Pepper *et al.* 2000). Typically nest sites occur close (<2 km) to areas with a plentiful supply of *Allocasuarina*.	Live or dead Eucalypt >700mm DBH usually <1km from feeding area.	5-28	210	400-1200		Known to use nest boxes constructed from hollow logs.
Yellow-tailed Black Cockatoo (*Calyptorhynchus funereus*)	The Yellow-tailed Black Cockatoo inhabits temperate rainforest, sclerophyll forests, woodlands and coastal heaths throughout eastern Australia (Pizzey and Knight 2008). It has a varied diet of grubs, seeds from *Pinus*, *Hakea*, *Banksia* and other plants, fruits and plant shoots. Breeding usually takes place in a large senescent eucalypt of considerable age (Nelson and Morris 1994).	Hollow in mature senescent tree	5-56	460	600-2400		Mean estimated age of nest trees used by Yellow-tailed Black Cockatoo 221 years (Nelson and Morris 1994)
Sulphur Crested Cockatoo (*Cacatua galerita*)	Inhabitant of most forested and wooded areas including urban areas (Pizzey and Knight 2008). Tend to display sedentary habits.	Hollow in limb or trunk of dead or living tree often near water	1-35	220	200-1800		
Galah (*Cacatua roseicapilla*)	Inhabitant of most forested and wooded areas including urban areas often close to water (Pizzey and Knight 2008). Seeds of grasses and cultivated crops are eaten, making these birds agricultural pests in some areas where they are often described as abundant. Birds may travel large distances in search of favorable feeding grounds.	Hollow in limb or trunk of dead or living tree often near water	1-19	250	700-2000		
Forest Owls							

Fauna Group Common Name (Latin Name)	**Habitat**	**Den tree type**	**Height (m)**	**Entrance diameter (mm)**	**Depth (mm)**	**Density of hollow use within home range**	**Comment**
Powerful Owl (*Ninox Strenua*)	An inhabitant of sclerophyll forests and occasionally woodlands of eastern and south-eastern Australia (Pizzey and Knight 2008). Studies suggest it is highly mobile species occupying large home ranges of approximately 1000-3000 ha in tall sclerophyll forests with pairs of birds holding territories are rarely found within 4-5 kilometres of another territory. The Powerful Owl often nests in trees growing near creeks along drainage lines (McNabb 1996; Kavanagh 1997) and have occasionally been recorded nesting in parkland next to forest (Pavey *et al.* 1994). Roost sites are traditional and used year after year but the number of roost sites can vary considerably (e.g. McNabb 1996, Kavanagh 1997). Kavanagh (1997) found the most important roost sites are trees in the roost or nest-grove which can be used for many months of the year. Prey are generally hollow dwelling (Garnett and Crowley 2000).	> 1m DBH located on steep slopes	12 - 45	450 -750	2000		Feather identified as belong to this species off this species was recorded in the vicinity of chainage 8420 during the hollow bearing tree survey. There has been no record of this species utilising artificial nest boxes (Carbery 2004).
Masked Owl (*Tyto novaehollandiae*)	Inhabitant of dry sclerophyll forests and woodlands generally with a low sparse understorey but is known to utilise open and partially cleared habitat (Kavanagh and Peake 1993). This species is mainly encountered in coastal areas and tablelands but can extend far inland along riparian habitats. Nest and roost sites are often associated with large hollows in wet sclerophyll gullies where hollows may be used for several years.		10 - 30	450 - 550	400-5000		The Masked Owl may also roost in caves and rock crevices (Gibbons and Lindenmayer 1997). There has been no record of this species utilising artificial nest boxes (Carbery 2004).
Sooty Owl (*Tyto tenebricosa*)	Occurs in wet eucalypt forest and rainforest on fertile soils with tall emergent trees. Typically found in old growth forest with a dense understorey, however, it is known to utilise younger forests if suitable nesting trees occur nearby. Nest site selection is normally within a large eucalypt hollow (Garnett and Crowley 2000).	Smooth barked eucalypts 400-600 mm DBH	16 - 30		400- 3000		The Sooty Owl may also roost in caves, rock overhangs and dense gully vegetation (Gibbons and Lindenmayer 1997). There has been no record of this species utilising artificial nest boxes (Carbery 2004).
Small Owls							
Southern Boobook (*Ninox novaeseelandiae*)	Inhabits most vegetated landscapes from heathlands to dense forest and open deserts where it often feeds on insects, small mammals (such as the House Mouse, *Mus musculus* and small dasyurids) along with other small animals including frogs (Pizzey and Knight 2008).	Vertical hollow in live or dead tree	3-30	200-300	300-2500		

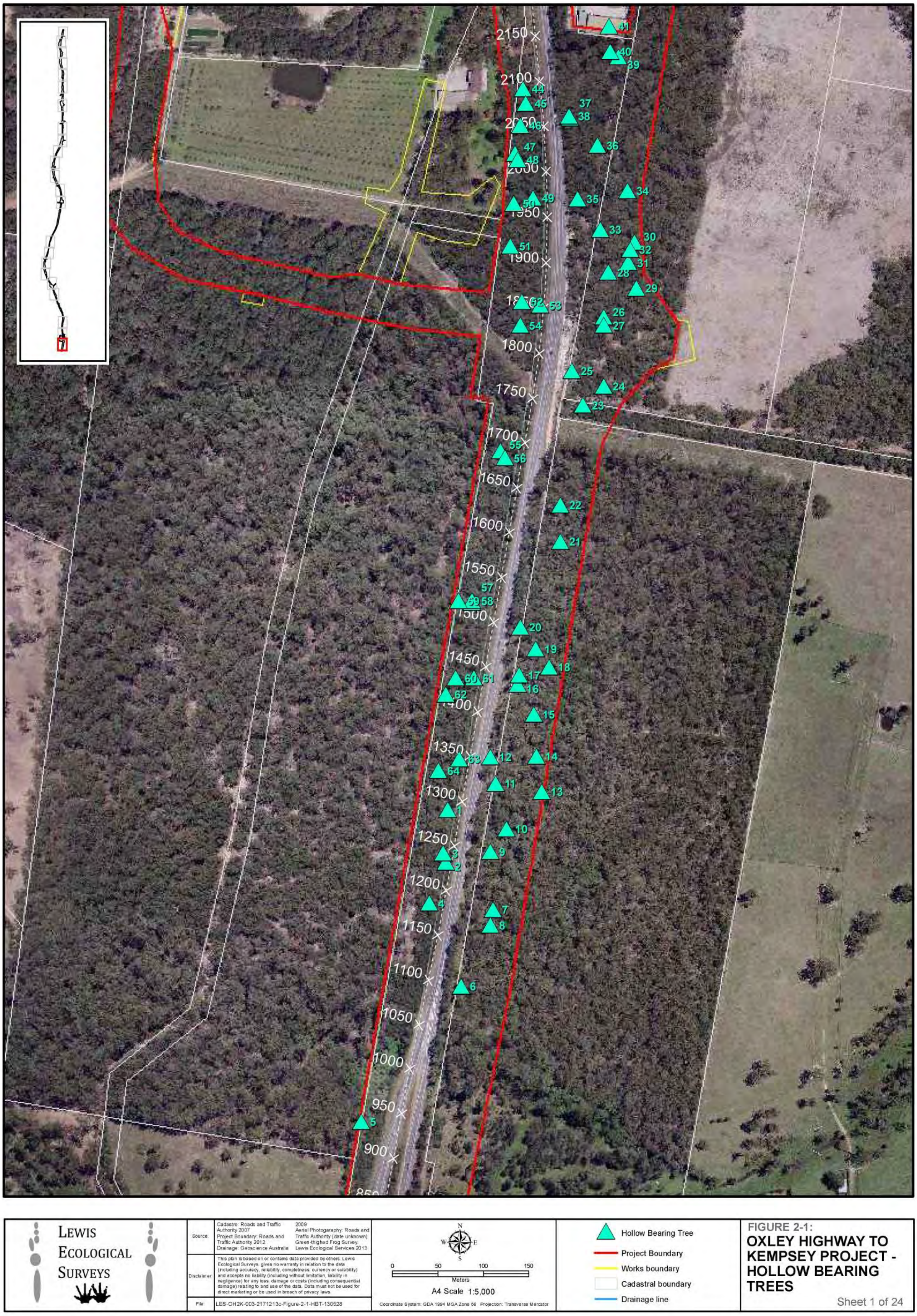
Fauna Group **Common Name** **(Latin Name)**	**Habitat**	**Den tree type**	**Height (m)**	**Entrance diameter (mm)**	**Depth (mm)**	**Density of hollow use within home range**	**Comment**
Barn Owl (*Tyto alba*)	This species is found throughout Australia where its distribution is limited only by habitat and food availability (Pizzey and Knight 2008). Its preferred habitat is open, often arid landscapes, fragmented farming landscapes, heath and lightly wooded forest.	Hollow in live or dead tree	0-20	200-250	600-2000		
Australian Owlet Nightjar (*Aegothesles cristatus*)	Most treed habitats that support tree hollows and nearby adjacent areas. During the day this species roosts in a limb or trunk hollow (Pizzey and Knight 2008).	Hollow in live or dead tree	0.2-30	70-250	200-3500		May use multiple roost hollows over short periods (Brigham *et al.* 1998)
Parrots/Lorikeets & Rosellas							
Australian King Parrot (*Alisterus scapularis*)	An inhabitant of rainforests, sclerophyll forests and woodlands particularly near riparian habitats where it forages for seeds and fruits (Pizzey and Knight 2008).	Deep vertical hollow in trunk of large Eucalypt	6-25	600	50-18000		
Rainbow Lorikeet (*Trichoglossus haematodus)*	This species inhabits a range of treed landscapes from heathlands to woodlands, sclerophyll forests and rainforests (Pizzey and Knight 2008). It is largely sedentary although some nomadic movements are undertaken in response to seasonal flowering and fruiting of plants.	Live or dead tree	3-30	220	300-600		Will readily use artificial sites
Musk Lorikeet (*Glossopsitta concinna*)	A nomadic species following the flowering and fruiting of trees in tall, open and dry forest or woodlands dominated by eucalypts and *Corymbia*. Treed suburban areas, parks and landscaped street trees are also used. This species may also feed upon the seeds, fruits and insects and their larvae found within its preferred habitat.	Live or dead tree often close to water	3-8	40	500		
Scaly-breasted Lorikeet (*Trichoglossus chlorolepidotus*)	This species inhabits lowland eucalypt forests, woodlands heathlands and well-treed urban areas, including parks and gardens (Pizzey and Knight 2008). Numbers within any particular area often fluctuate in response to seasonal flowering of eucalypts, *Melaleuca*, *Callistemon* and *Banksia*.	Live or dead tree with an inclined hollow	3-20	50-150	200-1980		

Fauna Group Common Name (Latin Name)	**Habitat**	**Den tree type**	**Height (m)**	**Entrance diameter (mm)**	**Depth (mm)**	**Density of hollow use within home range**	**Comment**
Little Lorikeet (*Glossopsitta pusilla*)	A nomadic species that mostly occurs in dry, open eucalypt forests and woodlands (Pizzey and Knight 2008). They have been recorded from both old-growth and logged forests in the eastern part of their range, and in remnant woodland patches and roadside vegetation on the western slopes.	Hollows and knot holes usually in senescent trees	6-18	29-32	180-500		Very small entrance used.
Eastern Rosella (*Platycercus eximius*)	An inhabitant of open woodlands, grasslands, farmlands and remnant bushland. May also occur in urban habitats such as parks, gardens and golf courses (Pizzey and Knight 2008).Within these habitats it forages on the ground, especially amongst grasses in lawns, pastures and other clearings.	Hollow in any part of usually large Eucalypt	1-30	60-410	180-2440		Will utilise artificial structures.
Kookaburra/Kingfishers							
Laughing kookaburra (*Dacelo novaeguineae*)	Open Sclerophyll forest or woodland, with open or sparse understorey or grass ground cover (Pizzey and Knight 2008).	Live or dead tree often a Eucalypt	2-60	80-400	200-1500		Often utilises burrows and termitaria as well as artificial sites.
Sacred Kingfisher (*Todiramphus sanctus*)	An inhabitant of woodlands, mangroves and paperback forests, tall open eucalypt forest and *Melaleuca* forest. Sacred Kingfishers spend the winter in the north of their range and return south (including NSW) in the spring to breed (Pizzey and Knight 2008).		0.5-35				Often utilises burrows and termitaria.
Dollarbird (*Eurystomus orientalis*)	An inhabitant of open wooded areas, normally with mature, hollow-bearing trees suitable for nesting (Pizzey and Knight 2008).	Mostly in senescent Eucalypt	6-35				May occasionally use termitaria.
White-throated Treecreeper (*Cormobates leucophaeus*)	An inhabitant of sclerophyll forests, rainforests, woodlands and timbered watercourses where it maintains permanent territories (Pizzey and Knight 2008).		4-5				
Striated Pardalote (*Pardolotus* striatus)	Striated Pardalotes are found in almost any habitat with trees or shrubs, but favor eucalypt forests and woodlands where they forage in the tops of trees, occasionally coming close to the ground in low shrubs (Pizzey and Knight 2008).	Maybe a burrow in a termite mound, hollow branch or river bank.					Often nests in burrows constructed in roadside cuttings, riverbanks and steep hillsides.
Reptiles							

Fauna Group Common Name (Latin Name)	Habitat	Den tree type	Height (m)	Entrance diameter (mm)	Depth (mm)	Density of hollow use within home range	Comment
Southern Leaf-tailed Gecko (*Phyllurus platurus*)	Sclerophyll forests, rainforests often with exposed rock and/or abundant fallen timber and old growth trees.	Under rock or exfoliating bark or tree hollow					Nothing known of its hollow habits.
Tree Skink (*Egernia mcpheei*)	Arboreal inhabitant of sclerophyll forests, rainforest margins and woodlands from coastal floodplains to upland areas of the Great Dividing Range (Wilson and Swan (2004).	Under rock or exfoliating bark or tree hollow, particularly fissures on dead stags					Little known on its hollow habits.
Lace Monitor (*Varanus varius*)	Arboreal inhabitant of sclerophyll forests, rainforest margins and woodlands (Wilson and Swan (2004).	Hollows with nearby large limbs for sunning	1->10m	>150	>300		
Frogs							
Bleating Tree Frog (*Litoria dentata*)	Coastal swamps and lagoons, rainforests, wet and dry sclerophyll forests and urban bushland. During the day it often hides beneath stones and bark (Barker *et al.* 1995).	Any hollow form but particular those that hold water					
Common Green Tree Frog (*Litoria caerulea*)	Inhabitant of forests, woodlands, shrublands and open areas. Tends to take refuge in tree hollows, cracks and beneath exfoliating bark and occasionally under rocks (Barker *et al.* 1995).	Any hollow form but particular those that hold water					
Eastern Dwarf Frog (*Litoria fallax*)	Inhabitant of sclerophyll forest and occasionally rainforest and coastal heaths and woodlands where it normally occurs in permanent dams, swamps and ponds (Barker *et al.* 1995).	Mainly foliage but known to use tree hollows					
Graceful Tree Frog (*Litoria gracilenta*)	Inhabitant of mainly moist forest associated along coastal seaboard where it normally selects permanent dams, swamps and ponds for breeding (Barker *et al.* 1995).	Mainly foliage but known to use tree hollows					
Perons Tree Frog (*Litoria peronii*)	Inhabitant of forests, woodlands, shrublands and open areas. Tends to take refuge in tree hollows, cracks and beneath exfoliating bark (Barker *et al.* 1995).	Any hollow form but particular those that hold water	Ground level to >10 m	20-400	50-750		
Tyler's Tree Frog (*Litoria tyleri*)	Inhabitant of sclerophyll forest and occasionally rainforest and coastal heaths and woodlands where it normally occurs a short distance from permanent dams, swamps and ponds (Barker *et al.* 1995).	Any hollow form but particular those that hold water					

APPENDIX C

Hollow Bearing Tree Locations and Tree Hollow Field data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LEWIS ECOLOGICAL SURVEYS
Source: Cadastre: Roads and Traffic Authority 2007 Project Boundary: Roads and Traffic Authority 2012 Drainage: Geoscience Australia 2009 Aerial Photogaraphy: Roads and Traffic Authority (date unknown) Green-thighed Frog Survey: Lewis Ecological Services 2013
Disclaimer: This plan is based on or contains data provided by others. Lewis Ecological Surveys. gives no warranty in relation to the data (including accuracy, reliability, completness, currency or suiability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to and use of the data. Data must not be used for direct marketing or be used in breach of privacy laws.
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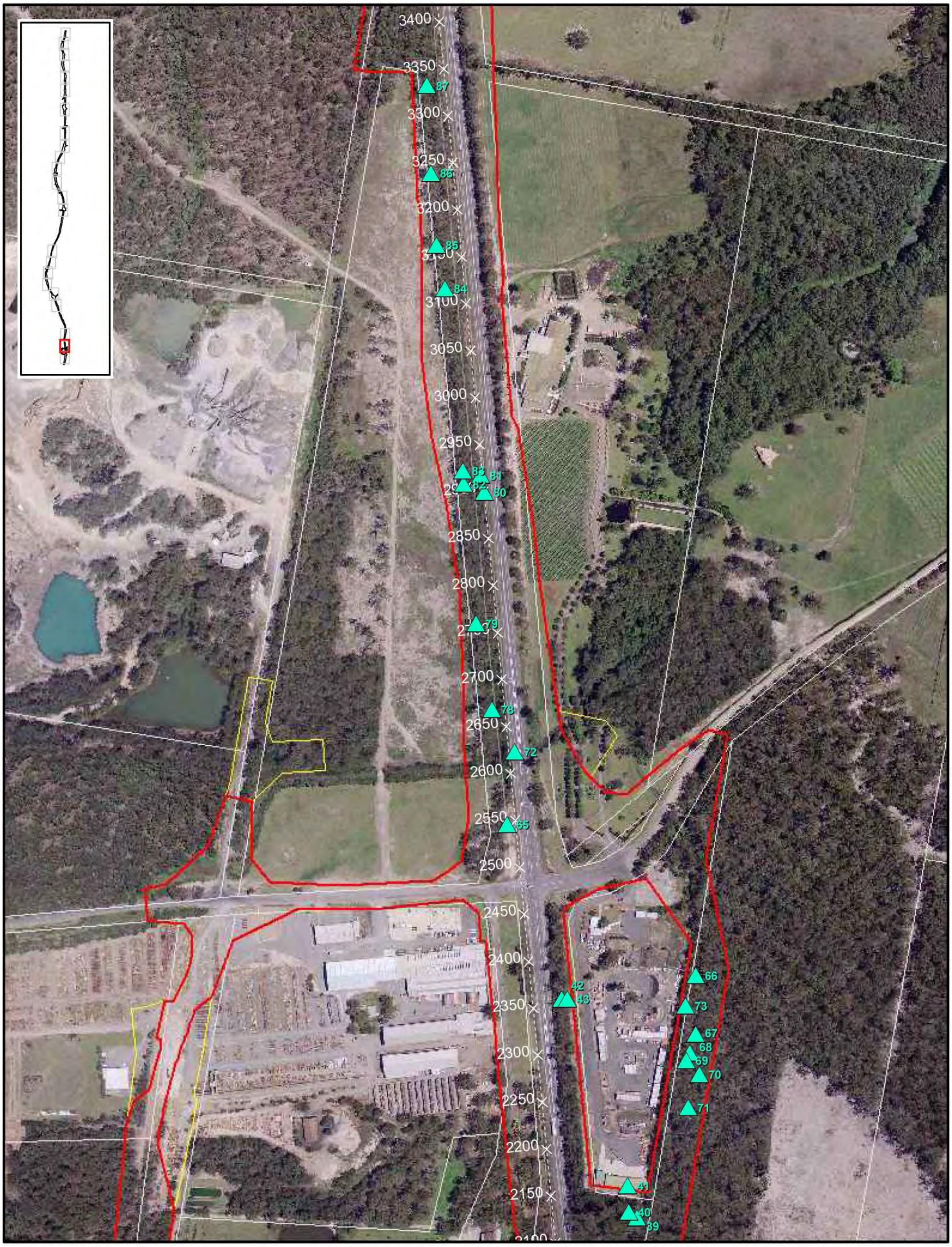
Meters
A4 Scale 1:5,000
Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator
Hollow Bearing Tree
Project Boundary
Works boundary
Cadastral boundary
Drainage line
FIGURE 2-1:
OXLEY HIGHWAY TO KEMPSEY PROJECT - HOLLOW BEARING TREES
Sheet 1 of 24



LEWIS ECOLOGICAL SURVEYS

Source:	Cadastre: Roads and Traffic Authority 2007 Project Boundary: Roads and Traffic Authority 2012 Drainage: Geoscience Australia 2009 Aerial Photogaraphy: Roads and Traffic Authority (date unknown) Green-thighed Frog Survey: Lewis Ecological Services 2013
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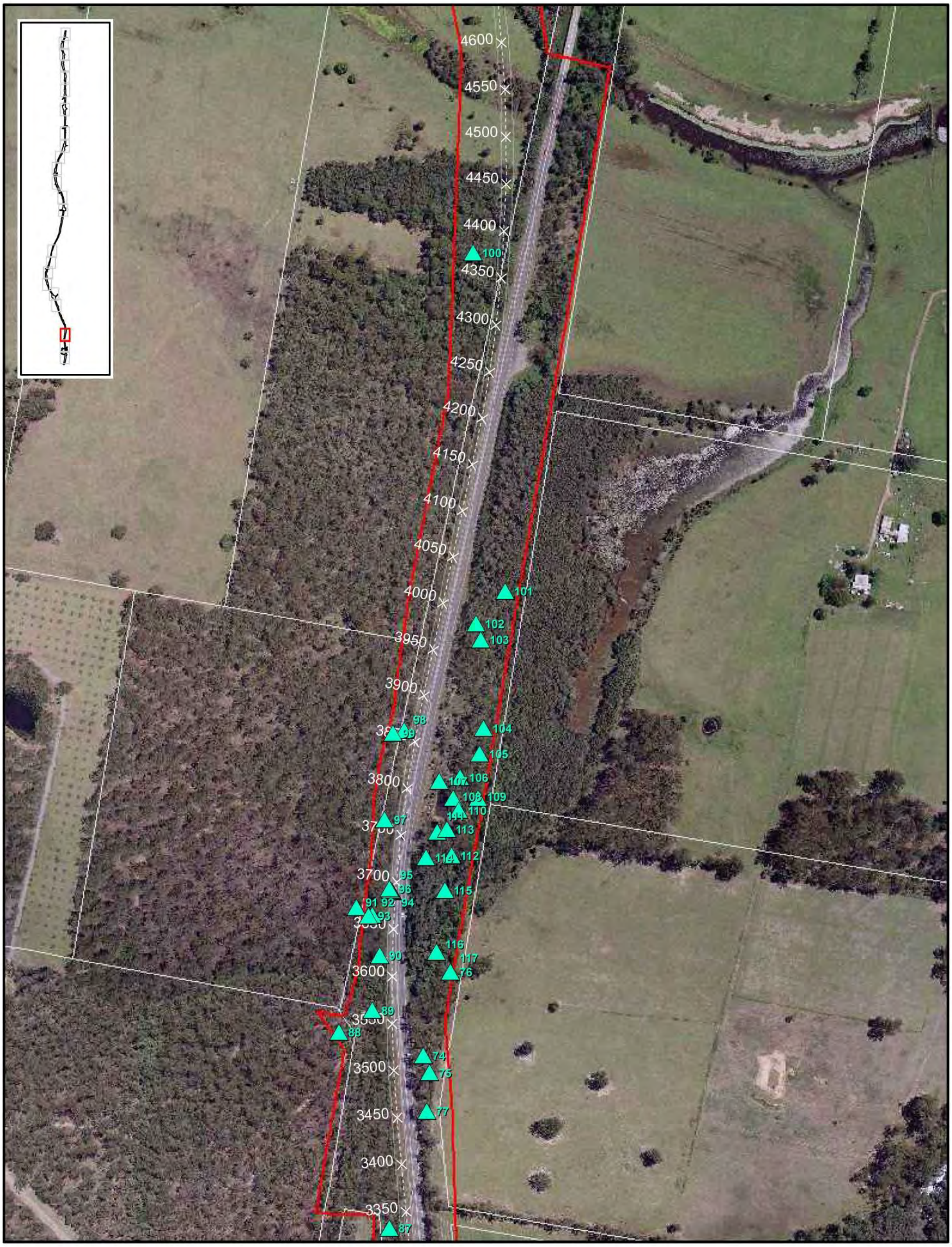
Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator

- Hollow Bearing Tree
- Project Boundary
- Works boundary
- Cadastral boundary
- Drainage line

FIGURE 2-1:
OXLEY HIGHWAY TO KEMPSEY PROJECT - HOLLOW BEARING TREES

Sheet 2 of 24



Lewis Ecological Surveys

Source:	Cadastre: Roads and Traffic Authority 2007 Project Boundary: Roads and Traffic Authority 2012 Drainage: Geoscience Australia	2009 Aerial Photogaraphy: Roads and Traffic Authority (date unknown) Green-thighed Frog Survey: Lewis Ecological Services 2013
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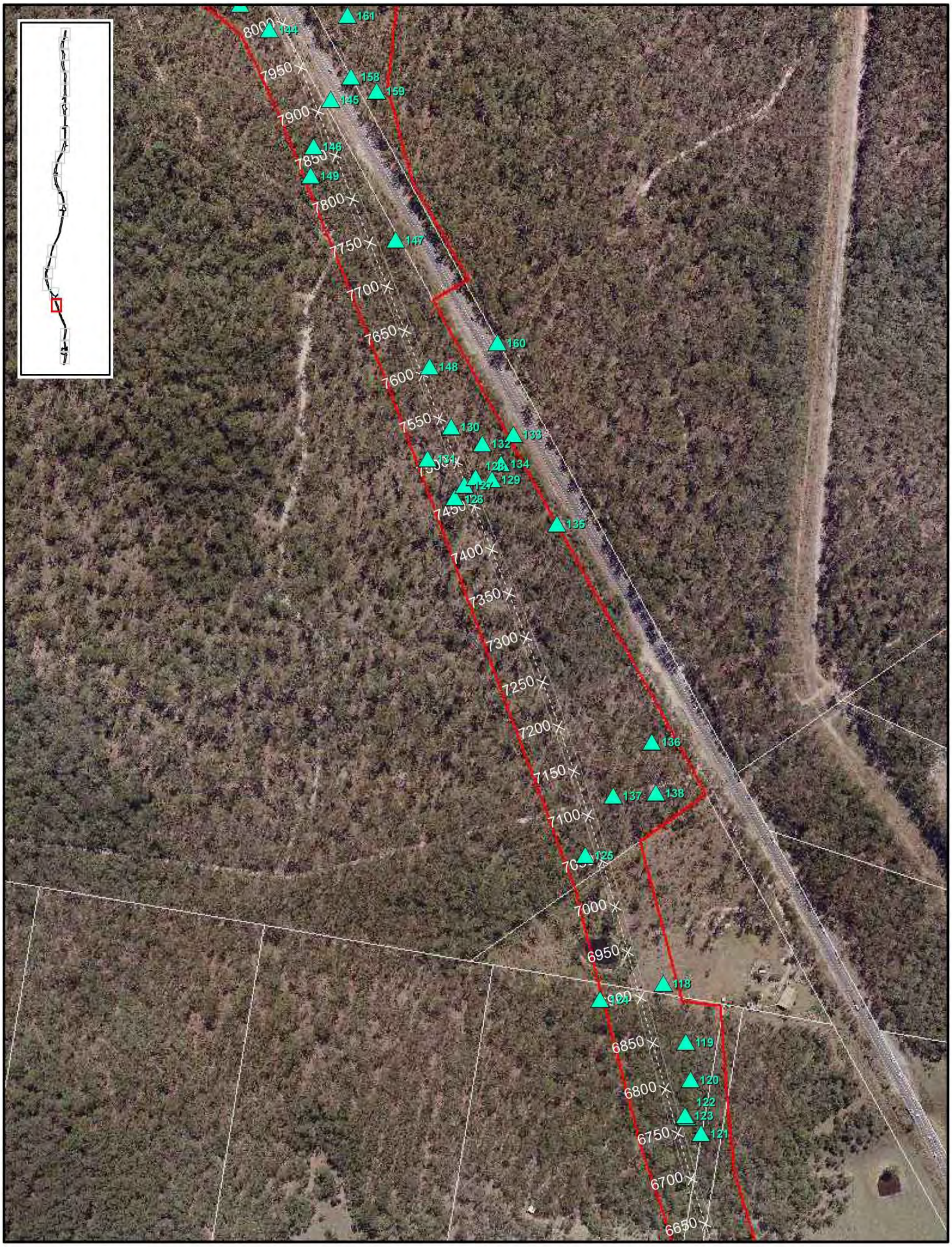
Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator

- Hollow Bearing Tree
- Project Boundary
- Works boundary
- Cadastral boundary
- Drainage line

FIGURE 2-1:
OXLEY HIGHWAY TO KEMPSEY PROJECT - HOLLOW BEARING TREES

Sheet 3 of 24



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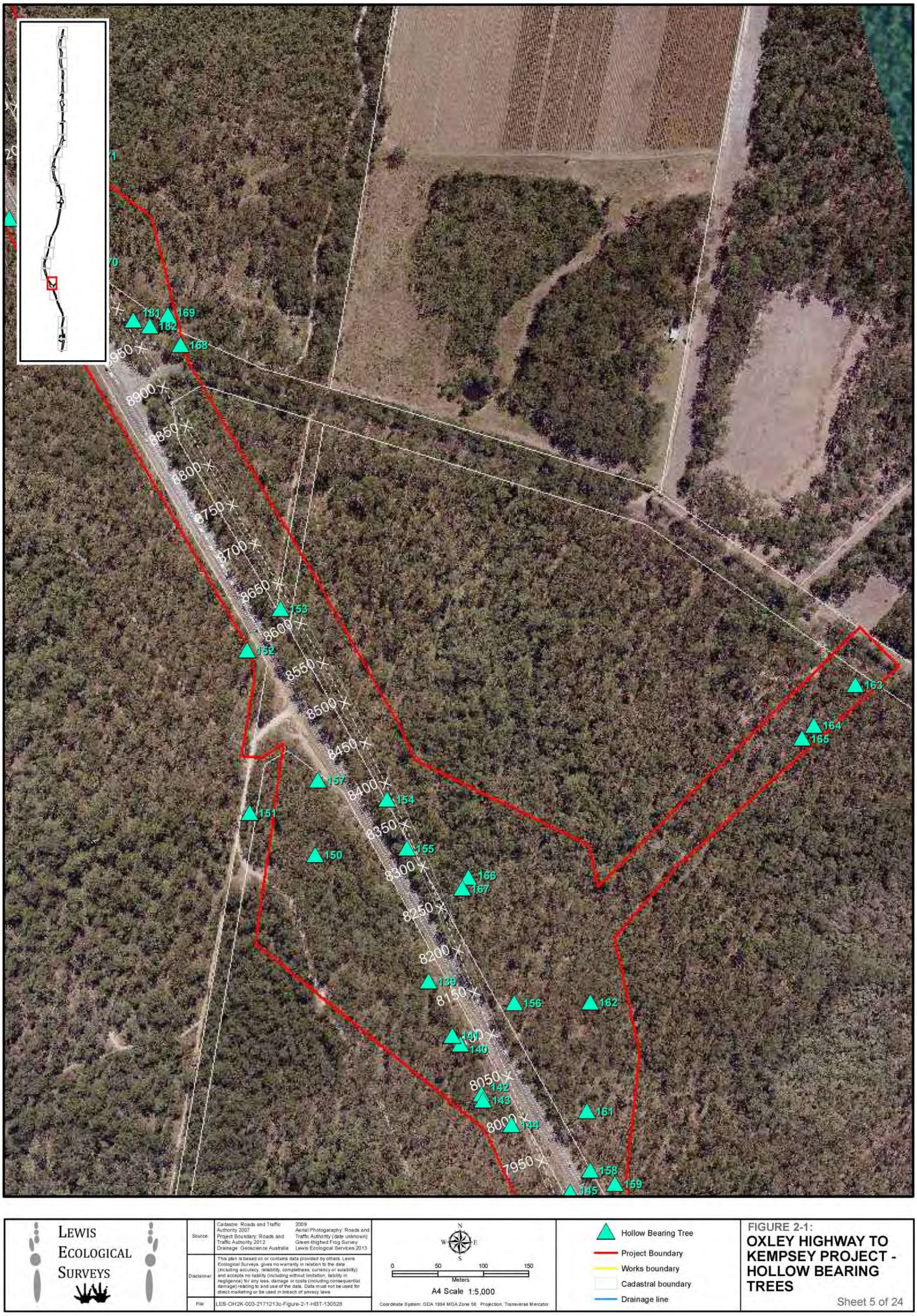
Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator

Hollow Bearing Tree
Project Boundary
Works boundary
Cadastral boundary
Drainage line

FIGURE 2-1:
OXLEY HIGHWAY TO KEMPSEY PROJECT - HOLLOW BEARING TREES

Sheet 4 of 24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LEWIS ECOLOGICAL SURVEYS
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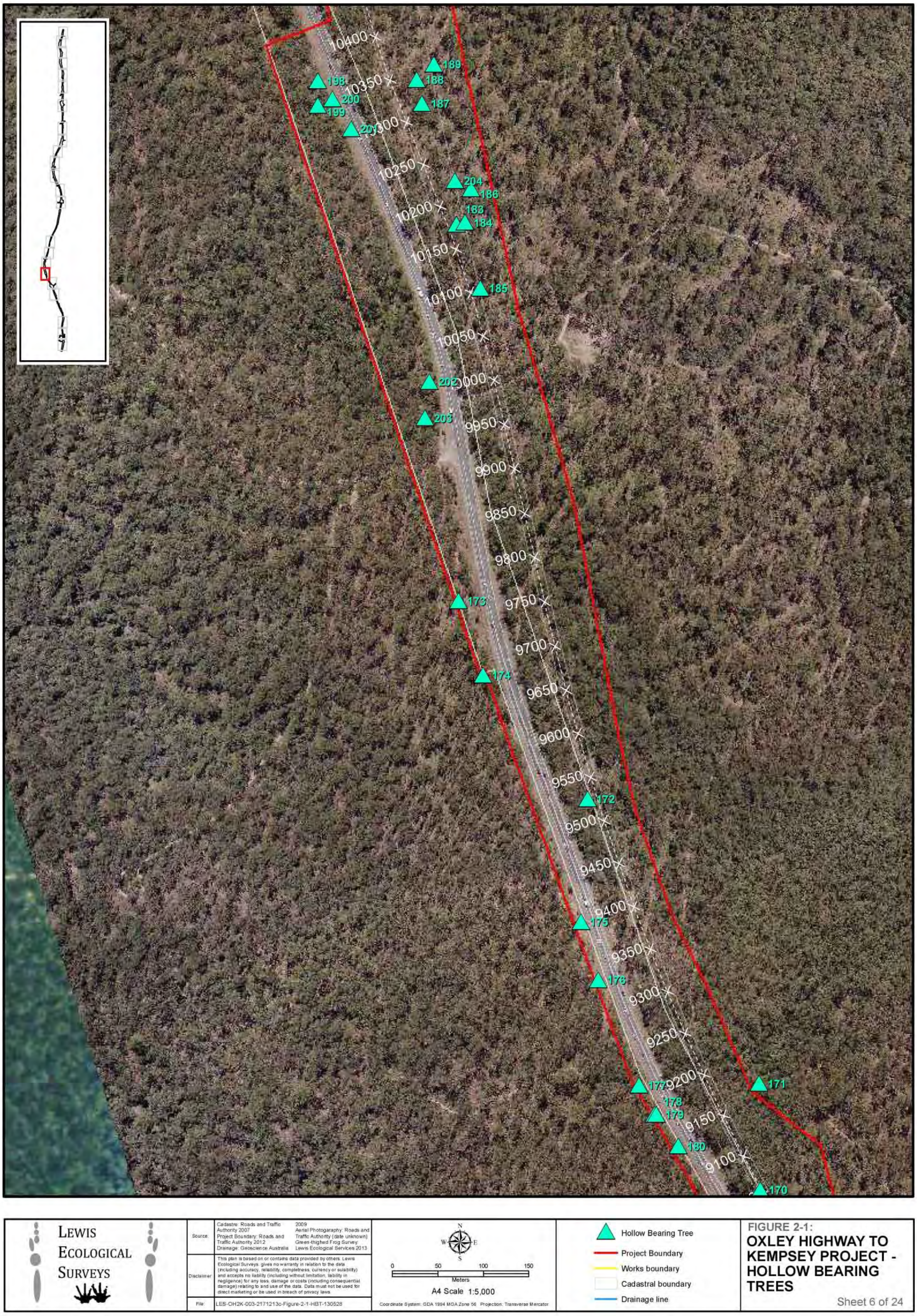
A4 Scale 1:5,000
Hollow Bearing Tree
Project Boundary
Works boundary
Cadastral boundary
Drainage line
FIGURE 2-1:
OXLEY HIGHWAY TO KEMPSEY PROJECT - HOLLOW BEARING TREES
Sheet 5 of 24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LEWIS ECOLOGICAL SURVEYS
Source:
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Project Boundary: Roads and Traffic Authority 2012
Drainage: Geoscience Australia
2009
Aerial Photogaraphy: Roads and Traffic Authority (date unknown)
Green-thighed Frog Survey: Lewis Ecological Services 2013
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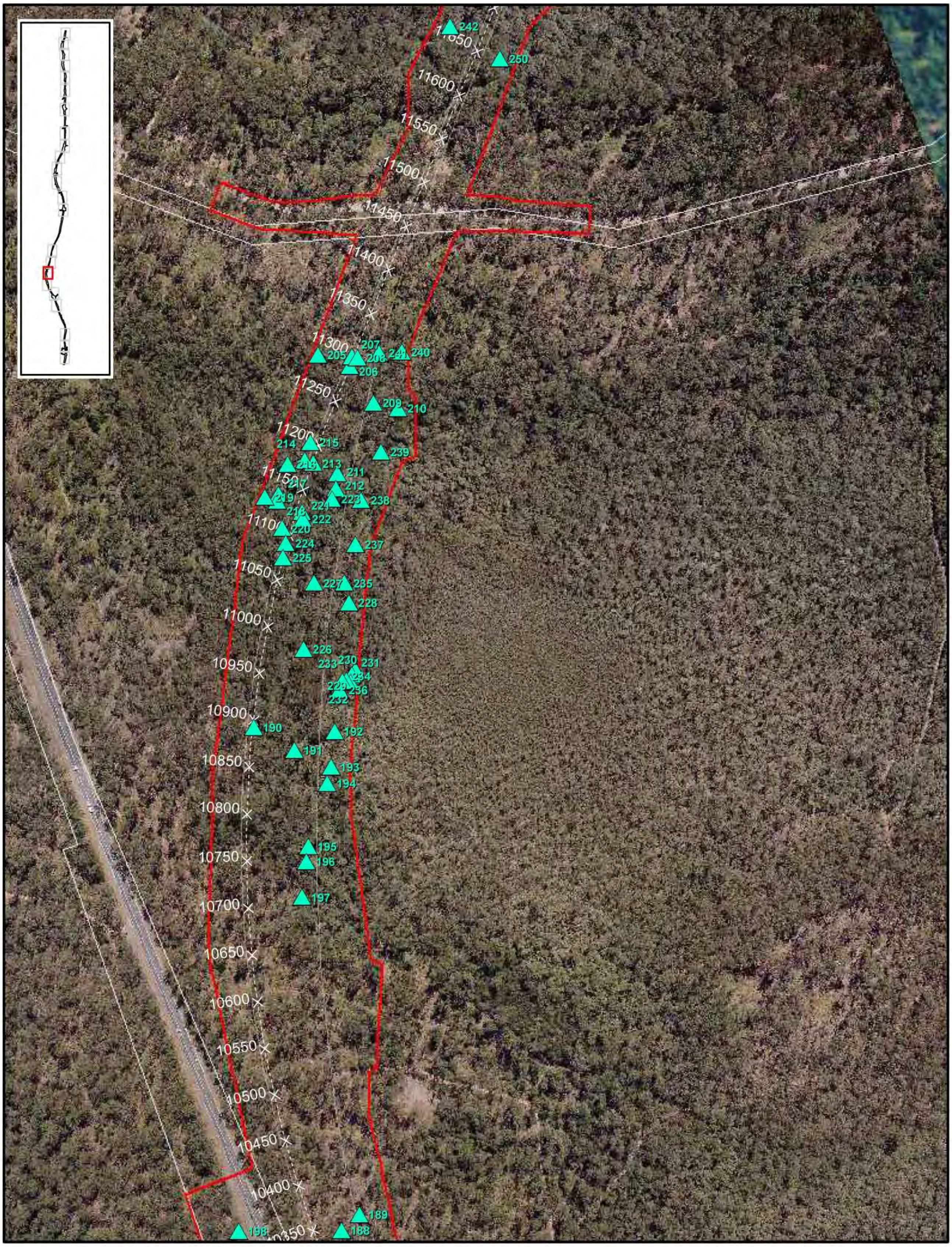
Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator
Hollow Bearing Tree
Project Boundary
Works boundary
Cadastral boundary
Drainage line
FIGURE 2-1:
OXLEY HIGHWAY TO KEMPSEY PROJECT - HOLLOW BEARING TREES
Sheet 6 of 24



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	Disclaimer:	This plan is based on or contains data provided by others. Lewis Ecological Surveys. gives no warranty in relation to the data (including accuracy, reliability, completness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to and use of the data. Data must not be used for direct marketing or be used in breach of privacy laws.
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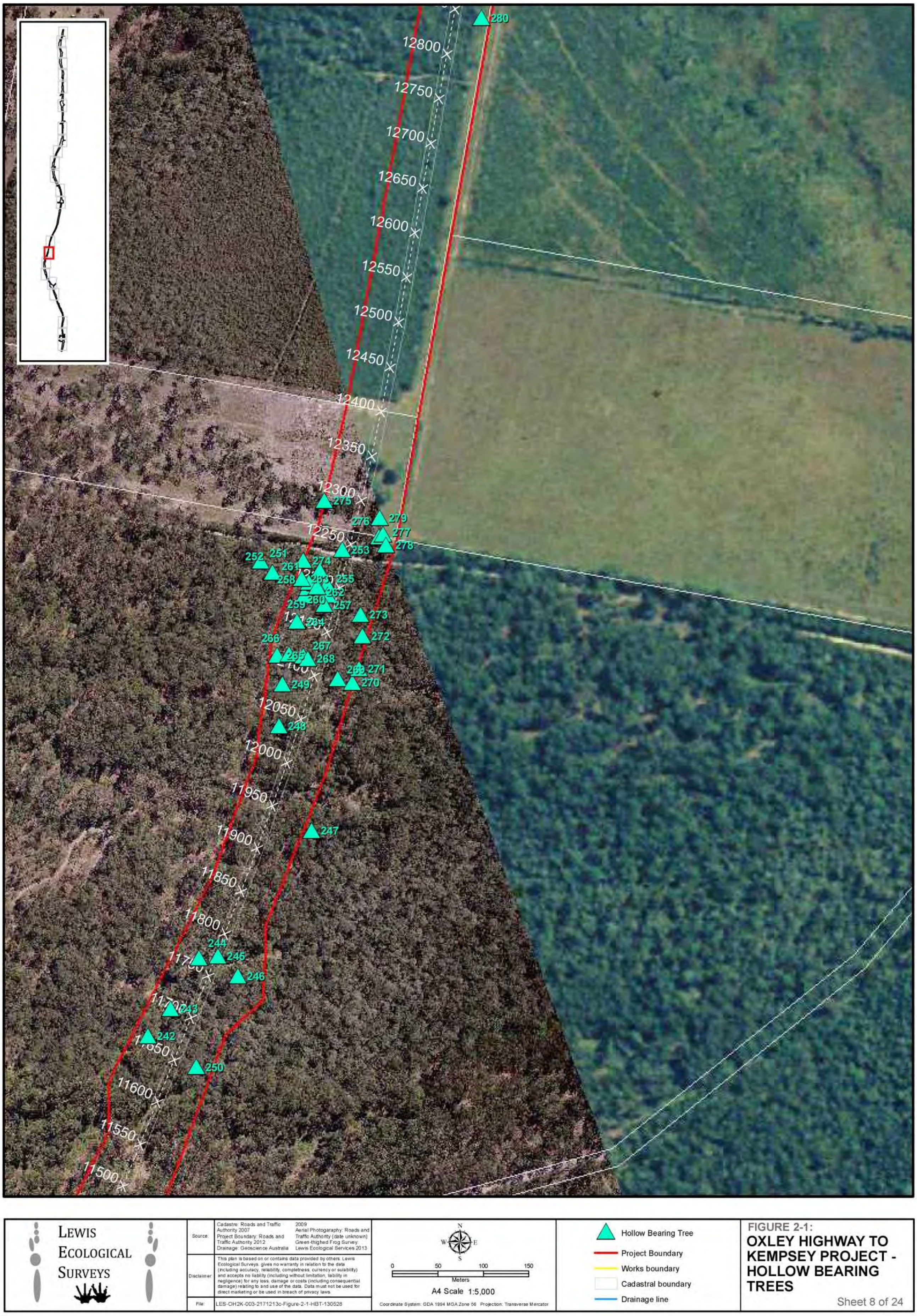
Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator

- Hollow Bearing Tree
- Project Boundary
- Works boundary
- Cadastral boundary
- Drainage line

FIGURE 2-1:
OXLEY HIGHWAY TO KEMPSEY PROJECT - HOLLOW BEARING TREES

Sheet 7 of 24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Source:
Cadastre: Roads and Traffic Authority 2007
Project Boundary: Roads and Traffic Authority 2012
Drainage: Geoscience Australia
2009
Aerial Photogaraphy: Roads and Traffic Authority (date unknown)
Green-thighed Frog Survey: Lewis Ecological Services 2013
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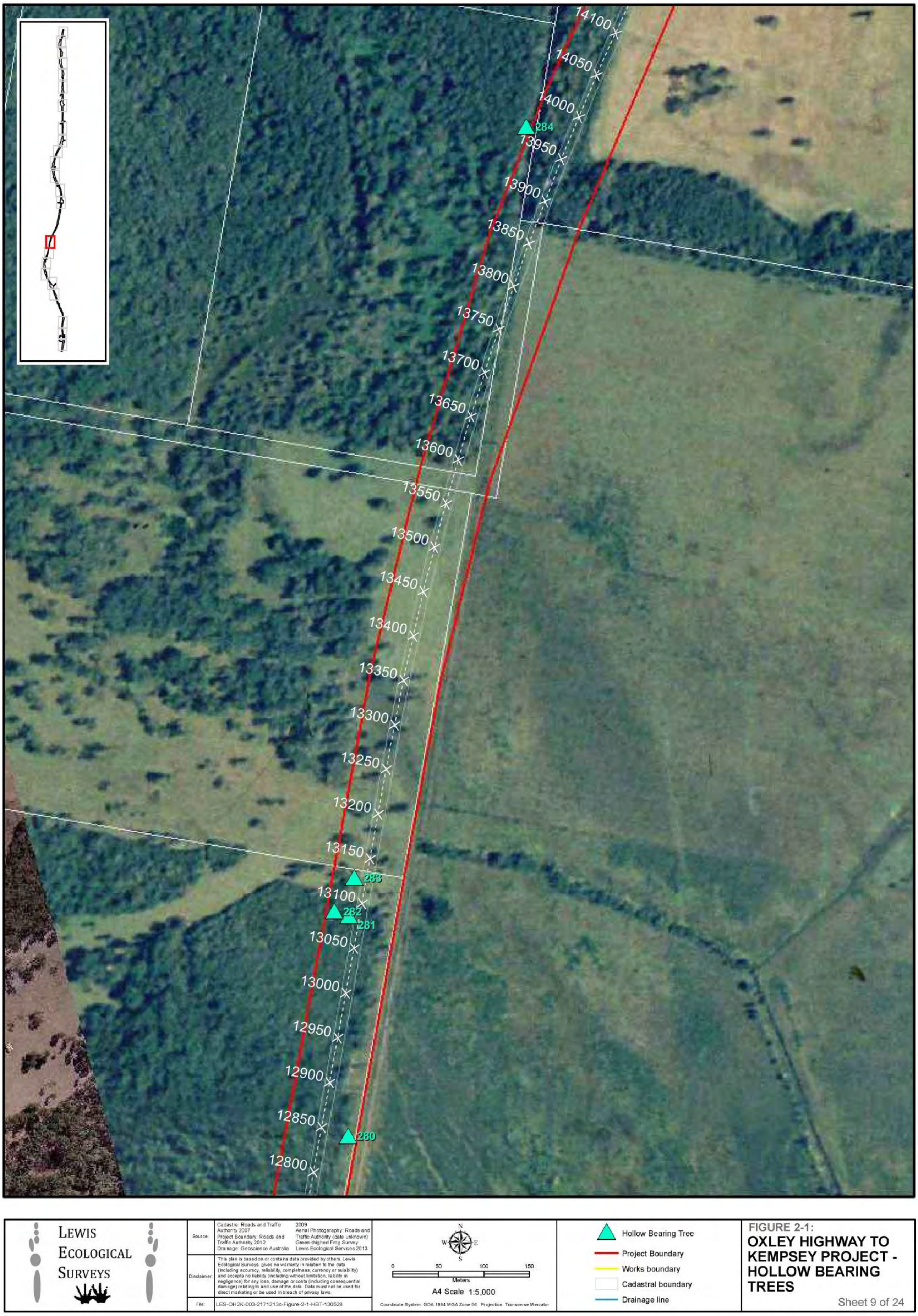
Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator
Hollow Bearing Tree
Project Boundary
Works boundary
Cadastral boundary
Drainage line
FIGURE 2-1:
OXLEY HIGHWAY TO KEMPSEY PROJECT - HOLLOW BEARING TREES
Sheet 8 of 24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LEWIS ECOLOGICAL SURVEYS
Source:
Cadastre: Roads and Traffic Authority 2007
Project Boundary: Roads and Traffic Authority 2012
Drainage: Geoscience Australia
2009
Aerial Photogaraphy: Roads and Traffic Authority (date unknown)
Green-thighed Frog Survey: Lewis Ecological Services 2013
Disclaimer:
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File:
LES-OH2K-003-2171213c-Figure-2-1-HBT-130528
N
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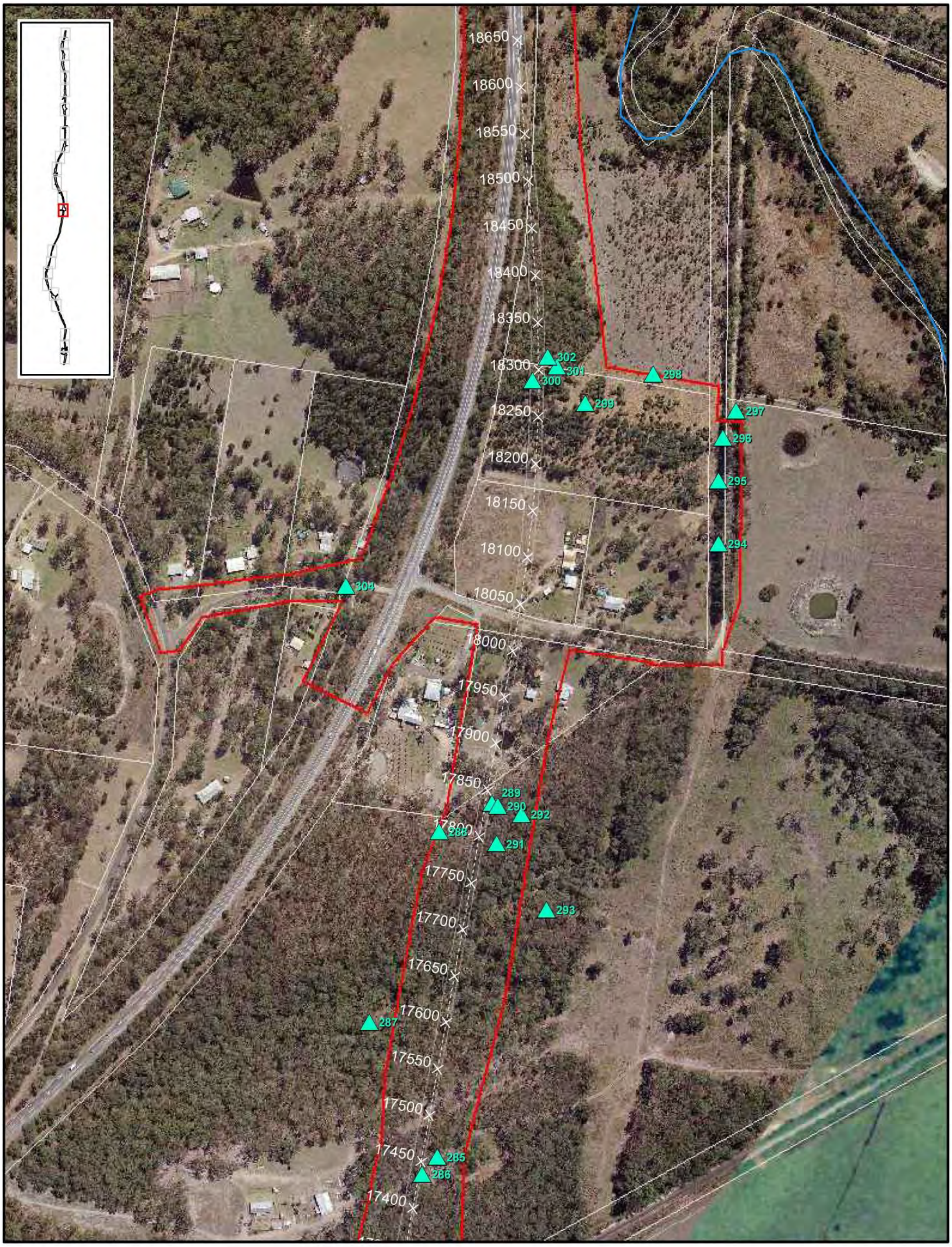
Meters
A4 Scale 1:5,000
Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator
Hollow Bearing Tree
Project Boundary
Works boundary
Cadastral boundary
Drainage line
FIGURE 2-1:
OXLEY HIGHWAY TO KEMPSEY PROJECT - HOLLOW BEARING TREES
Sheet 9 of 24



Source:	Cadastre: Roads and Traffic Authority 2007 Project Boundary: Roads and Traffic Authority 2012 Drainage: Geoscience Australia 2009 Aerial Photogaraphy: Roads and Traffic Authority (date unknown) Green-thighed Frog Survey: Lewis Ecological Services 2013
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File:	LES-OH2K-003-2171213c-Figure-2-1-HBT-130528

LEWIS ECOLOGICAL SURVEYS

N W E S

0 50 100 150

Meters

A4 Scale 1:5,000

Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator

Hollow Bearing Tree

Project Boundary

Works boundary

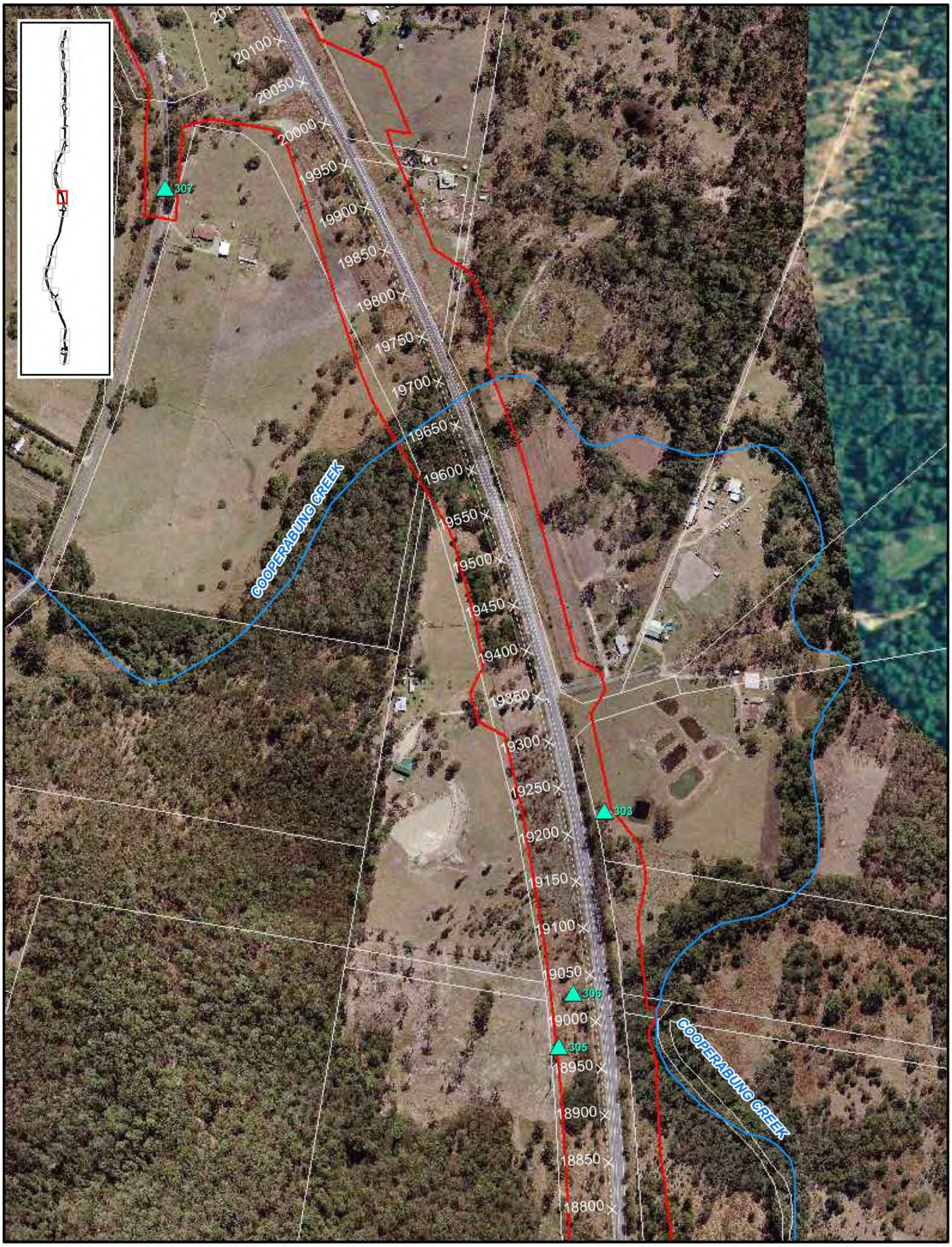
Cadastral boundary

Drainage line

FIGURE 2-1:

OXLEY HIGHWAY TO KEMPSEY PROJECT - HOLLOW BEARING TREES

Sheet 10 of 24



LEWIS ECOLOGICAL SURVEYS	Source:	Cadastre: Roads and Traffic Authority 2007 Project Boundary: Roads and Traffic Authority 2012 Drainage: Geoscience Australia 2009 Aerial Photogaraphy: Roads and Traffic Authority (date unknown) Green-thighed Frog Survey: Lewis Ecological Services 2013
	Disclaimer:	This plan is based on or contains data provided by others. Lewis Ecological Surveys. gives no warranty in relation to the data (including accuracy, reliability, completness, currency or suiability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to and use of the data. Data must not be used for direct marketing or be used in breach of privacy laws.
	File:	LES-OH2K-003-2171213c-Figure-2-1-HBT-130528

N W E S

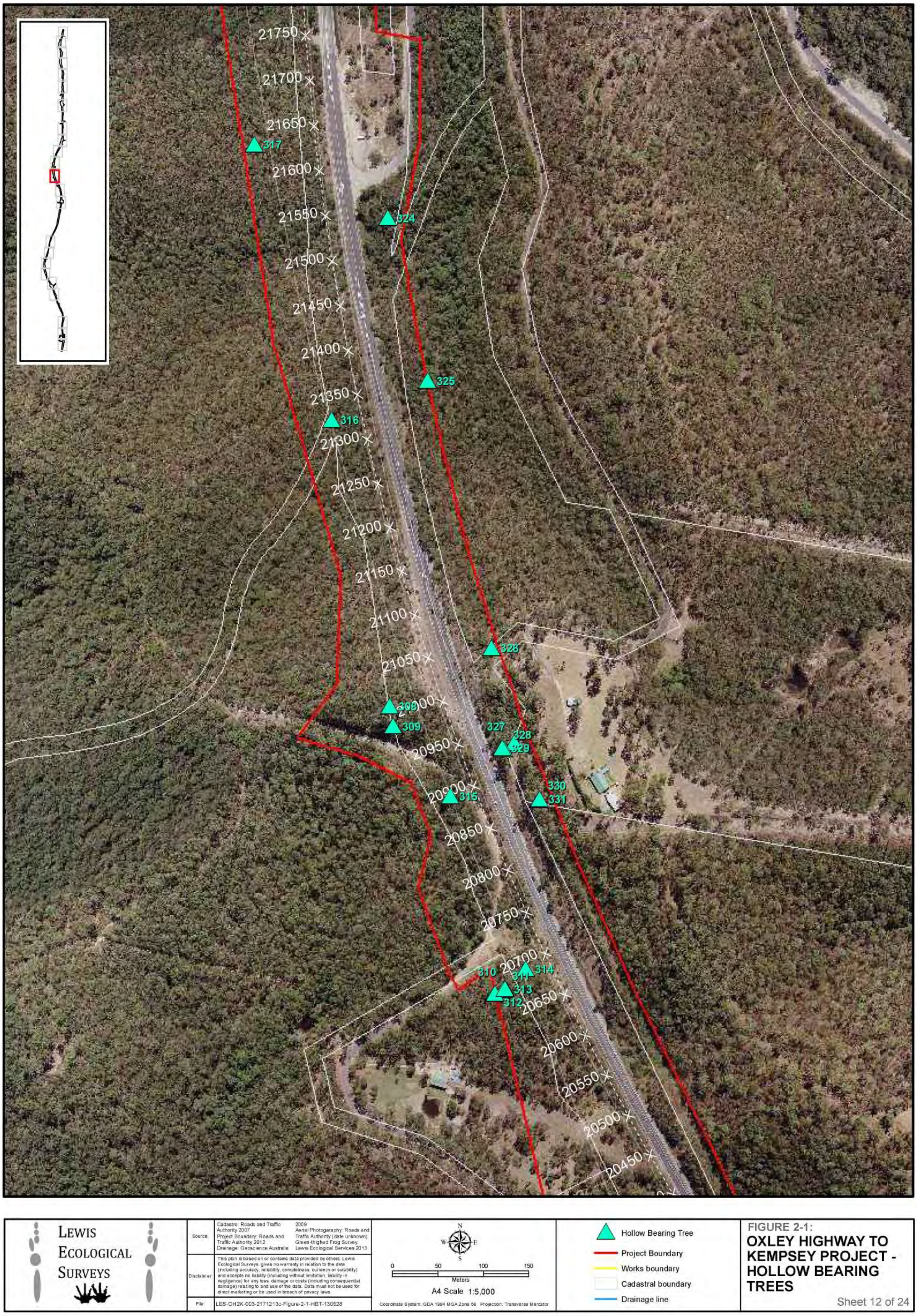
0 50 100 150
Meters
A4 Scale 1:5,000

Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator

Hollow Bearing Tree
Project Boundary
Works boundary
Cadastral boundary
Drainage line

FIGURE 2-1:
OXLEY HIGHWAY TO KEMPSEY PROJECT - HOLLOW BEARING TREES

Sheet 11 of 24



LEWIS ECOLOGICAL SURVEYS

Source:	Cadastre: Roads and Traffic Authority 2007; Project Boundary: Roads and Traffic Authority 2012; Drainage: Geoscience Australia 2009; Aerial Photogaraphy: Roads and Traffic Authority (date unknown); Green-thighed Frog Survey: Lewis Ecological Services 2013
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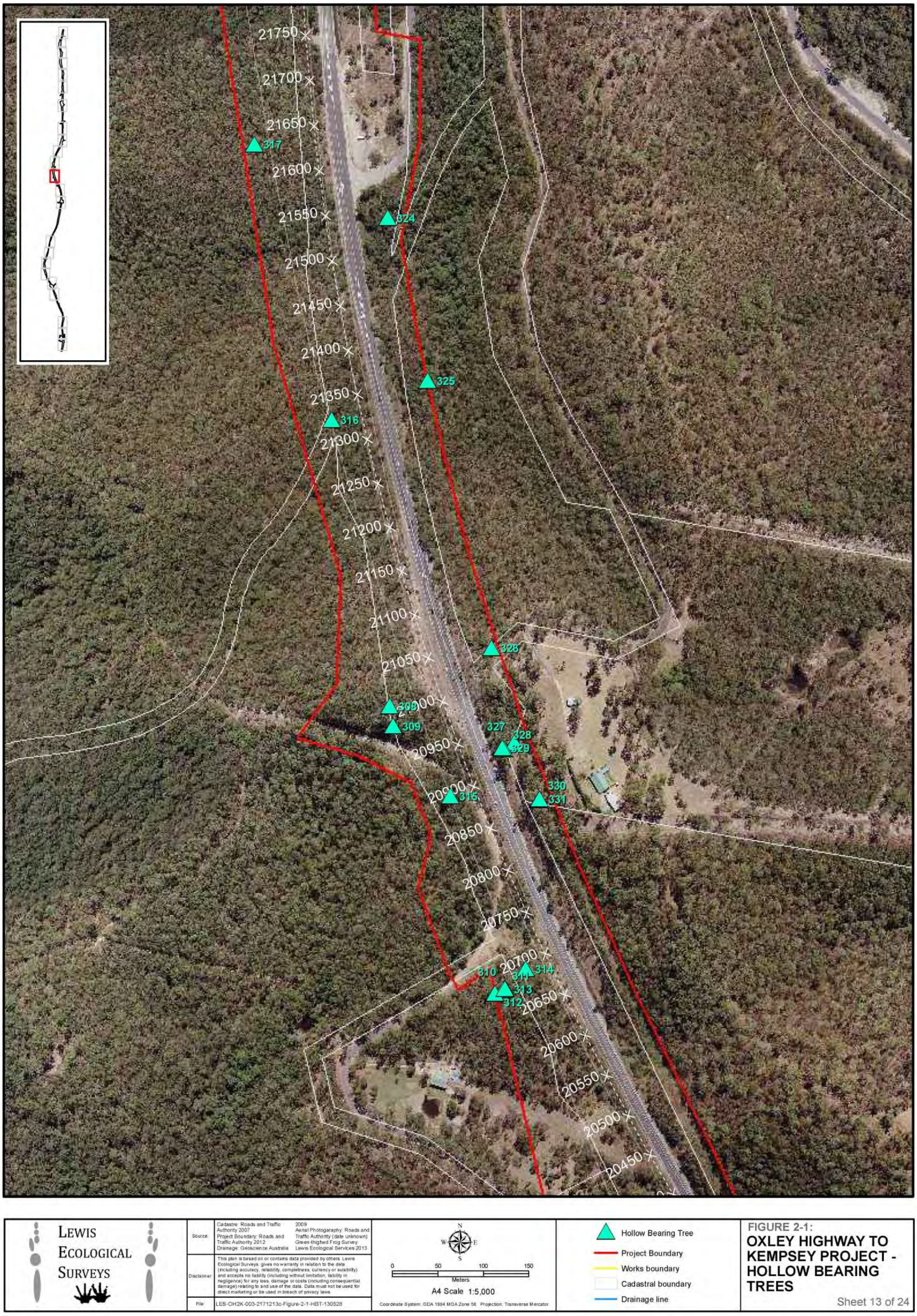
File:	LES-OH2K-003-2171213c-Figure-2-1-HBT-130528

FIGURE 2-1:
OXLEY HIGHWAY TO KEMPSEY PROJECT - HOLLOW BEARING TREES

Sheet 12 of 24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LEWIS ECOLOGICAL SURVEYS
Source: Cadastre: Roads and Traffic Authority 2007
Project Boundary: Roads and Traffic Authority 2012
Drainage: Geoscience Australia 2009
Aerial Photogaraphy: Roads and Traffic Authority (date unknown)
Green-thighed Frog Survey: Lewis Ecological Services 2013
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File: LES-OH2K-003-2171213c-Figure-2-1-HBT-130528
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Meters
A4 Scale 1:5,000
Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator
Hollow Bearing Tree
Project Boundary
Works boundary
Cadastral boundary
Drainage line
FIGURE 2-1:
OXLEY HIGHWAY TO KEMPSEY PROJECT - HOLLOW BEARING TREES
Sheet 13 of 24

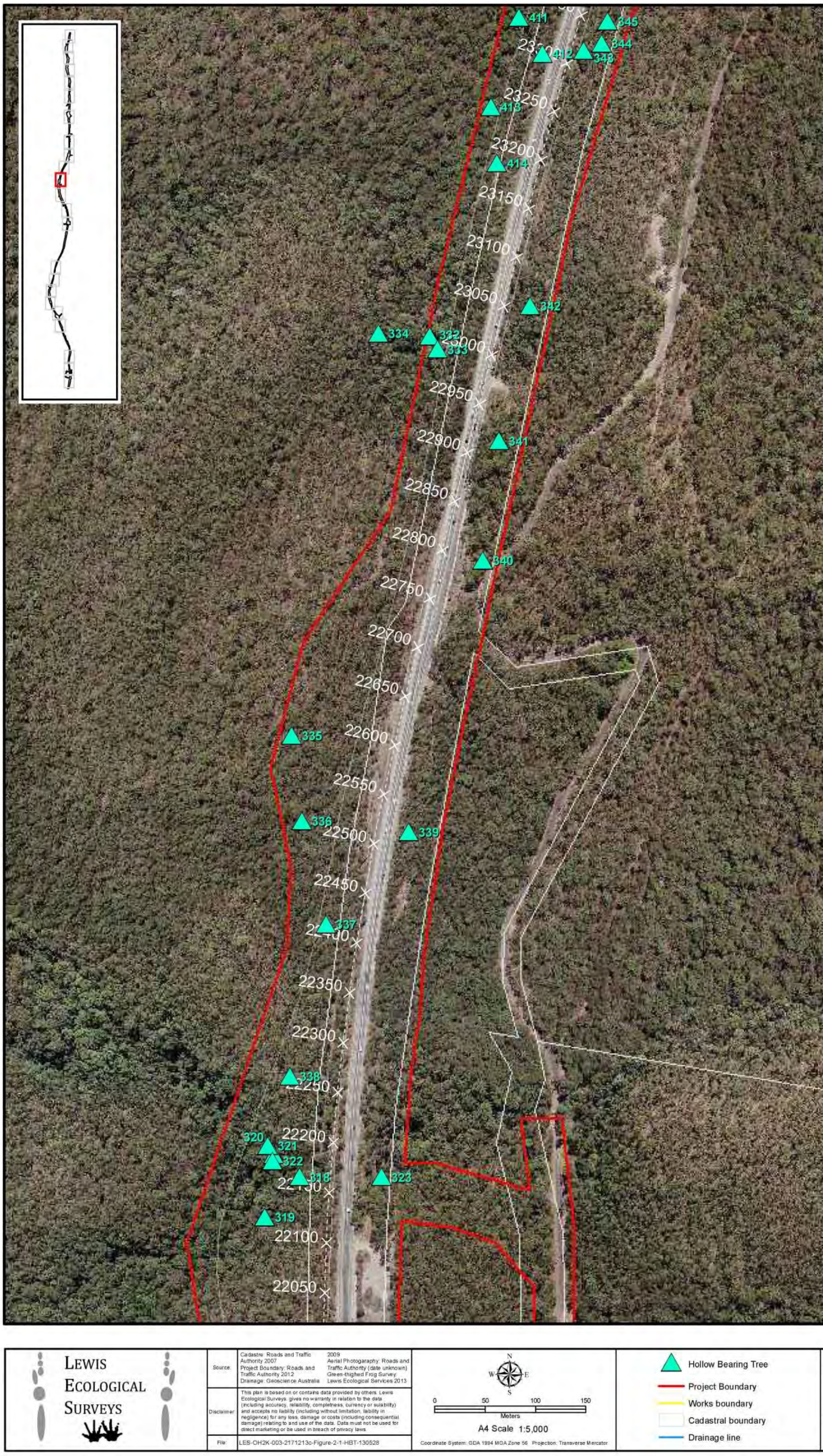


FIGURE 2-1:
OXLEY HIGHWAY TO KEMPSEY PROJECT - HOLLOW BEARING TREES

Sheet 14 of 24

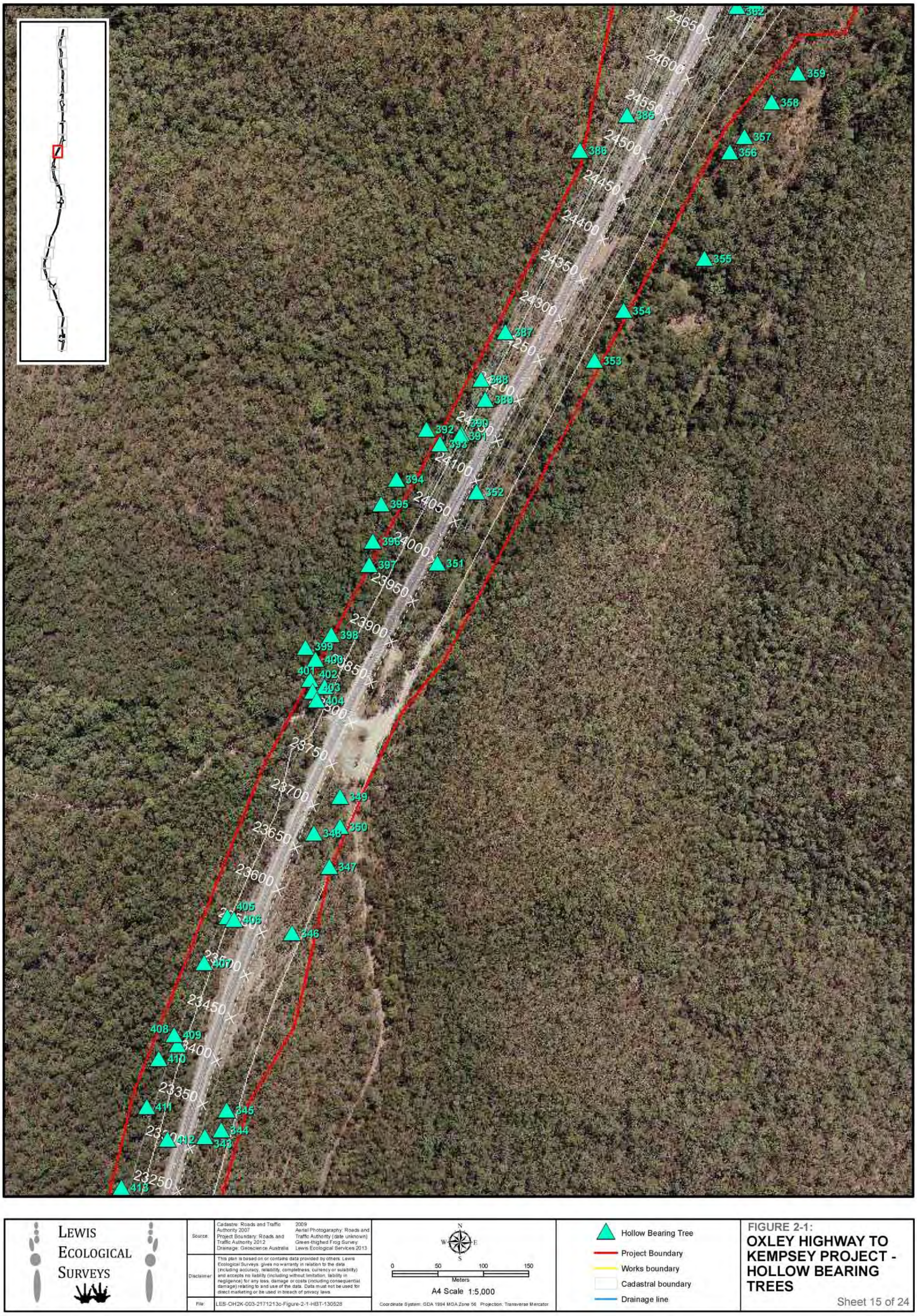
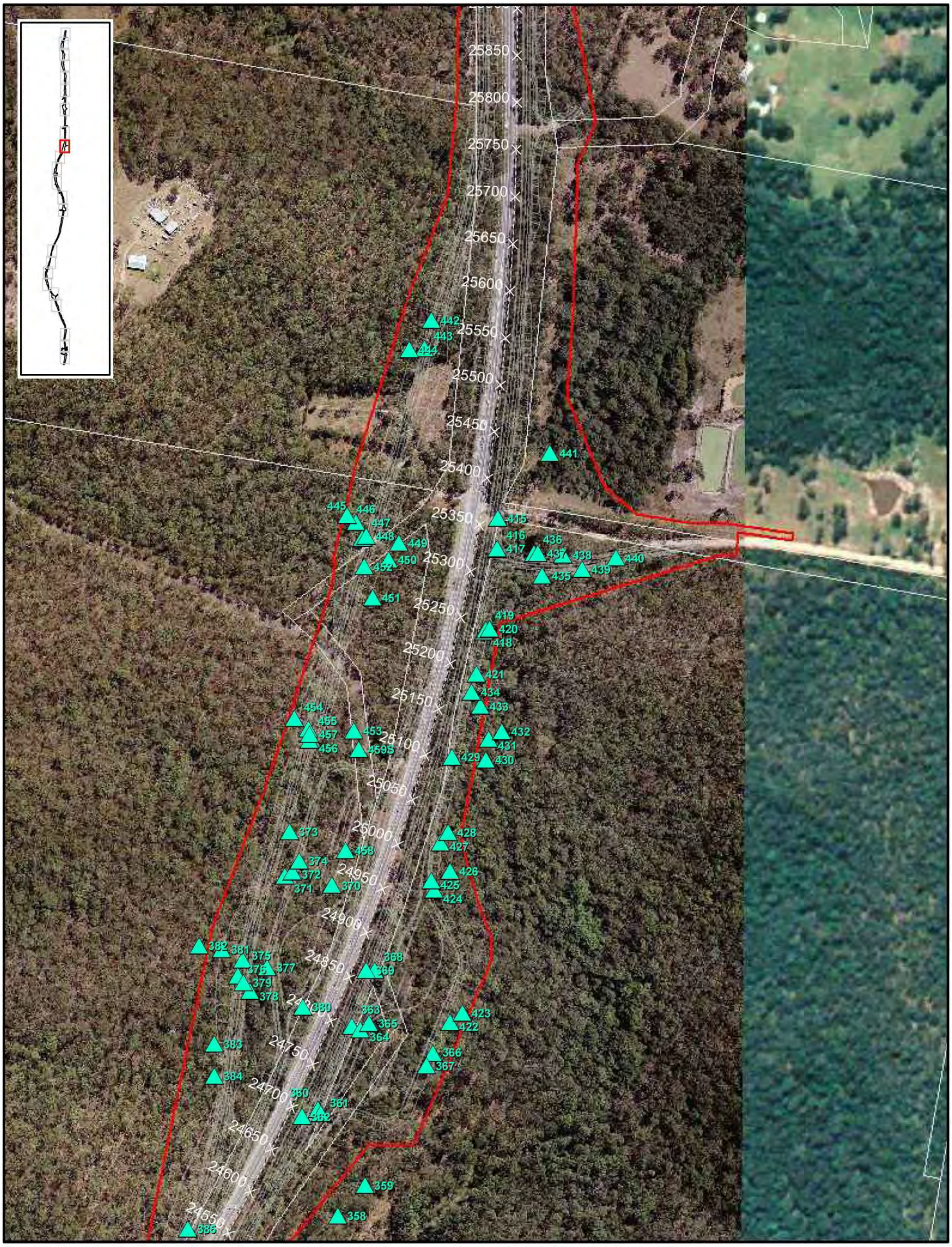


FIGURE 2-1:
OXLEY HIGHWAY TO KEMPSEY PROJECT - HOLLOW BEARING TREES



LEWIS ECOLOGICAL SURVEYS

Source	Cadastre: Roads and Traffic Authority 2007 Project Boundary: Roads and Traffic Authority 2012 Drainage: Geoscience Australia	2009 Aerial Photography: Roads and Traffic Authority (date unknown) Green-thighed Frog Survey: Lewis Ecological Services 2013
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File	LES-OH2K-003-2171213c-Figure-2-1-HBT-130528	

0 50 100 150
Meters
A4 Scale 1:5,000
Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator

- Hollow Bearing Tree
- Project Boundary
- Works boundary
- Cadastral boundary
- Drainage line

FIGURE 2-1:
OXLEY HIGHWAY TO KEMPSEY PROJECT - HOLLOW BEARING TREES

Sheet 16 of 24

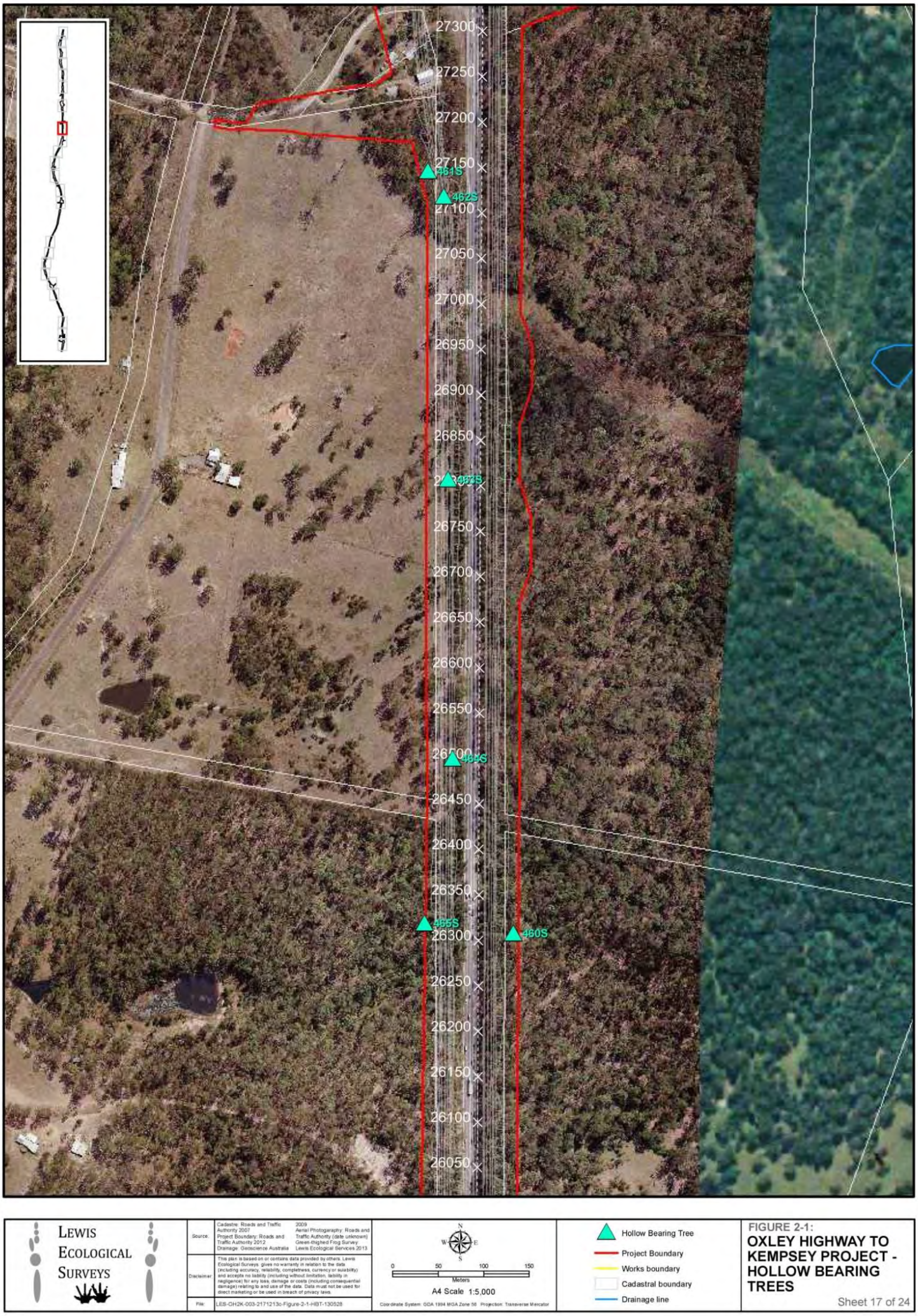
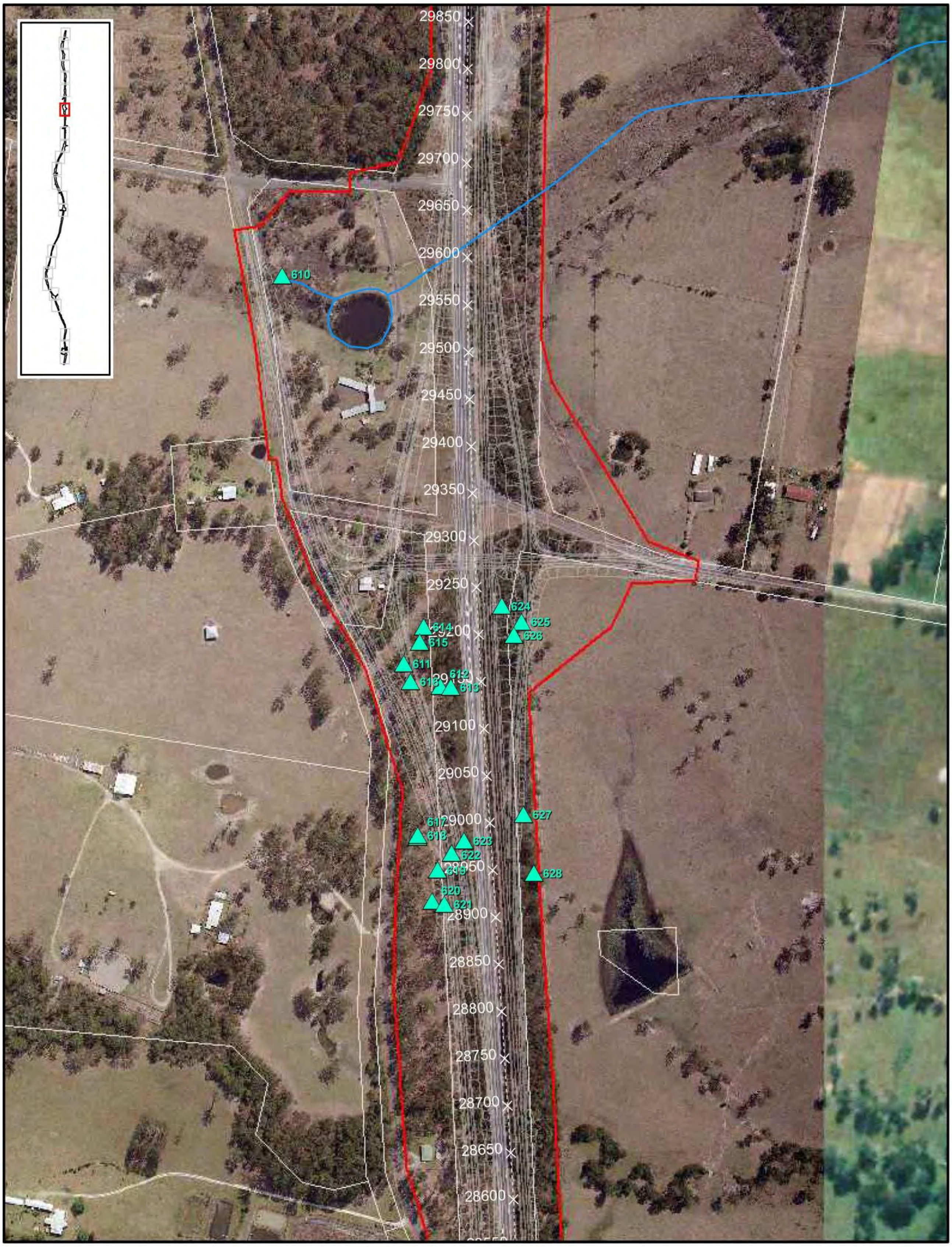


FIGURE 2-1:
OXLEY HIGHWAY TO KEMPSEY PROJECT - HOLLOW BEARING TREES

Note – No HBTs were recorded between ch.27350 and ch.28550 and therefore no figure has been provided.



LEWIS ECOLOGICAL SURVEYS		
Source:	Cadastre: Roads and Traffic Authority 2007 Project Boundary: Roads and Traffic Authority 2012 Drainage: Geoscience Australia	2009 Aerial Photogarаphy: Roads and Traffic Authority (date unknown) Green-thighed Frog Survey: Lewis Ecological Services 2013
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File:	LES-OH2K-003-2171213c-Figure-2-1-HBT-130528	

N W E S

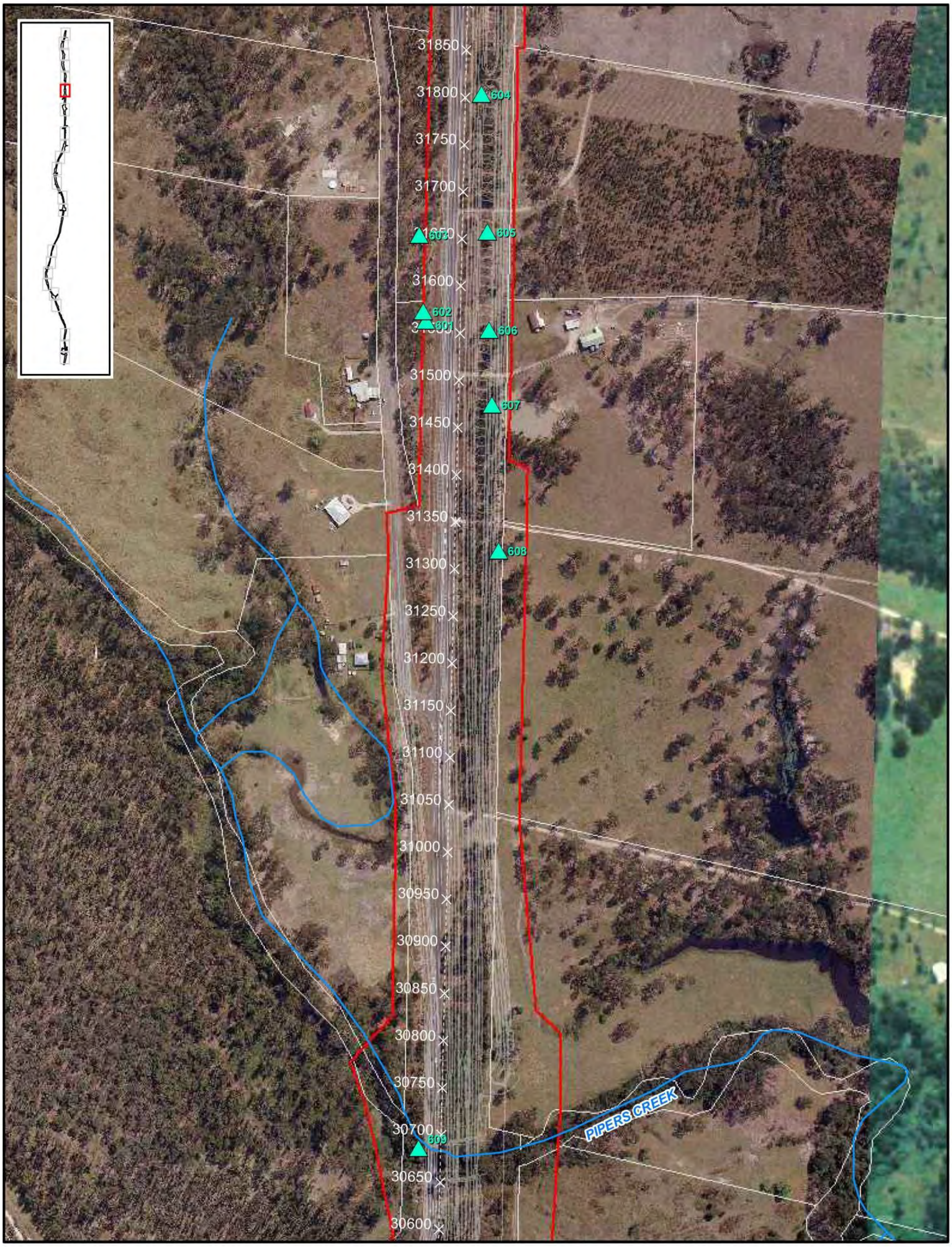
0 50 100 150
Meters
A4 Scale 1:5,000

Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator

Hollow Bearing Tree
Project Boundary
Works boundary
Cadastral boundary
Drainage line

FIGURE 2-1:
OXLEY HIGHWAY TO KEMPSEY PROJECT - HOLLOW BEARING TREES

Sheet 18 of 24



LEWIS ECOLOGICAL SURVEYS	Source:	Cadastre: Roads and Traffic Authority 2007 Project Boundary: Roads and Traffic Authority 2012 Drainage: Geoscience Australia	2009 Aerial Photogaraphy: Roads and Traffic Authority (date unknown) Green-thighed Frog Survey: Lewis Ecological Services 2013
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	File:	LES-OH2K-003-2171213c-Figure-2-1-HBT-130528	

N W E S

0 50 100 150

Meters

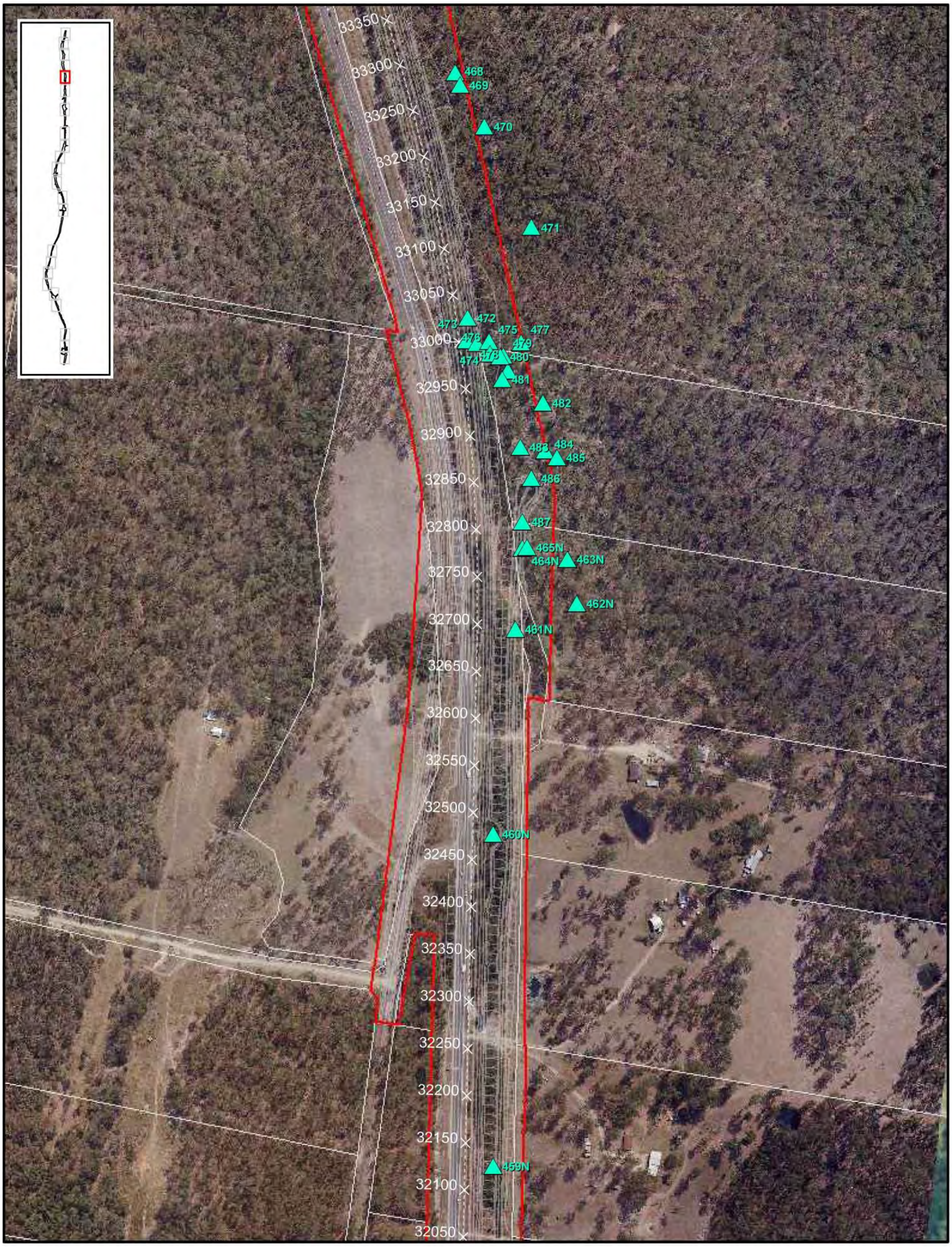
A4 Scale 1:5,000

Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator

Hollow Bearing Tree
Project Boundary
Works boundary
Cadastral boundary
Drainage line

FIGURE 2-1:
OXLEY HIGHWAY TO KEMPSEY PROJECT - HOLLOW BEARING TREES

Sheet 19 of 24



LEWIS ECOLOGICAL SURVEYS

Source:	Cadastre: Roads and Traffic Authority 2007 Project Boundary: Roads and Traffic Authority 2012 Drainage: Geoscience Australia 2009 Aerial Photogaraphy: Roads and Traffic Authority (date unknown) Green-thighed Frog Survey: Lewis Ecological Services 2013
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File:	LES-OH2K-003-2171213c-Figure-2-1-HBT-130528

N S W E

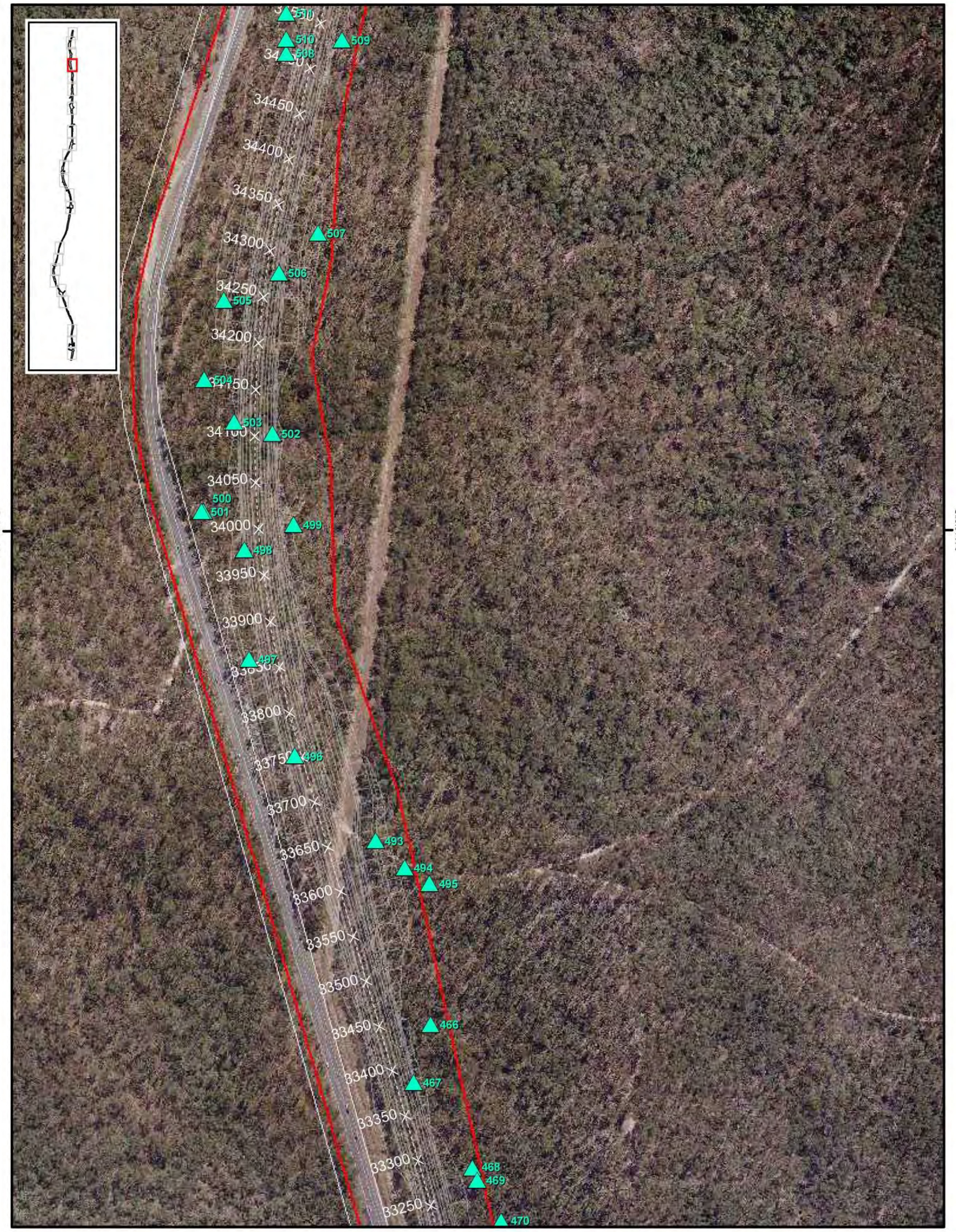
0 50 100 150
Meters
A4 Scale 1:5,000

Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator

Hollow Bearing Tree
Project Boundary
Works boundary
Cadastral boundary
Drainage line

FIGURE 2-1:
OXLEY HIGHWAY TO KEMPSEY PROJECT - HOLLOW BEARING TREES

Sheet 20 of 24



LEWIS ECOLOGICAL SURVEYS

Source:	Cadastre: Roads and Traffic Authority 2007; Project Boundary: Roads and Traffic Authority 2012; Drainage: Geoscience Australia; 2009 Aerial Photogaraphy: Roads and Traffic Authority (date unknown); Green-thighed Frog Survey: Lewis Ecological Services 2013
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File:	LES-OH2K-003-2171213c-Figure-2-1-HBT-130528

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Meters
A4 Scale 1:5,000

Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator

- Hollow Bearing Tree
- Project Boundary
- Works boundary
- Cadastral boundary
- Drainage line

FIGURE 2-1:
OXLEY HIGHWAY TO KEMPSEY PROJECT - HOLLOW BEARING TREES
Sheet 21 of 24

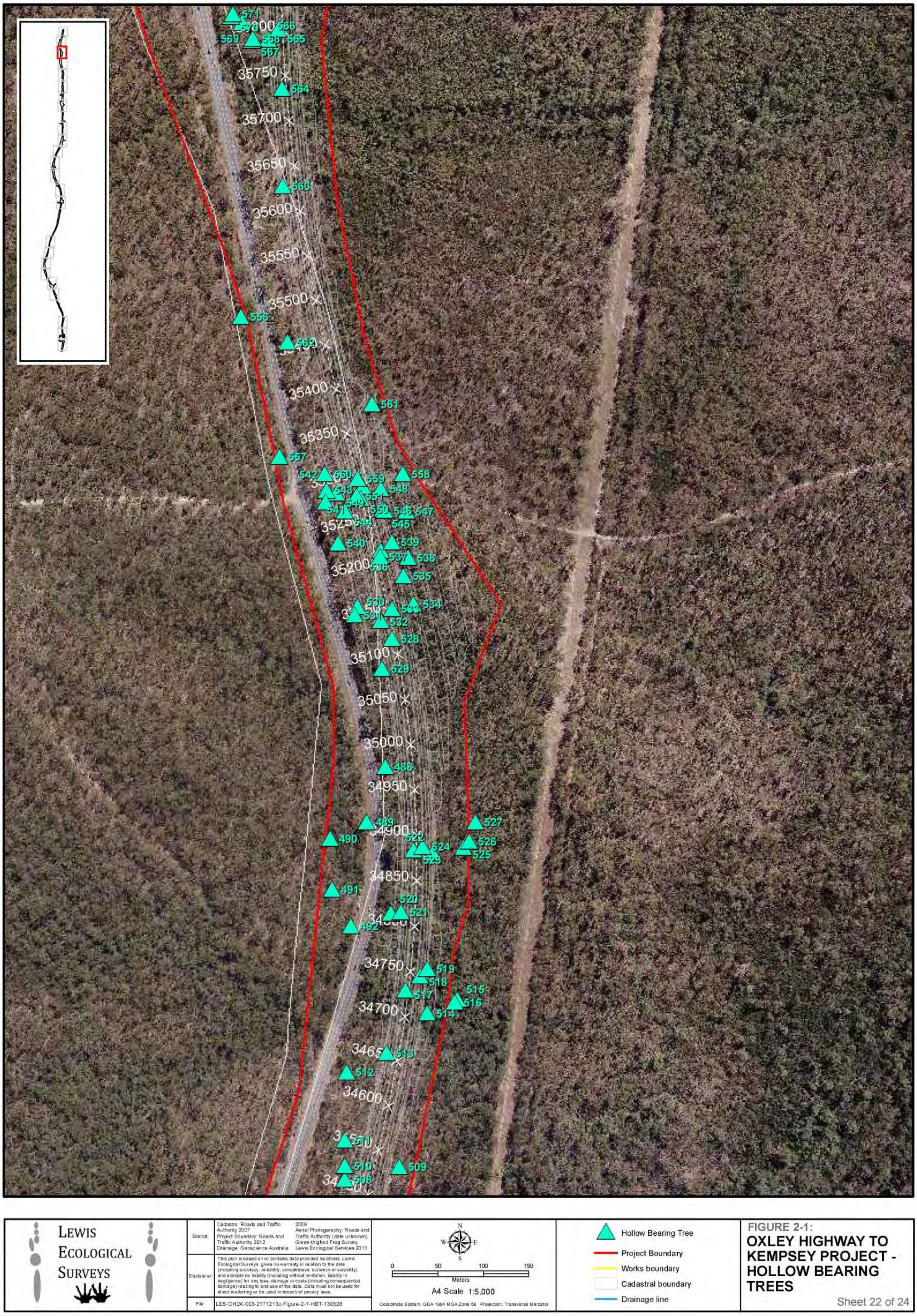
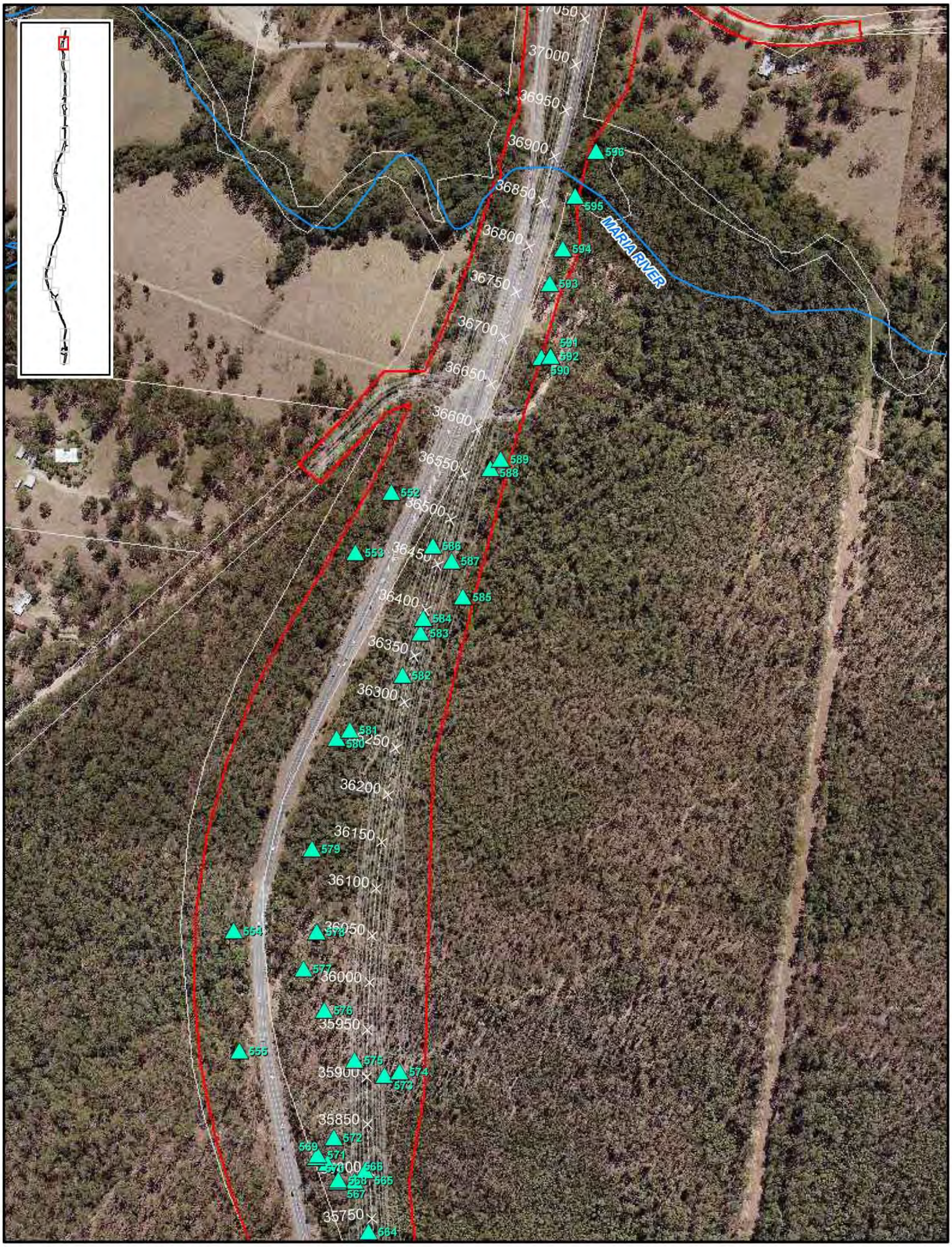


FIGURE 2-1: OXLEY HIGHWAY TO KEMPSEY PROJECT - HOLLOW BEARING TREES



LEWIS ECOLOGICAL SURVEYS	Source:	Cadastre: Roads and Traffic Authority 2007 Project Boundary: Roads and Traffic Authority 2012 Drainage: Geoscience Australia	2009 Aerial Photogaraphy: Roads and Traffic Authority (date unknown) Green-thighed Frog Survey: Lewis Ecological Services 2013
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	File:	LES-OH2K-003-2171213c-Figure-2-1-HBT-130528	

N W E S

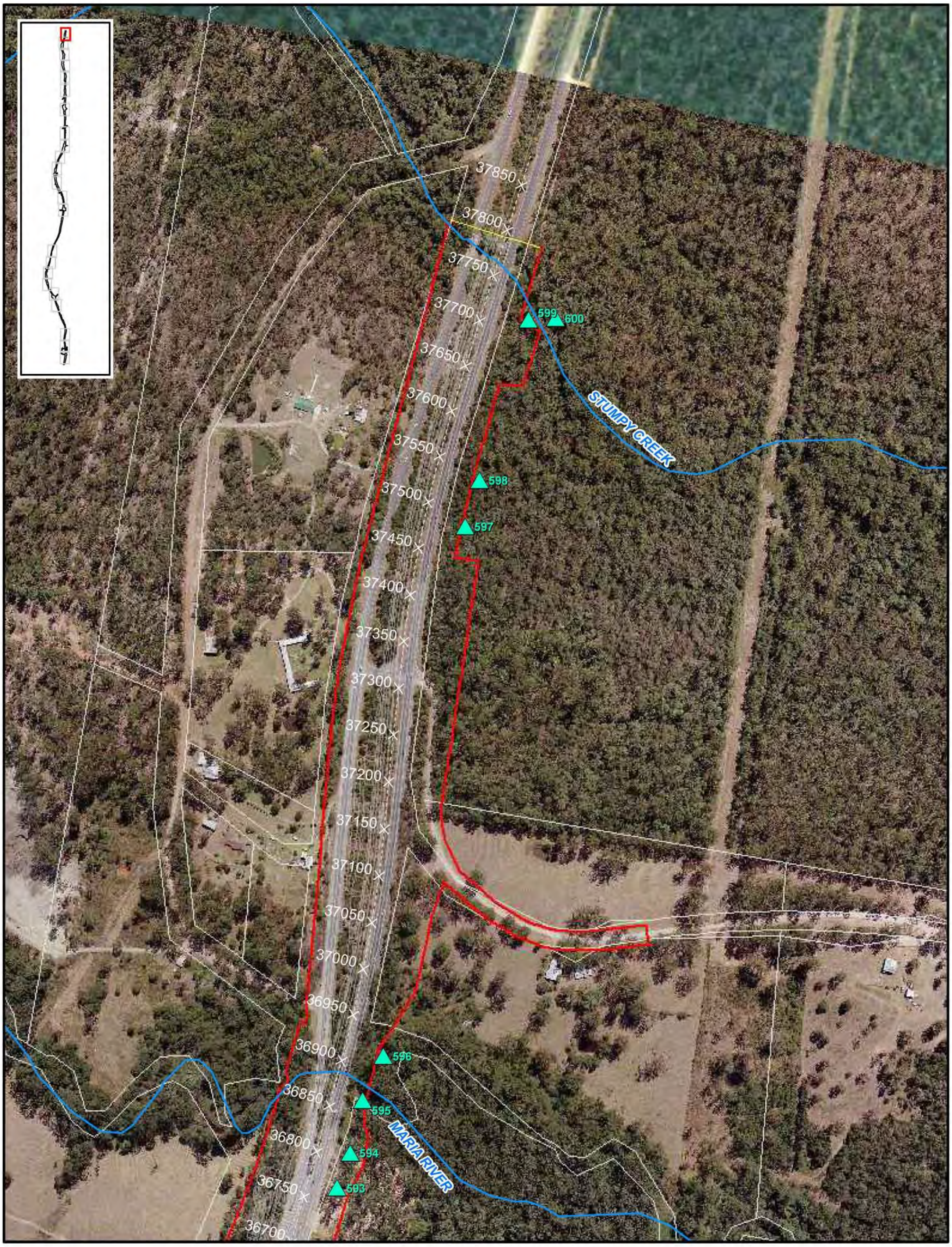
0 50 100 150
Meters
A4 Scale 1:5,000

Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator

Hollow Bearing Tree
Project Boundary
Works boundary
Cadastral boundary
Drainage line

FIGURE 2-1:
OXLEY HIGHWAY TO KEMPSEY PROJECT - HOLLOW BEARING TREES

Sheet 23 of 24



LEWIS ECOLOGICAL SURVEYS

Source:	Cadastre: Roads and Traffic Authority 2007 Project Boundary: Roads and Traffic Authority 2012 Drainage: Geoscience Australia 2009 Aerial Photogaraphy: Roads and Traffic Authority (date unknown) Green-thighed Frog Survey: Lewis Ecological Services 2013
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File:	LES-OH2K-003-2171213c-Figure-2-1-HBT-130528

N W E S

0 50 100 150

Meters

A4 Scale 1:5,000

Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator

- Hollow Bearing Tree
- Project Boundary
- Works boundary
- Cadastral boundary
- Drainage line

FIGURE 2-1:
OXLEY HIGHWAY TO KEMPSEY PROJECT - HOLLOW BEARING TREES

Sheet 24 of 24

Table C. Summary data from the hollow bearing tree survey conducted on those accessible properties for the Oxley Highway to Kempsey Pacific Highway Upgrade between September 2012 and May 2013.

HBT = Hollow bearing tree and reference number, ~ = approximate or estimate, No. Func. Holl. = Number of functional tree hollows SF = Scansorial fauna, MB = Microbats, Small gliders, LG = Larger Gliders, Po = Possums, Pa = Parrots, Lorikeets, Treecreeper, SO = Small owls, LFO = Large forest owls, EB = European Bees, LM = Lace Monitor, AH = Arboreal herpetofauna.

HBT Ref No.	Species	Easting	Northing	DBH (cm)	~Tree Height (m)	No. Func. Hol.	Trunk Butt	Trunk Fissures	Trunk Small	Trunk Medium	Trunk Large	Limb Small	Limb Medium	Limb Large	AH	SF	MB	SG	LG	Po	Pa	Co	SO	LFO	EB	LM	Comments
		WGS84	WGS84						<5cm	5-15 cm	>15 cm	<5cm	5-15 cm	>15 cm													
1	Pink Bloodwood	483156	6520367	88	18	3						2	1		1	1	1	1									
2	White Stringybark	483154	6520309	80	15	6			2	1		3			1	1	1	1	1	1	1						
3	Tallowwood	483151	6520319	60	17	5			2			2	1		1	1	1	1	1	1	1						
4	Stag	483136	6520264	45	9	1					1				1	1											
5	Pink Bloodwood	483061	6520024	105	23	7						3	3	1	1	1	1	1	1	1	1		1			1	
6	Pink Bloodwood	483171	6520173	145	23	21			2	2	2	2	8	5	1	1	1	1	1	1	1	1	1			1	
7	White Stringybark	483206	6520257	45	20	4		1				2	1		1	1	1	1									
8	White Stringybark	483203	6520240	70	20	4						2	2		1	1	1	1									
9	White Stringybark	483203	6520321	90	20	14			3			7	4		1	1	1	1	1		1						
10	Tallowwood	483221	6520346	90	15	15			3	3		4	4	1	1	1	1	1	1	1	1						
11	Pink Bloodwood	483209	6520396	95	19	6						3	2	1	1	1	1	1	1	1	1		1				
12	White Stringybark	483203	6520425	45	17	5			2			2	1		1	1	1	1									
13	White Stringybark	483260	6520387	90	20	15			2	2		5	4	2	1	1	1	1	1	1	1	1	1			1	
14	White Stringybark	483254	6520426	35	17	3			1			2			1	1	1	1									
15	Stag	483251	6520472	125	23	8					1	2	2	3	1	1	1	1	1	1	1	1	1			1	
16	White Stringybark	483233	6520505	105	21	5						3	2		1	1	1	1	1								
17	White Stringybark	483235	6520515	35	11	3				1		1	1		1	1	1	1	1								
18	White Stringybark	483268	6520524	80	17	8			2			4	2		1	1	1	1	1		1						A lot of White Stringybark contain potential tree hollows. Pre-clearing surveys will probably identify at least double the amount of tree identified for this nest box plan of management
19	Stag	483253	6520544	75	9	2		1			1				1	1				1						1	
20	White Stringybark	483236	6520568	95	15	4			1	1		2			1	1	1	1	1	1	1						
21	Pink Bloodwood	483280	6520662	95	17	8						5	2	1	1	1	1	1	1	1	1	1	1			1	
22	White Stringybark	483280	6520702	60	19	3						3			1	1	1	1									
23	Turpentine	483305	6520812	105	13	4						1	2	1	1	1				1							
24	Coastal Blackbutt	483328	6520833	100	23	14						8	4	2	1	1	1	1	1	1	1	1	1			1	
25	Coastal Blackbutt	483293	6520850	105	15	9		1			1	4	3		1	1	1	1			1						
26	Stag	483328	6520909	90	21	4			2	2							1			1		1				1	
27	White Stringybark	483328	6520900	35	13	1		1							1			1	1	1	1						
28	Stag	483333	6520958	135	25	19						7	6	6	1	1	1	1	1	1	1	1	1			1	
29	Stag	483364	6520941	95	19	10						5	4	1	1	1	1	1	1	1	1					1	native bees using medium limb hollow 14 mts above ground
30	White Stringybark	483362	6520991	55	17	7					1	4	2		1	1	1	1	1		1						
31	Pink Bloodwood	483355	6520969	45	17	5						3	2		1	1	1	1	1	1	1	1				1	

HBT Ref No.	Species	Easting	Northing	DBH (cm)	~Tree Height (m)	No. Func. Hol.	Trunk Butt	Trunk Fissures	Trunk Small	Trunk Medium	Trunk Large	Limb Small	Limb Medium	Limb Large	AH	SF	MB	SG	LG	Po	Pa	Co	SO	LFO	EB	LM	Comments
		WGS84	WGS84						<5cm	5-15 cm	>15 cm	<5cm	5-15 cm	>15 cm													
32	Pink Bloodwood	483357	6520983	125	22	9						4	3	2	1	1	1	1	1	1	1	1				1	
33	Pink Bloodwood	483324	6521005	110	22	14						6	5	3	1	1	1	1	1	1	1	1	1			1	
34	Pink Bloodwood	483354	6521048	125	24	9		1				5	3		1	1	1	1	1		1						
35	Stag	483299	6521039	40	14	2						2			1		1	1									
36	Coastal Blackbutt	483321	6521098	70	21	3						3			1		1	1									
37	Coastal Blackbutt	483291	6521128	80	20	4						3	1		1	1	1	1									
38	Coastal Blackbutt	483290	6521130	70	21	2						1	1		1	1	1	1									
39	Coastal Blackbutt	483344	6521195	75	19	3						3			1		1	1									
40	Coastal Blackbutt	483335	6521201	85	20	2						1	1		1		1	1									
41	Coastal Blackbutt	483334	6521229	105	21	6						4	2		1	1	1	1	1	1	1						
42	Stag	483264	6521427	55	18	11		1	3			4	3		1	1	1	1	1	1	1						
43	Stag	483270	6521427	50	18	9		1				5	3		1	1	1	1	1	1	1						
44	Coastal Blackbutt	483239	6521160	150	22	8						5	3		1	1	1	1	1	1	1						
45	Coastal Blackbutt	483242	6521144	105	20	6			2	1		2	1		1	1	1	1	1	1	1						
46	Coastal Blackbutt	483236	6521120	100	23	8			2	2		3	1		1	1	1	1	1	1	1						
47	Coastal Blackbutt	483230	6521089	80	19	5						3	2		1	1	1	1	1	1	1						
48	White Stringybark	483233	6521082	85	22	7						5	2		1	1	1	1	1	1	1						
49	White Stringybark	483250	6521040	65	17	6			1	1		3	1		1	1	1	1	1	1	1						
50	Pink Bloodwood	483229	6521034	90	19	9						6	3		1	1	1	1	1	1	1						
51	White Stringybark	483225	6520987	100	18	8						4	4		1	1	1	1	1	1	1						
52	Pink Bloodwood	483238	6520926	60	22	4							2	2	1	1	1	1	1	1	1						
53	Pink Bloodwood	483258	6520922	105	21	13					1	4	4	4	1	1	1	1	1	1	1	1	1			1	
54	Pink Bloodwood	483236	6520900	60	18	8			2	1		3	2		1	1	1	1	1	1	1						
55	White Mahogany	483214	6520762	105	16	14				3	1	3	4	3	1	1	1	1	1	1	1	1	1			1	
56	Pink Bloodwood	483219	6520754	55	18	2				1	1				1	1				1						1	
57	Pink Bloodwood	483183	6520595	75	19	6						4	2		1	1		1	1	1	1						
58	Stag	483183	6520597	175	11	4					1			3	1	1				1						1	
59	Pink Bloodwood	483168	6520597	85	21	14				2	2	4	4	2	1	1	1	1	1	1	1					1	Likely possum hollow
60	White Mahogany	483165	6520512	105	23	15	1			2	2	6	2	2	1	1	1	1	1	1	1	1	1			1	Really good basal hollow for bats
61	White Stringybark	483185	6520512	60	14	6			1			3	2		1	1	1	1	1	1	1						
62	Pink Bloodwood	483154	6520494	85	21	15				2	1	6	5	1	1	1	1	1	1	1	1	1	1			1	
63	Turpentine	483169	6520423	90	15	6						6			1			1									
64	White Mahogany	483146	6520410	90	21	17				2	2	7	3	3	1	1	1	1	1	1	1	1				1	
65	Coastal Blackbutt	483206	6521612	80	19	2						2			1		1	1									
66	Tallowwood	483406	6521452	65	17	3			3						1			1									
67	White Stringybark	483406	6521390	60	16	9			4	3		2			1	1	1	1	1		1						
68	Tallowwood	483400	6521370	50	16	2			2						1	1		1									

HBT Ref No.	Species	Easting	Northing	DBH (cm)	~Tree Height (m)	No. Func. Hol.	Trunk Butt	Trunk Fissures	Trunk Small	Trunk Medium	Trunk Large	Limb Small	Limb Medium	Limb Large	AH	SF	MB	SG	LG	Po	Pa	Co	SO	LFO	EB	LM	Comments
		WGS84	WGS84						<5cm	5-15 cm	>15 cm	<5cm	5-15 cm	>15 cm													
69	White Stringybark	483396	6521362	65	18	5						3	2		1	1	1	1									
70	Pink Bloodwood	483410	6521347	95	20	5				1		3	1		1	1	1	1	1								
71	Forest Red Gum	483398	6521312	100	13	7	1			2	1	1	2		1		1			1						1	Excellent basal hollow for bats with a deep chimney formation
72	White Mahogany	483214	6521689	60	17	8			2	2		2	2		1	1	1	1	1		1						
73	White Stringybark	483395	6521420	65	10	1				1					1	1		1									
74	Coastal Blackbutt	483157	6522578	70	23	3						2	1		1	1	1	1									
75	Coastal Blackbutt	483164	6522560	70	19	6						3	3		1	1	1	1	1		1						
76	Coastal Blackbutt	483186	6522667	105	19	4						3	1		1	1	1	1	1		1						
77	Coastal Blackbutt	483161	6522519	90	19	2						2			1		1	1									
78	Coastal Blackbutt	483190	6521734	125	23	2				1	1				1	1	1	1	1	1	1						
79	Stag	483173	6521825	85	23	8			2	2		3	1		1	1	1	1	1		1						
80	White Stringybark	483182	6521964	60	9	4		1	1	1	1				1	1				1						1	
81	White Stringybark	483178	6521982	70	15	8			3	1	1	3			1	1	1	1	1	1						1	
82	Turpentine	483160	6521973	70	16	2				2					1	1		1	1	1							
83	Pink Bloodwood	483159	6521987	80	20	6						3	3		1	1	1	1	1	1							
84	Stag	483140	6522180	40	20	5		1			1	2	1		1	1	1	1	1		1						
85	Coastal Blackbutt	483131	6522226	115	17	18				2	2	8	4	2	1	1	1	1	1	1	1	1	1			1	
86	Coastal Blackbutt	483125	6522302	75	19	3						3			1		1	1									
87	White Mahogany	483121	6522395	85	15	9				2	1	4	2		1	1	1	1	1	1	1					1	
88	White Stringybark	483068	6522603	40	12	2			1	1					1	1	1	1									
89	Stag	483103	6522626	95	22	11		1	3			3	2	2	1	1	1	1	1	1	1					1	
90	Coastal Blackbutt	483111	6522684	95	22	5						3	2		1	1	1	1	1		1						
91	White Stringybark	483086	6522735	60	16	5						3	2		1	1	1	1	1		1						
92	White Mahogany	483103	6522727	80	16	12				2	1	4	3	2	1	1	1	1	1	1	1	1	1			1	
93	White Stringybark	483099	6522726	95	19	3			2	1					1	1		1	1								
94	Coastal Blackbutt	483124	6522752	100	22	6						4	2		1	1	1	1	1		1						
95	Stag	483123	6522753	75	23	4		1	1			2			1		1	1									
96	Coastal Blackbutt	483121	6522755	95	20	6						3	3		1	1	1	1	1		1						
97	White Stringybark	483116	6522828	100	15	5						3	2		1	1	1	1	1		1						
98	White Stringybark	483137	6522923	45	16	5			3			2			1	1	1	1									
99	White Stringybark	483125	6522920	45	15	5			2	1		2			1	1	1	1									
100	White Stringybark	483210	6523429	85	17	4			2	1			1		1	1		1									
101	Forest Red Gum	483244	6523070	80	18	2						2			1	1	1	1									
102	Tallowwood	483213	6523036	95	18	6						4	2		1	1	1	1									
103	Coastal Blackbutt	483218	6523019	115	15	4						2	2		1	1	1	1									
104	Coastal Blackbutt	483221	6522925	85	18	8				1		4	3		1	1	1	1	1		1						
105	White Stringybark	483217	6522898	70	19	4						2	2		1	1	1	1	1		1						

HBT Ref No.	Species	Easting	Northing	DBH (cm)	~Tree Height (m)	No. Func. Hol.	Trunk Butt	Trunk Fissures	Trunk Small	Trunk Medium	Trunk Large	Limb Small	Limb Medium	Limb Large	AH	SF	MB	SG	LG	Po	Pa	Co	SO	LFO	EB	LM	Comments
		WGS84	WGS84						<5cm	5-15 cm	>15 cm	<5cm	5-15 cm	>15 cm													
106	White Stringybark	483196	6522873	45	17	4						2	2		1	1	1	1	1		1						
107	Coastal Blackbutt	483174	6522869	105	23	9						4	4	1	1	1	1	1	1	1	1					1	Dam at base of this tree so likely to be a good microbat roost
108	Coastal Blackbutt	483189	6522851	100	21	5						2	2	1	1	1	1	1	1		1						
109	White Mahogany	483215	6522851	100	18	2				1	1				1	1				1						1	
110	Prickly Tea Tree	483195	6522838	35	9	2			1	1					1	1											
111	White Stringybark	483172	6522815	50	18	4						2	2		1	1	1	1	1		1						
112	Coastal Blackbutt	483187	6522790	95	23	10			2	1		3	3	1	1	1	1	1	1	1	1		1			1	
113	White Stringybark	483182	6522818	90	20	8			2	1		3	2		1	1	1	1	1	1	1						
114	White Mahogany	483160	6522788	80	21	4						2	2		1	1	1	1	1	1	1						
115	Swamp Mahogany	483180	6522753	65	16	4						2	2		1	1	1	1	1		1						
116	Weeping Bottlebrush	483171	6522688	30	12	1				1					1	1		1									
117	Stag	483186	6522667	95	14	6				2	3			1	1	1				1						1	
118	Coastal Blackbutt	482468	6525815	80	17	2						2			**1**		1	1									
119	Coastal Blackbutt	482492	6525753	75	18	4			1			2	1		**1**	1	1	1			1						
120	Coastal Blackbutt	482497	6525713	85	16	5						4	1		**1**	1	1	1			1						
121	Pink Bloodwood	482508	6525656	75	16	3						2	1		**1**	1	1	1			1						
122	Coastal Blackbutt	482493	6525673	95	17	4						3	1		**1**	1	1	1	1		1						
123	Coastal Blackbutt	482491	6525675	85	17	5						4	1		1	1	1	1	1		1						
124	Coastal Blackbutt	482401	6525798	105	17	4						3	1		1	1	1	1	1		1						
125	Stag	482385	6525951	45	12	13		1	4	3	1	1	2	1	1	1	1	1	1	1	1					1	
126	Coastal Blackbutt	482247	6526330	95	23	3						2	1		1	1	1	1									
127	Stag	482257	6526343	40	9	2		1			1				1		1			1						1	
128	Stag	482269	6526351	50	11	3		1	2						1	1	1	1									
129	Coastal Blackbutt	482286	6526349	85	22	5				1		3	1		1	1	1	1	1	1	1					1	
130	White Stringybark	482243	6526405	65	19	5				1		3	1		1	1	1	1	1	1	1					1	
131	Coastal Blackbutt	482218	6526371	70	21	4		1				2	1		1	1	1	1	1	1	1					1	
132	Stag	482276	6526387	35	8	2		1		1					1	1				1							
133	Coastal Blackbutt	482309	6526397	80	18	6						4	2		1	1	1	1	1		1						
134	Coastal Blackbutt	482296	6526366	95	22	4						3	1		1	1	1	1	1		1						
135	Stag	482355	6526302	95	18	5						3	2		1	1	1	1	1		1						
136	Coastal Blackbutt	482456	6526071	50	17	1				1					1	1				1							
137	Coastal Blackbutt	482415	6526014	55	16	1							1		1	1		1	1								
138	Coastal Blackbutt	482460	6526017	55	19	2						1	1		1	1	1	1	1								
139	Coastal Blackbutt	481959	6526984	85	24	6				1		3	2		1	1	1	1	1		1						
140	Coastal Blackbutt	481994	6526915	70	23	3						2	1		1	1	1	1	1		1						
141	Coastal Blackbutt	481985	6526924	65	21	4						2	2		1	1	1	1	1		1						

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		WGS84	WGS84						<5cm	5-15 cm	>15 cm	<5cm	5-15 cm	>15 cm													
142	Coastal Blackbutt	482017	6526860	75	23	6				1	1	2	2		1	1	1	1	1		1						
143	Stag	482019	6526853	45	15	4			1	1		1	1		1	1	1	1	1	1	1					1	
144	Coastal Blackbutt	482050	6526826	100	20	3						1	2		1	1	1	1	1	1	1					1	
145	Tallowwood	482115	6526752	85	17	7						4	3		1	1	1	1	1		1						
146	Coastal Blackbutt	482097	6526702	80	21	5						3	2		1	1	1	1	1		1						
147	Coastal Blackbutt	482184	6526603	85	24	4						3	1		1	1	1	1	1		1						
148	Coastal Blackbutt	482220	6526469	60	19	3						2	1		1	1	1	1									
149	Coastal Blackbutt	482094	6526671	65	20	4						2	2		1	1	1	1									
150	Coastal Blackbutt	481834	6527123	100	25	4						2	2		1	1	1	1									
151	White Mahogany	481762	6527169	95	23	15			1	1		6	5	2	1	1	1	1	1	1	1		1			1	
152	White Stringybark	481759	6527348	70	17	3						3			1		1	1									
153	Coastal Blackbutt	481796	6527394	100	22	3						2	1		1	1	1	1	1		1						
154	Stag	481913	6527184	130	26	5						1	3	1	1	1	1	1	1	1	1	1	1	1		1	Possible Masked Owl roost/nest site. Requires confirmation
155	Stag	481935	6527130	95	24	7						4	2	1	1	1	1	1	1		1						
156	Coastal Blackbutt	482053	6526960	90	26	5						4	1		1	1	1	1	1		1						
157	White Stringybark	481837	6527205	65	19	3						3			1		1	1									
158	Coastal Blackbutt	482137	6526776	105	22	11						6	4	1	1	1	1	1	1	1	1	1	1			1	
159	Coastal Blackbutt	482164	6526761	85	21	6						5	1		1	1	1	1	1	1	1	1	1			1	
160	Coastal Blackbutt	482292	6526494	95	20	3						3			1		1	1									
161	Coastal Blackbutt	482133	6526841	70	21	3						2	1		1	1	1	1	1		1						
162	Stag	482137	6526961	175	16	8						2	2	4	1	1	1	1	1	1	1	1	1	1		1	
163	White Stringybark	482429	6527310	70	20	2						2			1		1	1									
164	Stag	482383	6527265	60	10	2			1	1					1	1	1	1			1						
165	Stag	482370	6527251	105	14	1					1				1	1				1						1	
166	White Mahogany	482003	6527098	65	22	2						2			1	1				1						1	
167	Coastal Blackbutt	481996	6527086	75	21	7						5	2		1	1	1	1	1		1						
168	Pink Bloodwood	481686	6527684	90	21	10						8	2		1	1	1	1	1		1						
169	Coastal Blackbutt	481672	6527717	115	26	5						4	1		1	1	1	1	1		1						
170	Stag	481587	6527775	105	27	14						4	3	7	1	1	1	1	1	1	1		1			1	
171	Stag	481586	6527892	105	16	8						3	3	2	1	1	1	1	1	1	1		1			1	
172	Coastal Blackbutt	481397	6528205	95	23	7						4	3		1	1	1	1	1		1						
173	White Stringybark	481255	6528423	70	21	5						3	2		1	1	1	1	1		1						
174	Pink Bloodwood	481282	6528341	105	25	13						7	5	1	1	1	1	1	1	1	1		1			1	
175	Coastal Blackbutt	481390	6528070	95	21	5						4	1		1	1	1	1	1		1						
176	Coastal Blackbutt	481409	6528006	100	22	6						4	2		1	1	1	1	1		1						
177	Coastal Blackbutt	481454	6527890	110	29	4						3	1		1	1	1	1									
178	Coastal Blackbutt	481471	6527858	100	28	4						4			1	1	1	1	1		1					1	

HBT Ref No.	Species	Easting	Northing	DBH (cm)	~Tree Height (m)	No. Func. Hol.	Trunk Butt	Trunk Fissures	Trunk Small	Trunk Medium	Trunk Large	Limb Small	Limb Medium	Limb Large	AH	SF	MB	SG	LG	Po	Pa	Co	SO	LFO	EB	LM	Comments
		WGS84	WGS84						<5cm	5-15 cm	>15 cm	<5cm	5-15 cm	>15 cm													
179	Coastal Blackbutt	481473	6527858	85	23	7						4	3		1	1	1	1	1		1						
180	Coastal Blackbutt	481497	6527823	105	23	7						4	3		1	1	1	1	1		1						
181	Coastal Blackbutt	481634	6527711	105	22	5			1			3	1		1	1	1	1	1		1						
182	Pink Bloodwood	481652	6527705	90	21	4						2	2		1	1	1	1	1		1						
183	Coastal Blackbutt	481253	6528837	115	25	17						9	6	2	1	1	1	1	1	1	1	1	1			1	
184	Stag	481262	6528839	85	21	10			1			1	3	5	1	1	1	1	1	1	1	1	1			1	
185	Tallowwood	481279	6528767	85	23	10			2			4	3	1	1	1	1	1	1	1	1					1	
186	Coastal Blackbutt	481269	6528876	135	30	21						11	6	4	1	1	1	1	1	1	1		1			1	
187	Stag	481215	6528970	130	28	7					1	2	2	2	1	1	1	1	1	1	1		1			1	
188	Coastal Blackbutt	481209	6528996	110	21	5						4	1		1	1	1	1	1		1						
189	Stag	481228	6529013	80	9	2			2						1	1		1									
190	White Mahogany	481116	6529529	80	21	5						3	2		1	1	1	1	1		1						
191	Stag	481159	6529505	95	17	3		1				2			1	1	1	1									
192	Stag	481202	6529525	95	14	26		1	2	2	1	7	9	4	1	1	1	1	1	1	1					1	
193	White Stringybark	481198	6529487	75	21	3						2	1		1	1	1	1	1		1						
194	Pink Bloodwood	481194	6529470	105	15	23			1	1		13	6	2	1	1	1	1	1	1	1	1	1			1	
195	White Stringybark	481174	6529403	110	25	8			2	1		3	1	1	1	1	1	1	1	1	1	1	1			1	
196	Pink Bloodwood	481172	6529387	115	25	26			2	2		11	5	6	1	1	1	1	1	1	1	1	1			1	
197	Coastal Blackbutt	481167	6529349	90	24	5						3	2		1	1	1	1	1		1						
198	White Mahogany	481100	6528995	80	21	3						2	1		1	1	1	1	1		1						
199	White Stringybark	481100	6528968	65	17	4						2	2		1	1	1	1	1		1						
200	Stag	481116	6528975	55	15	3						2	1		1	1	1	1									
201	Coastal Blackbutt	481137	6528942	100	29	7						4	2	1	1	1	1	1	1		1						
202	Coastal Blackbutt	481223	6528664	85	21	3						2	1		1	1	1	1	1		1						
203	Coastal Blackbutt	481218	6528624	90	24	5						2	2	1	1	1	1	1	1	1	1						
204	White Stringybark	481251	6528885	85	24	5						3	2		1	1	1	1	1		1						
205	Coastal Blackbutt	481184	6529924	90	21	3						2	1		1	1	1	1	1		1						
206	Stag	481218	6529912	55	10	3		1				2			1	1	1	1									
207	Stag	481220	6529922	55	12	2		1				1			1	1	1	1									
208	Stag	481226	6529921	45	12	5		1				2	2		1	1	1	1			1						
209	Stag	481243	6529873	90	22	5		1				2	1	1	1	1	1	1	1	1	1		1			1	
210	Stag	481269	6529867	95	22	17		1				8	4	4	1	1	1	1	1	1	1		1			1	Excellent Yellow-bellied Glider den tree
211	Coastal Blackbutt	481205	6529798	80	14	3						2	1		1	1	1	1	1		1						
212	Stag	481203	6529782	70	14	7						4	2	1	1	1	1	1	1		1						
213	Stag	481179	6529809	40	10	3		1				2			1		1	1									High likelihood of supporting Squirrel Gliders
214	Stag	481170	6529812	40	12	4				1		2	1		1	1	1	1	1		1						High likelihood of supporting Squirrel Gliders
215	Stag	481176	6529831	70	12	3		1			1			1	1	1	1			1							High likelihood of supporting

HBT Ref No.	Species	Easting	Northing	DBH (cm)	~Tree Height (m)	No. Func. Hol.	Trunk Butt	Trunk Fissures	Trunk Small	Trunk Medium	Trunk Large	Limb Small	Limb Medium	Limb Large	AH	SF	MB	SG	LG	Po	Pa	Co	SO	LFO	EB	LM	Comments
		WGS84	WGS84						<5cm	5-15 cm	>15 cm	<5cm	5-15 cm	>15 cm													
																											Squirrel Gliders
216	Coastal Blackbutt	481152	6529808	70	21	2						1	1		1	1	1	1	1		1						High likelihood of supporting Squirrel Gliders
217	White Mahogany	481142	6529776	105	21	11						5	4	2	1	1	1	1	1	1	1		1			1	High likelihood of supporting Squirrel Gliders
218	White Mahogany	481141	6529769	115	21	30				2	2	12	8	6	1	1	1	1	1	1	1	1	1			1	High likelihood of supporting Squirrel Gliders
219	White Mahogany	481128	6529773	105	20	13						5	6	2	1	1	1	1	1	1	1	1	1			1	High likelihood of supporting Squirrel Gliders
220	Stag	481146	6529740	105	14	3						1	1	1	1	1	1			1							High likelihood of supporting Squirrel Gliders
221	Coastal Blackbutt	481167	6529757	135	21	6						4	2		1	1	1	1	1		1						High likelihood of supporting Squirrel Gliders
222	White Mahogany	481168	6529750	75	18	5						3	2		1	1	1	1	1		1						High likelihood of supporting Squirrel Gliders
223	White Mahogany	481199	6529771	130	21	21				2	2	8	6	3	1	1	1	1	1	1	1	1	1	1		1	High likelihood of supporting Squirrel Gliders
224	Stag	481150	6529724	65	13	3		1	2						1	1		1									High likelihood of supporting Squirrel Gliders
225	Stag	481147	6529709	90	24	8		1				3	2	2	1	1	1	1	1	1	1	1	1			1	High likelihood of supporting Squirrel Gliders
226	Coastal Blackbutt	481169	6529612	110	32	4						3	1		1	1	1	1	1		1						High likelihood of supporting Squirrel Gliders
227	Coastal Blackbutt	481180	6529682	115	27	4						2	2		1	1	1	1	1		1						High likelihood of supporting Squirrel Gliders
228	White Mahogany	481217	6529661	120	24	10						7	3		1	1	1	1	1		1						High likelihood of supporting Squirrel Gliders
229	White Mahogany	481224	6529590	75	21	4						2	2		1	1	1	1	1		1						
230	White Mahogany	481219	6529583	110	22	18				2	1	9	4	2	1	1	1	1	1	1	1		1			1	
231	White Mahogany	481220	6529585	45	14	2						2				1	1	1									
232	Stag	481219	6529577	105	13	4		1				1	2		1	1	1	1	1								
233	White Mahogany	481214	6529579	110	22	15		1	3	1		2	5	3	1	1	1	1	1	1	1		1			1	
234	White Mahogany	481210	6529578	65	18	7						3	3	1	1	1	1	1	1	1	1						
235	Swamp Mahogany	481212	6529682	115	22	3						2	1		1	1		1	1	1	1						
236	White Stringybark	481207	6529569	55	13	4			3	1					1	1		1									
237	Stag	481224	6529723	75	16	2						2			1	1		1									
238	Stag	481230	6529770	105	18	7						5	2		1	1	1	1	1	1	1						
239	Coastal Blackbutt	481251	6529821	100	20	13			2	2		2	5	2	1	1	1	1	1	1	1		1			1	
240	Stag	481273	6529927	65	9	2		1						1	1	1				1						1	
241	Stag	481249	6529926	100	21	9	1	1				2	2	3	1	1	1	1	1	1	1		1			1	
242	Stag	481324	6530272	40	20	3			2	1					1	1		1									
243	White Mahogany	481349	6530302	100	23	17						7	4	6	1	1	1	1	1	1	1	1	1			1	
244	Stag	481380	6530358	105	21	7		1			2			4	1	1				1	1					1	A lot of stags in this area have been ring barked using chainsaw as part of forestry stand improvement techniques
245	Stag	481401	6530360	85	16	7		1		3		2	1		1	1	1	1	1		1						
246	Stag	481423	6530338	70	16	10						1	5	4	1	1	1	1	1	1	1		1			1	Good Yellow-bellied Glider den tree

HBT Ref No.	Species	Easting	Northing	DBH (cm)	~Tree Height (m)	No. Func. Hol.	Trunk Butt	Trunk Fissures	Trunk Small	Trunk Medium	Trunk Large	Limb Small	Limb Medium	Limb Large	AH	SF	MB	SG	LG	Po	Pa	Co	SO	LFO	EB	LM	Comments
		WGS84	WGS84						<5cm	5-15 cm	>15 cm	<5cm	5-15 cm	>15 cm													
247	Stag	481504	6530498	80	11	4		1				1	1	1	1	1	1	1	1		1						
248	Coastal Blackbutt	481468	6530613	100	21	3						3			1	1	1	1									
249	Swamp Mahogany	481472	6530659	105	14	8			2			2	2	2	1			1	1	1						1	
250	Stag	481377	6530238	45	12	4				1	1		2		1	1		1	1	1							
251	White Mahogany	481448	6530794	105	20	17						9	4	4	1	1	1	1	1	1	1		1			1	
252	Stag	481461	6530782	65	8	3		1		1	1				1	1				1						1	
253	White Mahogany	481538	6530807	105	21	7						4	2	1	1	1	1	1	1	1	1						
254	White Mahogany	481513	6530784	100	21	3				2	1				1					1			1			1	
255	White Mahogany	481521	6530769	105	20	15				2		5	5	3	1	1	1	1	1	1	1		1			1	
256	White Mahogany	481522	6530757	90	15	4						2	2		1	1	1	1	1		1						
257	White Mahogany	481518	6530747	70	17	6						4	2		1	1	1	1	1		1						
258	White Mahogany	481496	6530757	100	20	7						4	3		1	1	1	1	1		1						
259	White Mahogany	481500	6530765	95	20	9			2			4	3		1	1	1	1	1		1						
260	White Mahogany	481509	6530770	70	16	2						2			1	1	1	1									
261	White Mahogany	481501	6530771	75	18	6					1	3	2		1	1	1	1	1		1						
262	White Mahogany	481510	6530766	70	14	7						2	3	2	1	1	1	1	1	1	1						
263	White Mahogany	481493	6530775	90	18	5		1				3	1		1	1	1	1	1	1	1						
264	White Mahogany	481488	6530728	95	22	7		1		1		4	1		1	1	1	1	1		1						
265	Swamp Mahogany	481466	6530691	110	19	5						3	2		1	1	1	1	1		1						
266	White Mahogany	481479	6530692	75	18	4						3	1		1	1		1									
267	White Mahogany	481495	6530690	95	18	6						4	2		1	1	1	1	1		1						
268	Stag	481500	6530687	115	24	5						2	2	1	1	1	1	1	1		1						
269	White Mahogany	481533	6530665	110	20	6						3	2	1	1	1	1	1	1	1	1		1			1	
270	White Mahogany	481549	6530661	100	21	10						4	4	2	1	1	1	1	1	1	1		1			1	
271	White Mahogany	481556	6530676	115	23	7						4	2	1	1	1	1	1	1	1	1		1			1	
272	White Mahogany	481560	6530712	115	23	8						4	2	2	1	1	1	1	1	1	1		1			1	
273	Swamp Mahogany	481558	6530736	80	15	4						2	2		1	1	1	1	1		1						
274	White Mahogany	481495	6530795	95	19	3						2	1		1	1	1	1	1		1						
275	White Mahogany	481518	6530861	105	22	5						3	2		1	1	1	1	1		1						
276	White Mahogany	481578	6530821	105	17	5						2	2	1	1	1	1	1	1	1	1						
277	White Mahogany	481583	6530824	90	13	4						2	1	1	1	1	1	1	1	1	1						
278	White Mahogany	481586	6530812	105	23	10						6	3	1	1	1	1	1	1	1	1		1			1	
279	White Mahogany	481579	6530842	75	16	5						3	2		1	1	1	1	1		1						
280	Stag	481691	6531392	65	7	16		1	15						1	1		1									
281	White Mahogany	481692	6531634	85	14	3					1	2			1	1				1						1	
282	Stag	481676	6531639	75	21	6				1	2	2	1		1	1	1	1	1	1	1					1	
283	White Mahogany	481698	6531676	90	20	4						2	2		1	1	1	1									
284	Swamp Mahogany	481887	6532502	115	16	7						4	3		1	1	1	1	1		1						

HBT Ref No.	Species	Easting	Northing	DBH (cm)	~Tree Height (m)	No. Func. Hol.	Trunk Butt	Trunk Fissures	Trunk Small	Trunk Medium	Trunk Large	Limb Small	Limb Medium	Limb Large	AH	SF	MB	SG	LG	Po	Pa	Co	SO	LFO	EB	LM	Comments
		WGS84	WGS84						<5cm	5-15 cm	>15 cm	<5cm	5-15 cm	>15 cm													
285	Stag	482964	6535788	90	12	7		1		1	2	2	1		1	1		1	1	1						1	
286	Tallowwood	482948	6535770	45	19	1					1									1	1					1	
287	Stag	482892	6535931	95	12	5		1			2			2	1	1				1						1	
288	Tallowwood	482966	6536133	95	19	3						2	1		1	1	1	1	1								
289	Stag	483022	6536163	90	11	4		1			3				1	1				1						1	
290	Stag	483028	6536160	50	11	3		1		1	1				1	1	1	1	1	1	1					1	
291	Stag	483027	6536120	135	16	24		1			2	7	6	8	1	1	1	1	1	1	1	1	1			1	
292	Grey Ironbark	483053	6536151	75	21	4						2	2		1	1	1	1	1		1						
293	Small-fruited Grey Gum	483080	6536050	85	24	3				1		2			1			1									
294	Forest Red Gum	483262	6536438	130	24	8						5	3		1	1	1	1	1		1						
295	Forest Red Gum	483262	6536505	105	17	10						4	4	2	1	1	1	1	1	1	1		1			1	
296	Forest Red Gum	483267	6536550	120	22	6						4	2		1	1	1	1	1		1						
297	Forest Red Gum	483281	6536579	130	23	6					2	2	2		1	1	1	1	1	1	1		1			1	
298	Forest Red Gum	483193	6536618	95	20	2						1	1		1	1	1				1						
299	Forest Red Gum	483121	6536587	105	23	14						4	4	6	1	1	1	1	1	1	1		1			1	
300	Stag	483065	6536611	75	10	2		1		1						1		1	1	1	1					1	
301	Stag	483091	6536626	55	12	9		1				2	4	2	1	1	1	1	1	1	1						
302	Stag	483081	6536636	45	7	2		1			1				1	1				1						1	
303	Flooded Gum	483029	6537544	115	23	11						7	3	1	1	1	1	1	1	1	1						
304	Tallowwood	482867	6536393	165	26	37			3	3	4	12	8	7	1	1	1	1	1	1	1	1	1	1		1	
305	Forest Red Gum	482981	6537294	110	25	6						4	2		1	1	1	1	1		1						
306	Forest Red Gum	482996	6537351	100	10	3		1				2			1	1	1										
307	Pink Bloodwood	482563	6538204	95	20	5						4	1		1	1	1	1									
308	Spotted Gum	482221	6539157	60	21	4						2	2		1	1	1	1	1		1						
309	Tallowwood	482225	6539135	45	18	1				1										1						1	
310	White Mahogany	482348	6538847	50	16	2			1	1					1	1		1									
311	White Mahogany	482346	6538845	55	16	4						3	1		1	1	1	1	1		1						
312	Spotted Gum	482337	6538841	90	22	2			1	1					1	1		1									
313	White Mahogany	482348	6538846	40	16	4						3	1		1	1	1	1									
314	White Mahogany	482371	6538868	75	15	5						3	2		1	1	1	1	1		1						
315	Small-fruited Grey Gum	482288	6539058	85	25	5						3	2		1	1	1	1	1		1						
316	Stag	482157	6539472	65	18	25		1	9	5	3		3	4	1	1	1	1	1	1	1	1	1	1		1	
317	Small-fruited Grey Gum	482072	6539775	55	21	3						2	1		1	1	1	1	1		1						
318	Brush Box	482098	6540310	100	30	11				2		7	2		1	1	1	1	1	1	1						
319	White Mahogany	482063	6540270	105	28	10				1	1	5	2	1	1	1	1	1	1	1	1		1			1	
320	Tallowwood	482072	6540332	105	29	7			1	2		2	2		1	1	1	1	1		1						
321	Tallowwood	482066	6540341	110	27	3					1	1	1		1	1	1	1	1	1	1						

HBT Ref No.	Species	Easting	Northing	DBH (cm)	~Tree Height (m)	No. Func. Hol.	Trunk Butt	Trunk Fissures	Trunk Small	Trunk Medium	Trunk Large	Limb Small	Limb Medium	Limb Large	AH	SF	MB	SG	LG	Po	Pa	Co	SO	LFO	EB	LM	Comments
		WGS84	WGS84						<5cm	5-15 cm	>15 cm	<5cm	5-15 cm	>15 cm													
322	Pink Bloodwood	482071	6540326	50	25	2						1	1		1	1	1	1	1		1						
323	Pink Bloodwood	482179	6540310	95	19	4						1	1	2	1	1	1	1	1	1	1						
324	Small-fruited Grey Gum	482219	6539694	105	30	18		1	2			8	5	2	1	1	1	1	1	1	1		1			1	
325	Pink Bloodwood	482263	6539515	90	18	7						5	2		1	1	1	1	1		1						
326	Tallowwood	482333	6539221	90	22	2						2				1	1	1									
327	Tallowwood	482358	6539117	85	23	6						4	2		1	1	1	1	1		1						
328	Stag	482347	6539110	70	21	4						3	1		1	1	1	1	1		1						
329	Small-fruited Grey Gum	482345	6539111	60	21	2						2					1	1									
330	Stag	482385	6539054	30	10	7			2	1		2	2		1	1	1	1	1		1						
331	Spotted Gum	482386	6539055	85	23	5						4	1		1	1	1	1	1		1						
332	Small-fruited Grey Gum	482227	6541146	105	22	4						3		1	1	1	1	1	1	1	1						
333	Stag	482235	6541133	50	14	2		1			1				1	1				1						1	
334	Stag	482176	6541149	45	10	5		1	2	1	1				1	1		1	1	1						1	
335	White Mahogany	482090	6540749	85	19	5						3	2		1	1	1	1	1		1						
336	Stag	482100	6540664	75	11	7		1		2	2			2	1	1				1		1	1			1	
337	White Mahogany	482124	6540561	55	16	7			1	1		3	1	1	1	1	1	1	1	1	1						
338	Stag	482088	6540410	50	24	3						3					1	1									
339	White Mahogany	482206	6540653	50	18	4			1	1		2			1	1		1									
340	White Mahogany	482280	6540923	50	15	4						3	1		1	1	1	1	1		1						
341	Spotted Gum	482296	6541042	75	19	6						3	3		1	1	1	1	1		1						
342	Stag	482327	6541176	50	21	2						2			1		1	1									
343	Spotted Gum	482380	6541430	85	20	3						2	1		1		1	1									
344	White Mahogany	482398	6541437	75	22	7				1		3	3		1	1	1	1	1	1	1						
345	White Mahogany	482404	6541459	85	23	8			1			3	4		1	1	1	1	1	1	1						
346	Small-fruited Grey Gum	482476	6541654	45	19	3						2	1		1	1	1	1	1		1						
347	White Mahogany	482517	6541727	85	14	15				1	1	7	4	2	1	1	1	1	1	1	1						Glossy Black Cockatoo suspected to be using large hollow bearing tree immediately east of project boundary. Birds here at dusk
348	White Mahogany	482500	6541764	55	21	3						3			1		1	1									
349	Stag	482529	6541804	65	9	1					1					1				1						1	
350	Tallowwood	482529	6541771	85	22	2						2			1	1		1									
351	Flooded Gum	482636	6542061	100	29	3						2	1		1		1	1									
352	Flooded Gum	482679	6542139	95	27	4						1	2	1	1		1	1	1		1						
353	Flooded Gum	482809	6542284	115	29	7			2	1		3	1		1		1	1	1		1						
354	Flooded Gum	482841	6542339	105	33	4						2	2		1		1	1	1		1						
355	Pink Bloodwood	482930	6542396	105	24	8						3	2	3	1	1	1	1	1	1	1		1			1	

HBT Ref No.	Species	Easting	Northing	DBH (cm)	~Tree Height (m)	No. Func. Hol.	Trunk Butt	Trunk Fissures	Trunk Small	Trunk Medium	Trunk Large	Limb Small	Limb Medium	Limb Large	AH	SF	MB	SG	LG	Po	Pa	Co	SO	LFO	EB	LM	Comments
		WGS84	WGS84						<5cm	5-15 cm	>15 cm	<5cm	5-15 cm	>15 cm													
356	Flooded Gum	482958	6542513	105	29	5						2	2	1	1	1	1	1	1	1	1						
357	Flooded Gum	482974	6542530	115	30	5					1	2	1	1	1	1	1	1	1	1	1						
358	Stag	483004	6542568	50	14	23			9	5	3	2	4		1	1	1	1	1	1	1						
359	Stag	483033	6542600	90	13	5		1			2			2	1	1				1	1	1	1			1	Good hollows for Glossy Black cockatoo given surrounding Allocasuarina resources. Also likely point for Green-thighed Frogs
360	White Mahogany	482983	6542681	115	23	14						6	6	2	1	1	1	1	1	1	1						
361	Pink Bloodwood	482986	6542676	100	21	6						4	2		1	1	1	1	1								
362	Pink Bloodwood	482966	6542673	100	23	3						3			1		1	1									
363	White Mahogany	483019	6542769	110	22	8				1		4	2	1	1	1	1	1	1	1	1						
364	Stag	483028	6542765	80	14	4		1			1		1	1	1	1				1						1	
365	Stag	483037	6542772	125	23	17			3	2	1	4	2	5	1	1	1	1	1	1	1	1	1	1		1	
366	Stag	483105	6542740	55	18	9		1	3			2	2	1	1	1	1	1	1		1						
367	Forest Red Gum	483098	6542727	110	28	4						2	1	1	1	1	1	1	1	1	1						
368	Pink Bloodwood	483043	6542828	80	23	4						2	2		1	1	1	1	1	1	1		1			1	
369	White Mahogany	483034	6542828	105	21	13			1	1		4	4	3	1	1	1	1	1	1	1					1	
370	White Mahogany	482998	6542918	100	22	9						3	4	2	1	1	1	1	1	1	1						
371	Stag	482948	6542928	90	13	6			2	2				2	1	1		1	1	1	1	1	1			1	
372	Stag	482956	6542932	100	19	16		1	3	2	2		3	5	1	1		1	1	1	1	1	1			1	
373	Stag	482953	6542975	160	29	38					1	13	12	12	1	1	1	1	1	1	1	1	1	1		1	Every attempt should be made to retain this hbt
374	Stag	482963	6542944	105	29	13			2	2		3	3	3	1	1	1	1	1	1	1		1			1	
375	Stag	482903	6542839	55	16	2		1					1		1	1	1	1	1								
376	White Mahogany	482898	6542822	60	19	3							1	2	1	1		1	1	1	1						
377	Stag	482929	6542831	70	20	15				1	1	3	4	6	1	1	1	1	1	1	1		1			1	
378	Stag	482911	6542806	160	11	4			2		2				1	1				1						1	
379	Stag	482904	6542815	40	20	1		1							1	1		1									
380	Pink Bloodwood	482967	6542789	75	21	3						3			1	1	1	1									
381	Stag	482881	6542850	105	19	10						5	4	1	1	1	1	1	1	1	1		1			1	
382	Stag	482857	6542854	60	8	4		1			2			1	1	1				1						1	
383	White Mahogany	482873	6542750	95	14	4						2	2		1	1	1	1	1		1						
384	Pink Bloodwood	482873	6542716	100	18	4			1	1			1	1	1	1	1	1	1	1	1						
385	White Mahogany	482845	6542554	110	20	13						6	5	2	1	1	1	1	1	1	1		1			1	
386	Pink Bloodwood	482793	6542515	100	21	10						6	2	2	1	1	1	1	1	1	1		1			1	
387	Small-fruited Grey Gum	482711	6542315	115	23	11						4	3	4	1	1	1	1	1	1	1		1			1	
388	Pink Bloodwood	482684	6542263	70	22	4						2	2		1	1	1	1	1	1	1						
389	Small-fruited Grey Gum	482689	6542241	70	19	11						6	4	1	1	1	1	1	1	1	1						
390	Pink Bloodwood	482662	6542203	100	26	6						2	2	2	1	1	1	1	1	1	1		1			1	

HBT Ref No.	Species	Easting	Northing	DBH (cm)	~Tree Height (m)	No. Func. Hol.	Trunk Butt	Trunk Fissures	Trunk Small	Trunk Medium	Trunk Large	Limb Small	Limb Medium	Limb Large	AH	SF	MB	SG	LG	Po	Pa	Co	SO	LFO	EB	LM	Comments
		WGS84	WGS84						<5cm	5-15 cm	>15 cm	<5cm	5-15 cm	>15 cm													
391	Pink Bloodwood	482661	6542201	110	26	11				1	1	3	3	3	1	1	1	1	1	1	1		1			1	
392	Tallowwood	482624	6542208	145	24	14						8	4	2	1	1	1	1	1	1	1		1			1	
393	Pink Bloodwood	482639	6542192	95	27	3						2	1		1	1	1	1	1		1						
394	Pink Bloodwood	482591	6542153	115	28	11				1	1	3	3	3	1	1	1	1	1	1	1	1	1	1		1	
395	Tallowwood	482574	6542126	105	23	10						4	4	2	1	1	1	1	1	1	1		1			1	
396	Stag	482565	6542085	85	13	2		1			1				1	1				1						1	
397	Flooded Gum	482561	6542059	105	28	6						5	1		1		1	1	1								
398	White Mahogany	482519	6541982	110	23	9						4	4	1	1	1	1	1	1	1	1						
399	White Mahogany	482491	6541968	125	27	23			2	3	1	5	7	5	1	1	1	1	1	1	1	1	1	1		1	
400	Pink Bloodwood	482502	6541955	105	25	8						2	2	4	1	1	1	1	1	1	1		1			1	
401	Small-fruited Grey Gum	482512	6541925	105	28	10						3	4	3	1	1	1	1	1	1	1		1			1	
402	White Mahogany	482496	6541933	140	30	24					2	7	8	7	1	1	1	1	1	1	1	1	1	1		1	
403	White Mahogany	482499	6541920	90	20	4						2	2		1	1	1	1	1		1						
404	White Mahogany	482503	6541910	85	20	2						2			1	1	1	1									
405	Stag	482405	6541672	80	19	11		1	2			3	4	1	1	1	1	1	1	1	1						
406	Small-fruited Grey Gum	482412	6541669	60	17	4						2	2		1	1	1	1	1		1						
407	Stag	482379	6541621	65	14	3							1	2	1	1				1						1	
408	Small-fruited Grey Gum	482350	6541531	65	23	6						3	2	1	1	1	1	1	1	1	1						
409	Stag	482346	6541542	38	11	3		1			1			1	1	1	1	1	1	1	1					1	
410	Brush Box	482329	6541516	90	22	5						5			1	1	1	1									
411	Brush Box	482316	6541463	95	20	2						1	1		1	1		1	1								
412	Small-fruited Grey Gum	482339	6541427	100	26	6						4	2		1	1	1	1	1		1						
413	Pink Bloodwood	482288	6541374	70	23	6			2			3	1		1	1	1	1	1		1						
414	Small-fruited Grey Gum	482294	6541318	105	26	5				2	3									1		1	1	1		1	
415	Stag	483174	6543307	150	14	11				1	2	3	2	3	1	1	1	1	1	1	1		1			1	
416	Forest Red Gum	483173	6543274	90	20	6					1	2	2	1	1	1	1	1	1	1	1		1			1	
417	Stag	483173	6543275	100	25	10						2	2	6	1	1	1	1	1	1	1		1			1	
418	Flooded Gum	483159	6543187	105	27	4						2	2		1	1	1	1	1		1						
419	Coastal Blackbutt	483161	6543189	70	25	2						1	1		1	1	1	1	1		1						
420	Pink Bloodwood	483165	6543190	75	24	4						3	1		1	1	1	1	1		1						
421	Forest Red Gum	483151	6543142	105	17	4				1	1		1	1	1					1						1	
422	Small-fruited Grey Gum	483123	6542773	105	30	7				1	2	2	2		1	1	1	1	1	1	1		1			1	
423	Pink Bloodwood	483136	6542783	100	23	13						6	3	4	1	1	1	1	1	1	1		1			1	
424	Pink Bloodwood	483106	6542913	120	22	14						4	5	5	1	1	1	1	1	1	1		1			1	
425	White Mahogany	483103	6542923	105	20	8				2		2	2	2	1	1	1	1	1	1	1		1			1	
426	Stag	483123	6542933	100	13	2		1			1				1	1				1						1	

HBT Ref No.	Species	Easting	Northing	DBH (cm)	~Tree Height (m)	No. Func. Hol.	Trunk Butt	Trunk Fissures	Trunk Small	Trunk Medium	Trunk Large	Limb Small	Limb Medium	Limb Large	AH	SF	MB	SG	LG	Po	Pa	Co	SO	LFO	EB	LM	Comments
		WGS84	WGS84						<5cm	5-15 cm	>15 cm	<5cm	5-15 cm	>15 cm													
427	Stag	483113	6542963	50	13	4						2	2		1	1		1									
428	Pink Bloodwood	483121	6542974	100	21	15					2	3	6	4	1	1	1	1	1	1	1		1			1	
429	Stag	483125	6543054	65	10	1					1				1	1				1						1	
430	Pink Bloodwood	483161	6543051	70	21	2						1	1		1	1		1	1	1						1	
431	Small-fruited Grey Gum	483164	6543073	95	23	9						4	3	2	1	1	1	1	1	1	1		1			1	
432	Pink Bloodwood	483178	6543081	80	24	7						5	2		1	1	1	1	1		1						
433	Forest Red Gum	483155	6543108	115	23	16			2	1	2	3	3	5	1	1	1	1	1	1	1		1			1	
434	Pink Bloodwood	483146	6543123	85	21	4						2	2		1	1	1	1	1		1						
435	Small-fruited Grey Gum	483221	6543246	120	13	1					1					1				1						1	
436	Stag	483212	6543270	55	12	3					1		1	1	1	1		1	1	1						1	
437	Small-fruited Grey Gum	483216	6543270	120	30	27	1			2	3	8	6	7	1	1	1	1	1	1	1	1	1	1		1	
438	Tallowwood	483243	6543268	95	23	4			1			1	2		1	1	1	1									
439	Stag	483263	6543253	110	20	8		1		2	2			3	1	1	1			1		1	1			1	
440	White Mahogany	483299	6543265	80	22	5						3	2		1	1	1	1	1		1						
441	Flooded Gum	483229	6543376	135	33	4						3	1				1	1	1		1						
442	Pink Bloodwood	483103	6543517	115	28	15						9	4	2	1	1	1	1	1	1	1		1			1	
443	Stag	483096	6543487	75	14	3				1	2				1	1				1						1	
444	White Mahogany	483080	6543486	65	17	11				2	1	3	3	2	1	1	1	1	1	1	1		1			1	
445	Tallowwood	483023	6543303	175	25	43			3	5	5	12	8	10	1	1	1	1	1	1	1	1	1	1		1	Every attempt to retain this tree should be made
446	Pink Bloodwood	483014	6543310	80	20	12			1	2		3	3	3	1	1	1	1	1	1	1		1			1	
447	Pink Bloodwood	483030	6543286	100	24	8						3	3	2	1	1	1	1	1	1	1	1	1			1	
448	Tallowwood	483034	6543288	135	22	23				1	2	4	8	8	1	1	1	1	1	1	1		1			1	
449	Stag	483069	6543281	80	21	14		1	3			3	4	3	1	1	1	1	1	1	1		1			1	
450	Forest Red Gum	483058	6543263	105	23	10			1	1		2	2	4	1	1	1	1	1	1	1	1	1			1	
451	Stag	483041	6543223	70	15	9			2	2	2		1	2	1	1	1	1	1	1	1	1	1			1	
452	White Mahogany	483032	6543256	105	25	15						7	4	4	1	1	1	1	1		1						
453	Tallowwood	483021	6543082	100	22	6						4	2		1	1	1	1	1	1	1		1			1	
454	Stag	482958	6543095	95	17	8		1		1		1	2	3	1	1	1	1	1		1						
455	Stag	482973	6543084	45	25	5						3	2		1	1	1	1	1		1						
456	Stag	482974	6543072	110	10	2		1			1				1	1				1						1	
457	White Mahogany	482974	6543078	75	17	8			2			3	2	1	1	1	1	1	1	1	1		1			1	
458	Pink Bloodwood	483012	6542955	100	27	12			3	2	2	3	2		1		1	1	1	1	1					1	
459S	White Mahogany	483026	6543062	100	22	3						2	1		1	1	1	1	1								
460S	Grey Ironbark	483235	6544256	100	24	1					1																Just native bees using this hollow
461S	Scribbly Gum	483141	6545094	85	21	4						2	2		1	1	1	1	1		1						
462S	Stag	483158	6545066	95	22	10		1	3			4	2		1	1	1	1	1		1						Safety issue and has a high risk of falling onto the north bound

HBT Ref No.	Species	Easting	Northing	DBH (cm)	~Tree Height (m)	No. Func. Hol.	Trunk Butt	Trunk Fissures	Trunk Small	Trunk Medium	Trunk Large	Limb Small	Limb Medium	Limb Large	AH	SF	MB	SG	LG	Po	Pa	Co	SO	LFO	EB	LM	Comments
		WGS84	WGS84						<5cm	5-15 cm	>15 cm	<5cm	5-15 cm	>15 cm													
																											carriageway
463S	Forest Red Gum	483163	6544755	85	17	3						3			1	1	1	1									
464S	Coastal Blackbutt	483168	6544448	85	22	3						2	1		1	1	1	1									A lot of broken branches in the canopy of trees within 1 km of this area. Storms 2-3 years ago created this
465S	Pink Bloodwood	483137	6544267	70	14	2						2			1	1		1									
459N	Stag	483233	6550071	100	23	4						1	3		1	1	1	1		1	1						
460N	Small-fruited Grey Gum	483233	6550423	120	29	7							4	3	1	1	1	1	1	1	1	1	1	1		1	
461N	Stag	483257	6550640	35	12	5			1			2	2		1	1	1										
462N	Coastal Blackbutt	483322	6550667	60	16	1						1			1	1	1										
463N	White Mahogany	483312	6550714	95	17	6			1		1	1	2	1	1	1	1	1		1	1		1			1	
464N	White Mahogany	483264	6550726	35	20	2						2			1	1	1										
465N	Pink Bloodwood	483269	6550727	70	20	2						1	1		1		1	1		1	1						
466	Stag	483148	6551384	30	9	2						1		1	1	1	1			1							
467	Stag	483130	6551322	100	16	4					2			2	1	1	1			1	1	1	1			1	
468	Stag	483193	6551230	50	9	1					1				1	1	1			1	1	1	1			1	
469	Stag	483198	6551217	55	17	8						3	4	1	1	1	1	1			1						
470	Stag	483224	6551173	115	15	10						4	5	1	1	1	1	1	1	1	1	1	1			1	
471	Stag	483274	6551066	40	12	6						2	2	2	1	1	1	1	1	1	1	1	1	1		1	
472	Stag	483206	6550970	75	13	9			1	2	1		3	2	1	1	1	1	1	1	1	1	1			1	
473	Turpentine	483205	6550946	45	13	3						3			1		1										
474	Stag	483216	6550943	30	9	3						2	1		1	1	1	1									
475	Stag	483229	6550945	35	8	2				1		1			1	1	1	1									
476	Pink Bloodwood	483230	6550932	45	10	2						2					1										
477	Turpentine	483263	6550944	60	13	10			1			2	5	2	1	1	1	1	1	1	1	1	1			1	
478	Pink Bloodwood	483249	6550914	65	16	1						1			1		1										
479	Turpentine	483244	6550930	30	15	1				1					1	1	1	1									
480	Pink Bloodwood	483241	6550929	70	16	5						2	3				1	1									
481	Pink Bloodwood	483243	6550905	50	14	1						1			1		1										
482	Pink Bloodwood	483286	6550880	65	15	5						3	2		1	1	1	1									
483	Turpentine	483262	6550833	65	14	5						3	2		1	1	1	1									
484	Pink Bloodwood	483288	6550829	45	15	4						2	2		1	1	1	1									
485	Pink Bloodwood	483301	6550822	60	16	3						3			1		1										
486	Coastal Blackbutt	483274	6550800	40	15	3						3			1		1										
487	Pink Bloodwood	483264	6550754	90	19	2						2			1	1	1	1									
488	White Mahogany	483038	6552880	85	22	4						1	2	1	1	1	1	1	1	1	1		1			1	
489	Coastal Blackbutt	483017	6552819	95	24	5						1	4			1	1	1			1						
490	White Mahogany	482977	6552801	70	21	3				1	1	1			1	1	1	1		1	1						

HBT Ref No.	Species	Easting	Northing	DBH (cm)	~Tree Height (m)	No. Func. Hol.	Trunk Butt	Trunk Fissures	Trunk Small	Trunk Medium	Trunk Large	Limb Small	Limb Medium	Limb Large	AH	SF	MB	SG	LG	Po	Pa	Co	SO	LFO	EB	LM	Comments
		WGS84	WGS84						<5cm	5-15 cm	>15 cm	<5cm	5-15 cm	>15 cm													
491	White Mahogany	482979	6552745	50	18	2					1	1			1			1		1	1						
492	Coastal Blackbutt	483000	6552705	50	18	1				1					1	1	1	1			1						
493	Pink Bloodwood	483089	6551581	65	16	1							1		1	1	1	1									
494	Pink Bloodwood	483120	6551552	120	20	4							2	2		1	1	1	1	1	1	1	1	1		1	
495	Pink Bloodwood	483147	6551535	30	11	3						2	1		1	1	1	1									
496	White Mahogany	483002	6551672	65	17	3						3			1	1	1	1									
497	Coastal Blackbutt	482953	6551776	90	23	1						1			1	1	1	1			1						
498	Pink Bloodwood	482948	6551893	45	17	3						3			1	1	1	1			1						
499	Coastal Blackbutt	483001	6551920	110	28	5						2	1	2	1	1	1	1	1	1	1	1	1	1		1	
500	Coastal Blackbutt	482904	6551934	110	25	2							2		1		1	1									
501	Coastal Blackbutt	482902	6551934	55	17	4						2	2		1	1	1	1									
502	Turpentine	482978	6552018	60	14	2						2			1		1										
503	Turpentine	482937	6552030	35	14	1							1		1		1										
504	Pink Bloodwood	482905	6552076	45	15	5						5			1	1	1	1									
505	stag	482926	6552161	30	10	1					1				1	1	1	1	1	1		1	1			1	
506	Stag	482985	6552190	30	9	2				1	1				1	1	1	1	1	1	1	1	1			1	
507	Stag	483027	6552233	35	8	1				1						1	1	1	1	1	1		1			1	
508	Coastal Blackbutt	482993	6552426	100	21	1								1		1	1	1	1	1	1						
509	White Mahogany	483053	6552440	40	13	2				1		1				1	1	1	1	1							
510	Stag	482993	6552441	45	9	6			3	1	2					1	1	1	1	1	1						
511	Stag	482993	6552469	50	9	4						3	1		1	1	1										
512	stag	482995	6552544	35	11	3						2	1		1	1	1										
513	White Mahogany	483039	6552565	65	16	1					1				1	1	1	1	1	1	1						
514	Prickly-leaved paperbark	483084	6552609	45	10	3					1	1	1		1	1	1	1	1	1	1						
515	White Mahogany	483117	6552624	95	25	4							4		1	1	1	1	1	1	1	1				1	
516	Tallowwood	483114	6552621	50	25	1					1				1		1	1									
517	White Mahogany	483060	6552634	95	20	2							1	1	1	1	1	1	1		1						
518	Stag	483076	6552650	35	15	1				1						1		1	1								
519	Pink Bloodwood	483084	6552658	65	19	3							3		1	1			1	1	1						
520	Pink Bloodwood	483044	6552719	65	17	2			1	1					1			1	1		1						
521	Stag	483055	6552720	30	9	1							1		1	1		1	1		1						
522	Coastal Blackbutt	483090	6552785	70	18	1				1																	
523	White Stringybark	483069	6552788	60	13	1					1				1					1						1	
524	White Stringybark	483079	6552792	60	18	1							1		1	1		1			1						
525	Pink Bloodwood	483124	6552791	40	14	1						1			1		1										
526	Pink Bloodwood	483130	6552798	65	17	6						5	1		1	1	1	1	1	1	1						
527	stag	483137	6552819	80	11	1					1				1					1						1	

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		WGS84	WGS84						<5cm	5-15 cm	>15 cm	<5cm	5-15 cm	>15 cm													
528	White Mahogany	483045	6553021	30	13	4			3		1									1	1					1	
529	stag	483034	6552988	35	14	5						3	2		1	1	1	1	1	1	1	1	1			1	
530	White Mahogany	483007	6553056	50	17	2						2					1	1									
531	Coastal Blackbutt	483004	6553047	65	17	3						3			1	1	1	1									
532	White Stringybark	483033	6553041	30	16	3				1		2			1	1	1	1			1						
533	Coastal Blackbutt	483045	6553054	100	20	6						2	4		1	1	1	1			1						
534	Pink Bloodwood	483069	6553059	60	18	4						1	3		1	1	1	1	1	1	1					1	
535	Coastal Blackbutt	483058	6553090	95	18	10					1	4	4	1	1	1	1	1	1	1	1	1	1			1	
536	stag	483033	6553118	50	13	4						2	2		1	1	1	1									
537	Coastal Blackbutt	483032	6553111	60	17	1						1			1	1	1	1									
538	Pink Bloodwood	483063	6553110	60	13	3						1	2		1	1	1	1			1						
539	stag	483045	6553127	30	9	2			1		1				1	1	1			1							
540	Spotted Gum	482986	6553126	30	16	4						4			1		1	1									
541	Pink Bloodwood	482984	6553181	40	16	4						2	2		1	1	1	1			1						
542	Coastal Blackbutt	482973	6553184	55	16	2					1	1					1	1	1	1	1	1	1			1	
543	Coastal Blackbutt	482972	6553171	70	18	4						3	1				1	1	1	1	1						
544	White Mahogany	482993	6553161	40	17	2						2			1	1	1	1			1						
545	Pink Bloodwood	483035	6553163	50	16	2						2			1		1										
546	stag	483037	6553162	45	16	3						3			1	1	1	1									
547	Pink Bloodwood	483061	6553161	45	14	4						2	2		1	1	1	1			1						
548	Coastal Blackbutt	483033	6553186	30	11	1						1			1	1	1										
549	Pink Bloodwood	483013	6553188	40	10	2						2			1	1	1										
550	Pink Bloodwood	483011	6553175	35	13	2						1	1		1	1	1	1									
551	Coastal Blackbutt	483006	6553178	65	17	7						4	2	1	1	1	1										
552	Coastal Blackbutt	482948	6554410	45	17	1						1			1	1	1										
553	White Mahogany	482910	6554346	40	11	3				1		1	1		1	1	1	1	1	1	1						
554	stag	482781	6553945	30	9	6						4	2		1	1	1	1									
555	stag	482787	6553818	30	10	3						2	1				1										
556	stag	482879	6553375	55	11	6						3	3		1	1	1	1			1						
557	stag	482921	6553221	50	11	5						2	3		1		1				1						
558	White Stringybark	483057	6553202	60	15	8					1	3	3	1	1	1	1	1		1	1						
559	White Stringybark	483007	6553197	70	16	2						1		1	1	1	1	1		1	1						
560	Coastal Blackbutt	482971	6553202	60	17	3							3		1	1	1	1			1						
561	stag	483023	6553279	55	18	6						6					1										
562	Grey Ironbark	482930	6553347	70	20	5						3	2		1	1	1	1			1						
563	Coastal Blackbutt	482925	6553519	55	17	2							2		1	1	1	1			1						
564	stag	482924	6553626	30	12	4				1		2	1		1	1	1	1		1	1						
565	Pink Bloodwood	482920	6553691	70	24	3						2	1				1	1									

HBT Ref No.	Species	Easting	Northing	DBH (cm)	~Tree Height (m)	No. Func. Hol.	Trunk Butt	Trunk Fissures	Trunk Small	Trunk Medium	Trunk Large	Limb Small	Limb Medium	Limb Large	AH	SF	MB	SG	LG	Po	Pa	Co	SO	LFO	EB	LM	Comments
		WGS84	WGS84						<5cm	5-15 cm	>15 cm	<5cm	5-15 cm	>15 cm													
566	Stag	482909	6553680	35	12	3				1		2			1	1	1										
567	White Stringybark	482891	6553679	50	22	5						3	2		1	1	1	1									
568	White Stringybark	482892	6553681	45	22	3						2	1		1	1	1	1									
569	White Stringybark	482880	6553699	55	17	7						3	3	1	1	1	1	1	1	1							
570	Stag	482868	6553705	25	5	2					1			1	1		1										
571	Stag	482870	6553708	20	5	1					1				1		1										
572	Stag	482887	6553726	25	7	1					1				1		1										
573	Stag	482941	6553792	60	8	2					1		1		1	1			1	1	1						
574	White Stringybark	482957	6553796	50	8	3					2			1	1	1	1	1	1	1	1						
575	Stag	482909	6553808	60	10	6						4	1	1	1	1	1	1	1	1	1						
576	Stag	482877	6553861	45	12	4				1		1	2		1	1	1	1	1	1	1						
577	Stag	482855	6553905	25	12	4						4			1		1	1									
578	Stag	482869	6553944	60	15	6						3	2	1	1	1	1	1	1		1					1	
579	Small-fruited Grey Gum	482864	6554032	50	16	3						3			1	1	1	1									
580	White Stringybark	482890	6554149	50	17	2				2					1	1		1									
581	Coastal Blackbutt	482904	6554158	80	23	5						3	2		1	1	1	1			1						
582	Stag	482960	6554216	50	19	5				1		1	3		1	1	1	1	1		1						
583	Tallowwood	482979	6554261	70	20	3						1	1	1	1	1	1	1	1	1	1						
584	Coastal Blackbutt	482982	6554276	60	21	4						4			1	1	1	1									
585	Coastal Blackbutt	483024	6554299	70	20	4					1	2	1		1	1	1	1	1		1						
586	Small-fruited Grey Gum	482992	6554353	50	16	6						6			1	1	1	1									
587	White Stringybark	483012	6554337	55	16	2					1		1		1			1	1	1	1						
588	Coastal Blackbutt	483053	6554435	55	16	4						2	2		1	1	1	1									
589	Coastal Blackbutt	483064	6554445	60	16	4						2	2		1	1	1	1									
590	Coastal Blackbutt	483107	6554553	60	18	4						2	2		1		1	1									
591	Coastal Blackbutt	483117	6554555	50	16	3						1	2		1		1	1									
592	Coastal Blackbutt	483117	6554554	55	17	6						2	2	2	1		1	1	1		1					1	
593	Coastal Blackbutt	483116	6554631	55	18	1							1		1		1	1			1						
594	Coastal Blackbutt	483130	6554668	65	20	2						2			1	1	1										
595	Flooded Gum	483143	6554724	65	24	5						4	1		1		1	1		1	1						
596	Flooded Gum	483165	6554771	70	23	6						1	3	2	1	1	1	1	1	1	1	1	1			1	
597	Stag	483252	6555332	30	12	2						2			1	1	1	1									
598	Stag	483267	6555381	50	15	6				1	1	4			1	1	1	1		1	1						
599	Coastal Blackbutt	483319	6555551	65	21	4						3	1		1		1	1									
600	Coastal Blackbutt	483348	6555553	35	14	6			1			3	2		1		1	1									
601	Pink Bloodwood	483154	6549509	60	21	2						1	1		1	1	1	1									
602	Stag	483151	6549519	95	16	11		1	2			3	2	3	1	1	1	1	1	1	1		1				

HBT Ref No.	Species	Easting	Northing	DBH (cm)	~Tree Height (m)	No. Func. Hol.	Trunk Butt	Trunk Fissures	Trunk Small	Trunk Medium	Trunk Large	Limb Small	Limb Medium	Limb Large	AH	SF	MB	SG	LG	Po	Pa	Co	SO	LFO	EB	LM	Comments
		WGS84	WGS84						<5cm	5-15 cm	>15 cm	<5cm	5-15 cm	>15 cm													
603	Stag	483147	6549600	100	24	15						4	5	6	1	1	1	1	1	1	1		1			1	
604	Small-fruited Grey Gum	483213	6549749	70	22	3						2	1		1	1	1	1								1	
605	Small-fruited Grey Gum	483219	6549603	95	24	5			2			3			1	1	1	1									
606	White Mahogany	483221	6549499	45	11	3						3			1	1	1	1									
607	Stag	483224	6549420	85	18	7		1	2			4			1	1	1	1									
608	Small-fruited Grey Gum	483231	6549265	95	24	8						5	3		1	1	1	1	1		1						
609	Red Ash	483146	6548632	35	12	2				1	1				1	1	1			1							
610	Forest Red Gum	482953	6547527	100	23	6			1	1		2	1	1	1	1	1	1	1	1	1						
611	White Stringybark	483082	6547116	105	22	5						2	2	1	1	1	1	1	1	1	1						
612	Stag	483121	6547092	70	14	6						6			1	1	1	1									
613	Stag	483132	6547091	50	15	5		1				3	1		1	1	1	1									
614	White Stringybark	483103	6547155	50	20	4						2	2		1	1	1	1			1						
615	White Stringybark	483099	6547139	55	22	6					2	2	1	1	1	1	1	1	1	1	1						
616	Pink Bloodwood	483089	6547097	65	17	10			4			3	1	2	1	1	1	1	1	1	1						
617	Stag	483097	6546932	55	15	3						3					1	1									
618	Scribbly Gum	483097	6546934	65	17	3						2	1		1	1	1	1			1						
619	Stag	483118	6546897	70	10	2					1			1	1	1				1						1	
620	Stag	483112	6546864	70	11	2		1			1				1	1		1									
621	Stag	483125	6546861	75	10	2		1			1				1	1		1									
622	White Stringybark	483133	6546915	95	20	5						3	2		1	1	1	1	1		1						
623	Stag	483146	6546928	70	20	16			13			2	1		1	1	1	1									These were exposed bardy grub holes but suitable for herpetofauna and bats
624	White Stringybark	483186	6547177	75	20	5						4	1		1	1	1	1	1		1						
625	White Stringybark	483207	6547160	95	24	8		1				3	2	2	1	1	1	1	1	1	1					1	
626	Stag	483199	6547146	100	26	11						6	3	2	1	1	1	1	1	1	1					1	
627	Stag	483209	6546956	10	9	3						3			1	1	1	1									
628	Small-fruited Grey Gum	483220	6546894	135	26	25			2	3	2	6	5	7	1	1	1	1	1	1	1	1	1			1	
					Totals	3860	4	74	241	211	180	1622	1052	476	604	553	541	548	383	293	401	67	128	17	0	199	

APPENDIX B – ECOLOGICAL MONITORING PROGRAM

Oxley Highway to Kempsey

Ecological Monitoring Program

Roads and Maritime Services | August 2019

NSW GOVERNMENT

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Date	Status	Revision	Approved by
Report prepared by SMEC Hyder Joint Venture			
18 November 2013	Final		DP&E
Roads and Maritime Update to report prepared by SMEC Hyder Joint Venture			
19 September 2014	Final	Updates to meet DoEE requirements	DP&E and DoEE
17 February 2016	Draft	Various updates, predominantly regarding landowner access	
04 August 2016	Final	Updates to address DoEE comments	DP&E and DoEE
2 April 2019	Draft	Various updates including; • Previously approved plan changes • Updates to certain monitoring methods, locations and frequencies • Addition of clarifications and descriptions	
2 July 2019	Draft	Updates to address DoEE comments	
8 August 2019	Draft	Updates to address DoEE comments	
30 August 2019	Final	Updates to address DoEE comments	DP&E and DoEE

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1 INTRODUCTION

1.1 THE PROJECT

The Oxley Highway to Kempsey Project (the Project) forms part of the Pacific Highway Upgrade program, that will ultimately provide a continuous four lane divided carriageway between Hexham (near Newcastle) and the Queensland border.

The Project is approximately 37 kilometres in length, commencing approximately 700 metres north of the Oxley Highway interchange and tying in with the existing dual carriageways to the south, and finishing near Stumpy Creek tying in with the dual carriageways of the Kempsey to Eungai Pacific Highway upgrade. Upgrading the highway to a dual carriageway predominantly involves duplicating the existing highway, with the exception of two sections where the Project deviates from the alignment of the existing highway in the vicinity of the Hastings River and the Wilson River.

After consideration of the Project EA and Submissions Report, the Minister for Planning approved the Oxley Highway to Kempsey Pacific Highway upgrade under part 75J of the *Environmental Planning and Assessment Act 1979* (EP&A Act) on 8 February 2012 subject to the Minister's Conditions of Approval (MCoA) being met.

The Project was also referred to the former Department of Sustainability, Environment, Water, Population and Communities (DSEWPC), now the Department of the Environment & Energy (DoEE) on 17 August 2012. On 21 September 2012, a delegate of the Federal Minister for the Environment (the Minister) determined that the project referral (EPBC 2012/6518) was a controlled action under section 75 and 87 of the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Project was approved by the Minister on 24 January 2014, subject to 15 conditions.

1.2 OBJECTIVE

This Ecological Monitoring Program (EMP) has been developed to address MCoA B10, which states:

The Proponent shall develop an Ecological Monitoring Program to monitor the effectiveness of the biodiversity mitigation measures implemented as part of the Project. The program shall be developed by a suitably qualified and experienced ecologist in consultation with the EPA and DPI (Fishing and Aquaculture) and shall include but not necessarily be limited to:

(a) an adaptive monitoring program to assess the effectiveness of the mitigation measures identified in conditions B1, B4, B7 and B31(b) and allow amendment to the measures if necessary. The monitoring program shall nominate performance parameters and criteria against which effectiveness will be measured and include operational road kill surveys to assess the effectiveness of fauna crossings and exclusion fencing implemented as part of the project;

(b) mechanisms for developing additional monitoring protocols to assess the effectiveness of any additional mitigation measures implemented to address additional impacts in the case of design amendments or unexpected threatened species finds during construction (where these additional impacts are generally consistent with the biodiversity impacts identified for the project in the documents listed under condition A1);

(c) monitoring shall be undertaken during construction (for construction-related impacts) and from opening of the project to traffic (for operation/ ongoing impacts) until such time as the effectiveness of mitigation measures can be demonstrated to have been achieved over a minimum of three successive monitoring periods (i.e. 6 years) after opening of the project to traffic, unless otherwise agreed by the Director General. The monitoring period may be reduced

with the agreement of the Director General in consultation with the OEH and DPI (Fishing and Aquaculture), depending on the outcomes of the monitoring;

(d) provision for the assessment of the data to identify changes to habitat usage and whether this can be directly attributed to the project;

(e) details of contingency measures that would be implemented in the event of changes to habitat usage patterns directly attributable to the construction or operation of the project; and

(f) provision for annual reporting of monitoring results to the Director General and the OEH and DPI (Fishing and Aquaculture), or as otherwise agreed by those agencies.

The Program shall be submitted to the Director General for approval no later than 6 weeks prior to the commencement of construction that would result in the disturbance of native vegetation (unless otherwise agreed by the Director General)..

This EMP has also been developed to address the EPBC Act approval condition 4, which states:

Prior to ***commencement of stage 2*** *and* ***stage 3*** *of the action**,** the* ***person taking the action*** *must submit an Ecological Monitoring Program for approval by the* ***Minister*** *that determines the effectiveness of the mitigation measures implemented as part of the project. The Ecological Monitoring Program must be approved in writing by the* ***Minister*** *prior to* ***commencement*** *of* ***stage 2*** *and* ***stage 3,*** *and must include:*

a. *The baseline data collected from surveys undertaken by a* ***suitably qualified expert*** *on the Koala, Spotted-tail Quoll and Giant-Barred Frog within all habitat areas outside areas to be cleared of vegetation for the proposed action, that are likely to contain these species and that are likely to be adversely impacted by the action (as determined by a* ***suitably qualified expert****).The data must address the densities, distribution, habitat use and movement patterns of these species;*

b. *The methodology to be implemented for the ongoing monitoring of road kill, the species densities, distribution, habitat use and movement patterns, and the use of* ***fauna crossing*** *during construction and operation of the action, including the timing, and duration of the methodology;*

c. *Goals and performance indicators to measure the success of proposed* ***fauna crossings****, which must be specific, measureable, achievable, realistic and timely (SMART), and be compared against baseline data described in condition 4a)*

d. *Details of contingency measures that would be implemented in the event of changes to densities, distribution, habitat use and movement patterns that are attributable to the construction or operation of the project.*

Monitoring must continue until mitigation measures can be demonstrated to have been ***effective*** *for the Koala, Spotted-tail Quoll, and Giant-Barred Frog.*

Should monitoring associated with this condition demonstrate that the use of ***fauna crossings*** *and/or* ***fencing*** *is not achieving its intended purpose or is having a detrimental effect upon Koala, Spotted-tail Quoll, and Giant-Barred Frog (as determined by* ***the Minister****),* ***the Minister*** *may require that the person taking the action implement alternative forms of mitigation and/or corrective actions to address the relevant impacts to Koala, Spotted-tail Quoll, and Giant-Barred Frog, Such measures must be implemented as requested.*

Broadly, this EMP aims to:

- Outline the environmental context of the Project, identify potential impacts of the Project and the subsequent requirement for mitigation measures, which relate to:

- Pre-clearing surveys and clearing procedures.
- Fauna underpasses.
- Rope bridges.
- Glider Poles.
- Fauna Fencing.
- Widened Median.
- Nest Boxes.
- Green-thighed frog breeding ponds.
- Landscaping and revegetation.

- Detail the requirements for baseline monitoring of threatened species (known or likely to occur in the Project area that may be adversely affected by the Project) to be undertaken before construction of the Project commences, including the results of the baseline monitoring for the EPBC listed species.
- Describe the timing and methodology for monitoring of mitigation measures, during construction and upon completion of the Project, and detail performance measures that will measure the effectiveness of mitigation measures.
- Identify potential contingency measures that may be implemented if any mitigation measure proves to be insufficient.
- Describe the maintenance requirements that are relevant to the mitigation measures.
- Detail the reporting requirements, related to monitoring events.

In the event of an inconsistency between this program and individual species management plans contained within the Flora and Fauna Management Plans for each stage, the requirements of this program will prevail.

1.3 SCOPE

The scope of this EMP is prescribed within the Project approval documentation. This EMP has also been developed in accordance with the revised Statement of Commitments (refer Table 1).

Table 1 Statement of Commitments relevant to the Ecological Monitoring Program

SoC Reference	**Requirement**
SoC F21	A monitoring program will be developed to allow the effectiveness of mitigation and offset measures to be assessed and allow for their modification if necessary. The program will be for a minimum of 12 months after construction completion.

1.4 STRUCTURE OF THIS ECOLOGICAL MONITORING PROGRAM

This Ecological Monitoring Program (EMP) addresses the requirement of MCoA B10 and the EPBC Act CoA 4. Where each CoA is addressed within this EMP is listed in Table 2.

Table 2: Requirements of this Ecological Monitoring Program

Source	Detail	Where addressed in this document
MCoA B10 (a)	An adaptive monitoring program to assess the effectiveness of the mitigation measures identified in conditions B1, B4, B7 and B31(b) and allow amendment to the measures if necessary. The monitoring program shall nominate performance parameters and criteria against which effectiveness will be measured and include operational road kill surveys to assess the effectiveness of wildlife crossings and exclusion fencing implemented as part of the Project;	Section 4
MCoA B10 (b)	Mechanisms for developing additional monitoring protocols to assess the effectiveness of any additional mitigation measures implemented to address additional impacts in the case of design amendments or unexpected threatened species finds during construction (where these additional impacts are generally consistent with the biodiversity impacts identified for the Project in the documents listed under condition A1);	Section 4.1.1
MCoA B10 (c)	Monitoring shall be undertaken during construction (for construction –related impacts) and from opening of the Project to traffic (for operation/ongoing impacts) until such time as the effectiveness of mitigation measures can be demonstrated to have been achieved over a minimum of three successive monitoring periods (i.e. 6 years) after opening of the Project to traffic, unless otherwise agreed by the Director General. The monitoring period may be reduced with the agreement of the Director General in consultation with the EPA and DPI (Fishing and Aquaculture), depending on the outcomes of the monitoring;	Section 4
MCoA B10 (d)	Provision for the assessment of the data to identify changes to habitat usage and whether this can be directly attributed to the Project;	Section 3
MCoA B10 (e)	Details of contingency measures that would be implemented in the event of changes to habitat usage patterns directly attributable to the construction or operation of the Project; and	Section 5
MCoA B10 (f)	Provision for annual reporting of monitoring results to the Director General and the EPA and DPI (Fishing and Aquaculture), or as otherwise agreed by the agencies.	Section 7

Source	Detail	Where addressed in this document
EPBC 4a.	The baseline data collected from surveys undertaken by a **suitably qualified expert** on the Koala, Spotted-tail Quoll and Giant-Barred Frog within all habitat areas outside areas to be cleared of vegetation for the proposed action, that are likely to contain these species and that are likely to be adversely impacted by the action (as determined by a **suitably qualified expert**).The data must address the densities, distribution, habitat use and movement patterns of these species.	Appendix A Appendix B
EPBC 4b.	The methodology to be implemented for the ongoing monitoring of road kill, the species densities, distribution, habitat use and movement patterns, and the use of **fauna crossing** during construction and operation of the action, including the timing, and duration of the methodology.	Section 3.2.1, 3.2.2, 3.2.3, 3.3 and 4.2.
EPBC 4c.	Goals and performance indicators to measure the success of proposed **fauna crossings**, which must be specific, measureable, achievable, realistic and timely (SMART), and be compared against baseline data described in condition 4a)	Section 4.2.4.
EPBC 4d.	Details of contingency measures that would be implemented in the event of changes to densities, distribution, habitat use and movement patterns that are attributable to the construction or operation of the project.	Section 5

1.5 DEFINITIONS

Barrier Effect

The functional or behavioural barrier to fauna movement, created by a road fragmenting otherwise continuous habitat. The barrier effect may result in mortality of wildlife due to collisions with vehicles or avoidance of roads by wildlife as a result of noise, light and pollutants associated with vehicles.

Contingency measure

Adaptive management measures undertaken in response to a monitoring trigger.

Contingency measures may include additional/adjusted mitigation measures (eg procedures, structures and/or design features) and/or appropriate targeted actions as required (e.g. vertebrate pest control, soil erosion control).

Effective

Result in the complete, safe crossing of the crossing by the targeted **EPBC species** at a sufficient frequency to ensure that habitat connectivity is maintained or improved from baseline conditions (determined by surveys condition 4a and information provided in the preliminary documentation), and ongoing population viability by providing opportunities for species dispersal and re-colonisation; and result in reduced incidence of road kill from baseline conditions (determined by surveys condition 4a and information provided in the preliminary documentation).

Fauna Crossings

Purpose built structures which are designed to allow passage for fauna and facilitate natural permeability of linear infrastructure.

Fencing

Purpose built fencing that is designed to stop fauna accessing the road surface. Fauna fencing must be durable and the design targeted to the relevant species.

Mitigation Measure

In this report, a specific structure or design feature incorporated in the Project that aims to minimise the impact of the Project on flora and fauna in the Project area.

Mitigation measures include procedures (for vegetation clearing), wildlife crossing structures (such as underpasses, rope bridges and glider poles) fauna fencing and structures such as nest boxes and frog breeding ponds.

Performance Measure

A standard or benchmark that quantifies the effectiveness or success of a mitigation measure, or in some cases, monitoring methodology.

Project

The upgrade of the Pacific Highway between the Oxley Highway and Kempsey. The 37 kilometre upgrade section will be widened from the existing single carriageway to a four-lane dual carriageway.

Project footprint

The area in which all Project-related activities required for the completion of the upgrade will occur. The Project footprint will be directly affected by works including vegetation clearing and grubbing, cut and fill, establishment of stockpiles and compound areas.

Project area

The Project footprint in addition to adjoining similar habitat. This includes areas of Cairncross, Ballengarra and Maria River State Forests and Cooperabung and Rawdon Creek Nature Reserves.

Project Ecologist

A Project ecologist will be engaged during construction works by Roads and Maritime Services or the construction contractor. The Project ecologist will be degree qualified, suitably experienced with expertise in fauna rescue and hold current and relevant fauna handling licenses. The Project ecologist will manage and supervise all fauna rescue tasks to minimise the impacts on fauna.

Sufficient Frequency

The effectiveness of crossing structures based on sufficient frequency of crossings has been determined from species information and baseline surveys:

Koala: Koala activity varied along the alignment during baseline surveys and density is considered to vary along the alignment based on historical records. The monitored underpasses occur in areas where the alignment bisects Koala habitat, as such sufficient frequency of crossing to demonstrate opportunity for dispersal and re-colonisation is considered to be a single crossing at each of the monitored underpasses during each monitoring event.

Spotted-tailed Quoll: No Spotted-tailed Quolls were recorded during baseline surveys. This species is known to occur at low densities and maintains large generally non-overlapping home ranges (females 88-1515 hectares and males 359-5512 hectares), with males encompassing multiple female home ranges. Given the absence of baseline records, sufficient frequency of crossing to demonstrate opportunity for dispersal and re-colonisation is considered to be a single crossing at one or more of the monitored underpasses after year 8 monitoring.

Giant-barred frog: Use of the crossing structures by the EPBC species listed Giant Barred Frog will not be used as a measure of effective mitigation for these structures as, while considered as 'possibly' occurring within the vicinity of one underpass (which occurs over 500 metres from the nearest baseline record), this species has not been nominated as a likely candidate for any monitored underpass.

Suitably Qualified Expert

An individual with tertiary qualifications and/or a minimum of three years demonstrated experience relevant to the task in question. The expert engaged to advise on **fauna crossings** must have expertise both in the ecology of Koalas and/or Spotted-tail Quolls and/or the Giant Barred Frog, as well as, the design and application of **fauna crossings** and road ecology.

2 BACKGROUND

2.1 ENVIRONMENTAL CONTEXT

The Project is located within the Port Macquarie-Hastings and Kempsey local government areas on the NSW mid-north coast.

Land use within the Project area includes residential, rural, commercial, industrial, state forests, national parks and reserves. Rural land use (grazing, aquaculture, oyster farming, orchards, tea tree plantations, vineyards, poultry farms, and other agricultural activities), state forests and conservation areas are the dominant land uses. The Project traverses Rawdon Creek Nature Reserve, Cairncross State Forest, Ballengarra State Forest and Maria River State Forest (Table 3). These state forests are scheduled for logging and contribute to State-wide logging production targets (GHD 2010).

Table 3: Conservation areas

State forest/ conservation area	Area (ha)	Location
Rawdon Creek Nature Reserve	560	Located west of the existing highway between the Hastings and Wilson rivers and maintains connectivity with Cairncross State Forest
Cairncross State Forest	5,908	Straddles the existing highway between the Hastings and Wilson rivers
Cooperabung Creek Nature Reserve	325	Previously part of Ballengarra State Forest
Ballengarra State Forest	6,325	Straddles the existing highway at Cooperabung Hill, north of Telegraph Point.
Maria River State Forest	2,119	Located east of the existing highway to the south of the Maria River

National parks in proximity to the Project include Kumbatine National Park, located approximately 100 metres to the west of the proposed alignment at the northern end of the Project, and Maria National Park located two kilometres to the east of the proposed alignment, also at the northern end of the Project. Kumbatine National Park covers approximately 15,100 hectares and adjoins the Kumbatine State Conservation Area, which covers an additional 783 hectares. Maria River National Park covers an area of 2,335 hectares that was formerly part of Maria River State Forest and vacant crown lands.

The Project intercepts five regional and two sub-regional corridors (Scotts 2003) that may facilitate the movement of fauna between coastal and inland habitats in response to seasonal resource ability and habitat conditions. Regional corridors are likely to support resident populations of certain fauna species, and to supplement habitats of wide-ranging, nomadic and migratory species. Sub-regional corridors serve more as routes for dispersal and movement for assemblage reference species and wide-ranging species, rather than habitats in their own right (Scotts 2003).

The Project spans two major rivers; the Hastings and Wilsons River (the Wilson River is a tributary of the Hastings River). There are two State–listed wetlands in the area; Dalhunty Island in the Wilson River and an area on the northern banks of the Wilson River near the Project alignment.

A number of second and third order streams flow through the Project area, such as Smiths Creek, Pipers Creek and Cooperabung Creek. Permanent and ephemeral drainage lines that flow under the existing Pacific Highway provide connectivity corridors for aquatic and riparian species.

2.2 MITIGATION OF POTENTIAL PROJECT IMPACTS

Planning for the Oxley Highway to Kempsey Upgrade, has followed a hierarchy of principles with regard to biodiversity values along the road corridor; avoid, minimise and mitigate impacts. Where impacts are unavoidable, mitigation measures are incorporated into the Project to reduce impacts.

2.2.1 IMPACTS OF ROAD UPGRADES

A major impact of roads is habitat fragmentation, where a division of otherwise continuous habitat reduces habitat connectivity. A reduction in habitat connectivity may impact upon the ability of an animal to move through habitat to obtain food, shelter and breeding resources. Other impacts of roads include mortality of wildlife due to collisions with vehicles; avoidance of roads by wildlife as a result of noise, light and pollutants associated with vehicles; and invasion along road edges by weeds and feral animals (QDMR 2000, Goosem 2005, van der Ree *et al* 2010, Mcall *et al* 2010).

These factors create a barrier to the movement of fauna and disrupt ecological processes, such as foraging and breeding activities, dispersal away from natal areas or seasonal migrations (van der Ree *et al* 2007). A disruption to such processes may affect the long-term viability of a population. As populations become smaller and more isolated, they are more susceptible to local extinction (Goosem 2005, Taylor and Goldingay 2009).The widening from the existing single carriageway to a four-lane dual carriageway will likely increase the existing barrier effect of the Pacific Highway, potentially reducing population viability further (Goosem 2005).

2.2.2 THREATENED SPECIES IN THE PROJECT AREA THAT MAY BE IMPACTED

Habitat adjoining the Project supports a diversity of fauna species that may be adversely affected by habitat fragmentation and resultant barrier effects, including threatened species listed under the *Threatened Species Conservation Act* (TSC Act) and *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) (Table 4). The movement of gliders may be particularly affected by road widening: they may be deterred by the larger gap (i.e. a larger distance between trees) that may exceed their gliding capability; or may attempt to cross and fall short of reaching vegetation on the other side of the road, resulting in increased mortality (van der Ree *et al* 2010, Mcall *et al* 2010).

Table 4: Fauna species known or likely to occur in Project area that may be potentially affected by habitat fragmentation

Fauna group	Scientific Name	Common Name	Status under TSC Act	Status under EPBC Act	Occurrence in Project area
Gliders	*Acrobates pygmaeus*	Feathertail glider	-	-	Known
	Petaurus australis	Yellow-bellied glider	Vulnerable	-	Known
	Petaurus breviceps	Sugar Glider	-	-	Known
	Petaurus norfolcensis	Squirrel Glider	Vulnerable	-	Moderate likelihood
Arboreal mammals	*Phascolarctos cinereus*	Koala	Vulnerable	Vulnerable	Known
	Trichosurus vulpecula	Common brushtail possum	-	-	Known
	Pseudocheirus peregrinus	Common ringtail possum	-	-	Known
	Phascogale tapoatafa	Brush-tailed Phascogale	Vulnerable		High likelihood
Frogs	*Mixophyes iteratus*	Giant Barred Frog	Vulnerable	Endangered	Known
	Litoria brevipalmata	Green-thighed frog	Vulnerable		Known
Terrestrial mammals	*Melomys cervinipes*	Fawn-footed melomys	-	-	Known
	Isoodon macrourus	Northern Brown bandicoot	-	-	Known
	Perameles nasuta	Long-nosed bandicoot	-	-	Known
	Rattus fuscipes	Bush rat	-	-	Known
	Rattus lutreolus	Swamp rat	-	-	Known
	Macropus giganteus	Eastern grey kangaroo	-	-	Known
	Macropus rufogriseus	Red-necked wallaby	-	-	Known
	Wallabia bicolor	Swamp wallaby	-	-	Known

Fauna group	Scientific Name	Common Name	Status under TSC Act	Status under EPBC Act	Occurrence in Project area
	Tachyglossus aculeatus	Short-beaked echidna	-	-	Known
	Dasyurus maculatus	Spotted-tailed Quoll	Vulnerable	Endangered	Moderate likelihood

Some of these species will be used as indicator species to measure the success of fauna crossings. This is described in more detail in Section 4.2.4.

The upgrade will not represent a barrier to all species; bats and most birds are readily capable of traversing the gap created by a dual carriageway, and would likely fly between the canopies above traffic height. Species that fly at lower elevations, such as Glossy Black Cockatoos (*Calyptorhynchus lathami*) and Grey-crowned Babblers (*Pomatostomus temporalis temporalis*) may be at increased risk of vehicle strike; potential impacts can be reduced by planting feed trees away from the carriageways in consultation with the Project ecologist

2.2.3 OBJECTIVE OF MITIGATION MEASURES

Crossing structures such as underpasses (culverts, tunnels) and overpasses (land bridges, rope bridges, glider poles) are increasingly being adopted in highway designs to mitigate barrier effects and reduce mortality rates of fauna (Mata 2003, McKenzie and Royle 2005, Soannes and van der Ree 2007, van der Ree *et al* 2009).

The Project incorporates several physical structures that aim to maintain habitat connectivity, allowing fauna to safely move between areas of habitat to the east and west of the Project. These structures include combined and dedicated fauna underpasses, rope bridges, glider poles, a widened median and associated fauna fencing. Underpasses will typically facilitate movement of smaller animals, while the widened median, rope bridges and glider poles will allow for the safe crossing of arboreal and gliding mammals.

2.2.4 INDICATOR SPECIES

The effectiveness of wildlife crossings will be based on their use by fauna groups previously recorded in proximity to the Project (<one kilometre). It is assumed that the Project bisects the habitat of at least some individuals from each of the nominated fauna groups (Table 4). Fauna species known to occur within the Project area that may be potentially adversely affected by the upgrade are listed in Table 5. These species will indicate the successful usage of crossing structures.

Table 5: Indicator and target species to assess usage of crossings

Fauna group	Indicator species (known from Project area)	Target (threatened) species
Frogs	*Litoria sp., Limnodastyes sp., Crinia sp.,* Giant barred frog	Green-thighed frog, Giant barred frog
Small ground-dwelling mammals	*Antechinus,* rodents and bandicoots, echidna, Spotted-tail Quoll	Spotted-tail Quoll, brush-tailed phascogale
Arboreal mammals	Brush-tail possum, ringtail possum	Brush-tailed phascogale
Koala	Koala	Koala
Gliders	Sugar glider, feathertail glider	Squirrel glider, yellow-bellied glider
Macropods	Swamp wallaby, red-necked wallaby, eastern grey kangaroo	N/A

The effectiveness of each structure for the EPBC species will be determined by the complete, safe crossing of the crossing by the targeted EPBC species at a sufficient frequency to ensure that habitat connectivity is maintained or improved from baseline conditions as defined in Section 1.5 and result in reduced incidence of road kill from baseline conditions which was determined to be set at 1 koala individual per 8 weeks and zero spotted-tailed quoll or giant barred frog (refer Appendix A).

For State listed species, the effectiveness of each structure will be determined by the complete passage of the target species or their nominated indicator species on at least one occasion in order to demonstrate opportunity for dispersal and re-colonisation.

For other species/fauna groups, the effectiveness of each structure will be determined by the complete passage of one or more individuals on at least once occasion from each of the relevant fauna groups for each crossing type (aerial or underpass), where the fauna group/species has been nominated (Table 12), to demonstrate opportunity for dispersal and re-colonisation.

3 BASELINE MONITORING

In accordance with MCoA B10 (d), baseline monitoring will be undertaken to identify changes in habitat usage before and after construction of the Project, and whether changes can be directly attributed to the Project. Baseline monitoring results for the EPBC listed species, that address the densities, distribution, habitat use and movement patterns of these species, has been included in Appendix A. The CV of the ecologist who conducted these surveys is included in Appendix B to demonstrate that they meet the definition of ‘suitably qualified expert’.

Habitat usage refers to the way fauna species use habitat features to survive and reproduce (Lindenmayer and Burgman 2005). Habitat features include food resources (nectar, pollen, blossom, lerp, foliage, or other animals); breeding resources (tree hollows, hollow logs, nests, caves, rocky features or crevices) and shelter (leaf litter, vegetation, tree or log hollows).

Habitat usage by a particular species may vary with seasons, weather conditions, breeding and dispersal periods and the availability of food and shelter resources. Habitat usage may also change as a result of direct or indirect impacts of the Project. A primary impact of the Project, habitat fragmentation, may adversely affect the ability of an animal to access or move through habitat to obtain food, shelter and breeding resources.

3.1 SITE FOR MONITORING: CONTROL AND IMPACT SITES

Baseline monitoring undertaken for this Ecological Monitoring Program has been designed in accordance with the 'Before After Control Impact' (BACI) design. In BACI design, data is collected at Impact sites and at Control sites both before and after the impact occurs (Underwood 1991). This design is preferred over a simple Before-After comparison as a change in the results collected may occur independently of any impact because of temporal effects. For example, changes in the abundance or distribution of a species, between the before and after periods, may be related to external variables such as bushfire rather than the construction of the upgrade.

The exact number and location of Control and Impact sites will be determined during a site visit by the Project Ecologist prior to the commencement of baseline surveys, in consultation with Roads and Maritime. Control and Impact sites will generally be paired, and will be selected with regard to localised habitat conditions at that time; stochastic events between the date of publication of this document and Project completion (e.g. bushfire) may affect the location of Control and Impact sites.

3.1.1 CONTROL SITES

Control sites have been located adjacent to roads/tracks in the locality that are not being upgraded and do not support wildlife crossing structures. Control sites have been located in habitat similar to that in which the Impact sites are located, with similar physical features (Underwood 1994). Control sites are located at:

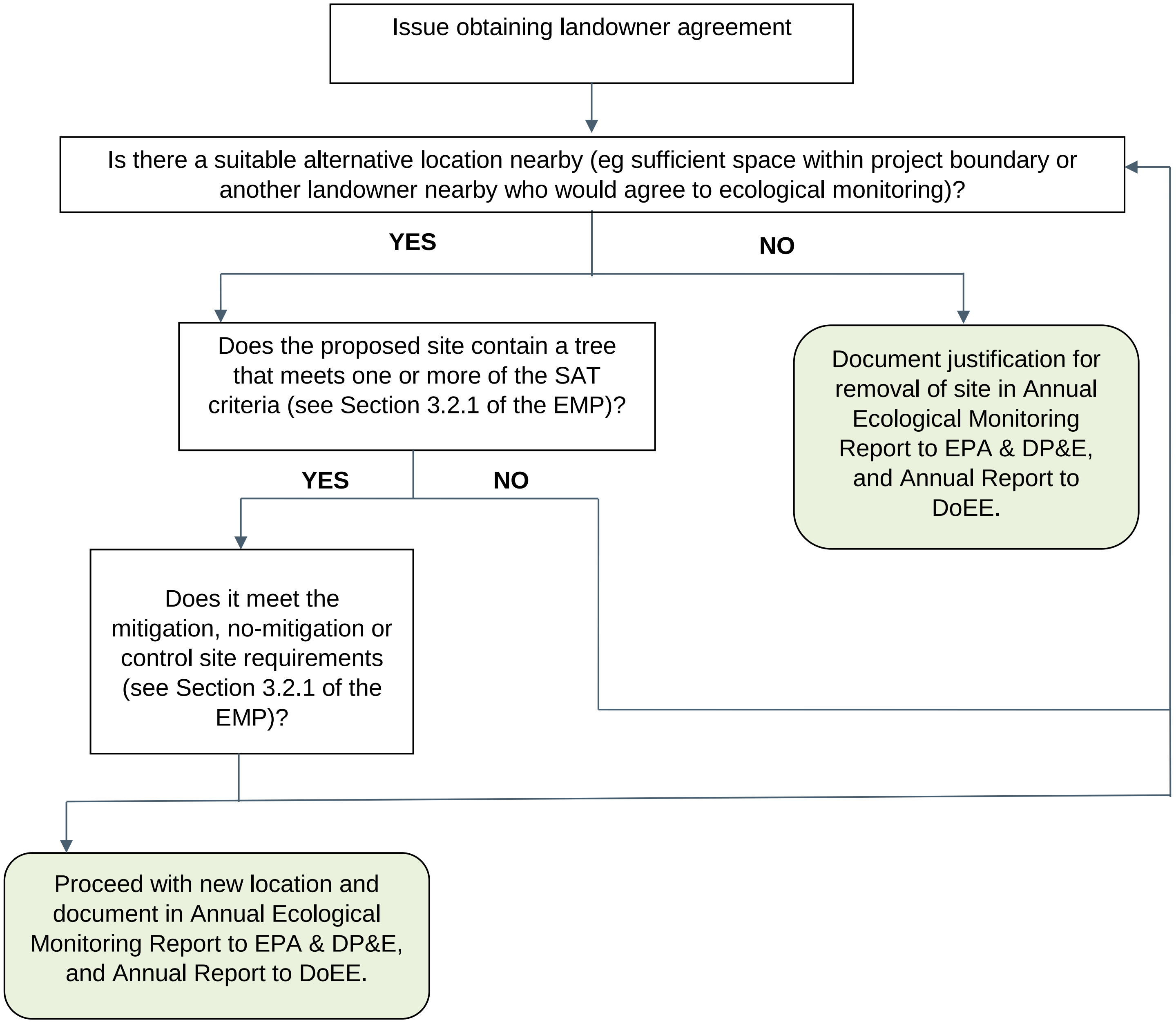
- Oxley Highway, west of the Pacific Highway at southern extent of the Project.
- Pembroke Road, west of the Pacific Highway in proximity to Cairncross State Forest and Rawdon Creek Nature Reserve.
- Rollands Plains Road, west of the Pacific Highway and north of the Wilson River.
- Old Coast Road, west of the Pacific Highway in proximity to Maria River State Forest.
- Smiths Creek Road, west of the Pacific Highway in proximity to Ballengarra State Forest.
- Scribbly Gum Road, east of the Pacific Highway in proximity to Maria River State Forest.
- Crescent Head Road, east of the Pacific Highway at northern extent of the Project.

3.1.2 IMPACT SITES

Impact sites are located in habitat adjacent to the completed Project and:

- Near dedicated and combined fauna passes, rope bridges, glider poles and the widened median.
- Some sites should be located away from fauna crossing structures.
- Should be stratified; i.e. be located in each habitat type that occurs adjacent to the Project.
- Should be located both near and away from drainage features.

Where landowner agreement cannot be obtained for control or impact sites, the following process will be implemented:


Issue obtaining landowner agreement
Is there a suitable alternative location nearby (eg sufficient space within project boundary or another landowner nearby who would agree to ecological monitoring)?
YES
NO
Does the proposed site contain a tree that meets one or more of the SAT criteria (see Section 3.2.1 of the EMP)?
Document justification for removal of site in Annual Ecological Monitoring Report to EPA & DP&E, and Annual Report to DoEE.
YES
NO
Does it meet the mitigation, no-mitigation or control site requirements (see Section 3.2.1 of the EMP)?
Proceed with new location and document in Annual Ecological Monitoring Report to EPA & DP&E, and Annual Report to DoEE.

3.2 THREATENED SPECIES TO BE MONITORED

As required by EPBC Act CoA 4a, the methodology for the pre-construction baseline surveys for the Spotted-tail Quoll, Koala and Giant Barred Frog are provided below, with the results provided in Appendix A. The baseline survey methodology for the Green-thighed frog and Yellow-bellied glider have also been included, given that they are threatened species listed under the EPBC and/or TSC Act, are known to occur in proximity to the proposed alignment and may be potentially affected by habitat fragmentation. The baseline survey methodology for the Squirrel Glider and Brush-tail Phascogale have been included given that they are threatened species listed under the TSC Act, are predicted to occur in proximity to the proposed alignment and may be potentially affected by habitat fragmentation.

Generally, all locations of known or potential habitat identified for each species below comprises an Impact site, as outlined in section 3.1.2. These sites will be monitored before and after construction of the Project and will be compared to Control sites.

3.2.1 KOALA

One Koala was sighted during field surveys undertaken for the EA crossing the highway approximately 200 metres south of Sancrox Road. Searches for koala scats and scratches on potential feed trees indicated recent koala activity within Ballengarra State Forest and south of Sancrox Road (GHD 2010). More recently, road kill koalas have been identified within the Project area at Wharf Road, Cooperabung Road, at the southern extent of Maria River State Forest and near Stumpy Creek (B Lewis 2013 pers. comm. 11 Sept).

Koala feed trees occur throughout much of the Project area, occurring in most vegetation communities (with the exception of swamp oak forest and cleared open pasture/weedy fallow). Koala feed trees are common to dominant canopy species in moist floodplain forest, moist slopes forest, riparian forest and swamp mahogany/forest red gum swamp forest (GHD 2010). Koalas may occur along the entire length of the Project; however, GHD (2010) has identified areas in which koalas are most likely to occur:

- Either side of Sancrox Road.
- Cairncross State Forest.
- Rawdon Creek Nature Reserve.
- Cooperabung Hill (Ballengarra State Forest and Cooperabung Nature Reserve).
- Mingaletta Road to Smiths Creek.
- Kundabung Road to north of Pipers Creek.
- Maria River State Forest.

The *Comprehensive Koala Plan of Management for Eastern Portion of Kempsey Shire LGA* (Kempsey Shire Council 2011) aims to provide for conservation of areas of habitat most important to koala populations in the eastern portion of Kempsey Shire. The Plan includes preferred koala habitat mapping that encompasses the Kundabung to Kempsey portion of the Project. This mapping shows that the Project transects large areas of Secondary Preferred Koala Habitat (Class B). The Project adjoins very few areas of Secondary Preferred Koala Habitat (Class A) and patches of Other Vegetation (not koala habitat) and Unknown Vegetation (predominantly cleared or partially cleared). Maria River State Forest, Kalateenee State Forest and Kumbatine National Park are exempt from any Preferred Koala Habitat classification.

Secondary Preferred Koala Habitat (Class B) comprises vegetation communities and/or associations in which primary food trees are absent and secondary and supplementary food tree species (*E. propinqua, E. globoidea* and/or *E, tindaliae)* are present. Secondary Preferred

Koala Habitat (Class A) comprises vegetation communities and/or associations in which primary food trees are sub-dominant components of the overstorey tree species and usually (but not always) growing in association with one or more secondary food tree species.

Timing

Baseline koala surveys were undertaken in the spring-summer period prior to the commencement of works, and will be undertaken in spring-summer once substantial construction has commenced in Year 1, 2 and 3 (construction phase) and Year 4, 5, 6 and 8 (operation phase) or until mitigation measures can be demonstrated to have been effective for the Koala, as defined in the EPBC approval.

Monitoring procedure

The Spot Assessment Technique

The Spot Assessment Technique (SAT) developed by Phillips and Callaghan (2011) will be used to monitor baseline populations and habitat use by koalas, in accordance with *Interim koala referral advice for proponents* (DSEWPC 2012). The SAT method involves a radial assessment of koala activity within the immediate area surrounding a tree that is known to have been utilised by the species or is considered to be of importance to the species. The SAT will be applied in the eight areas of habitat likely to represent core koala habitat within the project area (Impact sites), listed below:

- South of Sancrox Road.
- North of Sancrox Road
- Cairncross State Forest (south).
- Cairncross State Forest (north).
- Cooperabung Hill (Ballengarra State Forest and Cooperabung Nature Reserve).
- Mingaletta Road to Smiths Creek.
- Kindabung Road to north of Pipers Creek.
- Maria River State Forest.

The treatments include:

- Mitigation (Treatment A) centred on areas of sufficiently large culverts (ie > 1.8m) and floppy top fencing;
- No Mitigation (Treatment B) where the mitigation described above has not been proposed or only part mitigation is proposed;
- Control or reference (Treatment C) located in areas at least 3km and often 5-10km from the Project.

The Spot Assessment method as developed by Phillips and Callaghan (2011) is described below:

1) Locate and mark a tree that meets one or more of the following selection criteria:

   a) A tree of any species beneath which one of more koala faecal pellets have been observed; and/or

   b) A tree in which a koala has been observed; and/or

   c) Any other tree known or considered to be important for koalas, or of interest for other assessment purposes.

2) Identify and mark the 29 nearest trees to the tree marked initially.

3) Undertake a search for koala faecal pellets beneath each of the 30 marked trees. Visually inspect the ground surface beneath trees to a distance of one metre from the trunk. If no pellets are observed, a more thorough inspection involving raking the leaf litter and inspection of the ground cover within the prescribed search area. Two person minute per tree should be dedicated to the search for faecal pellets. The search should be concluded once a single pellet is found or the search time has expired (whichever happens first). Faecal pellets should not be removed from the site unless verification is necessary.

4) The activity level of a site is calculated as the percentage of surveyed trees within the site (of 30 trees) that has a koala faecal pellet recorded within its search area. The result is used to assess whether the site supports “Low”, “Medium (normal)” or “High” koala activity (Table 6).

Table 6: Categorisation of koala activity (Phillips and Callaghan 2011)

Activity Category	Low use	Medium (normal) use	High use
East coast (low density area)	-	3.33% but ≤12.59%	>12.59%
East coast (medium-high density area)	<22.52%	≥22.52% but ≤32.84%	>32.84%
Western Plain (medium-high density area)	<35.84%	≥35.84% but ≤46.72%	>46.72%

5) The results of the survey will be recorded. Attributes to be included in the report include:

a. date,

b. weather conditions,

c. geographic coordinates of the search area,

d. selection criteria,

e. tree species assessed,

f. DBH of the tree identified and marked as per item 1) of the monitoring procedure above,

g. radial search area surveys (distance from centre tree) and

h. the proportion of each tree species used versus the number sampled.

Spotlighting

Spotlighting will be undertaken as per the procedures employed in the baseline surveys (Appendix A) at a sub set of six sites in Cairncross State Forest (ch. 10400), Ballengarra State Forest (ch. 24000) and Maria River (ch. 36850). Spotlighting locations have been set up in a paired BACI configuration comprising an impact site and a control site which exhibits similar vegetation/habitat type and landscape features (Appendix A Figure 4.2; Table 4-3).

Field surveys will involve a listening period when first arriving at each location for 10 minutes. Spotlighting will be performed by two observers using hand held variable beam ~100 watt spotlights whilst walking a timed 500 m transect over 30 minutes (1 person hour effort). This will be repeated on three separate occasions on non-consecutive nights during Spring. The minimum time between consecutive surveys will be generally 7 days to maximize the opportunity of detection.

NSW BioNet wildlife Atlas

NSW BioNet wildlife Atlas records will be used to compare Koala distribution and density. Pre-construction records (i.e. 2004 - 2013 inclusive) will be compared to post-construction records at Year 8 (i.e. 2014 – 2022 inclusive), as per baseline methods.

Performance Measures

- Monitoring is undertaken during baseline surveys and from Year 1 – Year 6 & 8, or until mitigation measures are demonstrated to be effective.
- Monitoring during Year 1 – 6 & 8 is undertaken at the Impact and Control sites where monitoring was undertaken during baseline surveys, subject to ongoing landowner agreement. Where landowner agreement cannot be obtained and the process in Section 3.1.2 has been followed, this performance indicator will also be considered to have been met.
- Mitigation measures are demonstrated to be effective as defined in the EPBC approval when all monitoring events are considered at Year 8.
- Fauna fence is installed at a minimum in areas identified in Schedule 3 of the EPBC approval at Year 4.
- Density: Koala spotlighting records are compared to and discussed with reference to the baseline records, with the baseline detection frequency rate of 1 Koala per spotlight hour considered as the baseline density, as recommended in the baseline report. Compare the NSW BioNet wildlife Atlas density ranking of 5km2 grids, as per the baseline report, between pre and post-construction at Year 8.
- Movement: “Reduction in koala road kill compared to the baseline of 1 koala road kill per 8 weeks for an average baseline plot activity level of 5%, whereby proportional changes in average plot activity level may be reflected in the acceptable level of koala road kill
- Distribution: Compare the number of records and clustering of records, as per the baseline report, between pre-construction and construction/post-construction at year 8.
- Habitat Use: Koala SAT activity levels will be compared to the baseline activity levels data (below) with a 10% tolerance level, as recommended in the baseline report, to account for variability:
  - Broader study area set at 5% activity;
  - The treatment classes of mitigation set at 8.05%, no mitigation set at 2.64% and control / reference set at 4.03%
  - Comparison of percent tree use with baseline tree use.

3.2.2 SPOTTED-TAILED QUOLL

The spotted-tail quoll was not recorded in the Project area during field surveys undertaken for the Environmental Assessment (GHD 2010). The habitat assessment performed as part of the field surveys reported suitable den and latrine sites in the form of rock shelters and small caves were absent whilst large logs were generally found to be sparsely scattered throughout the Project area (GHD 2010). Nonetheless, it was still considered a likely inhabitant of the Project area as this species is known from multiple records in Limeburners Creek Nature Reserve around 5-10 km to the east.

Database searches (registered licence user CONO1022) identified 75 records of Spotted-tailed Quoll within 10 km of the Upgrade. Most of the records have originated from a community survey performed by Dan Lunney with recording dates spanning relatively long time periods of 10-20 years (e.g. 1991-2006). Apart from several records located within the residential landscape of Port Macquarie most records are broadly associated with large patches of contiguous vegetation. Interestingly, there are only a handful of records in close proximity to the existing Pacific Highway with these being located around the southern boundary of the Upgrade (i.e. Port Macquarie Interchange, Cowarra State Forest and Lake Innes), just to the north west of the Telegraph Point and two records in Maria River State Forest in the northern part of the Upgrade. There was a reported road kill quoll from July 1992 at Ch. 35500 with another reported road kill originating from the Oxley Highway which bisects Cowarra State Forest 5 km west of the southern end of the Project.

Timing

Spotted-tail quoll surveys will be undertaken during high movement periods for the species. The spotted-tail quoll typical breeds between April to August and disperses in spring and summer (Belcher 2003).

Baseline camera surveys were conducted in August 2013, prior to the commencement of construction, and additional surveys will be conducted in Autumn/ Winter (preferably March – mid-July) in Year 4, 6 and 8 (operation phase) or until mitigation measures can be demonstrated to have been effective for the Spotted-tail Quoll, as defined in the EPBC approval.

Monitoring procedure

Monitoring for the Spotted-tailed Quoll will be undertaken in three broad areas, which have been selected as they comprise the largest patches of vegetation, referred to here as Cairncross State Forest, Ballengarra State Forest and Maria River State Forest (Table 7).

Table 7 Monitoring sites for Spotted-tailed Quoll

Area	Monitoring Sites (each is 100 hectares)
Cairncross State Forest (dry sclerophyll forest with some swamp forest associations)	3 Control sites 3 Impact sites in proximity to fauna underpasses 3 Impact sites where no specific quoll mitigation (fauna underpasses) has been proposed
Ballengarra State Forest (dry sclerophyll forest with some moist forest and swamp forest associations)	3 Control sites 3 Impact sites in proximity to fauna underpasses 3 Impact sites where no specific quoll mitigation (fauna underpasses) has been proposed
Maria River State Forest (dry sclerophyll forest with some moist forest and swamp forest associations)	3 Control sites 3 Impact sites in proximity to fauna underpasses 3 Impact sites where no specific quoll mitigation (fauna underpasses) has been proposed

Within each of the three areas, a stratified BACI (Before-After-Control-Impact) survey design will be adopted following consultation with the EPA and include the following three treatments:

- 1 x **Control site** unaffected by the Project. The location of the Control site will be greater than 5 km from the Project corridor and often 7-10 km away. Every attempt will be made to locate a site which exhibits a similar array of topography and habitat attributes as both the nominated control and treatment sites located within the Project corridor.
- 1 x **Impact site** where fauna underpasses will be located in neighbouring areas to the control (no mitigation) site. A treatment site will be considered suitable if there is a combined or dedicated fauna underpass proposed within 500 m. Bridges will not be considered in this survey design following consultation with the EPA who recognised they provide an acceptable form of habitat connectivity to most ground dwelling fauna.
- 1 x **Impact site** where no specific quoll mitigation has been proposed within the Project for >500 m. For the purposes of this study, quoll mitigation is deemed as a fauna underpass structure referred to as a dedicated or combined fauna underpass (SMEC-Hyder 2013). Drainage culverts will be ignored in this instance because they are not being installed for the purpose of facilitating fauna movements; and

The above survey design will be repeated at three locations to provide a stratified sampling design of three replicates of each treatment within each of the three survey areas (Cairncross, Ballengarra, and Maria River). This will result in 9 x 100 ha survey plots across three treatments for each area culminating in 2700 ha.

The adopted sampling regime will be commensurate to the Department of Sustainability and Environment Approved Survey Standards: Spot-tailed Quoll *Dasyurus maculatus maculatus* publication (DSE 2011). At each monitoring site, four remotely triggered cameras (Faunatech, ScoutGuard or similar) will be installed 500 metres apart across each 100 ha plot with three plots representing each treatment (n=12 cameras) for each of the large patches of vegetation (Table 7). Cameras will operate continuously for 24 hours over 21 consecutive nights. Camera stations will be baited using an olfactory predator lure of chicken, fish or canned cat food so as to attract the animal into the area and allow sufficient opportunity for the camera to take a picture. This baiting will occur at the commencement of the study with the bait cached into a bag or cage.

At each camera station, the following habitat attributes will be recorded on one occasion:

- Structure and floristics of vegetation, including dominant species of each vegetation stratum, height and per cent cover.
- Presence and type of hydrological and surface drainage features.
- Presence and type of rocky features.
- Abundance and type of tree and log hollows.

Any changes in the local environment would be noted during subsequent monitoring events.

The monitoring data will be analysed in accordance with appropriate paired BACI design methods to determine if there is a statistically significant difference between the number of quolls detected at the control site and the impacted sites.

Performance Measures

- Monitoring is undertaken in Year 4, 6 and 8 or until monitoring can demonstrate that mitigation measures are effective.
- Monitoring during Year 4, 6 & 8 is undertaken at the Impact and Control sites where monitoring was undertaken during baseline surveys, subject to ongoing landowner agreement.

3.2.3 GIANT-BARRED FROG

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

Timing of monitoring

Baseline data will be collected prior to construction and consist of one survey in autumn, spring and summer (i.e. three surveys) prior to the commencement of construction. Baseline surveys will be conducted within one week following rainfall events when at least 10 millimetres of rain is recorded within a 24 hour period.

Construction monitoring will be conducted once substantial construction has commenced in spring, summer and autumn of Year 1, 2 & 3.

Following completion of the Project, surveys will be undertaken for five consecutive years, in spring and summer and autumn of Year 4, 5, 6, 7 and 8 (operation phase) or until mitigation measures can be demonstrated to have been effective for the Giant-Barred Frog, as defined in the EPBC approval.

Surveys will be conducted in the middle of each season, or if suitable rainfall does not occur, after a rainfall event deemed suitable by the Project Ecologist. .

Water quality monitoring is also being conducted within Giant-Barred Frog habitat and potential habitat. Water quality monitoring commenced at least 12 months prior to the commencement of construction, and will continue during construction and for three years post construction completion.

Monitoring Procedure

Monitoring procedures for the Giant Barred Frog described here have been extracted from the *Giant Barred Frog Management Strategy* (Lewis Ecological Surveys 2013).

Four areas of habitat for the Giant Barred Frog will be monitored:

- Cooperabung Creek.
- Smiths Creek.
- Pipers Creek.
- Maria River.

In addition, two reference sites will be monitored:

- Sun Valley Road, where it crosses Cooperabung Creek, several kilometres upstream of the Project footprint.
- Old Coast Road, where it crosses Pipers Creek, several kilometres upstream of the Project footprint.

Each survey will involve:

- Call-playback. Upon arrival at site, listen for vocalisations for 10 minutes. Play calls intermittently for 15 minutes. Listen for another 10 minutes.

- Frog surveys. Surveys will comprise two person hours per one kilometre transects. A one kilometre transect will be established at each monitoring site, which extends 450 metres upstream and downstream of the Project footprint (assumes project boundary width of 100 metres). This is subject to landowner agreement.
- Habitat surveys. The following variables will be recorded within the 100 metre zones established along the one kilometre transect at each monitoring site (subject to landowner agreement), from the top of the primary stream bank:
    - Overstorey vegetation cover (expressed as a cover percentage out of 100%).
    - Shrub cover (expressed as a cover percentage out of 100%).
    - Ground cover (expressed as a cover percentage out of 100%).
    - Leaf litter cover (expressed as a cover percentage out of 100%).
    - Bare soil/earth (expressed as a cover percentage out of 100%).
    - Presence of cattle (based on hoof marks, manure and whether it is recent or aged evidence).
    - Number of pools and riffles within the zone.
    - Approximate depth of the deepest pool within the zone.
    - Number of breaches in frog fencing, if applicable.

Any captured Giant Barred Frogs will be fitted with a Passive Integrated Transponder (PIT) tag. The PIT system is a radio-frequency identification tag which consists of an electromagnetic coil, tuning capacitor and microchip. The PIT tag is implanted under the skin or in the body cavity. Each PIT tag is encoded with a unique alphanumeric code, which may be read directly by a hand-held scanner.

Juvenile/sub adult frogs (<40 mm snout vent length) may be marked in accordance with the animal care and ethics licence of the Project Ecologist or frog expert. *The frog hygiene protocol will be adopted at Giant Barred Frog survey sites. This protocol will be in accordance with Department of Environment and Climate Change (DECC) (now EPA) Hygiene protocol for the control of disease in frogs Information Circular Number 6 (2008).*

For each Giant Barred Frog captured, the following data will be recorded:

- Location according to demarcated survey zone.
- Distance from stream edge.
- Sex (male, female, unknown).
- Breeding condition with:
    - Males assessed on the colouration of their nuptial pads (i.e. no colour, light moderate, dark)
    - Females based on whether they are gravid or not gravid (egg bearing).
- Snout-vent length (millimetres).
- Weight (grams).
- General condition of the frog

Additional variables that will be collected during each survey will include:

- Rainfall measured in four scales:
    - During the survey.
    - Within past 24 hrs.

- o Within past 7 days.
- o With past 30 days.

- Relative humidity measured with wet/dry bulb thermometer at the start and finish of the frog survey.
- Air temperature measured with a thermometer at the start and finish of the frog survey.
- Wind speed measured in subjective scale (0= no wind, 1 = light rustles of leaves on trees, 2 = leaves and branches moving and 3 = whole canopy moving).
- Water level
- Anecdotal information such as the presence of exotic fish.

Water quality monitoring in Giant-Barred habitat and potential habitat will be undertaken as outlined in Table 8 and Table 9 below.

Table 8 Water quality monitoring frequency in Giant-Barred Frog habitat

Project phase	Frequency
Pre-construction	All parameters except trace metals: one wet event per month and one dry event per month Trace metals: one wet event and one dry event per quarter
Construction*	All parameters except trace metals: two wet events per month and one dry event per month Trace metals: one wet event and one dry event per month
Operations*	All parameters except trace metals: one wet event per month and one dry event per month Trace metals: one wet event and one dry event per quarter

Table 9 Parameters to be measured during water quality monitoring

Parameter type	Parameter	Analysis type
Chemical properties	pH	In field measurement
	Dissolved oxygen (DO)	In field measurement
Physical properties	Electrical conductivity (EC)	In field measurement
	Temperature	In field measurement
	Turbidity (NTU)	In field measurement
	Total suspended solids (TSS)*	Laboratory analysis
Chemical properties	Total Petroleum Hydrocarbons	In field visual assessment. If oils and grease are visually evident, a sample will be forwarded to the laboratory for analysis.

Parameter type	Parameter	Analysis type
	Trace metals: Aluminium (Al) Arsenic (As) Cadmium (Cd) Chromium (Cr) Copper (Cu) Iron (Fe) Lead (Pb) Manganese (Mn) Mercury (Hg) Nickel (Ni) Silver (Ag) Zinc (Zn)	Laboratory analysis
Nutrients	Total Nitrogen (TN)	Laboratory analysis
	Total Phosphorous (TP)	Laboratory analysis

Performance Measure

- Monitoring is undertaken during baseline surveys and Years 1 – 8 and subsequently until monitoring and reporting demonstrates that mitigation measures are effective.
- Monitoring during Year 1 – 8 is undertaken at the Impact and Control sites where baseline monitoring was undertaken, subject to landowner agreement (see Section 3.1.2).
- Continued presence of Giant Barred Frogs during each survey event in Year 1 – 8 at sites where it was identified during baseline surveys, subject to access due to landowner agreement (see Section 3.1.2).
- Mitigation measures are effective as defined in the EPBC approval when all monitoring events are considered at Year 8.
- Median values of all downstream water quality monitoring at GBF habitat or potential habitat locations during construction and operation (Year 1 – 6) is less than the 80th percentile value of the upstream site (where 80th percentile is the value at which median values at the downstream site are above 80% of the recorded background water quality records), where this change is found to be attributable to construction or operation.
- At Year 8, no change to GBF densities, distribution, habitat use and movement patterns compared to baseline data.

3.2.4 GREEN-THIGHED FROG

A population of at least 10 Green-thighed frogs were observed and heard calling from vegetation surrounding a flooded pool in Maria River State Forest, suggesting this could comprise potential breeding habitat. The species has also been recorded in Rawdon Creek Nature Reserve (GHD 2010). Targeted surveys undertaken in January 2013 identified over 38 Green-thigh frogs at seven locations (all comprising potential breeding sites) between Cairncross State Forest (Ch.9050, Blackmans Point Road) and Kalatennee State Forest (Ch.33650) (Lewis Ecological Surveys 2013b).

Dry sclerophyll forest communities, Riparian Forest, Moist Floodplain Closed Forest with Rainforest Elements, Paperbark Swamp Forest, Swamp Mahogany/Forest Red Gum Swamp Forest, Moist Floodplain Forest, Moist Gully Forest and Moist Slopes Forest in the Project area offer potential habitat to the species (GHD 2010, Lemckert *et al* 2006, Lewis Ecological Surveys 2013 c).

Timing of monitoring

Baseline data was collected between 27th and 30th January 2013, when the study area received in excess of 200 millilitres over a 48 hour period.

Construction of the Project will directly impact (remove) or indirectly impact at least seven known breeding and non-breeding habitat areas for the Green-thighed Frog. As a result, monitoring will be unable to be undertaken at these sites during construction and following completion of the Project. Instead, constructed breeding ponds will be monitored and timing is detailed in Section 4.9.

Monitoring Procedure

Monitoring procedures for the Green-thighed Frog are in accordance with the *Green-thighed Frog Management Strategy* (Lewis Ecological Surveys 2013b) and Lemckert *et a*l (2006).

Baseline Green-thighed Frog surveys were undertaken at 27 sites that were identified as the most likely locations to support the species. Each site was then visited between one to three occasions to listen for calling males with an estimate provided on the calling intensity. The sites were again revisited on the 28th March 2013 to investigate the overall success of the January breeding event, approximately 57 days after the calling/breeding event. During these surveys active searches were performed for 20 minutes to survey for metamorphs around the pond edges and the surrounding vegetation, litter and beneath logs. Dip-netting for tadpoles was also undertaken.

Following completion of the Project, constructed breeding ponds will be monitored and this methodology is detailed in Section 4.9

Performance Measures

Following completion of the Project, constructed breeding ponds will be monitored and performance measures for this monitoring are detailed in Section 4.9.

3.2.5 YELLOW-BELLIED GLIDER

The Yellow-bellied glider was recorded calling in northern Ballangarra State forest during surveys undertaken in 2007 (GHD 2010). Larger tracts of forest communities offer potential habitat to this species. Hollow-bearing trees are used for sheltering and breeding. More recently, the species has been identified in Cairncross State Forest (at approximately Ch. 10400) and Maria River State Forest (east of the Maria River Bridge).

Timing of monitoring

Baseline yellow-bellied glider surveys will be undertaken during high movement periods for the species. The yellow-bellied glider typically breeds between July and September and disperses between spring and summer. Surveys will be undertaken in spring prior to the commencement of construction and in August-December in Year 4, 6 and 8 (operation phase).

Monitoring Procedure

Each survey (Kavanagh and Baking 1995, Wintle *et al* 2005) will involve:

- Call-playback. Upon arrival at site, listen for vocalisations for 10 minutes. Play calls intermittently for 15 minutes. Listen for another 10 minutes. Vocalisations of this species can be heard up to 400 metres away. Surveys will be repeated three times in each season

- Spotlighting. Surveys will conducted along 500 metre transects, with the observer walking at a rate of 30 minutes/500 metres. Surveys to be conducted on three non-consecutive nights. Although this species is considered spotlight-shy, it may be detected by its frequent movements during foraging activities. During spotlighting the observers will listen for Yellow-bellied Glider vocalisations

Performance Measures

- Monitoring is undertaken before and after construction of the upgrade.
- Monitoring is undertaken at Impact and Control sites.
- Continued presence of Yellow-bellied gliders at sites where it was identified during baseline surveys.

3.2.6 BRUSH-TAILED PHASCOGALE

The Brush-tailed Phascogale (*Phascogale tapoatafa*) has not been identified within the Project area. It was considered likely to occur in Moist Slopes Forest and Dry Ridgetop Forest (GHD 2010).

Ecological investigations undertaken by Lewis Ecological Surveys of the proposed alignment in October 2012 identified areas of potential Brush-tailed Phascogale habitat. It was noted that Cairncross State Forest likely facilitates the movement of the species through the landscape, although there is a lack of preferred habitat features such as hollow-bearing trees in the area. Potential phascogale habitat in the north of the Project occurs from Ch. 17100 (Wilsons River) to Ch. 37600, encompassing previous records of the species, mapped regional corridors, expanses of native vegetation contained in Cooperabung Nature Reserve and Ballengarra and Maria River State Forests. There is a recent (<5 years) record of the species in partly cleared Swamp Oak Floodplain forest in proximity to the southern bank of the Wilsons River, on the eastern side of the existing highway (B Lewis 2012 pers. comm. 18 Oct.). Potential Phascogale habitat (possible Impact sites) is located at:

- Ch.11680. In proximity to dedicated fauna culvert F11.68. Both sides of carriageway.
- Ch.21240. In proximity to dedicated fauna culvert F21.24. Both sides of carriageway.
- Ch.23100. In proximity to Barrys Creek bridge. Both sides of carriageway.
- Ch.34720. In proximity to dedicated fauna culvert F34.72. Both sides of carriageway.

Timing of monitoring

Baseline Brush-tail Phascogale surveys will be undertaken during high movement periods for the species. The Brush-tail Phascogale typically breeds between May and July and disperses in mid- summer (Strahan 2005). Surveys will be undertaken in summer prior to the commencement of construction and in winter and summer in Year 4, 6 and 8 (operation phase).

Monitoring Procedure

Surveys will be undertaken in areas of phascogale habitat. Surveys will comprise:

- Arboreal trapping. A grid configuration of 10 Elliot B traps will be established in approximately one hectare of habitat on both sides of the carriageway. Elliot B Traps baited with vegetable bait (generally rolled oats, peanut butter & honey) will be positioned on brackets approximately two metres above the ground and left operating over four consecutive nights.
- Hair tubes. A grid configuration of arboreal hair-tubes will be established in approximately one hectare of habitat and will be baited with vegetable bait. Transects will be established for a period of 14 consecutive nights per season. Hair samples will be sent to an appropriately qualified/experienced specialist for identification.

For each Phascogale captured, the following attributes will be recorded:

- Sex.
- Age class.
- Weight.
- Breeding condition.

Performance Measures

- Monitoring is undertaken before and after construction of the upgrade.
- Monitoring is undertaken at Impact and Control sites.
- Presence of Brush-tailed Phascogales during Brush-tail Phascogale monitoring and/or nest box monitoring.

3.2.7 SQUIRREL GLIDER

The Squirrel Glider has not been identified within the Project area. It was considered likely to occur in Moist Slopes Forest and Dry Ridgetop Forest (GHD 2010).

Timing of monitoring

Squirrel Glider surveys will be undertaken in gaps between flowering resource availability, when baited traps are likely to have the highest success rate (typically during autumn). Surveys will be undertaken between April and August (exact timing depends on gaps in flowering resources) in Year 4, 6 and 8 (operation phase).

Monitoring Procedure

Each survey period (Kavanagh and Bamkin 1995, Wintle *et al* 2005) will involve:

- Arboreal Trapping. A grid configuration of 20 Elliot B traps will be established in approximately two hectares of habitat. Elliot B Traps will be baited with a standard mixture of rolled oats, peanut butter and honey. The trunk of each tree will be sprayed with a 50:50 honey/water solution to act as an attractant. Traps will be positioned on brackets approximately three metres above the ground and left operating over four consecutive nights.

Performance Measures

- Monitoring is undertaken after construction of the upgrade.
- Monitoring is undertaken at Impact and Control sites.
- There is no statistically significant difference in presence of Squirrel Glider between Impact and Control sites during the operation monitoring phase of the Project.
    - Where statistical analysis is not possible due to low trapping success, detection of the Squirrel Glider using aerial crossings and/or the widened median.
    - Where statistical analysis is not possible due to low trapping success, detection of the Squirrel Glider within 75 metres (assuming conservative minimum home range size of 2 ha) of the Project corridor, so that it may be inferred that the local population may be incorporating habitat immediately adjacent to the Project within their home ranges

3.3 ROAD KILL MONITORING

3.3.1 TIMING OF MONITORING

Timing of road kill surveys is described in Table 10.

Table 10: Timing and locations of road kill surveys

Project Phase	Timing of survey	Location
Baseline	Weekly during October (spring), January (summer) and April (autumn) prior to commencement of construction (12 weeks)	Entire length of existing highway in Project area
During clearing operations	Daily	Portion of existing highway adjacent to clearing operations
One month following clearing operations	Daily	Portion of existing highway adjacent to clearing operations
For the duration of construction	Weekly	Entire length of existing highway in Project area
Within one month of opening of the Project	Weekly for 12 weeks. If this period does not coincide with the season (i.e. October (spring), January (summer) and April (autumn) in which baseline surveys were undertaken, also undertake weekly surveys during the first survey period (April, October or January) to occur after the opening of the Project (to allow for comparison to baseline results).	Entire length of completed Project
Upon completion of the Project (operation phase)	Weekly during October (spring), January (summer) and April (autumn (12 weeks) in Year 4, 5, 6 and 8, or until mitigation measures can be demonstrated to have been effective as defined in the EPBC approval.	Entire length of completed Project

3.3.2 MONITORING PROCEDURE

Road kill survey methodology is adapted from that described by Taylor and Goldingay (2004) and Ramp *et al* (2006). Baseline road kill surveys will involve a vehicle being driven along the entire length of the existing highway in the Project area and identifying dead wildlife (road kill) seen on the roads and within three metres of the road edge. Both driver and passenger will search the left-hand side of the road and its verge for road kill. When a road kill is observed from the vehicle, a closer inspection of the carcass will be undertaken where access is possible and where safety limitations permit. If safe access is not possible, due to local traffic conditions, binoculars will be used to try to identify carcasses. Road kill fauna will be identified to species level where possible, with reference to field guides. Those too seriously damaged to be accurately identified will be recorded as “unknown”. Upon identification of the road kill, the animal should be removed if safe to do so, so as to avoid double counting during subsequent surveys.

For each road kill observed, the following attributes will be recorded:

- Geographic coordinates of the road kill location.
- Species of road kill where possible.

If the animal is identified as a TSC Act or EPBC Act threatened species, the following information will also be recorded:

- Sex and age class (juvenile or adult) where possible and safety limitations permit.
- Presence of pouch young (for marsupials) where possible and safety limitations permit.

In addition, for TSC Act or EPBC Act threatened species, the following information will also be recorded where possible and safety considerations permit:

- Distance to a fauna connectivity structure.
- Distance to drop down structure.
- If fauna fencing was installed, is there any damage to the fence in the vicinity.

3.3.3 PERFORMANCE MEASURES

- Lower rates of road kill in proximity (ie areas of the main carriageways within areas adjacent to installed fauna fencing, and within 200m of rope bridges and fauna underpasses) to fauna fencing, rope bridges and fauna underpasses than in sections of the upgrade not near wildlife crossing structures or fauna fences in Year 1 – 6 & 8 monitoring events.
- Reduced incidence of road kill from baseline conditions during monitoring events in Years 1 – 6 & 8 and when all monitoring events are considered at Year 8.
- Fauna exclusion fencing is installed at a minimum in the locations identified in Schedule 3 of the EPBC approval at Year 4.

4 MONITORING OF MITIGATION MEASURES

The Project incorporates procedures and several physical structures that aim to reduce fauna mortality, maintain habitat connectivity and allow fauna to safely move between areas of habitat to the east and west of the Project. The mitigation measures will be monitored to determine their effectiveness.

4.1 PRE-CLEARING AND CLEARING PROCEDURES

4.1.1 DESCRIPTION

The Revised Statement of Commitments (SoC) Report includes several mitigation measures to be implemented during the pre-construction and construction phases of the Project. These measures aim to minimise impacts on flora and fauna and include:

- SoC F1: Detailed design will minimise the area of native vegetation and habitat to be cleared wherever reasonable and feasible.
- SoC F2: The limits of clearing and other native vegetation disturbance will be clearly marked on relevant work plans and on site with temporary fencing installed prior to clearing.
- SoC F4: Habitat features and resources for native fauna (such as hollow-bearing trees, hollow logs, nest boxes and bush rocks) impacted by the Proposal will be relocated where feasible and reasonable. Such relocation will be undertaken in a manner to limit damage to existing vegetation and will not occur in high condition remnant vegetation.
- SoC F9: Threatened plants in proximity to the Proposal that are to be retained will be identified by pre construction surveys and protected during construction through exclusion fencing and education of construction workers through the site induction process.
- SoC F10: The feasibility of relocating individuals of threatened species to suitable habitat will be investigated.
- SoC F12: A suitably qualified ecologist will undertake preclearance surveys. Searches will include nests and large hollow-bearing trees and target habitats of hollow-dwelling species, koalas and frogs. Fauna species found in pre-clearance surveys will be relocated to suitable habitat as close as possible to the area in which they were found.
- SoC F13: Where feasible and reasonable, removal of frog habitat along drainage lines will not be undertaken during periods of wet weather.
- SoC F14: The construction contractor will maintain contact details for local DECCW officers, WIRES and/or other relevant local wildlife carer groups.
- SoC 15: Surveys will be undertaken for threatened bat species by a suitably qualified ecologist to identify any roosting bats prior to the demolition of the existing highway bridges. Any bats will be moved and relocated following consultation with DECCW.

Although not specified in the SoC, the EA (GHD 2010) states that a two-stage clearing process will be implemented. Pre-clearing and clearing processes will be undertaken in accordance with *Biodiversity Guidelines: Protecting and managing biodiversity on RTA Projects* (RTA 2011).

Pre-clearing and clearing procedures (including fauna relocation procedures) are also detailed in the Construction Flora and Fauna Management Plans for the Project. A brief description of pre-clearing survey methodology is included in Table 11 in accordance with *MCoA B10 (c): Monitoring construction-related impacts.* The Project ecologist will assess the habitat present within the clearing footprint each day of clearing operations, and will be responsible for implementing the appropriate level of survey effort accordingly.

Fauna species identified within the clearing footprint will be relocated to similar habitat adjacent to the Project. Release sites for fauna will be identified prior to the commencement of clearing by the Project ecologist and in consultation with EPA. In determining release sites, habitat requirements for each species/fauna group will be considered.

If a threatened fauna or flora species is unexpectedly found within clearing limits, management of the threatened fauna or flora species (Figure 1) will be undertaken in accordance with *Biodiversity Guidelines: Protecting and managing biodiversity on RTA Projects* (RTA 2011).

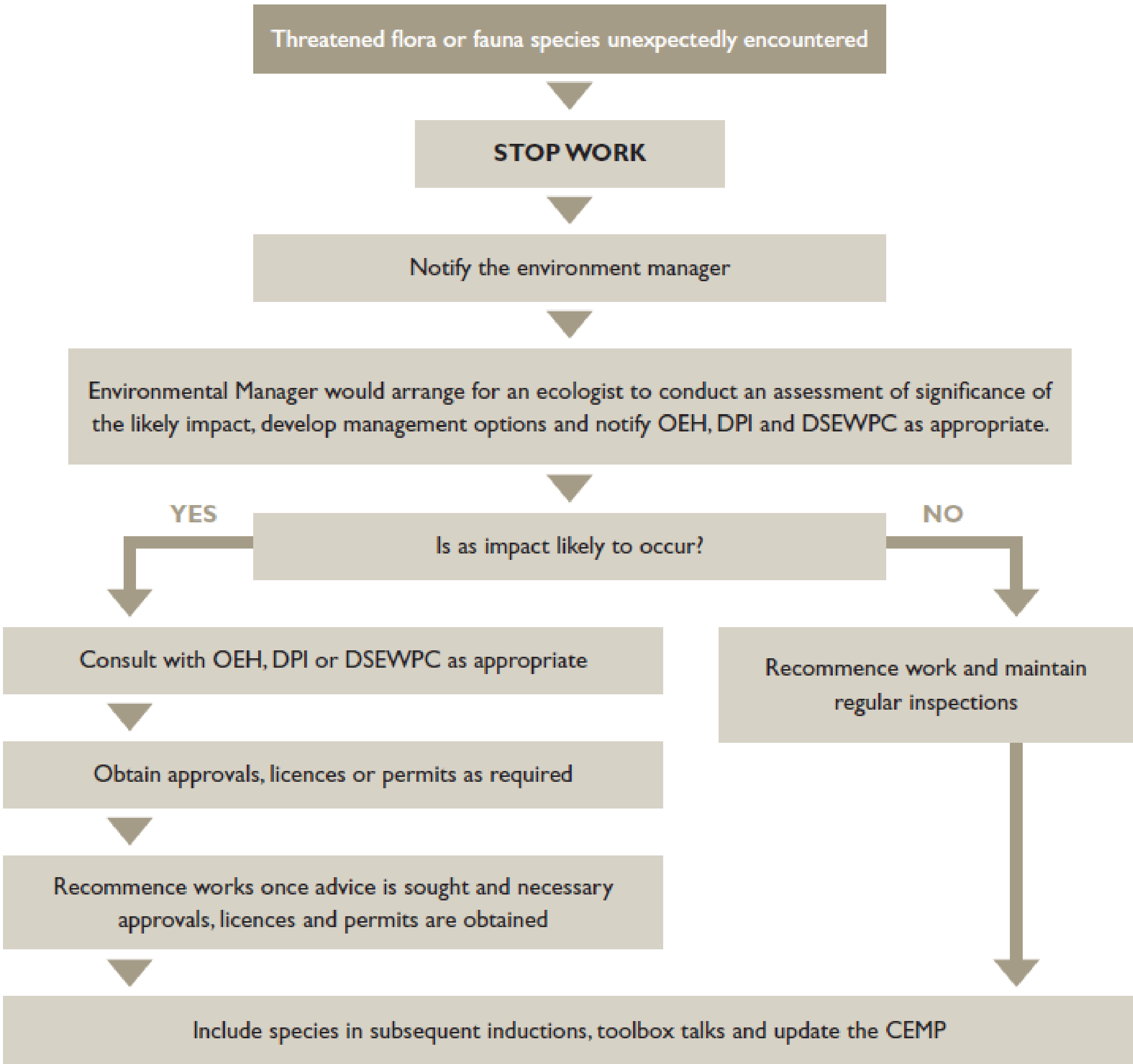


Figure 1: Unexpected find of threatened flora or fauna

Table 11: Methodology of pre-clearing surveys

Flora/Fauna to be protected	Methodology	Timing	Responsibility
Vegetation to be retained	Vegetation to be retained within the Project footprint will be clearly identified and marked on survey plans and delineated. Known locations of threatened flora species and the boundaries of Endangered Ecological Communities (EEC) to be retained within the Project footprint will be clearly delineated	Within twenty days of the commencement of clearing Check and verify limits 48 hours prior to the commencement of clearing. Highly visible flagging tape or fencing that delineates vegetation to be retained will be maintained until no longer required, or until the date of construction completion.	Project Ecologist
Threatened frogs - Green-thighed Frog (*Litoria brevipalmata)*	Targeted searches for Green-thighed Frog (*Litoria brevipalmata) will be undertaken where known or potential habitat for the species occurs within clearing limits.* Frog surveys will consist of nocturnal spotlight searches and call-playback detection. Active searches of microhabitats; turning rocks, logs, debris and checking defoliating bark, will be undertaken immediately prior to (<2 hrs) clearing operations. Captured frogs will be held temporarily in a plastic bag with a small amount of water (1 frog per bag). Frogs be relocated to similar habitat adjacent to the clearing footprint. *A frog hygiene protocol will be adopted at sites with Giant Barred Frog. This protocol will be in accordance with DECC (now EPA) Hygiene protocol for the control of disease in frogs Information Circular Number 6.*	Within 2 hours of scheduled clearing/ground disturbance operations. The need for additional nocturnal surveys will be at the discretion of the Project Ecologist.	Project Ecologist

Flora/Fauna to be protected	Methodology	Timing	Responsibility
Threatened frogs - *Giant Barred Frog (Mixophyes iteratus*	Pre-clearing survey methodology specific to the Giant Barred Frog is detailed in the *Giant Barred Frog Management Strategy* (Lewis Ecological Surveys 2013a) and will also be included in the Flora and Fauna Management Plan. Targeted searches for *Giant Barred Frog (Mixophyes iteratus) will be undertaken where known or potential habitat for the species occurs within clearing limits.* *Surveys to last 1 person hour per hectare of habitat to be disturbed/ removed and involve the use of call broadcast, spotlighting and active searches of litter, debris and logs.* *All Giant Barred Frogs captured will be relocated to the nearest side of the clearing limit with information collected on sex, breeding condition and snout-vent length. Alternative relocation sites may be considered provided they occur within the same drainage line. As a general rule frogs should not be relocated further than 300 m from the capture site, which should theoretically remain within an individual's home range.* *Frogs with a snout-vent length >40 millimetres will be PIT3 tagged to document the performance measure of this as a suitable relocation strategy. Juvenile/sub adult frogs may be marked in accordance with the animal care and ethics licence of the Project Ecologist or frog expert. Toe clipping is one possible method, however, not all animal care and ethics committees support this approach.* *A frog hygiene protocol will be adopted at sites with Giant Barred Frog. This protocol will be in accordance with DECC (now EPA) Hygiene protocol for the control of disease in frogs Information Circular Number 6.*	Within five days of scheduled clearing/ground disturbance operations, surveys will be conducted over a minimum of two non-consecutive nights	Project Ecologist

Flora/Fauna to be protected	Methodology	Timing	Responsibility
Arboreal mammals	Arboreal mammal surveys will consist of stag watching, spotlighting and call-playback detection. If an arboreal mammal is identified within the clearing limits during nocturnal surveys, the location will be checked during a diurnal visual inspection undertaken on the following morning immediately prior to clearing. The removal of any arboreal mammals from within the clearing should be undertaken in accordance with *Biodiversity Guidelines: Protecting and managing biodiversity on RTA Projects* (RTA, 2011). If a threatened arboreal mammal is identified within the clearing limits, the tree that it is occupying will be retained, a 50m buffer around the tree will be instated.	Nocturnal spotlighting will be undertaken the night immediately prior to clearing. A diurnal visual inspection of trees identified as supporting arboreal fauna within the clearing limits would be undertaken immediately prior to the commencement of clearing	Project Ecologist
Koalas	Koala surveys will consist of spotlighting and diurnal surveys. If a koala is identified within the clearing limits during nocturnal surveys, the location will be checked during a diurnal visual inspection undertaken on the following morning immediately prior to clearing. The removal of any arboreal mammals from within the clearing should be undertaken in accordance with *Biodiversity Guidelines: Protecting and managing biodiversity on RTA Projects* (RTA, 2011). If a koala is identified within the clearing limits, the tree that it is occupying will be retained, a 50m buffer around the tree will be instated. If the koala does not vacate the clearing footprint, a corflute fence will be erected around the base of the tree occupied by the koalas. A wire cage trap will be placed at the exit in the fence. The trap will be set during the day and checked every 2-3 hours through the night until the koala is caught (AMBS 2011). The wildlife carer will manage any injured koalas, and the Project ecologist will relocate koalas upon confirmation of their health.	Nocturnal spotlighting will be undertaken no earlier than 48 hours prior to clearing. A diurnal visual inspection of trees identified as supporting koalas within the clearing limits would be undertaken immediately prior to the commencement of clearing	Project ecologist
Microchiropteran bats	Searches of potential microbat roost sites such as culverts and bridges likely to be disturbed by clearing works will be undertaken. Surveys will involve active searches of structures for signs of use by microbats and the use of an endoscope, torch and an Anabat if required. Any microbats found should be managed in accordance with the *Microbat Management Plan.*	Timing of microbat surveys will be accordance with the *Microbat Management Strategy.*	Project Ecologist

Flora/Fauna to be protected	Methodology	Timing	Responsibility
Natural habitat features	Natural habitat features such as hollow logs, felled branches and bush rocks will be identified from the Project footprint. Locations of habitat features will be recorded with a GPS and marked with flagging tape or fluorescent paint. Habitat features will be considered for relocation or avoided by contractors where possible.	Within twenty days of the commencement of clearing	Project Ecologist
Habitat trees	Habitat trees (trees currently in flower, sap feeding trees, trees supporting nests or dreys) will be clearly demarcated so that they are retained for the second stage of clearing or avoided by contractors, where possible. Its location will be recorded using a GPS.	Within twenty days of the commencement of clearing	Project Ecologist
Hollow-bearing trees	Hollow-bearing trees (HBT) occurring within the Project footprint were surveyed in October-November 2012 for the preparation of the *Nest Box Plan* (Lewis Ecological Surveys 2013d). The location of each HBT was marked using the following techniques: ▪ Plotted using a handheld GPS ▪ Flagged with fluorescent flagging tape ▪ Spray-painted with a number in the event that the flagging tape was removed ▪ Plotted on survey plans to advise on Project site works Data collected on each HBT included tree species, height, DBH, position of hollows (trunk or limb), estimated size of hollow, suitability for fauna species	The demarcation of HBTs is to be checked within 48 hours of the commencement of clearing.	Project Ecologist

4.1.2 TIMING

Pre-clearing flora and fauna surveys will be conducted prior to Stage 1 removal of vegetation (i.e. non-habitat trees). Inspections of habitat trees and fauna rescue procedures will be undertaken during Stage 2 clearing.

4.1.3 MONITORING PROCEDURE

Pre-clearing survey techniques, timing and responsibilities for surveying are briefly detailed in Table 11. A report will be prepared and submitted to the principal contractor, Roads and Maritime and EPA as part of the subsequent annual ecological monitoring report after the clearing operations have been completed. The reports will include:

- Survey date.
- Time.
- Surveyors.
- Weather conditions.
- Details of methods used during pre-clearing surveys and clearing operations.
- Fauna species displaced by clearing, species captured, species released and any wildlife mortalities resulting either directly or indirectly from the clearing operations.
- Location of fauna within clearing footprint (recorded with GPS) and release locations.
- Hollow-bearing tree register, and comparison of this data to nest box plan (assess the adequacy of nest boxes installed and how they are mitigating the loss of tree hollows).
- Discussion of the effectiveness of those methods employed.
- Recommendations for future pre-clearing and/or clearing procedures.

4.1.4 PERFORMANCE MEASURES

The performance of pre-clearing and clearing procedures will be assessed against:

- Low rates of fauna injury and mortality resulting from clearing operations, and no mortality of TSC Act and EPBC Act threatened species.
- Stop work implemented immediately when fauna observed, and recommenced upon successful capture and release of fauna displaced by clearing operations (ie being released within 1 hour without mortality, unless the animal is injured and is instead managed in accordance with the Fauna Handling and Rescue Procedure in the FFMP).
- Immediate contact with Project Ecologist / Suitably Qualified Expert or wildlife carer when injured fauna are identified.
- Accurate quantification of fauna habitat features and hollow-bearing trees being removed against the predicted quantities identified in the Nest Box Management Plan.

4.2 FAUNA UNDERPASSES

4.2.1 DESCRIPTION

The Revised Statement of Commitments includes measures to be implemented to provide for fauna movement:

- *SoC F17: Culverts and bridges identified in the Environmental Assessment as having a potential role in wildlife crossing will be designed to* facilitate *fauna movements where feasible and reasonable.*

Wildlife crossing structures, locations and target species are described in detail in the *Oxley Highway to Kempsey Upgrade Wildlife crossing Strategy* (HSJV 2012a).

The Project includes over 51 underpasses that may facilitate the passage of fauna species, which comprise of:

- Nine bridges that provide fauna passage beneath them: Fernbank Creek, Hastings River, Wilsons River, Cooperabung Creek, Barrys Creek, Smiths Creek, Pipers Creek, Maria River and Stumpy Creek.
- 11 dedicated underpasses (10 built as part of Stage 2 and 3, and one to be built as part the upgrade of the highway to Motorway Class [Class M]). Dedicated fauna underpasses will support fauna furniture to encourage the passage of target fauna species.
- 30 combined culverts (culverts that provide for both drainage and fauna passage). Fauna furniture has been provided in a few combined culverts to encourage the passage of target fauna species.

It is proposed that 14 fauna underpasses be monitored, including the10 dedicated fauna underpasses that have been constructed and 4 combined fauna underpasses. Fauna underpasses to be monitored upon completion of the Project are listed in Table 12. The selection criteria for fauna underpasses to be monitored are as follows:

- All constructed dedicated fauna underpasses will be monitored.
- No combined underpasses that are located in cleared, disturbed or modified areas will be monitored, as the usage expectancy of these culverts is low (primarily due to a lack of fauna habitat in proximity to the underpass).
- No combined culverts will be monitored, that are located within 600 metres of another monitored underpass that will be monitored.

No incidental underpasses will be monitored. These typically comprise small culverts that are not intended to allow for the passage of fauna. Small terrestrial mammals, reptiles and amphibians may use these underpasses on occasion.

Table 12: Fauna underpasses to be monitored upon completion of the Project

Culvert ID	Ch.	Underpass type	Cells	Width (m)	Height (m)	Length (m)	Target species (other species that may use crossing)	Adjoining habitat	Fauna furniture (target species)
F1.04	1040	Dedicated	1	3	3	50	Koala (macropods, small mammals, reptiles, amphibians)	Modified environment. Mapped as Cleared Scattered Trees, adjoining intact Moist Slopes Forest and Moist Gully Forest	Rails and refuge poles (koalas)
F1.62	1670	Dedicated	1	3	3	48	Koala (macropods, possums, small mammals, reptiles, amphibians)	In a mapped sub-regional corridor	Rails and refuge poles (koalas)
C4.46	4450	Combined	3	3	2.1	41	Koala (Small macropods, possums, small mammals, frogs, reptiles)	Located in fragmented habitat in a drainage line. Links native vegetation east and west	Rails and refuge poles (koalas)
C7.26	7270	Combined	1	3	2.4	41.6	Koala (spotted-tailed quoll, possums, smaller macropods, small mammals, reptiles, amphibians	Links native vegetation east and west, Located in vegetation contiguous with Cairncross state forest and Rawdon Creek nature reserve	Rails and refuge poles (koalas)

Culvert ID	Ch.	Underpass type	Cells	Width (m)	Height (m)	Length (m)	Target species (other species that may use crossing)	Adjoining habitat	Fauna furniture (target species)
F9.70	9700	Dedicated	1	3	3	38	Koala (spotted-tailed quoll, possums, smaller macropods, small mammals, reptiles, amphibians	On the margin of a regional corridor in Moist Floodplain Forest in Cairncross state forest	Rails and refuge poles (koalas) Rocks, logs, hollow logs (frogs) Rocks, hollow logs (quolls)
F11.67	11660	Dedicated	1	3	2.4	38	Koala (spotted-tailed quoll, possums, smaller macropods, small mammals, reptiles, amphibians	Dry Ridgetop Forest in Cairncross State Forest	Rails and refuge poles (koalas) Rocks, logs, hollow logs (frogs) Rocks, hollow logs (quolls)
F20.54A	20560	Dedicated	1	3	3	53	Koala (Spotted-tailed quoll, macropods, small mammals, reptiles, amphibians	Links native vegetation to east and west, continuous with regional corridor linking key habitat in Cooperabung Nature reserve and Ballengarra State Forest	Rails and refuge poles (koalas) Rocks, hollow logs (quolls)
F21.24	21240	Dedicated	1	3	3	58	Koala (macropods, spotted-tailed quoll, small mammals, reptiles, amphibians	Regional corridor linking key habitat in Cooperabung Nature reserve and Ballengarra State Forest	Rails and refuge poles (koalas) Rocks, hollow logs (quolls)

Culvert ID	Ch.	Underpass type	Cells	Width (m)	Height (m)	Length (m)	Target species (other species that may use crossing)	Adjoining habitat	Fauna furniture (target species)
F22.32	22320	Dedicated	1	3.6	3.6	59.4	Koala (possums, spotted-tailed quoll, macropods, small mammals, reptiles, amphibians)	Regional corridor linking key habitat to east and west, vegetation continuous with mapped climate change corridor to east	Rails and refuge poles (koalas) Rocks, hollow logs (quolls)
F26.40	26400	Dedicated	1	3	3	49	Koala (macropods, spotted-tailed quoll, small mammals, reptiles, amphibians)	Links vegetation to east and west	Rails and refuge poles (koalas) Rocks, hollow logs (quolls)
C32.35	32350	Combined	1	3	3	64	Koala (macropods, small mammals, reptiles, amphibians)	Located in regional corridor, however, surrounding landscape is modified by farmland and roads. Fragmented connectivity of vegetation adjoining culverts with larger patches of vegetation to east and west.	No
F33.40	33400	Dedicated	1	3	3	49	Koala (possums, spotted-tailed quoll, macropods, small mammals, reptiles, amphibians possibly Green-thighed frog)	Maria River State Forest	Rails and refuge poles (koalas)

Culvert ID	Ch.	Underpass type	Cells	Width (m)	Height (m)	Length (m)	Target species (other species that may use crossing)	Adjoining habitat	Fauna furniture (target species)
F34.72	347200	Dedicated	1	3	3	48	Koala (possums, spotted-tailed quoll, macropods, small mammals, reptiles, amphibians)	Moist Gully Forest Maria River National Park Key regional corridor	Rails and refuge poles (koalas) Rocks, logs, hollow logs (frogs) Rocks, hollow logs (quolls)
C36.40	36400	Combined	1	3	3	66	Koala (possums, spotted-tailed quoll, macropods, small mammals, reptiles, amphibians possibly Green-thighed frog and giant barred frog)	Moist Gully Forest	Rails and refuge poles (koalas)

4.2.2 TIMING

Timing of monitoring of fauna underpasses will coincide with the breeding seasons and dispersal periods of target species (Table 13). Higher frequencies of movements increase the likelihood of fauna to utilise and be detected in underpasses. Timing may require amendment in accordance with the actual completion date of the Project.

Table 13: Breeding seasons and likely dispersal periods of threatened species targeted by underpasses

Scientific Name	Common Name	Breeding season	Likely dispersal period
Dasyurus maculatus	Spotted-tail Quoll	April to July	Spring and summer
Litoria brevipalmata	Green-thighed Frog	Late spring and summer	In association with rainfall events
Mixophyes iteratus	Giant Barred Frog	Late spring to early summer	In association with rainfall events
Phascogale tapoatafa	Brush-tailed Phascogale	May to July	Mid-summer
Phascolarctos cinereus	Koala	Spring and summer	Spring and summer

Fauna underpass monitoring will commence upon completion of the Project (Year 4) and will be undertaken in late autumn and late spring/early summer each year for a minimum of 60 days. Monitoring will continue in Year 6 and 8 of the operation phase and additional monitoring may be required if fauna underpasses are determined to be ineffective whereby performance measures are not met.

4.2.3 MONITORING PROCEDURE

Monitoring of underpasses will be undertaken using the following techniques:

- A motion-detecting camera installed in each specified combined and dedicated fauna underpasses (Table 12). Cameras will be installed in the middle of each underpass and/or at each end of the underpass, depending on what provides the best field of view. Cameras are to operate continuously for a period of 60 days during autumn and 60 days during late spring/early summer. Cameras will not be installed in all combined underpasses.
- Sand-plots established at each end of combined fauna underpasses for a period of eight nights per monitoring period. Sand plots, at least one metre wide, will be established across the entire width of the underpass when not inundated with water and will be inspected each following morning for tracks and then raked clean.
- Ten (10) Hair-tubes placed upon fauna furniture within crossing structures and placed in habitat adjoining wildlife crossing structures. Hair tubes will be baited with a mixture of peanut butter, honey and oats for 14 nights per monitoring period. Hair samples will be sent to an appropriately qualified/experienced specialist for identification.
- Scat searches within crossing structures (approximately one to two metres from the end to minimise wind and rain disturbance) and in adjoining habitat. Searches to be undertaken when installing and checking sand plots (ie twice per monitoring period).

4.2.4 PERFORMANCE MEASURES

Indicators of success of fauna underpasses include:

- Complete safe crossing by the targeted EPBC species, the Spotted-tailed quoll and Koala, at a sufficient frequency as defined in Section 1.5. This would ensure that the underpass performance measure would trigger the contingency measures in section 5 for underpass performance after each koala monitoring event to review / modify underpass furniture, habitat, monitoring and if required, agency discussions.
- For non-EPBC species (Brush-tailed Phascogale), the complete safe crossing of the nominated underpass by the target species or their indicator species on at least one occasion in order to demonstrate opportunity for dispersal and re-colonisation (excluding frogs which are unlikely to be detected using camera monitoring).
- For fauna groups, the complete safe crossing of the nominated underpass by one or more individuals on at least once occasion from each of the relevant fauna groups (small ground-dwelling mammals, arboreal mammals and macropods) to demonstrate opportunity for dispersal and re-colonisation.
- Reduced incidence of road kill from baseline conditions.

4.3 ROPE BRIDGES

4.3.1 DESCRIPTION

Rope bridges will provide connectivity for arboreal mammals and will be suspended across the dual carriageway between poles on each side. General design considerations include:

- The rope ladder must be constructed of marine grade silver (high UV rating) rope and stainless steel cables.
- The rope bridge must be linked to adjacent glider habitat trees by ropes or ladders tied off onto the support poles and the trees.
- The preferred minimum clearance above the road pavement surface for the rope bridge is 10.6 metres, however this may be varied in consultation with EPA.

Rope bridges at three locations between the Kundabung and Kempsey section of the Project will be monitored (Table 14).

Table 14: Locations of rope bridges to be monitored between Kundabung and Kempsey

Chainage	Target Species	Existing Environment
24100	Squirrel Glider Yellow-bellied Glider	Located in proximity to Barrys Creek and riparian zone Riparian Forest/Moist Floodplain Closed Forest with Rainforest Elements/ Moist Gully Forest Within mapped Regional corridor Ballengarra State Forest

Chainage	Target Species	Existing Environment
33990	Squirrel Glider Yellow-bellied Glider	Located in proximity to Combined underpass C34.10 Located in proximity to glider poles Maria River State Forest Within mapped Regional corridor Moist Slopes Forest/ Moist Gully Forest/ Dry Ridgetop Forest
35700	Squirrel Glider Yellow-bellied Glider	Located in proximity to Combined underpass C35.70 Maria River State Forest In proximity to unnamed watercourse Within mapped Regional corridor Moist Slopes Forest/ Moist Gully Forest/ Dry Ridgetop Forest

Rope bridges for the Oxley Highway to Kundabung section of the Project (eight in total) are located at chainages 9360, 11350, 11830, 12030, 22920, 23290, 23590 and 23670.Timing

Monitoring of rope bridges will coincide with the breeding seasons and dispersal periods of target (Table 15) and other arboreal species known from the Project area. Higher frequencies of movements increase the likelihood of fauna to utilise and be detected on rope bridges; monitoring will be undertaken in autumn and spring. In autumn, movement of arboreal species generally increases in frequency and range as individuals seek flowering resources, while animals are typically dispersing post-breeding in spring.

Table 15: Breeding seasons and likely dispersal periods of threatened species targeted by rope bridges

Scientific Name	Common Name	Breeding season	Likely dispersal period
Petaurus australis	Yellow-bellied Glider	Between July and September	Winter to spring
Petaurus norfolcensis	Squirrel Glider	Between April and November	Autumn to spring
Phascogale tapoatafa	Brush-tailed Phascogale	May to July	Mid-summer

Rope bridge monitoring would commence within the first six months of operation (Year 4). Cameras are to operate continuously for a period of eight weeks during autumn and eight weeks during late spring/early summer at Year 4, 6 and 8. Additional monitoring may be required in the event the monitoring data suggests that rope bridges are ineffective and modification/treatments are required.

4.3.2 MONITORING PROCEDURE

Monitoring of rope bridges will be undertaken using the following techniques (Soanes 2009):

- Remotely triggered infrared cameras (Faunatech or similar) will be installed at each end of each rope ladder. Two active infra-red beam sensors will be positioned on the canopy bridge approximately one and four metres from each camera. The sensors will detect an animal's movement across the bridge. This should allow for the entire sequence of the animals crossing behaviour to be recorded. All photos will be time and date stamped.

- At each download, the road verge 50 metres north and south of each rope bridge pole will be searched for road kill.
- Fauna is to be identified to species and the following attributes are also to be recorded: date, time, direction of movement. An assessment of whether a full crossing was made, with reference to picture taken at both glider poles in a pair, will be undertaken.
- Hair tubes will be screwed onto each pole approximately three metres high. Hair-traps consist of hair-tubes made from 100 millimetre lengths of 40-millimetre diameter PVC. A smaller plastic tube (three centimetres long, two centimetres diameter) with several small holes will be packed with a bait mixture of peanut butter, honey and oats and inserted into the hair-tube. Double-sided tape is to be applied to the end of each tube. Hair-tubes will be in place for approximately four weeks in both autumn and spring.

4.3.3 PERFORMANCE MEASURE

Indicators of success of rope bridges include:

- Complete crossing of the rope bridge, (through camera monitoring or other evidence of complete crossings), by native arboreal fauna species known to occur in the Project area, (see Table 4) or other indicator species (see Table 5) on at least one occasion in order to demonstrate opportunity for dispersal and re-colonisation. This performance measure would also be considered to be met where gliders are not detected at both ends of the rope bridge due to the likelihood of gliders to leave the bridge once within gliding distance of habitat.
- For target non-EPBC listed species (Brush-tailed Phascogale, Squirrel Glider and Yellow-bellied Glider), complete crossing of the rope bridge, (through camera monitoring or other evidence of complete crossings), by the arboreal target species or their nominated indicator species on at least one occasion in order to demonstrate opportunity for dispersal and re-colonisation. This performance measure would also be considered to be met where gliders are not detected at both ends of the rope bridge due to the likelihood of gliders to leave the bridge once within gliding distance of habitat.
- Lower rates of road kill arboreal species in proximity to rope bridge than in sections of the upgrade away from crossing structures.

4.4 GLIDER POLES

4.4.1 DESCRIPTION

Glider poles will provide connectivity for gliding mammals and will comprise of poles located on each side of the dual carriageway. General design considerations include:

- Glider poles must not be located more than 40 metres apart.
- Cross bars on glider poles must point to the desired landing.
- Glider poles must include shelter pipes and predator shields to discourage attack from aerial predators.
- Habitat trees for gliders must be within gliding distance of glider poles for glides in both directions.

Glider poles at three locations between the Kundabung and Kempsey section of the Project will be monitored (Table 16).

Table 16: Locations of glider poles

Chainage	Target Species	Details
25100	Squirrel Glider Yellow-bellied Glider	Located in proximity to Barrys Creek Ballengarra State Forest Within mapped Regional corridor Moist Slopes Forest/ Riparian Forest
25100	Squirrel Glider Yellow-bellied Glider	Located in proximity to Barrys Creek Ballengarra State Forest Within mapped Regional corridor Moist Slopes Forest/ Riparian Forest/
35780	Squirrel Glider Yellow-bellied Glider	Located in proximity to rope bridge at Ch. 35700 Maria River State Forest, within mapped Regional corridor Located in association with drainage line Moist Slopes Forest/ Moist Gully Forest/ Dry Ridgetop Forest

Locations of glider poles for the Oxley Highway to Kundabung section of the Project are located on southbound carriageway into widened median at chainages 10770 and 10920 and across the full alignment at chainage 11240 and 9020.

4.4.2 TIMING

Monitoring of glider poles will coincide with the breeding seasons and dispersal periods of target species (Table 17) and other gliding species known from the Project area. Higher frequencies of movements increase the likelihood of fauna to utilise and be detected on glider poles; monitoring will be undertaken in autumn and spring. In autumn, movement of arboreal species generally increases in frequency and range as individuals seek flowering resources, while animals are typically dispersing post-breeding in spring.

Table 17: Breeding seasons and likely dispersal periods of threatened species targeted by glider poles (Tyndale-Biscoe 2005, Goldingay 2008, Van der Ree & Suckling 2008)

Scientific Name	Common Name	Breeding season	Likely dispersal period
Petaurus australis	Yellow-bellied Glider	Between July and September (variable depending on habitat characteristics)	Winter to spring (when young 12-24 months of age)
Petaurus norfolcensis	Squirrel Glider	Between April and November 9peak during winter)	Autumn to spring

Glider pole monitoring would commence within six months of the operation of the project (Year 4) installed and focus on a four week sampling period in autumn and spring at Year 4, 6 and 8.

Additional monitoring may be required in the event the monitoring data suggests that glider poles are ineffective and modification/treatments are required.

4.4.3 MONITORING PROCEDURE

Monitoring of glider poles will be undertaken using the following techniques (Goldingay *et al* 2011):

- Infrared motion sensor digital camera (Faunatech or similar) will record use of glider poles by glider. As gliders could ascend a pole on any side, making it difficult for a single camera to effectively record pole use, a sheet-metal collar will be placed around the pole at a height of approximately 3m above ground. The collar will be designed and installed to direct the passage of fauna into the ideal view of a pole-mounted wildlife camera positioned to capture images of fauna ascending or descending the upper portions of glider poles.
- All photos will be time and date stamped
- At each download, the road verge 50-metres north and south of each glider pole will be searched for road kill.
- Downloaded pictures will be enlarged and examined for glider presence. Gliders are to be identified to species where possible and the following attributes are also to be recorded: date, time, direction of movement and location across carriageway, if possible.

4.4.4 PERFORMANCE MEASURE

Indicators of success of glider poles include:

- Evidence of use of glider poles by native gliders known to occur in the Project area, (see Table 4).
- For target non-EPBC listed species (Squirrel Glider and Yellow-bellied Glider), the complete passage of the target species or their nominated indicator species (see Table 5) on at least one occasion in order to demonstrate opportunity for dispersal and re-colonisation.
- Lower rates of road kill gliders in proximity to glider poles than in sections of the upgrade away from crossing structures.

4.5 FAUNA FENCING

4.5.1 DESCRIPTION

The Revised Statement of Commitments includes a commitment to erect fauna fencing, which aims to prevent animals crossing the road surface, thereby reducing road kill. Fauna fencing is also used to guide animals towards safe wildlife crossing structures or passages such as underpasses:

- SoC F19: Fauna exclusion fencing (eg floppy-top fencing) will be erected along the Proposal at appropriate locations to direct fauna movement towards wildlife crossing structures.

Standard fauna fencing will be installed at locations described in the *Oxley Highway to Kempsey Upgrade Fauna Fencing Strategy* (HSJV 2012b). In summary, three types of fauna fencing will be used, including

- Standard floppy-top fencing.
- Frog fencing.

▪ Phascogale fencing.

Notwithstanding the information detailed below, fauna fencing will be installed at a minimum as per Schedule 3 of the EPBC approval.

Standard floppy-top fencing

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

Standard fauna fencing will be installed:

- Where the Project traverses Cairncross, Ballengarra and Maria River State Forests.
- Where the Project traverses regional habitat corridors.
- Between dual carriageway bridges and culverts where there are gaps between structures to prevent fauna accessing the median strip.
- On the outside of all spill containment / water quality treatment basins to prevent fauna from accessing polluted water sources.

Frog fencing

Giant Barred Frog fencing will be installed in areas where the presence of Giant Barred Frogs has been confirmed and there is a 'high' risk of frogs accessing the carriageway in accordance with the *Giant Barred Frog Management Strategy* (Lewis Ecological Surveys 2013a). Giant Barred frog fencing will be located at:

- Ch.18500. Eastern side of the Project extending north to Ch.19100 (Cooperabung Creek).
- Ch.19550 to Ch.19725. Both side of the carriageway (Cooperabung Creek).
- Ch.28175 to Ch.28325. Both side of the carriageway (Smiths Creek).
- Ch.36800 to Ch.36950. Both side of the carriageway (Maria River).

Giant Barred Frog fencing is to be at least 900 millimetres in height and will comprise of gauze size 30-40millimetres to present frogs from moving through the fence, yet allow for the flow of overland water. The gauze will include a small return of not less than 150 millimetres on the ground.

Green-thighed Frog fencing will be installed in areas of Green-thighed Frog breeding ponds and/ or where there is an obvious threat of frogs accessing the new carriageway, in accordance with the *Green-thighed Frog Management Strategy* (Lewis Ecological Surveys 2013b). Green-thighed Frog fencing will be located at:

- Ch.8900-9400. Both sides of the carriageway (Cairncross State Forest).
- Ch.11500-11800. Both sides of the carriageway (Cairncross State Forest).

The Green-thighed Frog fencing is described in the *Green-thighed Frog Management Strategy* to be made of 500 millimetres high neoprene rubber sheeting (>4 millimetre thickness) including a small rubber return of not less than 100 millimetres on the ground. This type of fencing has failed in its installation and effectiveness.

The Green-thighed Frog fencing is now comprised of 1mm dia. 6.5mm * 6.5mm vermin proof galvanized steel wire mesh connected to the 3.15mm fencing chain wire mesh with galvanized steel ties at 300mm centres.

Both species of frogs occur in association with Pipers Creek. As a result, a combination of fencing requirements is required in this location. Frog fencing will be installed at:

- Ch. 30500 to Ch.30825. West side carriageway (Pipers Creek)
- Ch.30650 to Ch.30900. East side carriageway (Pipers Creek).

Frog fencing at Pipers Creek must account for both frog morphologies (ie include the minimum requirements for each species, specifically height requirements of GBF fence and thickness/ permeability requirements of GTF fence) and is comprised of 1mm dia. 6.5mm * 6.5mm vermin proof galvanized steel wire mesh and a hot dip galvanized pressed sheet metal lip connected to the 3.15mm fencing chain wire mesh.

Phascogale fencing

Phascogale fencing is attached to floppy top fauna fencing. At the base of floppy top fauna fences, a second layer of mesh is installed to 200 millimetres above ground level height, offset from the first layer of mesh to create maximum opening size of 25 millimetres. Above 200 millimetres, 600 millimetre hot dip galvanised pressed steel sheet or powder coated aluminium pressed sheet are affixed to the floppy top fauna fencing.

Phascogale fencing has been installed at areas of known or high potential habitat, to direct phascogales away from the highway and towards underpasses between:

- Chainages 9400 – 12400 North bound
- Chainages 9400 – 12320 South bound
- Chainages 21500 – 22480 North bound
- Chainages 20900 – 24160 South bound
- Chainages 22650 – 24160 North bound
- Chainages 34500 – 34950 North bound
- Chainages 34500 – 34900 South bound

4.5.2 TIMING

Where fauna fencing adjoins fauna underpasses, a length of 200m of fencing either side of the crossing will be inspected in conjunction with underpass monitoring periods i.e. four weeks in late autumn and four weeks in late spring/early summer in Years 4, 6 and 8.

4.5.3 MONITORING PROCEDURE

Monitoring of fauna fencing will be undertaken using the following techniques:

- Inspection of the lengths of fauna fencing detailed in Section 4.5.2 to identify and report any breaches.
- Inspection of the entire length of frog and phascogale fencing and the edge of the highway in proximity to frog and phascogale fencing, to identify and report any breaches.
- Searches for threatened frogs will be undertaken on both sides of the frog fencing n spring and summer after rainfall deemed suitable by the Project Ecologist s to identify the

presence of any frogs that may have breached frog fencing. If a suitable rainfall event does not occur in spring and/or summer, surveys may be undertaken in autumn after rainfall, and if temperatures are considered suitable for frog activity by the Project Ecologist.

4.5.4 PERFORMANCE MEASURE

Indicators of success of fauna fencing include:

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

4.6 WIDENED MEDIAN

4.6.1 DESCRIPTION

The Revised Statement of Commitments includes measures to be implemented to provide for fauna movement and maintain habitat connectivity:

- SoC F18: The feasibility of widening the median will be further investigated in consultation with DECCW during the detailed design.

Retaining tall trees in the median that separates the carriageways may mitigate the barrier effect of roads on gliders, provided that the gap in tree cover is within their glide distance capacity. Median widening is an alternative means of providing safe crossing opportunities for gliding species in locations where mature vegetation between carriageways would allow gliding species to cross the upgraded highway in a staged manner (GHD 2011).

The feasibility of providing a widened median was investigated (SHJV 2012c) and a widened median is proposed to be located in Cairncross State Forest, between Bill Hill Road in the north (Ch. 11400) and where the carriageways diverge at Ch. 10300 in the south.

The median is approximately 50 metres at its widest at Ch. 10700. Vegetation communities in the widened median and either side of the carriageway include Moist Gully Forest, Paperbark Swamp Forest, Swamp Mahogany/Forest Red Gum Swamp Forest, Moist Floodplain Forest and Dry Ridgetop Forest. One EEC, Swamp Sclerophyll Forest on Coastal Floodplain, occurs between Ch. 11100 and Ch. 11300. Vegetation within and adjoining the widened median is continuous with native vegetation of the regional corridor mapped to the north (Ch. 11600).

4.6.2 TIMING

Monitoring of the widened median will coincide with the breeding seasons and dispersal periods of target species (Table 18) and other gliding species known from the Project area. Higher frequencies of movements increase the likelihood of fauna to utilise and be detected in the widened median; monitoring will be undertaken in autumn and spring. In autumn, movement of arboreal species generally increases in frequency and range as individuals seek flowering resources, while animals are typically dispersing following breeding in spring.

Table 18: Breeding seasons and likely dispersal periods of threatened species targeted by glider poles (Tyndale-Biscoe 2005, Goldingay 2008, Van der Ree & Suckling 2008)

Scientific Name	Common Name	Breeding season	Likely dispersal period
Petaurus australis	Yellow-bellied Glider	Between July and September (variable depending on habitat characteristics)	Winter to spring (when young 12-24 months of age)
Petaurus norfolcensis	Squirrel Glider	Between April and November (peak during winter)	Autumn to spring

Monitoring of the widened median will commence during the first optimal season for target species (Table 18) following completion of the Project (Year 4). Monitoring will be undertaken over 16 weeks from June-September each year for a minimum of three years (Years 4, 6 and 8). Additional years of monitoring may be required if the widened median is found to be ineffective and requires modification or supplementation with alternative crossing structures.

4.6.3 MONITORING PROCEDURE

Monitoring of the widened median will involve sampling within the widened median and within retained habitat either side of the Upgrade corridor. Monitoring will involve the use of several fauna census techniques including, but not limited to:

- Hairtube sampling.
- Spotlighting surveys.
- Nestbox monitoring (see Section 4.7)

Additional or alternative monitoring approaches proposed by the Project Ecologist may also be used to assess the effectiveness of the widened median against the performance measures, subject to agreement with the EPA.

Hair tube sampling

Hair tube sampling will be conducted over three 14-night periods during each monitoring event. The first sampling period will be undertaken in mid-June, the second sampling period during the last week of July and the first week of August and the third sampling period during mid-September.

Hair tube transects, each containing 20 hair tubes (spaced 25 to 30 metres apart), will be established in retained forest habitat either side of the Upgrade corridor at the widened median. One hair tube transect, containing 20 hair tubes (spaced 25 metres apart), will be established in the widened median.

Each hair tube will be attached to the main trunk of a mature Eucalypt at approximately three metres above the ground, and baited with a mixture of honey, oats and peanut butter. The main trunk above the hair tube will be sprayed with a mixture of honey and water upon installation to provide an additional attractant for gliders.

Spotlighting surveys

Two observers will conduct spotlighting surveys one night per week over each 16-week monitoring event. Within the widened median spotlighting transects (minimum 500 metres long), will be established in retained forest habitat either side of the Upgrade corridor and within the widened median (three transects in total)

Nest box monitoring

See Section 4.7.

4.6.4 PERFORMANCE MEASURES

Indicators of success of the widened median monitoring will include:

- Evidence of use of median vegetation by the target glider species.
- Evidence of use by dispersing individuals and different age cohorts.
- Use by glider species other than threatened species e.g. sugar glider

4.7 NEST BOXES

The monitoring methodology for nest boxes described here has been extracted from the *Nest Box Management Plan* (Lewis Ecological Surveys 2013c).

4.7.1 DESCRIPTION

The Revised Statement of Commitments includes a measure to be implemented to mitigate the loss of tree hollows during vegetation clearing prior to construction of the Project:

- SoC F16: Development of a nest box strategy will be undertaken.

A *Nest Box Management Plan* has been prepared by Lewis Ecological Surveys (2013c). The Management Plan describes the attributes of tree hollows to be removed, the number of nest boxes needed to mitigate the loss of tree hollows, the design and distribution of nest boxes and ongoing management of nest boxes.

The Management Plan described a two stage assessment method to calculate the number of nest boxes required for the Oxley Highway to Kempsey project. Following the calculation after the final design of the project the following numbers of nest boxes were required and installed:

- 267 nest boxes required for the Oxley highway to Kundabung (Ch.0-24040).
- 257 nest boxes required for the Kundabung to Kempsey (Ch.24040-37850).

The contractor installed 60% of the nominated nest boxes prior to or during the clearing works to provide temporal refuge habitat for those hollow dependent fauna displaced during clearing operations. The remaining 40% of nest boxes were installed by the contractor once a final tally of functional tree hollows was compiled and reviewed as a result of the data collected during the clearing supervision.

4.7.2 TIMING

Nest boxes were installed in Year 1 and 2 (construction phase). Monitoring will commence in summer and winter shortly after the installation period (Year 2) and will continue in summer and winter of Year 4, Year 6, Year 8. A pre-handover maintenance inspection will be undertaken at Year 8.

4.7.3 MONITORING PROCEDURE

A visual inspection of each nest box will be undertaken. During each monitoring period, the following information will be collected for each nest box (Lewis 2013c):

- Inspection date, weather conditions (rain, wind, cloud cover, ambient temperature) and time each nest box was inspected.
- Nest box identification number.
- If the nest box is occupied by native fauna, and if so, the species. If the next box is not occupied by a native species, record any signs of use by native species such as feathers, droppings, scats, hair or nesting material.
- If the nest box is occupied by a pest species such as European bees, or common myna.
- Is there any deterioration of the nest box and is any maintenance required.
- Any changes to the *surrounding habitats*, such as clearing or installation of wildlife crossing structures.

The maintenance regime during the monitoring period will involve:

- The removal of exotic species such as common myna, common starlings and European bees (if these are outcompeting native fauna as determined by a second repeat occupancy by the exotic species).
- The replacement of fallen, damaged or deteriorated nest boxes.
- The repositioning or relocation of nest boxes that show no sign of use after several successive monitoring periods
- The removal of excess nesting material that may block access to the nest box over time.

4.7.4 PERFORMANCE MEASURES

Indicators of success of nest boxes include:

- Use of nest boxes by a wide range of native fauna species.
- Use of next boxes designed for specific species by those same species.
- Low rate of use of nest boxes by introduced fauna species.
- Low level of maintenance of nest boxes.

4.8 MICROBAT ROOST BOXES

The monitoring methodology for roost boxes described here has been extracted from the *Microchiropteran Bat Management Strategy* (Lewis Ecological Surveys 2013d).

4.8.1 DESCRIPTION

A *Microchiropteran Bat Management Strategy* has been prepared by Lewis Ecological Surveys (2013d). The Management Strategy describes existing locations of roosting microbats and management strategies used to avoid, minimise and mitigate impacts on identified bat roosts, which includes the installation of bat roost boxes. 158 bat roost boxes (Table 19) were installed in late September / early October 2013, which is 6-12 months prior to planned roost exclusion from existing structures.

Table 19: Bat roost boxes that have been installed

Location	Roost Box Type A (small slotted style bat box)	Roost Box Type B (wedge style)	Roost Box Type C (tree mounted removable slots)
K2K	31	32	28
OH2Ku	20	23	24
Total	**51**	**55**	**52**

4.8.2 TIMING

Bat roost boxes have been installed prior to the commencement of construction (Year 0). Monitoring of bat boxes will commence six months after their installation (Year 1), followed by quarterly inspections (each season) for two years (Years 2 and 3), before addressing corrective actions. After the first two years of monitoring, monitoring of the bat roost boxes will continue twice a year (summer and winter of Year 4, 6 and 8) up until Year 8.

4.8.3 MONITORING PROCEDURE

A visual inspection of each bat roost box on the OH2Ku section of the project will be undertaken. During each monitoring period, the following information will be collected for each bat roost box:

- Inspection date, weather conditions (rain, wind, cloud cover, ambient temperature) and time each bat roost box was inspected.
- Bat roost box identification number.
- If the bat roost box is occupied by microbats, and if so, the species. If the next box is not occupied by a native species, record any signs of use by microbats.
- If the bat roost box is occupied by a pest species such as European bees.
- Is there any deterioration of the bat roost box and is any maintenance required.
- Any changes to the surrounding habitats, such as changes to flyways or vegetation structure.

4.8.4 PERFORMANCE MEASURES

Indicators of success of bat roost boxes include:

- Use of bat roost boxes by microbats.
- Low rate of use of roost boxes by introduced fauna species.
- Low level of maintenance of roost boxes

4.9 GREEN-THIGHED FROG BREEDING PONDS

The monitoring methodology for Green-thighed Frog breeding ponds described here has been extracted from the *Green-thighed Frog Management Strategy* (Lewis Ecological 2013b).

4.9.1 DESCRIPTION

The Revised Statement of Commitments includes measures to be implemented to mitigate the loss of potential frog breeding habitat:

- SoC F11: Consideration would be given to constructing artificial frog ponds if appropriate.

Frog breeding ponds were constructed at three locations; one (see below) within the Oxley Highway-Kundabung section and two within the Kundabung-Kempsey section. These locations and their attributes are described in detail in the *Green-thighed Frog Management Strategy* (Lewis 2013b). Ponds were constructed as per the design requirements outlined in the *Green-thighed Frog Management Strategy* (Lewis 2013b). Ponds are located at:

- Ch.9050-9350. Five ponds to be constructed on each side of the carriageway.
- Ch.30660. Five ponds to be constructed on the western side of the carriageway.
- Ch.33650. Five ponds to be constructed on each side of the carriageway.

4.9.2 TIMING

Monitoring will be undertaken on five occasions commencing in Years 3-7 (construction and operation phase). Each monitoring event should be at least 10-12 months apart but ultimately dependant on rainfall events. On each occasion the site would be surveyed for 30 minutes during Stage 1 and for 20 minutes during stage 2 (see section 4.9.3). Four of the five monitoring events are to occur during the operational phase of the Project (Years 4-7). The first round of monitoring (Year 3) is to commence once the vegetation on the edges of the constructed ponds is considered sufficient (>20% groundcover), to be determined by a suitably qualified Ecologist. The timing would be staggered accordingly for either stage of the Upgrade.

4.9.3 MONITORING PROCEDURE

Monitoring of the constructed breeding ponds would ideally be undertaken on a rainfall event basis when 24-hour rainfall totals exceed 75 millilitres or a cumulative total of 150 millilitres over a 72-hour period. Where sufficient rainfall is unlikely to occur during the monitoring period, surveys may be undertaken during an alternative rainfall event deemed suitable by the ecologist. Such rainfall events would be monitored via the Bureau of Meteorology (BOM) website, specifically the Port Macquarie (Station No. 060183) and/or Kempsey (Station No. 059017) weather stations. The suitability of the rainfall trigger chosen would be subject to the reference site visit outlined in Stage 1 below. Surveys would be performed using a two-stage process outlined below.

Stage 1 – Determining Presence and Breeding Activity

Upon the study area receiving the required rainfall, a reference site would be visited to determine the extent of Green-thighed Frog activity.

The survey would comprise a 30-minute nocturnal active search at each of the four breeding pond areas using a hand held spotlight. Peripheral habitats (i.e. <50 m) would also be surveyed at this time. Upon the completion of Stage 1 surveys the next stage would be implemented.

Stage 2 – Determining the Success of the Breeding Event

All frog breeding pond areas would be subject to follow-up surveys between 30-40 days after Stage 1 to assess the outcome of the breeding event. This follow up survey will comprise:

- A 20-minute active search for metamorphs and juvenile frogs around the pond edge and vegetation immediately adjacent to the pond (i.e. <10 m).
- Dip netting of the constructed pond and subsequent tadpole identification. Specific attention will be given toward identifying the presence of fish (both native and exotic) along with predatory invertebrates such as dytiscid larvae.
- The depth of the ponds would be measured from the permanently installed water staff.
- Photo taken from a designated photo point (to be established during the first Stage 2 survey).

4.9.4 PERFORMANCE MEASURE

Performance indicators of success will be based on either the:

- Continued presence of Green-thighed Frog at two or more of the three frog breeding pond sites.
- Green-thighed Frogs calling from the edge of the constructed ponds.
- The presence of tadpoles, juveniles or metamorphs during follow up surveys.

Signs of the mitigation being unsuccessful will be based on the:

- Absence of Green-thighed Frogs from the area.
- Ponds not holding water for a sufficient time to enable tadpoles to reach metamorphosis.
- Ponds holding water for too long and representing unsuitable habitat (i.e. permanent versus ephemeral).

4.10 *MAUNDIA TRIGLOCHNOIDES* HABITAT PROTECTION

4.10.1 DESCRIPTION

Areas of potential *Maundia triglochnoides* habitat were surveyed by the SMEC-Hyder Joint Venture (SHJV) ecologists in November 2012, following the identification of *M. triglochinoides* in the Project corridor in August 2012 by Lewis Ecological Surveys. Three distinct sub-populations of *M. triglochinoides* were recorded in the project area (Table 20).

Table 20: *Maundia triglochnoides* in the project area

Location	*M. triglochinoides* potentially impacted by the project
Fernbank Creek (Ch.4450-5080)	0.75 ha
Wilson River Floodplain –wetlands (Ch.15,890)	0.03 ha
Wilson River Floodplain – canal (Ch.13,900-14,100)	0.09 ha
Barrys Creek	-
Total	**0.87 ha**

4.10.2 TIMING

Monitoring would commence in the summer of Year 1 (construction phase) and be undertaken three times a year (summer, autumn and spring) until Year 4 (operation phase) of the Project. Weekly inspections during construction will be undertaken by the Contractor with regard to exclusion fencing, signage and erosion and sediment controls.

4.10.3 MONITORING PROCEDURE

Monitoring locations will comprise both *M. triglochnoides* sites within the Project boundary that will be retained and protected, and sites outside of the project boundary. Exact locations of Impact (within the project boundary) and Control (outside of the project boundary) sites will be determined during the detailed design of the Oxley Highway to Kundabung section. Impact and Control sites will be paired to enable a paired t test or a non-parametric equivalent (i.e. Mann Whitney) of the attributes of each site. At each monitoring location, the following attributes will be recorded:

- Current extent of cover (%) along a 50m transect.
- Water depth recorded from a permanently installed water staff or other suitable method.
- The extent of flowering or seeding.
- Signs of recruitment.
- Signs of disturbance (i.e. cattle) and to what extent/area.
- Specific photo point installed.

4.10.4 PERFORMANCE MEASURE

Indicators of success will focus on the following:

- Exclusion fencing with signage identifying these as ‘no go’ zones (during construction).
- Sediment control fencing in place (during construction).
- Flowering and/or seeding is consistent with paired control and/or nearest reference site.
- Signs of the habitat protection procedure not working will be based on the following:
- Breached exclusion fencing
- No signage identifying the sensitive nature of the location as threatened species habitat
- A significant (if statistics are used) or substantial difference (15% allowance) between the paired monitoring sites with regard to flowering/seeding and overall extent or recruitment over subsequent monitoring events that cannot be attributed to environmental factors.

4.11 LANDSCAPING AND REVEGETATION

4.11.1 DESCRIPTION

Landscaping and revegetation of disturbed areas will be undertaken in all areas of the project. Urban Design and Landscaping Plans will be prepared for each stage of the project that address the urban design and landscaping requirements of Minister’s Condition of Approval B20.

4.11.2 TIMING

Monitoring of landscaping would be conducted at eight months and 12 months.

The need for additional monitoring would be determined following analysis of the monitoring data.

Maintenance of the landscaping and weeds would continue for the duration of the three year maintenance period as outlined in Section 6 or until such time as the revegetation is determined successful and is no longer requiring active management to maintain its survival.

4.11.3 MONITORING PROCEDURE

All areas of native plant stock would be monitored by the Contractor, Roads and Maritime, and the independent Landscape Representative or Project Ecologist to establish whether the performance measures in Section 4.11.4 have been met.

4.11.4 PERFORMANCE MEASURE

Indicators of success will focus on the following:

- Each area revegetated by native seeding must achieve the following minimum standards as assessed at 12 months following revegetation:
  - One native plant every 6m2
  - Average minimum height of 15cm, and
  - Native vegetation diversity to be assessed to the satisfaction of the Landscape Representative or the Project Ecologist.
- All areas required to be revegetated by native planting must achieve the following minimum standards as assessed at 12 months following revegetation:
  - Minimum plant growth of 30cm following planting, and
  - Minimum plant survival rate of 80%.
- Weed cover is less than 5% per restored area.

If these performance indicators are not achieved a non-conformance would be raised, to be closed out to the satisfaction of Roads and Maritime, and the Landscape Representative or the Project Ecologist.

Reporting on the outcomes of landscape monitoring would form part of the annual ecological monitoring report, and would be presented in a format similar to the spreadsheet provided in Appendix C.

4.12 SUMMARY OF MONITORING ACTIONS

A summary of monitoring actions, from baseline surveys to be undertaken prior to the commencement of construction, through to Year 8 of the operation phase, is provided in Table 21.

Table 21: Summary of monitoring requirements outlined in this EMP

Mitigation Measure	Baseline Surveys				Construction Phase												Operation Phase																					
	Year 0 (2014)				Year 1 (2015)				Year 2 (2016)				Year 3 (2017)				Year 4 (2018)				Year 5 (2019)				Year 6 (2020)				Year 7 (2021)				Year 8 (2022-2023)					
	Su	A	W	S	Su	A	W	S	Su	A	W	S	S	A	W	S	Su	A	W	S	Su	A	W	S	Su	A	W	S	Su	A	W	S	Su	A	W	S	Su	Au
Koala																																						
Spotted-tail Quoll																																						
Giant Barred Frog																																						
Green-thighed Frog																																						
Green-thighed frog ponds																																						
Yellow-bellied Glider																																						
Brush-tailed Phascogale																																						
Squirrel Glider																																						
Road Kill																																						
Pre-clearing / clearing																																						
Fauna underpasses																																						
Rope Bridges																																						
Glider Poles																																						
Fauna Fencing																																						
Widened Median																																						
Nest boxes																																						
Bat Roost Boxes																																						
Maundia Habitat Protection																																						
Landscape monitoring																																						

5 POTENTIAL CONTINGENCY MEASURES

MCoA B10 (e) and the EPBC Act CoA 4d require the Ecological Monitoring Program to provide details of contingency measures that would be implemented in the event of changes to densities, distribution, habitat usage and movement patterns attributable to the construction and operation of the Project. Types of contingency measures that would be implemented in the event that a mitigation measure is deemed ineffective are dependent upon the nature, location and magnitude of the impact. However, potential problems and contingency measures are detailed in Table 22.

Table 22: Potential contingency measures

Mitigation Measure	Potential Problem	Contingency Measure
Pre-clearing surveys	Previously undetected fauna is located prior to clearing.	Notify Environmental Manager and EPA within 24 hours. Project ecologist to record location of species immediately with GPS. Project ecologist to relocate and release fauna into suitable adjoining habitat. Obtain approval from relevant authorities to relocate threatened species if required, at least 24 hours before relocation is conducted.
	Previously undetected flora species is located prior to clearing.	Notify Environmental Manager and EPA. Project ecologist to record location of species with GPS. Delineate threatened species with highly visible tape to protect it from clearing. Seek approval from relevant authorities to translocate species if required.
	Identification of previously undocumented EEC.	Notify Environmental Manager and EPA. Project ecologist to delineate boundaries of the EEC with a GPS and highly visible tape. Consult with relevant authorities for management of additional EEC
Clearing Procedures	Fauna injury and mortality resulting from clearing operations.	Immediately commence review of clearing procedures and complete review prior to clearing recommencing. Modify habitat tree retention times and/or Stage 2 (habitat tree felling) clearing procedures prior to clearing recommencing. Review approach of clearing contractor prior to clearing recommencing.

Mitigation Measure	Potential Problem	Contingency Measure
Fauna Underpasses and Fauna Fencing	No recorded presence of indicator species from the nominated classes in underpasses, No recorded presence of cover dependent species or fauna species with low mobility in underpasses, Increases incidence of road kill from baseline conditions, in proximity to underpasses, particularly target species. Inferior results compared to baseline surveys for the EPBC species, relevant to reference site monitoring.	Commence review/modification of fauna furniture associated with underpasses within two weeks of results reported by ecologist. Commence review/modification of habitat (ie vegetation composition and structure; type and abundance of natural habitat features) adjoining the underpass within two weeks of results reported by ecologist. Commence review/modification of frequency and/or timing of monitoring periods within two weeks of results reported by ecologist. If it is not reasonable or feasible to redesign/modify the underpass, discussions with EPA, DP&I and DoEE will be undertaken to determine if additional biodiversity offsets are required within 1 month of above reviews being completed.
Fauna fencing	Breach in fauna fencing. Road strike mortality of threatened fauna within 200m of fauna underpasses. Vehicle strike of Glossy Black Cockatoos (*Calyptorhynchus lathami*) and Grey-crowned Babblers (*Pomatostomus temporalis temporalis*).	Commence review/modification of fauna exclusion fencing design, location or extent depending on species struck by vehicles within two weeks of results reported by ecologist. Inspect fence for breaches and inform maintenance as necessary within two weeks of results reported by ecologist. Any damage to fauna fencing will be temporarily repaired within one week of a breach being identified. Permanent repair to occur as soon as possible and within two months of the breach being identified. Investigate planting feed trees away from the carriageways in consultation with project ecologist.
Rope Bridges/glider poles	No use of rope bridge by arboreal native fauna. No use glider poles of gliding species. Arboreal fauna vehicle strike in proximity to rope bridges.	Review/modify frequency and/or timing of monitoring periods. Review/modify habitat (ie canopy species adjoining rope bridge and connectivity to rope bridge).

Mitigation Measure	Potential Problem	Contingency Measure
Nest Boxes	Nest box being used by non-target species. Nest boxes become occupied by exotic or invasive fauna such as European bees. Poor uptake or usage by native fauna species. Nest boxes deteriorating rapidly and requiring maintenance.	Review number and design of next boxes. Review/modify nest box design to exclude undesirable species, treat nest boxes to deter/eradicate pest species, or relocate nest boxes. Review the types and numbers of next box designs, their location or positioning within the tree. Identify causes of nest box failure, modify design and construct accordingly.
Bat Roost Boxes	Absence of target microbat species from roost boxes. Roost boxes become occupied by introduced fauna species. Roost boxes deteriorating rapidly and requiring maintenance.	Undertake inspections of newly constructed culvert and bridge structures to determine the uptake of these structures by target microbat species. Assess the adequacy of the new bridge/culvert structures as suitable and alternative mitigation for the Project and to determine the need for ongoing monitoring and maintenance. Review/modify roost box design to exclude undesirable species, treat roost boxes to deter/eradicate pest species, or relocate roost boxes. Identify causes of roost box deterioration, modify design and construct accordingly.
Green-thighed frog breeding ponds	Ponds not used by Green-thighed frog. Ponds not being holding water long enough to enable breeding to succeed. Ponds holding water for too long encouraging competition from non-target frog fauna. Exotic fish species recorded in breeding ponds.	Survey adjacent areas to confirm frogs remain in area. Review/modify ponds to improve potential site suitability problems. Review/modify ponds either by placing a semi permeable layer or further excavation. Improve drainage. Modify pond to ensure it dries out.
Widened Median	No evidence of use of the median vegetation by the target glider species.	Investigate alternative crossing structures (eg glider poles and/or rope bridges) in consultation with EPA.

Mitigation Measure	Potential Problem	Contingency Measure
Baseline Surveys Before, After, Control Impact (BACI) design (specifically the Koala, Spotted-tail Quoll, Giant Barred Frog, Yellow-bellied Glider, Brush-tailed Phascogale).	Decline in presence of target species recorded at Impact sites after the upgrade has been completed, when compared to change in Control sites.	The cause of the decline in populations at impacts sites will be investigated in consultation with EPA and DoEE within two weeks of results reported by ecologist. If the cause of decline is considered most likely attributed to the upgrade of the highway (and not another event such as bushfire), mitigation measures, such as the location and types of fauna crossings and fauna fencing will be reviewed within two months of the above consultation being completed.

6 MAINTENANCE

The ongoing function of the mitigation structures discussed in Section 4 is also dependent on a clear commitment to their maintenance. Regular inspections of the mitigation structures are essential to ensure they remain safe for motorists and are functional for wildlife.

During construction, maintenance requirements associated with the mitigation structures will be undertaken by the contractor and will consist of, but not be limited to, the following:

- Weed and landscaping maintenance.
- Unplanned maintenance as required of nest boxes, fauna furniture, fauna fencing, etc. identified through environmental inspections and audits.

Prior to operation of the Project, the ongoing maintenance requirements of the mitigation structures will be identified as part of the hand over process to the road asset manager. During operation, maintenance requirements will be undertaken by Roads and Maritime and will consist of, but not be limited to, the following:

- Weed and landscaping maintenance.
- Planned maintenance of nest boxes, fauna furniture, fauna fencing, glider poles and rope bridges, and green-thighed frog breeding ponds.
- Unplanned maintenance as required of the above structures identified through the monitoring detailed in Section 4.

Roads and Maritime will remain responsible for the roadway and its corridor as part of a Controlled Access Road required to be maintained by NSW legislation in perpetuity.

7 REPORTING

A report on the clearing procedures will be prepared upon the completion of clearing operations and will include:

- Details of methods used during pre-clearing surveys and clearing operations.
- Fauna species displaced by clearing, species, captured, species released and any wildlife mortalities resulting either directly or indirectly from the clearing operations.
- Location of fauna within clearing footprint (recorded with GPS) and release locations.
- Hollow-bearing tree register, and comparison of this data to nest box plan (assess the adequacy of nest boxes installed and how they are mitigating the loss of tree hollows).
- Discussion of the effectiveness of those methods employed.
- Recommendations for future pre-clearing and/or clearing procedures.

Annual reporting of all other monitoring results (i.e. of target fauna species, fauna mitigation measures and habitat usage) will outline:

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

All reports prepared under the Ecological Monitoring Program will be submitted to the Director General of the Department of Planning and Infrastructure and the EPA.

In accordance with EPBC Act approval condition 8, within three months of every 12 month anniversary of the commencement of the action a report will be published on the website addressing compliance the implementation of the Ecological Monitoring Plan.

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Appendix A Baseline Results for EPBC Species

KOALA

Introduction

The Environmental Assessment recorded one Koala crossing the highway approximately 200 metres south of Sancrox Road whilst searches for scats and scratches around potential feed trees indicated recent Koala activity within Ballengarra State Forest and south of Sancrox Road (GHD 2010). The EA reported suitable feed trees occur through most of the identified vegetation communities and often occur as dominant or co dominant in most of the moist floodplain forests, moist slopes forest, riparian forest and swamp mahogany/forest red gum swamp forest (GHD 2010).

Given the above, Koala was nominated as a species requiring specific monitoring in order to measure the impacts associated with the Upgrade and to assess the performance of various mitigation measures being proposed. To address this, the following monitoring program was developed as part of collecting pre construction baseline data.

Survey Design and Method

The following survey design has been developed to provide baseline information in relation to the distribution, activity, density, habitat use and likely movement patterns of Koala in the vicinity of the Upgrade. In order to derive the required information Koala was considered at a broader meso scale with a 10 km buffered search area of the Upgrade or an area of 116,000 ha spanning from the Cowarra region in the south to the Kempsey township and the Macleay River in the north. Together, this area is referred to as the study area for the Koala baseline monitoring.

Measuring Koala Distribution

Baseline Koala distribution was measured using the Office of Environment (OEH) Bionet Wildlife Atlas as a registered user. The search area was buffered to within 10 km of the Upgrade so as to provide some indication on the broader distribution across the coastal plains and adjacent foothills. The atlas data was then divided into the following three chronological time scales:

- Pre 1984 being used to measure historic presence of Koala prior to major expansion of residential and rural residential areas;
- 1984-2003 to reflect a 20 year period when Port Macquarie and rural residential allotments underwent substantial expansion in the study area; and
- 2004-2014 to reflect more recent records for use as a current guide to describe the existing Koala distribution.

This information was illustrated by means of GIS outputs into figures and described both quantitatively and descriptively with reference to obviously clustering of records as focal points for Koala populations and to explore differences in changed reporting rates between historical data (pre 1984) with more recent records (2004-2014).

Measuring Koala Activity

Koala activity was measured using the Spot Assessment Technique (SAT) developed by Phillips and Callaghan (2011). The following describes the application of this technique:

1) Locate and mark a tree that is:

    a) A tree of any species beneath which one of more koala faecal pellets have been observed; and/or

    b) A tree in which a koala has been observed; and/or

    c) Any other tree known or considered to be important for koalas or of interest for other assessment purposes.

2) Identify and mark the 29 nearest trees to the tree marked initially.

3) Undertake a search for koala faecal pellets beneath each of the 30 marked trees. Visually inspect the ground surface beneath trees to a distance of one metre from the trunk. If no pellets are observed, rake the leaf litter within the prescribed search area. Two person minute per tree should be dedicated to the search for faecal pellets. The search should be concluded once a single pellet is found or the search time has expired (whichever happens first). Faecal pellets should not be removed from the site unless verification is necessary.

4) The activity level of a site is calculated as the percentage of surveyed trees within the site (of 30 trees) that has a koala faecal pellet recorded within its search area. Then result is used to assess whether the site supports "Low", "Medium (normal)" or "High" koala activity (Table 4-1).

Table 4-1. Categorisation of Koala activity (Phillips and Callaghan 2011).

Activity Category	Low use	Medium (normal) use	High use
East coast (low density area)	-	3.33% but ≤12.59%	>12.59%
East coast (medium-high density area)	<22.52%	≥22.52% but ≤32.84%	>32.84%
Western Plain (medium-high density area)	<35.84%	≥35.84% but ≤46.72%	>46.72%

The SAT data was collected using a stratified BACI (Before-After-Control-Impact) survey design which included three treatment classes across eight Koala monitoring areas which had been previously proposed in the draft Ecological Monitoring Program (*see* Section 3.1 and Section 3.2.1) and endorsed by the EPA during the consultation and review process. The treatments included:

- Mitigation (Treatment A) centred on the RMS providing sufficiently large culverts (i.e. > 1.8 m) and floppy top fencing (orange circles);
- No Mitigation (Treatment B) where the mitigation described above has not been provided by the RMS (red circles) or only a part mitigation site could be located (yellow); and
- Control or Reference (Treatment C) located in areas at least 3 km and often 5-10 km from the Upgrade (green circles) as shown in Figure 4-1.

Within each treatment class, a subset of three Spot Assessment Technique (SAT) sites (3 x 30 = 90 trees) were established with the objective to increase the confidence level in each treatment sample. This culminated in 2160 trees being searched for Koala scats during late Spring (i.e. November) of 2013.

Measuring Koala Density

Koala density was measured in three ways:

1) Using historic records from the wildlife atlas to describe reporting rates using a standardised 5 km^2 across the study area;
2) Spotlighting within a sub set of these grid sites to compare current surveys with the reporting rates contained within the wildlife atlas; and
3) Using camera traps set in a randomised grid configuration given that Koala regularly move along the ground to access to new trees for foraging and refuge.

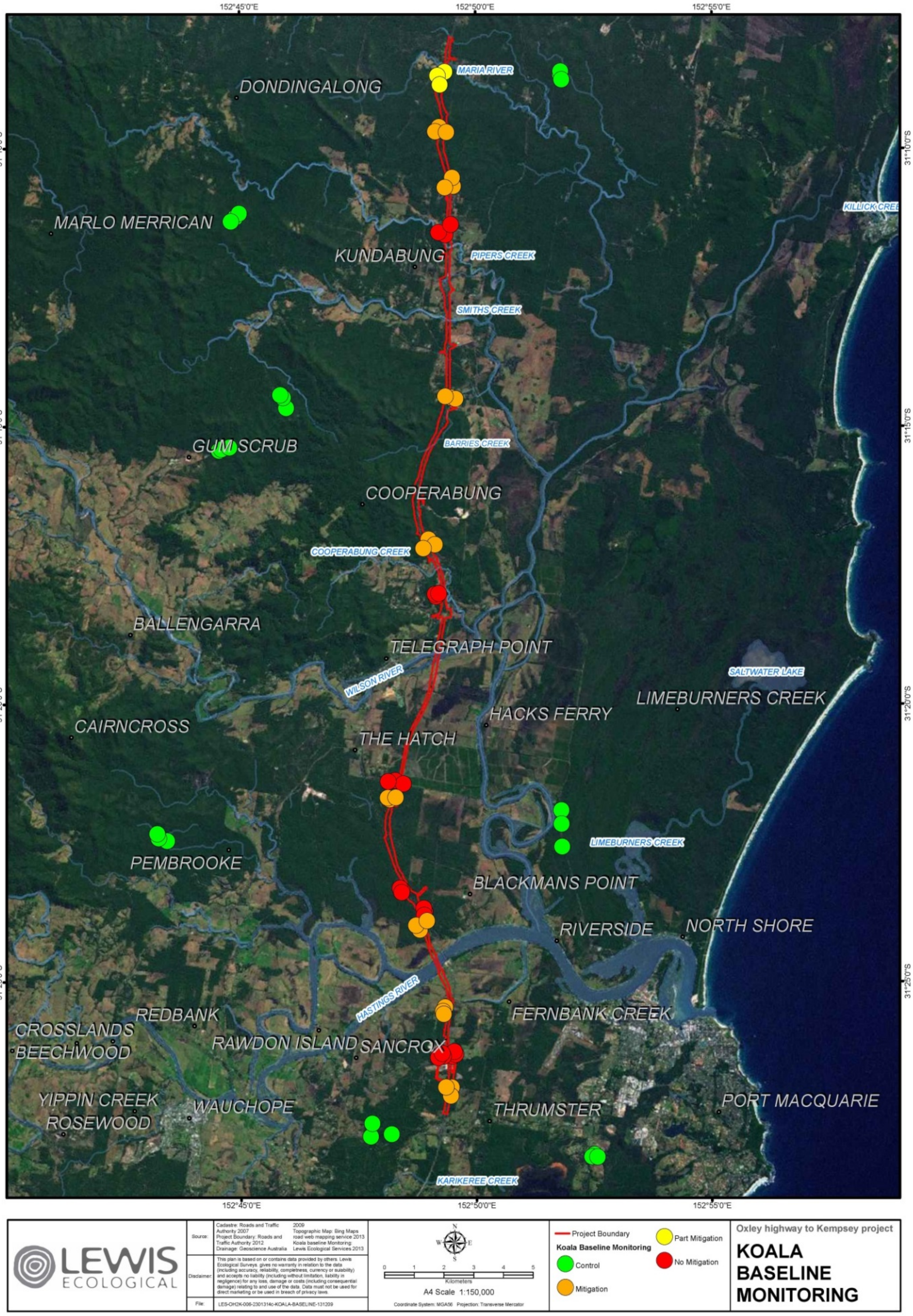

Figure 4-1. Distribution of Koala monitoring sites and treatment classes used during the pre-construction baseline survey.

i. Grid Based Sampling Using Historic Data

The number of records from the Bionet Wildlife Atlas data was measured using a 5 km^2 grid installed across the study area. The number of records reported for the time period 2004-2014 was used as a surrogate measure of Koala density given that area's containing higher densities of Koala should yield a greater number of records. The number of records were then summed with each grid then prioritised or ranked from the highest to lowest.

ii. Spotlighting

Spotlighting was undertaken at a sub set of six sites in Cairncross State Forest (ch. 10400), Ballengarra State Forest (ch. 24000) and Maria River (ch. 36850) with each spotlight location being set up in a paired BACI configuration comprising an impact site and a control or reference site (hereafter reference) which preferably exhibited similar vegetation/habitat type and landscape features (Figure 5-1; Table 5-1).

Field surveys involved a listening period when first arriving at each location for 10 minutes. Spotlighting was then performed by two observers using hand held variable beam 100 watt spotlights whilst walking a timed 500 m transect over 30 minutes (1 person hour effort). This was repeated on three separate occasions on non-consecutive nights between the 27th September and the 24th November 2013. The minimum time between consecutive surveys was 7 days to maximize the opportunity of detection.

The approach described above is broadly consistent with the Kempsey Koala Plan of Management which advocated for the purposes of monitoring "*a minimum of 4-6 randomly selected, permanent spotlighting transects collectively sampling > 50ha of preferred koala habitat within that area captured by the Dondingalong – Kundabung – Crescent Head KMA boundary*" of which the northern 14 km of the Upgrade bisects.

Table 4-2. The BACI survey design for sampling Koala numbers using paired sampling.

Broad Survey Area	Treatment Class	Paired Reference location	Status of Records
Cairncross	Impact but with Mitigation (floppy top fencing and underpasses)	Cairncross State Forest in Pembrooke area around 10 km west in forest managed by Forests NSW	Impact Site – Koala consistently recorded as road kill on the existing Pacific Highway carriageway. Reference/Control – Area of contiguous forest managed by Forests NSW with relevant prescriptions around drainage lines supporting similar vegetation type.
Ballengarra	Impact but with Mitigation (floppy top fencing and underpasses)	Greg's Road area around 5 km west in Ballengarra State Forest.	Impact Site – Koala consistently recorded as road kill on the existing Pacific Highway carriageway. Reference/Control – An area comprising a ridge with adjoining lower slopes supporting similar vegetation types around 5 km west of the Upgrade.
Maria River	Impact but with Mitigation (floppy top fencing and underpasses)	Maria River NP east near suitable feed trees.	Impact Site - Koala consistently recorded as road kill on the existing Pacific Highway carriageway. Reference/Control – An area considered likely to support Koala.

iii. Camera Traps

Camera traps were used as an ancillary technique to obtain a relative measure of Koala density broadly across the three largest patches of contiguous vegetation. These areas provided the most obvious areas for Koala to maintain viable populations and were more likely to remain in an intact state during the monitoring period. Camera traps were established in the following areas:

Patch 1 – Cairncross State Forest and neighbouring private lands where the Upgrade corridor bisects a contiguous patch of predominantly dry sclerophyll forest with some swamp forest associations between chainages 8000 and 13500.

Patch 2 – Ballengarra State Forest and neighbouring private lands where the Upgrade corridor bisects a contiguous patch of predominantly dry sclerophyll forest with some moist forest and swamp forest associations along several drainages between chainages 20000 and 27000.

Patch 3 – Maria River State Forest and neighbouring private lands where the Upgrade corridor bisects a contiguous patch of predominantly dry sclerophyll forest with some moist forest and swamp forest associations along several drainages between chainages 33000 and 38000.

Within each of the three areas, a stratified BACI (Before-After-Control-Impact) survey design was adopted following consultation with the EPA and included the following three treatments:

- 1 x reference site unaffected by the Upgrade (Figure 4-2; Table 4-2). The location of the reference site was normally greater than 5 km from the Upgrade corridor and often 7-10 km away. Every attempt was made to locate a site which exhibited a similar array of topography and habitat attributes as both the nominated control and treatment sites located within the Upgrade corridor. Additional factors including the presence of two fires at Beranghi and Limeburners Creek Nature Reserve necessitated the relocation of the Maria River reference site to a secondary location much further to the north;
- 1 x control site where no specific Koala mitigation has been proposed within the Upgrade for >500 m (Figure 3-1; Table 3-1). For the purposes of this study, Koala mitigation was deemed as a fauna underpass structure referred to as a dedicated or combined fauna underpass >1.8 m in height and supported with floppy top fencing (SMEC-Hyder 2013). Drainage culverts were ignored in this instance because they are not being installed for the purposes of facilitating fauna movements; and
- 1 x treatment site where the RMS providing sufficiently large culverts (i.e. > 1.8 m) and floppy top fencing fauna underpasses have been located in neighbouring areas to the control (no mitigation) site. A treatment site was considered suitable if there was a combined or dedicated fauna underpass within 500 m. Bridges were not considered in this survey design following consultation with the EPA who recognised they provide an acceptable form of habitat connectivity to most ground dwelling fauna.

The above survey design was repeated at three locations to provide a stratified sampling design of three replicates of each treatment within each of the three survey areas (Cairncross, Ballengarra, Maria River). This resulted in 9 x 100 ha survey plots across three treatments for each area culminating in 2700 ha (Table 4-2).

Camera Traps Sampling Regime

Four infrared cameras (Scoutguard 560 P model) were installed 500 m apart across each 100 ha plot with three plots representing each treatment (n=12 cameras) for each of the large patches of vegetation. Cameras were set in continuous 24 hour mode for a minimum of 21 nights using the following parameters:

- Sensor Sensitivity was set at a variable rate from 'normal' or 'high' depending on the amount of grass and other fine vegetation present at the camera site. Some pruning of vegetation was undertaken at sites in order to maximize the opportunity to setting the camera sensitivity to high;
- The number of images was set to 2 with the reset or PIR set at 30 second intervals;
- All images were time and date stamped for later verification and to facilitate in the understanding of Koala and any predator activity and interactions.

Cameras were installed between the 8 and 14th August 2013 and retrieved between 22-26 days later culminating in 2340 nights of survey effort.

Table 4-3. Summary of camera monitoring sites.

Area	Monitoring Sites (each is 100 hectares)
Cairncross State Forest	• 3 Control Sites ("Reference" sites in *Monitoring Strategy)* • 3 Impact sites in proximity to fauna underpasses ("Treatment" sites in *Monitoring Strategy)* • 3 Impact sites where no specific quoll mitigation (fauna underpasses) has been proposed ("Control" sites in *Monitoring Strategy)*
Ballengarra State Forest	• 3 Control Sites ("Reference" sites in *Monitoring Strategy)* • 3 Impact sites in proximity to fauna underpasses ("Treatment" sites in *Monitoring Strategy)* • 3 Impact sites where no specific quoll mitigation (fauna underpasses) has been proposed ("Control" sites in *Monitoring Strategy)*
Maria River State Forest	• 3 Control Sites ("Reference" sites in *Monitoring Strategy)* • 3 Impact sites in proximity to fauna underpasses ("Treatment" sites in *Monitoring Strategy)* • 3 Impact sites where no specific quoll mitigation (fauna underpasses) has been proposed ("Control" sites in *Monitoring Strategy*)

Interpreting the Camera Data

All images were reviewed by one person (BDL). The maximum abundance or activity levels for any species within a given 1 hour period was one and this applied to both Koala and eutherian predators. The only exception to this was where the individuals could clearly be identified from another within that 1 hour period. For example, a sandy coloured Dingo that was repeatedly photographed on 10 occasions over the spaced of 30 minutes was counted as a single record of occurrence whilst a different coloured Dingo captured during the same period would allow the counting of a second animal.

Assessing Koala Habitat Use

Koala habitat use was measured in two ways, firstly, at a broader study area scale (i.e. 10 km buffer), and secondly, using the SAT survey data from the 2160 trees checked to identify and rank the importance of each tree species sampled.

i. Assessing Habitat Use Throughout the Study Area

Vegetation mapping was obtained from OEH using the CRAFTI lower north east florsitics GIS layer. Historic Koala records from the Bionet Wildlife Atlas were then overlayed and summed for each vegetation community at the three chronological times scales of pre 1984; 1984-2003; and 2014-2014. Vegetation communities were then ranked according to the number of records obtained. The results were then compared to other relevant broad scale Koala surveys in the region including the Kempsey Koala Plan of Management for the eastern part of the LGA which includes the northern 14 km of the Upgrade between Mingaletta and South Kempsey (KSC 2011).

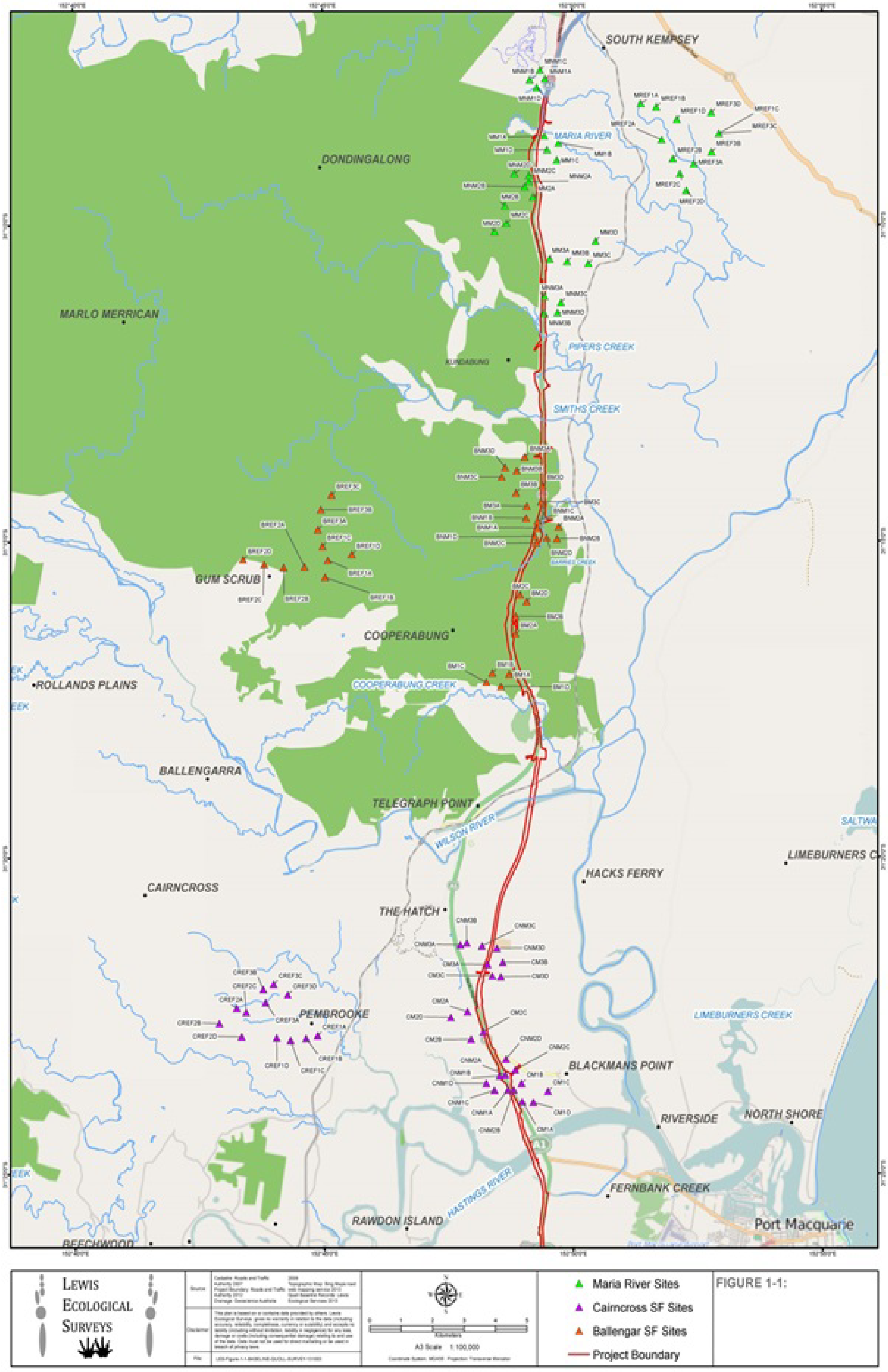

Figure 4-2. Distribution of treatments and camera trap locations during the pre-construction baseline survey.

ii. Assessing Habitat Use at a Tree Species Scale

Koala habitat was also assessed at a tree species scale with the data obtained from the 2160 trees sampled during the SAT surveys. Trees that returned positive Koala use were classified as forage species with those that returned higher scores deemed to be of greater importance as Koala foraging habitat.

Assessing Koala Movements

Koala movements were assessed by using the Bionet Wildlife Atlas and summing all of the historic data for each of the CRAFTI derived vegetation community polygons. Those polygons which scored higher were considered to have a potentially higher habitat value to Koala and based on the score obtained the following categories of potential habitat value were derived and displayed using GIS:

High Value: Polygons scoring more than 150 records
Moderate Value: Polygons scoring between 10-150 records
Low Value: Polygons scoring between less than 10 records
Very Low Value: Polygons were no Koala records existed.

The distribution of those polygons which scored a high value were deemed as being potential nodal areas for Koala through the landscape.

Road kill data was also used to describe localised Koala movements and as a vetting process to the broader mapping approach described above. These road kill surveys were performed weekly over a four week period in October 2013 (i.e. Spring) and repeated again between the 17th January – 7th February 2014 (i.e. Summer) with further information provided in Section 8.0. Some additional information collected by the author over the past 10 years has also been used to describe Koala nodal areas and road kill hot spots.

Results

Koala Distribution

The distribution of Koala in relation to the Upgrade and a 10 km buffer culminated in 1611 records (Figure 4-3). The majority of these records (i.e. 1249 or 77%) were recorded in the past 10 years (2004-2014) indicating it provides an accurate appraisal on the current distribution of Koala.

Koala is broadly distributed throughout the study area with a distinct clustering of records in the south eastern precinct which includes Port Macquarie, Lake Innes and the Thrumster area (Figure 4-3). Records are consistently distributed throughout the Upgrade corridor and these are linked to the vegetated land parcels the Upgrade corridor bisects (e.g. Cairncross State Forest, Ballengarra State Forest, Maria River State Forest). Only the floodplain environs of both the Hastings River and the Wilson River show obvious gaps in Koala distribution due largely to the historic development of these areas for agricultural pursuits. There are a number of records associated with the existing Pacific Highway carriageway with concentrations of records at Cooperabung Hill (ch.21000), northern end of Ballengarra State Forest extending to Mingaletta and Upper Smiths Creek Road (ch. 24000-27000), Kundabung Area (ch. 30000), both the southern and northern extents of Maria River State Forest (ch. 33000 and ch.36000) and at the northern limit of the Upgrade at Stumpy Creek (ch. 38000). A substantial portion of these records have been entered as road killed individuals or injured and requiring rehabilitation.

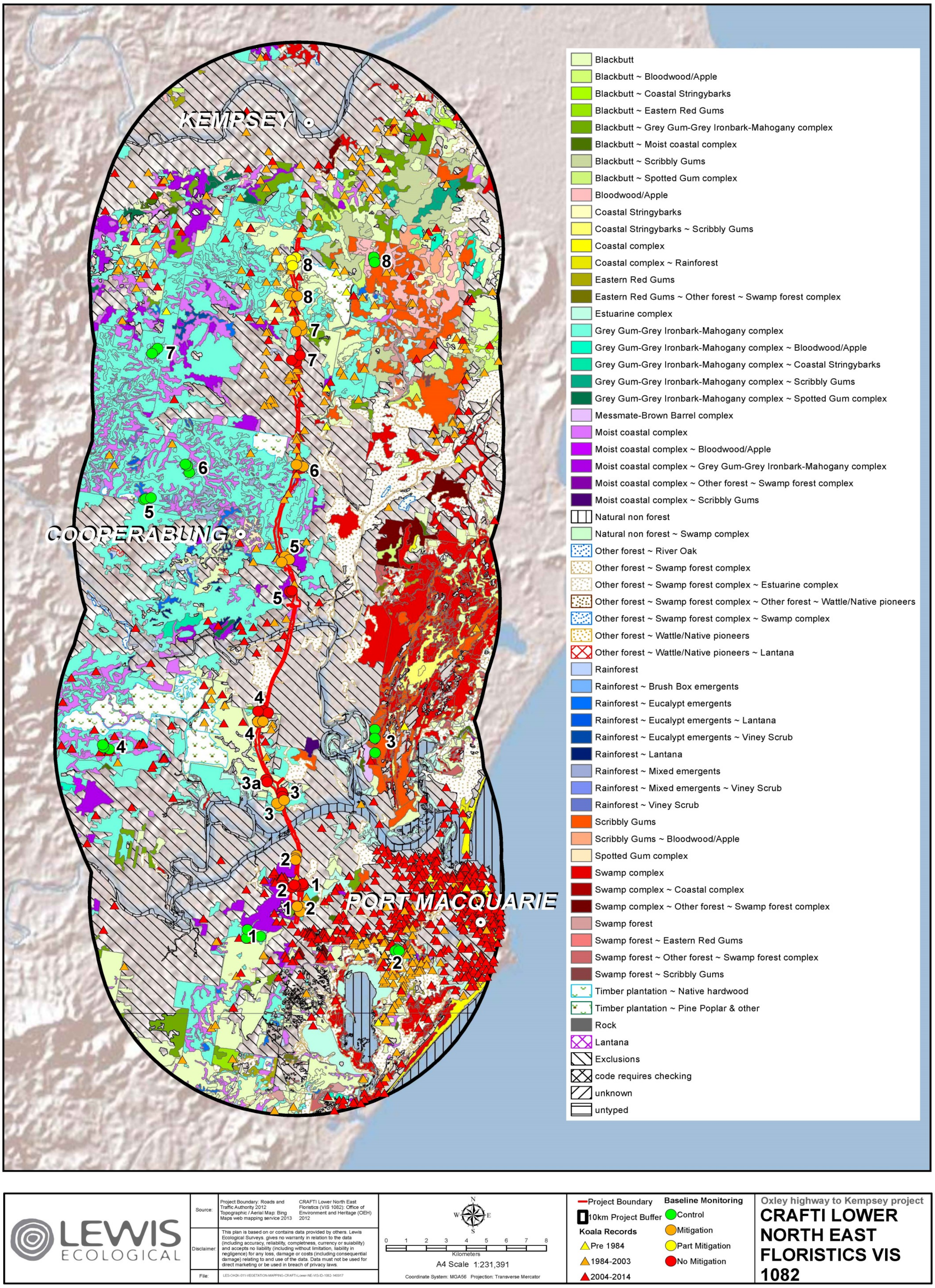

Figure 4-3. Koala distribution through the study area at three chronological scales.

Koala Activity

The recorded mean SAT site activity levels across the eight monitoring areas was 4.91% (SD=7.95%) with levels ranging from zero at Mingaletta-Smiths Creek (Area 6) to 14.81% (SD=13.65) north of Sancrox Road (Fernbank Creek area known as Area 2 ch. 3350-4450; Figure 4-4). The remaining sites recorded mean SAT activity levels of <5% except for the Kundabung area with 7.78% (SD= 10.93).

At a treatment level, mean SAT site activity was highest in the 'mitigation' treatment class with 8.05% (SD = 10.99%) which was twice that of the 'control reference' class with 4.03% (SD = 6.37%) and almost three times higher than the 'no mitigation' treatment class with 2.64% (SD = 4.17%; Figure 4-5). At a site level, mean SAT site activity levels were highest in the mitigation treatment for South Sancrox Road, North Sancrox Road, Cairncross State Forest (south) and at Kundabung but not at Cooperabung Hill and Maria River State Forest (Figure 4-6). No activity was recorded at any of the SAT sites for Mingaletta-Smiths Creek for either the 'mitigation' or 'control/reference' treatments and a 'no mitigation' treatment class could not be located due to the RMS providing extensive mitigation devices.

The SAT site activity data was highest at the following locations:

- South of Sancrox Road between ch.1000-1750 and particularly the eastern side of the road where a female was observed and mean activity levels of 8.89% (SD =2.94);
- South of Fernbank Creek between ch. 3350-4450 and particularly the western side of the road where a large male was observed with activity levels reaching 28.89% (SD=2.94); and
- Kundabung in the vicinity of ch. 32700 on both sides of the existing carriageway with activity levels of 18.89% (SD=7.29).

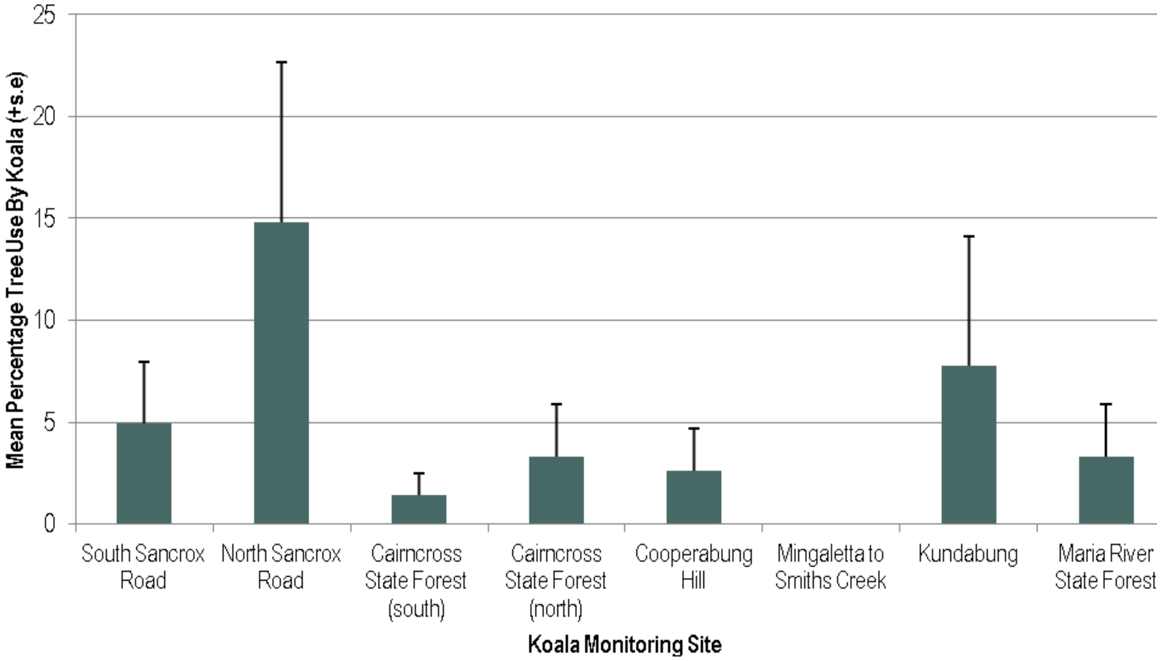

Figure 4-4. Mean (+s.e) SAT activity levels at each of the eight Koala monitoring areas.

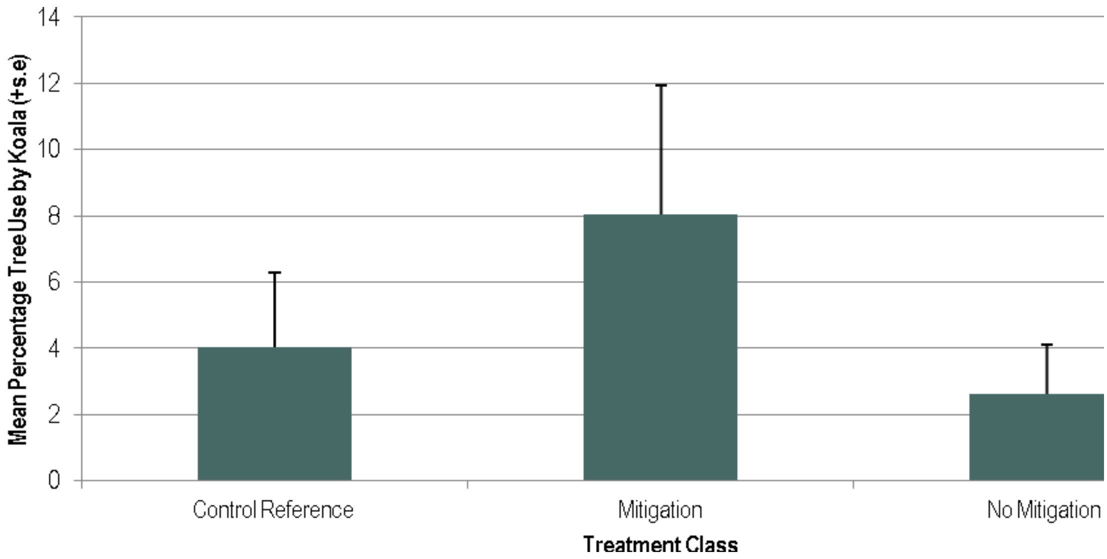

Figure 4-5. Mean (+s.e) Koala use between the three treatment classes.

Koala Density

i. Density Estimate Across the Entire Study Area

The highest density of Koala records occurs in the south eastern study area in the vicinity of Port Macquarie with more than 200 records in the 5 km^2 grids of J5, K5 and J4 (Figure 4-7). Vegetation that supports suitable browse tree species (i.e. Tallowwood, Small-fruited Grey Gum, Scribbly Gum, Swamp Mahogany) within each of these grids is likely to support high densities of Koala. The neighbouring grids of K3 and K4 in the Lake Innes and Thrumster area recorded 85 and 77 records respectively with K3 forming the southern extent of the Upgrade corridor. These areas are likely to support medium to high densities of Koala. All three grids occur some distance away from the Upgrade.

The grid J3 which includes the Upgrade between ch. 0-6000 recorded the 6th highest density of Koala records with 41 whilst I1 which features the control sites for the spotlighting program and the SAT activity levels in the western extent of Cairncross State Forest returned 36 Koala records (Figure 4-7). These areas are likely to support medium densities of Koala. The remaining grids which returned >10 records included I4 (Settlement Point, Port Macquarie), C2 (Burnt Bridge, Kempsey) and L4 (Lake Cathie) which lie some distance adjacent to the Upgrade. The grid E3 (Kundabung) includes the Upgrade between ch. 25000-30000 and D3 (Maria River State Forest) which extends from ch. 30000-36000 contain records on both sides of the Upgrade. These areas are likely to support moderate to lower densities of Koala.

The remaining grids returned <10 records indicating Koala probably occur at low densities. This includes a lot of the Upgrade corridor from the Cairncross State Forest area (I3 and H3), Cooperabung area (G3), Ballengarra State Forest (F3) and South Kempsey (C3). Grids C5 (Beranghi), E1 (Ballengarra-Gum Scrub), H5 (Limeburners Creek) returned no Koala records indicating that Koala may be occasionally absent from some small areas due to unsuitable habitat types. Other grids including B1, L1, L5 were at the limit of the buffered search area and no density estimate has been provided.

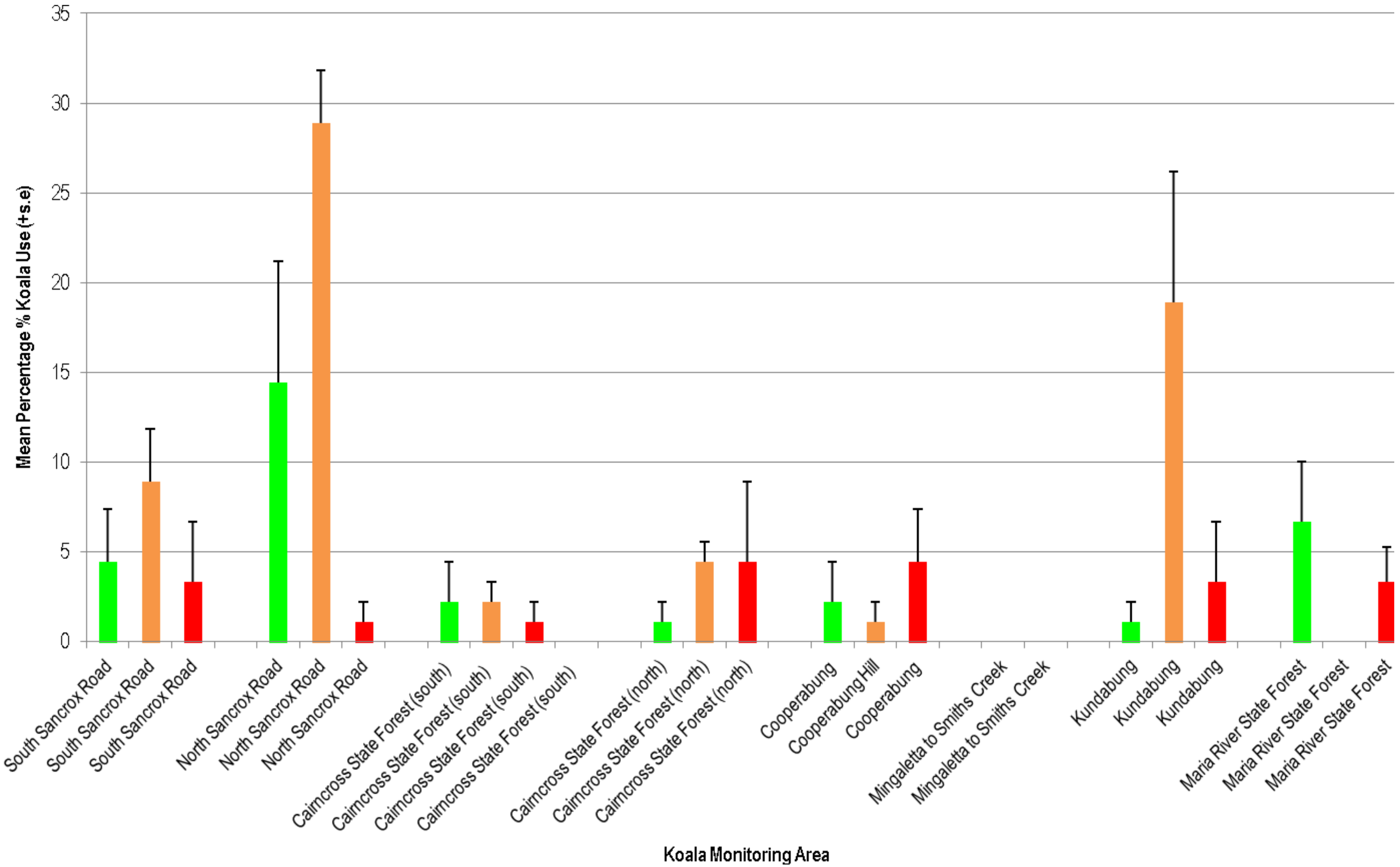

Figure 4-6. Mean recorded activity levels of Koala (+s.e) for each treatment across the eight monitoring areas. Treatment Types Control = Green; Mitigation = Orange, No Mitigation = Red

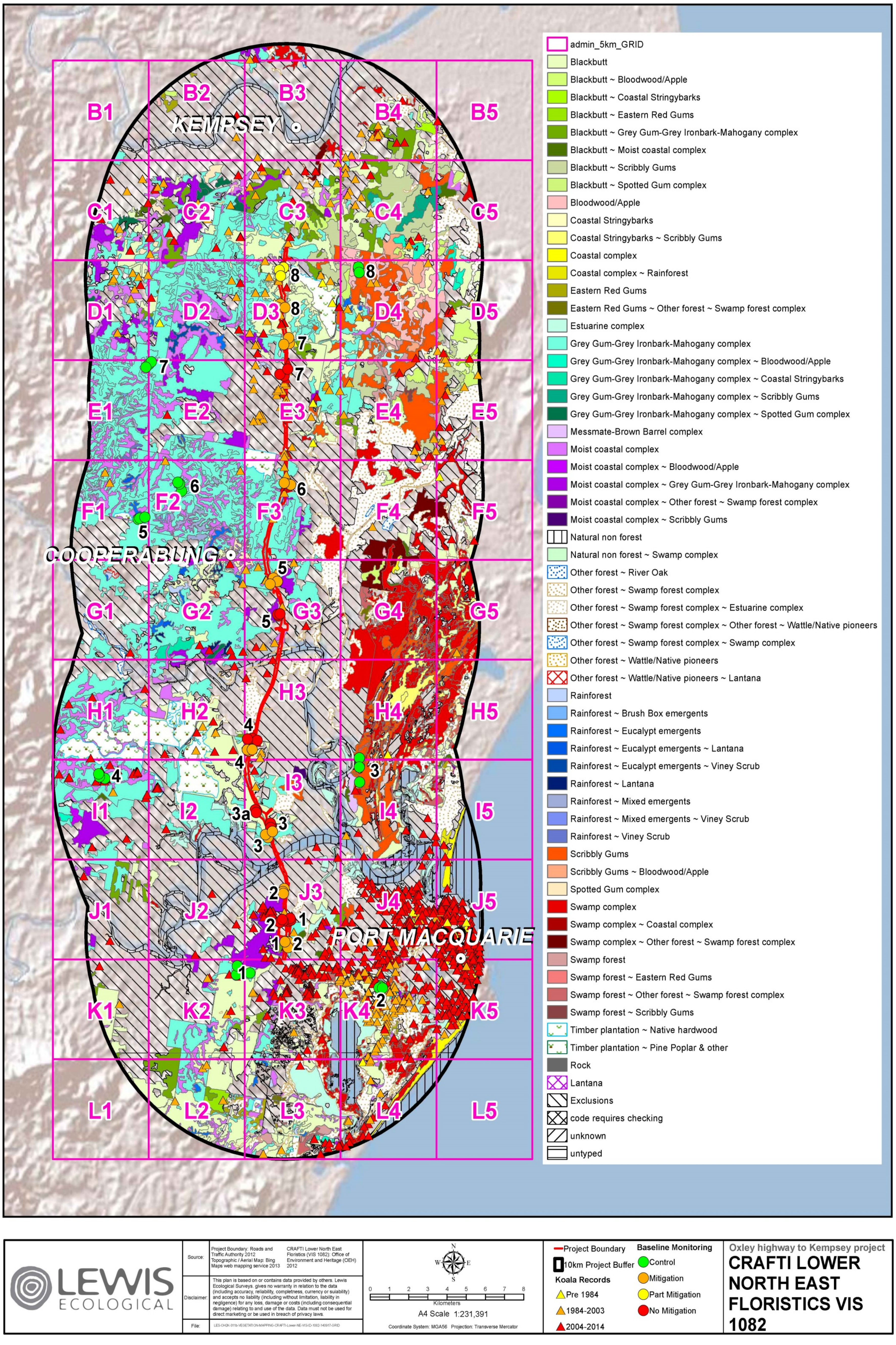

Figure 4-7. Density of Koala records across the study area.

ii. Baseline Count Data

Spotlighting resulted in Koala being recorded at five (83%) of the six spotlighting sites with only the riparian forest site located along the Maria River unable to detect Koala (Table 4-4). Koala were normally detected at a reporting rate of 1 individual per 60 minutes of search effort and this has been used as a baseline measure of Koala density for any spotlighting surveys in sclerophyllous forests supporting suitable browse tree species. The repeated sampling regime recorded Koala during 10 (56%) of the 18 spotlight transects with most of the records being attributed to vocalising males and confirms the importance of performing comparable surveys during the breeding season.

Camera traps resulted in Koala being recorded at five (18%) of the 27 locations with a reporting rate summarised as follows:

- Cairncross State Forest with one individual from 808 nights or 0.12%
- Ballengarra State Forest with two individuals from 826 camera trap nights or 0.24%
- Maria River State Forest two individuals from 706 camera traps nights or 0.28%;

These reporting rates are considered the baseline data for camera trap use to randomly monitor Koala density across the three largest tracts of continuous vegetation the Upgrade will bisect.

Koala Habitat Use

Koala habitat use was measured in two ways, firstly, at a broader study area scale (i.e. 10 km buffer), and secondly, using the SAT survey data from the 2160 trees checked to identify and rank the importance of each tree species sampled.

i. Landscape and Vegetation Community Scale

The potential habitat value of vegetation communities across the study area is shown in Figure 4-8. Areas of 'potential high value' for Koala are widespread across the study area and are mostly linked to the low foothills some distance from the coast. Areas of 'potential medium value' to Koala are more widely scattered throughout the study area whilst those communities assigned as being of 'potential low and very low value' to Koala are either more coastal and linked with heathland or rainforest communities, or are comprised of forestry plantations such as the central precincts of Cairncross State Forest or the northern extent of Ballengarra State Forest.

The Upgrade has been mapped as a mosaic of 'potential medium and high value' to Koala (Figure 4-8). Areas considered to have 'potential high value' to Koala include the area to the south of Sancrox (i.e. ch. 1500) and east of the Upgrade, Cairncross State Forest (ch. 8000-13000), Ballengarra State Forest (ch. 20000-25000), Maria River State Forest (ch. 33000-36500) and the northern extent associated with Stumpy Creek(~ch. 38000). Vegetation communities in these areas comprise suitable browse tree species including Tallowwood and Small-fruited Grey Gum with higher densities generally found on the southern slopes of hills or along drainage lines. In this capacity, these areas are more likely to be frequented by Koala.

Table 4-4. Summary of the field survey program for the Koala spotlight surveys.

Site Name	Treatment	Transect Coordinates				Survey Number & Sample Dates & Times				Abiotic Conditions						Survey Results & Comments	
		Easting Start	Northing Start	Easting Finish	Northing Finish	Survey Number	Survey Date	Start Time	Finish Time	Air Temp. oC	Humidity %	Wind	Rain	Night Light	Cloud Cover	Spotlight	Comments
Cairncross Sf - Forest Hut Road	Impact	480979	6528629	480642	6529045	1	27.9.2013	1845	2000	15.5	61	0	0	0	0	Nil	Road noise elevated with holiday traffic but bulk of noise affecting surveys was attributed to trucks
	Impact	480979	6528629	480642	6529045	2	6.10.2013	0051	0159	13.9	64	1	0	0	0	Koala x 1 calling 250 m north west of site	Late night spotlight to counteract the effect of road noise.
	Impact	480979	6528629	480642	6529045	3	26.10.2013	2015	2130	17.1	73	0	0	0	50	Koala x 1 heard 250 m to the south	Road noise affecting ability to hear fauna calls
Cairncross Sf - Loggy Creek in	Control/reference	473377	6528875	473246	6529151	1	28.9.2013	1825	1945	20	50	1	0	0	0	Nil	Site installed within retained filter strips of vegetation post logging event
	Control/reference	473377	6528875	473246	6529151	2	6.10.2013	2304	0031	14.4	52	0	0	0	0	Koala x 1 calling north west of site	
	Control/reference	473377	6528875	473246	6529151	3	26.10.2013	2158	2314	15.8	76	0	0	0	0	Koala x 1 heard 250 m downstream to the east	Koala expected to rely heavily on the retained filter strips
Ballengarra Sf - Barrys Creek road	Impact	482438	6541886	482042	6541985	1	27.9.2013	2015	2137	14	74	0	0	0	0	Koala x 1 male calling to north	Road noise elevated with holiday traffic and trucks
	Impact	482438	6541886	482042	6541985	2	6.10.2013	2132	2245	17.2	54	0	0	0	0	Koala x 1 male calling to the south	
	Impact	482438	6541886	482042	6541985	3	12.10.2013	1935	2103	22	81	1	0	2	50	Koala x 1 male calling to the south	
Ballengarra Sf - Greg's Road reference	Control/reference	477352	6543849	477025	6544218	1	28.9.2013	2216	2330	15.5	43	0	0	0	0		
	Control/reference	477352	6543849	477025	6544218	2	6.10.2013	1945	2115	18	52	1	0	0	0		
	Control/reference	477352	6543849	477025	6544218	3	12.10.2013	2117	2249	20	88	0	0	2	30	Koala x 1 Ad	
Maria River - East Road	Control/reference	488492	6555068	487962	6555160	1	27.9.2013	2207	2331	12	77	0	0	0	0	Koala x 1 male calling to north	Site at northern extent of National park to allow for access during wet weather
	Control/reference	488492	6555068	487962	6555160	2	11.10.2013	2020	2151	18.8	82	0	0	1	100	Koala x 1 calling male	
	Control/reference	488492	6555068	487962	6555160	3	24.11.2013	2105	2137	19.3	87	0	1	1	100		Survey after rainfall
Maria River Bridges	Impact	483092	6554739	482946	6555055	1	28.9.2013	2041	2157	17	51	1	0	0	0		
	Impact	483092	6554739	482946	6555055	2	11.10.2013	2219	2357	19	81	1	1	1	100		Light shower of rain recorded
	Impact	483092	6554739	482946	6555055	3	24.11.2013	2207	2246	18.7	83	0	1	1	85		Road noise making it difficult to hear calls

ii. Tree Species Use

Koala scats were recorded from 15 tree species with overall tree use calculated at 5% (Table 4-5). The most commonly encountered feed tree was Tallowwood (*Eucalyptus microcorys*) which comprised 22.9% of all recorded feed tree species. From a proportional perspective, Koala scats were most frequently recorded beneath Forest Red Gum (*Eucalyptus tereticornis*) and Swamp Mahogany (*Eucalyptus robusta*) with 18.2% and 15.6% although both tree species were uncommon at the SAT sites. Other commonly used tree species included Tallowwood (*Eucalyptus microcorys*), Snow-in-summer (*Melaleuca linariifolia*), Broad-leaved White Mahogany (*Eucalyptus umbra*), Scribbly Gum (*Eucalyptus signata*), Small-fruited Grey Gum (*Eucalyptus propinqua*), White Stringybark (*Eucalyptus globoidea*), Coastal Blackbutt (*Eucalyptus pilularis*) and Broad-leaved Paperbark (*Melaleuca quinquenervia*) with the proportion of use ranging from 6.1-9.5% (Table 4-5). Other species including Red Mahogany (*Eucalyptus resinifera*), Grey Ironbark (*Eucalyptus siderophloia*), Pink Bloodwood (*Corymbia intermedia*), White Mahogany (*Eucalyptus acmenoides*) and Turpentine (*Syncarpia glomulifera*) are used less often.

The proportion of tree use shown in Table 4-5 should be used as the baseline data set to compare with future monitoring events.

Table 4-5. Summary of tree species used by Koala during the SAT surveys (n=2160).

Common name	Species Name	No. Trees With Koala Scats	No. Trees Surveyed	Proportion of Use (%) & Baseline Dataset
Forest Red Gum	*Eucalyptus tereticornis*	4	22	18.2
Swamp Mahogany	*Eucalyptus robusta*	5	32	15.6
Tallowwood	*Eucalyptus microcorys*	40	419	9.5
Snow in Summer	*Melaleuca linariifolia*	6	73	8.2
Broad-leaved White Mahogany	*Eucalyptus umbra*	2	25	8
Scribbly Gum	*Eucalyptus signata*	5	70	7.1
Small-fruited Grey Gum	*Eucalyptus propinqua*	13	189	6.9
White Stringybark	*Eucalyptus globoidea*	8	125	6.4
Coastal Blackbutt	*Eucalyptus pilularis*	10	158	6.3
Broad-leaved Paperbark	*Melaleuca quinquenervia*	2	33	6.1
Red Mahogany	*Eucalyptus resinifera*	2	43	4.7
Grey Ironbark	*Eucalyptus siderophloia*	2	82	2.4
Pink Bloodwood	*Corymbia intermedia*	5	254	2
White Mahogany	*Eucalyptus acmenoides*	2	191	1
Turpentine	*Syncarpia glomulifera*	1	114	0.9
		107		5.0%

Koala Movements

i. Using Atlas Data to Predict Movements

The records of Koala show a broad pattern that alludes to Koala moving predominantly in an east west direction to the south of the Hastings River. The clustering of records in the Sancrox area suggest that some individuals maintain home ranges that abut or encompass the existing carriageway (Figure 4-7). This is similar for the area north of the Hastings River where there is some clustering of records in Cairncross State Forest north of Blackmans Point Road.

The records of Koala associated with the Wilson River show individuals move along the floodplain habitats and associated foothills. There are, however, lower reporting rates from the eastern precincts of Grids G3 and H3 indicating Koala movements may be restricted in this area due in part to unsuitable habitat (Figure 4-7). Grids G4 and H4 further to the east have very low reporting rates of 0 and 1 records respectively. The multiple records around Cooperabung Hill suggest individuals probably reside in this area but perform occasional movements across the existing Pacific Highway carriageway. This is supported by the presence of road killed individuals during January and August 2013 which includes both upper slope and gully movements across the carriageway.

In the Mingaletta and Kundabung areas the presence of records on either side of the highway indicates that Koala frequently maintain home ranges in close proximity to the Upgrade and it would be expected that individuals occasionally attempt to cross it. The absence of Koala road kill in this area during the road kill monitoring period indicates that Koala may either move up to the edge of the highway and don't cross it or only small numbers of individuals may occasionally cross the existing carriageway. For example, males during the breeding season or there may be some reliance or learned behaviours with individuals potentially traversing along the watercourses and beneath the bridges at Smiths Creek and Pipers Creek.

The Koala records from Maria River State Forest indicate movements may be concentrated toward the southern extent of the forest bordering private land with a second nodal area around 0.5–1 km south of the Maria River. Another movement corridor occurs at the northern limit of the Upgrade at Stumpy Creek.

ii. Koala Movements and Highway Interactions

Only one Koala was recorded during the weekly road kill transects performed in Spring and again in Summer. This animal had been struck in the south bound lane at ch. 22300 on the 22nd August and it's remains were still present during the initial road kill survey in Spring (4th October). Records compiled between August 2013 and February 2014 shows at least four Koala were killed from road strike over the 7 month period. They include:

- Adult hit in the middle of the south bound lane at ch. 22300 on 22nd August 2013 (Moist Forest growing in gully in Ballengarra State Forest);
- Adult hit in the south bound lane at ch. 32700 on the 10th September 2013 (Southern extent of Maria River State Forest);
- Adult hit on the north bound lane at approximate ch. 11000 on the 29th October 2013 (northern extent of Cairncross State Forest); and
- Adult hit on the edge of the south bound carriageway just south of the Project southern boundary on the 21st February 2014 (Cowarra State Forest and neighbouring private lands).

Only the animal from the 22nd August remained on the carriageway way for any length of time whilst the remaining individuals had been removed within 48 hours. Based on the data above, the baseline count for road kill should be set at 1 individual per 8 weeks.

Discussion of Findings

Koala Distribution

The wildlife atlas data show a widespread population or populations of Koala exist across the entire Project. This is consistent with the mapping prepared for the *Comprehensive Koala Plan of Management for Eastern Portion of Kempsey Shire LGA* which shows the Upgrade traverses large areas of Secondary Preferred Koala Habitat (Class B) and some scattered areas of Secondary Preferred Koala Habitat (Class A) in the Kundabung area (KKPoM 2011). Although the same level of comprehensive mapping is not yet available for the Oxley Highway to Kundabung section of the Project (i.e. Port Macquarie-Hastings LGA) the wildlife atlas data indicates these areas are likely to be similarly mapped as Preferred Koala Habitat (Class B) and some scattered areas of Secondary Preferred Koala Habitat (Class A). For example, the mapping compiled by BioLink (2008) for Area 13 Urban Investigation Area (Thrumster) identifies secondary rather than primary habitat borders the south eastern part of the Project between chainages 0-1750.

Koala Activity & Habitat Use

The results of the baseline SAT monitoring show that whilst the Koala population may be widespread across the Upgrade corridor the activity levels align with medium use of a low density east coast Koala population with some occasional high use areas such as the Fernbank Creek area to the north of Sancrox Road. This is consistent with the findings of Phillips and Callaghan (2011) categorisation of habitat use when describing the application of the Spot Assessment Technique. The results of the baseline survey infer vegetation communities which support Tallowwood, Small-fruited Grey Gum and to a lesser extent Coastal Blackbutt and White Stringybark tend to support Koala populations in the Project area regarding of the topographic relief. At lower relief sites, species including Forest Red Gum, Swamp Mahogany and *Melaleuca* also form important feed tree species whilst Scribbly Gum growing on sandy soils tends to be used in the eastern study area. The overall importance of Tallowwood to Koala has been previously used as the basis for defining 'Primary' Koala habitat in the eastern portion of the Kempsey Shire LGA which extends south to Kundabung (ch. 25350). Given that Tallowwood is both widespread, was frequently surveyed and still yielded relatively high activity scores (i.e. 9.5%) it should be used for future comparison with successive monitoring events.

At a treatment level, Koala activity was highest in the 'mitigation' treatment class which was twice that of the 'control reference' class and almost three times higher than the 'no mitigation' treatment class. This provides some confidence in the fact that a lot of the mitigation devices have been placed in areas of relatively high Koala activity for the Project. In contrast, the data obtained from Cairncross State Forest (north) suggest comparable activity levels between the mitigation and no mitigation treatment classes whilst Cooperabung Hill and Maria River State Forest showed lower activity levels at sites where mitigation has been proposed. In these later two instances, the no mitigation treatments feature no floppy top fencing for the western side of the Cooperabung Hill (ch. 19100) and breaks in the fauna fencing as part of service roads at Maria River (ch. 36550). This existing design may present a risk of some future road kill of Koala.

Regrowth forests support a greater density of tree stems and Koala are likely to travel distances of many tens of metres to access their preferred feed trees. In this context, a SAT site checking 29 trees from the focal tree may not extend far enough to capture additional feed trees and thus may return a lower than expected activity level. In this context only a handful of preferred browse species may be sampled within a single SAT site as numerous other stems of less suitable species (i.e. *Allocasuarina*) require sampling. During the current baseline survey some additional techniques were used and this proved useful to confirm the continued existence of Koala. For example, the sampled SAT sites between Mingaletta and Smiths Creek returned zero activity, however, the use of camera traps confirm their continued existence in this area. This demonstrates the usefulness of a multidisciplinary approach that uses other monitoring technicaues across the Ecological Monitoring Program, rather than relying on a single survey technique.

Koala Density

Koala density was measured in three ways during the current baseline survey. Spotlighting showed that Koala could be consistently recorded across a range of sclerophyll forests and at a consistent rate of 1 individual per hour effort. This recording rate was heavily reliant on detecting vocalising males indicating that any future monitoring event must also be undertaken during the breeding season. One problem encountered during the spotlighting surveys was the presence of an often dense mid stratum reducing the permeability of the light. This was often confounded by the fact that more suitable feed trees were generally found on the lower slopes and gullies which supported this dense mid stratum vegetation.

The use of historic records to obtain a relative measure of Koala density through record reporting was useful to describe the likely density of Koala across the entire study area. Ideally, it would require a vetting process to measure its accuracy and be reliant on spotlight transect counts at a number of these grids. This approach was able to identify that Koala probably reach their highest densities in and around the Port Macquarie area and radiate out into the satellite areas of Lake Innes and Thrumster. Given that a lot of these areas now face expanding residential estate the residual tracts of vegetation are likely to support Koala densities at a magnitude well above the densities expected around the Upgrade. This is supported by some casual distance surveys which have been performed in the past which often result in the detection of Koala at densities far greater than 1 individual per hour (B. Lewis unpublished data).

The use of camera traps provide a repeatable way in which to standardise a survey effort to measure Koala density across the three largest tracts of forest the Upgrade bisects. Whilst this technique relies purely on chance occurrences of individuals wondering past the camera the approach is systematic in that survey effort can be standardised and can be more extensive with longer periods of monitoring.

The results described above tend to be broadly consistent with the SAT activity levels obtained for the baseline survey which in themselves align with that of low density Koala population of medium (normal) use but the regularity with which individuals were recorded with other ancillary techniques including spotlighting and road kill surveys would suggest at least some areas support at least a medium density Koala population. Examples of this occur to the South of Sancrox Road and particularly the area to the east of ch. 1000-1750, south of Fernbank Creek between ch. 3350-4350 and to the north of Kundabung around ch. 32700 where SAT activity levels were relatively high for the Project and animals were observed or encountered during the course of the field study.

Koala Movements

Fundamental to the maintenance of Koala meta population dynamics across the study area is the issue of habitat linkages, or connectivity. The broader landscape between Oxley Highway Interchange and Kempsey is effectively bisected by the Pacific Highway, which currently contributes significantly to annual Koala mortalities within the study area. This is due to the broader movements being in an east-west direction and the fact that Koala maintain home ranges that abut and occasional encompass the existing carriageway. During the current baseline survey only one individual was recorded during the weekly surveys performed in October and January/February. Ad hoc monitoring which spanned a 7 month period revealed additional road killed individuals but was consistent with Koala being struck every 6-8 weeks during the breeding period. Given the Upgrade will provide mitigation measures in the form of floppy top fencing and fauna underpasses of suitable size there are opportunities to clearly measure how road kill mortality changes in response to the Upgrade.

Performance Indicators

The draft Ecological Monitoring Program has identified the performance indicators of the Koala monitoring program as being reliant on

- Monitoring is undertaken during baseline surveys and from Year 1 – Year 8, or until mitigation measures are demonstrated to be effective.
- Monitoring during Year 1 – 8 is undertaken at the Impact and Control sites where monitoring was undertaken during baseline surveys.
- Mitigation measures are demonstrated to be effective as defined in the EPBC approval when all monitoring events are considered at Year 8.
- Fauna fence is installed at a minimum in areas identified in Schedule 3 of the EPBC approval at Year 4.

- No change to densities, distribution, habitat use and movement patterns compared to baseline data.

This study represents the first part of the Koala monitoring program with baseline data being collected during the Spring 2013 with several ancillary techniques spanning a broader time period, all well in advance of construction. The use of a three treatment BACI design for Koala monitoring proved problematic for this Project. Whilst this design was able to comfortably locate and collect data at impact sites receiving mitigation in the form of suitably sized culverts to maintain connectivity and floppy top fencing to prevent animals was venturing onto the carriageway the extent of this across most of the vegetated areas meant that 'no mitigation' treatments were difficult to locate and with any form of data independence from neighbouring mitigation sites (i.e. often only a few hundred metres from mitigation sites). This resulted in the Mingaletta to Smiths Creek area not being able to meet the survey design requirements of having a 'no mitigation' treatment and having to locate other 'no mitigation' treatments in areas best described as offering partial mitigation whereby there was some floppy top fencing but with obvious openings in the vicinity of interchanges or entry and exit points of connecting roads. Examples of this occurred at Maria River, Cooperabung Hill, Cairncross State Forest (south) and to some extent Sancrox and all of these areas may present a risk of reporting Koala road kills during the operational phase of the Upgrade.

Considering the above, the removal of the 'no mitigation' treatments would allow for a more simplified paired BACI design using impact mitigation sites (mitigation baseline sites in this study) and simply pairing them for later comparison with the control/reference sites. This approach is consistent with a number of monitoring programs being currently developed for the Woolgoolga to Ballina Pacific Highway Upgrade.

Key Recommendations

1. Ensure any future comparison of Koala activity levels take into account the following baseline data and with a 10% tolerance level to account for variability:
    a. Broader study area set at 5% activity;
    b. The three treatment classes of Mitigation set at 8.05%, control reference set at 4.03% and no mitigation set at 2.64%.
2. Ensure habitat use takes into account the proportion of each tree species used versus that actually sampled. Table 4-5 provides an opportunity for direct comparison.
3. Set the density baseline monitoring to 1 individual per 1 hour of spotlight effort and ensure monitoring is performed during spring to coincide with the breeding season.
4. Set the baseline for road kill Koala to 1 individual every 8 weeks. Ensure operational monitoring includes the entire carriageway, particularly interchanges where Koala are most at risk to road strike.

References

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Appendix – Field Data

Table 4-A. Summary of the Spot Assessment Technique (SAT) used in the baseline survey.

Area	Monitoring Area Name	Site Name	Treatment	Easting	Northing	Activity	Selection Criteria	Radial Search	Notes/Comment
1	South Sancrox Road	Sancrox South	Mitigation	483321	6520694	13.33	Tallowwood	12	
1	South Sancrox Road	Sancrox South	Mitigation	483296	6520413	3.33	Tallowwood	13	Female koala observed in Blackbutt 90 m further north
1	South Sancrox Road	Sancrox South	Mitigation	483139	6520700	10	Tallowwood	19	
1	South Sancrox Road	Sancrox East - Cassegrains	No Mitigation	483348	6521736	10	Tallowwood	13	
1	South Sancrox Road	Sancrox East - Cassegrains	No Mitigation	483455	6521789	0	Tallowwood	13	
1	South Sancrox Road	Sancrox East - Cassegrains	No Mitigation	483412	6521882	0	Tallowwood	16	
1	South Sancrox Road	Cowarra State Forest	Control	480608	6519056	0	Tallowwood	18	
1	South Sancrox Road	Cowarra State Forest	Control	480658	6519496	3.33	Tallowwood	17	
1	South Sancrox Road	Cowarra State Forest	Control	481305	6519136	10	Tallowwood	13	
2	North Sancrox Road	Sancrox North - Expressway Spares	No Mitigation	483042	6521731	3.33	Swamp Mahogany	15	
2	North Sancrox Road	Sancrox North - Expressway Spares	No Mitigation	482869	6521683	0	Tallowwood	12	
2	North Sancrox Road	Sancrox North - Expressway Spares	No Mitigation	482999	6521818	0	Tallowwood	11	
2	North Sancrox Road	Fernbank Creek	Mitigation	483101	6523362	33.33	Tallowwood	15	
2	North Sancrox Road	Fernbank Creek	Mitigation	483032	6523223	30	Tallowwood	12	
2	North Sancrox Road	Fernbank Creek	Mitigation	483056	6523123	23.33	Male Koala in Tallowwood	17	
2	North Sancrox Road	Lake Innes	Control	488124	6518469	26.67	Tallowwood	15	
2	North Sancrox Road	Lake Innes	Control	488047	6518398	13.33	Swamp Mahogany	16	
2	North Sancrox Road	Lake Innes	Control	488228	6518390	3.33	Swamp Mahogany	18	Very wet in this area and couldn't establish plot further to the east
3	Cairncross State Forest (South)	Cairncross State Forest (South)	No Mitigation	482428	6526536	0	Tallowwood	19	
3	Cairncross State Forest (South)	Cairncross State Forest (South)	No Mitigation	482385	6526644	3.33	Tallowwood	14	

Area	Monitoring Area Name	Site Name	Treatment	Easting	Northing	Activity	Selection Criteria	Radial Search	Notes/Comment
3	Cairncross State Forest (South)	Cairncross State Forest (South)	No Mitigation	482393	6526416	0	Tallowwood	18	
3a	Cairncross State Forest (south)	Cairncross State Forest (south)	No Mitigation	481655	6527256	0	Tallowwood	13	
3a	Cairncross State Forest (south)	Cairncross State Forest (south)	No Mitigation	481590	6527316	0	Tallowwood	26	
3a	Cairncross State Forest (south)	Cairncross State Forest (south)	No Mitigation	481637	6527175	13.33	Tallowwood	24	
3	Cairncross State Forest (South)	Cairncross State Forest (South)	Mitigation	482249	6525930	3.33	Tallowwood	18	
3	Cairncross State Forest (South)	Cairncross State Forest (South)	Mitigation	482125	6526077	3.33	Tallowwood	16	
3	Cairncross State Forest (South)	Cairncross State Forest (South)	Mitigation	482488	6526226	0	Tallowwood	13	
3	Cairncross State Forest (South)	Limeburners Creek "The Hatch"	Control	487011	6529909	0	Scribbly Gum	31	
3	Cairncross State Forest (South)	Limeburners Creek "The Hatch"	Control	487014	6529455	3.33	Scribbly Gum	32	
3	Cairncross State Forest (South)	Limeburners Creek "The Hatch"	Control	487035	6528694	0	Scribbly Gum	17	
4	Cairncross State Forest (north)	Cairncross State Forest (North)	No Mitigation	481420	6530890	0	White Mahogany	55	
4	Cairncross State Forest (north)	Cairncross State Forest (North)	No Mitigation	481695	6530786	0	Forest Red Gum	13	
4	Cairncross State Forest (north)	Cairncross State Forest (North)	No Mitigation	481184	6530864	0	Tallowwood	19	
4	Cairncross State Forest (north)	Cairncross State Forest (north)	Mitigation	481238	6530264	3.33	Swamp Mahogany	11	
4	Cairncross State Forest (north)	Cairncross State Forest (north)	Mitigation	481173	6530319	3.33	Tallowwood	13	
4	Cairncross State Forest (north)	Cairncross State Forest (north)	Mitigation	481438	6530335	6.67	Tallowwood	16	
4	Cairncross State Forest (north)	Cairncross State Forest (Pembrooke)	Control	473751	6528881	6.67	Tallowwood	20	
4	Cairncross State Forest (north)	Cairncross State Forest (Pembrooke)	Control	473464	6528969	0	Tallowwood	16	
4	Cairncross State Forest (north)	Cairncross State Forest (Pembrooke)	Control	473424	6529115	0	Tallowwood	18	
5	Cooperabung Hill	Cooperabung	No Mitigation	482793	6537012	3.33	Tallowwood	36	
5	Cooperabung Hill	Cooperabung	No Mitigation	482755	6537093	0	Tallowwood	31	
5	Cooperabung Hill	Cooperabung	No Mitigation	482876	6537115	10	Tallowwood	18	
5	Cooperabung Hill	Cooperabung	Mitigation	482539	6538907	0	Tallowwood	16	

Area	Monitoring Area Name	Site Name	Treatment	Easting	Northing	Activity	Selection Criteria	Radial Search	Notes/Comment
5	Cooperabung Hill	Cooperabung	Mitigation	482750	6538736	3.33	Forest Red Gum	17	
5	Cooperabung Hill	Cooperabung	Mitigation	482364	6538610	0	Tallowwood	14	
5	Cooperabung Hill	Cooperabung Hill (Gum Scrub)	Control	475489	6541854	6.67	Tallowwood	22	
5	Cooperabung Hill	Cooperabung Hill (Gum Scrub)	Control	475570	6541903	0	Tallowwood	14	
5	Cooperabung Hill	Cooperabung Hill (Gum Scrub)	Control	475838	6541962	0	Tallowwood	14	
6	Mingaletta to Smiths Creek	Not possible with current design							Would need to remove some koala fencing to enable no mitigation site to be installed in this area
6	Mingaletta to Smiths Creek	Not possible with current design							Would need to remove some koala fencing to enable no mitigation site to be installed in this area
6	Mingaletta to Smiths Creek	Not possible with current design							Would need to remove some koala fencing to enable no mitigation site to be installed in this area
6	Mingaletta to Smiths Creek	Mingaletta-Smiths Creek	Mitigation	483304	6543632	0	Tallowwood	9	
6	Mingaletta to Smiths Creek	Mingaletta-Smiths Creek	Mitigation	483444	6543585	0	Tallowwood	21	
6	Mingaletta to Smiths Creek	Mingaletta-Smiths Creek	Mitigation	483100	6543670	0	Tallowwood	15	
6	Mingaletta to Smiths Creek	Ballengarra State Forest (Greg's Road)	Control	477750	6543274	0	Tallowwood	10	
6	Mingaletta to Smiths Creek	Ballengarra State Forest (Greg's Road)	Control	477644	6543623	0	Small-fruited Grey Gum	19	
6	Mingaletta to Smiths Creek	Ballengarra State Forest (Greg's Road)	Control	477551	6543709	0	Tallowwood	16	
7	Kundabung Road to North of Pipers Creek	Kundabung	No Mitigation	483095	6549036	0	Tallowwood	23	
7	Kundabung Road to North of Pipers Creek	Kundabung	No Mitigation	482873	6549112	10	Tallowwood	20	
7	Kundabung Road to North of Pipers Creek	Kundabung	No Mitigation	483285	6549374	0	Tallowwood	15	
7	Kundabung Road to North of Pipers Creek	Kundabung	Mitigation	483369	6550655	33.33	Tallowwood	26	
7	Kundabung Road to North of Pipers Creek	Kundabung	Mitigation	483331	6550938	13.33	Tallowwood	16	
7	Kundabung Road to North of Pipers Creek	Kundabung	Mitigation	483083	6550608	10	Forest Red Gum	22	

	Monitoring Area Name	Site Name	Treatment	Easting	Northing	Activity	Selection Criteria	Radial Search	Notes/Comment
7	Kundabung Road to North of Pipers Creek	Kumbatine National Park	Control	476044	6549609	3.33	Tallowwood	14	
7	Kundabung Road to North of Pipers Creek	Kumbatine National Park	Control	476165	6549738	0	Tallowwood	16	
7	Kundabung Road to North of Pipers Creek	Kumbatine National Park	Control	475889	6549468	0	Tallowwood	15	
8	Maria River State Forest	Maria River	Part Mitigation	483074	6554460	0	Tallowwood	21	
8	Maria River State Forest	Maria River	Part Mitigation	482836	6554330	3.33	Tallowwood	15	
8	Maria River State Forest	Maria River	Part Mitigation	482917	6554027	6.67	Tallowwood	14	
8	Maria River State Forest	Maria River	Mitigation	482886	6552623	0	Tallowwood	15	
8	Maria River State Forest	Maria River	Mitigation	482754	6552462	0	Tallowwood	17	
8	Maria River State Forest	Maria River	Mitigation	483135	6552449	0	Tallowwood	14	
8	Maria River State Forest	Maria River National Park	Control	486965	6554366	0	Tallowwood	20	Camera trap recorded Koala here in late August 2013
8	Maria River State Forest	Maria River National Park	Control	486971	6554479	10	Tallowwood	25	
8	Maria River State Forest	Maria River National Park	Control	487004	6554203	10	Tallowwood	26	

Table 4B. Summary of the mean Spot Assessment Technique (SAT) activity levels across each treatment class for the eight Koala monitoring areas.

SE = Standard Error, SD = Standard Deviation

Koala Monitoring Area	Treatment Type	Monitoring Area Name	Mean	SE	SD
1	Control Reference	South Sancrox Road	4.44	2.94	5.09
1	Mitigation	South Sancrox Road	8.89	2.94	5.09
1	No Mitigation	South Sancrox Road	3.33	3.33	5.77
2	Control Reference	North Sancrox Road	14.44	6.76	11.71
2	Mitigation	North Sancrox Road	28.89	2.94	5.09
2	No Mitigation	North Sancrox Road	1.11	1.11	1.92
3	Control Reference	Cairncross State Forest (south)	2.22	2.22	3.85
3	Mitigation	Cairncross State Forest (south)	2.22	1.11	1.92
3	No Mitigation 1	Cairncross State Forest (south)	1.11	1.11	1.92
3	No Mitigation 2	Cairncross State Forest (south)	0	0	0
4	Control Reference	Cairncross State Forest (north)	1.11	1.11	1.92
4	Mitigation	Cairncross State Forest (north)	4.44	1.11	7.7
4	No Mitigation	Cairncross State Forest (north)	4.44	4.44	1.93
5	Control Reference	Cooperabung	2.22	2.22	5.09
5	Mitigation	Cooperabung Hill	1.11	1.11	3.85
5	No Mitigation	Cooperabung	4.44	2.94	1.92
6	Control Reference	Mingaletta to Smiths Creek	0	0	0
6	Mitigation	Mingaletta to Smiths Creek	0	0	0
7	Control Reference	Kundabung	1.11	1.11	5.77
7	Mitigation	Kundabung	18.89	7.29	1.92
7	No Mitigation	Kundabung	3.33	3.33	12.62
8	Control Reference	Maria River State Forest	6.67	3.33	5.77
8	Mitigation	Maria River State Forest	0	0	3.34
8	No Mitigation	Maria River State Forest	3.33	1.93	0

SPOTTED-TAILED QUOLL

The methodology outlined in Section 3.2.2 was followed for the Spotted-tailed Quoll surveys, with the exception of the Maria River State Forest reference site. Additional factors including the presence of two fires at Beranghi and Limeburners Creek Nature Reserve necessitated the relocation of the Maria River reference site to a secondary location much further to the north.

Cameras were installed between the 8 and 14th August and retrieved between 22-26 days later culminating in 2340 nights of survey effort. See Figure 5 for camera distribution. At the time of their installation an olfactory predator lure consisting of chicken drumsticks and 2-3 West Australian Pilchards (*Sardinops sagax*) were used to smear in the immediate vicinity on logs, stone, the base of trees and the remnants hidden within cavities of fallen branches and logs. The objective of this was to reduce the opportunity for a single animal to remove the olfactory lure and improved the opportunity to capture readily identifiable images of fauna entering the camera trap. The use of fish as a bait for quoll has been previously demonstrated in Limeburners Creek Nature Reserve when fish heads were used extensively for the trapping program (*see* Andrew 2005).

Cameras were set in continuous 24 hour mode for 21 nights using the following parameters:

- Sensor Sensitivity was set at a variable rate from ‘normal’ or ‘high’ depending on the amount of grass and other fine vegetation present at the camera site. Some pruning was undertaken at sites in order to maximize the opportunity to setting the camera sensitivity to high;
- The number of images was set to 2 with the reset or PIR set at 30 second intervals;
- All images were time and date stamped for later verification and to facilitate in the understanding of quoll or other predator and prey activity.

Interpreting the Camera Data

All images were reviewed by one person (BDL). For determining the abundance or activity levels of quoll, eutherian predators and suitable prey items (i.e. small and medium sized mammals) the maximum number of a species within a 1 hour period was set at one unless it could be clearly distinguished as a separate individual. For example, a tortoise shell Feral Cat that was repeatedly photographed on 10 occasions over the spaced of 30 minutes was counted as a single record of occurrence whilst a tabby coloured cat captured during the same period would allow the counting of a second animal.

Considerations of Predator Prey Relationship

A quoll study at Limeburners Creek Nature Reserve 5-10 km east of the Upgrade revealed more than half of their diet (63.5%) was comprised of mammals and only 8.8% bird with the residual made up of insects, fish, reptiles and garbage (Andrew 2005). Similarly, studies of quoll in the upland areas of the mid north coast have also reported similar high rates of mammalian consumption, particularly medium sized mammals such as bandicoots (e.g. Glen and Dickman 2008). In an attempt to understand the presence and abundance of this size class in the study area the number of medium and smaller mammals captured by the camera traps was also considered. The three particular classes of interest were arboreal fauna which regularly come to the ground (possums), bandicoots and smaller ground dwelling mammals such as rodents and Antechinus. Their presence and the number of recorded images were recorded as above.

Considerations of competitive interaction with eutherian predators

The number of eutherian predators including feral cat, wild dog/dingo and red fox was also considered within each treatment because they are suspected at influencing quoll distribution via competitive interactions for prey (Glen and Dickman 2008). The numbers of each species was calculated to provide a mean abundance for each treatment at each of the three areas.

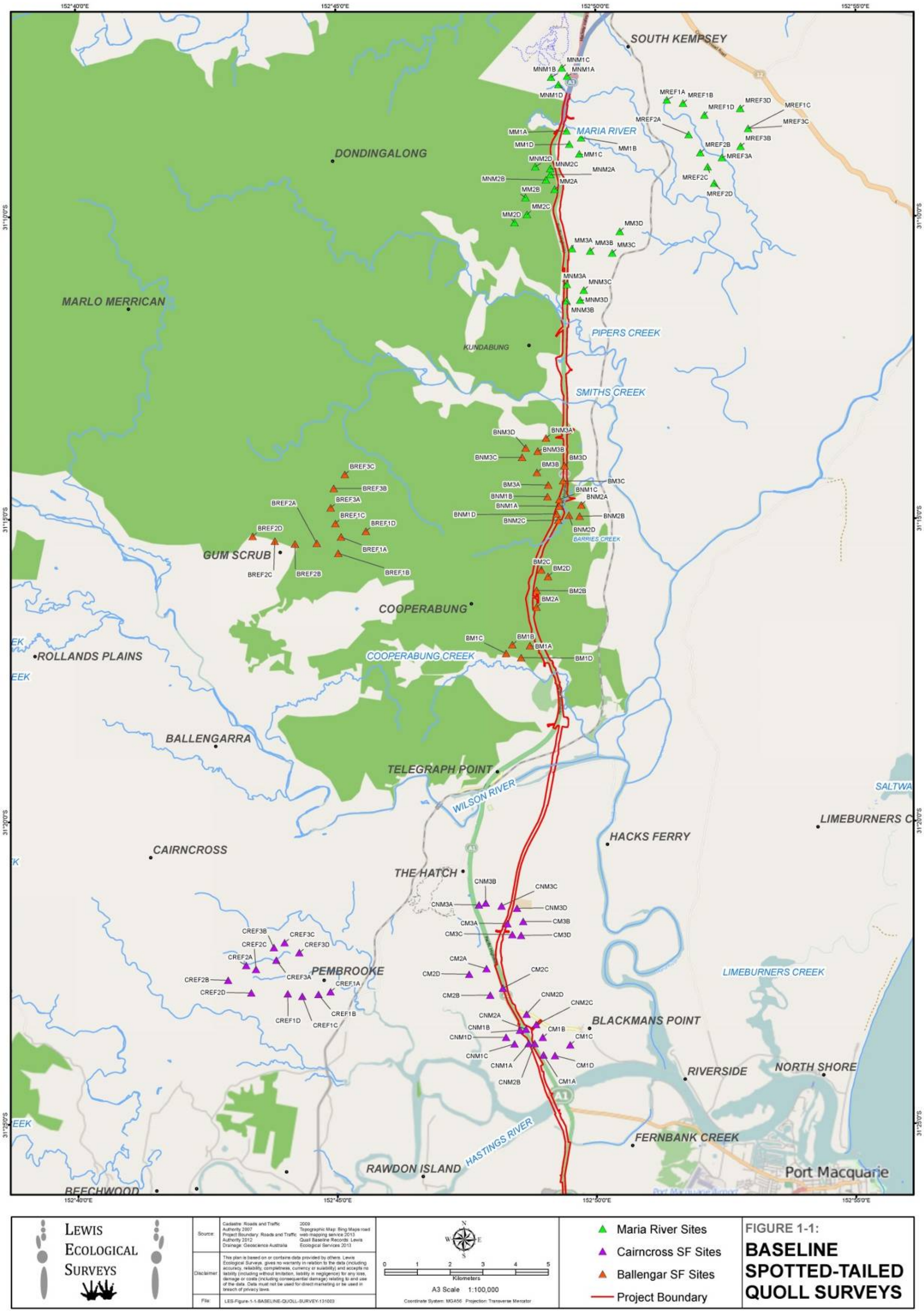

Figure 5 Baseline Spotted-tailed Quoll monitoring locations

Results

Camera Surveys

Field surveys retrieved 103 of the 108 installed cameras with the residual being stolen during the course of the field survey. Two of the retrieved cameras had suffered equipment malfunction leaving 101 functioning cameras which recorded 27208 images (mean=272 SD=469).

No Spotted-tailed Quoll were recorded during the camera surveys.

Abundance Indices of Suitable Prey Items

The camera traps in Cairncross State Forest recorded only 11 images comprising seven possums and four bandicoots from 808 camera trap nights. In Ballengarra State Forest the number of native prey items recorded doubled with 22 images from 826 camera trap nights comprising 13 possum, four bandicoot and five dasyurid and rodents. In Maria River State Forest the number of native prey items recorded was four images from 706 camera trap nights comprising three possum and one bandicoot and no dasyurid and rodents.

Abundance Indices of Introduced Eutherian Predators

In Cairncross State Forest there were 188 images of introduced eutherian predator comprising 48 wild dog, 101 fox and 39 feral cat. The majority of the wild dog images were recorded from the Cairncross reference location to the west of Pembrooke whilst most fox images were associated in areas proposed for no mitigation (Figure 6).

In Ballengarra State Forest there were 125 images of introduced predator comprising 51 wild dog, 48 fox and 26 feral cat. The majority of the wild dog and fox images were recorded from the reference location to the west of the Upgrade in the Gum Scrub area whilst Feral Cat showed a consistent presence across all three treatments (Figure 6).

In Maria River State Forest there were 206 images of introduced predator comprising 79 wild dog, 96 fox and 31 feral cat. The majority of the wild dog and fox images were recorded from the reference location to the east of the Upgrade whilst Feral Cat showed a consistent presence across all three treatments (Figure 6).

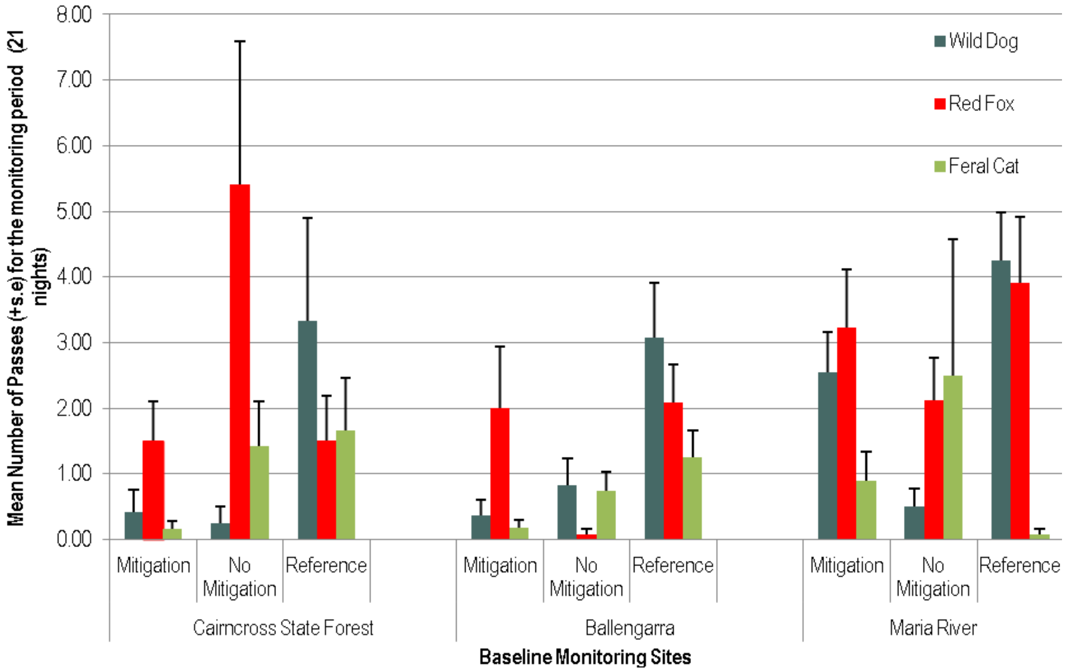

Figure 6 Mean number (+s.e bars) of wild dog, red fox and feral cat across each treatment for the monitoring period.

The highest mean levels of eutherian predators occurred at the reference sites with the activity levels almost three times higher than the mitigation treatment at Cairncross State Forest and Ballengarra State Forest (Figure 7). At Maria River State Forest all three treatment classes scored relatively high with the reference site containing the highest overall mean abundance of eutherians.

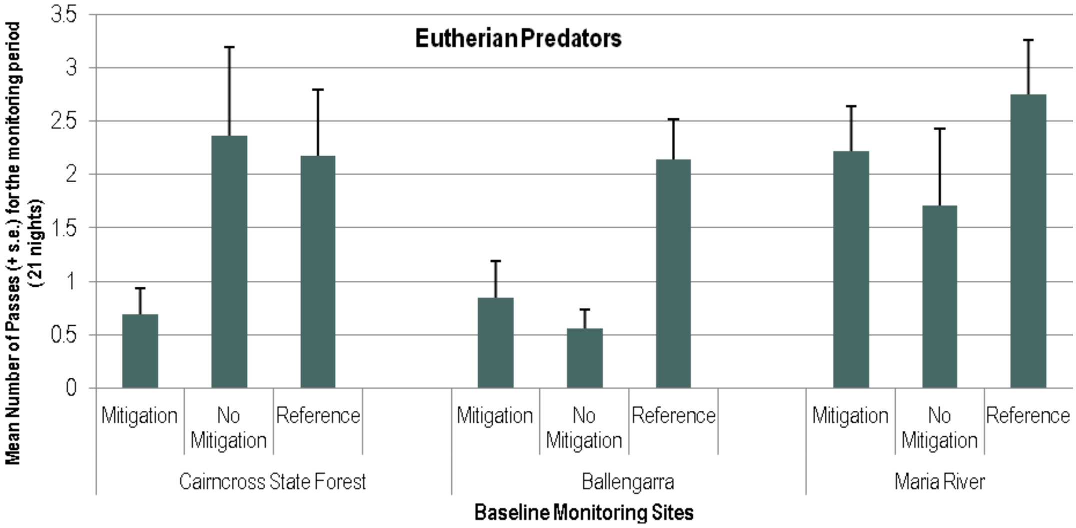

Figure 7 Mean number (+s.e bars) of eutherian predators across each treatment for the monitoring period.

Road Kill Monitoring

Road kill monitoring was undertaken in two ways, as part of the overall Ecological Monitoring Program. Firstly, a systematic survey was undertaken over 4 weeks in October 2013 and January-February 2014 and involved a weekly vehicle traverse of the existing Pacific Highway to observe and record all road kill fauna. The second approach was of a more *ad hoc* nature and reflects numerous vehicle traverses undertaken along the existing highway route between Port Macquarie Interchange and Kempsey between the period of 2010-2014. During this time more than 200 traverses were completed shortly after dawn (0600-0830 hours).

No Spotted-tailed Quoll were recorded during the road kill traverses.

Discussion

No quoll were recorded during the field surveys for this baseline monitoring program. The sampling approach adopted in this study has been proven elsewhere to provide a ‘probability of detection’ ranging from 80% in areas supporting high densities of quoll (i.e. Alpine areas of NSW/Victoria) to a much lower 34% in areas supporting lower quoll densities (*see* Nelson et al. 2010). The desktop surveys confirm quoll is a widely distributed species through the broader area but apart from Limeburners Creek Nature Reserve there does not appear to be a reliable population which could be used as a reference point to gauge the effectiveness of camera traps for monitoring quoll populations in lowland coastal forest on northern New South Wales. This area was originally identified as a reference site but the ignition of two fires burning in the area for weeks (Limeburners Creek Nature Reserve and Beranghi) prevented this from occurring. Without knowingly sampling in an area of higher density quoll habitat the probability of detection rate best aligns with an area supporting lower densities of quoll.

Other factors should also be considered to have influenced the survey results. The prevailing weather conditions were dry with virtually no rainfall recorded throughout the monitoring period, thus ensuring the chicken baits and pilchards remained effective lures so this is unlikely to have had a negative effect on the survey. The seasonal effect of conducting surveys during August and September best reflects a survey investigating habitat use during the post mating breeding period when breeding females may spend much of their time nurturing young in a den resulting in changed patterns of habitat use from other times of the year. It is unclear whether male Spotted-tailed Quoll undergo the dasyurid 'die off' in the weeks preceding mating but if this is the case then fewer males would have been present. For example, a radio tracked male quoll in Limeburners Creek Nature Reserve underwent dramatic loss in body weight, possible anaemia, hair loss and excessive parasite load indicating that such a 'die off' is possible (see Andrew 2005).

The review of historic records on the NSW Bionet Atlas found a lot of variability in the seasonal reporting rates of quoll with records for every season and the majority of all records originating from a community survey administered by Dan Lunney. Nonetheless, the only record of Quoll using the Project corridor was the road kill individual from mid July 1992. This highlights the need to consider the appropriate time during the year for monitoring quoll. For example, surveys conducted between July and October would provide information on habitat use during the breeding period with females in particular using smaller home ranges than they would during the non breeding period. Therefore, to understand broader movements associated with dispersal monitoring would be beneficial during the dispersal period regarded in this study area as between March and May when juveniles establish new home ranges and adults re-establish their non breeding home ranges. If patterns of habitat use during an alternative period of increased activity were required then the mating period between mid May to mid July would also be an optimum time.

The absence of quoll from the road kill data also suggests it may be an infrequent visitor to the Project or at least the existing Pacific Highway carriageway. This was supported by both the desktop surveys and the road kill monitoring data and would indicate that quoll probably occur at very low densities in the Project area. Comparative road kill surveys in the upland areas of the Great Dividing Range have noted quoll as being a regular road kill species in areas such as Cotton-Bimbang National Park (Oxley Highway) and areas much further to the north in Girard State Forest between Drake and Tenterfield (B. Lewis unpublished data).

Little information could be gained from the habitat assessment performed at each camera trap site because there were no confirmed records of quoll. Fallen logs with hollows capable of supporting den sites were recorded in multiple plots of all treatments and assessing these in isolation would be misleading.

Influence of Eutherian Predators

The exact influence eutherian predators have on quoll across the broader area is unknown because the former was found to be widespread and relatively common. In fact, it was the reference sites which often supported the highest levels of eutherian activity with the highest of these being the Maria River reference site which had been located in the northern end of Maria River National Park within a few kilometres of the Kempsey landfill site. By contrast, the research conducted in Limeburners Creek Nature Reserve reported low densities of eutherians and there was evidence to support quoll may have occasionally benefited from this as individuals foraging on the left over spoils of larger mammals including Swamp Wallaby and Eastern Grey Kangaroo (Andrew 2005). The natural geographical barriers of the Hastings River, Maria River, different vegetation communities with dense heaths and woodlands supporting dense shrub layers and perhaps a more strategic predator control program may best explain this as the two areas were often not more than 5-10 km apart. It is also unclear what current predator control programs are in place for areas used in this study.

Influence of Suitable Prey Items

The abundance of medium sized mammals, particularly bandicoots has been demonstrated as an important dietary component for quoll on the coastal plains (Andrew 2005) and the upland areas of the Great Dividing Range (Glen and Dickman 2008). Given the Project occurs between these two areas it is expected that medium sized mammals would also form an important dietary component for any quoll inhabiting the study area. The fact that both studies also reported medium sized mammals as the most important prey class for eutherian predators would indicate a potential for exploitative interactions. In this study, very few medium sized mammals were recorded with the cameras, with Ballengarra State Forest reporting twice the number of medium sized mammals than Cairncross State Forest and Maria River State Forest supporting far fewer. To overcome these exploitative interactions, previous studies have suggested the broader dietary habit of quoll as secondary prey including those with arboreal habits that may assist with coexistence (Glen and Dickman 2008). Therefore, in areas with high levels of introduced predators then more structurally diverse communities which have the capacity to support a more biologically rich source of prey items may become increasingly important for quoll. Obvious examples of these in the Project corridor include Maria River, Barrys Creek and it would be expected that individuals would periodically traverse along Pipers Creek, Smiths Creek and Cooperabung Creek. The value of Wilson River and Hastings River is currently unknown but the latter is surrounded by open grazing land for at least 1 km either side of the northern shoreline and for several kilometres on the southern bank.

Recommendations

1. Operational monitoring is undertaken either during the dispersal period of March-May or alternatively May-mid July during the mating period.
2. A reference site should be located in known quoll habitat in Limeburners Creek Nature Reserve to improve our understanding of detection probabilities of quoll using remote cameras.
3. The study would benefit from retracting the current BACI survey design of three treatment classes to a paired sampling BACI design involving an impact site and a paired control/reference site. This is because the opportunities for locating ‘no mitigation control sites’ along the Project corridor is limited because of the mobility of the target species, which can travel a number of kilometres in an evening, combined with the presence of suitable fauna underpasses located only 2-3 km apart and often much closer. The reduction in the number of treatments would allow for an increase in the number of within treatment replicates from three to four.

GIANT BARRED FROG

The survey methodology outlined in Section 3.2.3 of the Ecological Monitoring Program was adopted for Giant Barred Frog surveys, which is also consistent with the methodology outlined in the Giant Barred Frog Management Strategy (Lewis 2013).

In accordance with this strategy, breeding condition of males was assessed on the colouration of their nuptial pads (i.e. no colour, light moderate, dark) (see Table 4).

Table 4 A key developed for determining reproduction condition in barred frogs (*Mixophyes*).

Nuptial Pad Colour	Comments
No Colour	• Males may be active or dormant but don't present as being sexually active to mate with females. • No colour can occur at any time throughout the year but pronounced periods include dry springs and late autumn with the onset of winter.
Light	• Some colouration indicating frogs are likely to become active (late winter) or have been active but generally not breeding. For example, prevailing weather conditions are unsuitable. • Frogs with light nuptials are generally on the shoulder periods of breeding events and a small percentage of the male population is likely to classify into this category at almost any time of the year apart from June and July.
Moderate	• Males are normally active, will often readily respond to calls. ready to mate with gravid females if conditions are suitable. • These frogs may occasionally be involved in intraspecific aggression indicating their readiness to mate with females. • Colouring may be evident between August-May and is considered cyclic and surrounding breeding events.
Very Dark	• Males are normally active, ready to mate with gravid females if conditions are suitable. • Some observations of intraspecific aggression can occur between males at this stage. • Colouring may be evident between August-May and is considered cyclic with early season suspected of being driven through warming air temperature whilst prevailing rainfall conditions are considered the primary queue during summer and autumn.

Determining Population Size

The **Lincoln–Petersen method** (also known as the Petersen–Lincoln index) can be used to estimate population size if only two visits are made to the study area. This method assumes that the study population is "closed". In other words, the two visits to the study area are close enough in time so that no individuals die, are born, move into the study area or move out of the study area between visits. The model also assumes that no marks fall off animals between visits to the field site by the researcher, and that the researcher correctly records all marks.

The Lincoln–Peterson estimator is asymptotically unbiased as sample size approaches infinity, but is biased at small sample sizes. An alternative less biased estimator of population size is given by the **Chapman estimator.**

$$N = \frac{(M+1)(C+1)}{R+1} - 1,$$

Where, as before,

N = Estimate of total population size

M = Total number of animals captured and marked on the first visit

C = Total number of animals captured on the second visit

R = Number of animals captured on the first visit that were then recaptured on the second visit

An approximately unbiased variance of N, or var(N), can be estimated as:

$$\mathrm{var}(N) = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)(R+1)(R+2)}.$$

Juvenile frogs were removed from the population estimation process because frogs less than 40 mm snout-vent length would have metamorphed between the spring and summer sampling event. This is based on some cross referencing at each site with recaptured frogs and working out their mean growth rate between the two time periods. For example, at Smiths Creek one recapture sub adult was 45.1 mm in September 2013 and had grown to 56.2 mm in January whilst another frog was 46.2 mm in September and 55.4 mm in January. The mean difference being 10.15 mm over the four month period. For most metamorphs their snout vent length is in the general vicinity of 28-31 mm.

Results

A detailed summary of all survey results in provided in Table 17.

Baseline data for the spring and summer surveys has been provided below, however compliance with the submission and approval timeframes in the Department's Condition of Approval 4 could not be achieved if the report was delayed to include the autumn monitoring results. These results will be provided in the first annual report, to be prepared in accordance with Condition of Approval 8.

Impact Sites

Cooperabung Creek

Date and Time Taken To Complete The Survey: Spring - 22nd September 2013 between 1900-2235 hours. Summer – 26th January 2014 between 2125-0220 hours

Abiotic Conditions: A summary of the prevailing abiotic variables is shown in Tables 5 & 6. The conditions were described as mild and becoming more difficult to locate frogs following rainfall earlier in the week.

Table 5 Spring abiotic conditions during the spring survey of Cooperabung Creek

Date	Time		Air Temp ^{o}C	Water Temp ^{o}C	Cloud Cover %	Humidity %	Wind[1]	Rain[2]	Steam Depth (mm)
22.9.2013	Start Time	1900	14.2	15	0	77	0	0	
	Finish time	2235	10.6	14.75	0	88	0	0	
Summary		3 hrs 35 minutes	12.4	14.9	0.0	82.5	0.0	0.0	

Table 6 Summer abiotic conditions during the summer survey of Cooperabung Creek

Date	Time		Air Temp	Water	Cloud Cover	Humidity	Wind[1]	Rain[2]	Steam Depth

			°C	Temp °C	%	%			(mm)
22.9.2013	Start Time	2125	21.3	19.5	10	67	0	1	0
	Finish time	0220	18.6	19.0	90	88	0	0	0
Summary		4 hrs 55 minutes	19.95	19.25	50	77.5	0	0.5	0

Number of Giant Barred Frogs Recorded: Spring - Three Giant Barred Frogs were recorded/captured during the survey. They comprised two sub adult males and one adult female. Although no male frogs were recorded/captured they have been previously recorded a further 300 m downstream of the monitoring transect. At the time of the survey male frogs are likely to have been dormant beneath leaf litter and overhanging vegetation on the primary creek bank. **Summer** - Nine Giant Barred Frogs were recorded/captured during the survey. They comprised two juveniles, one sub adult, one female and five males. At the time of the survey, male frogs displayed a range of nuptial pad colours with one frog each exhibiting 'no colour', light nuptials, medium nuptials and three frogs exhibited dark nuptials indicating most males were in a reproductive state to commence breeding.

Population Estimate: No recaptures of frogs has taken place over the course of the two monitoring surveys. As such, a cursory estimate of seven adults comprising two females and five males is known with three sub adults and two juveniles.

Evidence of Breeding Recorded: Yes via the presence of two sub adult frogs in spring and two juveniles and a young sub adult frog during the summer survey.

Zones Inhabited By Giant Barred Frogs: Restricted to zones C10, C11-C13, C15 and C18 which lie within and immediately upstream of the existing carriageway. Both zones C10 and C11 are considered to form part of the construction footprint (see Figure 8).

Summer Sampling of Chytrid: All nine frogs were swabbed and tested negative for Chytrid (Table 18).

Giant Barred Frog Tadpoles: No tadpoles were recorded using bait traps. Mixophyes tadpoles were observed in zones C11-C15 (see Figure 8).

Habitat: See Figure 8 for the zones within the Cooperabung Creek survey area in which the Giant Barred Frogs were identified. In addition, microhabitat within these zones included flood debris as overhang shelter, grass and leaf litter.

Figure 8 Cooperabung Creek Frog Survey Sites

Smiths Creek

Date and Time Taken To Complete The Survey: Spring - 19th September 2013 between 1845-0020 hours. Summer – 28th January 2014 between 2102-0302 hours

Abiotic Conditions: A summary of the prevailing abiotic variables is shown in Table 7 & 8. Following a significant rainfall event in the Kundabung area on the 16th September conditions were mild with relative low rates of humidity and cool dry air. Larger adult frogs tended to react to this by emerging later at night.

Table 7 Abiotic conditions during the spring survey at Smiths Creek

Date	19.9.2013	Air Temp ºC	Water Temp ºC	Cloud Cover %	Humidity %	Wind[1]	Rain[2]	Steam Depth (mm)
Start Time	1845	15.7	17	0	76	0	0	
Finish time	0020	9	15.5	0	90	0	0	
Summary	5 hrs 35 minutes	12.4	16.3	0.0	83.0	0.0	0.0	

Table 8 Abiotic conditions during the summer survey at Smiths Creek

Date	28.1.2014	Air Temp ºC	Water Temp ºC	Cloud Cover %	Humidity %	Wind[1]	Rain[2]	Steam Depth (mm)
Start Time	2102	20.4	22.5	10	68	0	0	
Finish time	0302	16.5	22.5	0	91	0	0	
Summary	5 hrs	18.45	22.5	5	79.5	0	0	

Number of Giant Barred Frogs Recorded: Spring - Ten (10) Giant Barred Frogs were recorded/captured during the survey. They comprised two females and one male with the remainder classified as sub adults although frog with the identifier 000735C27C is likely to be a male frog showing early pigmentation on its throat and abdomen. **Summer** – Sixteen (16) Giant Barred Frogs were recorded/captured during the survey. They comprised one female, four males, nine sub adults and two juveniles. Two frogs were recaptures from the spring survey.

Population Estimate: For the purposes of mark recapture calculations 2 juvenile frogs <40 mm snout-vent were removed from the population estimate leaving 14 of the 16 captured frogs during the summer survey. This resulted in a population estimate of 54 individuals with variance of 20.98. The 95% confidence interval was calculated at 41.12.

Evidence of Breeding Recorded: Yes via the presence of seven sub adult frogs.

Zones Inhabited By Giant Barred Frogs: Distributed across seven zones including the construction footprint (see Figure 9).

Giant Barred Frog Tadpoles: No tadpoles were recorded using bait traps. Tadpoles were observed in the shallower pools and expected to occur also in the deeper pools.

Summer Testing of Chytrid: Two of the 12 swabbed frogs contained infected zoospores. One of these was a recaptured sub adult frog and another being an adult male from the edge of the construction footprint (see Table 18).

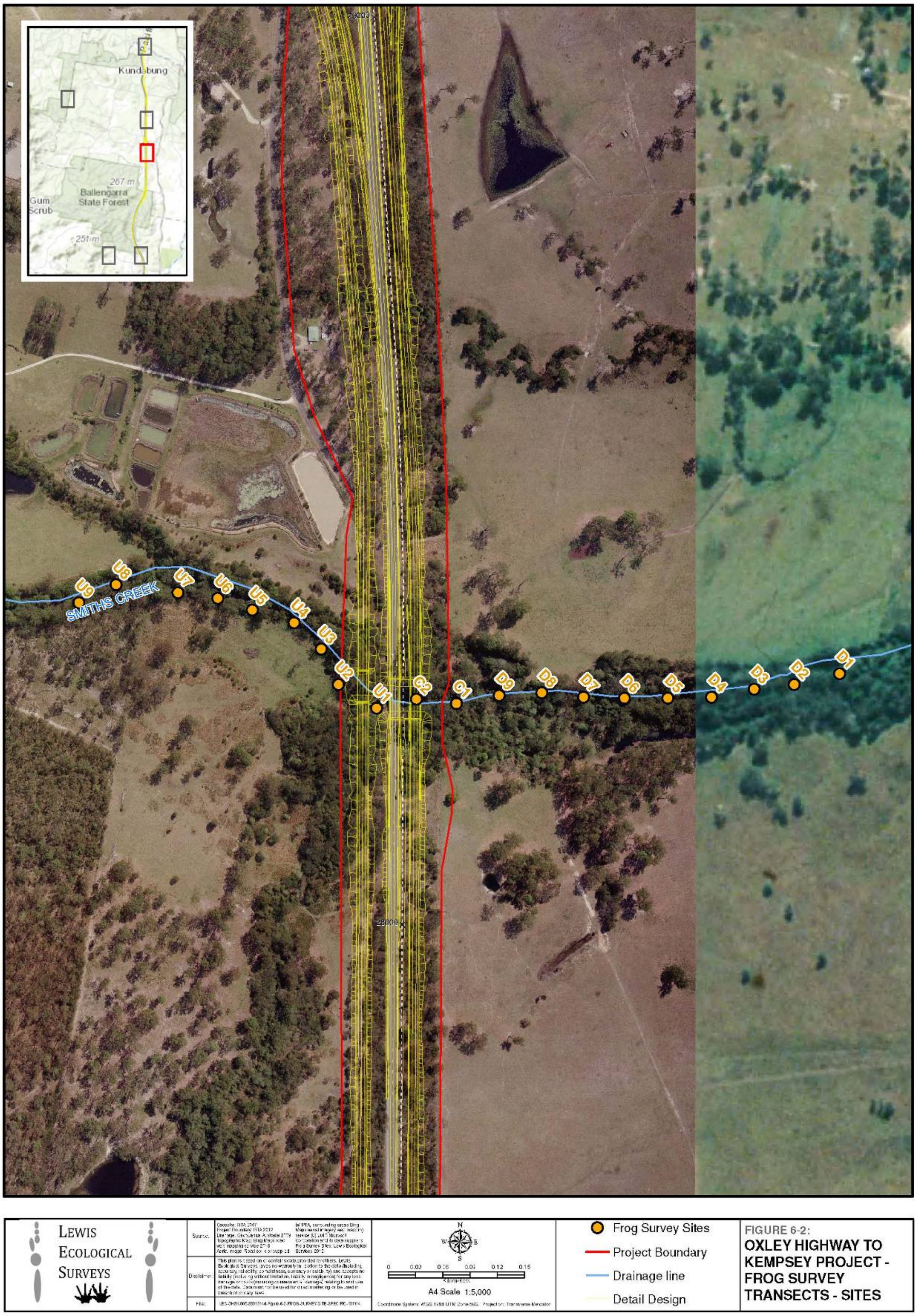

Figure 9 Smiths Creek Frog Survey Sites

Habitat: See Figure 9 for the zones within the Smiths Creek survey area in which the Giant Barred Frogs were identified. In addition, microhabitat within these zones included above and partially buried in leaf litter, sheltering beneath Lomandra, and on dirt, gravel, and logs.

Pipers Creek

Date and Time Taken To Complete The Survey: 18th October between 1958-0048 hours and 28th January between 2045-0220 hours.

Abiotic Conditions: A summary of the prevailing abiotic variables is shown in Table 9 & 10. The spring conditions were described as very dry for the month leading up to this survey until a significant rainfall event of 29 mm was recorded 12 hours prior to the survey. Some light rain fell for up to 3 hours before the survey but then conditions changed with cloud dissipating.

Table 9 Abiotic conditions during the spring survey of Pipers Creek

Date	18.10.2013	Air Temp °C	Water Temp °C	Cloud Cover %	Humidity %	Wind[1]	Rain[2]	Steam Depth (mm)
Start Time	2000	16.6	15	95	79	0	1	
Finish time	0205	11	15	0	100	0	1	
Summary	6 hours 5 minutes	13.8	15.0	47.5	89.5	0.0	1.0	550

Table 10 Abiotic conditions during the summer survey of Pipers Creek

Date	28.1.2014	Air Temp °C	Water Temp °C	Cloud Cover %	Humidity %	Wind[1]	Rain[2]	Steam Depth (mm)
Start Time	2045	25	19	25	70	0	0	
Finish time	0220	23	19	0	90	0	0	
Summary	5 hours 35 minutes	24	19	12.5	80	0	0	210

Number of Giant Barred Frogs Recorded: Spring - Eight Giant Barred Frogs were recorded during the spring survey with three identified as adult males, two females and three sub adults on unknown sex. **Summer** - Nine Giant Barred Frogs were captured with five identified as females, two adult males and two sub adults of unknown sex. Four of the frogs were recaptures from the spring survey.

Population Estimate: All frogs captured during the summer survey would have been present in the population during the spring sampling. This resulted in a population estimate of 15.2 individuals with variance of 2.94. The 95% confidence interval was calculated at 5.76.

Evidence of Breeding Recorded: Yes via the presence of sub adult frogs.

Zones Inhabited By Giant Barred Frogs: Recorded from zones 4 downstream, zone 10 within the construction footprint and zones 12, 13, 15, 17 and 18 upstream (see Figure 10).

Giant Barred Frog Tadpoles: No tadpoles were recorded using bait traps. No tadpoles were recorded dip-netting.

Summer Testing of Chytrid: All of the eight captured frogs showed no sign of being infected with Chytrid (see Table 18).

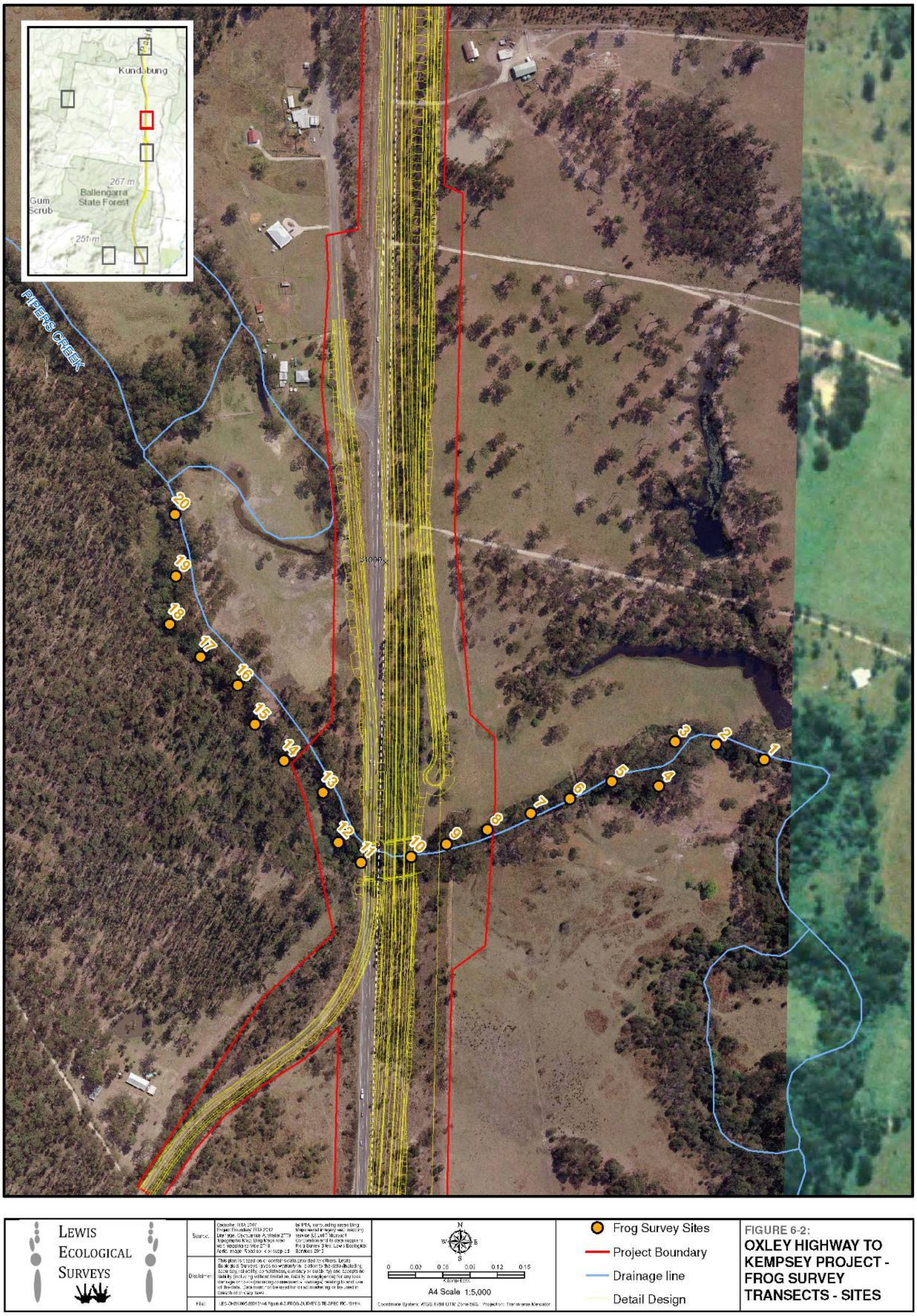

Figure 10 Pipers Creek Frog Survey Sites

Habitat: See Figure 10 for the zones in which the Giant Barred Frogs were identified within the Pipers Creek survey area. In addition, microhabitat within these zones included above and partially buried within leaf litter, and on bare ground.

Maria River

Date and Time Taken To Complete The Survey: The spring survey was undertaken on the 18th September 2013 between 1928-0022 hours and the summer survey on the 31st January between 2055-0315 hours.

Abiotic Conditions: A summary of the prevailing abiotic variables is shown in Table 11 & 12. Following a significant rainfall event at Maria River 16th September conditions were mild with relative low rates of humidity and cool dry air.

Table 11 Abiotic conditions during the spring survey of Maria River

Date	18.9.2013	Air Temp °C	Water Temp °C	Cloud Cover %	Humidity %	Wind[1]	Rain[2]	Steam Depth (mm)
Start Time	1928	16	19.5	0	58	0	1	
Finish time	0022	9.7	17.5	0	90	0	0	
Summary	4 hours 54 minutes	12.9	18.5	0.0	74.0	0.0	0.5	410

Table 12 Abiotic conditions during the summer survey of Maria River

Date	31.1.2014	Air Temp °C	Water Temp °C	Cloud Cover %	Humidity %	Wind[1]	Rain[2]	Steam Depth (mm)
Start Time	2055	23.3	18	0	70	0	0	
Finish time	0315	15.9	18	0	89	0	0	
Summary	6 hours 20 minutes	19.6	18	0	79.5	0	0	290

Number of Giant Barred Frogs Recorded: Spring - Ten (10) Giant Barred Frogs were recorded/captured during the survey. They comprised 6 females with the remainder classified as sub adults although frog with the identifier 0007357806 is likely to be a male nearing maturity (Table 17). **Summer** – Nine Giant Barred Frogs were recorded during the survey comprising three adult males, one female, one sub adult and two juveniles. There were no recaptures.

Population Estimate: There were no recaptures to allow a calculation of population size. Based on the number of captures to date there is at least seven females, three males, five sub adults and two juveniles present along the transect.

Evidence of Breeding Recorded: Yes via the presence of sub adult and juvenile frogs.

Summer Testing of Chytrid: All of the six captured frogs showed no sign of being infected with Chytrid (see Table 18).

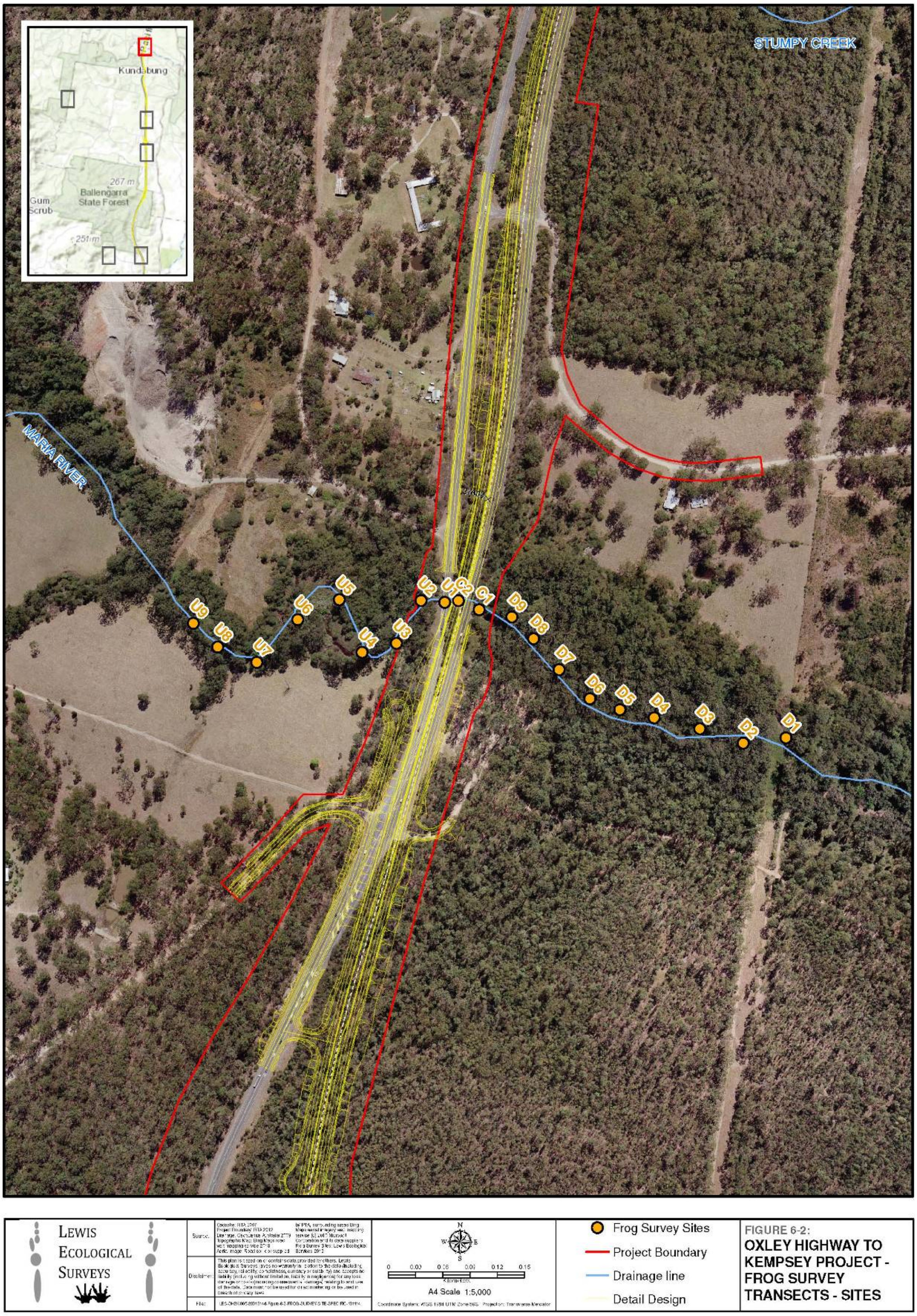

Figure 11 Maria River Frog Survey Sites

Zones Inhabited By Giant Barred Frogs: Distributed across nine zones including zones bordering the construction footprint (see Figure 11).

Giant Barred Frog Tadpoles: No tadpoles were recorded using bait traps. Some follow up dip netting wasn't able to record tadpoles.

Habitat: See Figure 11 for the zones in which the Giant Barred Frogs were identified within the Maria River survey area. In addition, microhabitat within these zones included above and partially buried within leaf litter, the undercut of the bank, sheltering under lantana, under vines and on bare ground.

Reference Sites

Cooperabung Creek

Date and Time Taken To Complete The Survey: The spring survey was undertaken on the 19th October between 1958-0048 hours and the summer survey on the 30th January between 2050-0145 hours.

Abiotic Conditions: A summary of the prevailing abiotic variables is shown in Table 13 & 14. The conditions were described as very dry for the month leading up to this survey until a significant rainfall event of 29 mm was recorded 36 hours prior to the survey. Some light rain fell immediately prior and during the initial stages of the survey.

Table 13 Abiotic conditions during the spring survey of Cooperabung Creek (reference) west of the Upgrade

Date	19.10.2013	Air Temp °C	Water Temp °C	Cloud Cover %	Humidity %	Wind[1]	Rain[2]	Steam Depth (mm)
Start Time	1958	18.3	16	95	82	0	1	
Finish time	0048	14.8	15	0	100	0	1	
Summary	4 hrs 50 minutes	16.6	15.5	47.5	91.0	0.0	1.0	270

Table 14 Abiotic conditions during the summer survey of Cooperabung Creek (reference) west of the Upgrade

Date	30.1.2014	Air Temp °C	Water Temp °C	Cloud Cover %	Humidity %	Wind[1]	Rain[2]	Steam Depth (mm)
Start Time	2050	18.4	21	0	83	0	0	
Finish time	0145	16.8	21	0	91	0	0	
Summary	4 hours 55 minutes	17.6	21	0	87	0	0	190

Number of Giant Barred Frogs Recorded: Spring - Twenty (20) Giant Barred Frogs were recorded during the survey with 17 of these captured for PIT tagging. The three uncaptured frogs were adult males calling in the lower reaches of the transect. Of the captures frogs, seven were males, seven were females and three were sub adults of unknown sex (Table 17). **Summer** – Twenty-one (21) Giant Barred Frogs were recorded with two of these being recaptures from the spring survey. The captured frogs comprised four females, four males, nine sub adults and four juveniles. There were two recaptures from the spring survey.

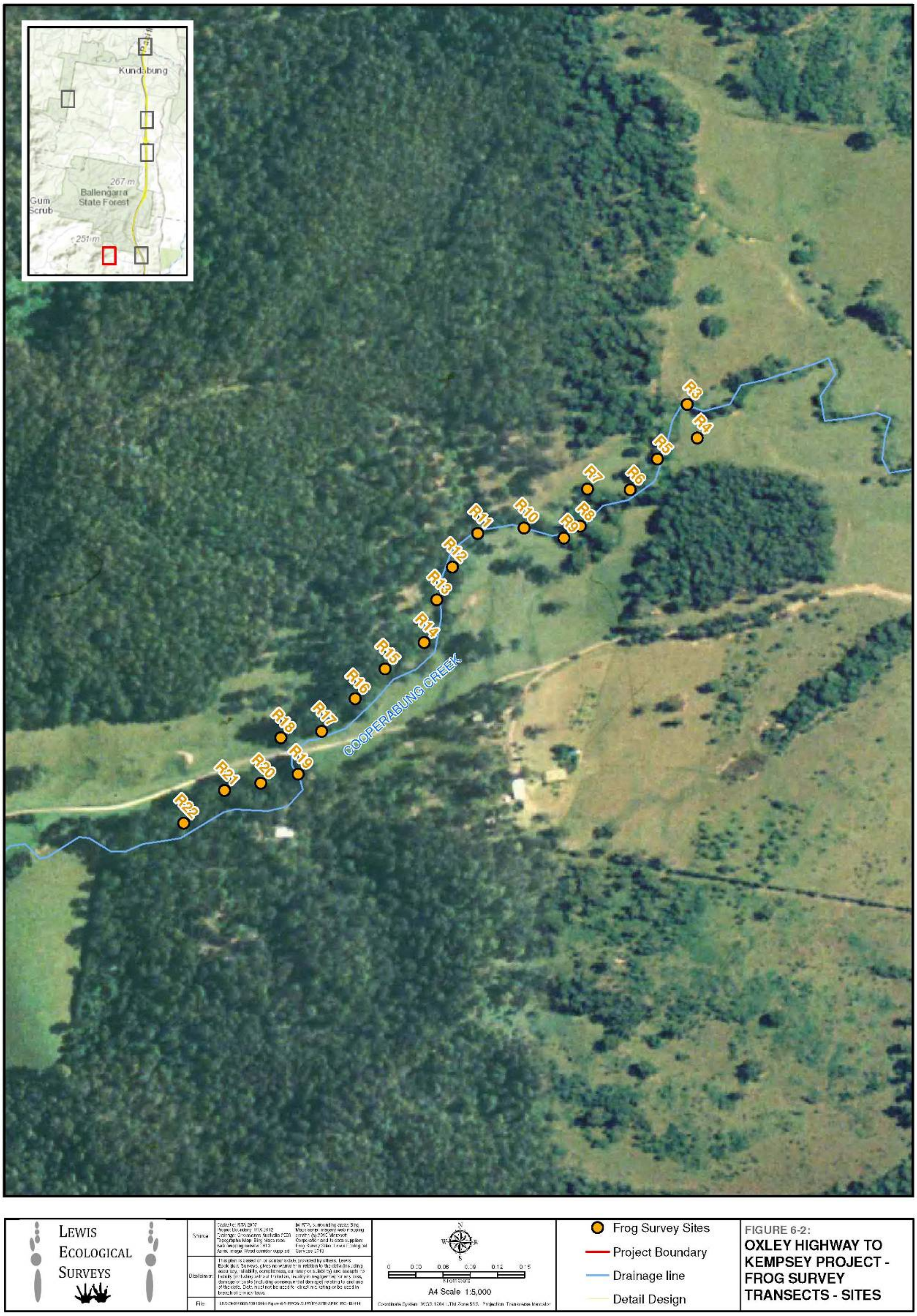

Figure 12 Cooperabung Creek (reference) survey sites

Population Estimate: Five of the 21 frogs captured were removed from the population estimate as they were considered unlikely to be part of the population during the spring sampling. This resulted in a population estimate of 118 individuals with variance of 51.36. The 95% confidence interval was calculated at 100.7.

Evidence of Breeding Recorded: Yes via the presence of sub adult and juvenile frogs.

Zones Inhabited By Giant Barred Frogs: Broadly distributed across 15 zones with some consistent presence in the middle and lower reaches of the transect (see Figure 12).

Giant Barred Frog Tadpoles: No tadpoles were recorded using bait traps. Tadpoles were present in most pools during the spring sampling.

Summer Testing of Chytrid: One of the 10 frogs swabbed for Chytrid returned a positive result across all three tested replications. The infected frog was located at the downstream end of this transect (see Table 18).

Habitat: See Figure 12 for the zones in which the Giant Barred Frogs were identified within the Cooperabung Creek (reference) survey area. In addition, microhabitat within these zones included above and partially buried within leaf litter (some of which included Lomandra shelters), pasture grass, within the undercut of the bank, and on dirt and rock.

Pipers Creek

Date and Time Taken To Complete The Survey: The spring survey was undertaken on the 21st September 2013 between 1837-2245 hours whilst the summer survey was undertaken on the 27th January 2014 between 2045-0250 hours.

Abiotic Conditions: A summary of the prevailing abiotic variables is shown in Table 15 & 16. The conditions were described as mild and becoming more difficult to locate frogs following rainfall earlier in the week.

Table 15 Abiotic conditions during the spring survey of Pipers Creek in Kalantenee National Park.

Date	21.9.2013	Air Temp °C	Water Temp °C	Cloud Cover %	Humidity %	Wind[1]	Rain[2]	Steam Depth (mm)
Start Time	1837 hrs	14.7	15.5	0	70	0	0	
Finish time	2245 hrs	9.5	15	0	84	0	0	
Summary	**4 hours 8 minutes**	**12.1**	**15.3**	**0.0**	**77.0**	**0.0**	**0.0**	**575.0**

Table 16 Abiotic conditions during the summer survey of Pipers Creek in Kalantenee National Park.

Date	27.1.2014	Air Temp °C	Water Temp °C	Cloud Cover %	Humidity %	Wind[1]	Rain[2]	Steam Depth (mm)
Start Time	2045	24.7	20	100	78	0	0	
Finish time	0250	19.0	20	0	85	0	0	
Summary	**6 hours 5 minutes**	**21.9**	**20**	**50**	**81.5**	**0**	**0**	**170.0**

Number of Giant Barred Frogs Recorded: Spring - Ten (10) Giant Barred Frogs were recorded/captured during the survey. They comprised 1 sub adult frog of unknown sex, four males and 5 adult females (Table 17). **Summer** – Thirteen (13) Giant Barred Frogs comprising eight adult males and five adult females. There were no recaptures.

Population Estimate: There were no recaptures to allow a calculation of population size. Based on the captured data for the spring and summer survey there is at least 10 males, 10 females and the sub adult frog is unlikely to have grown into an adult at the time of the summer survey.

Evidence of Breeding Recorded: Yes via the presence of one sub adult frog.

Zones Inhabited By Giant Barred Frogs: Distributed across 10 zones 5,6,7,8, 9,10,13,15, 16 and 19 (see Figure 13).

Giant Barred Frog Tadpoles: No tadpoles were recorded using bait traps.

Summer Testing of Chytrid: None of the 10 frogs swabbed for Chytrid returned a positive result (see Table 18).

Habitat: See Figure 13 for the zones in which the Giant Barred Frogs were identified within the Pipers Creek (reference) survey area. In addition, microhabitat within these zones included above, partially buried and completely buried within leaf litter, sheltering under Lomandra, and within holes in the bank.

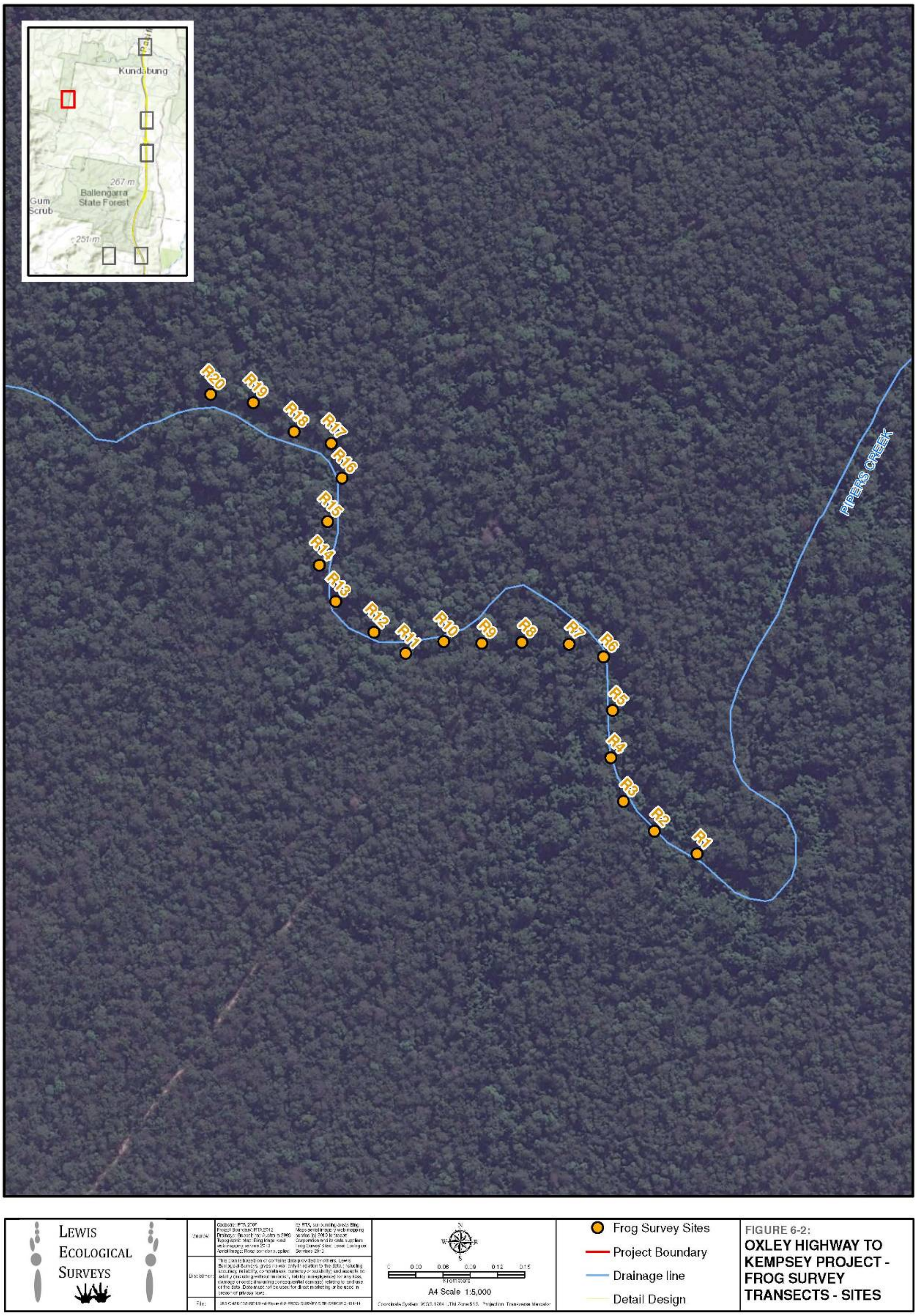

Figure 13 Pipers Creek (reference) survey sites

Discussion

All six of the monitoring sites show that a successful breeding event occurred in the past 2012/13 summer. Male frogs were noticeably absent from Smiths Creek and Cooperabung Creek but this is believed to be a result of the one off survey rather than an imbalance in the population structure. For example, surveys around 300 m downstream of the Cooperabung transect during the development of the Giant barred Frog management strategy recorded 4 males over a 500 m transect.

Table 17 Summary of Giant Barred Frog captures for the spirng and summer ecological monitoring

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
Impact Sites													
Cooperabung Creek													
Spring Sample													
1	Male	Sub Adult	Immature	52.4	17.5	000735C1E9	11	North Bank	1.5	First time capture	Observed	Using flood debris as overhang shelter on dirt	Yellowing throat indicating likely to be a male frog once it matures
2	Male	Sub Adult	Immature	54.1	19.75	000735A97E	12	South Bank	2.1	First time capture	Observed	Above litter	Yellowing throat indicating likely to be a male frog once it matures
3	Female	Adult	Not Gravid	95.6	143.0	000735B40B	13	South Bank	3.7	First time capture	Observed	Above litter	
Summer Sample													
1	Unknown	Juvenile	Immature	38.2	8.25	000735B812	11	North Bank	3.2	First time capture	Observed	Above litter	Swabbed
2	Male	Adult	No Colour	77.7	58.25	0007352F47	12	South Bank	7.3	First time capture	Observed	Above litter	Swabbed
3	Female	Adult	Not Gravid	91.0	118.0	000735830E	18	North Bank	6.8	First time capture	Observed	On Grass	Swabbed

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
4	Male	Adult	Dark Nuptial	69.7	44.0	0007352816	18	North Bank	5.5	First time capture	Observed	Above litter	Swabbed
5	Male	Adult	Dark Nuptial	68.1	38.25	0007359A50	18	North Bank	2.3	First time capture	Observed	Using flood debris	Swabbed
6	Unknown	Juvenile	Immature	32.5	5.25	0007359E3E	15	South Bank	1.6	First time capture	Observed	Above litter	Swabbed
7	Male	Adult	Moderate Nuptial	73.7	56.0	0007358413	15	South Bank	3.5	First time capture	Observed	Above litter	Swabbed
8	Male	Adult	Light Nuptial	64.7	33.75	0007359026	12	South Bank	3.8	First time capture	Observed	Above litter	Swabbed
9	Unknown	Juvenile	Immature	40.2	10.0	0007357F41	10	North Bank	1.0	First time capture	Observed	On Grass	Swabbed
Smiths Creek													
Spring Sample													
1	Unknown	Sub Adult	Immature	39.6	9.5	000735797B	C1	North Bank	1.5	First time capture	Observed	Above Litter	
2	Unknown	Sub Adult	Immature	40.5	10.5	000735A06F	D5	North Bank	1.0	First time capture	Observed	Above Litter	
3	Unknown	Sub Adult	Immature	46.0	10.75	000735C27C	D6	North Bank	1.0	First time capture	Observed	Above Litter	Yellowing underbody indicative of a young male frog

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
4	Male	Adult	Light Nuptial	74.1	63	0007357455	U6	North Bank	3.5	First time capture	Observed	Partially Buried	
5	Unknown	Sub Adult	Immature	45.1	13.75	000735C206	U6	North Bank	1.5	First time capture	Observed	Above Litter	
6	Unknown	Sub Adult	Immature	41.5	9	00073546CD	U7	North Bank	4.0	First time capture	Observed	Above Litter	
7	Female	Adult	Not Gravid	117.5	190	00073587DF	U6	North Bank	4.0	First time capture	Observed	Sheltering beneath Lomandra	
8	Unknown	Sub Adult	Immature	46.2	12	00073564F9	U9	North Bank	3.0	First time capture	Observed	Above Litter	
9	Female	Adult	Not Gravid	96.0	149	000735AC9F	U9	North Bank	4.5	First time capture	Observed	Sheltering beneath Lomandra	
10	Unknown	Sub Adult	Immature	45.8	11.75	000735B72A	U8	North Bank	1.0	First time capture	Observed	On Dirt	
Summer Sample													
1	Unknown	Sub Adult	Immature	55.5	19.75	0007354559	C1	South Bank	8.0	First time capture	Observed	Above Litter	Probably a male frog. Swabbed
2	Male	Adult	No Colour	66.7	33.25	000735B6F8	D6	South Bank	7.5	First time capture	Observed	Above Litter	Swabbed
3	Unknown	Sub Adult	Immature	41.5	9.25	0007356DEB	D5	South Bank	2.3	First time capture	Observed	Above Litter	Swabbed

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
4	Unknown	Sub Adult	Immature	58.2	27.25	0007353FA9	D2	North Bank	4.1	First time capture	Observed	Above Litter	Probably a male frog. Swabbed
5	Unknown	Juvenile	Immature	36.9	7.75	000735B8C9	D5	North Bank	3.0	First time capture	Observed	Above Litter	Swabbed
6	Unknown	Juvenile	Immature	36.0	6.75	000735A09D	D5	North Bank	3.3	First time capture	Observed	Above Litter	Swabbed
7	Male	Adult	Moderate Colour	70.2	44.75	0007358B84	U1	North Bank	3.2	First time capture	Observed	On Log	Swabbed
8	Unknown	Sub Adult	Immature	45.3	12.75	000735C7EC	U3	North Bank	4.4	First time capture	Observed	Above Litter	Swabbed
9	Male	Adult	No Colour	59.6	26.5	0007357443	U5	North Bank	4.0	First time capture	Observed	Partially buried under litter	Swabbed
10	Unknown	Sub Adult	Immature	46.7	12	0007355C06	U5	North Bank	8.5	First time capture	Observed	Above Litter	Swabbed
11	Unknown	Sub Adult	Immature	56.2	23.75	000735C206	U6	North Bank	9.3	Remained in same zone and same side of creek as spring	Observed	Above Litter	Swabbed
12	Unknown	Sub Adult	Immature	49.0	15.5	000735CB5C	U7	North Bank	1.3	First time capture	Observed	On Gravel	Swabbed

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
13	Male	Adult	Moderate Colour	64.6	39.0	000735C3ED	U8	North Bank	6.2	First time capture	Observed	Above Litter	
14	Unknown	Sub Adult	Immature	43.9	12.0	0007357690	U8	North Bank	2.3	First time capture	Observed	Above Litter	
15	Unknown	Sub Adult	Immature	55.4	18.75	00073564F9	U9	North Bank	3.8	Remained in same zone and same side of creek as spring	Observed	Above Litter	
16	Female	Adult	Gravid	98.7	165.0	00073542D7	U9	South Bank	7.5	First time capture	Observed	Above Litter	
Pipers Creek													
Spring Sample													
1	Unknown	Sub Adult	Immature	48.2	16.0	000735C107	4	South bank	3.9	First time capture	Observed	Above litter	
2	Unknown	Sub Adult	Immature	56.0	21.5	000735B231	4	North Bank	2.7	First time capture	Observed	Above litter	
3	Unknown	Sub Adult	Immature	53.5	19.0	0007356DF2	4	North Bank	2.9	First time capture	Observed	Above litter	
4	Male	Adult	Dark Nuptials	83.9	86.0	000735BFCC	18	South bank	5.8	First time capture	Observed	Above litter	

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
5	Male	Adult	Light Nuptials	81.0	82.5	000735BCBE	18	South bank	7.3	First time capture	Observed	Above litter	
6	Male	Adult	No Colour	66.0	36.5	0007353695	18	South bank	8.4	First time capture	Observed	Above litter	Some yellowing spots not recorded at other locations. This frog deemed very light very its size and possible unhealthy or feeling the effects of a long dry spring
7	Male	Adult	Moderate Nuptials	75.6	56.0	0007358A4C	17	South bank	5.2	First time capture	Observed	Above litter	Some yellowing spots not recorded at other locations
8	Female	Adult	Not Gravid	66.6	41.0	0007358DDC	17	South bank	6.2	First time capture	Observed	Above litter	Some yellowing spots not recorded at other locations
Summer Sample													
1	Female	Adult	Not Gravid	63.8	31.0	000735B231	4	North Bank	5.0	Remained in same zone and same side of creek but 2.3 m further from water	Observed	Partially buried under litter	Swabbed
2	Unknown	Sub Adult	Immature	58.9	28.0	000735C107	4	Centre Island	2.7	Remained in same zone and same side of creek	Observed	Above litter	Swabbed

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
3	Female	Adult	Not Gravid	64.1	38.0	0007356DF2	4	North Bank	5.0	Remained in same zone and same side of creek	Observed	Above litter	Swabbed
4	Male	Adult	Moderate Nuptials	63.6	32.0	000735BA08	10	North Bank	2.3	First time capture	Observed	Above Litter	Swabbed
5	Unknown	Sub Adult	Immature	53.0	18.0	00073585C3	12	South Bank	2.1	First time capture	Observed	On Bare Ground	Swabbed
6	Female	Adult	Gravid	99.9	181.0	0007354BC4	13	North Bank	1.0	First time capture	Observed	Above Litter	Swabbed
7	Female	Adult	Gravid	94.3	132.0	0007359B0F	15	South Bank	6.0	First time capture	Observed	Above Litter	Swabbed
8	Female	Adult	Not Gravid	78.8	64.0	0007358DDC	17	South Bank	2.3	Same zone and side of creek but closer to water	Observed	Partially buried under litter	Swabbed
Maria River													
Spring													
1	Unknown	Sub Adult	Immature	49.2	19.75	00073531A8	U9	North Bank	3.5	First time capture	Observed	Above Litter	
2	Female	Adult	Not Gravid	96.6	145	000735B70C	U1	North Bank	3	First time	Observed	Above Litter	

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
										capture			
3	Female	Adult (young)	Not Gravid	77.8	67.5	00073579A3	U1	North Bank	3.2	First time capture	Observed	Using Undercut of Bank	
4	Sub Adult	Sub Adult	Immature	57.8	28.5	0007357806	U1	North Bank	3.7	First time capture	Observed	Sheltering beneath lantana	Predict this will be a male frog once it matures
5	Female	Adult	Not Gravid	99.2	148	0007357A85	U1	South Bank	2.6	First time capture	Observed	Part Buried Under Litter	
6	Female	Adult	Not Gravid	85.6	83	000735974B	D8	South Bank	7.8	First time capture	Observed	Above Litter	
7	Male	Sub Adult	No Colour	59.9	30	0007356F68	D6	North Bank	2.4	First time capture	Observed	Above Litter	
8	Female	Adult	Not Gravid	90.4	103	000735BEBE	D5	North Bank	13.3	First time capture	Observed	Above Litter	
9	Male	Sub Adult	No Colour	59.9	27	00073531B0	D5	South Bank	1.8	First time capture	Observed	Under Vines	
10	Female	Adult	Not Gravid	99.8	147	000735508E	D4	South Bank	1.9	First time capture	Observed	Above Litter	
Summer													
1	Male	Adult	Light Nuptials	64.6	38.0	000735B2F4	U1	North Bank	2.0	First time capture	Observed	Above Litter	Swabbed

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
2	Unknown	Juvenile	Immature	38.2	8.5	000735BE05	U1	North Bank	0.8	First time capture	Observed	Above Litter	Swabbed
3	Unknown	Sub Adult	Immature	49.4	13.0	0007359976	U1	North bank	1.5	First time capture	Observed	Above Litter	Swabbed
4	Male	Adult	No data	No data	No data	No data	D3	No data	No data	No data	Calling	Under Litter	Could not be captured
5	Female	Adult	Not Gravid	94.4	158.0	000735D09C	U2	South Bank	3.0	First time capture	Observed	On Dirt	Swabbed
6	Unknown	Juvenile	Immature	37.4	11.0	000735AEE9	U8	North Bank	0.3	First time capture	Observed	On dirt using hole in bank	Swabbed
7	Male	Adult	Light Nuptials	75.8	70.0	000735B020	U9	North Bank	3.0	First time capture	Observed	Part buried under litter	Swabbed
8	Unknown	Juvenile	Immature	No data	No data	No data	D8	North Bank	No Data	No Data	Observed	Above Litter	Could not be captured
9	Unknown	Juvenile	Immature	No data	No data	No data	D8	South Bank	No Data	No Data	Observed	Above Litter	Could not be captured
Reference Sites													
Cooperabung Creek													
Spring													
1	Male	Adult	Dark Nuptial	70.8	50.5	000735C3DB	15	North Bank	3.1	First time capture	Call response	Above Litter	

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
2	Male	Adult	Light Nuptial	74.4	64	0007359C3A	15	North Bank	4.1	First time capture	Observed	Above Litter	
3	Male	Adult	Light Nuptial	71.9	63.5	00073588FF	14	North Bank	1.9	First time capture	Observed	Above Litter	
4	Unknown	Sub Adult	Immature	50.3	21.5	0007356F32	14	North Bank	2.1	First time capture	Observed	Above Litter	
5	Female	Adult	Not Gravid	110.6	142.5	00073576C7	13	North Bank	8.5	First time capture	Observed	Above Litter	
6	Unknown	Sub Adult	Immature	44.9	13.5	00073599EE	11	South bank	2.6	First time capture	Observed	On Pasture Grass	
7	Male	Adult	Moderate Nuptial	71.2	61.5	000735A504	10	South bank	1.2	First time capture	Call response	Above Litter	
8	Female	Adult	Not Gravid	97.0	132.5	000735613C	9	North Bank	2.8	First time capture	Observed	Above Litter	
9	Female	Adult	Not Gravid	96.6	141	0007359F76	5	South bank	1.3	First time capture	Observed	Above Litter	
10	Female	Adult	Not Gravid	97.7	124	00073546F4	9	South bank	7.2	First time capture	Observed	On Pasture Grass	
11	Female	Adult	Not Gravid	94.0	132	0007353E49	17	North Bank	5.9	First time capture	Observed	Above Litter	
12	Unknown	Sub Adult	Immature	54.9	25.5	0007359659	17	North Bank	0.9	First time	Observed	Above Litter	

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
										capture			
13	Female	Adult	Part Gravid	97.2	147	00073530F3	18	North Bank	3.3	First time capture	Observed	Above Litter	
14	Male	Sub Adult	Immature	57.9	28.5	0007359D56	20	South bank	3.1	First time capture	Observed	Above Litter	Yellow underbody indicating probably a young sub adult male
15	Female	Adult	Part Gravid	98.0	172	000735ADC9	20	South bank	2.4	First time capture	Observed	Above Litter	
16	Male	Sub Adult	Immature	58.3	28.5	0007353F6E	22	North Bank	5.7	First time capture	Observed	Above Litter	
17	Male	Sub Adult	Immature	53.7	22.5	0007358D13	19	South bank	3.2	First time capture	Observed	Above Litter	Yellow underbody indicating probably a young sub adult male
Summer													
1	Unknown	Sub adult	Immature	44.9	13.5	0007357B14	16	South Bank	0.5	First time capture	Observed	Above Litter using Lomandra shelter Site	Swabbed
2	Female	Adult	Not Gravid	91.7	130.0	0007359D67	15	North Bank	1.0	First time capture	Observed	Partially Buried Under Litter	Swabbed
3	Unknown	Juvenile	Immature	40.1	10.0	0007357BBC	15	North Bank	0.3	First time capture	Observed	Above Litter	Swabbed
4	Male	Adult	Light Nuptials	73.6	61.0	000735C59A	15	South Bank	0.7	First time capture	Observed	On Dirt	Swabbed

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
5	Male	Adult	Light Nuptials	75.5	62.0	0007359C3A	15	South Bank	1.1	Same zone but changed side of creek and closer to water	Observed	On Rock	Swabbed
6	Unknown	Sub adult	Immature	45.0	13.5	0007352C3A	14	North Bank	0	First time capture	Observed	Above Litter at Waters Edge	Swabbed
7	Unknown	Sub adult	Immature	45.0	14.0	0007359E7B	11	North Bank	0.3	First time capture	Observed	Using Bank Undercut	
8	Unknown	Sub adult	Immature	45.6	14.5	000735A74D	8	North Bank	2.6	First time capture	Observed	On Grass	
9	Unknown	Juvenile	Immature	37.3	9.0	000735A4D1	8	North Bank	2.9	First time capture	Observed	On Grass	
10	Female	Adult	Not Gravid	95.7	123.0	0007359F76	7	South Bank	4.2	Moved 2 zones upstream	Observed	On Grass	Swabbed
11	Male	Adult	Dark Nuptials	74.1	57.5	00073535CD	7	South Bank	3.6	First time capture	Observed	On Grass	Swabbed
12	Unknown	Sub Adult	Immature	48.5	17.0	0007359D2A	5	South Bank	1.4	First time capture	Observed	Above Litter	
13	Female	Adult	Not Gravid	78.7	68.0	00073563EA	3	South Bank	1.4	First time capture	Observed	Partially Buried Under Litter	Swabbed

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
14	Male	Adult	Moderate Nuptials	65.9	40.25	000735B0E5	3	North Bank	5.0	First time capture	Observed	On Grass	Swabbed
15	Female	Adult	Not Gravid	68.7	38.75	000735C733	3	South Bank	0.8	First time capture	Observed	Using Bank Undercut	
16	Unknown	Sub Adult	Immature	47.5	18.0	000735C584	15	South Bank	1.9	First time capture	Observed	Above Litter	
17	Unknown	Sub Adult	Immature	41.7	12.5	000735BD28	17	South Bank	1.2	First time capture	Observed	On Grass	
18	Unknown	Juvenile	Immature	39.7	10.0	000735B42E	19	North Bank	2.7	First time capture	Observed	Above Litter	
19	Unknown	Sub Adult	Immature	43.5	13.0	000735A858	19	North Bank	3.0	First time capture	Observed	Above Litter	
20	Unknown	Juvenile	Immature	39.5	11.25	0007354212	22	North Bank	2.4	First time capture	Observed	Above Litter	
21	Unknown	Sub Adult	Immature	40.6	11.25	000735546E	22	South Bank	0.7	First time capture	Observed	Above Litter	
Pipers Creek (Boonie Corner Road)													
Spring													
1	Female	Adult	Not Gravid	93	130	000735AE22	16	North bank	1.1	First time	Observed	Partially buried	

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
										capture		under litter @ 1910 hrs	
2	male	Adult	Medium Nuptials	77.8	60	0007359C08	16	North bank	1.4	First time capture	Observed	Partially buried under litter/moss	
3	male	Adult	Light Nuptials	67.6	39	0007359F7C	19	North bank	2	First time capture	Observed	Shelter beneath Lomandra fronds	
4	Unknown	Sub Adult	Immature	44	13.5	0007352736	9	North bank	2.1	First time capture	Observed	Partially buried under litter	Yellowing underbody indicative of a young male
5	Female	Adult	Not Gravid	89.2	98	0007358076	7	North bank	3.3	First time capture	Observed	Above litter	Missing right hand - photographed
6	male	Adult	Dark Nuptials	77.8	68	0007355C05	7	North bank	1.1	First time capture	Observed	Under litter	Just eye of frog protruding
7	Female	Adult	Not Gravid	97.6	148	0007355ED1	7	Southbank	2.1	First time capture	Observed	Partially buried under litter	
8	male	Adult	Dark Nuptials	78.1	57	00073581E2	6	Southbank	0.9	First time capture	Observed	Above litter	
9	Female	Adult	Not Gravid	113.1	153	0007354E33	5	Southbank	2.1	First time capture	Observed	Above litter	
10	Female	Adult	Not Gravid	91.2	117	00073525A5	7	North bank	1.1	First time capture	Observed	Partially buried under litter and Lomandra	

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
Summer													
1	Male	Adult	Dark Nuptials	64.9	37.0	000735C44D	7	South Bank	4.0	First time capture	Observed	Partially Buried Under Litter	Swabbed
2	Male	Adult	Moderate Nuptials	72.8	57.0	0007355572	6	North Bank	2.5	First time capture	Observed	Partially Buried Under Litter	Swabbed
3	Female	Adult	Not Gravid	61.7	27.0	0007352335	6	South Bank	0.5	First time capture	Observed	Above Litter	Swabbed
4	Female	Adult	Not Gravid	66.1	41.0	00073593EC	6	South Bank	4.0	First time capture	Observed	Above Litter	Swabbed
5	Male	Adult	Moderate Nuptials	76.1	74.0	00073555B9	8	North Bank	1.5	First time capture	Observed	Partially Buried Under Litter	Swabbed
6	Male	Adult	Moderate Nuptials	74.1	55.0	0007357086	9	North Bank	2.0	First time capture	Observed	Partially Buried Under Litter	Swabbed
7	Female	Adult	Gravid	98.6	178.0	00073573F1	10	North Bank	1.5	First time capture	Observed	Using hole in bank	Swabbed
8	Male	Adult	Moderate Nuptials	76.0	68.0	00073529AE	13	South Bank	1.0	First time capture	Observed	Partially Buried Under Litter	Swabbed
9	Male	Adult	Dark Nuptials	73.7	52.0	000735CA5F	15	South Bank	2.5	First time capture	Observed	Above Litter	Swabbed
10	Female	Adult	Gravid	96.0	165.0	0007356674	19	South Bank	3.6	First time capture	Observed	Above Litter	Swabbed

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
11	Female	Adult	Gravid	94.6	141.0	0007356F20	19	South Bank	5.0	First time capture	Observed	Above Litter	Swabbed
12	Male	Adult	No Data	No Data	No Data	No Data	6	No Data	No Data	No Data	Call Response	No Data	Frog could not be captured
13	Male	Adult	No Data	No Data	No Data	No Data	18	No Data	No Data	No Data	Call Response	No Data	Frog could not be captured

Table 18 Results of the chytrid testing

Date	Species	Animal number	Location	Sex	Rep 1	Rep 2	Rep 3	Mean calculated concentration	Chytrid Outcome Based on Newcastle University - James Garnham
26/01/2014	*Mixophyes iteratus*	0735830E	Cooperabung Creek	Female	0	0	0	0	No
26/01/2014	*Mixophyes iteratus*	07359E3E	Cooperabung Creek	Juvenile	0	0	0	0	No
26/01/2014	*Mixophyes iteratus*	07359A50	Cooperabung Creek	Male	0	0	0	0	No
26/01/2014	*Mixophyes iteratus*	07352F47	Cooperabung Creek	Male	0	0	0	0	No
26/01/2014	*Mixophyes iteratus*	07358413	Cooperabung Creek	Male	0	0	0	0	No
26/01/2014	*Mixophyes iteratus*	07359026	Cooperabung Creek	Male	0	0	0	0	No
26/01/2014	*Mixophyes iteratus*	07352816	Cooperabung Creek	Male	0	0	0	0	No
26/01/2014	*Mixophyes iteratus*	07357F41	Cooperabung Creek	Juvenile	0	0	0	0	No
26/01/2014	*Mixophyes iteratus*	0735B812	Cooperabung Creek	Juvenile	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	07356F20	Pipers Creek Reference/Control	Female	0	0	0	0	No

27/01/2014	*Mixophyes iteratus*	073593EC	Pipers Creek Reference/Control	Female	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	07356674	Pipers Creek Reference/Control	Female	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	073573F1	Pipers Creek Reference/Control	Female	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	073529AE	Pipers Creek Reference/Control	Male	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	07357086	Pipers Creek Reference/Control	Male	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	0735CA5F	Pipers Creek Reference/Control	Male	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	07355572	Pipers Creek Reference/Control	Male	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	073555B9	Pipers Creek Reference/Control	Male	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	07352335	Pipers Creek Reference/Control	Female	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	07359B0F	Pipers Creek	Female	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	0736DF2	Pipers Creek	Female	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	07358DDC	Pipers Creek	Female	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	0735B231	Pipers Creek	Female	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	07354BC4	Pipers Creek	Female	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	0735BA08	Pipers Creek	Male	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	073585C3	Pipers Creek	Sub Adult	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	0735C107	Pipers Creek	Sub Adult	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	07356DEB	Smiths Creek	Juvenile	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	0735A09D	Smiths Creek	Juvenile	0	0	0	0	No

28/01/2014	*Mixophyes iteratus*	0735B8C9	Smiths Creek	Juvenile	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	07358B84	Smiths Creek	Male	1.866	0	0.9	0	Yes
28/01/2014	*Mixophyes iteratus*	07353FA9	Smiths Creek	Male	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	0735C7EC	Smiths Creek	Sub Adult	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	0735CB5C	Smiths Creek	Sub Adult	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	07355C06	Smiths Creek	Sub Adult	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	0735C206	Smiths Creek	Sub Adult	0.052	0	0	0	Yes
28/01/2014	*Mixophyes iteratus*	07354559	Smiths Creek	Sub Adult	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	07357443	Smiths Creek	Male	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	0735B6F8	Smiths Creek	Male	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	0735C44D	Pipers Creek Reference/Control	Male	0	0	0	0	No
30/01/2014	*Mixophyes iteratus*	073563EA	Cooperabung Creek Reference/Control	Female	0	0	0	0	No
30/01/2014	*Mixophyes iteratus*	07359D67	Cooperabung Creek Reference/Control	Female	0	0	0	0	No
30/01/2014	*Mixophyes iteratus*	07359F76	Cooperabung Creek Reference/Control	Female	0	0	0	0	No
30/01/2014	*Mixophyes iteratus*	07357BBC	Cooperabung Creek Reference/Control	Juvenile	0	0	0	0	No
30/01/2014	*Mixophyes iteratus*	07359C3A	Cooperabung Creek Reference/Control	Male	0	0	0	0	No
30/01/2014	*Mixophyes iteratus*	0735535CD	Cooperabung Creek Reference/Control	Male	0	0	0	0	No
30/01/2014	*Mixophyes iteratus*	0735B0E5	Cooperabung Creek Reference/Control	Male	5.029	10.689	6.455	7.027	Yes
30/01/2014	*Mixophyes iteratus*	07357B14	Cooperabung Creek Reference/Control	Sub Adult	0	0	0	0	No

30/01/2014	*Mixophyes iteratus*	07352C3A	Cooperabung Creek Reference/Control	Sub Adult	0	0	0	0	No
30/01/2014	*Mixophyes iteratus*	0735C59A	Cooperabung Creek Reference/Control	Male	0	0	0	0	No
31/01/2014	*Mixophyes iteratus*	0735D09C	Maria River	Female	0	0	0	0	No
31/01/2014	*Mixophyes iteratus*	0735AEE9	Maria River	Juvenile	0	0	0	0	No
31/01/2014	*Mixophyes iteratus*	0735BE05	Maria River	Juvenile	0	0	0	0	No
31/01/2014	*Mixophyes iteratus*	0735B2F4	Maria River	Male	0	0	0	0	No
31/01/2014	*Mixophyes iteratus*	0735B020	Maria River	Male	0	0	0	0	No
31/01/2014	*Mixophyes iteratus*	07359976	Maria River	Sub Adult	0	0	0	0	No

Appendix B CV of Suitably Qualified Expert

Name	Ben Dean Lewis
DOB	13th July 1975
Business Registration Details	Lewis Ecological Surveys U9629936
ABN/ACN	ABN: 84 166 970 378 ACN: 166 970 378
GST	GST Registered
Business Address	(1) 1877 Wallanbah Road Bucca Wauka NSW 2429
Mailing Address	As Above
Phone/Fax	0265591761
Mobile	0413019279
Email	ben@lewisecological.com.au and lewisecological@yahoo.com.au
Qualifications (summary)	Higher School Certificate (1992) Bachelor of Applied Science (Honours) 1994-1997
Summary	Ben Lewis is a senior ecologist with more than 17 years full time professional experience in the fields of ecology and natural resource management. He has considerable experience assisting developing outcomes to meet project specific Conditions of Approval in relation to managing and monitoring impacts on biodiversity for large scale infrastructure projects. This includes extensive experience in the design and implementation of threatened species survey and monitoring programs, management plans and construction strategies. Key examples include: • Design and implementation of the Kempsey Bypass Ecological Monitoring Program (2010-2013); • Design of the Frederickton to Eungai Ecological Monitoring Program and early works Project ecologist for the RMS (2011-2014) • Design and implementation of the Tugun Bypass Integrated Long-nosed Potoroo Plan of Management (2003-2015) • Biodiversity benchmarking surveys for mammals across the Murrumbidgee Irrigation Area (2004-2005) • Development of several nest box plans of management for the Pacific Highway Upgrades • Design and early works procedures for micro bat management plans for the removal of bridges and culverts on several highway upgrades • Developing BACI design monitoring systems for both state and nationally listed threatened species on sections of the Pacific Highway Upgrades • Biodiversity Offsetting Strategies for several highway projects. Ben has performed hundreds of surveys over the past 17 years with many tens of these targeting commonwealth listed species including but not limited to the Giant Barred Frog, Koala and Spotted-tailed Quoll. Whilst his research back ground is in the fields of frogs and avifauna he has performed numerous surveys on other vertebrates and considered to have a broad area of expertise on terrestrial vertebrate fauna. In this capacity, he has attended several recovery planning workshops, been involved in predicted habitat monitoring programs for the EPA and been appointed by the judicial system as a court appointed expert on occasions. A chronological project list has been provided to demonstrate this experience.
Relevant Qualifications	Class C Drivers License (No: 07503313) Category AB Shooters License (No: 404682597) Unrestricted Boat License Open Water Scuba Certificate (PADI) Rail Safety Awareness (NSW) QLD Generic Coal Surface Induction Anglo Coal Callide Induction Collinsville Contractor Induction & Driver Competency Valid Coal Board Medical Rio Tinto Contractor Induction (TCC0002432) Consolidated Rutile Limited Contractor Induction Chainsaw Operators Ticket (C10260) Working at Heights Training (5497)
Consulting Skills	• Undertaken extensive surveys (>300) for vertebrate fauna throughout temperate, arid and sub tropical eastern Australia. • Conducted specialist surveys for many species listed on NSW TSC Act (1995), Queensland NCR (2006), EPBC Act (1999) and ICUN. • Expertise in fauna identification, research and survey design. • Work as both team member and leader during field surveys. • Reporting at senior and junior levels for consulting and scientific publications. • Fully licensed and insured to industry standards. • Own all survey equipment and experienced in the use of specialist techniques including mist netting, radio telemetry and electro fishing.
Relevant Employment History	• Demonstrator for Resource Assessment Techniques II and Biology at Southern Cross University 1997-1999 • Technical position (casual) with Australian Museum specialising in frogs 2001-2003

Name Consulting History as the principal or sub consultant	Ben Dean Lewis
2014	• Development of the BACI survey design program and implementation of baseline surveys for the Wallum Sedge Frog for the Woolgoolga to Ballina Pacific Highway Upgrade Project. • Development of the BACI survey design program and implementation of baseline surveys for the Giant Barred Frog for the Woolgoolga to Ballina Pacific Highway Upgrade Project. • Development of the BACI survey design program and implementation of baseline monitoring surveys for the Brush-tailed Phascogale on the Woolgoolga to Ballina Pacific highway Upgrade. • Development of the BACI survey design program and implementation of baseline monitoring surveys for the Rufous Bettong on the Woolgoolga to Ballina Pacific highway Upgrade. • Implementation of seasonal survey requirements for the Oxley Highway to Kempsey Pacific Highway Upgrade Ecological monitoring Program. • Implementation of Year 5 Long-nosed Potoroo long term monitoring program for the tugun Bypass Project in accordance with commonwealth approval conditions.
2013	• Targeted weed surveys and critique of rehabilitation works for the Abigroup Macleay Floodplain Bridge project: January • Green-thighed Frog monitoring program for Kempsey Bypass Alliance: January and March. • Technical review of the Warrell Creek to Urunga Biodiversity Offsets Strategy and development of habitat quality mapping for the dry sclerophyll forest communities into the offsets ratio for RMS. • Targeted surveys for the Giant Barred Frog for the Nambucca Heads to Urunga Pacific Highway Upgrade. • Targeted threatened frog surveys for the Woolgoolga to Glenugie Pacific Highway Upgrade program. • Advice on fauna fence design for the Woolgoolga to Glenugie Upgrade. • Common Blossom Bat Monitoring and radio telemetry surveys to determine day roost use at Koala Beach Estate. • Long-nosed Potoroo Plan of Management – Implementation of Year 4 program of works. • Glossy Black Cockatoo baseline monitoring surveys for the Frederickton to Eungai Pacific Highway Upgrade program. • Nest box monitoring program for Kempsey Bypass Alliance. • Baseline Spotted-tailed Quoll surveys for the Oxley Highway to Kempsey Upgrade. • Design and implementation of the spring baseline survey program for Oxley Highway to Kempsey: Yellow-bellied Glider, Giant Barred Frog, Koala and road kill surveys. • Pre-construction Giant Barred Frog surveys for the Warrell Creek to Nambucca Heads Upgrade. • Ecological services including pre-clearing surveys, fauna rescue and baseline ecological monitoring for the North West Rail Link project on behalf of Australian Museum Consulting. • Project ecologist services for the Frederickton to Eungai Upgrade for Thiess Pty Ltd. • Biodiversity offsetting strategy works for the Kempsey to Eungai Project – Flora and fauna surveys of the Latham and McCallister Land Parcels.
2012	• Systematic terrestrial vertebrate fauna surveys of the Atlas Deposit in south western NSW: January • Continuation of the Project Ecologist position for the Kempsey Bypass project centred around small scale ecological assessments, clearing supervision, dewatering strategies, threatened species surveys and implementation of biodiversity mitigation tools including fauna underpasses, fauna fencing, plantings and glider crossings: January-December • Implementation of the Kempsey Bypass Ecological Monitoring Program: Nest Box Monitoring, Green-thighed Frog breeding pond surveys: January-December • Nest box plan of management for Warrell Creek to Urunga Pacific Highway Upgrade: January-June • Micro bat management strategy for the Warrell Creek to Urunga Pacific Highway Upgrade: January-July • Giant Barred Frog (*Mixophyes iteratus*) management strategy for Warrell Creek to Urunga Pacific Highway Upgrade: January-July. • Green-thighed Frog (*Litoria brevipalmata*) management strategy for Warrell Creek to Urunga Pacific Highway Upgrade: January-July. • Target surveys for threatened raptor nests for Warrell Creek to Urunga Pacific Highway Upgrade: January-April • Preparation of the Ecological Monitoring Program for the Frederickton to Eungai Pacific Highway Upgrade: March • Preparation of the nest box plan for the Frederickton to Eungai Pacific Highway Upgrade: February-April • Target surveys for the vulnerable wetland plant *Maundia triglochinodes* on the Kempsey Bypass project: May • Target surveys for the vulnerable wetland plant *Maundia triglochinodes* on the Frederickton to Eungai Pacific Highway Upgrade: February-August • Biodiversity offsets package – compensatory land assessment of the following properties: Yerbury and Ainsworth: February-November • Implementation of the Long-nosed Potoroo Plan of Management for the Tugun Bypass Project: January-December • Biodiversity offsets package – compensatory land assessment of the following properties: Blair and Whalen: July-August • Bat box installation for the Nambucca Heads to Urunga Pacific Highway Upgrade. • Development of management strategies and plans of management for the Oxley Highway to Kempsey Pacific Highway Upgrade: Nest Box Plan of Management, Giant Barred Frog Management Strategy, Green-thighed Frog Management Strategy and Microbat Management Strategy: July-December. • Targeted glider surveys and advice on habitat connectivity for proposed widen median in Cairncross State Forest. • Targeted bird surveys for the Moreton Bay Rail Link Project: November.

Name	Ben Dean Lewis
2011	• Systematic terrestrial vertebrate fauna surveys of the Campaspe Deposit in south western NSW. • Field validation of endangered ecological communities and targeted surveys for threatened fauna and flora for the Frederickton to Eungai Pacific Highway Upgrade. • Compensatory assessment for offsetting the ecological impacts of the Kempsey to Eungai Pacific Highway Upgrade: Yerbury Property. • Continuing role as Project Ecologist for the Kempsey Bypass Project. • Flora and fauna assessment for proposed Abi Group site compound options adjacent Old Station Road, Verges Creek. • Expert advice in the NSW Land and Environment Court regarding Wallum Froglet and the likelihood of impacts arising from a bentonite spill at Thrumster Wetland. • Expert advice on de-watering and relocation strategies for the endangered Giant Barred Frog on the Sapphire to Woolgoolga Pacific Highway Upgrade. • Ecological constraints for proposed service centre at 556 Pacific Highway, South Kempsey. • Field validation of endangered ecological communities and targeted searches for threatened species for geotechnical works as part of the Frederickton to Eungai Pacific Highway Upgrade • Compensatory assessment for offsetting the ecological impacts of the Kempsey to Eungai Pacific Highway Upgrade: Griffin property • Compensatory assessment for offsetting the ecological impacts of the Kempsey to Eungai Pacific Highway Upgrade: Lallemand property • Implementation of the ecological monitoring program for the Kempsey Bypass Project: Glossy Black Cockatoo and Brush-tailed Phascogale monitoring.

2010	• Fauna assessment for proposed 11kv line maintenance at North Narrabeen: January.
	• Project ecologist for the Kempsey Bypass project performing:
	  o Nest box plans of management and implementation;
	  o Targeted surveys for rare flora and fauna;
	  o Noxious weed surveys;
	  o Design and advice on fauna underpasses, fauna fencing, frog fencing;
	  o Design and advice on Green-thighed Frog breeding ponds;
	  o Design and implementation of ecological monitoring program;
	  o Numerous ecological assessments associated with flood mitigation works;
	  o Compensatory land assessment as part of the Biodiversity offset Package for the Kempsey to Eungai project; and
	  o Clearing supervision involving capture, relocation of terrestrial and aquatic fauna: March 2010- January 2011.
	• Flora and fauna assessment for proposed Kirkwood Road at part of Tweed Heads Traffic Master Plan: May.
	• Blossom bat monitoring program at Koala Beach: July.
	• Ecological assessment and pre clearing surveys for Nirvana Way fence line: August & November.
	• Coolumboola to Wandoan Sub Station Powerline EIS: November.

2009	• Constraints and opportunities surveys and habitat mapping for the Abbott Point State Development Area near Bowen: January 2009 • Conservation assessment and advice on the flora and fauna values at Collinsville Mine Project: February • Targeted fauna survey as part of a proposed 25 km gas pipeline near Wandoan: February • Fauna surveys for proposed water pipeline from Miles to Wandoan: February • Biological flora, fauna and aquatic ecology monitoring with performance indices for the Spring Gully Coal Seam Gas Project Area for Origin Pty Ltd and advice on Squatter Pigeon: March-April • Biological monitoring of the Coleambally Irrigation Area in Riverina area of NSW: May & November • Pre-clearing surveys, delineation of fauna mitigation devices and associated clearing supervision for a transmission line at Tomago: June-July • Nest-box plan for the Oxley Highway Upgrade project: August-October. • Square-tailed Kite nest site selection survey for Oxley Highway Upgrade project: August-November.
2008	• Woolooga to Cooroy Transmission Line EIS: Target surveys for rare and threatened fauna: March and May. • Targeted pre-clearing surveys for threatened fauna associated with the Oxley Highway Upgrade between Pacific Highway and Wrights Road: March-July • Vertebrate fauna survey as part of proposed mining activities at Wandoan: March-April • Water for Bowen Pipeline Route Survey and benefited areas: April • Targeted fauna survey to assess impacts on the Mardi Dam to Mangrove proposed pipeline route: April-May • Long-nosed Potoroo workshop to improve habitat predication modelling for DECC: May. • Targeted surveys for threatened fauna for proposed re routing of a 11 KVA power line easement along Wyee Road: June • Targeted surveys for threatened fauna for proposed upgrading of transmission lines between Woodberry and Tomago: July • Targeted surveys for matters of national significance as part of the Kunioon Mine Project: July • Vertebrate fauna survey for proposed water pipeline between Spring Gully and the Wandoan Coal Project: August • Vertebrate fauna survey for proposed water pipeline between Condamine Power Station and the Wandoan Coal Project: August • Vertebrate fauna survey for the proposed eastern gas pipeline near Wandoan: August • Targeted surveys for the Black-breasted Button Quail near Gympie and Cooroy: September • Targeted surveys for Wallum Frogs and Coastal Planigale at six candidature sites in north–east NSW: October-December

Name	Ben Dean Lewis
	• Site selection for compensatory habitat package associated with upgrading of transmission lines and associated infrastructure at Tomago: October
2007	• Target surveys for rare and threatened fauna along the proposed conveyor route for the Tarong Transport Alliance: January & February • Development of an Integrated Plan of Management for Long-nosed Potoroo as part of the Tugun Bypass and Boyd Street Overpass Approvals Process: February • Review and advice on Oxbow Fauna Monitoring Program at Brisbane: February. • Fauna surveys for the proposed re-routing of the Pacific Highway at Banora Point: February-March. • Target surveys, delineation of important life cycle resources and mapping for the Yellow-bellied Glider along the proposed Kempsey to Eungai Pacific Highway Upgrade: March. • Target surveys for Five-clawed Worm Skink and Grassland earless Dragon for proposed fuel source route in the New Acland area: April-May. • Site assessment for proposed conveyor re-alignment between Meandu Creek and Tarong Power Station: May • Clarification of threatened species issues for a proposed retirement village at St Georges Basin: May. • Surveys as part of the DECC Bio-banking Pilot Study at Ballina and Pillar Valley: June. • Common Blossom Bat monitoring at Koala Beach: July • Habitat mapping and target surveys for the Coopernook to Herons Creek Pacific Highway Upgrade: July & August • Assessment of Wallum Froglet habitat and the potential impacts of dewatering strategies for the Tugun Bypass Project: August • Fauna survey for the proposed Port Macquarie Airport Runway Upgrade: August. • Ecological assessments for additional parcels of land associated with the Coopernook to Herons Creek Pacific Highway Upgrade: September-November • Fauna survey of proposed coal mine near Wandoan in Queensland Brigalow Belt: October. • Fauna surveys as part of route selection and design strategies for the proposed Water for Bowen project (130 km pipeline): October. • Clearing supervision and habitat critiquing as part of the Coopernook to Herons Creek Pacific Highway Upgrade. • Assessment of candidature sites identified as suitable compensatory habitat for Coastal Planigale and Wallum Sedge Frog: November. • Fauna surveys of lands identified as compensatory habitat for proposed mine activities in the Callide Range of central Queensland: November-December. • Target surveys for the Southern Bell Frog in the Lower Murray-Darling CMA December-January.
2006	• Targeted frog survey for Pacific Highway Upgrade Between Sapphire and Arrawarra: January. • Targeted frog survey for Pacific Highway Upgrade Between Iluka Road and Woodburn: February. • Proposed two lot sub-division of rural lands located at Lot 5 Manning Hill Road, Bunyah: February-March. • Fauna survey for the Glen Wilga Project at Chinchilla: March. • Fauna survey on selected lands identified for compensatory habitat as part of the Oxley Highway Upgrade Project: March-August. • Independent investigations of the Woodburn to Ballina Proposed Pacific Highway Upgrade study area: August • Pre-clearing surveys for Geo-technical Investigations for proposed upgrade of Pacific Highway between Moorland and Herons Creek: August-September. • Fauna survey and assessment of lands for proposed retirement village at St Georges Basin: September. • Target surveys for the Green-thighed Frog in the Bulahdelah region on NSW mid north coast, September. • Fauna survey of proposed Kunioon MDL and associated conveyor transport corridor near Kingaroy: September-October. • Fauna survey for proposed rail route between New Acland Coal Mine and Tarong Power Station: October-November. • Target surveys and assessment of local landscape for the Black-breasted Button Quail and Collared Delma lizard on the Kunioon MDL: December • Target surveys for Green and Golden Bell Frog on the Cronulla Rail Line Duplication Project: December.
2005	• Continuation of Species Impact Statement surveys for proposed Pacific Highway Upgrade: Kempsey-Eungai: January-April. • Flora and fauna assessment for proposed residential dwelling at Booral: February. • Target surveys for coastal planigale for proposed Pacific Highway Upgrade at Tugun: February. • Target surveys for frogs and bats for the proposed train support facility at Thornton: March. • Review and facilitation of the wallum sedge frog (*Litoria olongburensis*) and other related wallum species national recovery plan. • Baseline mammal survey of the Murrumbidgee Irrigation Area: Autumn Surveys: March-May. • Fauna survey of lands identified for compensatory habitat at Cobaki Broadwater: June. • Targeted fauna survey for proposed resort in the Wolgan Valley: August • Fauna assessment for proposed rail infrastructure upgrading on North Coast Rail Corridor: August-October. • Court Appointed Expert to conduct surveys for Wallum Sedge Frog on selected lands at Kingscliff: August • Fauna assessment of selected crown lands at Byron Bay: October • Targeted survey for wallum frogs and coastal planigale on selected lands at Bogangar for the Tugun Bypass Project: October • Fauna survey for the Glen Wilga Project at Chinchilla: November • Design and implementation of frog and bird monitoring at Eighteen Mile Swamp, North Stradbroke Island: November

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2004	• Microchiropteran bat survey of timber bridges along Kyogle Road, Tweed Shire Council: January. • Fauna assessment for the proposed Myall Way-Pacific Highway Intersection: January. • Conservation assessment for the southern bell frog between Balranald and NSW/South Australian border: January-March. • Assessment and delineation of *Callistemon linearifolius* for the proposed re-routing of Tea Garden – Pacific highway Intersection: March. • Biodiversity benchmarking surveys of the Coleambally Irrigation Area and neighbouring Kerarbury region in SW NSW with AMBS: April-May. • Clearing supervision for the removal of senescent trees at The Lakes Way – Pacific Highway intersection: May-July. • Target surveys and detailed habitat appraisal for coastal planigale in Tugun-Cobaki Area: June. • Flora and fauna assessment of Lot 14, 259 Cape Hawke Drive, Forster: July-August. • Fauna survey & section 5a assessment of selected lands at Goolawah Estate, Dept. Lands: July-September. • Targeted fauna surveys for proposed upgrading of Weakley's Drive – New England Hwy Intersection: September. • Implement baseline mammal survey in the Murrumbidgee Irrigation Area (500,000 ha) in SW NSW: September-October. • Independent assessment of Brush-tailed Rock Wallaby and proposed mitigation measures for the Shannon Creek Dam Proposal: November. • Species Impact Statement surveys for proposed Pacific Highway Upgrade: Kempsey-Eungai: December.
2003	• Population census of the green and golden bell frog at Homebush: January • Specialist bird survey assessment for the Coolangatta Airport Extensions: January & May • Site assessment of selected lands at Nambucca South for proposed medical centre: January • Site assessment at Wyee Point for proposed residential dwelling: February • Review of green-thighed frog monitoring program and implementation of field methodology in Nerong State Forest: February • Target surveys for threatened species on selected lands at Nambucca Heads: February • Desktop assessment of fauna at Trial Bay Goal: February • Vertebrate fauna survey and vegetation mapping at South Urunga: March • Assessment of selected lands for Mid Coast Water Depot at Forster: March • Ecological studies of the long-nosed potoroo at Cobaki for the proposed Pacific Highway upgrade at Tugun: April to July • Fauna survey of selected lands at Moonee: July • Additional SIS surveys and section 5a assessment for the proposed Bulahdelah Pacific Highway Bypass Project: July-September • Ecological assessment along the proposed Kempsey-Eunagi Pacific Highway Upgrade: August – September • Red-crowned Toadlet assessment at Little Bay for University of NSW: August • Mapping of *Eucalyptus fergusonii* and *Angophora inopina* along the proposed Bulahdelah Pacific Highway Bypass Project: August • REF 'The Lakes Way – Pacific Highway Intersection' for RTA/Acacia Pty Ltd. October. • Department Lands – Flora & Fauna Assessment at Goolawah Estate November. • Route surveys for the proposed Oxley re-routing project for AMBS: November & December.
2002	• Vertebrate fauna survey for route selection of the Kempsey Pacific Highway Bypass Project (Stage 1): January • Vertebrate fauna survey for the proposed Lilli Pilli Estate near Bateman's Bay: January • Site assessment for land capability statement at Shark Park (Caringbah): January • Supplementary surveys for insectivorous bats and other rare fauna at Lot 8 Kurnell: January • Fauna assessment of second ponds creek for Rous Hill Infrastructure Project: January – February • Site assessment of selected lands at Garden Street in Warriewood: February • Target surveys for the green and golden bell frog at Lot 101 Kurnell: February • Site assessment of selected lands at Wahroonga (north Sydney): February • Target surveys for glossy black cockatoo, common blossom bat, and common planigale at Kings Beach (north-east NSW): February • Vertebrate fauna assessment of selected lands at Sanctuary Point in southern NSW: March • Site assessment of selected lands for sewerage treatment facility at Tingha on northern tablelands: June • Pre-clearing surveys for threatened species along the construction route for the Shannon Creek pipeline: June & September • Site assessment and route design for the proposed Vodaphone mobile phone tower at Karuah: July • Squirrel glider assessment of selected lands at Tuncurry recycling centre: August • Assessment of the rare ironbark (*Eucalyptus fergusonni*) and foraging resources (swamp mahogany) for the squirrel glider along the proposed Bulahdelah Pacific Highway Bypass route: September • Auditory assessment of green and golden bell frog at Homebush: September • Fauna assessment of selected lands at South Urunga: September-October • Hair tube assessment for the Kempsey-Eungai Pacific Highway Upgrade: November • Annual vegetation and habitat monitoring for the endangered eastern bristlebird in the Border Ranges National Park: November • Population census of the green and golden bell frog at Homebush: December • Vertebrate fauna survey for proposed extension of Bellwood and Palmwood Estate at Nambucca Heads: December
2001	• Target surveys for threatened species along the proposed Summerland Highway upgrade at Woodenbong for RTA/Sandpiper Ecological Surveys: January

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	• Fauna survey for land compensation at Kinghorn Point in southern NSW: January • Fauna survey for land compensation at Culburra Urban Expansion area in southern NSW: January-March • Species Impact Statement for Forest Glades Development at Suffolk Park: January-February • Bird surveys for RTA/DMR along the proposed Chinderah-Tugun Bypass (SES): February • Target surveys for the green and golden bell frog, yellow-bellied glider, threatened bats, and large forest owls at Sussex Inlet in southern NSW: March • Fauna survey for land compensation at Vincentia in southern NSW: April • Fauna survey for proposed sub-division at Longbeach (Batemans Bay): July • Habitat assessment and target survey for common blossom bat and common planigale at proposed Kings Beach residential estate, northern NSW: August • Fauna survey for proposed Guranang powerline easement on the Summerland and Pringles Way in northern NSW: August • Population monitoring of eastern bristlebird territories and vegetation monitoring in north-east NSW: September-December • Site inspection for DA (erection of fence) of SEPP 26 remnant littoral rainforest at Lennox Head: September • Site assessment of selected lands in Richmond Range National Park for a proposed underground *Telstra* cable: October • Fauna survey for proposed powerline easement at Fat Duck Lane (Woombah): October • Target surveys for owls, squirrel glider, frogs, and microchiropteran bats at Mardi and Bushells Ridge on NSW central coast: November • Vertebrate fauna survey for route selection of the Kempsey Pacific Highway Bypass Project (Stage 1): November • LES study of selected lands at south Taree: November – December • Targeted surveys for southern bell frog (*Litoria raniformis*) in the Coleambally Irrigation Area, AMBS: November – December.
2000	• Threatened species surveys along an existing power line easement at Byron Bay: January • Bird surveys for the proposed Pacific Highway Deviation: Chinderah-Tugun Bypass (SES): January • Flora/fauna survey for the proposed ring road at Port Macquarie: February • Little tern surveys for NSW NPWS in the Tweed River estuary (SES): February • Population monitoring surveys for the eastern bristlebird: NPWS – Lismore District (SES): March. • Vertebrate fauna survey for Macmin Pty Ltd at the proposed Twin Hills Silver Project at Texas (SES): April • Conduct bird surveys for RTA/DMR along the proposed Chinderah-Tugun Bypass (SES): May • Population count of comb-crested jacana in stormwater canals in the Terranora region (SES): May • Vertebrate fauna survey at the Bonville International Golf Club and surrounding habitats: June • Eight part test for proposed building site at Pacific Palms: September • Field assessment (REF) for proposed developments at Sandbar and Bushlands, Pacific Palms: October • Vertebrate fauna survey for the proposed Tasman Mine Project at Maitland: October • Fauna/Flora Survey for a proposed sub-division at Smith's Lake: October • Bird surveys for RTA/DMR along the proposed northern alignment of the Chinderah-Tugun Bypass (SES): October • Assessment of fauna habitats at Shara Boulevard, north Ocean Shores (SES): November • Surveys for threatened species including Mitchell's Land Snail along the proposed re-routing of Johnson St bypass (Byron Bay) – November 2000 - January 2001 (SES) • Fauna survey for land compensation assessment at Vincentia, southern NSW: November-December
1999	• Surveys for the eastern bristlebird in the western Border Ranges National Park for NPWS – Lismore District(SES): March • Microchiropteran bat surveys along the proposed underground power line route from Mullumbimby-Terranora: April • Research assistant for the Australian Maritime College Research Project undertaking day/night comparisons on catch rates and fish quality in nets for the Tasmanian Aquaculture and Fisheries Institute (TAFI), April-May. Results were used in establishing recreational fishery regulations in northern Tasmania. • Provide assistance in determining the habitat requirements of the eastern bristlebird in the Border Ranges National Park for NPWS – Lismore District (SES): May-June • Target surveys for the wallum froglet (*Crinia tinnula*) at the Riley's Hill rock quarry: July • Assessment on the nesting/breeding activity of the peregrine falcon at Ilarwill Rock Quarry: August • Vertebrate fauna survey for the proposed sub division/golf course at Kings Beach/Kingscliff: October • Provide assistance in determining the potential impacts (edge affects) of the Karuah to Bulahdelah Pacific Highway upgrade using bird densities (SES): November • Target surveys for threatened species along the proposed underground cable route at Bogangar: December
1998	• Threatened bat surveys and radio telemetric studies of *Mormopterus spp*., *Myotis adversus* and *Scoteanax rueppellii* in the proposed Shannon Creek inundation area (Grafton). Department of Public Works: CVWSS: January-February • Flora/fauna survey of selected lands near Wauchope: March • Pre-logging surveys for NSW State Forests targeting threatened species: March • Species Impact Statement (SIS) surveys for the giant barred frog (*Mixophyes iterates*), large-footed myotis (*Myotis adversus*), greater broad-nosed bat (*Scoteanax rueppellii*), brush-tailed rock wallaby, and black bittern in the Shannon Creek/Grafton region: March-April • Implementation of baseline vertebrate fauna survey at Nymboi-Binderay National Park for NPWS – Dorrigo District: April-May • Pre-logging surveys for NSW State Forests targeting threatened species in the Nulla Five Day State Forest: May

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	• Target surveys for black bittern and brush-tailed rock wallaby in the Shannon Creek/Grafton region: May • Pre-clearing surveys on the Timbarra Plateau. This involved intensive standard fauna surveys and pre-clearing supervision over a continuos period of four months: May-September • Pre-logging surveys for NSW State Forests in Mistake State Forest: July-August • Population counts of waterbirds in the Tweed River Estuary for NSW NPWS/SES: October • Target searches for threatened herpetofauna (*Litoria brevipalmata* & *Hoplocephalus stephensi*) along the proposed Karuah-Bulahdelah Pacific Highway upgrade: November • Conduct fish surveys (incl. electro-fisher) and aquatic habitat assessments along the proposed Karuah-Bulahdelah Pacific Highway upgrade, December
1997	• Population census on the Green and Golden Bell Frog (*Litoria aurea*) on Metal Manufacture Lands (Port Kembla), Wollongong: January-March • Vertebrate fauna survey of lands below the proposed Kangaroo Creek Dam Storage (Grafton). Department of Public Works: Clarence Valley Water Supply Scheme (CVWSS): March • Vertebrate fauna surveys of lands below the proposed Shannon Creek inundation area (Grafton). Department of Public Works: CVWSS: November • Vertebrate fauna survey of the proposed Shannon Creek inundation area (Grafton): Public Works Department (CVWSS): December
1996	• Vertebrate fauna survey at Coombabah Creek for Department of Main Roads – Queensland (Rust PPK): July • Vertebrate fauna survey at Carol Park for Queensland Department of Small Business and Tourism (Rust PPK): September.
1995	• Vertebrate fauna survey at Border Ranges National Park for NPWS (Lismore District) in 1995 (volunteer). • Volunteer for the collation of wildlife records for the NSW NPWS Wildlife Atlas in northern NSW, 1995 onwards.
Current Projects	• Kempsey Bypass Project Ecologist • Long-nosed Potoroo Plan of Management Implementation
Additional Field Experience	• Field assistant (1996) for invertebrate surveys in the Richmond River estuary. The survey formed part of a PhD project on the foraging behaviour of migratory waders. • Field assistant (1996-1997) for pied oystercatcher surveys along northern NSW beaches for NPWS and Southern Cross University Honours Student. • Field assistant (April-May 1999) for Master of Research candidate at the Australian Maritime College looking at fish catch rates in various mesh sizes in northern Tasmania. • Volunteer (May 1999) for a fauna survey at Bean Creek Falls (Old Bonalbo) for Landcare (Terry Moody). • Volunteer (October 1999) to conduct migratory bird census counts in the Tweed River estuary. • Field assistant (November-December 1999) to conduct water bird surveys between Grafton and Rockhampton for PhD thesis. • Field assistant (March-April 2000) to conduct fish sampling in the lower Richmond River estuary. • Conduct census counts of migratory/sedentary birds in northern NSW for NSW wader study group, November 2000. • Assist in the collection of Stuttering Frogs (*Mixophyes balbus*) for the implementation of an endangered species-breeding program at Melbourne Zoo, February 2001. • Assist in research on the green and golden bell frog (*Litoria aurea*) at Broughton Island and Sandgate for the Australian Museum, January & April 2002. • Currently monitoring populations of the wallum frogs (*Litoria olongburensis* & *Crinia tinnula*) in northern NSW. • Currently monitoring giant barred frog (*Mixophyes iteratus*) populations in the Bungawalbin Catchment in northern NSW. • Currently looking at the population dynamics of stream dwelling frogs in the Bulga Plateau region in northern NSW. • Currently looking at the distribution of Pugh's Mountain Frog (*Philoria pugheii*) and New England Tree Frog (*Litoria subglandosa*) in northern NSW.
Plans of Management and Management Strategies	• Preparation of Wallum Frog (*Crinia tinnula, Litoria olongburensis*) PoM for proposed construction of the Tugun Bypass Project (SKM-Thiess): November • Preparation of Integrated Long-nosed Potoroo PoM for proposed construction of the Tugun Bypass Project: December-May 2007 • Preparation of PoM for compensatory habitat blocks A and E as part of the Tugun Bypass Project (QLD DMR): May-June. • Micro bat management strategy for Warrell Creek to Urunga Pacific Highway Upgrade: 2012 • Nest Box Plan of Management for several projects including Coopernook to Herons Creek (2007), Oxley Highway (2009), Kempsey Bypass (2010), Warrell Creek to Urunga (2012), Frederickton to Eungai (2012). • Giant Barred Frog management strategy for Warrell Creek to Urunga (2012) • Green-thighed Frog management strategy for Warrell Creek to Urunga (2012)
Independent Review	• Review of fauna issues relating to *SEPP 71* and other statutory requirements (EPBC 1999; TSC 1995; DCP's) associated with development application for DIPNR (formerly NSWPlanning) March 2003 to present. • Review and co-author of the national Acid Frog Recovery Plan. • Review of assessment of significance for Black-breasted Button Quail, Dunmalls Snake and Collared Delma as part of referral to Department of Environment and Water (DEW). • Technical review of the Kunioon fauna report.
Publications	• Lewis, B.D. (1997). An observation of the Beach Thick-Knee (*Esacus magnirostris*) attempting to forage on a pipi

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(*Donax deltoides*). *The Stilt*, Vol. 31: 42.

- Goldingay, R.L. & Lewis, B.D. (1999). Development of a conservation strategy for the green and golden bell frog (*Litoria aurea*) in the Illawarra region of New South Wales. *Australian Zoologist* 31 (2): 376-87.
- Lewis, B.D & Goldingay, R.L. (1999). A preliminary assessment of the status of the green and golden bell frog in north-eastern New South Wales. Pages 94-8 in *Declines and Disappearances of Australian Frogs* (ed) A. Campbell, Environment Australia -Canberra.
- Lewis, B.D. (2000). A breeding observation of the stuttering frog (*Mixophyes balbus*) in northern New South Wales. *Herpetofauna* 30 (1): 30-33.
- Lewis, B.D. (2000). Record of the green-thighed frog (*Litoria brevipalmata*) from north-east New South Wales. *Herpetofauna* 30 (2): 7-9.
- Rohweder, D.A. & Lewis, B.D. (2001). Day-night habitat use by double banded plovers (*Charadrius bicinctus*) in northern New South Wales. *Corella* 26(2): 33-37.
- Rohweder, D.A. & Lewis, B.D. (2004) Day-night foraging behaviour in double banded plovers (*Charadrius bicinctus*) in northern New South Wales. *Nortornis* 51: 41-46.
- Lewis, B.D. & Rohweder, D.A. (2005) Distribution, habitat, and conservation status of the giant barred frog (*Mixophyes iteratus*) in the Bungawalbin Catchment. *Pacific Conservation Biology* 11(3): 189-197.
- Lewis, B.D. & Goldingay, R.L. (2005). Conservation of the wallum sedge frog (*Litoria olongburensis*) in northern New South Wales. Australian Journal Zoology 53 (3): 185-194.
- Meyer, E., Hero, J-M., Shoo, L. and Lewis, B. (2005). Recovery plan for the wallum sedge frog and other wallum dependant frog species 2005-2009.Report to Department of Environment and Heritage, Canberra. Queensland Parks and Wildlife Service, Brisbane.
- Lewis, B.D. and Just, M.A. Submitted Herpetofauna. Range extension of two hylids (*Litoria caerulea* and *Litoria latopalmata*) in far south western NSW.
- Lewis, B.D. In prep. Home range and activity levels in the southern barred frog (*Mixophyes balbus*) in north-east NSW.
- Lewis, B.D. In prep. Breeding biology of the southern barred frog (*Mixophyes balbus*).
- Lewis, B.D. In prep. Distribution of the stuttering frog (*Mixophyes balbus*) in northern New South Wales.
- Lewis, B.D. In prep. Frog fauna and habitat correlates of the Bulga Plateau region.
- Bali, R. Lewis, B. and Brown, K. in prep. Ecology of the long nosed potoroo population at Cobaki in north eastern NSW.
- Lewis, B.D. and Bannerman, M. In prep. Conservation assessment of the southern bell frog (*Litoria raniformis*) in the Lower Murray-Darling Basin.

Nominations

- Lewis, B. Bali, R. and Brown, K. Preliminary listing. Nomination to list long nosed potoroo (*Potorous tridactylus*) at Cobaki at endangered on NSW *TSC* Act (1995).

Scientific Review

- Review of frog related research topics for *Pacific Conservation Biology*.

Unpublished Reports (Examples)

- Lewis, B.D. 1996. Distribution and habitat assessment of three threatened frog species in northern New South Wales. Unpublished Integrated Project, Southern Cross University- Lismore.
- Lewis, B.D. 1997. A general population census of the green and golden bell frog (*Litoria aurea*) at the Metal Manufacture Property, Port Kembla. Unpublished report prepared fro Kevin Mills and Associates.
- Lewis, B.D. 1997. A distribution assessment of the great barred frog (*Mixophyes iteratus*) in the Bungawalbin Catchment, northern New South Wales. Unpublished honours minor at Southern Cross University- Lismore.
- Lewis, B.D. 1997. A comparison in nocturnal and diurnal habitat use by double banded plovers (*Charadrius bicinctus*) in northern New South Wales. Unpublished honours minor at Southern Cross University- Lismore.
- Lewis, B.D. 1997. Studies of the green and golden bell frog (*Litoria aurea*) in the Illawarra region. Unpublished Honours major at Southern Cross University- Lismore.
- Rohweder, D.A & Lewis, B.D. 1999. Assessment of the likely occurrence of the wallum froglet (*Crinia tinnula*) at a rock quarry at Riley's Hill, northern NSW. Report prepared for ERM, Maitland.
- Rohweder, D.A. & Lewis, B.D. 2000. Assessment of the removal of the Byron South Feeder and the upgrade of the Byron No. 1 Feeder on threatened fauna. Report prepared for North Power.
- Rohweder, D.A. & Lewis, B.D. 2000. A vertebrate fauna survey of the proposed Twin Hills Silver Mine at Texas. Report prepared for Macmin NL.
- Lewis, B.D & Rohweder, D.A. 2001. Proposed cable route in Richmond Range National Park: Site assessment and potential impacts on fauna. Report prepared for Telstra Pty Ltd.
- Lewis, B.D. 2001. Flora and Fauna Assessment of Rural Lands at South Taree. Report Prepared for GeoLINK Pty Ltd.
- Lewis, B.D. 2002. Fauna assessment of selected lands at South Urunga. Internal report to EcoPro Pty Ltd.
- Lewis, B.D. 2003. Proposed Medical Centre at Nambucca Heads: Ecological Assessment and Section 5a (8 part test) at Lot 2 – DP250348.
- Lewis, B.D. 2003 Proposed residential dwelling at Lot 48 Rutleys Road Wyee Point: Fauna Assessment and Section 5a. Report to Bangalay Botanical Surveys.
- Lewis, B.D. 2003. Target surveys and fauna habitat mapping of selected lands at South Urunga. Internal report to EcoPro Pty Ltd.
- Lewis, B.D.2003. Proposed extensions of Palmwood and Bellwood residential estate at Nambucca Heads: Fauna Assessment. Report to Gary Leonard and Associates.
- Bali, R; Lewis, B & Brown, K. 2003. The status and distribution of the Cobaki long-nosed potoroo population. Report to Parsons Brinckerhoff: Brisbane.
- Lewis, B.D. 2003. Ecological assessment of the proposed Pacific Highway route at Kempsey Swamp. Internal report to EcoPro Pty Ltd.
- Lewis, B.D. 2003. Target fauna surveys and habitat mapping for the proposed route option one (eastern route):

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Quarry Road to Barraganyatti Creek Pacific Highway Intersection. Internal report to EcoPro Pty Ltd.

- Lewis, B.D. and Brown, K. 2003. Goolawah Estate: Flora Surveys and Fauna Habitat Assessment. Report prepared for Department of Lands by Lewis Ecological Surveys and EcoPRO.
- Lewis, B.D. 2003. The Lakes Way Pacific Highway Grade Separated Interchange: Flora and Fauna Assessment. Report prepared for Acacia Pty Ltd and RTA.
- Lewis, B.D. 2003. Proposed Runway Extension: Assessment of impacts on avifauna. Report prepared for Gold Coast Airport Limited (GCAL) by Lewis Ecological Surveys.
- Lewis, B.D. 2004. Microchiropteran bat surveys and impact assessment for replacement of timber bridges. Report to Tweed Shire Council.
- Lewis, B.D. 2004. Myall Way – Pacific Highway Intersection: Assessment of impacts on fauna. Report to EcoPRO Pty Ltd.
- Lewis, B.D. 2004. Conservation assessment of the southern bell frog (*Litoria raniformis*) in the lower Murray-Darling Catchment Management Area. Report to DEC – Dubbo.
- Lewis, B.D. 2004. Systematic surveys for coastal planigale (Planigale maculata) on Cobaki crown lands and a detailed habitat appraisal of the Tugun/Cobaki locality. Report prepared by Lewis Ecological Surveys for Parsons Brinckerhoff, Brisbane.
- Lewis, B.D. 2004. Flora and Fauna Impact Assessment – Proposed 2 lot sub division of Lot 14, DP262992 at 259 Cape Hawke Drive, Forster. Report Prepared by Lewis Ecological Surveys and EcoPRO for Highlight Consulting Pty Ltd.
- Lewis, B.D. 2004. Preparation of section 5a assessments for species of conservation concern on the proposed Kempsey Bypass Project: Brush-tailed Phascogale, Microchiropteran Bat Fauna and Glossy Black Cockatoo.
- Lewis, B.D. 2004. Proposed Shannon Creek Storage Facility: Clarification of issues on Brush-tailed Rock Wallaby. Report prepared for Friends of Shannon Creek Action group.
- Lewis, B.D. 2005. Seasonal surveys for the coastal planigale (*Planigale maculata*) at Cobaki/Tugun. Report prepared for Parsons Brinckerhoff (Brisbane).
- Lewis, B.D. and Brown, K. 2005. Proposed Goolawah Estate Stages 3-5: Flora and Fauna Assessment. Report prepared for Department of Lands (Taree): DIPNR.
- Lewis, B.D. 2005. Thornton Train Support Facility: Target Surveys for frogs and bats. Report prepared for Parsons Brinckerhoff (Sydney).
- Lewis, B.D. 2005. Proposed dwelling at Lot 696 Buckett's Way, Booral: Flora and Fauna Assessment.
- Lewis, B.D. 2005. Proposed Kempsey to Eungai Pacific Highway Upgrade: Fauna Survey. Report prepared for Parsons Brinckerhoff (Sydney).
- Lewis, B.D. (2005). Fauna survey of lands identified for compensatory habitat for the proposed Tugun Bypass Project. Report prepared for Parsons Brinckerhoff by Lewis Ecological Surveys.
- Lewis, B.D. 2005. Survey for the wallum sedge frog (*Litoria olongburensis*) on selected lands at Kingscliff, north-eastern New South Wales. Unpublished report prepared for Land and Environment Court Registrar by Lewis Ecological Surveys
- Lewis, B.D. 2005. Biodiversity Benchmarking Survey of the MIA: Mammals. Report prepared for Murrumbidgee Irrigation by Lewis Ecological Surveys.
- Lewis, B.D. 2005. Target surveys for Wallum Frog fauna and Coastal Planigale at Bogangar: Block F Proposed Compensatory Habitat. Report Prepared for Parsons Brinckerhoff (Brisbane).
- Lewis, B.D. (2005). Proposed House Site at Lot 696, DP 95402 – 2541 Bucketts Way, Booral: Flora and fauna Assessment. Report Prepared by Lewis Ecological Surveys and Bangalay Botanical Surveys for Coastplan Consulting Pty Ltd .
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Court Appearances	• Land and Environment Court – Sydney (November 2000) regarding threatened frog species on the Timbarra Plateau. • Land and Environment Court HWLE-MATTER.C060212.199665 – Thrumster Wetland Bentonite Spill.
Professional Affiliations	• Member Royal Zoological Society of New South Wales • Member of Australian Bird Study Association • Australian Society of Herpetologists
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August 2019

APPENDIX C – GIANT BARRED FROG MANAGEMENT STRATEGY

PACIFIC HIGHWAY UPGRADE:

OXLEY HIGHWAY TO KEMPSEY

GIANT BARRED FROG (*Mixophyes iteratus*)

MANAGEMENT STRATEGY

JULY 2013

PREPARED FOR THE SMEC-HYDER JOINT VENTURE BY:

LEWIS ECOLOGICAL SURVEYS

Commercial in Confidence

Disclaimer

....
Author
Ben Lewis
(Bachelor Applied Science – Honours)

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Zoe Wood (Hyder Consulting) – Review and project coordination.

Chontelle Perucich (Roads and Maritime Services) – Document review.

Aleesha Darlington (Roads and Maritime Services) – Document review.

Photography - Lewis Ecological Surveys © else stated

Top – The endangered Giant Barred Frog (*Mixophyes iteratus*) recorded from Smiths Creek.
Bottom – Giant Barred Frog habitat at Maria River and the resulting riparian habitat connectivity beneath the bridges.

Report to be cited as: Lewis, B.D (2013). Oxley Highway to Kempsey: Giant Barred Frog (*Mixophyes iteratus*) Management Strategy. Report prepared for Smec-Hyder Joint Venture by Lewis Ecological Surveys. ©

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Version.	Date	Description	Issued To	Position	Name
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C	30.5.2013	Final	Hyder Consulting	Assistant Project manager	Kevin Radford
C	30.5.2013	Final	Hyder Consulting	Senior Environmental Consultant	Zoe Wood
D	8.6.2013	Final	Hyder Consulting	Senior Environmental Consultant	Zoe Wood
D	8.6.2013	Final	Hyder Consulting	Assistant Project manager	Kevin Radford
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E	30.7.2013	Final	Hyder Consulting	Assistant Project manager	Kevin Radford

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Rev.	Project Number	Date	Description	Organisation	Reviewed By
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D	2171213a	19.6.2013	Updates to VerD	RMS	Aleesha Darlington

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1.0 INTRODUCTION

1.1 Background

Lewis Ecological Surveys (LES) has been contracted by the SMEC-Hyder Joint Venture (SHJV) to prepare a management strategy for the Giant Barred Frog (*Mixophyes iteratus*) as part of the Oxley Highway to Kempsey Pacific Highway Upgrade project. This species is currently listed as an endangered species pursuant to the NSW *Threatened Species Conservation* Act (1995) and Commonwealth *Environment Protection and Biodiversity Conservation* Act (1999) given that it has disappeared from much of its historic range (*see* Cogger 1995). Remnant populations of the Giant Barred Frog face a number of threats including:

- Chytrid fungal disease;
- Vegetation clearance;
- Reduction in water quality, from sedimentation or pollution;
- Changes in water flow patterns, either increased or decreased flows;
- Reduction of leaf-litter and fallen log cover through burning;
- Timber harvesting and other forestry practices;
- Predation on eggs and tadpoles by introduced fish; and
- Weed spraying close to streams; (*see* Mahony 1993; Mahony *et al.* 1997; NPWS 1998; Berger et al. 1999; Hines *et al*. 1999; Lemckert 1999; Lemckert and Brassil 2000; Lewis and Rohweder 2005; DEH 2006).

The Giant Barred Frog is most often associated with permanent flowing drainages, from shallow rocky rainforest streams to slower moving rivers in lowland forests. It has occasionally been recorded utilising still water bodies which have been constructed within drainage lines or within 100 m of them (BEM 2011; pers obs). The Giant Barred Frog is not restricted to a particular vegetation type and has been previously recorded in rainforest, wet sclerophyll forest, *Casuarina* line creeks and at times cleared land. Populations remain at sites dominated by exotic weeds including Camphor Laurel, Privet and Lantana. It is the structural elements of these vegetation types which allow frogs to remain at those sites rather than individual vegetation species (B. Lewis unpub. data). Previous habitat related surveys have revealed frogs show a preference for sites with permanent or near permanent pool riffle sequences, stream banks with undercuts and overhanging vegetation along with areas of deep leaf litter or organic matter (Lewis and Rohweder 2005). The permanency of water is required for the long larval stage of the tadpoles which can take in excess of 12 months to develop into frogs with some tadpoles remaining in their later Gosner stages of development for up to 2 years (Anstis 2002; B. Lewis unpub. data).

Within the Port Macquarie to Kempsey area, the Giant Barred Frog is known from two localities at Maria River and the eastern parts of Kumbatine National Park (Figure 1-1). The Environmental Assessment (EA) prepared for the Oxley Highway to Kempsey Pacific Highway Upgrade project recorded the Giant Barred Frog at Maria River and identified suitable habitat at Smiths Creek, Pipers Creek and Cooperabung Creek (GHD 2010). The Environmental Assessment concluded the proposal would have an impact on the Giant Barred Frog and identified the need to perform targeted surveys prior to construction and allow for minor refinements to the design and/or appropriate mitigation measures. This report documents the findings of these targeted surveys and provides a management framework to reduce impacts on the Giant Barred Frog during the construction and operational phases of the Upgrade. In this context it has been prepared to address components within MCoA B (31) b Construction Flora and Fauna Management Sub Plan and specifically (v):

A management strategy for the Green-thighed frog and Giant barred Frog in the case that the pre construction surveys identify the presence of these species or its habitats in the project corridor or its vicinity. The strategy shall include details of the measures to avoid, minimise and mitigate impacts to these species.

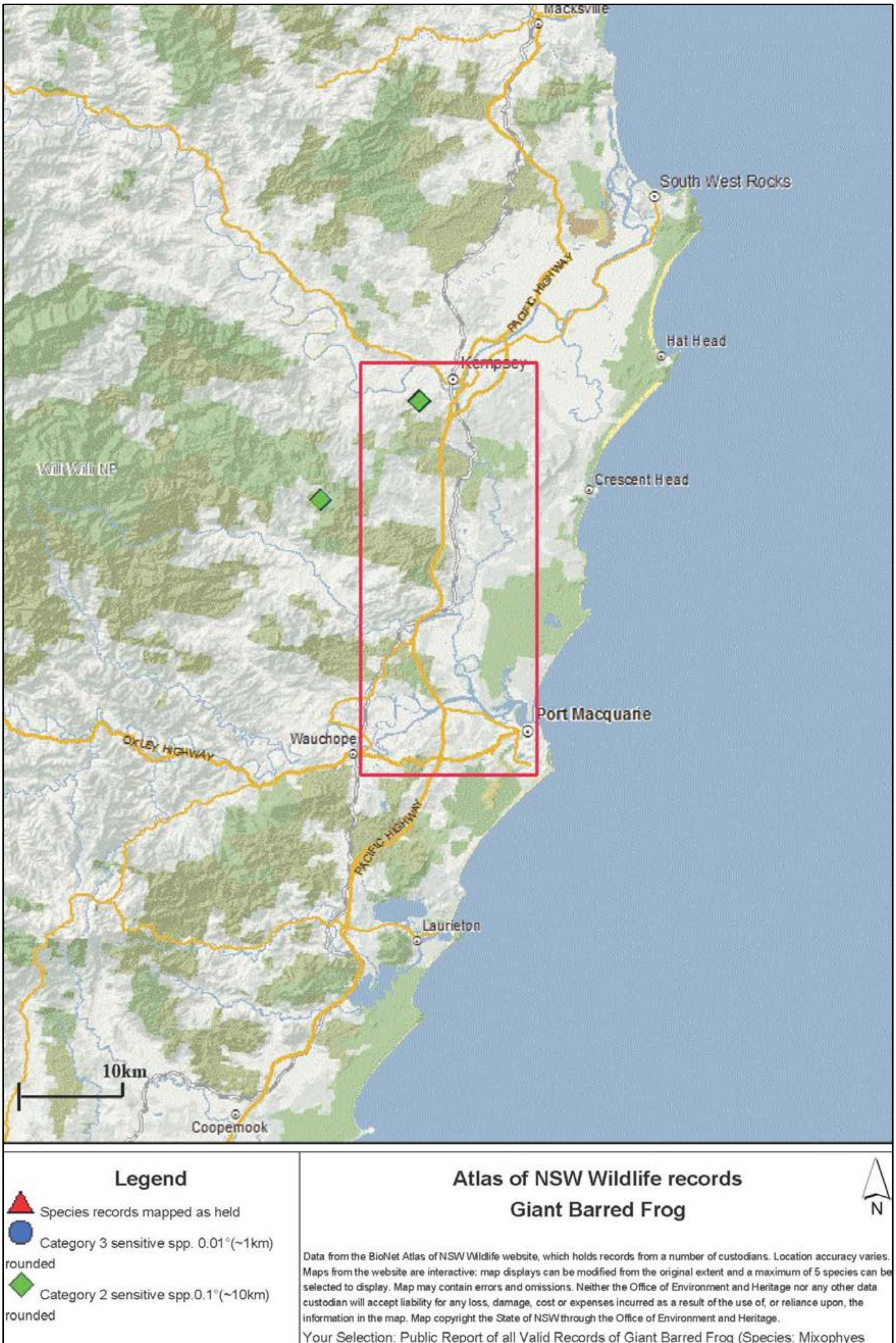

Figure 1-1. Regional historic distribution of Giant Barred Frog (*Mixophyes iteratus*) in the Port Macquarie (Oxley Highway) to Kempsey area. Source: Wildlife Atlas February 2013 www.bionet.nsw.gov.au/

2.0 FIELD SURVEYS

2.1 Survey Approach

Surveys were comprised of a literature review, a site perusal of the Oxley Highway to Kempsey construction corridor to select survey sites and a field survey program to assess the extent of local Giant Barred Frog populations.

2.1.1 Survey Sites

i. Stage 1 Surveys

Site selection was undertaken in August and September 2012 when 44 drainage lines were subject to a site visit/reconnaissance survey. At this time, each site was assessed as to whether the habitat was suitable for the species. Key determining factors included the permanency of the stream and the extent of suitable riparian habitats. Sites were surveyed regardless of the extent of exotic weeds.

ii. Stage 2 Surveys

Stage 1 surveys revealed many of the drainage lines were ephemeral in the study area. This resulted in a reduction from the original 44 sites back to the permanent and semi-permanent freshwater drainages of Stumpy Creek, Maria River, Pipers Creek, Smiths Creek, Barrys Creek, Cooperabung Creek, Fernbank Creek and some of their immediate tributaries. The Hastings River and Wilson River were also omitted from stage 2 surveys due to their saline or partly saline habits and were not considered riverine frog habitat.

Consideration was also given to surveying areas of suitable habitat that occur adjacent to the construction footprint but have the potential to be impacted (i.e. downstream or suitable construction water sources). For example, a site was established where Haydons Wharf Road crosses Cooperabung Creek as this area was viewed as a potential extraction point for water carts during construction.

At those retained survey sites, field sampling was undertaken over 8 nights between late November and late January 2013. Spring sampling was limited to late November and the start of December as the study area had received very little rainfall in October and most of November. Summer sampling was largely undertaken in January 2013 when the area had received some thunderstorm activity and there was reasonable separation in the field survey data (i.e. 3- 4 weeks).

Survey effort at each site was broadly consistent with the DEC (now EPA) survey guidelines (2004). Nocturnal surveys were undertaken over a 1-2 hour period and employed call broadcast, spotlighting and illumination of the water column to look for tadpoles. This was followed up by some diurnal surveys to further sample for tadpoles using a dip net and some habitat critiquing. Moreover, recent surveys completed for the EPBC Protected Matters report were also considered (GHD 2012). They included multiple surveys at Barrys Creek in early April 2012 that culminated in 8 hours of survey effort and some surveys performed at Pipers Creek, Cooperabung Creek and Maria River (GHD 2012).

2.2 Survey Results

2.2.1 Known Locations

Giant Barred Frogs were recorded at the following locations:

- Cooperabung Creek (south);
- Cooperabung Creek downstream at Haydons Wharf Road;
- Smiths Creek;
- Pipers Creek; and
- Maria River (Figure 2-1a-e).

At each of the locations, between 1-5 adults were recorded over a 500 m transect with evidence of more recent breeding (within 12 months) occurring at Cooperabung Creek (tadpoles) and a gravid female was recorded at Smiths Creek. Frogs were always recorded within 20 m of the primary or immediate stream bank but this is expected to vary over time depending on the width of the riparian vegetation. For example Giant Barred Frogs would be expected to utilise the riparian habitats for up to 75 m from the stream bank at both Maria River and Pipers Creek. All of the recorded locations are considered to contain viable populations of frogs.

2.2.2 Potential Locations

Areas of suitable habitat for the Giant Barred Frog were also identified at both Stumpy Creek and Barrys Creek.

i. Stumpy Creek

No Giant Barred Frogs were recorded at Stumpy Creek. Both the in stream and riparian habitat improves around 300 m downstream of the construction footprint (east of the power line easement) and at 1 km downstream the Giant Barred Frog would be expected to occur. Therefore, any Giant Barred Frog management strategy at this location should focus on potential secondary impacts surrounding water quality and sedimentation and would be captured within the Construction Environmental Management Plan (CEMP) for the project. Given the location of the potential habitat (outside the Project boundary) management actions to address the primary impacts surrounding habitat removal and direct mortality of individual frogs are not warranted at Stumpy Creek.

ii. Barrys Creek

No Giant Barred Frogs were recorded at Barrys Creek following surveys in late November 2012 and mid January 2013. This is consistent with the findings of other recently completed surveys at this location which included surveys over 2 nights in early April 2012 for a period of 8 person hours (GHD 2012). Based on these surveys and habitat critiquing, Barrys Creek appears unsuitable for Giant Barred Frog within the construction corridor due to the ephemeral nature of this water course which becomes increasingly more ephemeral to the west of the existing Pacific Highway. A dam around 250 m downstream of the Mingaletta Bridge provides some permanency for aquatic fauna and it is this area and immediately downstream that were considered more likely to contain Giant Barred Frog (Figure 2-2a). Further downstream this drainage line traverses through partly cleared farmland before it drains into the Maria River which is believed to contain brackish water and no longer represents riverine frog habitat.

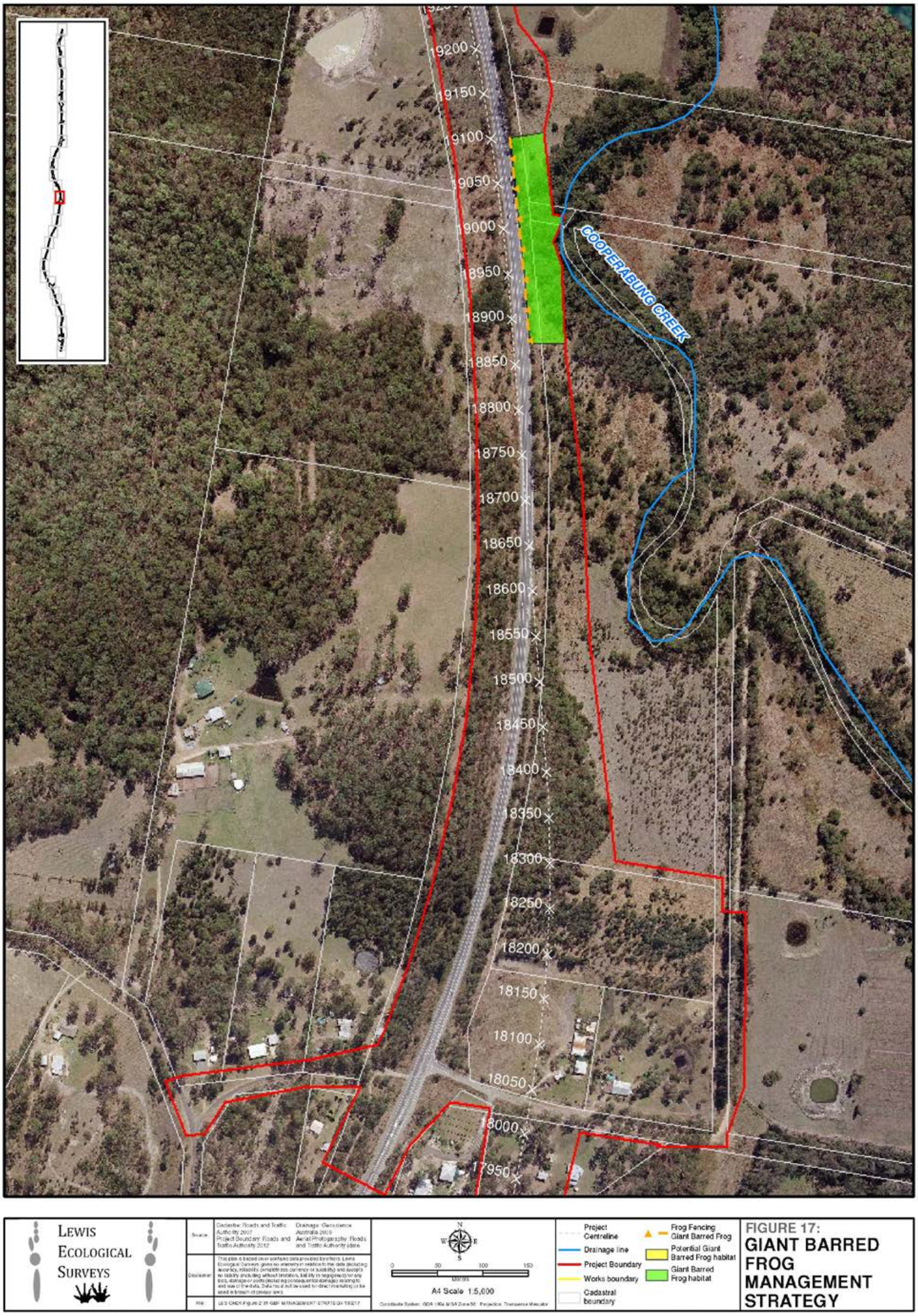

Figure 2-1a. Known Giant Barred Frog habitat at Cooperabung Creek (south).

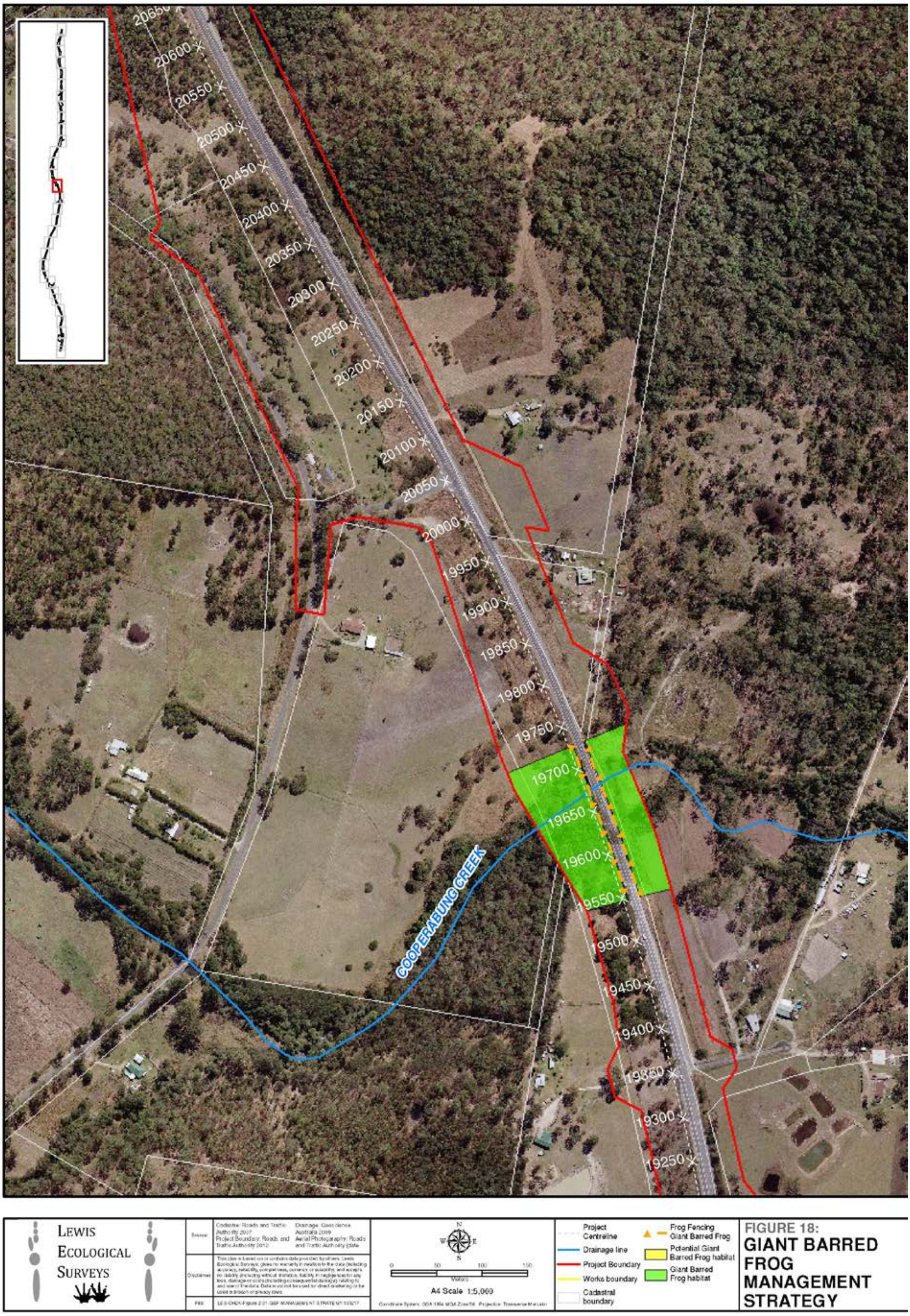

Figure 2-1b. Known Giant Barred Frog habitat at Cooperabung Creek.

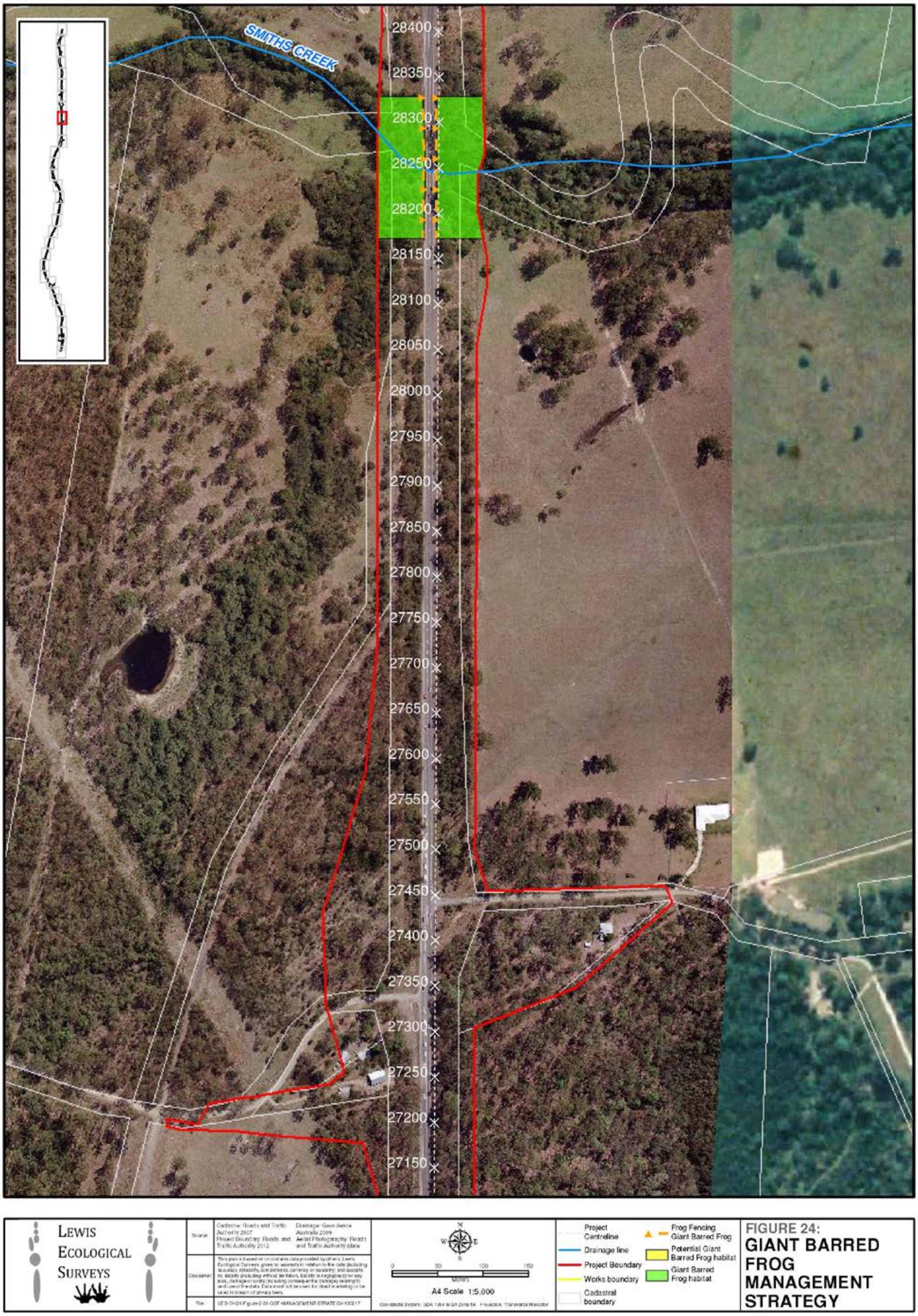

Figure 2-1c. Known Giant Barred Frog habitat at Smiths Creek.

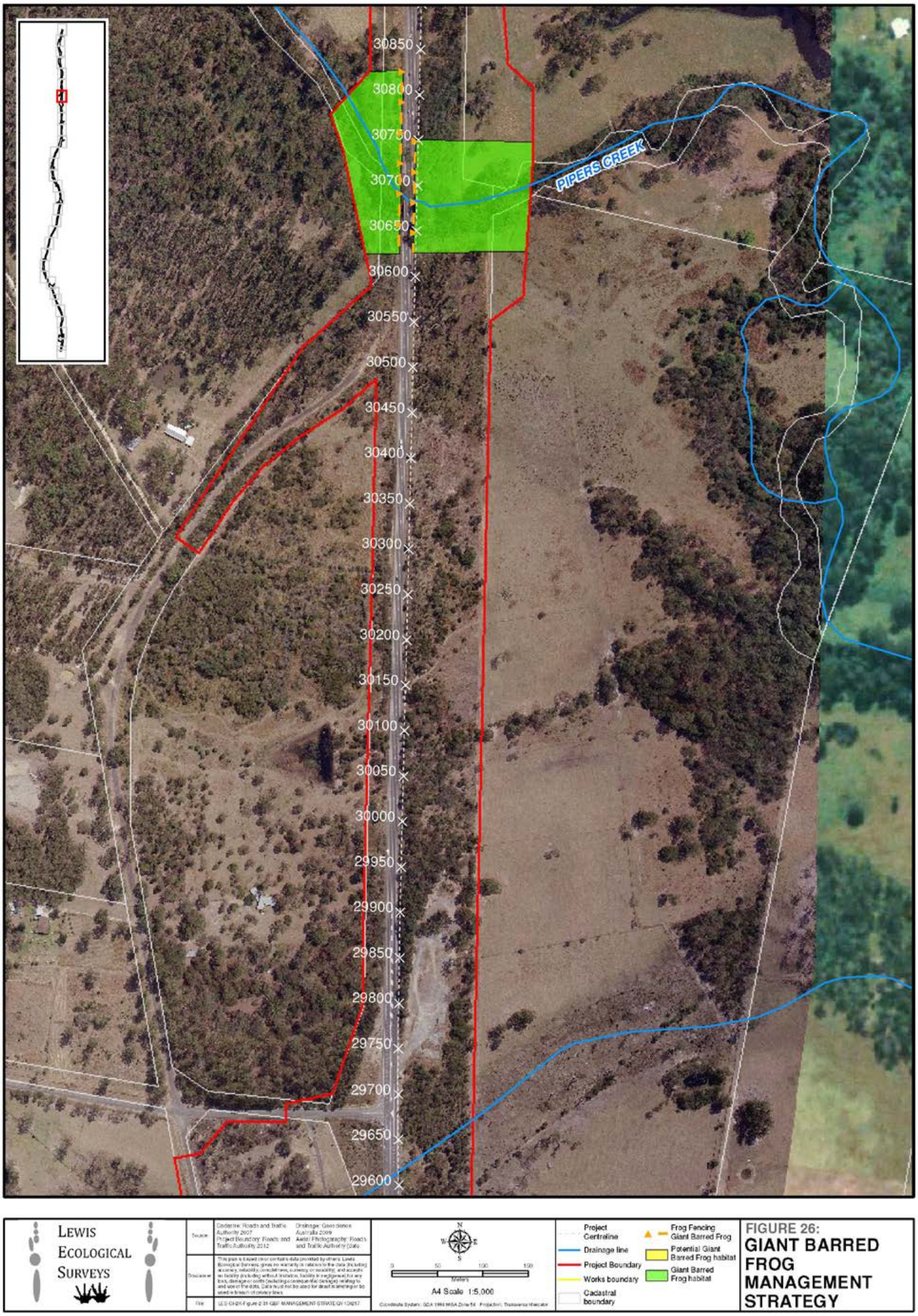

Figure 2-1d. Known Giant Barred Frog habitat at Pipers Creek.

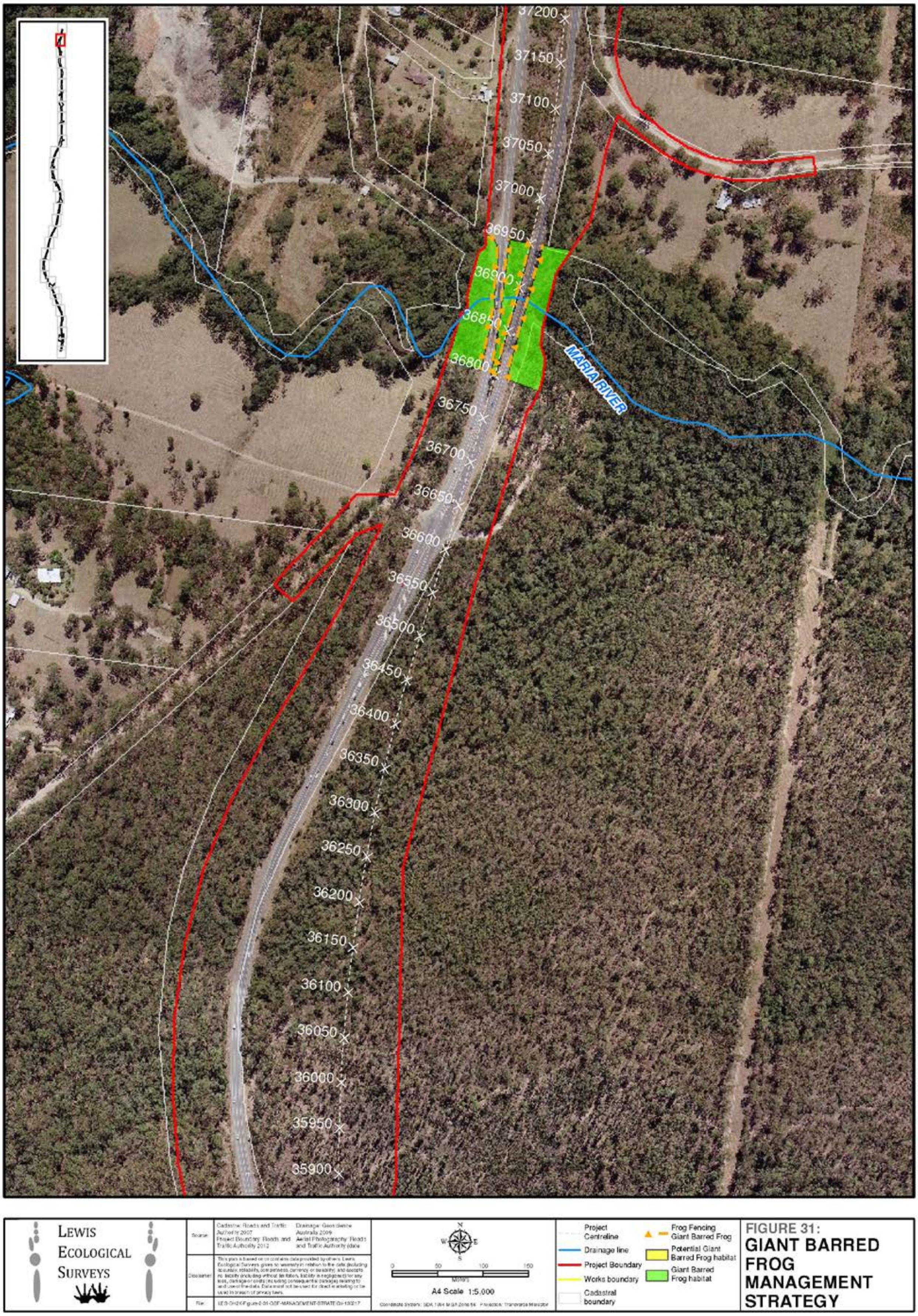

Figure 2-1e. Known Giant Barred Frog habitat at Maria River.

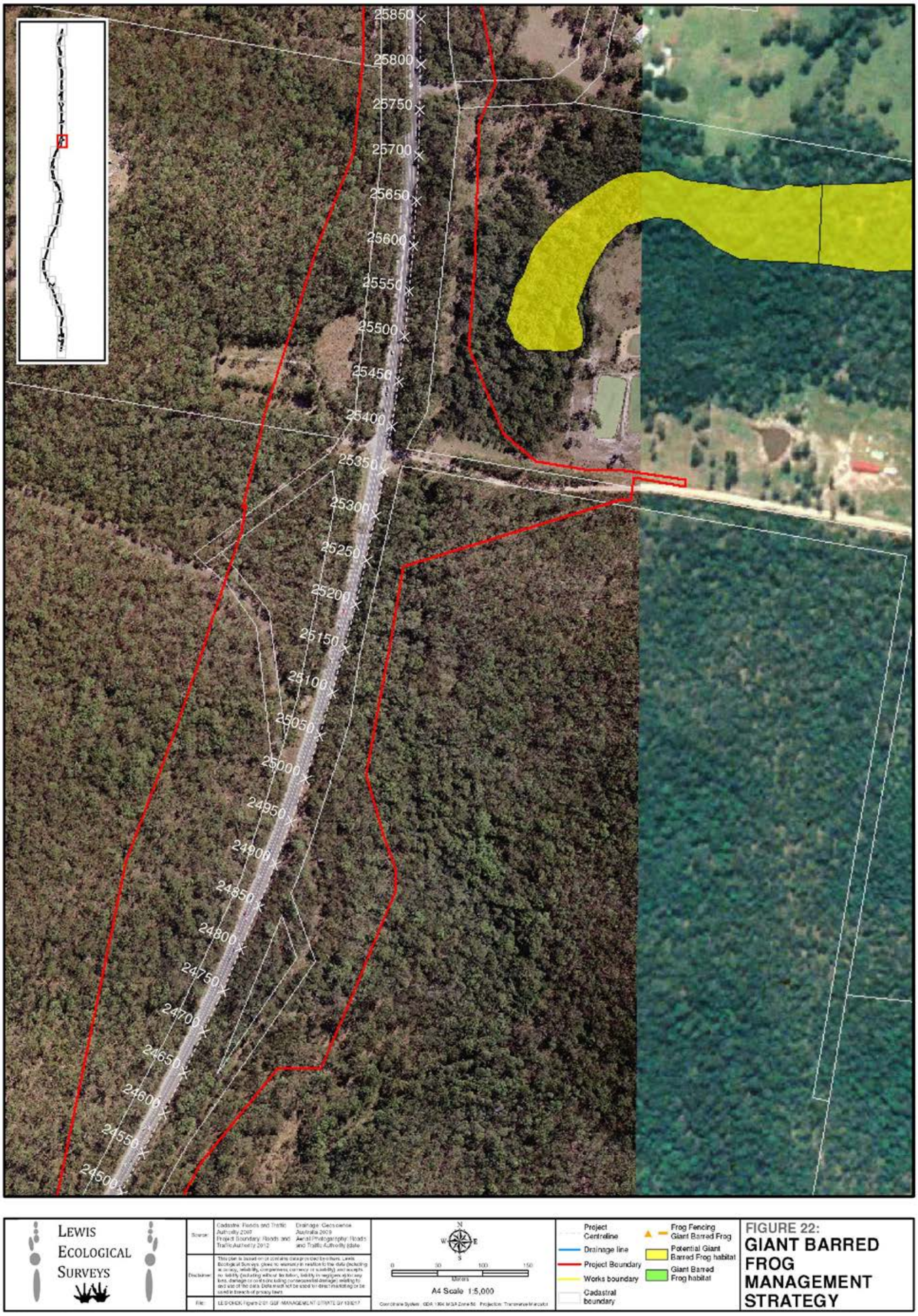

Figure 2-2a. Potential Giant Barred Frog habitat at Barrys Creek.

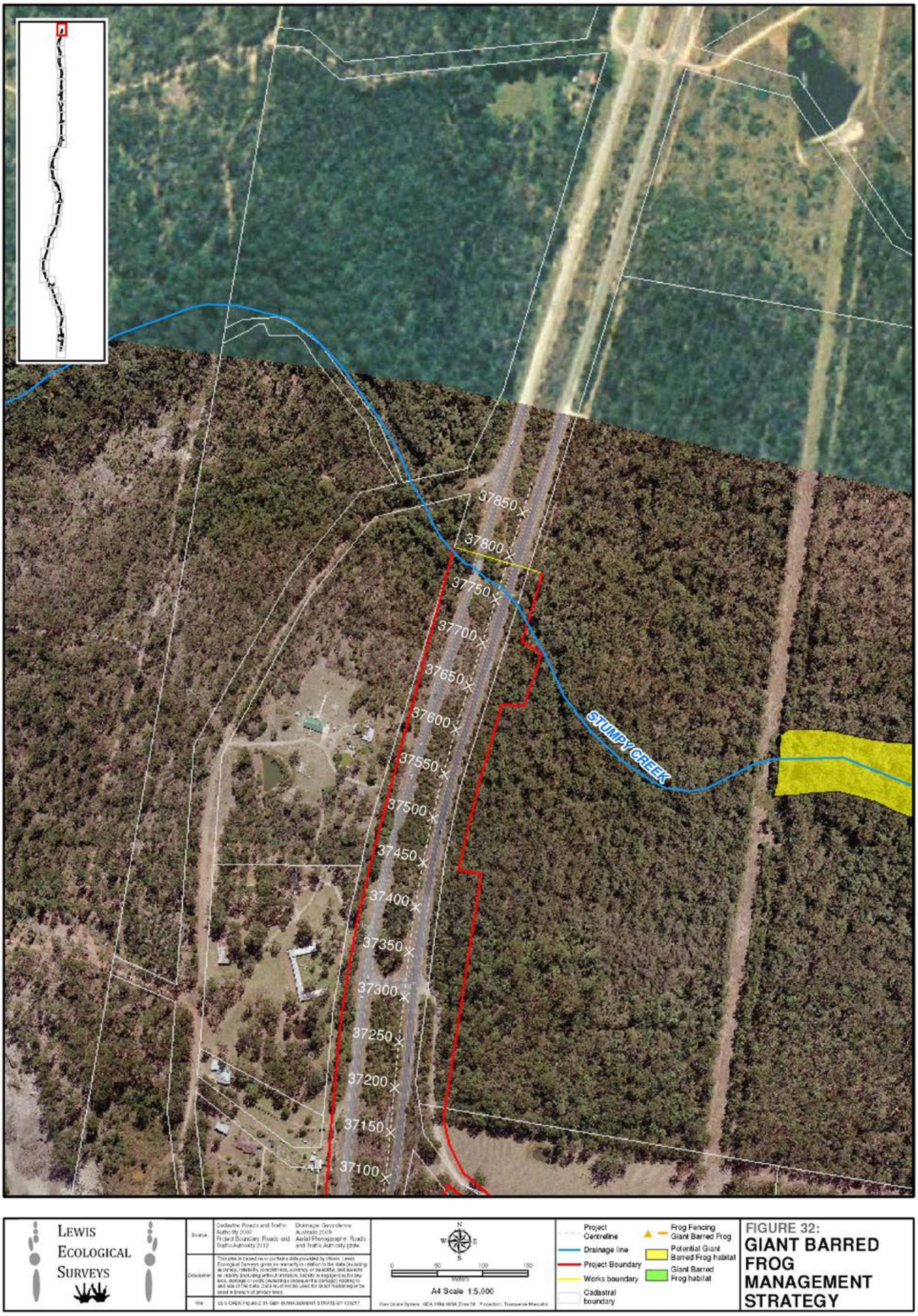

Figure 2-2b. Potential Giant Barred Frog habitat at Stumpy Creek.

3.0 MANAGEMENT PROCEDURE

3.1 Introduction

The following management strategies have been developed in consultation with:

- Past surveys performed for the Environmental Assessment (GHD 2010);
- More recent surveys undertaken as part of developing the EPBC Act Matters Report (GHD 2012),
- The Giant Barred Frog Management Plan for the Sapphire to Woolgoolga Pacific Highway Upgrade (Benchmark Environmental Management 2011);
- Results of the current targeted surveys combined with the authors expert knowledge on this species which includes:
    - Extensive surveys of this species throughout its range;
    - Scientific publications of this species (e.g. Lewis and Rohweder 2005); and
    - Understanding of the species ecological requirements.

3.2 Management Strategies

Five management strategies have been proposed as a means to avoid, minimise and mitigate impacts to the Giant Barred Frog. They include:

1. Identification and protection of Giant Barred Frog habitat;
2. Pre-clearing Surveys to be implemented in four stages of:
    a. Early works when establishing site controls (i.e. clearing limits for clearing and grubbing);
    b. Pre-clearing survey within 5 days of commencing the clearing and grubbing program;
    c. Clearing supervision during the clearing and grubbing program; and
    d. De-watering procedures within areas identified as Giant Barred Frog habitat (i.e. creek diversions).
3. Frog fencing in areas of Giant Barred Frog habitat considered in the context of:
    a. Temporary frog fencing; and
    b. Permanent frog fencing.
4. An unexpected finds procedure to address instances where Giant Barred Frogs are detected during routine pre-clearing surveys or at other times during the project.
5. Suitable land is identified within the Biodiversity Offset Package which contains a population of Giant barred Frogs.

Monitoring surrounding these management strategies is discussed separately in Section 4.

3.2.1 Identification of known and Potential Giant Barred Frog Habitat

Giant Barred Frog is known to occur at Cooperabung Creek (2 locations), Smiths Creek, Pipers Creek and Maria River (Figure 2-1a-e). Less suitable habitat was identified at Barrys Creek and further north at Stumpy Creek (Figure 2-2a-b). These areas of known and potential Giant Barred Frog habitat will be protected from construction related works other than what is considered essential. The locating of temporary access tracks, utilities redistribution, car parking facilities and other ancillary works including topsoil stockpiles, lay down areas, wash down bays, site shedding and compound sites will not be located in these areas, unless otherwise approved by the Director General. This approach will be in accordance with MCoA:

C1. The Proponent shall employ all feasible and reasonable measures to minimise the clearing of native vegetation during the construction of the project.

C28 Unless otherwise approved by the Director General in accordance with this condition, the sites for ancillary facilities associated with the construction of the project shall (c) be located in areas of low ecological significance and require minimal clearing of native vegetation (not beyond that already required by the project).

The protection of the identified areas of known and potential Giant Barred Frog habitat should include the demarcation of clearing limits and protection of vegetation outside clearing limits. Vegetation to be protected will be fenced and signed as environmentally sensitive areas.

3.2.2 Pre-clearing surveys

Pre-clearing surveys will provide an additional safeguard to reduce direct mortality to individual frogs during the clearing and grubbing phase of the project. At the five known Giant Barred Frog habitat sites (*see* Section 3-1) the Project Ecologist will carry out the following pre-clearing survey procedure.

i. Early Works – Establishing Site Controls (Temporary Frog Fencing)

a) The works area for the temporary fencing will be inspected/searched by the Project Ecologist immediately prior to installing the temporary fencing. The search will use active techniques such as raking the leaf litter, call broadcast (this species will readily call during the day) and inspections around tussocks (i.e. *Lomandra* clumps in particular) and logs. A nocturnal survey may be required the night before depending on the season and prevailing weather conditions, to be determined by the Project Ecologist.

b) Temporary frog fencing will be installed for 200 m either side of the stream (minimum 900 mm high above ground and buried to a depth of at least 50 mm)[1]. Where the terrestrial habitat bordering the stream is cleared land (i.e. at Cooperabung Creek) the temporary frog fencing will be installed for 100 m either side of the stream. Frog fencing will include a return wing (5 m in length) to reduce frogs breaching the fence.

c) Fencing will be installed and inspected/signed off by the Project Ecologist. This procedure is to form part of the pre clearing/ground disturbance checklist/permit and included in the Construction Flora and Fauna Management Plan.

d) Fencing will be installed at least 5 days prior to the scheduled clearing date so that active searches can be performed within the clearing footprint (see below).

e) All this is to be in place within 5 days of nominated clearing start date so that pre-clearing surveys can be performed in a closed environment (see below).

ii. Pre-clearing Survey for Frogs

[1] It is acknowledged that installation of the fence itself will represent ground/vegetation disturbance and as such it should be subject to a pre clearing active search survey and the works supervised by the Project Ecologist.

a) Within 5 days of scheduled clearing/ground disturbance operations, the Project Ecologist will perform pre-clearing surveys over a minimum of two non-consecutive nights (i.e. before clearing commences).

b) Surveys are to last 1 person hour per hectare of habitat to be disturbed/removed and involve the use of call broadcast, spotlighting and active searches of litter, debris and logs.

c) All Giant Barred Frogs captured will be relocated to the nearest side of the clearing limit with information collected on sex, breeding condition and snout-vent length. Alternative relocation sites may be considered provided they occur within the same drainage line. As a general rule, frogs should not be relocated further than 300 m from the capture site which should theoretically remain within an individual's home range[2].

d) Frogs with a snout-vent length >40 mm will be PIT[3] tagged to document the performance measure of this as a suitable relocation strategy. Juvenile/sub adult frogs may be marked in accordance with the animal care and ethics licence of the Project Ecologist.

e) A frog hygiene protocol will be adopted at sites with known Giant Barred Frog habitat. This protocol will be in accordance with Department of Environment and Climate Change DECC (now EPA) *Hygiene protocol for the control of disease in frogs* Information Circular Number 6 (DECC 2008). As part of this hygiene protocol the status of Chytrid fungus will be assessed by taking swab samples of captured frogs.

iii. Clearing Supervision

a) At the five known Giant Barred Frog habitat sites, the clearing and grubbing activities will be supervised by the Project Ecologist until such a time they are confident no Giant Barred Frogs remain within the work site.

b) Captured frogs will be treated as per 3.2.2 c) and 3.2.2 d).

c) The need to perform additional night time surveys will be at the discretion of the Project Ecologist. For example, where only part of the site may have been cleared or more suitable weather conditions present an increased opportunity to detect frogs.

iv. Dewatering Procedures in Giant Barred Frog areas

a) The dewatering process will be conducted in accordance with an Environmental Work Method Statement (EWMS) and the DECC (2008) *Hygiene protocol for the control of disease in frogs* Information Circular Number 6 (DECC 2008). All waterways and dams within those areas identified as Giant Barred Frog habitat will be subject to this dewatering process.

b) Where the water body is to be pumped dry, the intake pipe must be positioned in the deepest section. This will avoid further disturbance of the aquatic habitat prior to capture and relocation of aquatic fauna.

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[2] Based on mark recapture data and radio tracking of the *Mixophyes* genus (B. Lewis unpublished data).
[3] Passive Integrated Transponder (i.e. microchip as used to mark and identify domestic animals).

c) Screening of the pump intake (5mm mesh size) will be installed to prevent tadpole entrainment.

d) Dip netting will be undertaken to remove as many aquatic fauna as practical once the water body is shallow enough to be effectively waded through by field personnel.

e) All tadpoles will be identified and sorted by species and/or genus and placed into separate holding containers. The size of these containers will be left to the discretion of the Project Ecologist.

f) All tadpoles will be released into permanent/semi-permanent pools in adjacent habitats. Tadpoles will be first acclimatised to the recipient sites water temperature by immersing bags or aquaria in the release pools to allow a gradual equilibrium of water temperature prior to release.

g) In instances where there are numerous tadpoles from a wide range of species, preferential treatment will be given to Giant Barred Frog tadpoles due to their legislative status as an endangered species. The release of predatory species (i.e. eels) will not occur in areas where Giant Barred Frog tadpoles are being released. This will reduce the risk of additional predation and/or competition.

3.2.3 Permanent Frog Fencing

a) Frog fencing must be installed in areas where the presence of Giant Barred Frogs has been confirmed and there is a ‘high’ risk of frogs accessing the carriageway (Figure 2-1 a-e). A high risk has been defined as earth embankments/batters within 200 m of the stream.
b) The frog fence will be installed to provide the required protection for between 100-200 m either side of the stream. Based on the concept design frog fencing is proposed at:
    i. Eastern side of Ch. 18500 extending north to Ch.19100 (Cooperabung Creek);
    ii. Both sides of roadway between Ch. 19550 to 19725 (Cooperabung Creek);
    iii. Both sides of Ch. 28175 north to Ch. 28325 (Smiths Creek);
    iv. Both sides of Ch. 30625 north to Ch. 30750 with the western side extending to Ch. 30825 (Pipers Creek); and
    v. Both sides of Ch. 36800 north to Ch. 36950 for Maria River (figure 2.1 a-e).
c) A fence return of 5 m must be installed where the frog fencing does not extend for at least 50 m into unsuitable habitat (i.e. cleared land or non riparian habitat) at the above mentioned sites.

Design wise, the frog fencing will be incorporated into the standard fauna fencing or alternatively, where this is not feasible, into the boundary fence. From a design perspective, the fence is to use a gauze size of 30-40 mm to prevent frogs from moving through the fence whilst still allowing for overland water flows/drainage. The fence is to stand at least 900 mm in height with the residual 150 mm use as an on ground return (i.e. product 1050 mm in width/height).

An example of a supplier is the Waratah Range Heavy Galvanized Netting which is 1200 high with 30 mm wire spacing and a gauge wire diameter of 0.9 mm.

The success of this design will be based on the absence of Giant Barred Frog fence breaches[4]. As part of the monitoring procedures for measuring the effectiveness of the frog fencing, monitoring of fence breaches will be undertaken by a suitable qualified ecologist at certain times of the year (i.e. when population monitoring occurs). This monitoring program will involve surveys for Giant Barred Frog on both sides of the frog fence as this data will clearly show whether the frog fence is effective at excluding frogs. The monitoring of permanent frog fencing will be carried out by RMS as part of the Ecological Monitoring Program.

3.2.4 Unexpected Finds Process

An unexpected finds process will be implemented to manage instances where Giant Barred Frog may be detected during pre-clearing surveys, clearing operations or dewatering works for the upgrade. This is in response to field surveys not being exhaustive and the ability of Giant Barred Frogs to move relatively large distances in short time periods. For example, hundreds of metres when the clearing footprint will rarely extend beyond 120 m.

In an unexpected finds instance, the management strategies outlined in this plan will be adopted and include:

1. Protection of Giant Barred Frog habitat including provisions for its protection from ancillary areas and their associated impacts consistent with MCoA C1 and C28;
2. Temporary and if required permanent frog fencing;
3. Additional pre-clearing surveys as deemed appropriate by the Project Ecologist or frog specialist;
4. Implementation of the monitoring program in accordance with Section 4.2 and the performance measures outlined in Section 5.0 of this management strategy.

3.2.5 Biodiversity Offset Package (Compensatory Habitat)

The development of the Biodiversity Offset Package may result in the need to acquire land as compensatory habitat. In this instance, land suitable for the Giant Barred Frog should be given equal weighting along with the other seven fauna species identified as being significantly impacted by the project. Land containing suitable Giant Barred Frog habitat occurs adjacent to the project near Kundabung and South Kempsey and is subject to further investigation. Such an acquisition would provide improved conservation benefits on the current status of the Giant Barred Frog in the Kundabung and Kempsey area.

[4] This will also be detailed in the EMP required for the project.

4.0 MONITORING OF THE MANAGEMENT STRATEGIES

There are four concerns with the Giant Barred Frog and the Pacific Highway Upgrade program between Oxley Highway and Kempsey. They include:

1. Direct mortality of frogs resulting in further population declines;

2. Deterioration of habitat quality in the receiving or adjacent environment (i.e. habitat degradation);

3. Population connectivity with the construction footprint severing habitat; and

4. The potential introduction or spread of the chytrid fungus.

Whilst this management strategy demonstrates how the project will minimise these impacts during construction there is a need to demonstrate how successful this has been during the delivery of the project. The following monitoring program provides this and outlines the performance measures associated with the program of works and corrective actions therein.

4.1 Monitoring Sites

The monitoring program will be limited to Cooperabung Creek, Smiths Creek, Pipers Creek and Maria River. Between 1-2 reference sites will also be incorporated into this monitoring program. A site selected several kilometres upstream of the Cooperabung Creek would be considered a priority reference site because this creek will potentially be impacted to a greater extent than at other known Giant Barred Frog locations (i.e. affected at multiple points). One such reference location could be Sun Valley Road several kilometres upstream of the construction footprint for Cooperabung Creek. Alternative reference sites could include upstream locations where Smiths Creek Road crosses Smiths Creek and Old Coast Road where it crosses Pipers Creek.

4.2 Monitoring Survey

4.2.1 Frequency of Surveys

The survey program outlined below will be undertaken in spring, summer and autumn following operation of the project, between Year 4 and Year 8 (i.e. 5 years; Table 4-1. Year 4 represents the commencement of operation of either stage of the project – Oxley Highway to Kundabung or Kundabung to Kempsey). The survey period should aim to take place in the middle of each season. A baseline survey will be undertaken prior to construction and consist of one survey in spring, summer and autumn (i.e. three surveys). This approach will provide cues on habitat use within and adjacent to the road corridor leading up to construction and provide the basis for comparing the overall performance of the project.

The baseline survey and (survey report) is to be completed prior to the commencement of clearing and grubbing within 500 m of Giant Barred Frog habitat identified at Cooperabung Creek, Smiths Creek, Pipers Creek and Maria River.

4.2.2 Frog Surveys

- 1 km transect with 450 m either side of the construction footprint (100 m represents construction footprint);

- The survey will also inspect the frog fencing to look for frogs on either side of the fence. This survey would also inspect the edge of the carriageway for evidence of frogs being struck by vehicles;
- The duration for this transect will be set at 2 person hours;
- Each field survey will entail a meandering transect on both sides of the creek bank with all frogs marked via a PIT tag (i.e. micro-chipped). The objective of PIT tagging is to individually mark each frog with a unique alphanumeric identifier (i.e. code) which can be read via a bar code scanner. Juvenile/sub adult frogs (<40 mm snout vent length) may be marked in accordance with the animal care and ethics licence of the Project Ecologist or frog expert.
- For each frog, the following information will be collected:
  - Location according to demarcated survey zone;
  - Distance from the stream edge;
  - Position within the microhabitat (i.e. under litter, exposed, on rock/log)
  - Sex (male, female, unknown);
  - Breeding condition with:
    - males assessed on the colouration of their nuptial pads (i.e. no colour, light, moderate, dark);
    - females based on whether they are gravid or not gravid (egg bearing).
- Snout-vent length (mm);
- Weight (gms); and
- Swab sample to test for the presence of Chytrid fungus. This will be undertaken in year 4 during the summer monitoring event, with one follow up survey if required.

4.2.3 Tadpole Surveys

Tadpole surveys provide an additional means to assess population structure and as to whether frogs are breeding at the site. The survey procedure will be as follows:

- The 1 km transect will be divided up into 100 m zones which will equate to 4-5 zones downstream corridor, one zone within the corridor (i.e. construction site) and 4-5 zones upstream of the road corridor.
- Two bait traps (~300 mm x 200 mm) per 100 m of stream (as described above) and left operating for 3 hrs. This equates to 20 bait traps and 60 hrs of survey effort.
- Tadpole dip-netting to be undertaken opportunistically and the survey effort recorded.

4.2.4 Habitat Surveys

Habitat surveys provide an opportunity to measure changes in the receiving environment over the life of the monitoring program. The following variables will be measured within the 100 m zones of the monitoring transect (as detailed above) from standing at the top of the primary stream bank:

- Over storey Vegetation Cover
- Shrub Cover;
- Ground Cover;
- Litter Cover;
- Bare soil/earth;
- Presence of cattle;
- Number of pools and riffle within the zone;
- Approximate depth of the deepest pool within each zone; and

- Zones that contain frog fencing would be inspected and the number of breaches reported.

Habitat data would initially be collected each year during the spring sampling period and the need for additional habitat monitoring would be subject to review. This data would then be used to formulate a subjective scale of habitat quality at each site (i.e. good, moderate, low).

4.2.5 Other Data

Abiotic variables collected during each survey will include:

- Rainfall measured in four scales:
  - During the survey;
  - Within past 24 hrs;
  - Within past 7 days;
  - With past 30 days.
- Relative humidity measured with wet/dry bulb thermometer at the start and finish of the frog survey;
- Air temperature measured with a thermometer at the start and finish of the frog survey;
- Wind speed measured in subjective scale (0= no wind, 1 = light rustles of leaves on trees, 2 = leaves and branches moving and 3 = whole canopy moving);
- Water level measured with a permanently installed water staff or an electronic device if available from the Bureau of Meteorology (BOM).

Anecdotal information including the presence of exotic fish will also be recorded.

Table 4-1. Timing of key actions, responsibilities and documentation requirements for the Giant Barred Frog monitoring program.

Management Action/Year Number	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Responsibility	Documentation Requirements
Pre Construction										
Prepare Giant Barred Frog Management Strategy	√								RMS	Construction Environmental Management Plan
Construction										
Habitat Protection		√	√	√					Contractor	Ecological Monitoring Program
Pre-clearing Surveys		√	√						Contractor	Ecological Monitoring Program Post Clearing report Giant Barred Frog Management Strategy
Temporary Frog Fencing		√	√						Contractor	Construction Environmental Management Plan
Permanent Frog Fencing			√	√					Contractor	Ecological Monitoring Program
Unexpected Finds Procedure		√	√	√					Contractor	Giant Barred Frog Management Strategy Ecological Monitoring Program
Post Construction/Operation										
Monitoring effectiveness of mitigation				√	√	√	√	√	RMS	Ecological Monitoring Program - Annual reporting

5.0 PERFORMANCE MEASURES

5.1 Ways to Assess Successful Performance of the Management Strategy

Performance indicators of success will be based on either the:

- Continued presence of Giant Barred Frog along any part of the 1 km transect. This approach compensates for the mobile habitats of this species and the shifting patterns of seasonal habitat use;
- The recapture of one or more Giant Barred Frog following their relocation from the clearing footprint (if this occurs); or
- The presence of tadpoles, metamorphs or juveniles frogs during follow up surveys post construction.

5.2 Ways to Assess Unsuccessful Performance of the Management Strategy

Signs of the management strategy being unsuccessful will be based on the following six parameters:

1. Absence of Giant Barred Frog from the monitoring transect once construction has started.

Corrective Action – To employ more broad-scale surveys to determine presence of Giant Barred Frogs further upstream or downstream.

2. Giant Barred Frog injured or dying during the clearing and grubbing program.

Corrective Action –Review the clearing procedures and if necessary the performance of the Project Ecologist or frog specialist undertaking the works. Review the temporary frog fence structure and the need to implement additional controls and/or surveys.

3. Giant Barred Frog being struck by vehicles during either the construction or operational phase of the project.

Corrective Action – Review the integrity of the fence, its design, its extent for either the temporary or permanent fencing.

4. Procedures not being implemented as per the approved Giant Barred Frog management strategy unless the change or adoption of different techniques can be substantiated by a frog expert familiar with the ecology and behaviour of this species.

Corrective Action – Review the procedures that have been implemented. Seek advice from Environment Protection Authority to demonstrate transparency.

5. The detection of chytrid fungus ‘sick and dying’ frogs.

Corrective Action – Seek advice from Environment Protection Authority for current best practise.

6.0 REPORTING COMMITMENTS

The contractor will submit an annual monitoring report to Roads and Maritimes Services for review. Roads and Maritime Services will then provide a final copy of the report for information purposes to the Environment Protection Agency and the Department of Planning and Infrastructure.

For the Oxley Highway to Kempsey Upgrade, the baseline survey report will be submitted prior to the clearing and grubbing program commencing anywhere within 500 m of either Cooperabung Creek, Smiths Creek, Pipers Creek and Maria River. This should represent a ‘hold point’ for this stage of the Oxley Highway to Kempsey Upgrade but it should not prevent clearing and grubbing from other parts of the project corridor.

The subsequent monitoring reports will provide an assessment on the performance of the management strategies as per section 5.0 of this document.

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APPENDIX D – GREEN THIGHED FROG MANAGEMENT STRATEGY

Roads & Maritime

Oxley Highway to Kempsey

Green-Thighed Frog Management Strategy

Commercial in Confidence

Disclaimer

The client (SMEC-Hyder Joint Venture) may only use this document for the purposes for which it was commissioned. This report relies upon data, surveys, measurements and results based on a short-term objective study in response to earlier discussion with Roads and Maritime Services staff and a subsequent brief provided by the SMEC-Hyder Joint Venture and their representative: Kate Wiggins). Although conclusions have been based on the available data at the time, some professional judgement has been applied in reaching these conclusions due to the temporal limitations arising from the dynamic nature of available information, legislation, schedules, individual species and associated habitats. Every attempt has been made to ensure the accuracy and objectivity of the report's findings, conclusions and recommendations. Lewis Ecological Surveys does not accept responsibility for its use beyond the scope of works.

....
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ABBREVIATIONS

Abbreviation	Description
OH2K	Oxley Highway to Kempsey Pacific Highway Upgrade
OH2Ku	Oxley Highway to Kundabung Staged Construction of the OH2K Approval
K2K	Kundabung to Kempsey Construction of the OH2K Approval
MCoA	Ministers Condition of Approval
EPA	Environmental Protection Authority
RMS	Roads and Maritime Services
JV	SMEC – Hyder Joint Venture
LES	Lewis Ecological Surveys
Vulnerable	Species listed as vulnerable under schedule two of the NSW *Threatened Species Conservation* Act (1995)

1.0 INTRODUCTION

1.1 Background

Lewis Ecological Surveys (LES) has been contracted by the SMEC-Hyder Joint Venture (SHJV) to prepare a management strategy for the Green-thighed Frog (*Litoria brevipalmata*) as part of the Oxley Highway to Kempsey Pacific Highway Upgrade project. This species is currently listed as 'vulnerable' pursuant to the NSW *Threatened Species Conservation* Act (1995) but it is not currently listed on the *Environmental Protection and Biodiversity Conservation* Act (1999). Factors implicated in the decline of the Green-thighed Frog include habitat destruction and modification particularly the coastal lowlands which apparently form important breeding habitats (Ehmann 1997; Lemckert *et al.* 1997; Lemckert 1999).

Within the Port Macquarie to Kempsey area, the Green-thighed Frog is known from 28 localities scattered from the Sancrox area north through Cairncross State Forest, Rawdon Creek, Kalateenee State Forests and areas fringing Kempsey (Figure 1-1; OEH 2013). The Environmental Assessment (EA) prepared for the Oxley Highway to Kempsey Pacific Highway Upgrade recorded the Green-thighed Frog in Maria River State Forest with 10 males recorded calling from a flooded area and their desktop surveys revealed existing populations in Cooperabung Nature Reserve and further south at Rawdon Creek Nature Reserve (GHD 2010). The Environmental Assessment concluded the proposal would have an impact on the Green-thighed Frog and identified the need to perform targeted surveys prior to construction and allow for minor refinements to the design and/or appropriate mitigation measures. This report documents the findings of these targeted surveys and provides a management framework to reduce impacts on the Green-thighed Frog during the construction and operational phases of the Upgrade. In this context it has been prepared to address components within MCoA B31 (b) Construction Flora and Fauna Management Sub Plan and specifically (v):

A management strategy for the Green-thighed frog and Giant Barred Frog in the case that the pre construction surveys identify the presence of these speciesor its habitats in the project corridor or its vicinity. The strategy shall include details of the measures to avoid, minimise and mitigate impacts to these species.

1.2 Subject Species

1.2.1 Description

The Green-thighed Frog is a small to medium sized (max. 47 mm) hylid frog (Mahony 1993; Barker *et al.* 1995; Cogger 1995; Lemckert *et al.* 1997; Lemckert 1999; Murphy and Turnbill 1999; Lewis 2000). It is a relatively distinct species with a prominent white upper lip, armpits and groin marked in lime green with black markings (Barker *et al.* 1995; Cogger 1995; Lemckert 1999).

Plate 1-1. Green-thighed Frog.

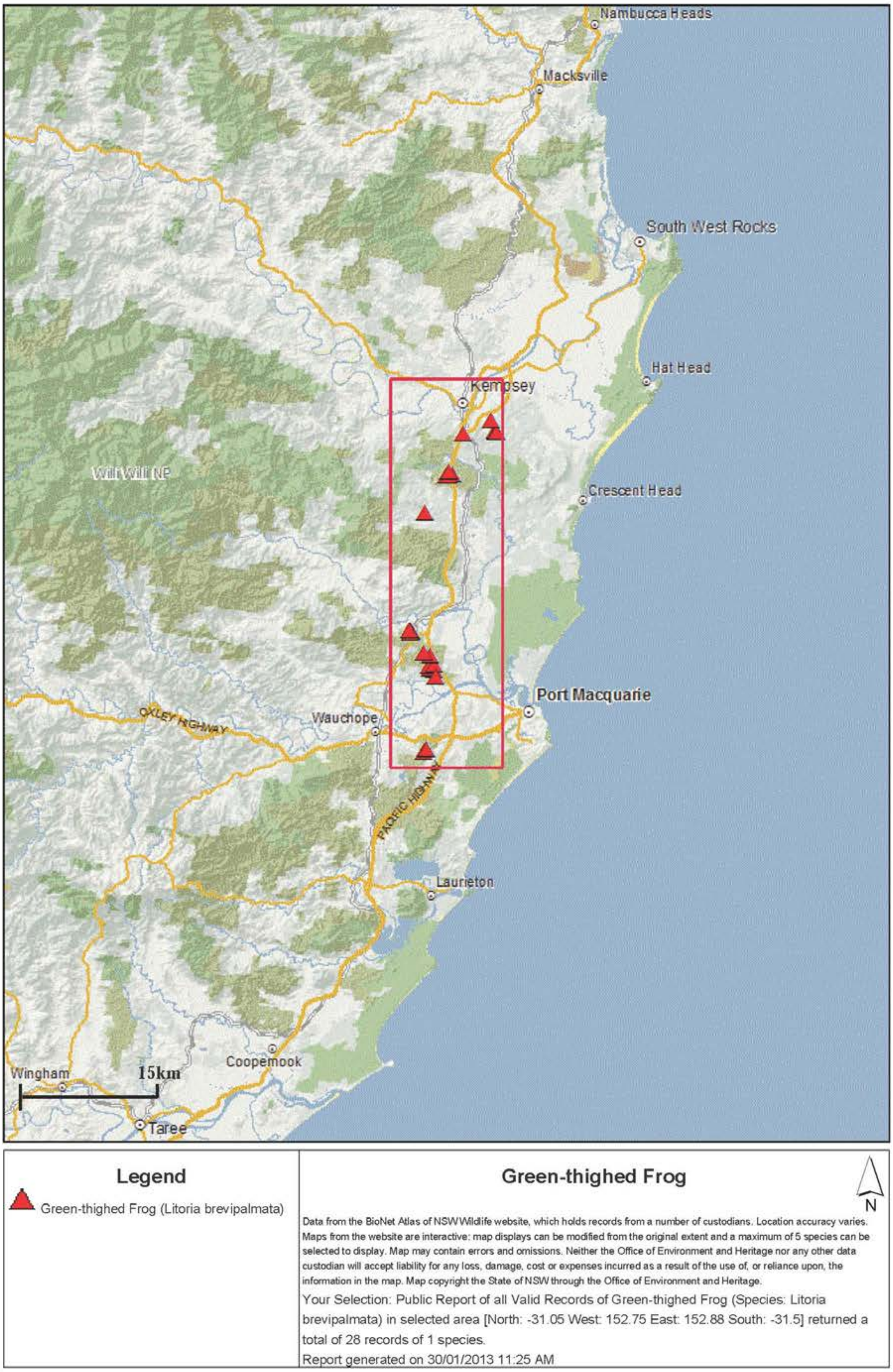

Figure 1-1. Location of documented Green-thighed Frog records prior to the targeted survey.

1.2.2 Distribution

The Green-thighed Frog is distributed in coastal and sub coastal areas from near Bundaberg (Cordalba) in the north to Ourimbah (i.e. central coast NSW) in the south (Mahony 1993; Barker *et al.* 1995; Cogger 1995; Lemckert *et al.* 1997; Lemckert 1999; Murphy and Turnbill 1999; Lewis 2000). Despite this relatively wide distribution, it is known from few areas (Mahony 1993; *see* Ehmann 1997; Lemckert *et al.* 1997; Murphy & Turnbill 1999).

1.2.3 Habitat and Ecology

The cryptic habits of the Green-thighed Frog ensured it remained unknown to science until 1972 (Tyler *et al.* 1972). The main habitat requirement of this species is warm temperate lowland forest, although more recent records have indicated other habitat types including dry sclerophyll forest, heathland and swamp forest are used (Tyler 1992; Nattrass and Ingram 1993; Lemckert 1999; Murphy and Turnbill 1999; Lewis 2005). The Green-thighed Frog is most often detected during breeding events between October and April when males congregate around flooded depressions and call from either the ground or low fallen branches or vegetation (Mahony 1993; Barker *et al.* 1995; Ehmann 1997; Lemckert *et al.* 1997; Lemckert 1999). Typically, calling events occur when the breeding site has received at least 75 mm in 24 hours or around 150 mm over a 72 hour period (B. Lewis unpublished data).

2.0 TARGETED FIELD SURVEYS

2.1 Field Techniques

Site reconnaissance surveys were undertaken between August and December 2012 when almost all drainage lines and potential inundation areas were visited between chainages 0-37750. From this, 27 areas were identified as the most likely locations for Green-thighed Frog and subject to remote weather monitoring using the rainfall prediction, 24 hour rainfall totals and radar tabs on the Beauru of Meteorology Website (www.bom.gov.au). Field surveys were then undertaken between the 27th–30th January 2013 when the study area received in excess of 200 mm over a 48 hour period (Table 2-1; Figure 2-1). The entire study area was then traversed either on foot or by vehicle with 27 sites established along with a reference site located in the northern study area (Kemps Road E:483801 N:6554893; Figure 2-1). Each site was then visited between 1-3 occasions to listen for calling males with an estimate provided on the calling intensity.

The sites were again revisited on the 28th March 2013 to investigate the overall success of the January breeding event. This time period was approximately 57 days after the calling/breeding event and was deemed a suitable median between shaded and unshaded breeding sites for Green-thighed Frog[1]. During these surveys active searches were performed for 20 minutes to survey for metamorphs around the pond edges and the surrounding vegetation, litter and beneath logs. Dip-netting for tadpoles was also undertaken.

Table 2-1. Summary of the rainfall data leading up to and shortly after the breeding site field survey.

Station Name	24th January (mm)	25th January (mm)	26th January (mm)	27th January (mm)	28th January (mm)	29th January (mm)	30th January (mm)	7 Day Total (mm)
Maria River	2.5	11	19	58	106	126	6.5	**329**
Telegraph Point (WTP)	0	14	17	No data	76	142	8.4	**257.4**
Port Macquarie Airport	0	6.8	2.2	71	108	144	17	**349**

2.2 Results

2.2.1 Distribution of Breeding Sites

Green-thighed Frogs were recorded from seven locations scattered between Cairncross State Forest (ch. 9050; Blackmans Point Road) north to Kalateenee State Forest (ch. 33650) approximately 0.5 km south of the Bloodwood Ridge Rest Area (Table 2-2). Frogs were also recorded in Ballengarra State Forest (i.e. Barrys Creek) and associated with Sub tropical Floodplain Forests bordering Pipers Creek and to a lesser extent Smiths Creek. A summary of the recorded sites is provided in Table 2-2.

[1] Tadpoles take longer to develop at shaded sites whilst at unshaded sites metamorph frogs would be expected to occur around the margins of the pond. At present, constructed ponds normally seek to replicate a drying period of between 40 (exposed unshaded sites) to 80 days (shaded locations).

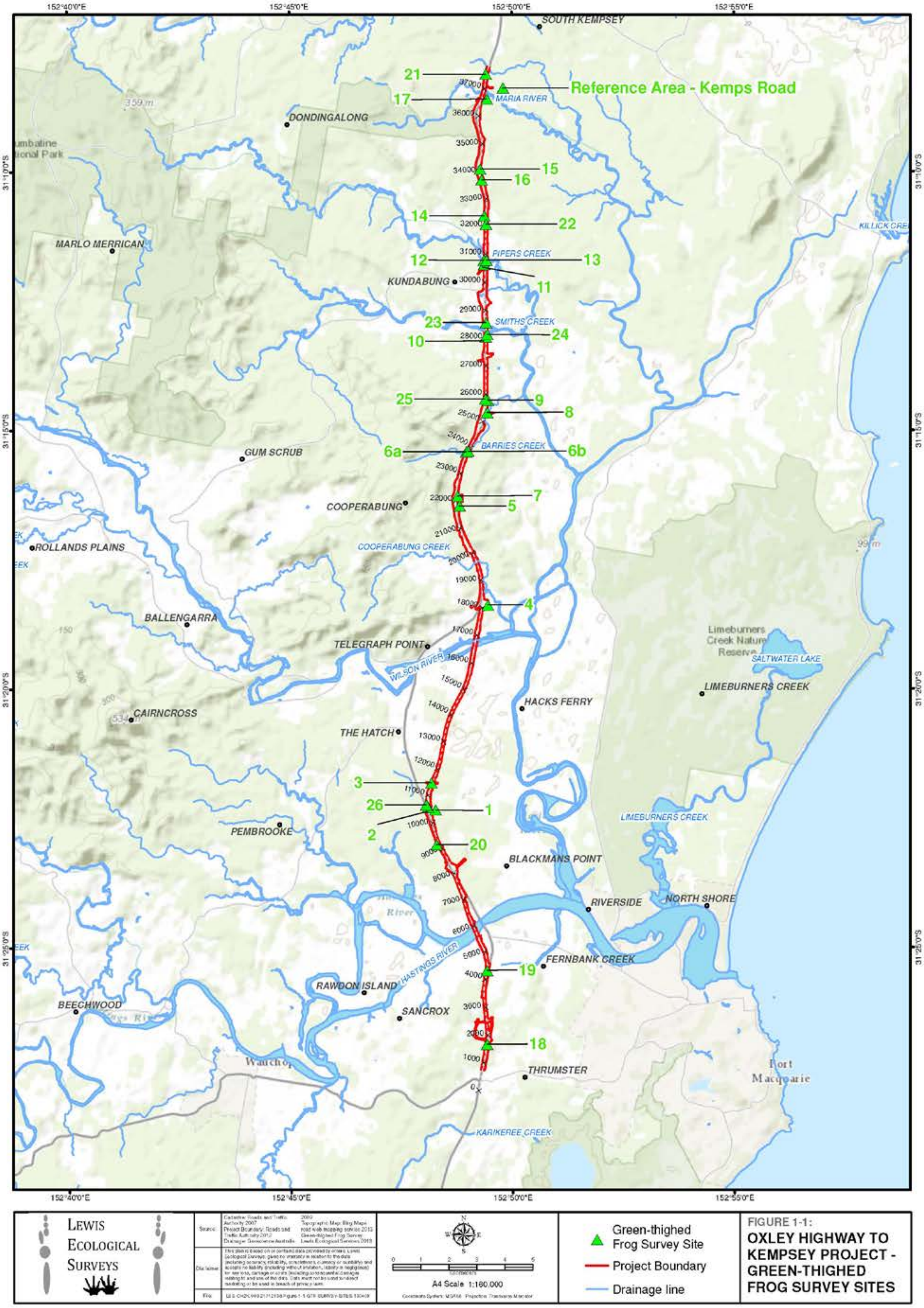

Figure 2-1. Distribution of survey sites across the Upgrade.

Table 2-2. Summary of sites where Green-thighed Frog were recorded in January 2013.

Site No	Easting	Northing	Chainage	Broad Location Details	Number of Green-thighed Frogs Calling	Breeding Site Survey	Notes
Oxley Highway to Kundabung							
20	481443	6527873	9050 & 9350	Blackmans Point Road	> 3 males calling on western side of highway. Another 2-3 males calling 300 m north on the eastern side of highway.	• No tadpoles, metamorphs or juvenile frogs recorded. • Dry except for two small pools at the inlet side of the culvert.	• Likely to inhabit most of the 1st order stream areas in Cairncross State Forest. • Tadpoles probably develop quickly at these sites in perhaps 30-35 days.
6b	482560	6541920	23900	Barrys Creek East	1	• No tadpoles, metamorphs or juvenile frogs recorded. • Dry but some moist depressions.	• Single male calling intermittently to the north east of the RMS gravel dump area. • More suitable areas further to the east well beyond the construction footprint.
Kundabung to Kempsey							
23	483196	6546517	28350	Northern side of Smiths Creek on west side	5 - 7 males calling	• No tadpoles, metamorphs or juvenile frogs recorded. • Moist depressions adjacent to the drainage line. Drainage line still contains pools of water but these are unlikely to represent suitable breeding sites.	• Sporadic choruses of frogs. • More suitable areas further west outside of the construction footprint.
25	483168	6543783	29050	South of Wharf Road	1	• No tadpoles, metamorphs or juvenile frogs recorded. • Some small pools of water to 100 mm depth.	• Male calling intermittently on the western side. • Likely to be more suitable habitat elsewhere beyond the construction footprint.

Site No	Easting	Northing	Chainage	Broad Location Details	Number of Green-thighed Frogs Calling	Breeding Site Survey	Notes
11	483125	6548582	30650	South west side of Pipers Creek	>10	• No tadpoles, metamorphs or juvenile frogs recorded. • Some small pools of water to 30 mm with tadpoles of other species seeking refuge in leaf litter.	• Males chorusing in regrowth Acacia vegetation around 30-40 m west of existing highway.
13	483219	6548748	30775	Pipers Creek north on Geotech Access Road	2	• No tadpoles, metamorphs or juvenile frogs recorded. • Main pool and calling site still contains approximately 300 mm of water.	• Males calling from flooded depression 30 m east of existing highway. • Other areas of suitable habitat further to the east.
16	483046	6551609	33650	South east of Bloodwood Rest Area on top of cut with existing powerline easement	Approximately 6-8 males calling	• No tadpoles, metamorphs or juvenile frogs recorded. • Main pools occur on the access track running east across the powerline easement. Pool depth still 50-100 mm.	• Males calling in this area but breeding site likely to require follow up rain to be successful. • Site likely to be disturbed by recreational and power line maintenance vehicles accessing this area.
Reference Area - Kemps Road	483801	6554893	37100	Around 750 m east of highway along Kemps Road. Location includes the Kempsey to Eungai Biodiversity offset Land known as the Norton Block	1-2	• Not surveyed as used other reference sites on the Kempsey Bypass Project.	• Only 1-2 heard intermittently calling at dark. • Unaffected by the OH2K Upgrade.

2.2.2 Calling Intensity

The numbers of calling Green-thighed Frogs was usually less than 10 calling males with only the Pipers Creek south site (Site 11; ch. 30650) recorded more than this (Table 2-2). The numbers of calling frogs is likely to have varied throughout the breeding event as is often the case. For example, the reference site at Kemps Road was represented by 1-2 calling males during the March 2013 survey compared to between 4-8 males calling at this same site in January 2012 (Lewis 2012). In this context, calling intensity should merely be used as a guide during short term surveys such as this study.

2.2.3 Breeding Sites

No tadpoles, metamorphs or juvenile Green-thighed Frogs were recorded at the breeding sites. Sites 11 (Pipers Creek south; ch. 30650), 13 (Pipers Creek north; ch. 30775), 16 (Bloodwood Rest Area; ch. 33650) and 23 (Smiths Creek north; ch. 28350) contained standing water at 57 days whilst the remaining three sites contained moist depressions with no visible standing water.

2.3 Discussion

Targeted surveys have confirmed the construction footprint for the Oxley Highway to Kempsey Upgrade will remove or impact on at least seven breeding and non breeding habitat areas for the Green-thighed Frog. This includes most of the low lying areas within Cairncross State Forest between ch. 8900 and ch. 12200, scattered lower slopes north of Cooperabung Hill to the Mingaletta area (ch. 22500-25500), areas adjacent to riparian habitats of Smiths Creek and Pipers Creek, and the cut area associated with ch. 36350 in Maria River State Forest.

Although the breeding surveys could not locate tadpole, metamorph or juvenile frogs they are suspected to have successfully breed and left the pond areas at less than 50 days. Previous surveys in the Kempsey and Eungai areas have shown that tadpoles of this species can start to reach metamorphosis in as little as 28 days (B. Lewis unpublished data). In a number of instances, the Upgrade is considered to lie adjacent to more suitable breeding habitat for the Green-thighed Frog. For example, the recorded area at Barrys Creek (ch. 23900) occurs at the edge of an RMS gravel laydown area whilst land further to the east is considered more suitable. Where this occurs it does not seem necessary to create ponds to entice the frogs closer to the carriageway.

The following management strategies in section 3 will provide the necessary framework to manage the impacts on the known populations of Green-thighed Frog and make allowances for any unknown populations.

3.0 MANAGEMENT & MONITORING STRATEGIES

Seven management strategies have been proposed as a means to avoid, minimise, mitigate and monitor impacts to Green-thighed Frog. They include:

1. **Identification of Green-thighed Frog habitat**
2. **Protection of existing habitat**
3. **Pre-clearing surveys**
4. **Creation of breeding ponds**
5. **Design and installation of permanent frog fencing**
6. **Unexpected finds procedure linking to strategies 2-5 and 7**
7. **Monitoring of the breeding pond areas and associated frog fencing**

A summary of these actions and the associated technique is shown in Table 3-1.

3.1 Identification of Green-thighed Frog Habitat

The targeted pre construction survey has confirmed the presence of Green-thighed Frog at the following locations:

- Oxley Highway to Kundabung:
    - Cairncross State Forest ch. 9050 and 9350;
    - Barrys Creek (ch. 23900).
    - Northern Cairncross State Forest (ch. 11500 – 11800) (identified as potential habitat, to be managed as known Green-thighed Frog habitat.
- Kundabung to Kempsey:
    - Smiths Creek north (ch. 28350)
    - Wharf Road south (ch. 29050)
    - Pipers Creek south (ch. 30650);
    - Pipers Creek north (ch. 30775); and
    - Bloodwood Rest Area (ch. 33650).

The areas of identified Green-thighed Frog habitat are shown in Figure 3-1 a-f.

Clearing of vegetation in the above identified locations should be kept to a minimum in accordance with MCoA:

C1. The Proponent shall employ all feasible and reasonable measures to minimise the clearing of native vegetation during the construction of the project

C28 Unless otherwise approved by the Director General in accordance with this condition, the sites for ancillary facilities associated with the construction of the project shall (c) be located in areas of low ecological significance and require minimal clearing of native vegetation (not beyond that already required by the project).

The protection of the eight identified Green-thighed Frog habitat areas should include the demarcation of clearing limits and protection of vegetation outside clearing limits. Vegetation to be protected will be fenced and signed as environmentally sensitive areas.

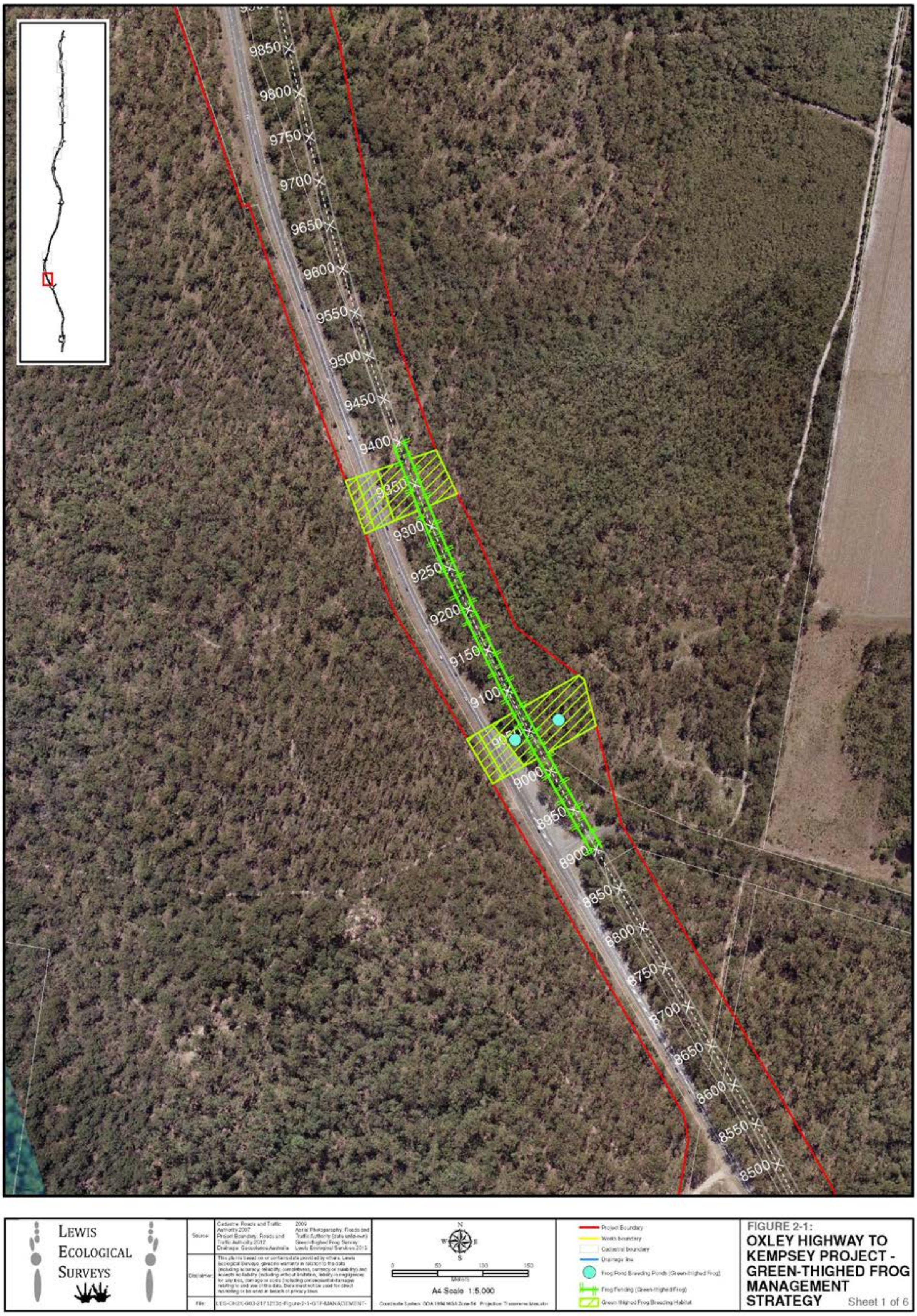

Figure 3-1a. Known Green-thighed Frog locations in southern Cairncross State Forest and the proposed mitigation strategies.

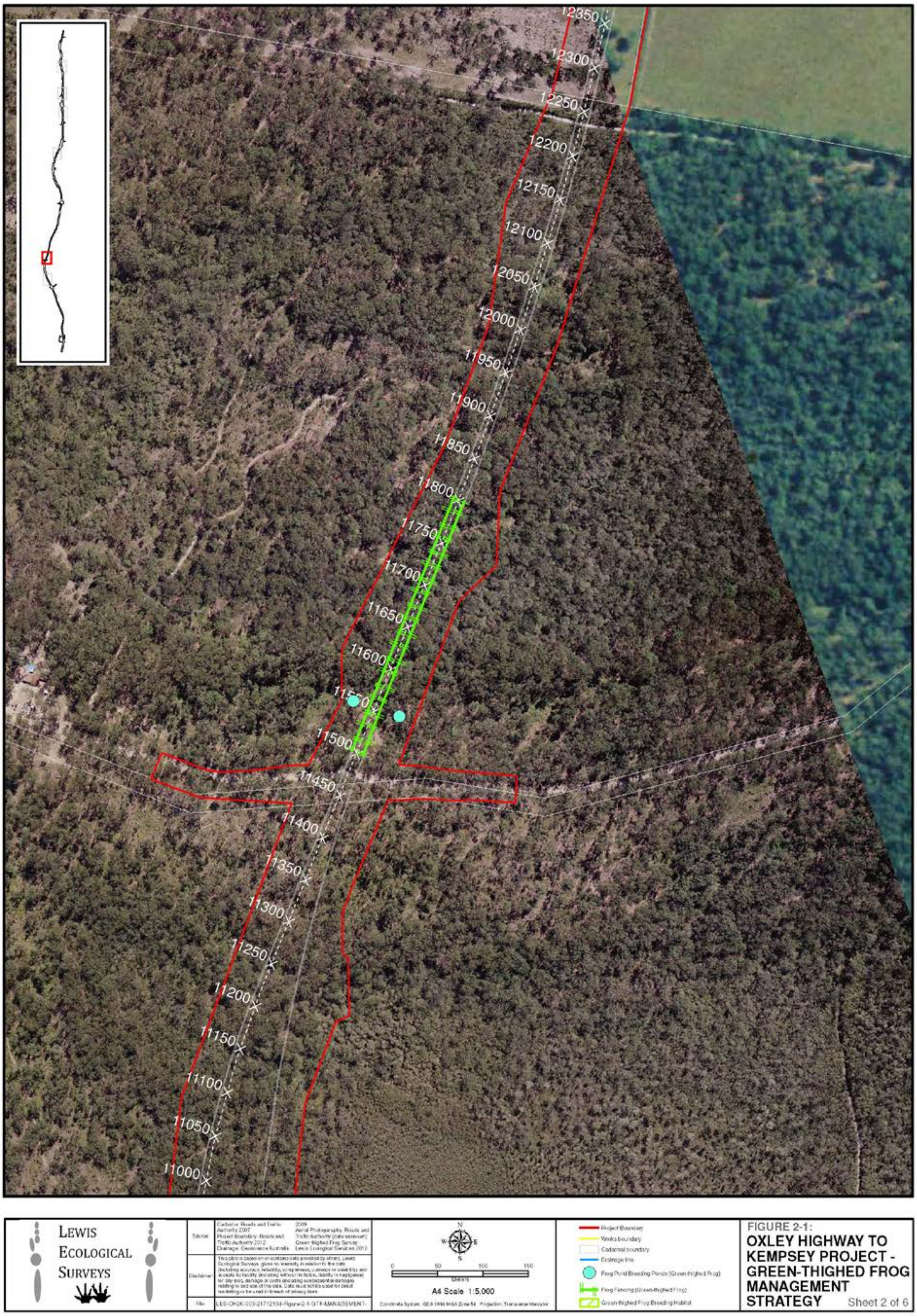

Figure 3-1b. Likely Green-thighed Frog habitat in the northern extent of Cairncross State Forest and the proposed mitigation strategies.

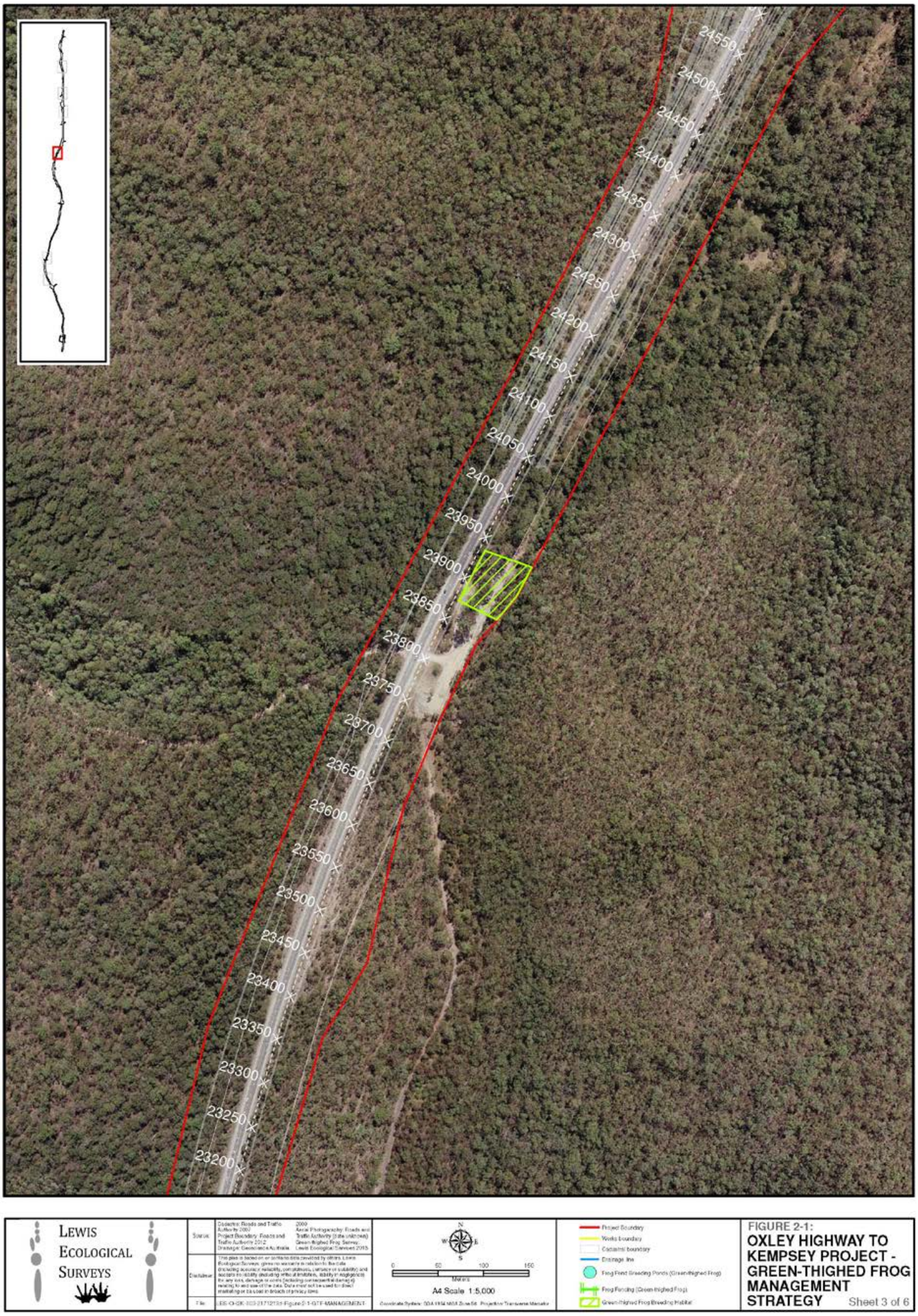

Figure 3-1c. Green-thighed Frog habitat at Barrys Creek.

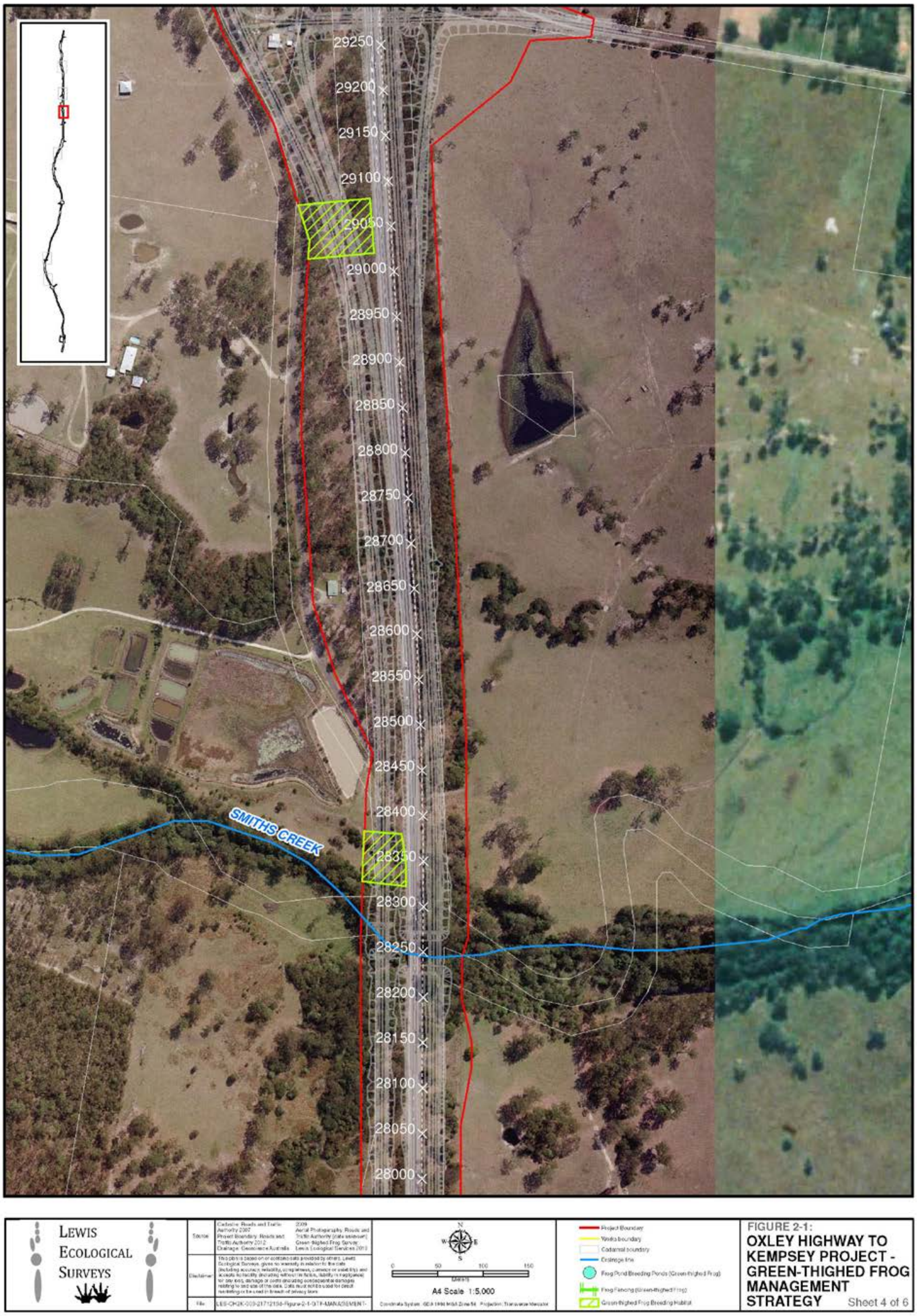

Figure 3-1d. Green-thighed Frog habitat associated with Smiths Creek to Wharf Road.

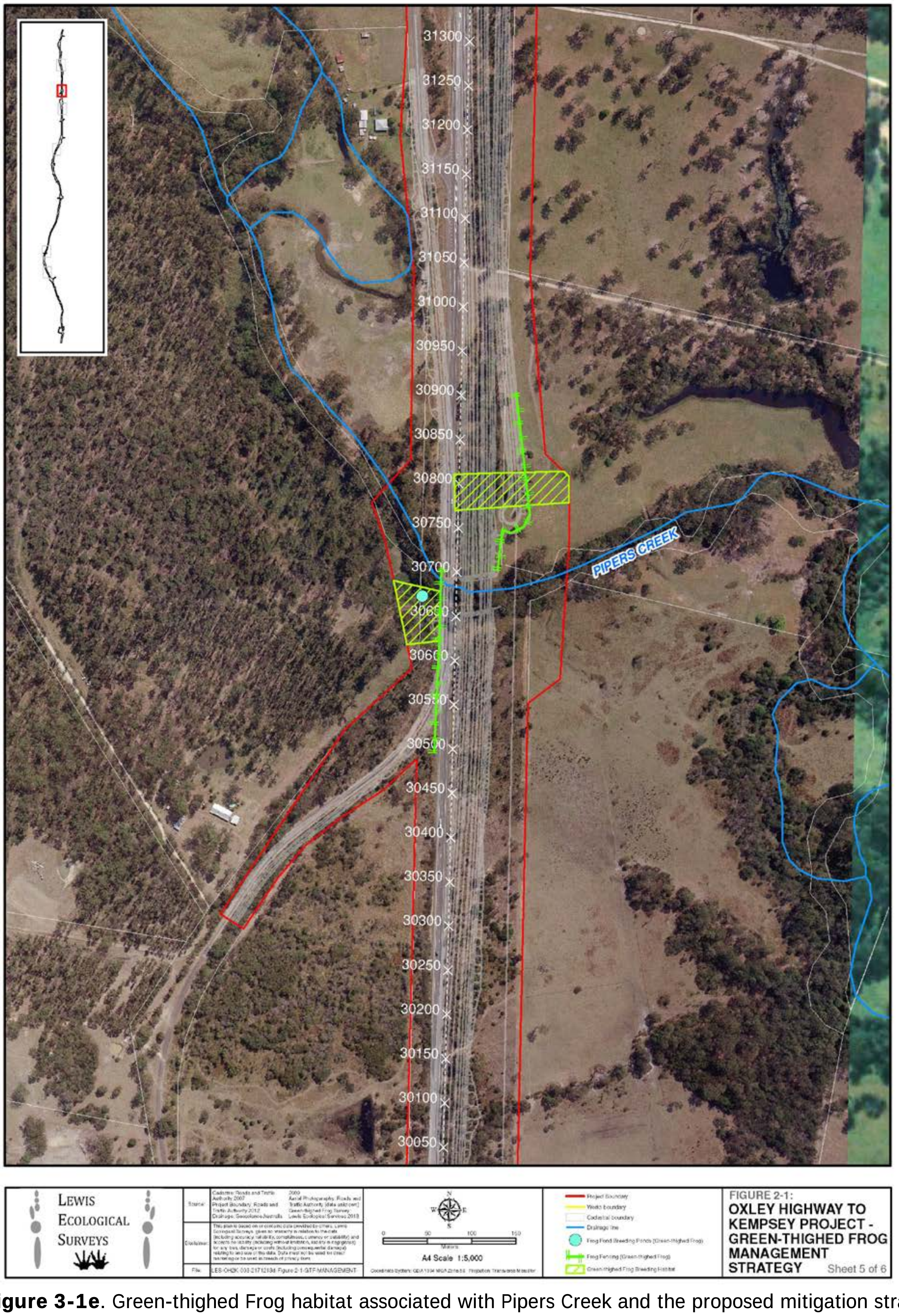

Figure 3-1e. Green-thighed Frog habitat associated with Pipers Creek and the proposed mitigation strategies.

Figure 3-1f. Green-thighed Frog habitat associated with ch. 33650 and the proposed mitigation strategies.

3.2 Protection of Existing Habitat

The identified Green-thighed Frog habitat areas must be protected from construction related works other than what is considered essential. The locating of access tracks, utilities redistribution, car parking facilities and other ancillary works including topsoil stock piles, lay down areas, wash down bays, site shedding and compound sites must not be located in these areas. This approach will be in accordance with MCoA C1 and C28:

Due consideration is required for drainage works and the design given that road projects of this nature normally improve drainage rather than impede it for Green-thighed Frog. Accordingly, construction and operation of the Project will ensure that drainage paths and the quantity and quality of water are maintained to Green-thighed Frog habitat. In addition, in areas where the most suitable breeding habitat will be removed, frog breeding ponds will be constructed. Frog breeding ponds should provide an adequate mitigation tool provided they are constructed correctly (*see* Section 3.4).

3.3 Pre-clearing Surveys

The Project Ecologist will conduct frog surveys consisting of active searches set at 15 minutes per hectare of suitable microhabitats immediately prior (<2 hours) to commencing clearing operations. Active searches will involve the use of a small wrecking bar or rake to actively turn rocks, logs, rake debris and search within low dense vegetation around depressions and drainage lines. The requirement for nocturnal surveys is to be made at the discretion of the Project Ecologist performing the pre clearing surveys.

Captured frogs will be held temporarily in a plastic bag with a small amount of water (1 frog per bag) and relocated in areas of suitable habitat adjacent to the clearing footprint and not more than 200 m from the capture site. At this time, a swab sample test for the presence of Chytrid fungus will be performed and the results used to inform a frog hygiene protocol at each Green-thighed Frog site, as required. This is consistent with the EPA Hygiene protocol for the control of disease in frogs (*see* NPWS 2001).

3.4 Creation of Breeding Ponds

Frog breeding ponds will be constructed at four locations, two within the Oxley Highway to Kundabung Upgrade section and two within the Kundabung to Kempsey section (Table 3-1; Figure 3-1a-f). Those remaining areas where breeding ponds have not been proposed are due to the adjacent environment containing suitable alternative breeding areas which are expected to remain unaffected by the Upgrade and often extend into the surrounding area for hundreds of metres[2].

Green-thighed Frog breeding ponds must be designed to ensure the water body periodically dries out. This provides two important advantages for this species, firstly, it reduces competitive interactions with pond dwelling frogs (i.e. Tyler's Tree Frog, *Litoria tyleri*) which are common in the study area, and secondly, it reduces predatory interactions associated with the exotic Mosquito Fish (*Gambusia holbrooki*). Based on site specific data and surveys of breeding sites on the mid north coast including monitoring of constructed Green-thighed Frog ponds at Kempsey, a temporary water body should hold surface water for between 30-40 days at sunny exposed sites and for between 50-60 days at shaded locations following a suitable summer rainfall event of 100-150 mm in 24-36 hours. The design parameters for the four frog breeding ponds required for Oxley Highway to Kempsey are identified in Table 3-1.

[2] Those sites where ponds have been proposed are likely to have the most suitable breeding habitat removed by the Upgrade.

Table 3-1. Summary of proposed Green-thighed Frog breeding pond locations. Ponds constructed as per Plate 3-1.

Site No.	Side of Carriageway	Chainage (north from Oxley Highway)	Design (*see* Plate 3-1)[1]	Landscaping[1]	Substrate[1]	Important Actions[1]
Oxley Highway to Kundabung						
1	Both sides of carriageway	9050-9350	On each side of the carriageway construct: • Five 4x3 m (12m²). • Maximum depth 400 mm. • No steeper than a 1:4 battered slope. • Install a water staff.	• Vegetated after construction • Open swale vegetated with grass or sedges (i.e. *Carax sp.*, *Fimbristylis*).	• In situ soil/clay obtained at or near to the site.	• Locate within and adjacent (<50 m) to the drainage line (southern side) within RMS corridor. • Ponds to support water for up to 30-40 days. • Ponds are to be staggered upslope to allow for variability in rainfall/flooding and hence drying out.
2	Both sides of carriageway	11550	On each side of the carriageway construct: • Five 4x3 m (12m²). • Maximum depth 400 mm. • No steeper than a 1:4 battered slope. • Install a water staff.	• Vegetated after construction • Open swale vegetated with grass or sedges (i.e. *Carax sp.*, *Fimbristylis*).	• In situ soil/clay obtained at or near to the site.	• Project Ecologist to investigate the suitability of ponds in consultation with RMS and EPA and be guided by the results of pre-clearing surveys. • Ponds to support water for 30-60 days (to be determined by Project Ecologist) to compensate for a range of sunny and shaded locations.
Kundabung to Kempsey						
3	Western side of carriageway	30660	On the western side of the carriageway construct: • Five 4x3 m (12m²). • Maximum depth 400 mm. • No steeper than a 1:4 battered slope. • Install a water staff.	• Vegetated after construction • Pond and verges to include native grasses or sedges (i.e. *Fimbristylis* or *Carax sp.*).	• In situ soil/clay obtained at the site.	• Ponds are to be constructed away from riparian zone of Pipers Creek. • Ponds are to support water for 30-60 days (to be determined by Project Ecologist) depending on whether the location is shaded or unshaded.

Site No.	Side of Carriageway	Chainage (north from Oxley Highway)	Design (*see* Plate 3-1)[1]	Landscaping[1]	Substrate[1]	Important Actions[1]
4	Both sides of carriageway	33650	On each side of the carriageway construct: • Five 4x3 m (12m^2). • Maximum depth 400 mm. • No steeper than a 1:4 battered slope. • Install a water staff.	• Vegetated after construction • Pond and verges to include native grasses or sedges (i.e. *Fimbristylis* or *Carax sp*.).	• In situ soil/clay obtained at the site.	• Locate ponds on edge of forest at the top of the cut. • Ponds to support water for 30-days.

[1]These parameters will be constructed as per the requirements of Table 3-1 or as otherwise proposed by the Project Ecologist, in consultation with the EPA.

a. September 2011

b. September 2011

c. March 2012

Plate 3-1. Construction of Green-thighed Frog ponds at Fill 6 Kempsey Bypass project (September 2011-March 2012).

Breeding ponds will not be over designed. Features from other known breeding locations on the mid north coast will be replicated and thus provide the best opportunity for a successful breeding event. A breeding pond requires a simple shallow excavation that will hold water for the required period as this species has been regularly encountered breeding in inundated motor vehicle wheel ruts, disused logging dumps, roadside culverts and eroded gully lines (B. Lewis unpublished data). The Project Ecologist may propose the use of existing *in situ* habitat in lieu of the proposed Green-thighed Frog breeding ponds identified in Table 3-1. The use of *in situ* habitat will be developed in consultation with RMS and the EPA. The design and construction of four breeding ponds will be supervised by the Project Ecologist and must be installed within 12 months of the clearing and grubbing operations in those locations.

3.5 Design and Installation of Permanent Frog Fencing

3.5.1 Temporary Frog Fencing

Temporary frog fencing will be installed at the following location and extents:

- Oxley Highway to Kundabung:
  - Cairncross State Forest between ch. 8900 and ch. 9400 (both sides);
  - Cairncross State Forest between ch. 11500 and 11800 (both sides).
- Kundabung to Kempsey:
  - Pipers Creek south between ch. 30500 and ch. 30700 (west side only) (ch. 30650);
  - Pipers Creek north between ch. 30700 and ch. 30900 (east side only).

The Project Ecologist must assess the need for additional temporary frog fencing based on the results of the pre-clearing surveys. The temporary frog fence should have the following design considerations:

a) Fence height of at least 500 mm[3] and buried to a depth of at least 50mm;
b) Return wing of 3-5 metres to reduce the opportunity for frogs to breach the fence;
c) The installed fence will be inspected/signed off by an ecologist with sufficient frog expertise. This procedure should form part of the pre clearing/ground disturbance checklist/permit.
d) Fencing will be installed within 72 hours of the clearing of the construction footprint[4].

[3] This height is considered sufficient to avoid the need to have a return lip at the top of the fence given its temporary nature and the objective of discouraging frog movement into the construction zone. This would be increased in areas of Giant Barred Frog habitat to 900 mm in height.

3.5.2 Permanent Frog Fencing

Frog fencing will be installed in areas of Green-thighed Frog breeding ponds and / or where there is an obvious threat of frogs accessing the new carriageway. The exception is ch. 33650 where the ponds will be constructed at the top of a large cut where there is a reduced risk of frogs accessing the carriageway. The Project Ecologist is to consider the need for further frog fencing after pre-clearing surveys have been undertaken or in light of new information. The current location and extents include:

- Oxley Highway to Kundabung:
  - Cairncross State Forest between ch. 8900 and ch. 9400 (both sides);
  - Cairncross State Forest between ch. 11500 and 11800 (both sides).
- Kundabung to Kempsey:
  - Pipers Creek south between ch. 30500 and ch. 30700 (west side only) (ch. 30650);
  - Pipers Creek north between ch. 30700 and ch. 30900 (east side only).

Design wise, the permanent frog fencing can be either a standalone fence positioned between the standard fauna fence and the carriageway (i.e. toe of the batter) or integrated into the standard fauna fence in areas outside of drainage lines. From a design perspective, the fence must stand at least 500 mm in height and comprise neoprene rubber sheeting (>4 mm thickness) including a small rubber return of not less 100 mm on the ground. The fence must consist of a hot dip galvanized pressed sheet metal or powder coated aluminum pressed sheet mounted on a galvanized star picket. An example design is shown in Figure 3-2.

The fence must be installed 6 months before the operational phase of the project. This will enable sufficient time to overcome any unforeseen installation problems or delays on materials.

3.5.2.1 Monitoring of Permanent Frog Fencing

As part of the monitoring procedures for measuring the effectiveness of the frog fencing, specific monitoring for frog fencing breaches must be undertaken by a suitably qualified Ecologist at certain times of the year (i.e. when breeding pond monitoring occurs). Moreover, surveys for frogs will be undertaken on either side of the frog fence. The success of this design will be based on the absence of Green-thighed Frog fence breaches. The monitoring of permanent frog fencing will be carried out by RMS as part of the Ecological Monitoring Program.

A conditional report must be prepared as part of the monitoring to identify damages, breaches, requirements for vegetation management along with a corrective action time period of 6 weeks. This information will be presented in a table format within the annual monitoring reports.

[4] It is not considered practical to install a frog fence prior to clearing as it will be damaged during the clearing operation. The pre-clearing survey performed by the Project Ecologist has the objective of capturing frogs within the clearing zone immediately prior to clearing.

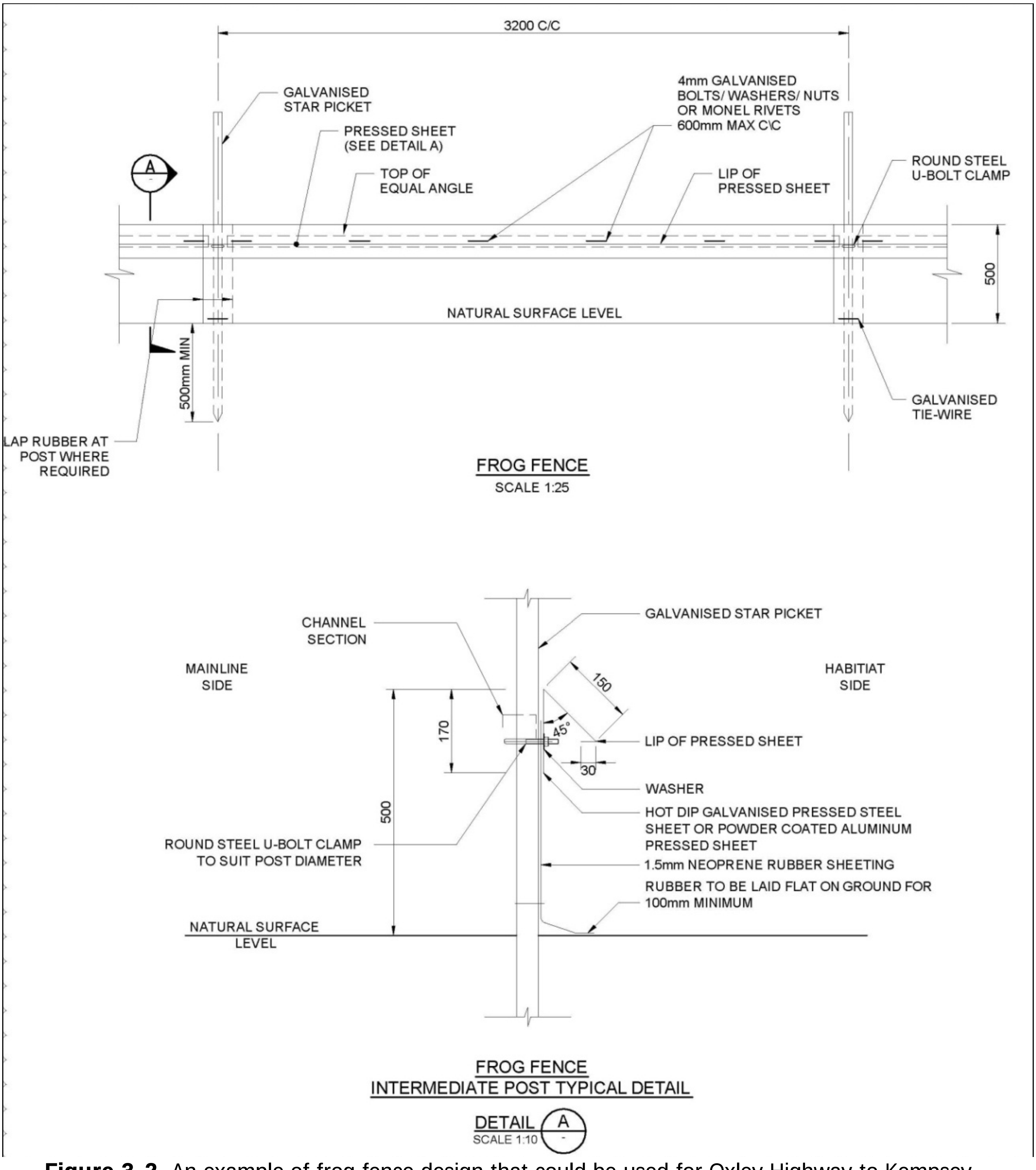

Figure 3-2. An example of frog fence design that could be used for Oxley Highway to Kempsey.

3.6 Unexpected Finds Process

An unexpected finds process will be implemented to manage instances where Green-thighed Frog are detected during pre-clearing surveys or during clearing operations for the Upgrade. In the case where a new location of Green-thighed Frog is recorded and is deemed important breeding habitat by the Project Ecologist the strategies outlined in this plan will be considered and implemented; specifically the provision for protection of existing habitat, creation of breeding ponds, installation of permanent fencing and the associated monitoring outlined in Section 3.7 of this strategy.

3.7 Monitoring of Green-thighed Frogs

Two components have been identified for the monitoring of Green-thighed Frogs:

1) Monitoring of breeding ponds; and
2) Monitoring the integrity of the frog fences

3.7.1 Green-thighed Frog Breeding Ponds

All four breeding pond locations would be monitored; however, the monitoring would be staggered over two construction stages of the project, Oxley Highway to Kundabung and Kundabung to Kempsey.

i. Timing

Monitoring will be undertaken on five occasions in Years 3-7 with each event at least 10-12 months apart but ultimately dependant on rainfall events (Table 3-2). At least one monitoring event will be undertaken during the construction phase of each stage of the Project (identified in Table 3-2 as Year 3). This will also ensure that all the frog mitigation measures have been correctly installed prior to the operational phase. Years 4 – 7 represent the first four years of operation the project.

During each monitoring event the site will be surveyed for 30 minutes during stage 1 and for 20 minutes during stage 2 (see below). Four of the five monitoring events are to occur during the operational phase of the project (Years 4-7). The first round of monitoring (Year 3) is to commence once the vegetation on the edges of the constructed ponds is considered sufficient (>20% groundcover), to be determined by a suitably qualified Ecologist. The timing would be staggered accordingly for either stage of the Upgrade.

ii. Monitoring Procedure

Monitoring of the constructed breeding ponds would be undertaken on a rainfall event basis when 24 hour rainfall totals exceed 75 mm or a cumulative total of 150 mm over a 72 hour period[5]. Such rainfall events would be monitored via ‘on site’ weather stations which are to be programmed to generate a sms message to the field survey team phone, or alternatively, the Bureau of Meteorology (BOM) website. Where sufficient rainfall is unlikely to occur during the monitoring period, the Project Ecologist will determine whether smaller rainfall events are suitable to conduct a monitoring event. The suitability of the rainfall trigger chosen would be subject to the reference site visit outlined in Stage 1 below. Surveys will be performed using a two stage process outlined below.

Stage 1 – Determining Presence and Breeding Activity

Upon the study area receiving the required rainfall, a reference site would be visited to determine the extent of Green-thighed Frog activity. At present, the reference sites used during the course of the current field surveys (*see* Figure 2-1) has been nominated given it is readily accessible, however, alternative sites should be located to counter the variability in the calling behaviour of

[5] 50 mm is often proposed, however, it is rarely considered suitable; B Lewis unpub data.

this species and the staged construction of the Upgrade. Regardless of the outcomes of this survey, the constructed ponds and their surrounds will also be surveyed.

The survey will comprise a 30 minute nocturnal active search at each of the four breeding pond areas using a hand held spotlight. Peripheral habitats (i.e. <50 m) would also be surveyed at this time. Upon the completion of Stage 1 surveys the next stage would be implemented.

Stage 2 – Determining the Success of the Breeding Event

All frog breeding pond sites would be subject to follow-up (Stage 2) surveys between 30-40 days after the Stage 1 survey to assess the outcome of the breeding event. This Stage 2 survey will comprise:

- A 20 minute active search for metamorphs and juvenile frogs around the pond edge and vegetation immediately adjacent to the pond (i.e. <10 m);
- Dip-netting of the constructed pond and subsequent tadpole identification. Specific attention will be given toward identifying the presence of fish (both native and exotic) along with predatory invertebrates such as dytiscid larvae;
- The depth of the ponds will be measured from the permanently installed water staff; and
- Photos will be taken from a designated photo point (to be established during the first Stage 2 survey event).

iii. Performance Indicators

Performance indicators of success will be based on either the:

- Continued presence of Green-thighed Frog at three or more of the four frog breeding pond sites;
- Green-thighed Frogs calling from the edge of the frog breeding ponds; or
- The presence of tadpoles, juveniles or metamorphs at the frog breeding ponds during Stage 2 surveys.

Signs of the mitigation being unsuccessful will be based on the:

- Absence of Green-thighed Frogs from one or more of the four sites. The corrective action for this would be to firstly, implement additional surveys of adjacent areas to confirm Green-thighed Frogs remain in that general area, and secondly, undertake a review and if deemed necessary modify the ponds to improve any site suitability problems;
- Ponds not holding water for a sufficient time to enable tadpoles to reach metamorphosis. The corrective action for this would involve a review and if deemed necessary, modify the ponds by placing a semi permeable layer or further excavation; and
- Ponds holding water for too long and representing unsuitable habitat (i.e. permanent versus ephemeral). The corrective action for this would be to improve drainage to ensure the pond dries out.
- Exotic fish fauna recorded in breeding ponds. The corrective action for this would be to improve drainage to ensure the pond dries out.

The monitoring of Green-thighed frog breeding ponds as detailed in this plan will be carried out by RMS as part of the Ecological Monitoring Program.

A summary of the timing, responsibilities and documentation requirements is outlined below in Table 3-2.

Table 3-2. Timing of key actions, responsibilities and documentation requirements.

Management Action/Year Number	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Responsibility	Documentation Requirements
Pre Construction									
Prepare Green-thighed Frog Management Strategy	√							RMS	Construction Environmental Management Plan
Construction									
Habitat Protection		√	√	√				Contractor	Ecological Monitoring Program
Pre-clearing Surveys		√	√					Contractor	Ecological Monitoring Program Post Clearing report Green-thighed Frog Management Strategy (updated)
Temporary Frog Fencing		√	√					Contractor	Construction Environmental Management Plan
Permanent Frog Fencing			√	√				Contractor	Ecological Monitoring Program
Breeding Ponds			√	√				Contractor	Ecological Monitoring Program
Unexpected Finds Procedure		√	√	√				Contractor	Green-thighed Frog Management Strategy (updated) Ecological Monitoring Program
Post Construction/Operation									
Monitoring effectiveness of mitigation			√	√	√	√	√	RMS	Ecological Monitoring Program - Annual reporting

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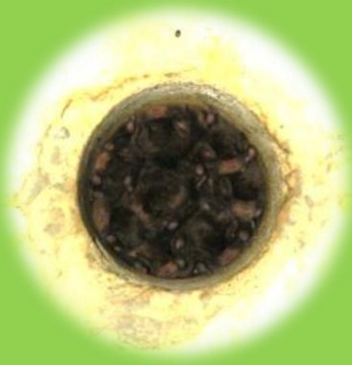
APPENDIX E – MICROBAT MANAGEMENT STRATEGY

PACIFIC HIGHWAY UPGRADE:

OXLEY HIGHWAY TO KEMPSEY

MICROCHIROPTERAN BAT MANAGEMENT STRATEGY

MAY 2013



PREPARED FOR SMEC-HYDER JOINT VENTURE BY:

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Disclaimer

The client (Smec-Hyder Joint Venture) may only use this document for the purposes for which it was commissioned. This report relies upon data, surveys, measurements and results based on a short-term objective study in response to earlier discussion with Roads and Maritime Services staff and a subsequent brief provided by the Smec-Hyder Joint Venture and their representative: Kate Wiggins. Although conclusions have been based on the available data at the time, some professional judgement has been applied in reaching these conclusions due to the temporal limitations arising from the dynamic nature of available information, legislation, schedules, individual species and associated habitats. Every attempt has been made to ensure the accuracy and objectivity of the report's findings, conclusions and recommendations. Lewis Ecological Surveys does not accept responsibility for its use beyond the scope of works.

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…30th May 2013………
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Narawan Williams (Lewis Ecological Surveys) – Bat call analysis.

Photography - Lewis Ecological Surveys © else stated

Top – Smiths Creek Bridge which provides breeding habitat for the vulnerable Southern Myotis (*Myotis macropus*).

Centre – Maria River Bridge (north bound) with the historic Doolan design bridge (background) both provide bat habitat along the Maria River.

Left to Right – Little Bent-wing Bats (*Miniopterus australis*) utilising vertical drainage points in structure 599035; Eastern Horseshoe Bat (*Rhinolophus megaphyllus*) roosting in 599026 during a winter survey; Bent-wing Bats utilising a large vertical drainage point in structure 599011.

Report to be cited as: Lewis, B.D (2013). Oxley Highway to Kempsey: Microchiropteran Bat Management Strategy. Report prepared for SMEC-Hyder Joint Venture by Lewis Ecological Surveys. ©

Distribution History

Version	Date	Issued To	Position	Name
A	5th March 2013	Hyder Consulting	Environmental Team Leader	Kate Wiggins
B	19th March 2013	Hyder Consulting	Environmental Team Leader	Kate Wiggins
C	30th May 2013	Hyder Consulting	Senior Environmental Consultant	Zoe Wood
C	30th May 2013	Hyder Consulting	Ecologist	Jane Rodd
C	30th May 2013	Hyder Consulting	Assistant Project Manager	Kevin Radford

Revision History

Rev.	Description	Prepared By	Date	Reviewed By
A	Draft for Comment	Ben Lewis t/a Lewis Ecological Surveys	16th March 2013	Kate Wiggins (Hyder Consulting)
B	Updates to Version B	Ben Lewis t/a Lewis Ecological Surveys	23rd May 2013	Chontelle Perucich (RMS)

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ABBREVIATIONS

Abbreviation	Description
RCBC	Reinforced Concrete Box Culvert
RCPC	Reinforced Concrete Pipe Culvert
OH2K	Oxley Highway to Kempsey Pacific Highway Upgrade
MCoA	Ministers Condition of Approval
EPA	Environmental Protection Authority
RMS	Roads and Maritime Services
SHJV	Smec Hyder Joint Venture
LES	Lewis Ecological Surveys
Vulnerable	Species listed as vulnerable under schedule two of the NSW *Threatened Species Conservation* Act (1995)

1.0 INTRODUCTION

1.1 Background

Lewis Ecological Surveys (LES) has been contracted by the SMEC-Hyder Joint Venture (SHJV) to prepare a management strategy following the discovery of microchiropteran bats (hereafter microbat) utilising bridge and culvert structures associated with the Oxley Highway to Kempsey Pacific Highway Upgrade project (Ecotone Ecological Consultants 2007; GHD 2010). The preparation of this management strategy addresses one component of MCoA **(B30)** Construction Environment Management Plan for the project and specifically B31 (b) *a Construction Flora and Fauna Management Plan to detail how construction impacts on ecology will be minimised and managed*. A component of this plan specifically relates to the management of microbats **(iv)** *a micro-bat management strategy in the case that the pre-construction surveys (undertaken at least 12 months in advance of disturbance to potential roosting structures, or as agreed by the Director General) identify the presence of or evidence of microbat roosting in the project corridor or its vicinity. The strategy shall detail measures to avoid, minimise and mitigate impacts to these species and identified roost sites, including short and long term management measures*.

The following strategy is applicable where construction works are planned to occur within 200 m of the identified structure known or considered potential bat roost habitat. The following is an outlined of the report structure.

1.2 Report Structure

This document is comprised of the following sections:

Section 2 reports on the field surveys undertaken as part of pre construction roost surveys;

Section 3 provides a framework used to establish the importance of the identified bat roosts

Section 4 presents the management strategies used to avoid, minimise and mitigate impacts on the identified bat roosts;

Section 5 outlines what strategies are required at each of the structures identified as microbat habitat;

Section 6 provides some concluding remarks on the current status of microbats in the Oxley Highway to Kempsey project area and the way they will be managed during construction and post construction of the Upgrade;

Section 7 cites the literature used as references; and

Section 8 illustrates the locations of the structures and the results of the field surveys.

2.0 FIELD SURVEYS

2.1 Survey Sites

No culvert nor bridge reference plan could be provided by the SHJV as part of these surveys (Kate Wiggins email August 2012). To overcome this, the area was traversed on foot and motor vehicle which resulted in the identification of 74 structures including bridges and culverts on both the existing Pacific Highway and adjoining service roads[1]. The broad distribution of the structure is shown in Figure 2-1. The structures have been summarized here as:

- 11 bridges with:
  - Seven of these structures being made of concrete of which two (Maria River) have been constructed in the past 10 years. Most of the concrete bridges are cast concrete constructed in the 1950-60's.
  - Four bridges are largely constructed of wood of which one is a recognized historic bridge (Doolan design over the Maria River).
- 52 pipes with:
  - 50 being Reinforced Concrete Pipe Culverts (RCPC);
  - 1 steel (Sancrox Quarry Access); and
  - 1 galvanised iron (599022) pipe.

These varied in size from 350 mm diameter to around 2750 mm and were comprised of 1-4 cells.

- 11 Reinforced Concrete Box Culvert (RCBC) varying in size from 300-3000 mm and between 1-5 cells.

2.2 Timing and Survey Techniques

Surveys were undertaken in both winter (August) and summer (January) in order to capture seasonal variation in the way bats use or potentially use the existing culvert and bridge structures. The field surveys were performed in two stages.

Stage I surveys comprised a visual inspection of each structure for signs of past or current microbat use. An electronic endoscope and a torch were used to thoroughly survey all of the accessible crevices/expansion joints, girders, head stocks, scuppers, abutment walls, drainage holes and any other area deemed as containing potential microbat habitat. A ladder was used in some instances to facilitate inspections of Welcome Swallow nests and other more difficult to access points.

Stage II surveys were undertaken at sites where the structure was too difficult or dangerous (as determined through risk assessment in SWMS) to survey in its entirety during stage I surveys. In this instance, an Anabat II was used to detect bats emerging from potential roost points at either dawn or dusk with these calls later analysed to determine the likely species.

2.3 Survey Results

2.3.1 Microbats Use of Existing Structures

Field surveys confirmed four species of microbat inhabiting 27 (36%) of the 74 surveyed structures (Table 2-1; Appendix A). They included:

- Little Bent-wing Bat (*Miniopterus australis*) found inhabiting 10 structures including a range of culverts and at some bridges distributed from Haydons Wharf Road (ch. 18050) area north to Maria River (ch. 36875) with the Smiths Creek Bridge record relying on call identification;
- Eastern Horseshoe Bat (*Rhinolophus megaphyllus*) detected at eight structures with most of these in the Cooperabung area;
- Southern Myotis (*Myotis macropus*) detected at 6 structures north from Haydons Wharf Road to Stumpy Creek (ch. 37700) with one of the record from Pipers Creek relying solely on call identification; and

[1] Not all of the culvert structure had RTA/RMS identifier plagues on them and may represent unknown structures.

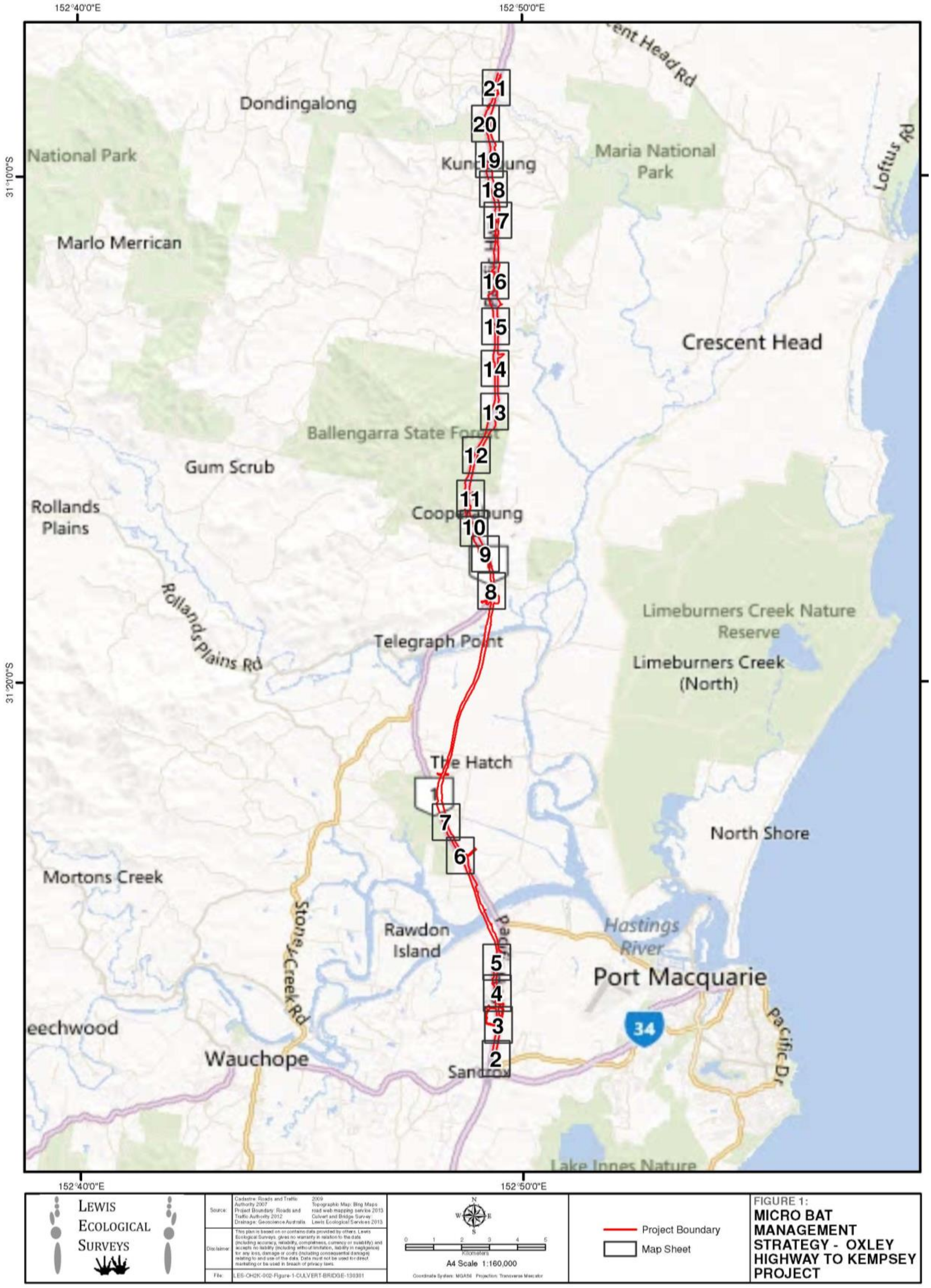


Figure 2-1. Broad distribution of structures surveyed (numbered squares) as part of this microbat management strategy.

- Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*) restricted to culvert 599011 near Haydons Wharf Road.

Another four species could have been potentially using the structures or were roosting nearby given their calls were recorded at the structure near dusk or dawn (Table 2-1). They included:

- Eastern Broad-nosed Bat (*Scotorepens orion*) from the Maria River bridges during the summer census;
- Eastern Forest Bat (*Vespadelus pumilis*) from the Maria River and Smiths Creek bridges during the summer census;
- Chocolate Wattled Bat (*Chalinolobus morio*) from Pipers Creek Bridge during the summer census; and
- Little Forest Bat (*Vespadelus vulturnus*) from Pipers Creek Bridge during the summer census.

The locations of species and culverts are shown in Appendix A.

The Southern Myotis, Eastern and Little Bent-wing Bats are currently listed as vulnerable species pursuant to the NSW *Threatened Species Conservation* Act (1995). None of the recorded species are currently listed under the Commonwealth *Environmental Protection and Biodiversity Conservation* Act (1999).

Table 2-1. Summary of pre-construction field surveys for microbats and evidence of roosting.
Note: Bold type denotes maternity sites. **A** denotes record relies on call identification from the Anabat surveys.

Bat Species	Culvert	Bridge
Southern Myotis (*Myotis macropus*)	• 599012, 599028, 599043	• Smiths Creek • Pipers Creek (A) • Stumpy Creek
Little Bent-wing Bat (*Miniopterus australis*)	• 599011, 599016, 599022, 599028, 599035, 599036, Private Access Driveway Culvert, 599039	• Maria River • Smiths Creek (A)
Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*)	• 599011	Not Recorded
Eastern Horseshoe Bat (*Rhinolophus megaphyllus*)	• 510067, 599017, 599019, 599020, 599021, 599022, 599023, 599026	Not Recorded
Eastern Broad-nosed Bat (*Scotorepens orion*)	Not Recorded	• Maria River (A)
Chocolate Wattled Bat (*Chalinolobus morio*)	Not Recorded	• Pipers Creek (A)
Eastern Forest Bat (*Vespadelus pumilis*)	Not Recorded	• Maria River (A) • Smiths Creek (A)
Little Forest Bat (*Vespadelus vulturnus*)	Not Recorded	• Pipers Creek (A)
Unknown Species (Scats only)	• Cassagrain Access Road, 599020, Yarrabee Road, 599031, 599033, 599036, 599038, 599052	-

In addition to those direct observations of microbats another eight (11%) structures were assigned as bat habitat on the basis that bat guano (scats) was recorded beneath roost points. Typically these roost sites showed rub marks on the surface of the concrete (Plate 2-1).

The surveys also found there was no evidence or potential for microbats to use 28 (38%) of the 74 structures because they were either:

- Too small to reduce the risk of predation. Often roosts lower than 1 m are considered too vulnerable to predatory fauna such as foxes, snakes and native dasyurids all of which occur throughout the project.
- The structures were constructed from *in situ* cast concrete which resulted in no gaps.

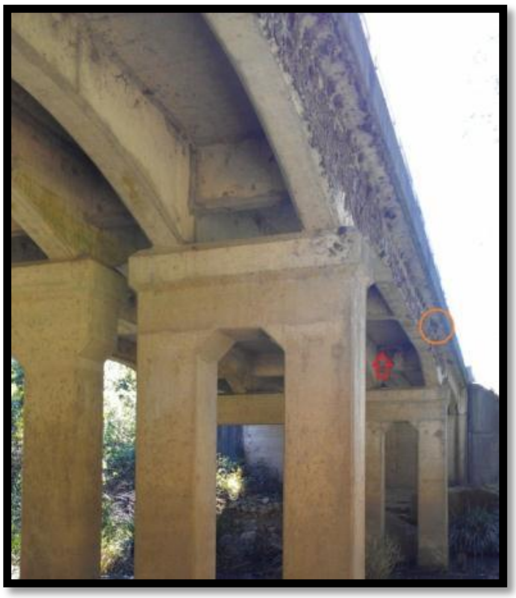
The remaining 19 structures provide some potential roost opportunities and have been considered further in this management strategy.

Plate 2-1. Drainage hole showing obvious rub marks on the concrete surface.

2.3.2 Size and Importance of the Roosts

Roost size varied from single individuals at numerous locations up to approximately 165 Little Bent-wing Bats recorded at the Maria River Southbound Bridge. Most colonies were comprised of <10 bats and usually not more than 2-3 individuals would roost together given the size of the roost sites (i.e. cylindrical drainage/lift points in culverts usually 50 mm wide and 50-100 mm deep). The Eastern Horseshoe Bat was always recorded roosting singularly whilst the other three observed species were often recorded with other bats. The importance of these colonies with regard to breeding (maternity) and over wintering (hibernation) roosts is presented below.

i. Breeding Sites



One maternity site was recorded for the Southern Myotis at Smiths Creek Bridge (Plate 2-2). This site was discovered on the 12th January within the scuppers on the eastern side of the bridge (orange circle). A subsequent survey on the 24th January revealed this maternity colony had since been abandoned, presumably due to thunderstorm activity and the subsequent runoff rendering the roost as no longer suitable. At this time, the colony of 10-12 individuals were observed roosting on the exposed concrete surface at the top of the headstocks and cast deck and were alternating their roost location depending on the temperatures (i.e. southern side on very hot days and northern side at other times; red arrow). This was obvious from the wear marks permeating onto the concrete surface. It is suspected that a small number of bats were also using a disused swallow nest at this time. Prior to the rainfall event, the study area had just one rainfall event of ~9 mm in the past month (http://www.bom.gov.au). This location is unlikely to be used during a wet spring or summer season.

Plate 2-2. Smiths Creek Bridge and location of the maternity site (orange circle) and the alternative roost location following abandonment of the roost.

Other potential locations for maternity roosts include the gaps between the plank girders of the south bound bridge at Stumpy Creek and beneath any of the three bridges over the Maria River. At both Barrys Creek (599028) and Cooperabung Creek (i.e. 599012 at ch. 18700) the roosts may possibly occur in tree hollows overhanging the water or at another suitable bridge or culvert structure outside of the project corridor.

Both species of bent-wing bat and the Eastern Horseshoe Bat are not expected to form maternity colonies in the surveyed structures. Generally, maternity colonies for these bats number in the hundreds and often thousands and require a much larger void to act as a nursery site. A low likelihood has been assigned to the small forest bats (*Vulturnus spp*), wattled bats (*Chalinolobus spp*) and broad-nosed bats (*Scotorepens spp*) using these structures as maternity sites as these groups of bats generally select tree hollows for breeding (*see* Churchill 2008).

ii. Over-wintering (Hibernation) Sites

Four broad areas have been identified as over wintering habitat for microbats. They include:

- South bound bridge over the Maria River where approximately 165 bent-wing bats were recorded in August 2012;
- Culvert 599011 to the north of Haydon's Wharf Road where 23 bent-wing bats comprising both Eastern and Little Bent-wings were observed using the vertical drainage holes in the 1800 mm RCP culverts. The amount of scat material at the bottom of these culverts suggests they are repeatedly used throughout the winter period (Plate 2-3);
- Multiple culverts and particularly those beneath deep earth fill (i.e. >5 m depth) north from Cooperabung Drive to Mingaletta. They are distributed north from ch. 20500 (599016) to ch. 23700 (599027) and consistently contain small numbers of Eastern Horseshoe Bat; and
- Multiple culverts north of Mingaletta from ch.25500 north to ch.27000 contain small numbers of Little Bent-wing Bats. These bats may move between these culverts over small periods of time but probably have some site fidelity to the area. For example, individuals using culvert 599035 over a number of nights may move to alternative culverts (i.e. 599036) but will remain within that general area.

Plate 2-3. Numerous bat scats (guano) on the bottom of culvert 599011.

2.3.2 Seasonal variation in Roost Use

The seasonal surveys recorded similar occupancy rates with 18 structures recording signs of use during the winter and 17 structures during the summer. The way in which these structures were used differed a lot, with the Southern Myotis only recorded during the summer surveys whilst the Eastern Bent-wing Bat was only recorded during the winter survey. The bent wing bats are suspected to have moved to nearby maternity sites including Willi Willi Bat Cave to the west of Kempsey and the sea caves directly east in the Point Plomer area. Both the Eastern Horseshoe Bat and Little Bent-wing Bat were recorded during the winter and summer surveys, however, the number of individuals were lower in summer than winter.

Some structures remained in use between the two survey periods. They included Culvert 599011, Barrys Creek (599028) and Mingaletta (599035) for the Little Bent-wing Bat whilst 599019 remained in constant use by the Eastern Horseshoe Bat. In fact, most culverts between 599017 north to 599027 are probably regularly used by Eastern Horseshoe Bats. The south bound Maria River Bridge remained in use over both seasons although there was less activity during the summer census when a few calls from multiple species were recorded.

2.4 Discussion

The results of this survey confirm microbats utilize structures on the existing Pacific Highway as both winter and summer roosts. Geographically, five broad areas of bat roost habitat have been identified.

Area 1 includes the culverts in the Haydon's Wharf area north to Cooperabung Drive which provide habitat for both bent-wing bats in the winter and Southern Myotis during the summer. In this area, both older and immature bent-wing bats may remain if they do not disperse to the breeding colonies located outside of the project (i.e. coastal sea caves). The removal or disturbance of these structures will require due consideration to the ecological and physiological needs of these species (*see* Section 4.0).

Area 2 encapsulates the Cooperabung Hill area and appears to represent a year round roosting site for small numbers of Eastern Horseshoe Bat. This area may be used by small numbers of Little Bent-wing Bat.

Area 3 extends north from Barrys Creek (599028) to just south of Upper Smiths Creek Road (599039) and provides both summer and winter roosts for Little Bent-wing Bat and a summer roost at Barrys Creek for the Southern Myotis.

Area 4 includes the bridges over Smiths Creek and to a lesser extent Pipers Creek. Normally these structures wouldn't represent bat habitat apart from the scuppers and the disused swallow nests. The scuppers could only be used during extended dry periods and therefore represent a periodic roost site. Measures have been proposed in this management strategy to address this.

Area 5 includes the bridges over Maria River and Stumpy Creek which provide year round roost sites. There is evidence to suggest the south bound bridge over the Maria River provides important over wintering habitat for the Little Bent-wing Bat whilst both Stumpy Creek south bound and all three bridges could be theoretically used as a maternity site for the Southern Myotis.

The combination of winter and summer surveys has proved useful in determining the overall roost value to the structures present on the OH2K project. The winter surveys identified important over wintering habitat for the Little Bent-wing Bat at the south bound Maria River Bridge and the 3 cell 1800 mm RCPC (599011) adjacent to Cooperabung Creek. By contrast, the summer surveys identified both structures may be of less importance and provide opportunities within this management strategy to allow for the passive relocation of microbats during the construction of the Upgrade (*see* Section 4). The summer surveys confirmed the presence of the Southern Myotis at a number of structures and in particular Barrys Creek (599028) and an unexpected find at the bridge over Smiths Creek. As for winter roosts, the Southern Myotis appears to roost elsewhere in the study area during the winter months.

It is difficult to predict whether bats will continue to utilize the structures in the same manner that was observed between August 2012 and January 2013. There are however, a number of consistencies in the findings between this survey and the more cursory one performed by Ecotone Ecological Consultants which has provided the basis for the following statements:

- The culverts in the Cooperabung area north from Cooperabung Drive (599016) to Barrys Creek (599028) represent long term roost habitat for small numbers of Eastern Horseshoe Bat. At any one time there is expected to be between 3-10 individuals using a number of these culverts with their roost use changing seasonally and in response to disturbance.
- The Barrys Creek Culvert (599028) has been continually used by Southern Myotis in late spring into summer and this is not likely to change. There is likely to be a small colony that breeds in this area and probably not within the culvert itself as the vertical drainage holes appear too small to hold more than a 4-5 individuals. A nearby hollow bearing tree and possibly one growing over water is considered the most likely breeding site. The historic Barrys Creek Bridge did not show signs of bat use during the course of these surveys, however, there are some sub optimal roost opportunities between the decking timbers, girders and wooden abutments.
- The south bound Maria River bridge has been previously (circa 2007) used by Little Bent-wing Bats, Chocolate Wattled Bat and Gould's long-eared Bat (*Nyctophilus gouldi*). Surveys undertaken as part of this study also reported Little Bent-wing Bat, Eastern Forest Bat and Eastern Broad-nosed bat. The Little Bent-wing Bat probably has the greater reliance on this structure as an over wintering site whilst the other species probably only use this structure intermittently as a temporal roost site.

The current survey has identified around a third of the surveyed structures show signs of use by microbats whilst another 25 % of these are considered to provide roosting opportunities depending on the season, extent of water due to flooding or simply as alternative flood refuge sites when bats are forced from other more suitable sites in times of flooding. In the following section the overall importance of these structures to microbats is considered.

3.0 IMPORTANCE OF THE BAT ROOST

The field surveys identified that 27 of the 74 (36%) culvert and bridge structures provide known roost habitat for microbats whilst an additional 19 (26%) structures provide potential roost habitat. Roost habitat and its overall importance is likely to vary between each of the structures and may even vary within the structure itself (i.e. multiple culverts), depending on the species using it, the season (i.e. summer versus winter) or the prevailing environmental conditions (i.e. flood or drought). The challenge for this management strategy is to adjust for varying needs of different species of microbats that would utilise a particular structure for breeding, during migration, winter hibernation or simply as a temporary site within a broader area of roost site fidelity (i.e. bats may utilise a number of roost sites within close proximity to one another such as the Eastern Horseshoe Bat around Cooperabung Hill). The field surveys noted extensive areas of alternative potential roost sites at culvert and bridges on local road networks, the retained areas of the Pacific Highway to be used as service roads (i.e. bridge over Wilson River and Hastings River) and the North Coast Railway notwithstanding numerous farm sheds and other structures. Many of these structures occurred on the same drainage line and were often within 1-2 kilometre of the project.

This section of the Strategy qualifies the relative importance of each structure (i.e. roost) and how this might be used over a seasonal gradient. They have been classified at three scales of conservation value:

- High;
- Moderate; and
- Low.

A summary on the indicative conservation value for each structure is presented in Table 3-1.

3.1 High Conservation Value

A roost assigned to this category would require careful planning during the planned roost exclusion and may require additional monitoring if bats are found to be present throughout the year. For example, the south bound Maria River Bridge may require additional monitoring to evaluate the overall importance of this roost throughout the year. Sites assessed as being high conservation value roosts would also require at least some bat boxes to be installed more than 100 m away from the construction works. Bat boxes would be installed 6-12 months prior to construction although some allowance should be given to interpreting the ecological needs of bats as opposed to time periods.

Examples of high conservation value roost sites include:

- Breeding colonies of microbats regardless of species legislative status (i.e. Southern Myotis if they were using the scuppers or disused swallow nests at Smiths Creek Bridge);
- Colonies of microbats exceeding 50 individuals (Maria River Bridge);
- Over wintering colonies exceeding 20 individuals such as Culvert 599011 near Haydons Wharf Road (reliance of Strategy B in this plan to provide more detail); and
- One individual or more of the nationally vulnerable Large-eared Pied Bat (*Chalinolobus dwyeri*).

3.2 Moderate Conservation Value

A roost assigned as moderate conservation value is used by microbats but its overall importance does not qualify it as high conservation value. In this instance, the roost is not being utilised for breeding, the roost is made up of relatively few individuals (<50 during warmer times of the year or <20 individuals in the case of an overwintering site) and could be considered a temporal roost. Whilst these may perform a relatively important function for bats during post breeding dispersal or as part of some other seasonal migration the OH2K study area supports numerous other roosting opportunities with numerous bridges over waterways, culverts on other roadways, numerous rural structures, North Coast Railway with bridges and culverts and in the case of bent-wing bats there are several sea caves at some of the coastal headlands (i.e. Point Plomer). In this context, there appears to be an adequate number of 'moderate' conservation roosts in the OH2K study area.

3.3 Low Conservation Value

A low conservation value roost shows no sign of past or current use by microbats and the roost habitat attributes are such that they could only contain a few individuals of any one species. For example, the 'vertical drainage holes' or 'lift points' in a culvert could theoretically provide habitat for only a few individuals (<5). Other considerations could include the overall configuration of the structure such as its height combined with only shallow or partial inundation of surface water would suggest that roost points would be susceptible to increased predatory pressure. Such roosts may only be used for short periods of time or in response to other roosts that may be disturbed or removed.

Table 3-1. Indicative conservation value based on the results of the field surveys for each structure.

Conservation Rating	Culvert	Bridge
High	• 599011 (as over wintering habitat for bent-wing bats)	• Smiths Creek (for Southern Myotis only and restricted to extended dry periods between late spring i.e. November to summer only) • Maria River (over wintering habitat for bent-wing bats and potentially breeding habitat for Southern Myotis)
Moderate	• 599012, 599028, 599035, 599043	• Stumpy Creek (South Bound)
Low[2]	• 510067, Cassagrain Access Road, 599016, 599017, 599019, 599020, Yarrabee Road, 599021, 599022, 599023, 599026, Private Access Driveway Culvert, 599031, 599033, 599036, 599038, 599039, 599052	• Pipers Creek

[2] All 19 structures identified as potential habitat have been assigned a low conservation value ranking until construction related pre clearing surveys demonstrate otherwise.

4.0 MANAGEMENT STRATEGIES

Seven management strategies have been proposed as a means to avoid, minimise and mitigate impacts to microbats and identified roost sites, including short and long term management measures. They include:

- **A. Installation of additional roosts**
- **B. Implementing additional field surveys**
- **C. Planned roost exclusion**
- **D. Seasonal limitation of construction works**
- **E. Protection of existing habitat**
- **F. Previously unconsidered structures and unexpected finds**
- **G. Monitoring Requirements**

A summary of these actions and the associated techniques is shown in Table 4-1.

Cumulative impacts/concerns are being managed by installing alternative roost sites at sites used by microbats 6-12 months in advance of any planned disturbance. Moreover, numerous other roost sites exist in the immediate area and include the numerous rail bridges and culverts with the North Coast Railway running more or less parallel to many of the affected RMS structures north of ch.17000. Notwithstanding this, local arterial roads managed by LGA's along with rural residual landscape provide numerous bat friendly structures in the form of shedding and housing; this can be seen in the maps provided within Appendix 1.

A. Installation of Additional Roosts (Bat Boxes)

The use of artificial bat roosts has proved a useful tool in bat management and mitigation in Australia and overseas. In Europe, retro-fitting of bat boxes on bridges and culverts is among standard environmental management for the construction and maintenance of road infrastructure (Halcrow 2006). It is increasingly used here in Australia with several recent examples on the Pacific Highway and use by local government and private developers. For example, bat roost boxes have been used as a management tool in the upgrading of several timber bridges in the Tweed Shire with success and there has been long term use of the slot design style box used at Koala Beach residential development (D. Hannah Tweed Shire Council Environmental Scientist pers. comm. February 2012).

The use of artificial bat roosts is considered a suitable means to encourage passive dispersal of the roost within a particular structure. The designs proposed have been limited to three designs:

1. Small slotted-style bat boxes
2. Wedge style
3. Tree mounted with removable slots.

Example of suppliers include but are not limited to hollow log homes (www.hollowloghomes.com.au) and NHBS (www.nhbs.com) with boxes constructed from a range of materials including hardwood, marine grade plywood and woodcrete.

Two mounting options are considered viable:

Option 1

For tree mounted roosts, the following considerations must be satisfied:

1. Every attempt made to install >2 m above ground and ideally 3-4 m;

2. Overhanging >100 mm of surface water;
3. Beneath tree canopy to reduce solar radiation;
4. Recipient tree considered robust and in good health (i.e. healthy tree canopy and unexposed roots); and
5. Consideration is given to installing a number of boxes to provide a number of thermoregulatory options. For example, painting some boxes in different colours or positioning the boxes with differing aspects (i.e. one on southern side of a tree another on the northern side).

Plate 4-1 below illustrates the practical implementation of Option 1 on the Warrell Creek to Urunga Upgrade.

Plate 4-1. Wedge style box intended for Southern Myotis installed over water at Cow Creek, Valla (left) and a selection of tree mounted boxes with different colours and aspects to address thermoregulatory considerations at Oyster Creek.

Option 2

Site considerations for bridge/culvert mounted roosts:

1. >1.5 m above ground;
2. Overhanging >100 mm of surface water;
3. Culvert or bridge unlikely to fill to capacity during a 1:20 rainfall event; and
4. Land tenure.

Plate 4-2 illustrates the practical implementation of Option 2 on the Warrell Creek to Urunga Pacific Highway Upgrade.

Plate 4-2. Bat boxes installed at a low culvert structure at Urunga (left and right) and Deep Creek, Valla (middle) using the full height capacity of each structure.

Bat boxes will be installed by an ecologist 6-12 months prior to planned roost exclusion. The monitoring and maintenance of these boxes will continue until Year 6 (i.e. to include 3 years of monitoring following commencement of operation of the project) with this monitoring to commence within 3 months of the structure being subject to planned roost exclusion or some other form of roost disturbance/ construction relating to the project (refer to Table 5-4).

B. Implementing Additional Field Surveys

Additional field surveys will be implemented for the following scenarios:

1. Qualified ecologist engaged by the Contractor (Project Ecologist) is to perform pre-clearing surveys to assess if bats are using a structure before planned construction works within 100 m of the structure; and
2. Surveys as part of planned roost exclusion procedures (see below).

C. Planned Roost Exclusion

Roost exclusion will be necessary at those structures requiring removal or substantial modification. At a minimum this will include those locations specified in Table 5.2. Additional roost exclusion will be as deemed necessary by the Project Ecologist. Planned roost exclusion will take place:

- Outside of the breeding season for Southern Myotis and any other species detected breeding (during the pre-clearing survey) by the Project Ecologist in the structure; and
- Outside over wintering times for the Little Bent-wing Bat, Eastern Horseshoe Bat and Southern Myotis.

Where required, roost boxes will be installed in adjacent habitat by an ecologist 6-12 months prior to the planned roost exclusion of microbats. For example, the removal/upgrading of 599011 (Adjacent Cooperabung Creek) would require the installation of bat boxes 6-12 months before any such planned exclusion could occur.

The contractor's Project Ecologist is to perform a pre clearing survey in accordance with strategy B in Table 4-1. The occupied roost(s) are to be left *in situ* at this point in time whilst most (**not all**) of the remaining unoccupied potential roost points (i.e. grab holes, pipe join, crack, expansion joint, drainage hole) are to be filled with an expandable foam filler or equivalent. It is important to leave some other alternative roost points (i.e. two) because these would be used as alternative or temporary roost sites whilst the main roost is decommissioned and thus provides a 'weaning' process of excluding microbats from the structure. Moreover, the culvert egresses are not to be blocked at any stage during the roost exclusion process.

On the evening the pre clearing survey is performed (i.e. strategy B), the main roost(s) are to be inspected by an ecologist using a variable beam torch and/or an endoscope about 90 minutes after nightfall. Once all the bats have vacated the roost, the ecologist is to then fill the roost with expandable foam or an equivalent. Where this cannot be achieved (i.e. due to an obscure cavity), one-way plastic flaps would need to be installed (*see* Mitchell-Jones 2004). Bats returning to the culvert would be left with two options; either seek refuge within one of the sub optimal roost points or seek an alternative site adjacent to the culvert. It is expected that some bats may:

- continue to roost within the alternative roost points (i.e. sub adults), or
- quickly abandon the structure and seek an alternative roost.

Alternate roosts may be the 3-4 bat roost boxes installed in the adjacent habitat, or alternatively the numerous other suitable roost habitat in the form of dwellings, culverts and bridges associated with the North Coast Railway and adjacent shire roads.

To improve the effectiveness of this as a management tool, planned roost exclusion will not be undertaken during forecast periods of heavy rainfall (i.e. >20 mm in 24 hours forecast on the Bureau of Meteorology Website www.bom.gov.au) when potential roost sites may be limited (i.e. bats unlikely to be roosting in scuppers during rainfall). Planned roost exclusion is to occur during periods that would avoid both the breeding season and overwintering period for microbats. The intended timing for roost exclusion would occur during autumn (mid April-May) and the start of spring (September).

D. Seasonal Limitation of Construction Works

Seasonal limitation of construction works will be required at high conservation value sites (i.e. breeding or important overwintering habitat) for specific construction activities including clearing and grubbing operations, the dumping of oversize rock material on the bridge abutments, piling or any other activity deemed as inappropriate by the Project Ecologist. For example, for a structure that supports a breeding colony of Southern Myotis, the seasonal limitation of construction works would be required between November and February for the above construction activities, whilst an overwintering colony of Little Bent-wing Bat would require seasonal limitation of between mid June and mid August. If the seasonal limitation of works is not possible, and some work must proceed, prior to the carrying out of construction works that may impact bat populations (as determined by the Project Ecologist), an attended noise and vibration monitoring program must be developed in consultation with the Project Ecologist. An environmental work method statement will also include provisions for the visual monitoring of the roost for signs of disturbance and a stop works procedure that includes a respite period. The details of this monitoring are to be recorded and submitted with the 6 monthly tracking compliance report.

Seasonal limitation of construction works would also apply to the bat boxes installed as part of Strategy A (i.e. Bat Box Installation). Therefore, it is important for bat boxes to be installed at nearby locations that would be unaffected by construction works.

E. Protection of Existing Habitat

The contractor is to manage the integrity of drainage lines and associated riparian vegetation so as to not constrict microbat flyways. This will include an:

- Ecological review/input from the Project Ecologist into the final design of bridges and culverts to ensure these structures do not constrict the existing flyway[3].
- Ecologist will monitor tree falls at the edge of the clearing footprint within the riparian zone as per Section G2 of this strategy.

The contractor will manage water quality and velocity of the adjoining waterways including creeks, rivers and dams in accordance with the Environmental Protection Licence (EPL) issued for the two construction stages of the OH2K Upgrade.

F. Previously Unconsidered Structures and Unexpected Finds

This strategy 'previously unconsidered structures and unexpected finds' must address:

- Structures where surveys could not be undertaken as part of this study (i.e. undetected culverts; houses identified for demolition); or
- Account for unexpected finds arising from the implementation of strategy B in this plan (i.e. implementing additional field surveys).

If microbats are found during a survey of previously unconsidered structures or unexpected finds, the Project Ecologist or bat ecologist should be guided by the RMS *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RMS 2011) and the use of strategies outlined in Table 4-1; Table 5-2 and 5-3.

[3] By default the design of bridge and culvert to mitigate against flooding would normally provide adequate flyways for the species considered in this management strategy.

G. Monitoring Requirements

Monitoring associated with this management strategy is divided into short term and long term commitments. Short term monitoring is required for planned roost exclusion activities which are expected to last for a number of nights at each structure and is dependent on the timing of the construction program. In contrast, long term monitoring is required up to Year 6 (i.e. for six years after the commencement of construction) and provides an opportunity to rationally evaluate the management strategies outlined in this plan.

G1. Bat Roost Boxes

Monitoring of bat boxes will commence 6 months after their installation, followed by quarterly inspections for 2 years before addressing corrective actions. After the first 2 years of monitoring, monitoring of the boxes will continue twice a year up until Year 6 (i.e. 2 surveys per year for Years 4-6) with the boxes inspected to determine species presence/absence, an estimate or count of numbers of microbats and breeding activity. Information would also be collected as to the roost identification number, date and time of the inspection.

G2. Habitat Monitoring

Habitat monitoring performed by the Project Ecologist will focus on inspections of the riparian zone to assess whether flyways have been constricted as part of construction works. Therefore, on either side of the construction corridor a photo point is to be installed and a visual assessment undertaken to gauge whether the flyway has been maintained or is in need of corrective actions (i.e. vegetation management).

Monitoring of water quality will also be undertaken on both the upstream and downstream sides of the construction works. This monitoring would be undertaken on a monthly cycle or in accordance with the Construction Environmental Management Plan (CEMP) and will include collection of the following parameters; turbidity, total suspended solids, conductivity and pH at both upstream and downstream points. This information will be reported in annual reports compiled for the bat box monitoring program.

Table 4-1. Microbat management strategies for the Oxley Highway to Kempsey Pacific Highway Upgrade.

Strategy	Definition	Techniques	Timing	Responsibility
A	Installation of additional roosts (bat boxes)	• The use of artificial bat roosts (3-4) to promote passive dispersal of the roost. Designs to be one or more of the following and that thermoregulatory considerations focus on aspect and paint/finish (i.e. bat friendly chemicals) of the box itself (i.e. black coloured box with absorb more heat than a neutral colour): **A** - small slotted-style bat boxes; **B** - wedge style; and **C** – tree mounted with removable slots. Two options are available: **Option 1** For tree mounted roosts, the following considerations must be satisfied: 1. Every attempt made to install >2 m above ground and ideally 3-4 m; 2. Overhanging >100 mm of surface water; 3. Beneath tree canopy to reduce solar radiation; 4. Recipient tree considered robust and in good health (i.e. healthy tree canopy and unexposed roots); 5. Consideration is given to installing a number of boxes to provide a number of thermoregulatory options. For example, painting some boxes in different colours or positioning the boxes with differing aspects (i.e. one on southern side of a tree another on the northern side). **Option 2** Site considerations for bridge/culvert mounted roosts: 1. >1.5 m above ground; 2. Overhanging >100 mm of surface water; 3. Culvert or bridge unlikely to fill to capacity during a 1:20 rainfall event; and 4. Land tenure.	Bat boxes are to be installed by an ecologist 6-12 months prior to planned roost exclusion. The monitoring and maintenance of these boxes would continue until Year 6 (refer to Table 5-4). Pre construction and construction.	Roads and Maritime Services
B	Implementing Additional Field Surveys	Additional field surveys will be implemented for the following scenarios: • Qualified ecologist engaged by the Contractor to perform pre-clearing surveys to assess if bats are using a structure before planned construction works within 100 m of the structure; and • Surveys as part of planned roost exclusion procedures.	Prior to construction disturbance (i.e. works occurring within 200 m of the structure).	The Contractor
C	Planned Roost Exclusion	Roost exclusion will be necessary at those structures requiring removal or substantial modification and only at those locations specified in Table 5.2 or as deemed necessary by the Project Ecologist. Planned roost exclusion would be used: • Outside of the breeding season for Southern Myotis and any other species detected breeding by the Project Ecologist in the structure; and • Outside over wintering times for the Little Bent-wing Bat, Eastern Horseshoe Bat and Southern Myotis. Once the conditions above have been satisfied the following 10 step process would occur: 1. Pre-clearing survey to identify presence/absence of the roost; 2. Once the roost(s) has been identified, record species and approximate number of individuals and assess importance of the roost; 3. Select two suitable alternative roost points (i.e. grab holes, pipe join, crack, expansion joint, drainage hole) with gaps of >25 mm and depths exceeding 50 mm; 4. For the remaining potential roost points the Project Ecologist/Bat Ecologist must be confident in ensuring the cavity is devoid of microbats and other native vertebrate fauna. Once absence has been confirmed, the void/roost point is closed up (i.e. filled with expandable foam or some other equivalent material). 5. At no stage shall the culvert inlets/outlets be constricted or closed off in any way. 6. Where all of the roost point cannot be confidently inspected for signs of native vertebrate fauna then one-way plastic flaps must be installed at that point in time or a minimum of 1 hour before dusk. 7. The active roost points identified during the pre-clearing survey are re inspected around 90 minutes after dark. If all individuals have vacated the roost then at this point in time the roost is filled with expandable foam or similar material. Again, where this cannot be ascertained (i.e. obscure cavity) one-way plastic flaps would need to be installed and left in place for 48-72 hrs prior to commencement of construction (*see* Mitchell-Jones 2004). The above procedure leaves microbats with two options: **Option A** – Individuals seek refuge within one of the sub optimal roost points; **Option B** – Individuals abandon the site and seek an alternative roost. 8. Inspect the culvert on the following day for signs of use in the sub optimal roost points. If they are not being utilised then decommission by filling with expandable foam or equivalent. 9. If they are being utilised repeat point 7. 10. Once the one-way plastic flaps have been installed for at least 72 hrs, reinspect with torch and endoscope and decommission with expandable foam or equivalent. Seasonal considerations associated with cool temperatures must be considered.	Southern Myotis "Likely Breeding Site": **November-February** Little Bent-wing Bat "Over Wintering Site": **mid June-mid August** Other Species: In consultation with Project Ecologist or EPA Opportunities to review on a site by site basis Optimum timing for planned roost exclusion is April and May or September.	The Contractor

Strategy	Definition	Techniques	Timing	Responsibility
D	Seasonal limitation of construction works	• Applied to sites/structure defined as high conservation value (i.e. breeding and important overwintering sites) for specific construction activities including clearing and grubbing operations, the dumping of oversize rock material on the bridge abutments, piling or any other activity deemed as inappropriate by the Project Ecologist. • During seasonal limitation of construction works, prior to the commencement of the construction activities listed above an Environmental Work Method Statement must be developed and include an attended noise and vibration monitoring program, to be developed in consultation with the Project Ecologist. Provisions must also be made for the visual monitoring of the roost for signs of disturbance and a stop works procedure that includes a respite period as part of this program. The details of this monitoring must be recorded and submitted with the 6 monthly tracking compliance report. • Seasonal limitation of construction works would also apply to the bat boxes installed as part of Strategy A (i.e. Bat Box Installation). Therefore, it is important for bat boxes to be installed at nearby locations that would be unaffected by construction works.	Southern Myotis "Likely Breeding Site": **November-February** Little Bent-wing Bat "Over Wintering Site": **mid June-mid August** Other Species: In consultation with Project Ecologist or EPA	The Contractor
E1	Protection of existing habitat	The contractor is to manage the integrity of drainage lines and associated riparian vegetation so as to not constrict microbat flyways. This would include an: • Ecological review/input from the Project Ecologist into the final design of bridges and culverts to ensure these structures do not constrict the existing flyway[4]. • Ecologist would monitor tree falls at the edge of the clearing footprint within the riparian zone as per Section H2 of this strategy.	Construction.	The Contractor
E2		The contractor is to manage water quality and velocity of the adjoining waterways including creeks, rivers and dams would be maintained in accordance with the Environmental Protection Licence (EPL) issued for the two construction stages of the OH2K Upgrade.	Construction and post construction.	The Contractor
F	Previously unconsidered structures and unexpected finds	This strategy 'previously unconsidered structures and unexpected finds' would address: • Structures where surveys could not be undertaken as part of this study (i.e. undetected culverts; houses identified for demolition); or • Account for unexpected finds arising from the implementation of strategy B in this plan (i.e. implementing additional field surveys). Microbats found during a survey of previously unconsidered structures or unexpected finds, the Project Ecologist or bat ecologist should be guided by the RMS *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RMS 2011) and the use of strategies outlined in Table 4-1; Table 5-2 and 5-3.	Pre-construction, during construction for both construction stages of the OH2K project (2014-2018)	The Contractor
G1	Monitoring Requirements (Habitat)	Habitat monitoring performed by the Project Ecologist will focus on inspections of the riparian zone to assess whether flyways have been constricted as part of construction works. Therefore, on either side of the construction corridor a photo point would be installed and a visual assessment undertaken to gauge whether the flyway has been maintained or is in need of corrective actions (i.e. vegetation management). Monitoring of water quality will also be undertaken on both the upstream and downstream sides of the construction works. This monitoring will be undertaken on a monthly cycle or in accordance with the Construction Environmental Management Plan (CEMP) and collect the following parameters; turbidity, total suspended solids, conductivity and pH at both upstream and downstream points. This information would be reported in annual reports compiled for the bat box monitoring program	Pre-construction, during construction and post construction. Pre-construction sampling for baseline data and monthly during construction.	RMS
G2	Monitoring Requirements (Bat Roost Monitoring)	Short term monitoring associated with planned roost exclusion outlined as strategy C. The data collected in this strategy reflects a short term monitoring commitment to the project and should be tabled within a post clearing report compiled by the project ecologist or sub consultant bat ecologist. Monitoring of bat boxes would commence 6 months after their installation, followed by quarterly inspections for 2 years before addressing corrective actions. Monitoring of the boxes would then continue twice a year up until Year 6 (i.e. 2 surveys per year for Years 4-6) with the boxes inspected to determine species presence/absence, an estimate or count of numbers of microbats and breeding activity.	Within 7-14 days of planned construction activities impacting on the roost. Commence monitoring 6 months after bat box installation followed by quarterly inspections for 2 years before addressing corrective actions. Monitoring of roosts every six months up until Year 6 of this management strategy (*see* Table 5-4).	RMS

[4] By default the design of bridge and culvert to mitigate against flooding would normally provide adequate flyways for the species considered in this management strategy.

5.0 IMPLEMENTATION OF THE MANAGEMENT STRATEGIES

Using the management strategies summarised in Table 4-1 this section identifies what strategies are required at each of the 46 identified structures. One limitation with identifying management strategies is that the design for the carriageway has not progressed from the concept design for the entire project. To overcome this, a matrix has been developed to address the potential nature of impacts at three scales:

- 100-200 m from the structure;
- <100 m of the structure; and
- Works on the structure itself.

In each instance, all construction works relating to the project that fall within 200 m of the structure would be subject to this management strategy.

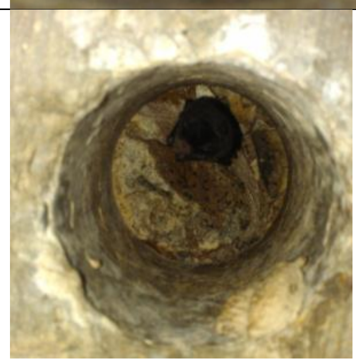
A subjective scale has been developed to qualify the likelihood of a particular bat species using each of the culvert structures (Table 5-1). In this context, biological traits (i.e. breeding/overwintering) that have been assigned as 'moderate' or 'high' have a real possibility of occurring in the particular structure. The 'low' category translates to a key habitat attribute missing from the structure but it could still theoretically provide roost habitat, albeit of lower importance or conservation value. The 'very low' category indicates the roost/structure does not align with a particular species biological traits or the structure could not physically support the required microhabitat elements. For example, a roost that could not physically support thousands of bats associated with a maternity colony of bent-wing bats or horseshoe bats.

A summary of the required strategies for known and potential structures for microbats is provided in Table 5-2 and Table 5-3 and the respective timing of key actions, responsibilities and documentation requirements is outlined in Table 5-4.

Table 5-1. Definitions of the subjective scale used to derive the likelihood of a species utilising the structure for a particular biological trait of breeding and over wintering.

Likelihood of species performing a particular biological trait	Description
Very Low	The structure provides unsuitable habitat attributes or does not align with the species' particular biological habits. For example, Bent-wing bats use regional maternity sites often found in caves where the structure can accommodate thousands of individuals. In contrast, the roost habitat within the identified structure could not physically support this requirement.
Low	There is normally a key habitat attribute missing but the structure could still physically provide roost points for this species. For example, a relatively small culvert (i.e. <1.5 m) that doesn't hold water and is relatively low but it contains suitable roost points for Southern Myotis. Another example is the structure lets too much light in to be considered suitable for Eastern Horseshoe Bat which generally prefers to roost in complete darkness.
Moderate	The structure provides the required attributes for the species but it is not considered 'ideal'. For example, a culvert that is <1.5 m in height, retains water and provides roost points with unconstricted inlets and outlets has a moderate chance of providing breeding habitat for Southern Myotis. In this context, the height of the culvert structure detracts slightly from its overall suitability.
High	The structure provides all the required roost attributes for the species to perform a particular biological trait such as breeding. For example, a culvert >1.5 m in height, permanent water and suitable roost points capable of holding >10 individuals with unconstricted inlets and outlets.
Known	Species was recorded during the survey.

Table 5-2. Proposed management strategies at bridges and culverts known to contain microbats. na = not applicable.
Refer to Appendix 1 for location on the project. [1] This list is merely indicative and is not intended to be an exhaustive list of bats known to utilise structures in north east NSW.

Structure	Roost Site	Species Recorded	Other Species to Consider[1]	Breeding Site	Overwintering Site	Works 100-200 m from roost	Works Within 100 m	Works on the structure
Oxley Highway to Kundabung (ch. 0-24040)						See Table 4-1.	See Table 4-1.	See Table 4-1.
Culverts								
510067 	No Picture	Eastern Horseshoe Bat (winter)	-	Very Low	Known	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Little Bent-wing Bat	Very Low	Moderate	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Bent-wing Bat	Very Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Southern Mytois	Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
599011 		Little Bent-wing Bat		Very Low	Known	E1, E2	B, D, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
		Eastern Bent wing Bat (winter)		Very Low	Known	E1, E2	B, D, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Southern Myotis	Low	Moderate	E1, E2	B, D, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Horseshoe Bat	Very Low	Moderate	E1, E2	B, D, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
599012 		Southern Myotis	-	Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Little Bent-wing Bat	Very Low	Moderate	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Bent-wing Bat	Very Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Horseshoe Bat	Very Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
599016 		Little Bent-wing Bat	-	Very Low	Known	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Southern Myotis	Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Bent-wing Bat	Very low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Horseshoe Bat	Very Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2

Structure	Roost Site	Species Recorded	Other Species to Consider[1]	Breeding Site	Overwintering Site	Works 100-200 m from roost	Works Within 100 m	Works on the structure
599017 	No picture	Eastern Horseshoe Bat	-	Very Low	Known	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Southern Myotis	Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Bent-wing Bat	Very low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Little Bent-wing Bat	Very Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
599019 	No Picture	Eastern Horseshoe Bat	-	Very Low	Known	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Southern Myotis	Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Bent-wing Bat	Very low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Little Bent-wing Bat	Very Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
599020 	No picture	Eastern Horseshoe Bat	-	Very Low	Known	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Southern Myotis	Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Bent-wing Bat	Very low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Little Bent-wing Bat	Very Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
599021 	No Picture	Eastern Horseshoe Bat	-	Very Low	Known	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Southern Myotis	Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Bent-wing Bat	Very low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Little Bent-wing Bat	Very Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2

Structure	Roost Site	Species Recorded	Other Species to Consider[1]	Breeding Site	Overwintering Site	Works 100-200 m from roost	Works Within 100 m	Works on the structure
Yarrabee Road – downstream of 599021 	No Picture	Bat Scats only (probably Eastern Horseshoe Bat)	Eastern Horseshoe Bat	Very Low	High	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Southern Myotis	Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Bent-wing Bat	Very low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Little Bent-wing Bat	Very Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
599022 	No picture	Little Bent-wing Bat (summer)		Very low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
		Past surveys have revealed Eastern Horseshoe Bat.		Very Low	Known	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Southern Myotis	Very Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Bent-wing Bat	Very Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
599023 No picture	No picture	Eastern Horseshoe Bat (summer)	-	Very Low	Moderate	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Southern Myotis	Very Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Bent-wing Bat	Very low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Little Bent-wing Bat	Very Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
599026 		Eastern Horseshoe Bat	-	Very Low	Known	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Southern Myotis	Very Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Bent-wing Bat	Very low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Little Bent-wing Bat	Very Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
Bridges								
No bridges with bat observation in this section of the Upgrade								

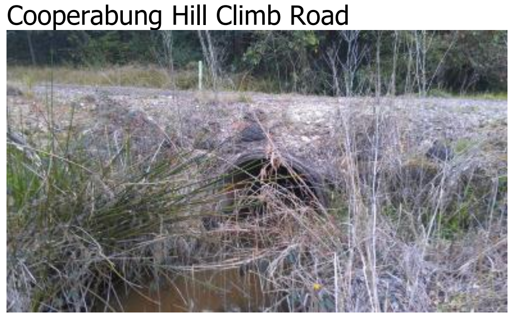
Structure	Roost Site	Species Recorded	Other Species to Consider[1]	Breeding Site	Overwintering Site	Works 100-200 m from roost	Works Within 100 m	Works on the structure
Kundabung to Kempsey (ch.24040-37770)								
Culverts								
599028 (Barrys Creek) 	No Picture	Little Bent-wing Bat (Winter)	-	Very low	Moderate	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
		Southern Myotis (summer)		Low	Moderate	E1, E2	B, E1, E2	A (option 2), B, C, D, E1, E2, G1, G2
			Eastern Bent-wing Bat	Very Low	Moderate	E1, E2	B, E1, E2	A (option 2), B, C, D, E1, E2, G1, G2
			Eastern Horseshoe Bat	Very low	Low	E1, E2	B, E1, E2	A (option 2), B, C, D, E1, E2, G1, G2
599031 	No Picture	Bat Scats only	Eastern Horseshoe Bat	Very Low	High	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Southern Myotis	Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Bent-wing Bat	Very low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Little Bent-wing Bat	Very Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
599033 (Mingaletta) 		Bat Scats only	Eastern Horseshoe Bat	Very Low	High	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Southern Myotis	Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Bent-wing Bat	Very low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Little Bent-wing Bat	Very Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
599035 		Little Bent-wing Bat		Very Low	Known	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Horseshoe Bat	Very Low	High	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Southern Myotis	Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Bent-wing Bat	Very low	Moderate	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2

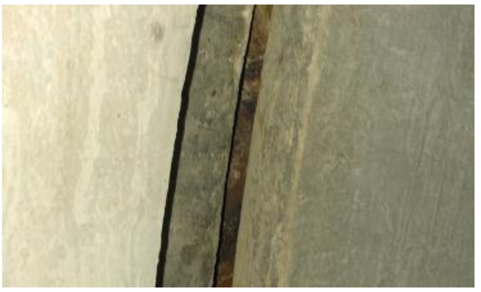
Structure	Roost Site	Species Recorded	Other Species to Consider[1]	Breeding Site	Overwintering Site	Works 100-200 m from roost	Works Within 100 m	Works on the structure
599036 		Little Bent-wing Bat		Very Low	Known	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Horseshoe Bat	Very Low	High	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Southern Myotis	Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Bent-wing Bat	Very low	Moderate	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
Private Access Driveway 	No Picture	Little Bent-wing Bat (winter)		Very Low	Known	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Horseshoe Bat	Very Low	Moderate	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Southern Myotis	Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Bent-wing Bat	Very low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
599038 	No Picture	Bat Scats only	Eastern Horseshoe Bat	Very Low	High	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Southern Myotis	Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Bent-wing Bat	Very low	Moderate	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Little Bent-wing Bat	Very Low	High	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
599039 	No Picture	Little Bent-wing Bat (winter)		Very Low	Known	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Horseshoe Bat	Very Low	Moderate	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Southern Myotis	Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Bent-wing Bat	Very low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2

Structure	Roost Site	Species Recorded	Other Species to Consider[1]	Breeding Site	Overwintering Site	Works 100-200 m from roost	Works Within 100 m	Works on the structure
599043 Smiths Creek Overflow No Picture	No Picture	Southern Myotis (summer)		Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Horseshoe Bat	Very Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Little Bent-wing Bat	Very Low	Moderate	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Bent-wing Bat	Very low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
599052 Kundabung 	No Picture	Bat scats	Eastern Horseshoe Bat	Very Low	High	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Southern Myotis	Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Bent-wing Bat	Very low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
			Little Bent-wing Bat	Very Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2
Bridges								
Smiths Creek Bridge 	No Picture	Southern Myotis	-	Known	Low	E1, E2	E1, E2, A (option 2), B	A (option 1), B, C, D, E1, E2, G1, G2
			Little Bent-wing Bat	Very Low	Low	E1, E2	E1, E2, A (option 2), B	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Bent-wing Bat	Very Low	Low	E1, E2	E1, E2, A (option 2), B	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Horseshoe Bat	Very Low	Low	E1, E2	E1, E2, A (option 2), B	A (option 1), B, C, D, E1, E2, G1, G2

Structure	Roost Site	Species Recorded	Other Species to Consider[1]	Breeding Site	Overwintering Site	Works 100-200 m from roost	Works Within 100 m	Works on the structure
Pipers Creek Bridge 		Calls of:						
		Southern Myotis		Low	Low	E1, E2	E1, E2, A (option 2), B	A (option 1), B, C, D, E1, E2, G1, G2
		Chocolate wattled Bat		Low	Low	E1, E2	E1, E2, A (option 2), B	A (option 1), B, C, D, E1, E2, G1, G2
		Little Forest Bat		Low	Low	E1, E2	E1, E2, A (option 2), B	A (option 1), B, C, D, E1, E2, G1, G2
			Little Bent-wing Bat	Very Low	Low	E1, E2	E1, E2, A (option 2), B	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Bent-wing Bat	Very Low	Low	E1, E2	E1, E2, A (option 2), B	A (option 1), B, C, D, E1, E2, G1, G2
Maria River Bridge (South bound) 		Little Bent-wing Bat (165 individuals)		Very Low	Known	E1, E2	E1, E2, A (option 2), B	A (option 1), B, C, D, E1, E2, G1, G2
		Calls of:						
		Eastern Broad-nosed Bat		Low	Low	E1, E2	E1, E2, A (option 2), B	A (option 1), B, C, D, E1, E2, G1, G2
		Eastern Forest Bat		Low	Low	E1, E2	E1, E2, A (option 2), B	A (option 1), B, C, D, E1, E2, G1, G2
			Southern Myotis	High	Low	E1, E2	E1, E2, A (option 2), B	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Bent-wing Bat	Very Low	Moderate	E1, E2	E1, E2, A (option 2), B	A (option 1), B, C, D, E1, E2, G1, G2
Stumpy Creek (South bound) 		Southern Myotis	-	Moderate	Low	E1, E2	E1, E2, A (option 2), B	A (option 1), B, C, D, E1, E2, G1, G2
			Little Bent-wing Bat	Very Low	Moderate	E1, E2	E1, E2, A (option 2), B	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Bent-wing Bat	Very Low	Low	E1, E2	E1, E2, A (option 2), B	A (option 1), B, C, D, E1, E2, G1, G2
			Eastern Horseshoe Bat	Very Low	Low	E1, E2	E1, E2, A (option 2), B	A (option 1), B, C, D, E1, E2, G1, G2

Table 5-3. Proposed management strategies at bridges and culverts that provide potential habitat for microbats.
Note – only those species most likely to use the structure have been considered.

Structure	Roost Habitat	Species to Consider	Breeding Site	Overwintering	Works 100-200 m from roost	Works Within 100 m	Works on the structure
Oxley Highway to Kundabung (ch. 0-24040)					See Table 4-1.	See Table 4-1.	See Table 4-1.
Culverts							
510068 	No Picture	Eastern Horseshoe Bat	Low	High	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
510070 	No Picture	Eastern Horseshoe Bat	Low	High	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
510086	No Picture	Eastern Horseshoe Bat	Low	High	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
East of Cooperabung Hill on Yarrabee Road 	No Picture	Eastern Horseshoe Bat	Low	High	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
Cooperabung Hill Climb Road 	No Picture	Eastern Horseshoe Bat	Low	High	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
599027	No Picture	Eastern Horseshoe Bat	Low	High	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2

Structure	Roost Habitat	Species to Consider	Breeding Site	Overwintering	Works 100-200 m from roost	Works Within 100 m	Works on the structure
Bridges							
		Southern Myotis	Moderate	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
		Little Bent-wing Bat	Nil	Moderate	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
		Eastern Bent-wing Bat	Nil	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
Barries Creek Bridge (Historic Structure) 		Southern Myotis	Moderate	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
		Little Bent-wing Bat	Nil	Moderate	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
		Eastern Bent-wing Bat	Nil	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
Kundabung to Kempsey (ch. 24040-37770)							
Culverts							
599041 		Southern Myotis	Low	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
		Little Bent-wing Bat	Nil	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
		Eastern Bent-wing Bat	Nil	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
		Eastern Horseshoe Bat	Nil	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
599046 	No Picture	Southern Myotis	Low	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
		Little Bent-wing Bat	Nil	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
		Eastern Bent-wing Bat	Nil	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
		Eastern Horseshoe Bat	Nil	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
599050	No Picture	Southern Myotis	Low	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
No Picture		Little Bent-wing Bat	Nil	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
		Eastern Bent-wing Bat	Nil	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
		Eastern Horseshoe Bat	Nil	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
599051		Southern Myotis	Low	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
No Picture		Little Bent-wing Bat	Nil	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2

Structure	Roost Habitat	Species to Consider	Breeding Site	Overwintering	Works 100-200 m from roost	Works Within 100 m	Works on the structure
	No Picture	Eastern Bent-wing Bat	Nil	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
		Eastern Horseshoe Bat	Nil	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
Bridges							
Maria River North Bound 		Southern Myotis	High	Moderate	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
		Little Bent-wing Bat	Nil	High	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
		Eastern Bent-wing Bat	Nil	Moderate	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
		Eastern Horseshoe Bat	Nil	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
		Eastern Broad-nosed Bat	Low	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
		Forest bats (*Vespadelus spp*)	Low	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
Doolan Design Bridge – Maria River 		Southern Myotis	High	Moderate	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
		Little Bent-wing Bat	Nil	High	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
		Eastern Bent-wing Bat	Nil	Moderate	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
		Eastern Horseshoe Bat	Nil	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
		Eastern Broad-nosed Bat	Low	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
		Forest bats (*Vespadelus spp*)	Low	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
Stumpy Creek – North bound		Southern Myotis	High	Moderate	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2

Structure	Roost Habitat	Species to Consider	Breeding Site	Overwintering	Works 100-200 m from roost	Works Within 100 m	Works on the structure
		Little Bent-wing Bat	Nil	High	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
		Eastern Bent-wing Bat	Nil	Moderate	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
		Eastern Broad-nosed Bat	Nil	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2
		Forest bats (*Vespadelus spp*)	Low	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, G1, G2

Table 5-4. Timing of key actions for this microbat management plan, responsibilities and documentation requirements.

Management Action/Year Number	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Responsibility	Documentation Requirements
Pre Construction								
Prepare Microbat Management Strategy	√						RMS	Construction Environmental Management Plan
Construction								
Commission Construction of Bat Boxes	√	√					Project Ecologist – Contractor responsibility	-
Install Bat Boxes	√	√					Project Ecologist – Contractor responsibility	Construction Environmental Management Plan
Planned Exclusion Works		√	√				Project Ecologist – Contractor responsibility	Construction Environmental Management Plan
Monitoring								
Summer		√	√	√	√	√	Project Ecologist – RMS responsibility	Yearly reporting
Autumn		√	√				Project Ecologist – RMS responsibility	Yearly reporting
Winter		√	√	√	√	√	Project Ecologist – RMS responsibility	Yearly reporting
Spring		√	√				Project Ecologist – RMS responsibility	Yearly reporting
Maintenance								
Maintenance of boxes			√			√	Project Ecologist – Contractor responsibility	
Pre Handover Maintenance Inspection						√	Project Ecologist – Contractor responsibility	Yearly reporting

6.0 CONCLUSION

The Oxley Highway to Kempsey bat management strategy incorporates seven management measures to address MCoA **(B30b iv)** including:

- Installation of additional roosts
- Implementing additional field surveys
- Planned roost exclusion
- Seasonal limitation of construction works
- Protection of existing habitat
- Previously unconsidered structures and unexpected finds
- Monitoring requirements

Together they are provided as bat management strategies A-G in this document with their implementation staged according to the proposed distance of construction works and the overall importance of the bat roost itself. Importantly, all construction works that fall within 200 m of the identified structures would be subject to management strategies outlined in this plan.

The use of bat boxes would provide opportunities for passive relocation of bat roosts and these would need to be installed at least 6-12 months prior to any planned roost exclusion and/or construction works. The monitoring framework would assess the overall performance of these measures and provide an opportunity to evaluate potential changes in habitat quality of flyways, water ways, the uptake of bat roost boxes and form part of the planned roost exclusion.

This microbat management strategy provides guidance to RMS and highlights the importance of planning ahead and acting in advance of the construction phase of the project. The strategic installation of additional roost sites followed by planned roost exclusion at culvert structures during September and again in April-May would provide a more equitable outcome for both construction and the local ecology as microbats should neither be breeding nor over wintering at these times.

7.0 REFERENCES

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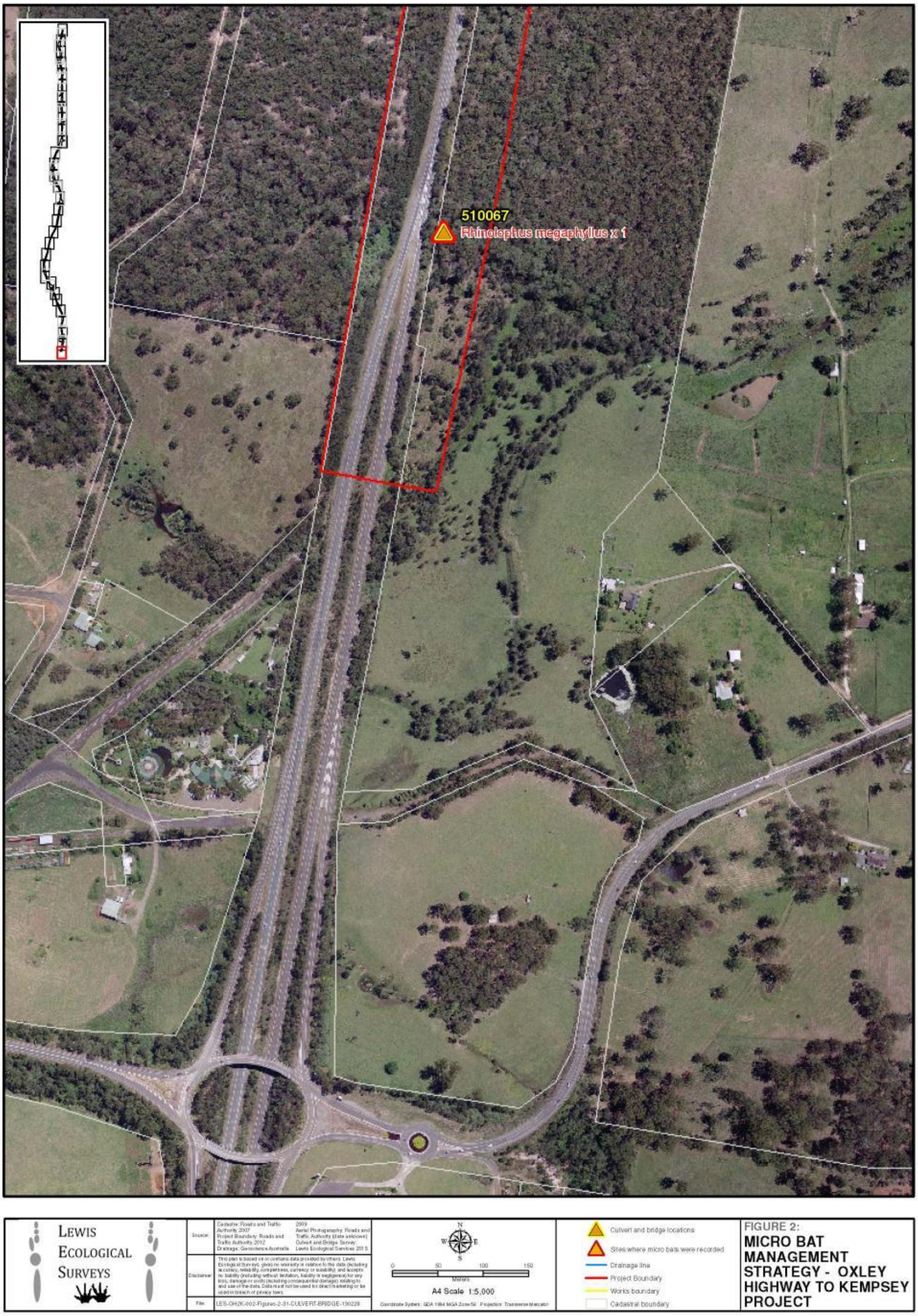
8.0 APPENDIX 1

CULVERT AND BRIDGE LOCATIONS


510067
Rhinolophus megaphyllus x 1
LEWIS ECOLOGICAL SURVEYS
Source:
Cadastre: Roads and Traffic Authority 2007
Project Boundary: Roads and Traffic Authority 2012
Drainage: Geoscience Australia 2009
Aerial Photography: Roads and Traffic Authority (date unknown)
Culvert and Bridge Survey: Lewis Ecological Services 2013
Disclaimer:
This plan is based on or contains data provided by others. Lewis Ecological Surveys gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to and use of the data. Data must not be used for direct marketing or be used in breach of privacy laws.
File: LES-OH2K-002-Figures-2-31-CULVERT-BRIDGE-130228
N
W
E
S
0
50
100
150
Meters
A4 Scale 1:5,000
Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator
Culvert and bridge locations
Sites where micro bats were recorded
Drainage line
Project Boundary
Works boundary
Cadastral boundary
FIGURE 2:
MICRO BAT MANAGEMENT STRATEGY - OXLEY HIGHWAY TO KEMPSEY PROJECT

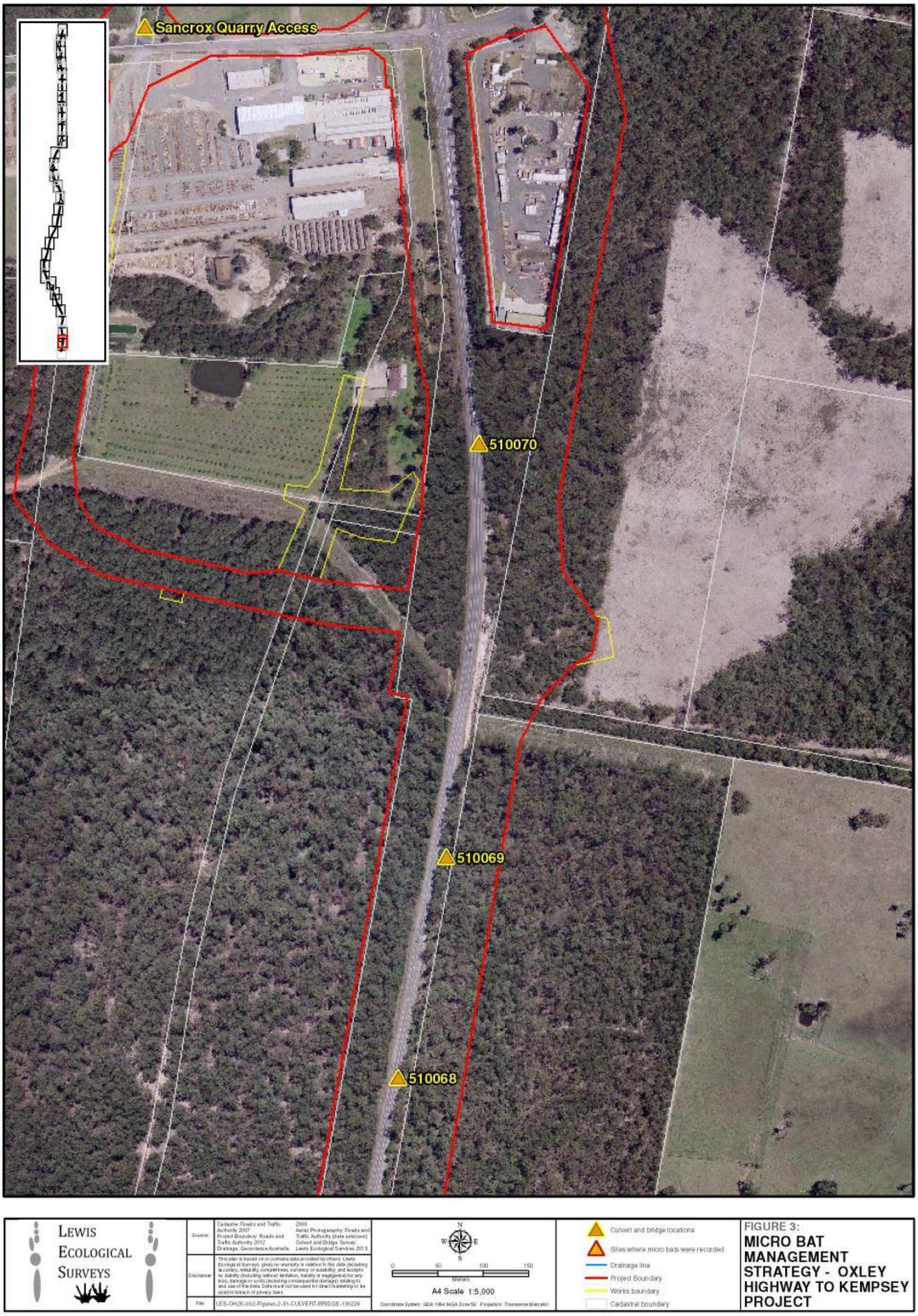
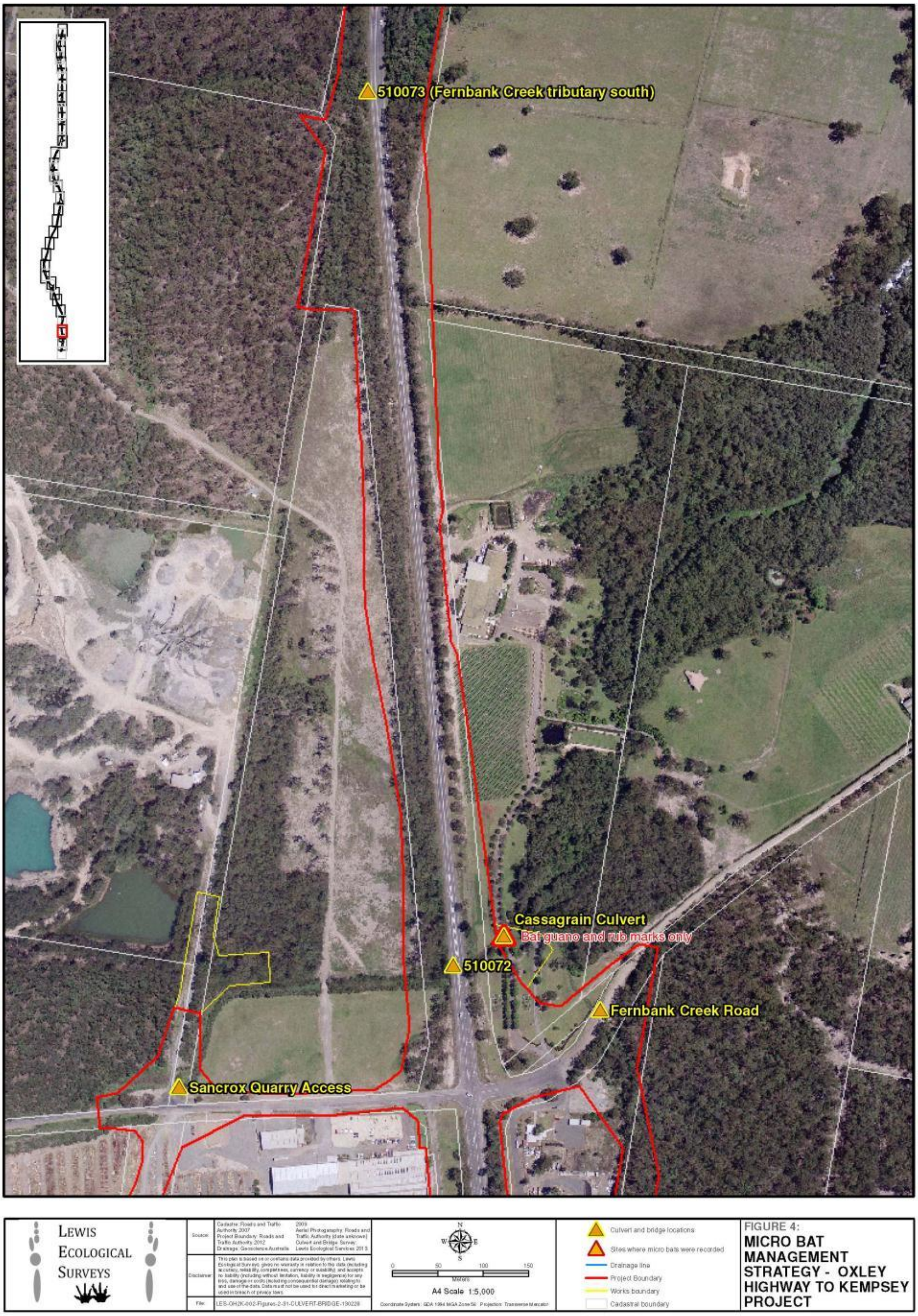


FIGURE 3: MICRO BAT MANAGEMENT STRATEGY - OXLEY HIGHWAY TO KEMPSEY PROJECT


510073 (Fernbank Creek tributary south)
Cassagrain Culvert
Bat guano and rub marks only
510072
Fernbank Creek Road
Sancrox Quarry Access
LEWIS
ECOLOGICAL
SURVEYS
Source:
Cadastre: Roads and Traffic Authority 2007
Project Boundary: Roads and Traffic Authority 2012
Drainage: Geoscience Australia
2009
Aerial Photography: Roads and Traffic Authority (date unknown)
Culvert and Bridge Survey: Lewis Ecological Services 2013
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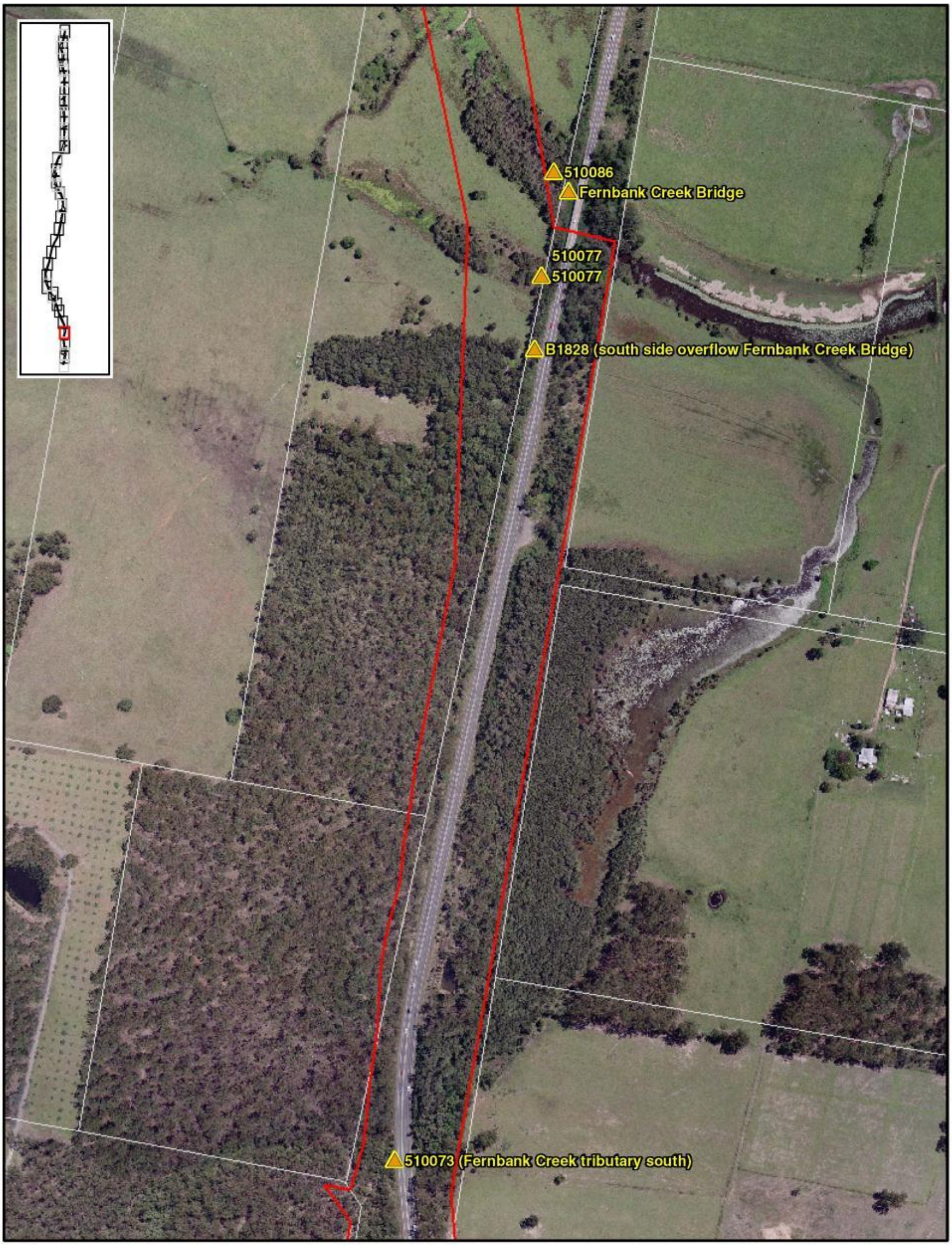
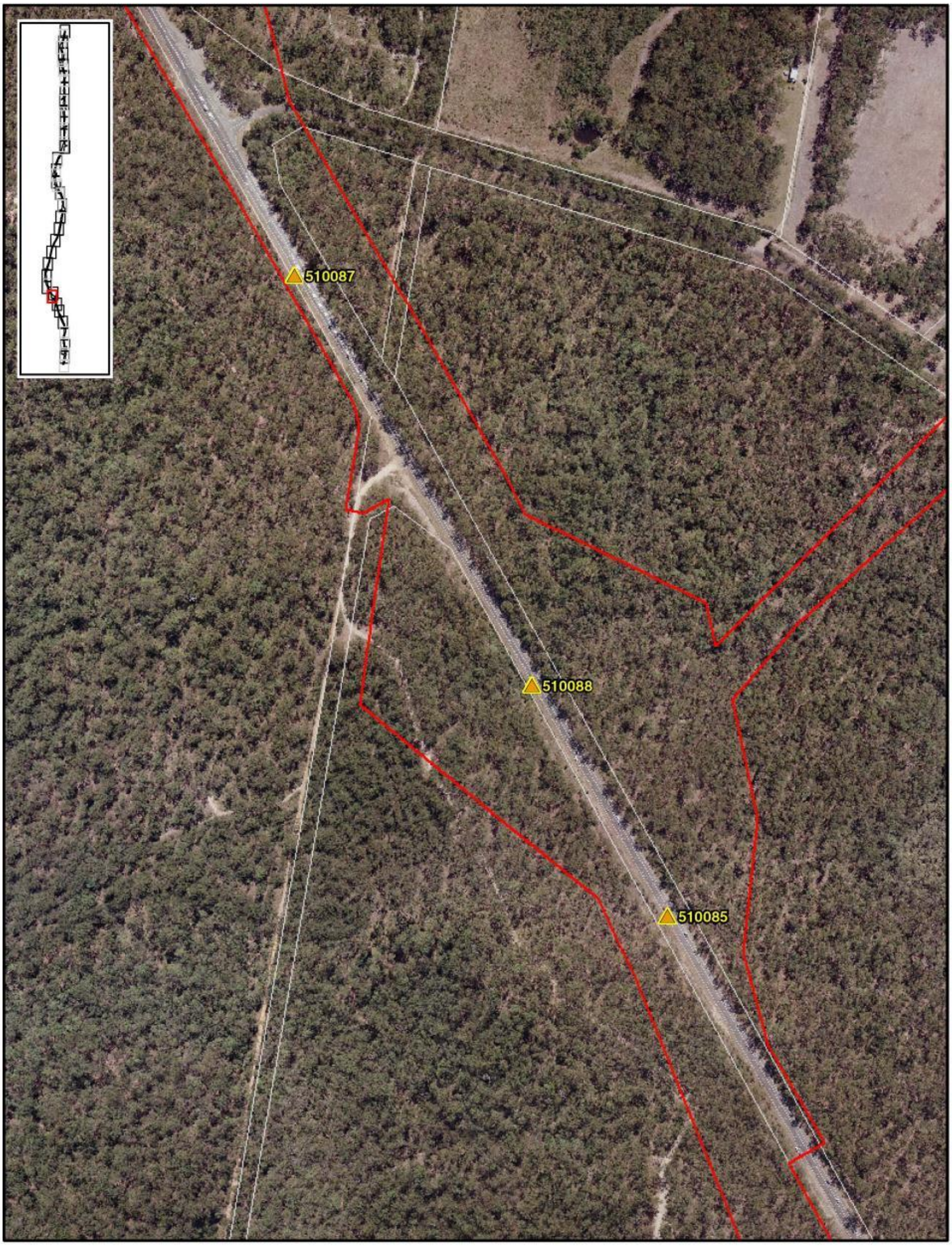
File:
LES-OH2K-002-Figures-2-31-CULVERT-BRIDGE-130228
N
W
E
S
0
50
100
150
Meters
A4 Scale 1:5,000
Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator
Culvert and bridge locations
Sites where micro bats were recorded
Drainage line
Project Boundary
Works boundary
Cadastral boundary
FIGURE 4:
MICRO BAT MANAGEMENT STRATEGY - OXLEY HIGHWAY TO KEMPSEY PROJECT



LEWIS ECOLOGICAL SURVEYS	Source: Cadastre: Roads and Traffic Authority 2007; Project Boundary: Roads and Traffic Authority 2012; Drainage: Geoscience Australia 2009; Aerial Photography: Roads and Traffic Authority (date unknown); Culvert and Bridge Survey: Lewis Ecological Services 2013	A4 Scale 1:5,000 (0, 50, 100, 150 Meters)	Culvert and bridge locations; Sites where micro bats were recorded; Drainage line; Project Boundary; Works boundary; Cadastral boundary	FIGURE 5: MICRO BAT MANAGEMENT STRATEGY - OXLEY HIGHWAY TO KEMPSEY PROJECT
	File: LES-OH2K-002-Figures-2-31-CULVERT-BRIDGE-130228	Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator		



LEWIS ECOLOGICAL SURVEYS

Source:	Cadastre: Roads and Traffic Authority 2007; Project Boundary: Roads and Traffic Authority 2012; Drainage: Geoscience Australia 2009; Aerial Photography: Roads and Traffic Authority (date unknown); Culvert and Bridge Survey: Lewis Ecological Services 2013
Disclaimer:	This plan is based on or contains data provided by others. Lewis Ecological Surveys gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to and use of the data. Data must not be used for direct marketing or be used in breach of privacy laws.
File:	LES-OH2K-002-Figures-2-31-CULVERT-BRIDGE-130228

N W E S

0 50 100 150

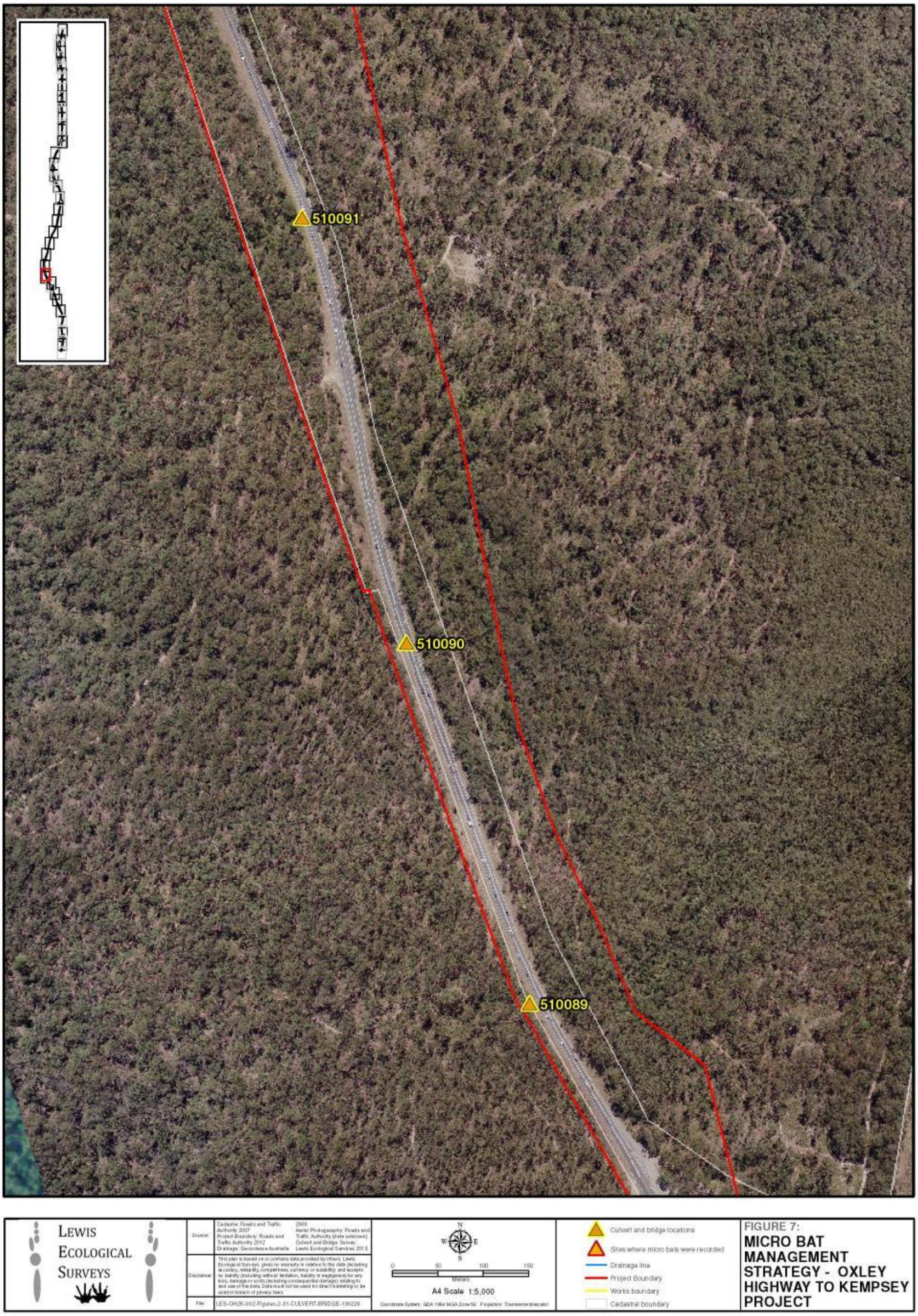
Meters

A4 Scale 1:5,000

Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator

Culvert and bridge locations
Sites where micro bats were recorded
Drainage line
Project Boundary
Works boundary
Cadastral boundary

FIGURE 6:
MICRO BAT MANAGEMENT STRATEGY - OXLEY HIGHWAY TO KEMPSEY PROJECT


510091
510090
510089
LEWIS ECOLOGICAL SURVEYS
Source:
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Project Boundary: Roads and Traffic Authority 2012
Drainage: Geoscience Australia
2009
Aerial Photography: Roads and Traffic Authority (date unknown)
Culvert and Bridge Survey: Lewis Ecological Services 2013
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File: LES-OH2K-002-Figures-2-31-CULVERT-BRIDGE-130228
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Meters
A4 Scale 1:5,000
Culvert and bridge locations
Sites where micro bats were recorded
Drainage line
Project Boundary
Works boundary
Cadastral boundary
FIGURE 7:
MICRO BAT MANAGEMENT STRATEGY - OXLEY HIGHWAY TO KEMPSEY PROJECT

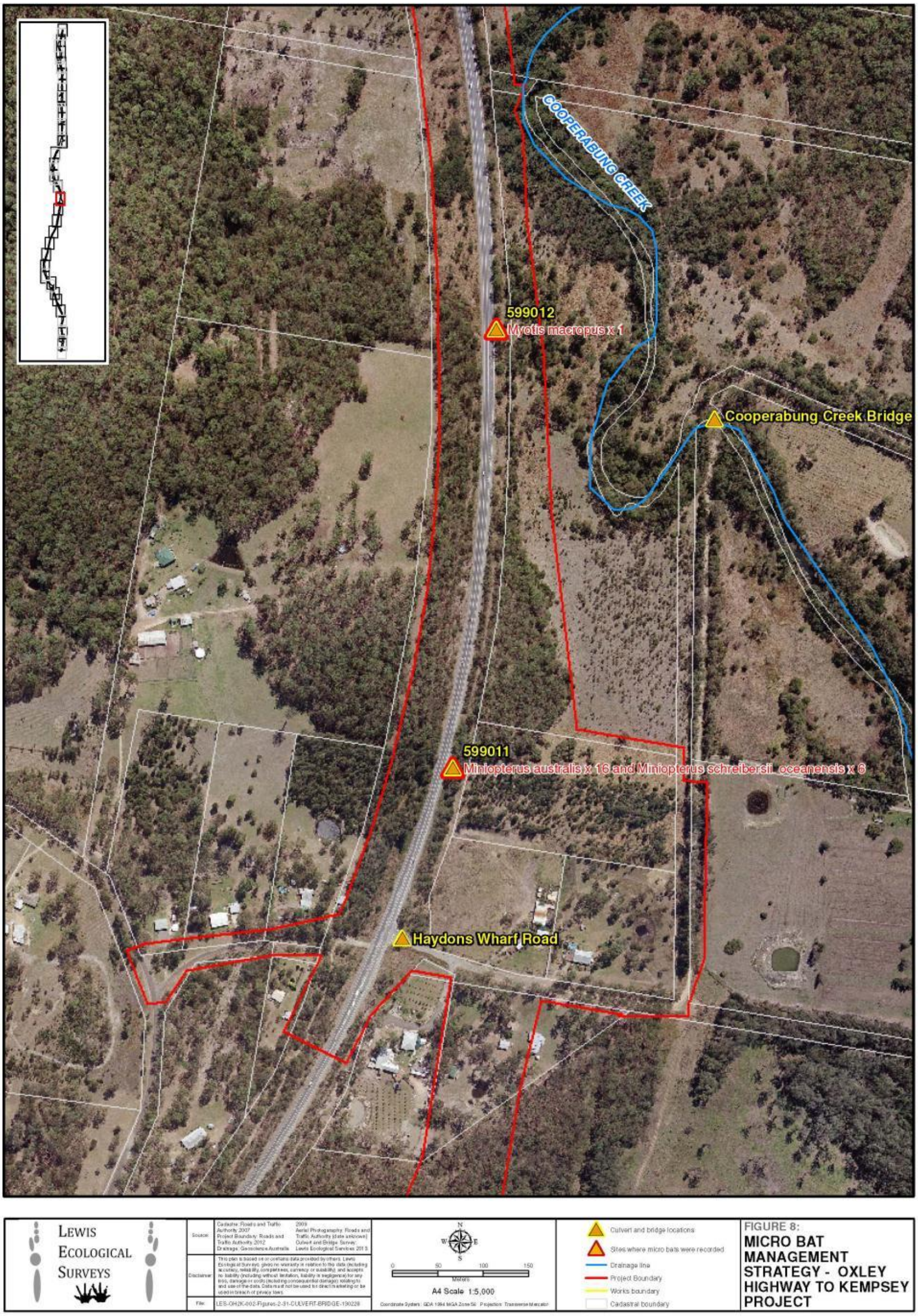
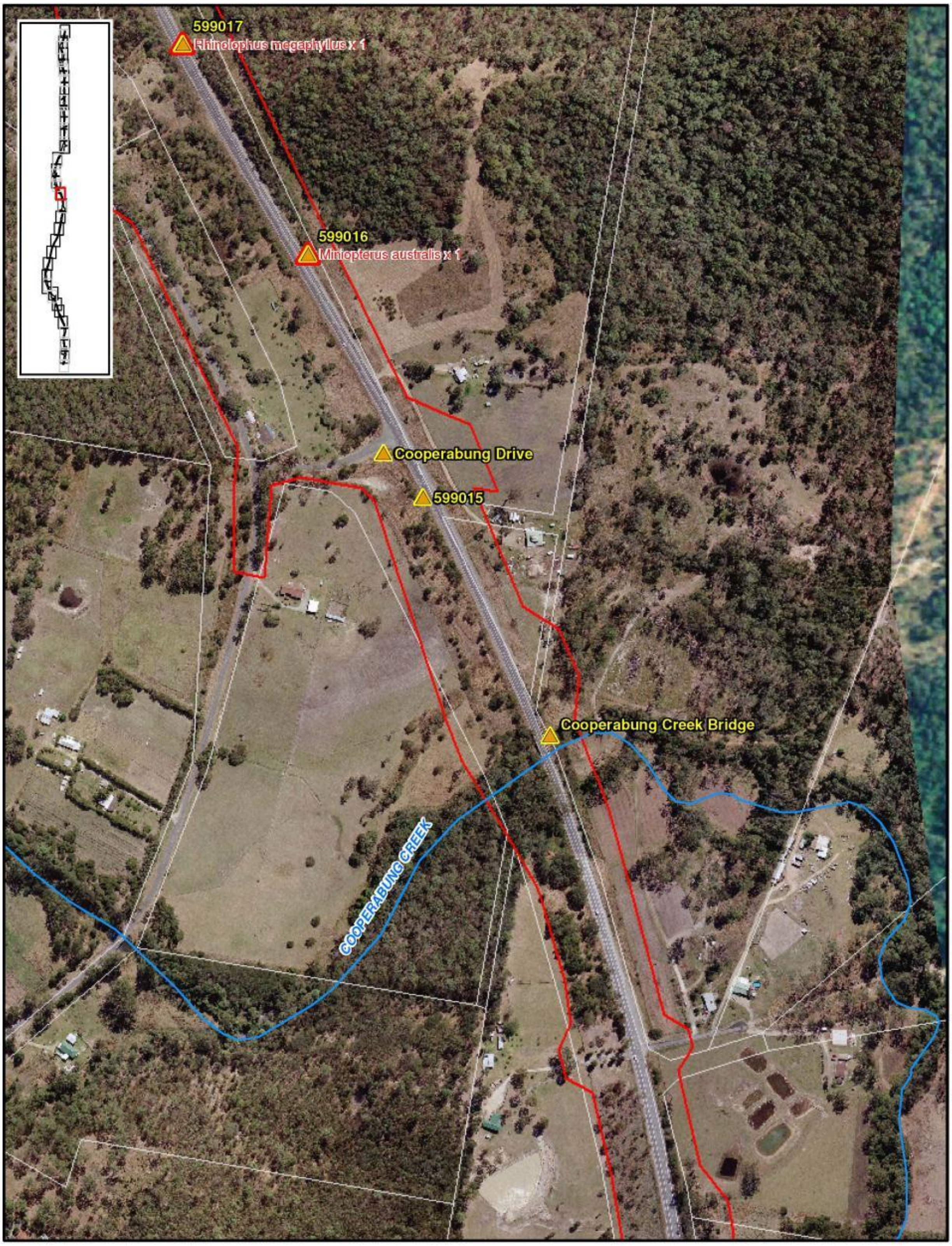


FIGURE 8:
MICRO BAT MANAGEMENT STRATEGY - OXLEY HIGHWAY TO KEMPSEY PROJECT



LEWIS ECOLOGICAL SURVEYS

Source: Cadastre: Roads and Traffic Authority 2007; Project Boundary: Roads and Traffic Authority 2012; Drainage: Geoscience Australia 2009; Aerial Photography: Roads and Traffic Authority (date unknown); Culvert and Bridge Survey: Lewis Ecological Services 2013.

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File: LES-OH2K-002-Figures-2-31-CULVERT-BRIDGE-130228

N W E S

0 50 100 150 Meters

A4 Scale 1:5,000

Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator

Culvert and bridge locations
Sites where micro bats were recorded
Drainage line
Project Boundary
Works boundary
Cadastral boundary

FIGURE 9:
MICRO BAT MANAGEMENT STRATEGY - OXLEY HIGHWAY TO KEMPSEY PROJECT

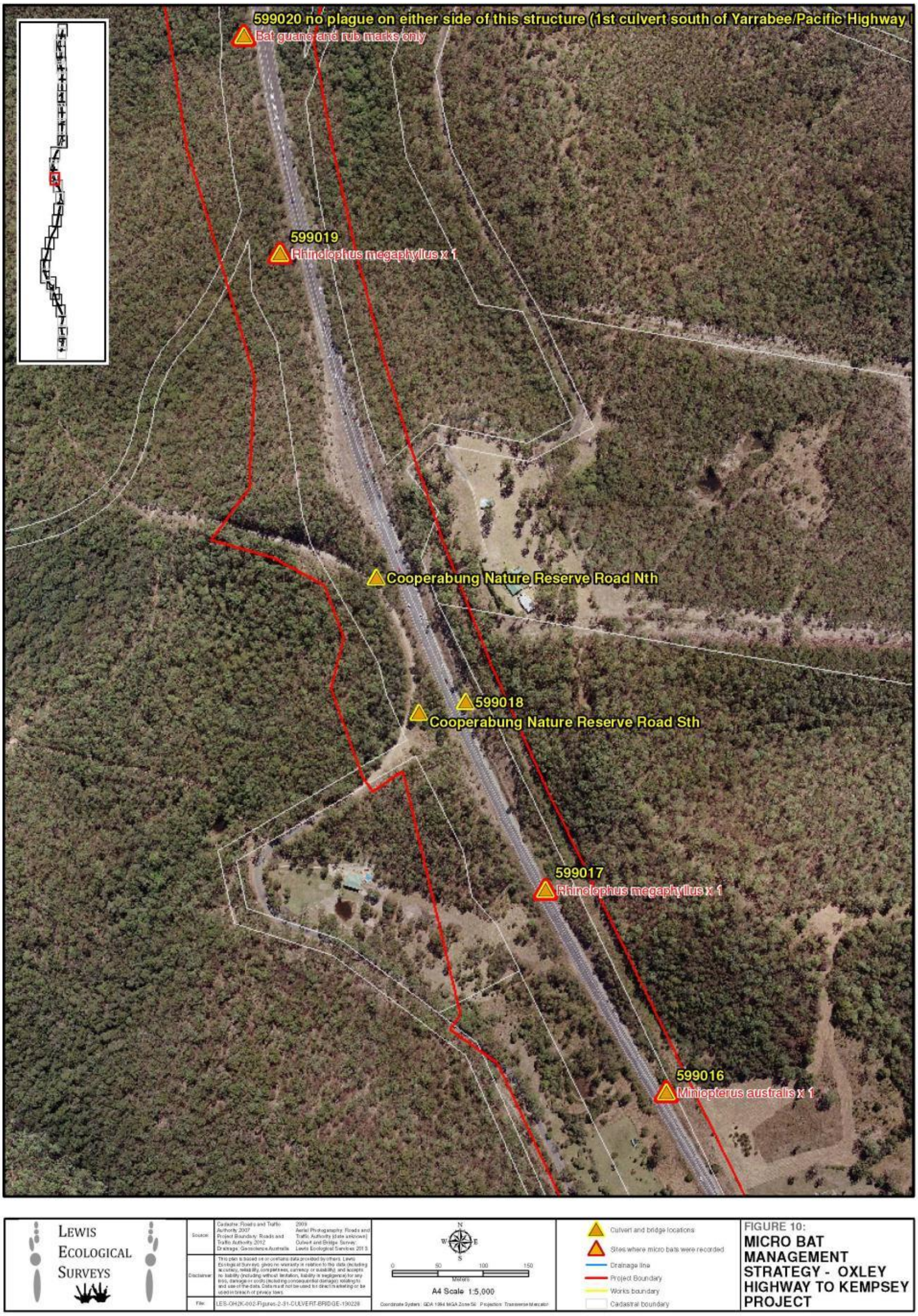
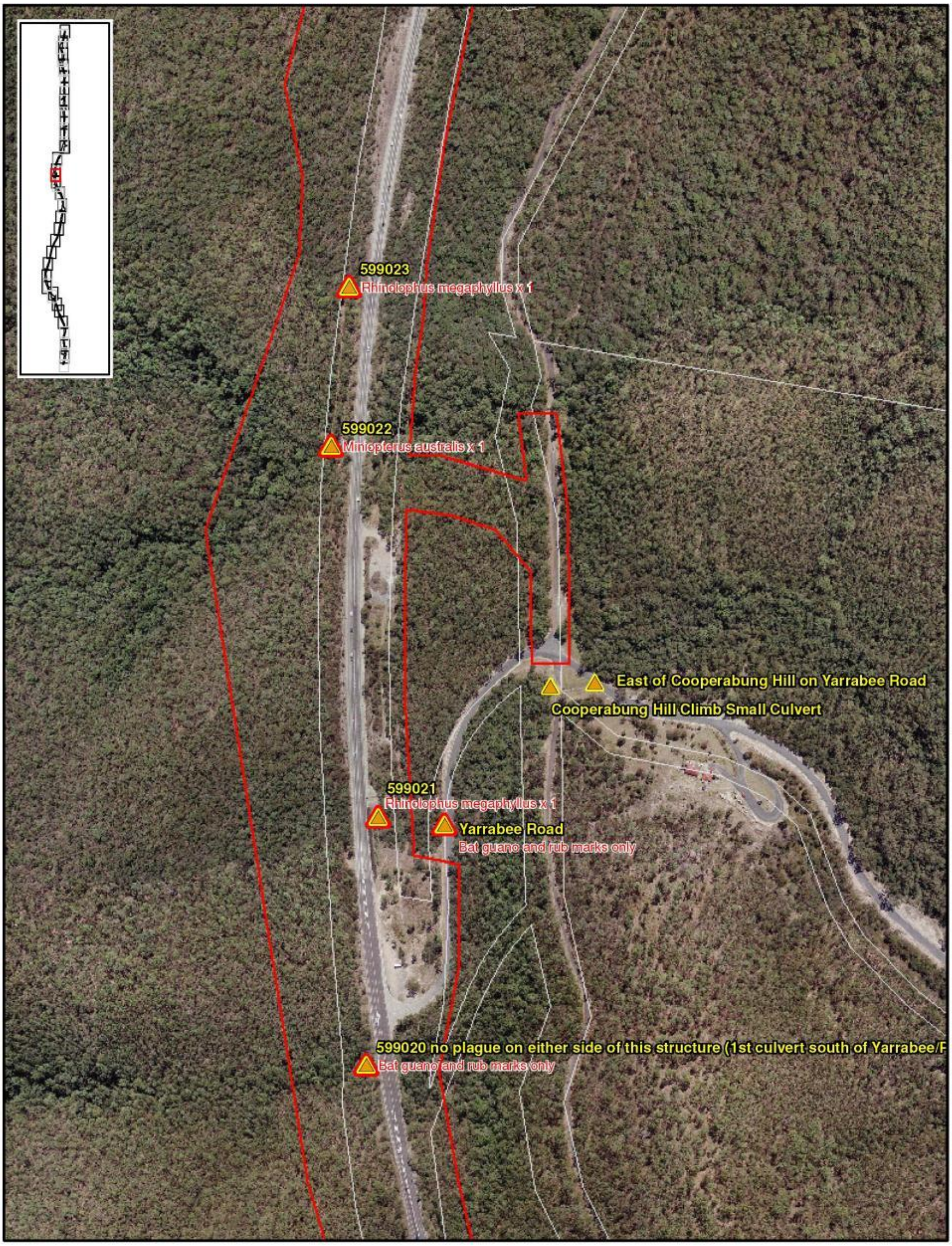


FIGURE 10:
MICRO BAT MANAGEMENT STRATEGY - OXLEY HIGHWAY TO KEMPSEY PROJECT



LEWIS ECOLOGICAL SURVEYS

Source:	Cadastre: Roads and Traffic Authority 2007; Project Boundary: Roads and Traffic Authority 2012; Drainage: Geoscience Australia 2009; Aerial Photography: Roads and Traffic Authority (date unknown); Culvert and Bridge Survey: Lewis Ecological Services 2013
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File:	LES-OH2K-002-Figures-2-31-CULVERT-BRIDGE-130228

N W E S

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Meters

A4 Scale 1:5,000

Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator

- Culvert and bridge locations
- Sites where micro bats were recorded
- Drainage line
- Project Boundary
- Works boundary
- Cadastral boundary

FIGURE 11:
MICRO BAT MANAGEMENT STRATEGY - OXLEY HIGHWAY TO KEMPSEY PROJECT

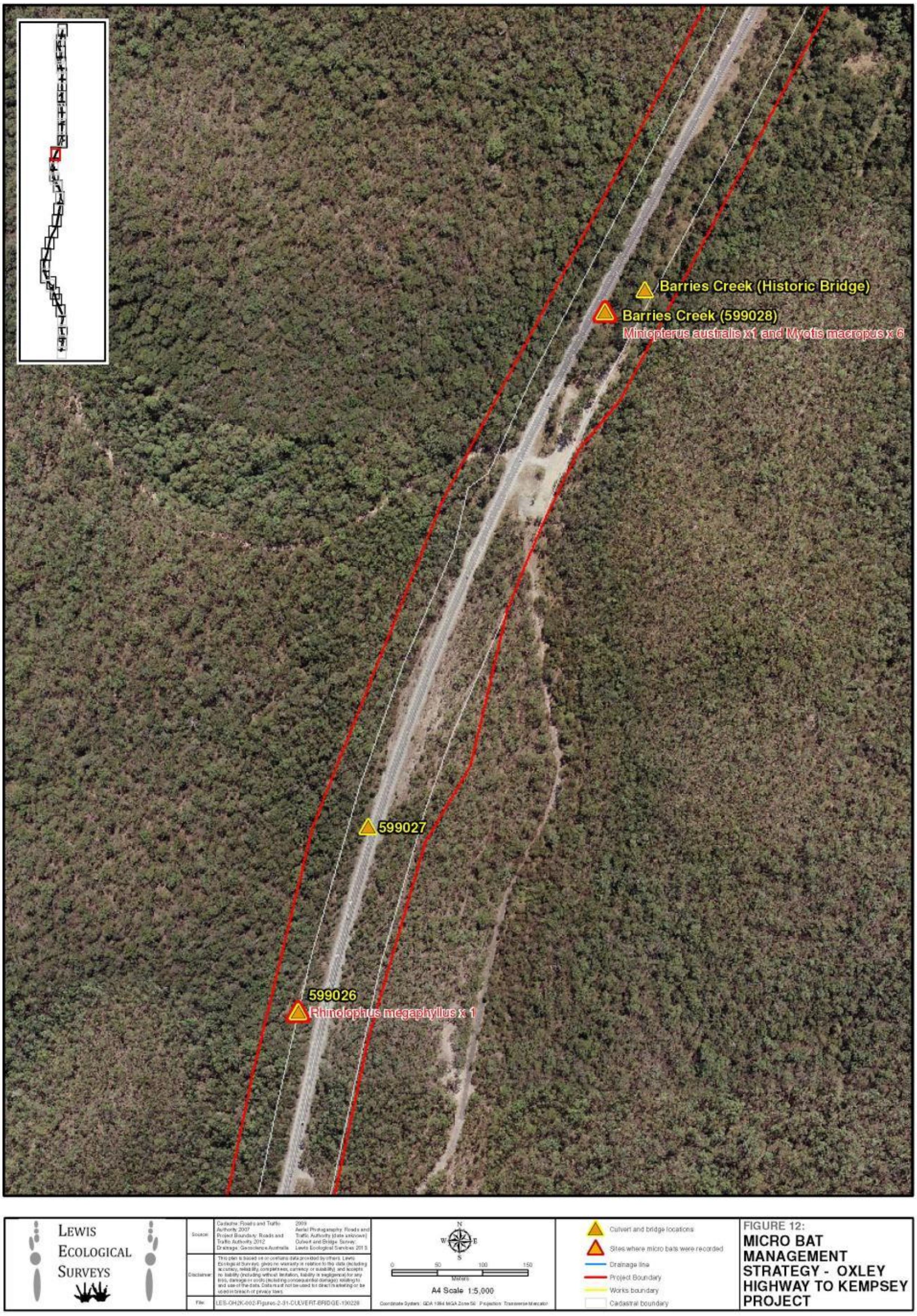


FIGURE 12:
MICRO BAT MANAGEMENT STRATEGY - OXLEY HIGHWAY TO KEMPSEY PROJECT

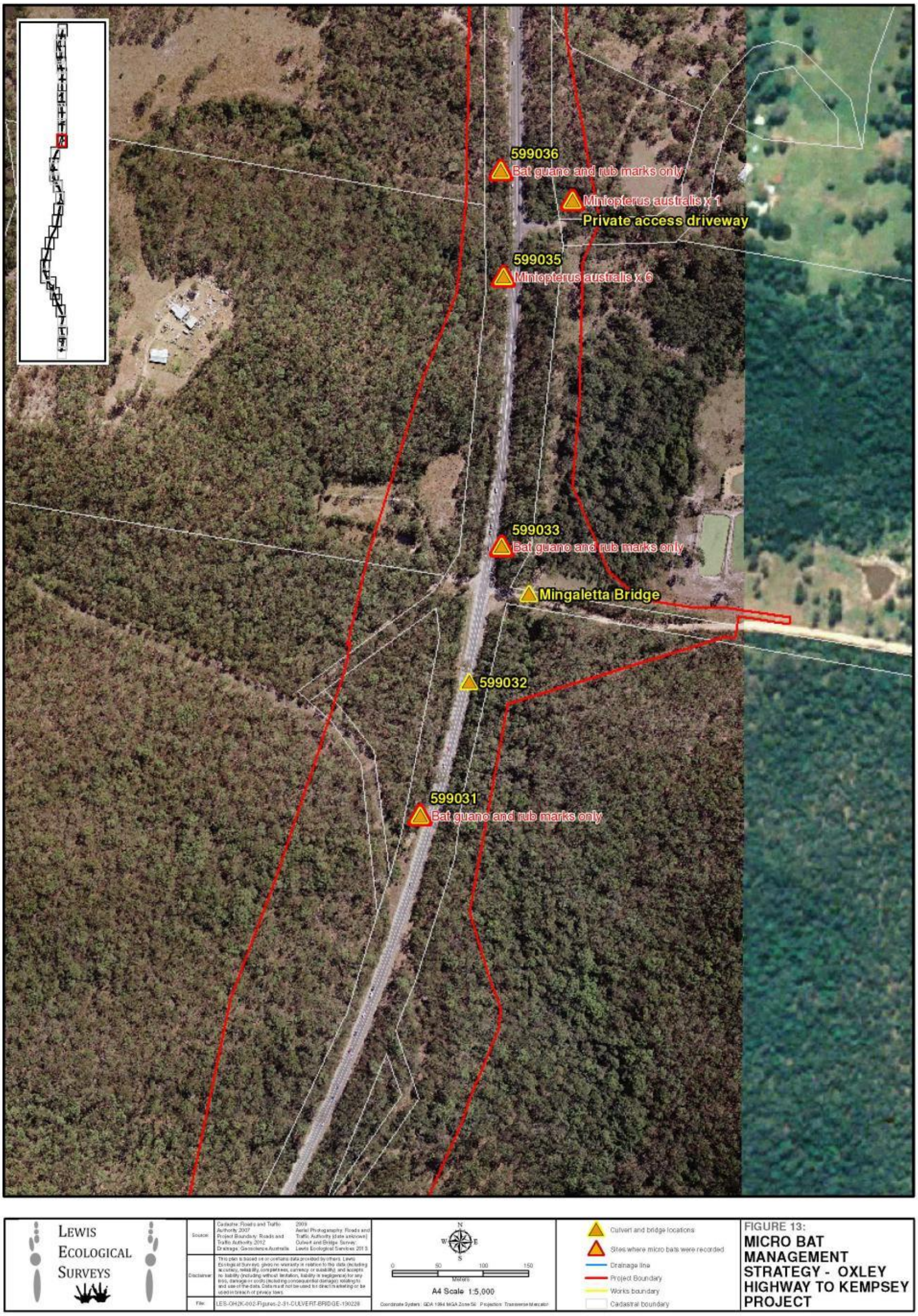
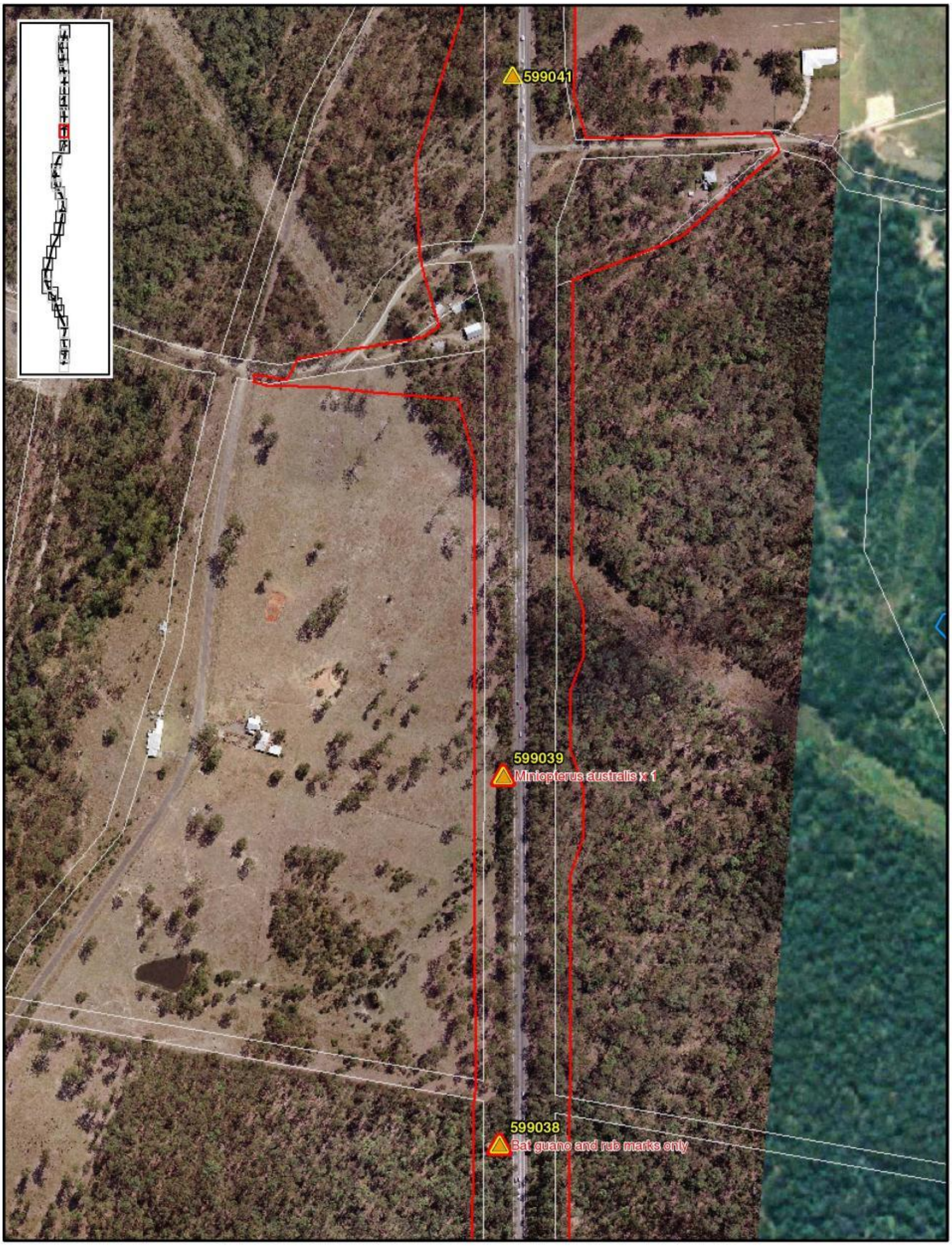


FIGURE 13:
MICRO BAT MANAGEMENT STRATEGY - OXLEY HIGHWAY TO KEMPSEY PROJECT



LEWIS ECOLOGICAL SURVEYS

Source:	Cadastre: Roads and Traffic Authority 2007; Project Boundary: Roads and Traffic Authority 2012; Drainage: Geoscience Australia 2009; Aerial Photography: Roads and Traffic Authority (date unknown); Culvert and Bridge Survey: Lewis Ecological Services 2013
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File:	LES-OH2K-002-Figures-2-31-CULVERT-BRIDGE-130228

0 50 100 150 Meters
A4 Scale 1:5,000
Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator

- Culvert and bridge locations
- Sites where micro bats were recorded
- Drainage line
- Project Boundary
- Works boundary
- Cadastral boundary

FIGURE 14:
MICRO BAT MANAGEMENT STRATEGY - OXLEY HIGHWAY TO KEMPSEY PROJECT

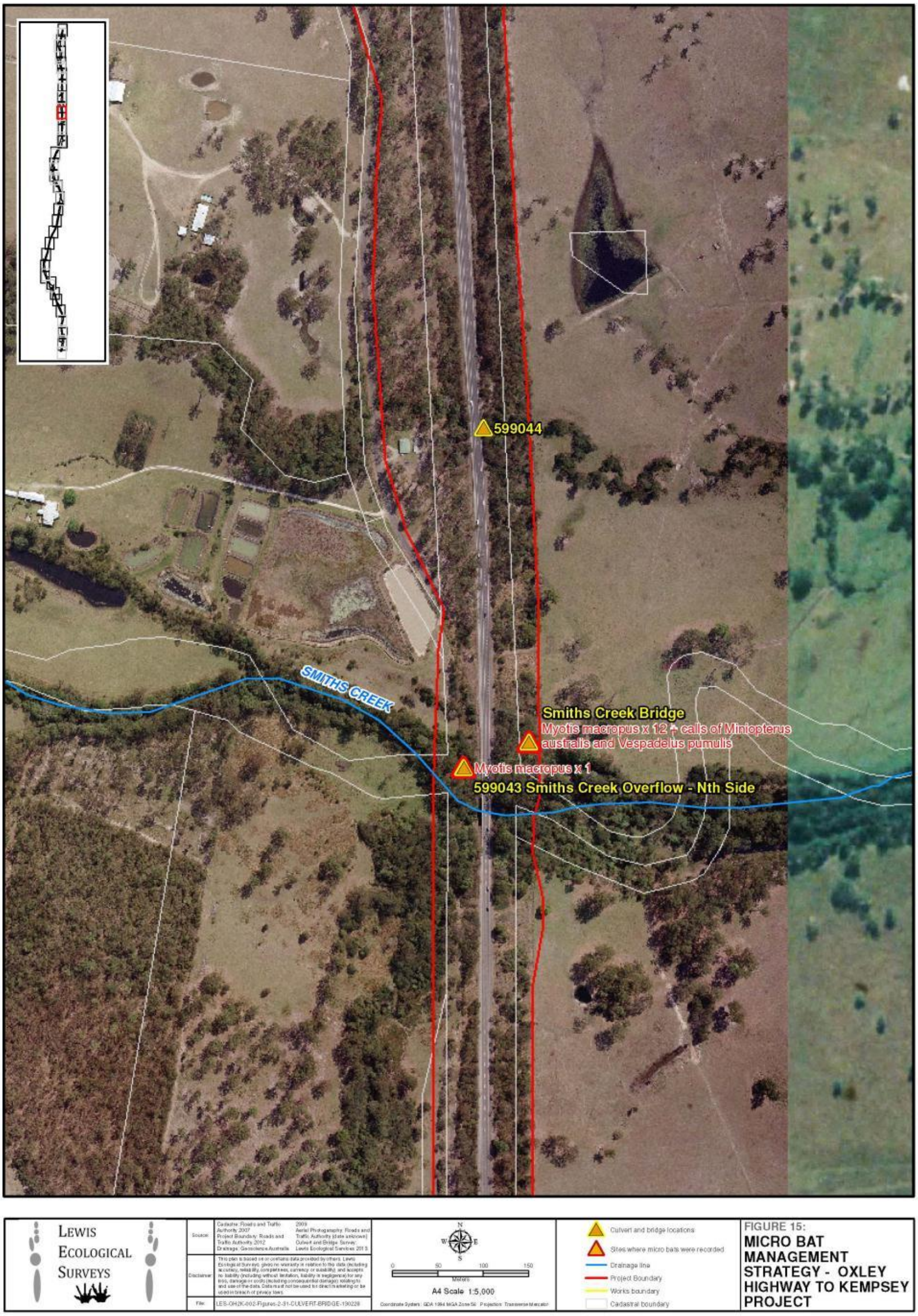


FIGURE 15:
MICRO BAT MANAGEMENT STRATEGY - OXLEY HIGHWAY TO KEMPSEY PROJECT

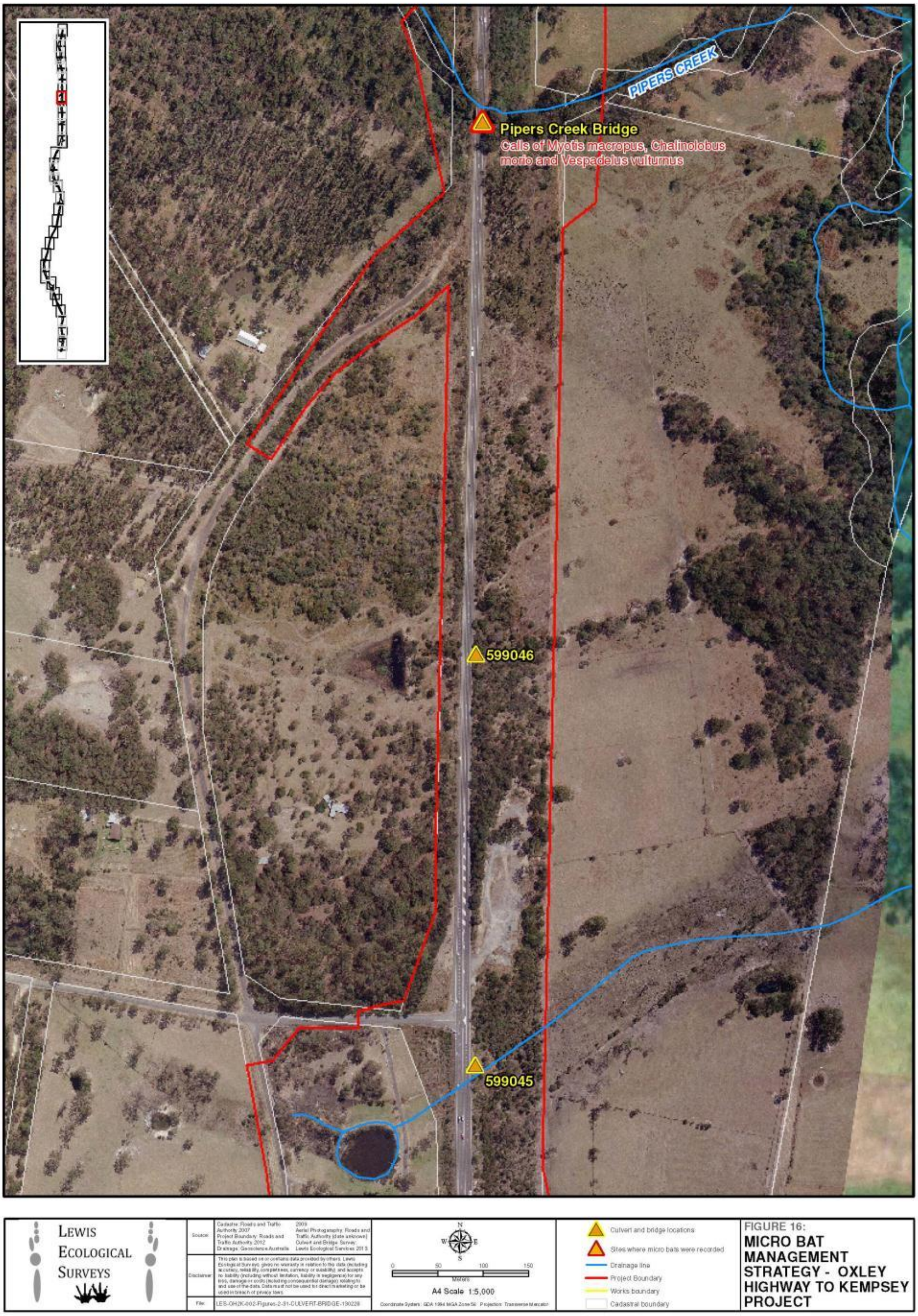
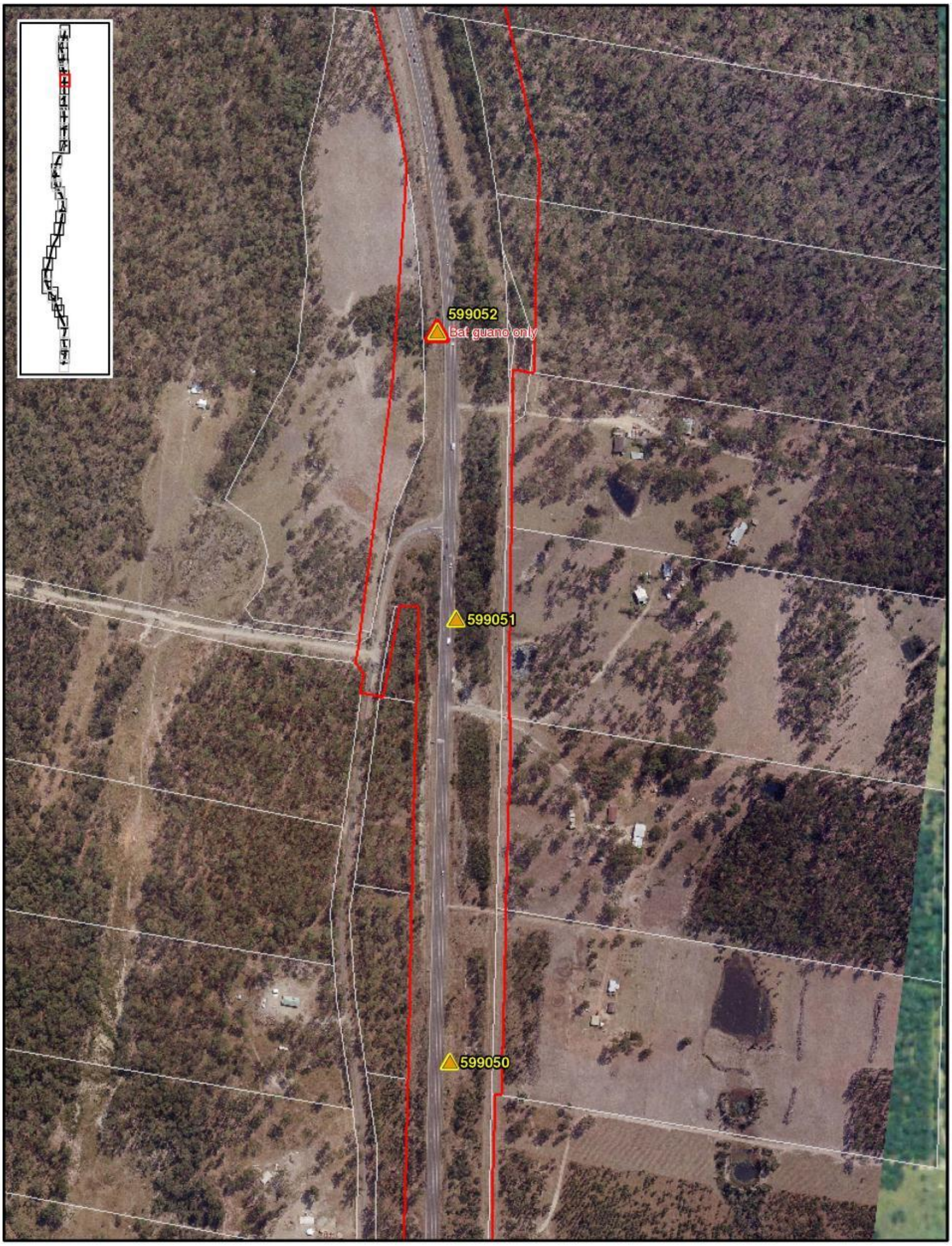


FIGURE 16:
MICRO BAT MANAGEMENT STRATEGY - OXLEY HIGHWAY TO KEMPSEY PROJECT



LEWIS ECOLOGICAL SURVEYS

Source:	Cadastre: Roads and Traffic Authority 2007; Project Boundary: Roads and Traffic Authority 2012; Drainage: Geoscience Australia 2009; Aerial Photography: Roads and Traffic Authority (date unknown); Culvert and Bridge Survey: Lewis Ecological Services 2013
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Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator

- Culvert and bridge locations
- Sites where micro bats were recorded
- Drainage line
- Project Boundary
- Works boundary
- Cadastral boundary

FIGURE 17:
MICRO BAT MANAGEMENT STRATEGY - OXLEY HIGHWAY TO KEMPSEY PROJECT


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LEWIS ECOLOGICAL SURVEYS
Source:
Cadastre: Roads and Traffic Authority 2007
Project Boundary: Roads and Traffic Authority 2012
Drainage: Geoscience Australia
2009
Aerial Photography: Roads and Traffic Authority (date unknown)
Culvert and Bridge Survey: Lewis Ecological Services 2013
Disclaimer:
File: LES-OH2K-002-Figures-2-31-CULVERT-BRIDGE-130228
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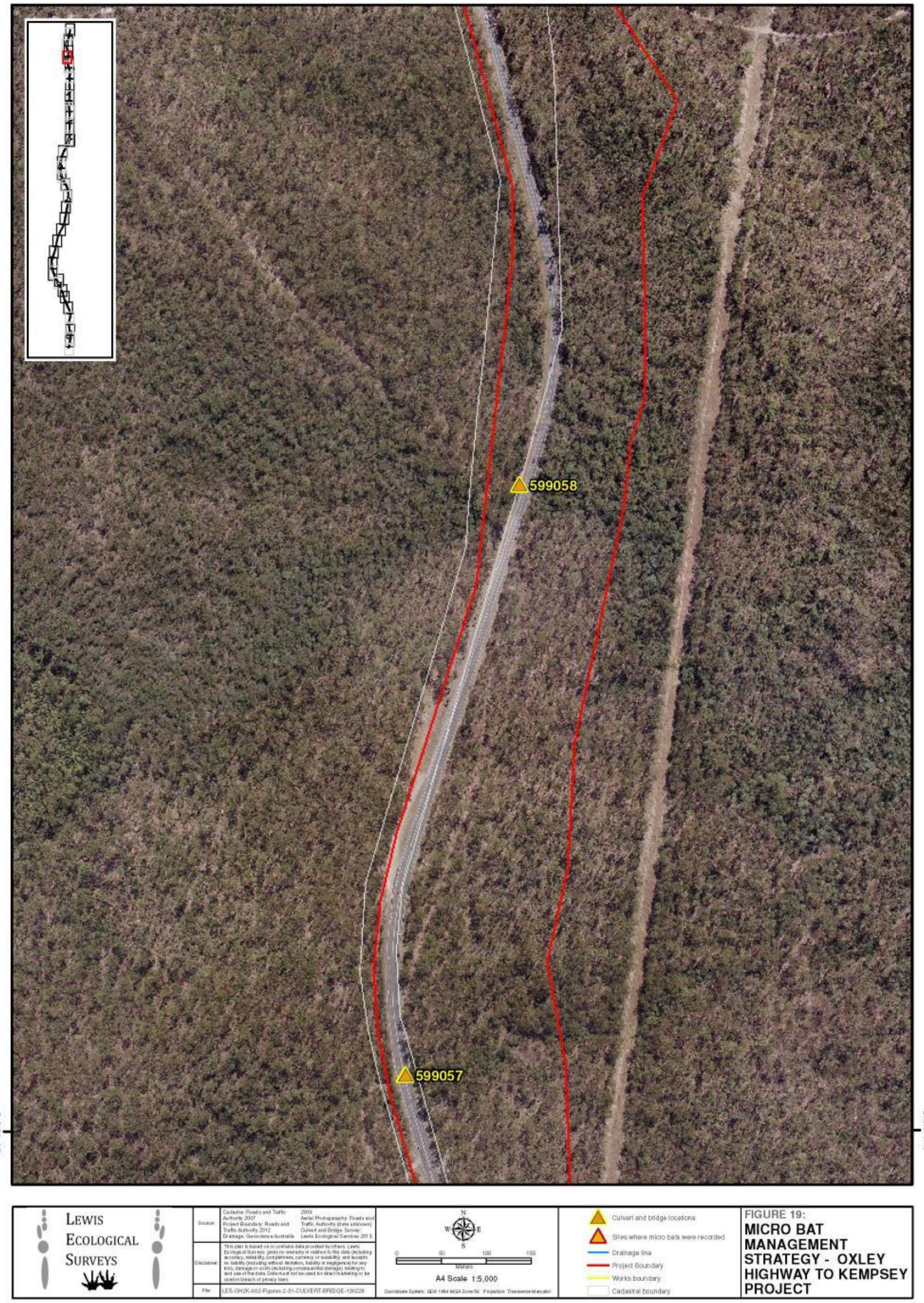
Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator
Culvert and bridge locations
Sites where micro bats were recorded
Drainage line
Project Boundary
Works boundary
Cadastral boundary
FIGURE 18:
MICRO BAT MANAGEMENT STRATEGY - OXLEY HIGHWAY TO KEMPSEY PROJECT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31°10'0"S
LEWIS
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SURVEYS
Source:
Cadastre: Roads and Traffic Authority 2007
Project Boundary: Roads and Traffic Authority 2012
Drainage: Geoscience Australia
2009
Aerial Photography: Roads and Traffic Authority (date unknown)
Culvert and Bridge Survey: Lewis Ecological Services 2013
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Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator
Culvert and bridge locations
Sites where micro bats were recorded
Drainage line
Project Boundary
Works boundary
Cadastral boundary
FIGURE 19:
MICRO BAT MANAGEMENT STRATEGY - OXLEY HIGHWAY TO KEMPSEY PROJECT

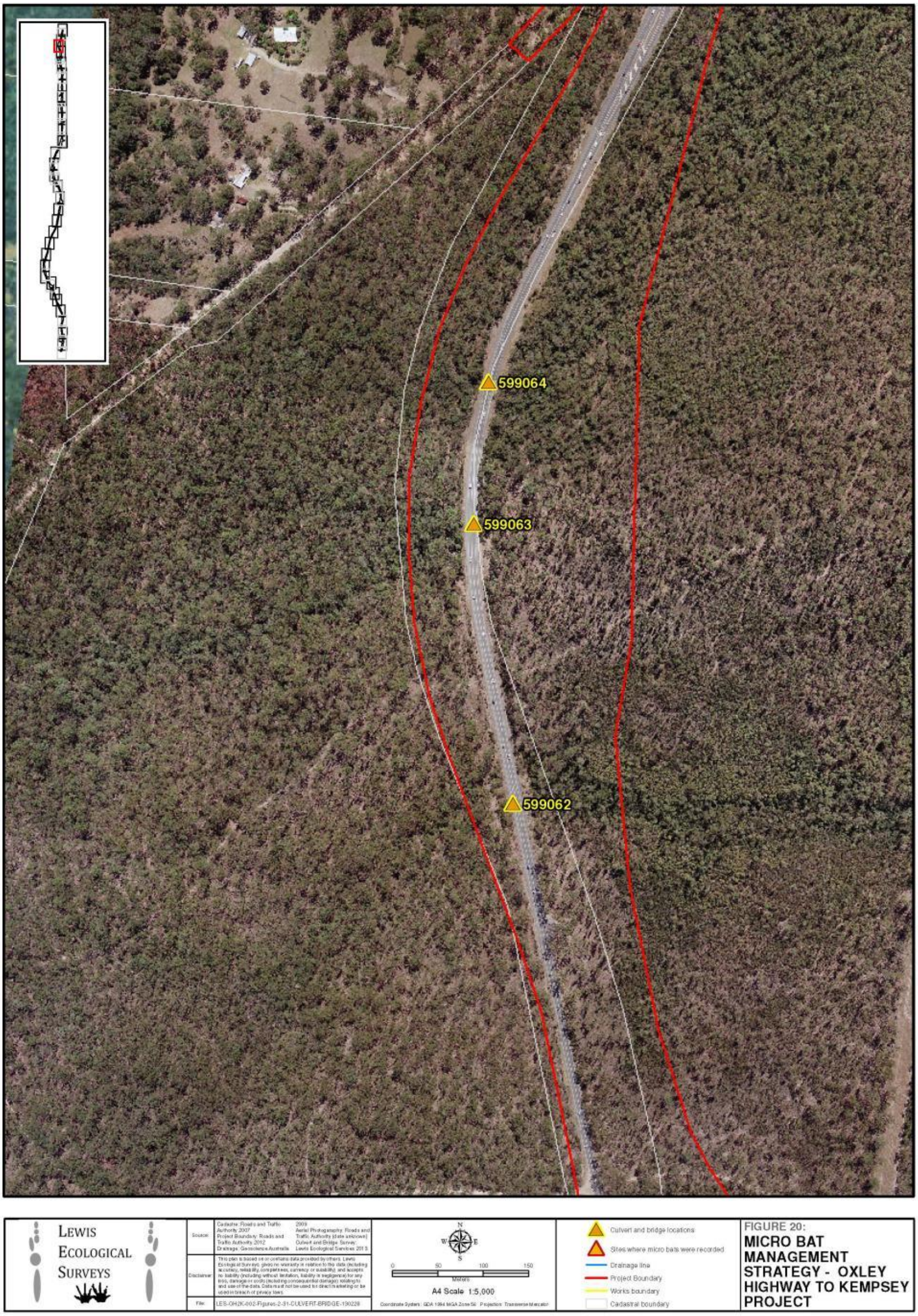


FIGURE 20:
MICRO BAT MANAGEMENT STRATEGY - OXLEY HIGHWAY TO KEMPSEY PROJECT

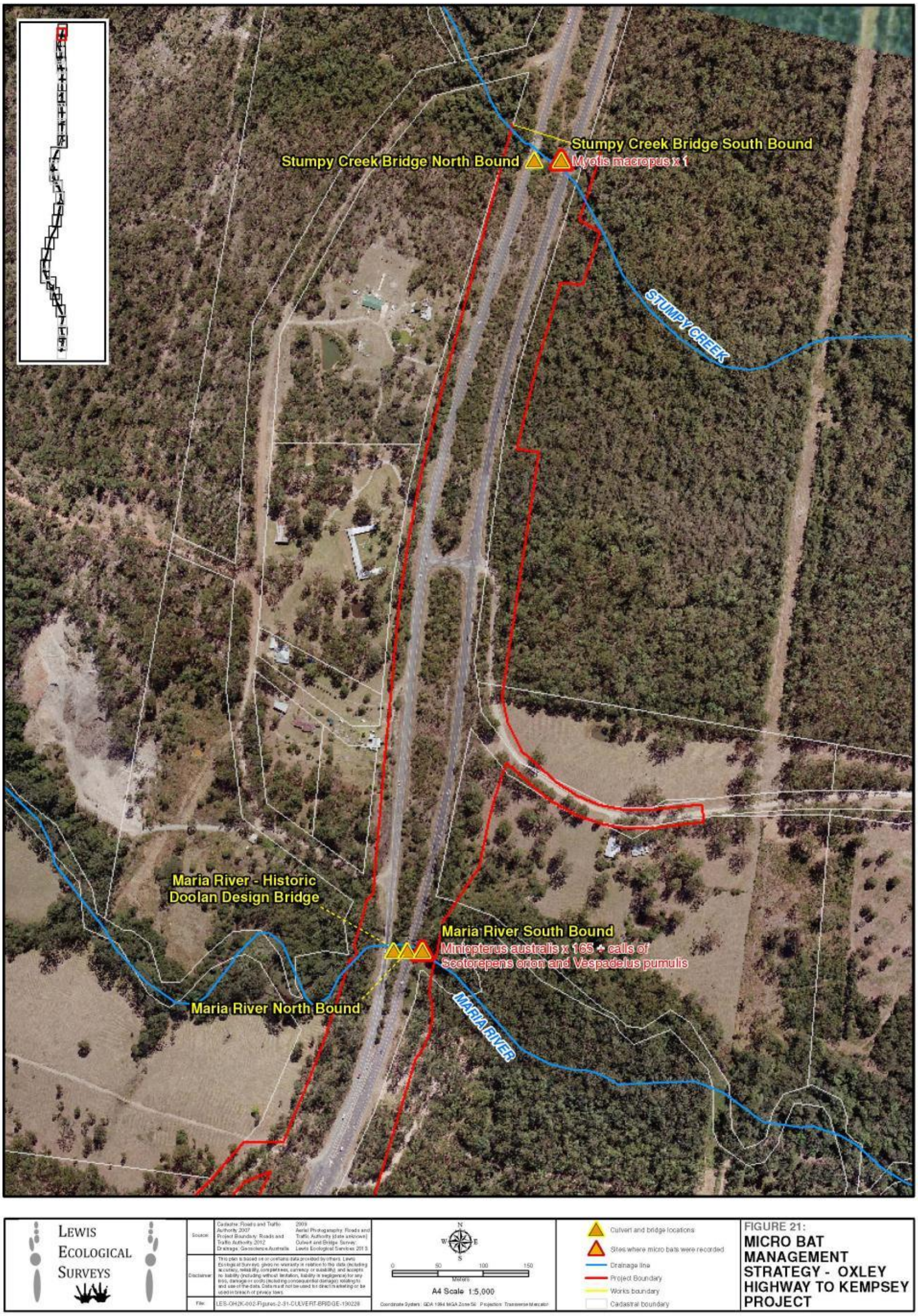


FIGURE 21:
MICRO BAT MANAGEMENT STRATEGY - OXLEY HIGHWAY TO KEMPSEY PROJECT

APPENDIX F – AQUATIC VEGETATION MANAGEMENT STRATEGY

An Aquatic Vegetation Management Strategy is not required due to the fact that no mangroves or segrasses have been identified within the Kundabung to Kempsey Stage of the Project.

APPENDIX G – PRE-CLEARING/ GROUND DISTURBANCE CHECKLIST

PRE-CLEARING AND GROUND DISTURBANCE CHECKLIST

McConnell Dowell OHL Joint Venture

QMS#
025-F023-2602

Project: *Pacific Highway Upgrade – Kundabung to Kempsey*	**Project No:** *2602*
Requested By:	**Permit Number:**
Vegetation Clearing Start Date:	**Expected Completion Date:**
Model/ Version Number of Survey:	**Description of Location:** **Chainages:**

VEGETATION CLEARING LOCATIONS – ATTACH DRAWINGS / SKETCHES IF NECESSARY

Ch. From	Ch. To	Carriageway	Location	Comments

This section to be completed by Project Ecologist / suitably qualified expert and Environmental Advisor

Has the vegetation to be cleared been clearly delineated? ☐ Yes ☐ No

All trees / vegetation to be retained identified by survey and exclusion areas fenced off? ☐ Yes ☐ No

State how identified:

Have relevant fauna rescue organisation (WIRES/FAWNA) been contacted and advised of the proposed clearing to ensure adequate resources available? ☐ Yes ☐ No

Have habitat trees been identified and appropriately marked by the Project Ecologist and has the 48-hour wait period for habitat trees elapsed? ☐ Yes ☐ No ☐ N/A

State how identified:

PRE-CLEARING AND GROUND DISTURBANCE CHECKLIST

McConnell Dowell OHL Joint Venture

QMS#
025-F023-2602

Any specific targeted surveys required in this work area? ☐ Yes ☐ No

(Refer to Ecological Monitoring Program)

Where required, state survey requirements how survey was completed and, include summary of results:

Has weed management been undertaken? ☐ Yes ☐ No ☐ N/A

Provide details:

Is the Project Ecologist present?	☐ Yes ☐ No
Are any animals present? (If *Yes*, relocation required)	☐ Yes ☐ No
Are any active nests present? (If *Yes*, relocation required)	☐ Yes ☐ No
Have checks for animals occurred at the appropriate times? (Dawn, dusk etc)	☐ Yes ☐ No
Have relevant workers been toolboxed on limit of clearing, fauna handling procedures and any other issues?	☐ Yes ☐ No
If soil disturbance is to occur, has an PESCP Plan been created and have these controls been installed?	☐ Yes ☐ No
Are the proposed works covered by an existing Approval?	☐ Yes ☐ No

Which document covers the works?

Comments:

PRE-CLEARING AND GROUND DISTURBANCE CHECKLIST

McConnell Dowell OHL Joint Venture

QMS#
025-F023-2602

Inspection completed by Project Ecologist / suitably qualified expert: **Date:**

Ecologist / suitably qualified expert suitably qualified expert Signature Required

Approval by Environmental Advisor / Environmental Manager: **Date:**

EO / EM Signature Required

APPENDIX H – WORKING AROUND TREES GUIDELINE

WORKING AROUND TREES GUIDELINE

1.0 PURPOSE & SCOPE

Many of the activities undertaken by the McConnell Dowell-OHL Joint Venture (the JV) involve works near trees and other vegetation. Damage to trees and roots from excavation or material / equipment storage can cause declining tree health leading to structural instability and tree death. Damage can also result in an increased risk to worker and public safety from unstable trees and possible fines for the JV and subcontractors.

This guideline has been prepared to provide project personnel with an easy-to-use guide to minimise the impact on trees and vegetation in the project area.

2.0 GUIDELINE

2.1 GENERAL

All project personnel (including JV staff and subcontractors) will be inducted on the location of environmental exclusion zones and the associated fencing and signage delineating these areas. Training will be undertaken with regards to this guideline for workers involved in working near vegetation that is to be retained.

For trees identified on the Sensitive Area Maps as being a threatened species, part of a threatened community, or of local importance, the project environmental (including Project Ecologist / suitably qualified expert) and construction personnel are to ensure exclusion fencing is installed and maintained to ensure no unnecessary impact to trees.

For any issues regarding works around trees that cannot be resolved by following this guideline contact the project Environment Manager as soon as possible prior to commencing your work activities.

2.2 CONSTRUCTION ACTIVITIES NEAR TREES

The following points are to be followed when working around tress and vegetation that are to be retained:

- All operations will be carried out to ensure that there is no damage to any trees outside the limits of clearing. Heavy plant must not be operated or parked within the drip line of retained trees, unless otherwise agreed by Roads and Maritime Services.
- Trees identified by the Project Ecologist / suitably qualified expert outside the limits of clearing which are unsound and are likely to fall upon the roadway or private property will be marked and identified in the Clearing and Grubbing EWMS.
- Stockpiled materials will not be placed inside vegetation protection areas or within driplines of retained trees. Prior to using any plant or locating stockpiles or laydown areas around trees, ensure damage to trunks, roots and branches is avoided by observing their location and taking extra care. Damage to tree trunks may result in future decay and death of the tree.
- If branch trimming is required report to the Superintendent/ Foreman, Environment Manager or Environment Advisor who will arrange for an arborist to provide advice on the situation and refer to Figure 1 below for most appropriate management method.
- Report any tree damage to the Superintendent/ Forman, Environment Manager or Environment Advisor as soon as possible. Quick remedial action can usually prevent long-term damage to the tree.

2.3 LOPPING AND PRUNING TREES

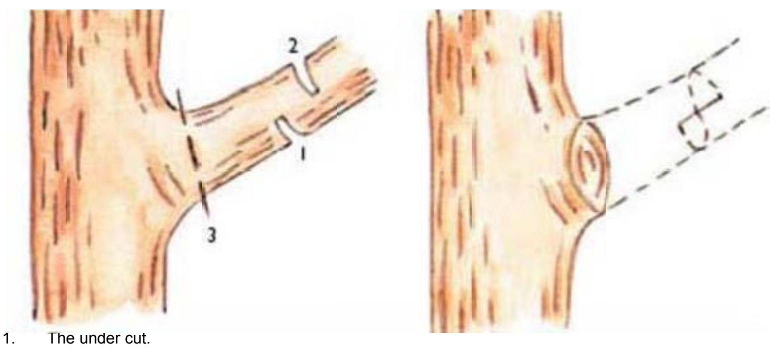
2.3.1 Branch Clearing

Branches may be cleared for the construction of bridges to ensure that there is 3 meters of clearance.

Any branch, which overhangs the road formation, must be cut back flush with the tree trunk in accordance with AS 4373.

2.3.2 Lopping, Pruning and Trimming Procedure

- Heavy machinery should not be used for pruning or trimming. Appropriate tools to use are loppers, chain saws and vehicle mounted saws.
- In the first instance, hollow bearing limbs should be retained. If this is not possible the hollow bearing limb should be inspected by the Project Ecologist / suitably qualified expert and placed in adjacent un-disturbed vegetation to provide fauna habitat.
- Tree limbs are to be r moved using the three cut method as shown below in Figure 1.



1. The under cut.
2. The upper cut to remove the branch.
3. The final trim cut.

Figure 1 – Three cut method

2.4 EXCAVATION NEAR TREES

Some construction works, particularly drainage, may be designed within close proximity to retained trees and vegetation. When carrying out excavation activities near trees, to ensure roots are not damaged in a way that could impact upon tree health, the following points re to be adhered to:

Excavation with machinery should occur outside the drip line of trees/vegetation where possible (Figure 2):

- Where excavation works and drainage lines encroach on drip lines of trees and vegetation consult Project Ecologist / suitably qualified expert or arborist on likely impacts including long term tree/vegetation health. Adopt advice provided by Project Ecologist / suitably qualified expert / arborist.
- Where tree roots greater than 50 mm are damaged by works seek advice from Project Ecologist / suitably qualified expert/Aborist and/or Environment Manager.

2.5 TREE REMOVAL OR TRIMMING

Some construction activities will require tree removal or trimming that has not been included in the design. This is to be avoided where at all possible.

Any clearing required outside the area approved to be cleared for the formation will be subject to approval by Roads and Maritime Services prior to the commencement of clearing.

Where additional impacts to trees are proposed, the following process should be followed:

1. The Superintendent/ Foreman should notify the Environment Manager of the location and need for the tree impact;

2. In consultation with the Project Ecologist / suitably qualified expert, the Environment Manager should confirm that the tree (or other vegetation type) is not heritage listed, a habitat tree, nominated for retention or protected under relevant legislation and is legally able to be removed and/or trimmed. Alternatives to removing the tree should also be investigated at this stage;

3. The Environment Manager should notify the arborist for advice on management options and where possible take and send photos or organise a site visit;

4. The Environment Manager should notify the RMS Environmental Representative of the works which may require a site visit;

5. If the tree is to be removed or trimmed, the Environment Manager will contact the arborist to undertake the removal or trimming of the tree(s) as required; and

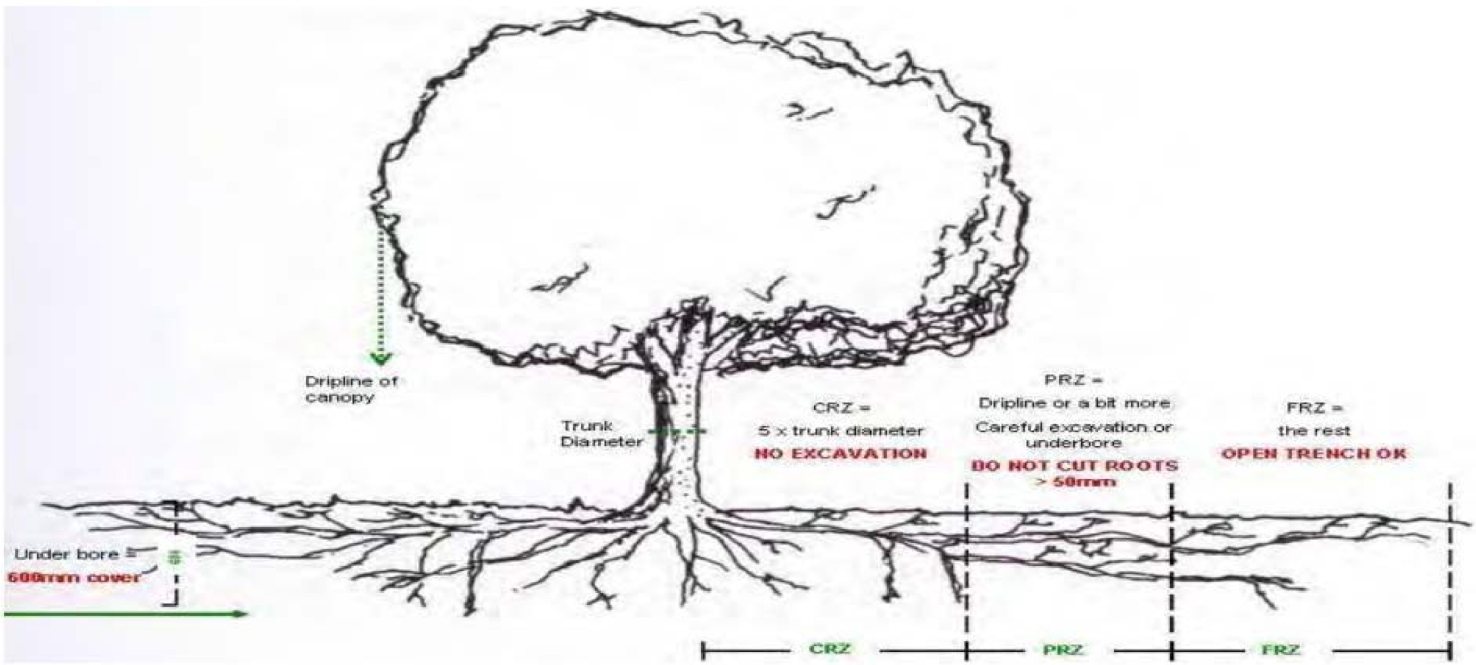
6. The Superintendent/ Foreman should await written confirmation from the Environment Manager prior to re-commencing works around the tree(s).

2.6 STOCKPILING

The storage of soils/material under trees can compact soil, limit water and oxygen uptake, damage roots and cause tree death. Before commencing works near trees, the Superintendent/ Foreman or other construction personnel should determine areas where machinery, materials and equipment can be stored that are outside the drip line of trees.

All stockpile locations are to be approved by the Environment Team prior to stockpiling activities.

Figure 2 – Tree Root Drip Zone



Critical Root Zone (CRZ): Is the distance from the tree trunk that is 5 times the diameter of the trunk. This is the most critical root area that contains the large, woody structural roots.	**Primary Root Zone (PRZ):** This is the area to the drip-line or outer edges of the canopy	**Fibrous Root Zone (FRZ):** The Fibrous Root Zone is the area one and a half times the canopy width

APPENDIX I – FAUNA HANDLING AND RESCUE PROCEDURE

FAUNA HANDLING AND RESCUE PROCEDURE

1.0 PURPOSE

This procedure explains the actions to be undertaken in the event fauna (including injured, shocked, juvenile or other animal) are discovered on the project site that require handling or rescue during vegetation and soil clearance and ongoing construction activities.

2.0 SCOPE

This procedure is applicable to all native and introduced fauna species that are found on the project site.

3.0 PROCEDURE

If wildlife is discovered on the project site during site construction activities that may harm the animal or pose risk to site personnel, the following steps will be taken.

Stop all work in the vicinity of the fauna and immediately notify project Superintendent who is then to notify the Environmental Manager or the Project Ecologist/ suitably qualified expert when the latter is present on site.

Preferably allow fauna to leave an area without intervention.

Use a licensed fauna ecologist or wildlife carer with specific animal handling experience to carry out any fauna handling.

3.1 TERRESTRIAL FAUNA

Where necessary, to minimise stress to native fauna and/or remove the risk of further injury before a licensed fauna handler arrives onsite, the Environmental Advisor shall:

- Cover larger animals with a towel or blanket and place in a cardboard box and/or hessian bag;
- Place smaller animals in a cotton bag, tied at the top;
- Keep the animal quiet, warm, ventilated and in a dark location away from noisy construction activities.

If the animal cannot be handled (i.e. venomous reptiles), exclude all personnel from the vicinity with fencing and/or signage; and the exact location of the animals is to be recorded and provided to the Project Ecologist / suitably qualified expert or appropriate rescue agency (i.e. FAWNA / WIRES).

1. Call the appropriate rescue agency immediately and follow any advice provided by the agency. Once the rescue agency arrives at the site, they are responsible for the appropriate care of the individual. Any decisions regarding the care of the animal will be made by the rescue agency. The relevant fauna rescue services and local veterinary surgeries contact details are as follow:

Agency/business	Contact Number
Project Ecologist / suitably qualified expert (Lewis Ecological Surveys)	Ben Lewis - 0413019279

Agency/business	Contact Number
FAWNA / WIRES	6581 4141 / 1300 094 737
Veterinary Services	Kempsey Veterinary Clinic – (02) 6562 4962 Macleay Valley Veterinary Services – (02) 6562 7391 East Port Veterinary Hospital – 1300 766 604 Port Macquarie Veterinary Hospital – (02) 6583 1611
Port Macquarie Koala Hospital	(02) 6584 1522

In the event the rescue service and/or local veterinary service cannot be contacted, the injured animal will be delivered to the relevant agency as soon as practically possible.

2. If the fauna species is identified as a threatened species that is not a species identified in the CFFMP, the Environmental Advisor or Environmental Manager must:
   a) Immediately cease all work likely to affect the threatened species;
   b) The Environmental Manager shall contact the Roads and Maritime Representative to inform of the situation.
   c) The Environmental Manger shall then contact the following stakeholders, in this order, to determine the appropriate corrective actions and additional safeguards to be undertaken:
      i. Project Ecologist - Ben Lewis, *0413019279*
      ii. OEH (131 555) and/or the Department of the Environment
      iii. Environmental Representative
      iv. Others as instructed by the Roads and Maritime Representative, OEH or the Department of the Environment

The adequacy of existing safeguards are to be reviewed in consultation with the above stakeholders.

3. Environmental Manager to record find in Roads and Maritime Environmental Incident Report where required following consultation with the Roads and Maritime Representative. All relevant characteristics of the fauna find should be recorded to the extent practicable (i.e. visual signs of behaviour; habitat; health signs; sex, time date, weather etc).
4. Following consultation with all relevant stakeholders, the Environmental Manager shall implement any corrective actions and additional safeguards.
5. Following confirmation by the Environmental Manager that all appropriate safeguards have been implemented, construction works shall recommence.
   a) Relocation of fauna along the footprint will be undertaken by the Project Ecologist/ suitably qualified expert or wildlife rescuer and will be recorded on the Weekly Environmental Inspection Checklist. If the animal is not injured or stressed, it may be released nearby in an area that is not to be disturbed by the project construction works, in accordance with the following procedures:
   b) Sites identified as suitable release points by the Project Ecologist/suitably qualified expert or wildlife rescuer;
   c) Release site will contain similar habitat and occur as close to the original capture location as possible;
   d) If the species is nocturnal, release will be carried out at dusk; and
   e) Release would generally not be undertaken during periods of heavy rainfall.

Clearing will be undertaken using a ‘two stage clearing process’.

3. Stage One - Non-habitat Tree Removal

When vegetation is proposed to be removed that may be habitat for native fauna the area shall be surveyed at least 24 hours and no greater than 48 hours prior to removal to establish if native fauna is present.

The Pre-Clearing Survey will include the following:

- A survey of the site to update information on fauna presence.
- Capture and removal of non-mobile fauna such as snakes and key habitat features such as active bird nests and re-location into pre-determined habitat.
- Translocation of fauna, if necessary.

If fauna is present, all fauna that can be physically captured during targeted works (i.e. active searches) will be relocated into areas of suitable habitat adjacent to the Project site (i.e. adjacent to the clearing footprint).

The species, number, sex, age, class and general health of each individual is to be recorded for later reporting. This procedure is outlined in Appendix I, Fauna Handling and Rescue Procedure.

4. Stage Two – Habitat Tree Removal

If the survey indicates that native fauna is present, the individual species habitat tree shall be retained for an additional 48 hours before revisiting the site. If individuals still remain after this time, the habitat may only be cleared in the presence of an appropriately qualified and licensed fauna rescue personnel.

Stage Two, must occur at least 24 hours after Stage One (removal of non-habitat trees), unless otherwise agreed with the EPA.

1. To minimise stress to native fauna and/or remove the risk of further injury the Project Ecologist/ suitable qualified expert shall:
   a) Cover larger animals with a towel or blanket and place in a covered carry cage/basketor sturdy cloth bag;
   b) Place smaller animals in a cotton bag, tied at the top;
   c) For terrestrial fauna keep the animal in a quiet, warm, ventilated and dark place away from noisy construction activities.
   d) For aquatic fauna species ensure sufficient amount of water and ensure adequate aeration. Every attempt should be made to expedite the relocation process in the least amount of time.

2. Habitat trees are to be felled using a harvester with a fixed head not a felling head. This will increase the likelihood of retrieving all fauna that have remained in the habitat tree and reduce the likelihood of fauna being injured during the felling process..

3. In the event an animal is injured the following fauna rescue services and local veterinary surgeries contact details are as follows:

Agency/business	Contact Number
Project Ecologist (Lewis Ecological Surveys)	Ben Lewis - 0413019279
FAWNA / WIRES	6581 4141 / 1300 094 737
RSPCA	Port Macquarie Shelter – (02) 6581 0380
Veterinary Services	Kempsey Veterinary Clinic – (02) 6562 4962 Macleay Valley Veterinary Services – (02) 6562 7391 East Port Veterinary Hospital – 1300 766 604 Port Macquarie Veterinary Hospital – (02) 6583 1611

In the event the rescue service and/or local veterinary service cannot be contacted, the most appropriate euthanasia will be administered by the Project Ecologist/ suitably qualified expert whom possesses the appropriate and current licence for performing euthanasia to vertebrate wildlife (i.e. cervical dislocation for small vertebrates, ice slurry for introduced fish).

4. If the fauna species is identified as a threatened species that is not a species identified in the CFFMP, notify the Environmental Advisor or Environmental Manager who then must:
   a) Immediately cease all work likely to affect the threatened species;
   b) The Environmental Manager shall contact the Roads and Maritime Representative to inform of the situation.
   c) The Environmental Manger shall then contact the following stakeholders, to determine the appropriate corrective actions and additional safeguards to be undertaken:
      i. EPA (131 555) and/or the Department of the Environment
      ii. Environmental Representative
      iii. Others as instructed by Roads and Maritime Representative, EPA or the Department of the Environment
   d) Environmental Manager to record find in Roads and Maritime Environmental Incident Report
   e) Following consultation with all relevant stakeholders, the Environmental Manager shall implement any corrective actions and additional safeguards.
   f) Following confirmation by the Environmental Manager that all appropriate safeguards have been implemented, construction works shall recommence.

5. Relocation of fauna captured during the clearing and associated works will generally take place in areas of suitable habitat immediately adjacent to the Project site taking into account:
   a) The release site contains similar habitat and o
   b) occurs as close to the original area as possible;
   c) If the species is nocturnal, release will normally be carried out at dusk;
   d) Release would generally not be undertaken during periods of heavy rainfall expect for aquatic fauna; and
   e) Non-native fauna will not be translocated and will be euthanized in accordance with the Project Ecologists Animal Care and Ethics Licence.

   If the animal has been placed into care due to injury, age (i.e. young) or stress, upon its rehabilitation it will be released in an area that is not to be disturbed by the project construction works, at the discretion of the Project Ecologist/ suitable qualified expert taking the above into account. The Project Ecologist/ suitable qualified expert will record and provide the capture and relocation data in the post clearing report.

3.2 AQUATIC FAUNA

3.2.1 Overview

From time to time it becomes necessary to relocate freshwater fish from their habitat either due to the effects of drought, maintenance of irrigation structures or for construction purposes. In the first instance a checklist of requirements should be undertaken to ensure that the relocation can be physically undertaken, can be safely undertaken and that a suitable site exists for the relocated fish.

If possible, prior to the arrival of a suitably qualified expert/ ecologist, place aquatic fauna in plastic aquaria or plastic bag with a sufficient amount of water. Place frogs/tadpoles in a plastic bag or plastic aquirina with a small amount of water or vegetation.

3.2.2 Legislative Requirements

A permit will be required under Section 37 of the Fisheries Management Act 1994 to use non recreational fishing equipment to capture fish, exceed bag limits or to take prohibited size or protected fish.

Any potential threatened species requiring relocation should be included as part of the Section 37 permit which provides a defence under Section 220ZF (1) (a) iii to take Threatened fish.

Other aquatic Threatened or protected species such as frogs or vegetation may be encountered during relocation. It is important to contact the Office of Environment and Heritage (OEH) during the planning phase of the relocation to establish what if any OEH managed Threatened or protected species are present and what legislative requirements are required by OEH for the relocation to proceed.

Consultation with the Department of the Environment (DoE) should also be conducted if any nationally listed Threatened species are potentially present at the either the relocation or the receiving site.

Water abstraction to lower pools or river bank works to gain access may require a permit from the Office of Water (NOW).

It is important to obtain land owners permission to conduct works prior to any works being undertaken.

3.2.3 Inland Rivers

Rescued fish should be released downstream and within the same catchment to avoid the inadvertent spread of disease and pests.

Spillway releases from dams have the potential to trap fish by either attracting fish from downstream into unsuitable areas or from fish travelling over the spillway from the dam. Once spillway releases cease fish may be trapped in remnant pools between the spillway and the river. As maintenance works are planned a fish rescue may be more feasible than when dealing with natural events such as black water and floods.

3.2.4 Artificial Waterbodies

Artificial waterbodies such as farm dams, irrigation infrastructure and storages and town water supplies require maintenance from time to time and may also contain freshwater fish. Construction projects such as major roads often have farm dams to be dewatered and decommissioned in order to construct the project. Some of these dams may have been stocked with native or exotic fish and some residual populations of endemic fish may also be present. Some protected or Threatened native flora and fauna such as frogs and turtles may be located during the operation and advice from OEH should be sought as to how these species should be managed.

Where dewatering or decommission of artificial waterbodies needs to occur the Project Ecologist / suitably qualified expert will establish the presence and abundance of native and pest species. The Project Ecologist / suitably qualified expert will then ascertain where the most suitable location is for native fish to be released and the number of fish that will be able to be accommodated by available pools.

An accurate record will be kept of the number of fish and species released and the number and species of fish that are euthanized.

3.2.5 Process Considerations

If it becomes necessary to relocate aquatic fauna, the following general principles will be adhered to:

- To avoid spreading diseases and pest species fish should be relocated downstream from the rescue point and retained within the same catchment.
- Populations with endemic diseases will not be translocated to unaffected areas.
- To maintain genetic integrity of fish populations it is undesirable to move fish between catchments.
- Pest species can be divided into aquatic plant pests such as *Cabomba* and *Salvinia* and pest fish species such as *Gambusia*, Carp, Redfin and non-endemic aquarium species.

In determining the approach to relocation the following logistical considerations will be made:

- The landholder should be contacted to establish if any fish have been stocked in the waterbody and/or if they are aware of any fish present in the waterbody.
- Access to the site for appropriate machinery such as pumps and light vehicles and for staff to safely capture fish and relocate to transporters.
- The size of the waterbody and approximate volume of water to be dealt with, including the approximate amount of water that will need to be treated in sediment basins.

- An ecologist should establish the presence and abundance of native and pest fish, an assessment of any aquatic weeds and ascertain if any suitable habitat exists downstream of the waterbody for native fish to be released into and how many fish could be accommodated by the available pools if any.
- A suitable disposal site (usually landfill) for euthanized fish.
- An accurate record must be kept of the number of fish and species released and the number and species of fish that are euthanized. This is a requirement of the NSW DPI permit.

The methodology for the relocation will generally be:

- To siphon or pump the waterbody down to a low level to allow fish to be physically removed using handheld environets or a combination of electro fishing and netting.
- In large flat waterbodies creating a sump or sumps with an excavator on one side will allow the fish to be concentrated during the dewatering to allow easier capture and minimise safety risks to workers and plant in soft unstable ground. The fish are separated into (1) pest/non endemic native fish for euthanasia in an ice slurry and (2) the fish for release are placed in tubs of water, immediately moved to the aerated transport tank and then driven to the release point/points and then released into the pools selected by the ecologist from the assessment.
- In waterways such as creeks it is important to regularly monitor the sections being dewatered for any stranded aquatic fauna and to rescue and treat any stranded fauna appropriately. It is important that pump sumps are adequately screened with a fine mesh to prevent the ingress of aquatic fauna. When large pumps are used creating a screened fauna exclusion area for the pump sump will generally be more effective.
- Following the fish relocation a visual check should be made downstream for any dead or dying fish which should be removed. A further check should be made the following day for any dead or dying fish which should be removed. The habitat pools selected for fish release should also be examined for dead or dying fish.

3.3 GUIDELINES FOR FAUNA HANDLING

- Some animals require particular handling (e.g. venomous reptiles, raptors) and should only be handled by appropriately qualified personnel i.e. Project Ecologist / suitably qualified expert or FAWNA / WIRES representative(s)
- If handling flying foxes, the handler must be vaccinated against the Australian Bat Lyssavirus (ABL) which is a form of rabies.
- Any frog handling would be undertaken in accordance with the Hygiene Protocol for the Control of Disease in Frogs (DECC 2008). This protocol recommends onsite hygiene precautions be undertaken to minimise the transfer of disease between and within wild frog populations. Measures recommended include:
    - Thoroughly cleaning/disinfecting footwear and equipment when moving from one site to another;
    - Where necessary in high risk areas, spraying/flushing vehicle tyres with a disinfecting solution;
    - Cleaning/disinfecting hands between collecting samples/frogs (preference would be given to using bags, rather than bare hands to handle frogs); and
    - Limiting one frog or tadpole to a bag. Bags should not be reused.

APPENDIX J - UNEXPECTED THREATENED SPECIES/ EEC FIND PROCEDURE

UNEXPECTED THREATENED SPECIES/ ECC FIND PROCEDURE

1.0 PURPOSE

This procedure details the actions to be taken when a threatened species / EEC is unexpectedly encountered during excavation / construction activities.

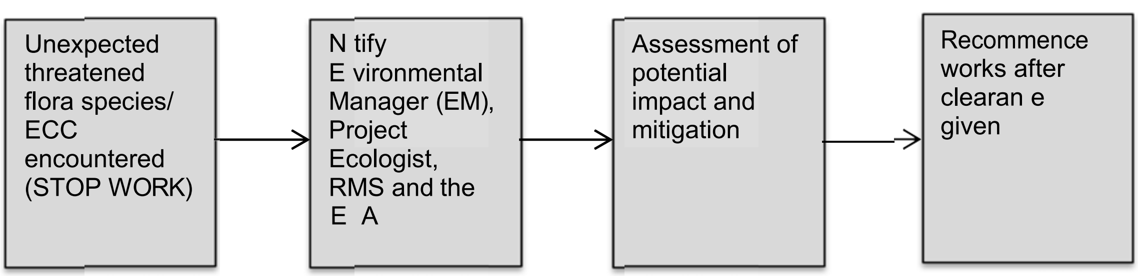
2.0 INDUCTION/TRAINING

Where required, personnel will be inducted on the identification of potential threatened species / EEC occurring on site and the relevant actions for them with regards to this procedure during the Project Induction, Site Inductions and egular Toolbox Talks.

3.0 SCOPE

This procedure is applicable to all activities conducted by personnel that have the potential to come into contact with threatened flora species. Where threatened fauna is unexpectedly encountered, refer to the Fauna Handling and Resc e Procedure.

Refer to **Figure 5.1** for Unexpected Flora Species / EEC Find Procedure flow chart.



4.0 PROCEDURE

1. Threatened flora species / EEC unexpectedly encountered during excavation/construction activities

If a threatened flora species / EEC is unexpectedly encountered during excavation / construction activities:

- **STOP ALL WORK** in the vicinity of the find

Immediately notify the Environmental Manager (EM), or Environmental Advisor (EA) who will notify the Project Ecologist / suitably qualified expert, RMS and the EPA.

2. Assessment of Impact

An assessment is to be undertaken by the EM and the Project Ecologist / suitably qualified expert to determine the likely impact to the threatened flora species / EEC and appropriate management options developed in consultation with RMS.

If a significant impact is likely to occur, consultation will be undertaken with the EPA and / or DP&E as appropriate.

3. Approvals

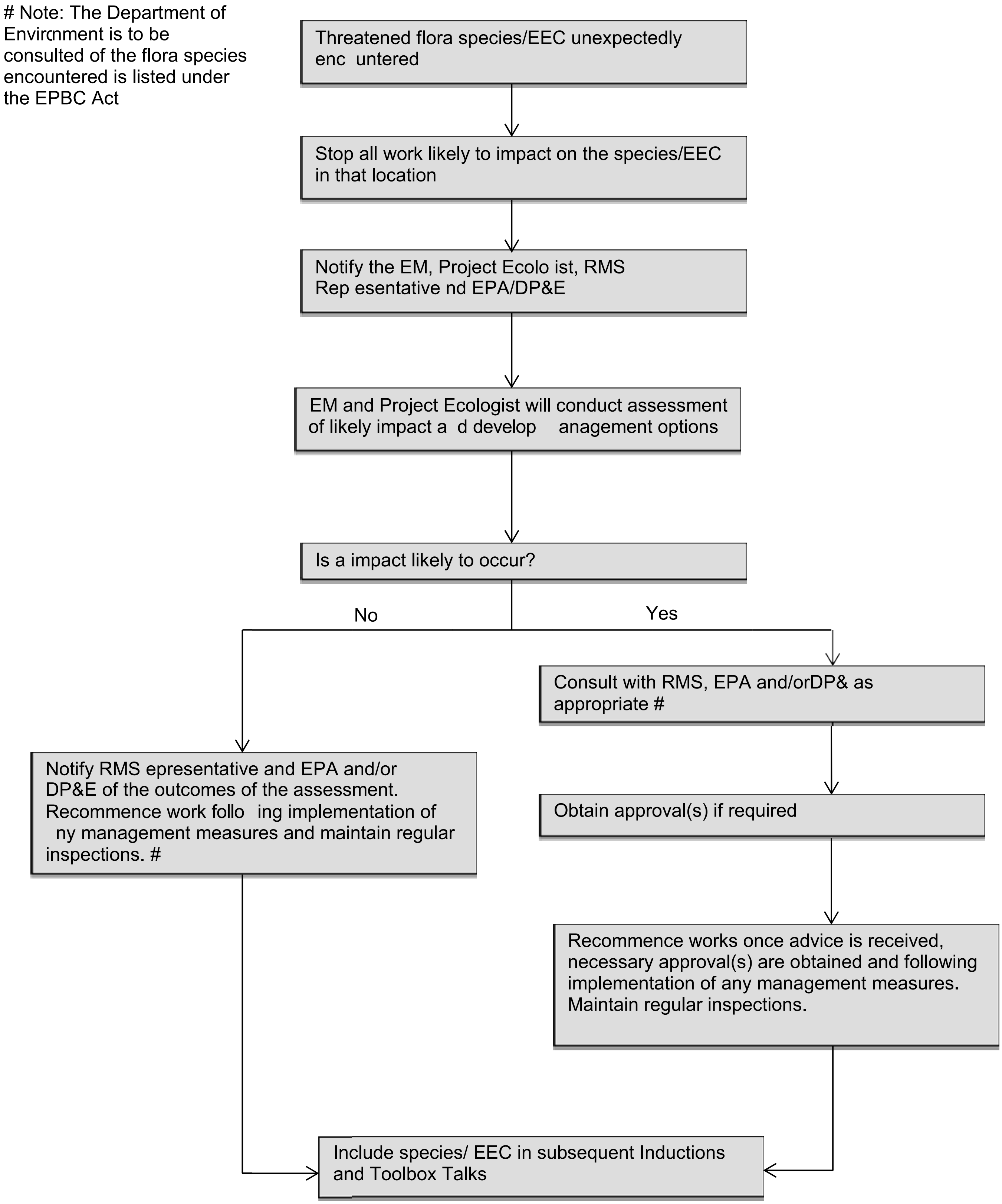
Obtain any relevant licences, permits or approvals required if the species / EEC is likely to be significantly impacted. Also, refer to procedure for management of unforseen additional impact on native vegetation, Section 5.1 Biodiversity Offset Strategy.

4. Recommencement of Works

Works will recommence once necessary advice has been sought and approval obtained if required.

Include threatened flora species / EEC in subsequent Project Inductions and Toolbox Talks.

Figure 5.1 Unexpected Threatened Flora Species/ EEC Find Procedure Flow Chart



APPENDIX K– WEED AND PATHOGEN MANAGEMENT PLAN

Refer to Weed and Pathogen Management Plan (QMS# 025-Y016-2602).

McConnell Dowell - OHL Joint Venture

CLIENT: ROADS AND MARITIME SERVICE

PROJECT: PACIFIC HIGHWAY UPGRADE - KUNDABUNG TO KEMPSEY

LOCATION: NSW

PROJECT NO.: 2602

Quality Management System

CFFMP APPENDIX K: WEED AND PATHOGEN MANAGEMENT PLAN

QMS number **025–Y016–2602**

Revision History

Rev	Date	Details	Author	Reviewer
A	03/03/14	Draft for Review by RMS and Project ER	J.Crawford	T.Jackson
B	22/07/14	Project ER and RMS Comments Incorporated	L.Watson	T.Jackson
C	23/07/14	Additional RMS and Project ER Comments Incorporated	L.Watson	T.Jackson
D	11/08/14	DPI Fisheries Comments Incorporated	J.Crawford	T.Jackson
E	16/09/14	Update plan for DoE submission	J Hamilton	T. Jackson
F	25/09/14	Update following DPE review	J.Crawford	T.Jackson
G	13/10/14	Update following DPE comment	J.Crawford	T.Jackson
H	16/10/14	Incorporate DOE comments	J.Hamilton	T.Jackson
0	04/11/14	Issued for Construction		J. Hamilton

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GLOSSARY AND ABBREVIATIONS

Term/ Abbreviation	Definition
CEMP	Construction Environmental Management Plan
Contractor	McConnell Dowell OHL Joint Venture (JV)
EPA	NSW Environmental Protection Authority
EPL	Environmental Protection License
ESCP	Erosion and Sediment Control Plan
EWMS	Environmental Work Method Statement
JV, the	McConnell Dowell-OHL Joint Venture
K2K	The Kundabung to Kempsey Project
MMS	McConnell Dowell Management System
Regulatory Authority	Any environmental service, authority, agency, department, office, etc. This includes, but is not limited to, the Environment Protection Authority (EPA), Department of Primary Industries (Fishing and Aquiculture), Office of Environment and Heritage (OEH), Department of Planning and Environment (DPE) and the Department of the Environment.
Roads and Maritime	Roads and Maritime Services
WPMP	Weed and Pathogen Management Plan (this document)

1.0 INTRODUCTION

1.1 BACKGROUND

This Weed and Pathogen Management Plan (WPMP) outlines the management measures, monitoring and reporting requirements relating to weed and pathogen associated with the construction of the Kundabung to Kempsey Pacific Highway Upgrade Project (K2K).

The Oxley Highway to Kempsey Upgrading the Pacific Highway Environmental Assessment (RMS 2010) indicates that the K2K project area has a number of weed species in the area.

This Plan has been prepared and is to be implemented in accordance with the Noxious Weeds Act 1993, and National Trust Weed Management Manual.

1.2 WEEDS

The definition of weeds for the purposes of this plan is consistent with the definition of noxious weeds in the Noxious Weeds Act 1993. A total of 97 exotic flora species were recorded within the study area during flora surveys (RMS 2010). Most noxious weed species were concentrated along the existing highway verges, cleared grazing land, tracks and other disturbed areas.

A pre-construction noxious weeds survey was undertaken in June 2014. In summary, 11 species identified across the site are listed under NSW Noxious Weeds Act (1993). Of these, two Class 3, seven Class 4 and two Class 5 species were identified. No Class 1 or 2 noxious weed species were identified during the pre-construction noxious weed survey. Relevant control strategies are identified in Section 2.2.

1.3 PATHOGENS

Chytridiomycosis is known to affect the Giant Barred Frog and other threatened frog species in the project corridor and surrounds. The cause of chytridiomycosis is the chytrid fungus. This is a water borne pathogen and could be spread through water or mud on vehicles, machinery, footwear and other equipment.

Baseline surveys for the Ecological Monitoring Program identified Chytrid in two of the 12 swabbed frogs at Smiths Creek, but no Chytrid at Pipers Creek or Maria River (Lewis 2014).

Myrtle rust (*Puccinia psidii s.l.*) is a pathogen which affects plants belonging to the family Myruaceae. Myrtle rust produces masses of powdery bright yellow spores on infected plants. It infects the leaves of susceptible plants producing spore filled lesions on young leaves, shoots, flower buds and fruits. Leaves may become buckled or twisted and are likely to die as a result of the infection. Infection in highly susceptible plants often leads to death. Myrtle rust is considered to be widely distributed within the project area.

Construction also has the potential to introduce or spread of root rot *Phytophthora cinnamomi.*

2.0 ENVIRONMENTAL CONTROLS

2.1 OVERARCHING WEED & PATHOGEN MANAGEMENT PROCESS

Figure 2-1 demonstrates the overarching weed management approach on the K2K project.

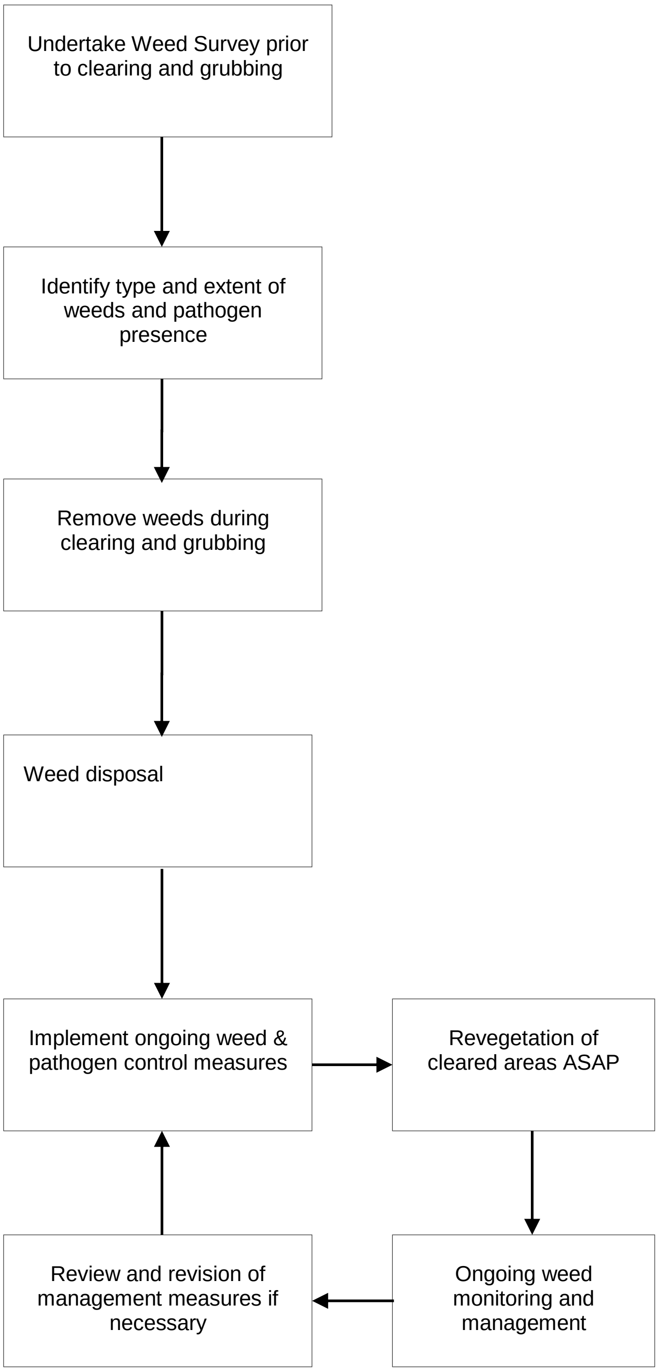

Figure 2-1– K2K Weed Management Process

2.2 CONTROL OF WEEDS

2.2.1 Noxious Weeds Survey

A Baseline Noxious Weeds Survey will be carried out and will:

- Map the location and extent/abundance of weed species.
- Establish exclusion zones in a manner consistent with the Conditions of Approval and applicable legislation.
- Mark the location of noxious weeds on site.

A Weed spray contractor will be engaged to provide strategic weed control of Class 3 weeds and to provide strategic control of weeds which create community and access issues within 7 days of the commencement of clearing operations within known areas of Class 3 weeds and weeds which create community and access issues.

Timing

The Baseline Noxious Weeds Survey will be carried out at least 4 weeks prior to the commencement of clearing

Performance Indicators

- Completion of the Baseline Noxious Weeds Survey;
- Engagement of weed spray contractor.

2.2.2 Mechanical Control of Weeds

Weeds will be preferentially controlled through mechanical means.

Example of mechanical control methods will include:

- Use of an excavator/harvester to remove shrub and larger trees and their stumps in accordance witrh the Noxious Weeds Act.
- Strategic use of seasonal slashing for select weed species in association with chemical application (i.e. spring slashing of easements and verges followed by chemical application to reduce seeding opportunities in Giant Parramatta Grass).

Timing

Weeds will be controlled during the clearing and grubbing program.

Performance Indicators

If required, all noxious weeds removed mechanically will be done so in accordance with the Noxious Weeds Act.

2.2.3 Chemical Control of Weeds

Chemical methods of weed control will be used in instances where mechanical removal of weeds is deemed inappropriate or ineffective. For example, in areas that are to be eventually rehabilitated back into a vegetated state or kept as a mown verge. Chemical application may also be applied to high priority noxious weeds prior to construction if this is deemed the most appropriate management action.

Timing

All Noxious weeds chemical application will be carried out within 7 days of clearing operations within known noxious weeds populations and will be undertaken by suitably qualified persons. Further chemical control will be carried out as required. An example of where chemical control may need to be carried out is to ensure the plants do not seed ahead of the clearing and grubbing program.

Performance Indicators

- Herbicide application administered by authorised personnel only, with ChemCert Accreditation AQF 3 (in accordance with Workcover requirements).
- Noxious weeds treated in accordance with the herbicide specific to each species, as listed in the Noxious and Environmental Weed Control Handbook (DPI 2011).

2.2.4 Stockpiling and Disposal

Weed infested materials will not be stockpiled adjacent to native vegetation wherever possible during topsoiling stripping operations. Under no circumstances will weeds or exotic species be used to make up any shortfall of mulch.

All classified weed material will be disposed of, in accordance with the requirements of the local council, by burial or disposal at an appropriate waste management facility following positive identification.

Timing

Weeds will be stockpiled and disposed of removed during the clearing and grubbing program.

Performance Indicators

- All classified weed material disposed of lawfully;
- No stockpiling of weed infested materials adjacent to native vegetation;
- No use of weed infested mulch for landscaping purposes.

2.2.5 Specific Management Measures

Specific management measures identified for those noxious weeds species identified during the pre-construction survey are identified in Table 2-1. Timing and performance indicators will be implemented as per Section 2.2.3 and 2.2.4 of this plan.

Table 2-1: Noxious Weeds present in the Kundabung to Kempsey section of the alignment

Scientific Name	Common Name	Control Class	Management
Baccharis halimifolia	Groundel Bush	3	The plant shall be fully and continuously suppressed and destroyed (Regional control). Plants have been marked with red and white hazard tape to assist in identification and any subsequent weed management actions.
Erythrina crista-galli	Cockspur Coral Tree		
Bryophyllum spp.	Mother of Millions	4	The growth and spread of the plant will be controlled according to the measures specified in a management plan published by the local control authority (Locally controlled).
Cinnamomum camphora	Camphor Laurel		
*Lantana spp.**	Lantana (All)		
Ligustrum lucidium	Privet - Broadleaf		
*Rubus fruticosus agg. spp.**	Blackberry		
*Senecio madagacariensis**	Fire Weed		
Sporobolus fertilis	Giant Parramatta Grass		
Ambrosia artemisiifolia	Annual Ragweed	5	Requirements in the *Noxious Weed Act 1993* for a notifiable weed shall be complied with (sale and movement restrictions).
Opuntia spp.	Prickley Pear		

2.3 CONTROL OF PATHOGENS

2.3.1 Overall Management Measures

Pathogens will be managed through the estahblishment of washout procedures and facilities. The wash down procedure will include the manual removal of thick soil deposits, high pressure wash down of the undercarriage followed by the application of a sterilant suitable for control of Chytrid Fugus (benzalkonium chloride).

Timing

Washout facilities will be established for plant, equipment and personnel at least 24 hours prior to entering a known area of pathogens.

Performance Indictors

- Plants and soil that is imported to site will be certified disease-free.
- Topsoil and other surface soil materials from infected areas stockpiled and/or re-used within the sub-catchment of its source location.
- All runoff in known infected areas captured and returned to the infected area.

2.3.2 Chytrid Fungus Disinfectant Protocol

The following measures will be implemented in areas where Chytrid fungus is known to exist:

- Footwear must be thoroughly cleaned and disinfected at the commencement of fieldwork and between each sampling site. This can be achieved by initially scraping boots clear of mud and standing the soles in a disinfecting solution. The remainder of the boot should be rinsed or sprayed with a disinfecting solution that contains benzalkonium chloride as the active ingredient. Disinfecting solutions should be prevented from entering any water bodies.
- Rubber boots such as 'gum boots' or 'Wellingtons' are recommended because of the ease with which they can be cleaned and disinfected.
- Several changes of footwear bagged between sites might be a practical alternative to cleaning.
- Equipment such as nets, balances, callipers, bags, scalpels, headlamps, torches, wetsuits and waders etc that are used at one site must be cleaned and disinfected before re-use at another site.
- Disposable items should be used where possible. Non-disposable equipment should be used only once during a particular field exercise and disinfected later or disinfected at the site between uses using procedures outlined below.
- Where necessary, vehicle tyres should be sprayed/flushed with a disinfecting solution in high-risk areas.
- Transmission of disease from vehicles is unlikely to be a problem. However, if a vehicle is used to traverse a known frog site, which could result in mud and water being transferred to other bodies of water or frog sites, then wheels and tyres should undergo cleaning and disinfection. Where possible disinfection will be carried out at a safe distance from water bodies and on an impervious surface in order to prevent infiltration of the soil and run-off into water bodies.
- Spraying with benzalkonium chloride is recommended to disinfect car wheels and tyres.
- Cleaning of footwear before getting back into the car will prevent the transfer of pathogens from/to vehicle floor and control pedals.
- Frogs should only be handled when necessary. Minimise the handling of frogs to only those personnel which must perform pre-clearing surveys, capture and relocation process (Project Ecologist). When handling frogs, use disposable gloves, sample bags and sterile equipment.
- Where handling of frogs is necessary the risk of pathogen transfer should be minimised as follows:
    - Hands should be either cleaned or disinfected between samples or a new pair of disposable gloves used for each sample. This may be achieved by commencing

with a work area that has a dish containing a disinfecting solution and paper towels.
    - A 'one bag – one frog' approach to frog handling should be used especially where several people are working together with one person processing frogs and others doing the collecting. Bags should not be reused.
    - A 'one bag – one sample' approach to tadpole sampling should be used. Bags should not be reused.
- All used disinfecting solutions, gloves and other disposable items should be stored in a sharps or other waste container and disposed or sterilised appropriately at the completion of fieldwork. Disinfecting solutions must not come into contact with frogs or be permitted to contaminate any water bodies.
- The disinfecting agents for hands and equipment will be effective against bacteria as well as both the vegetative and spore stages of fungi.

Timing

Disinfectant protocols will be implemented prior to the exit of personnel, or removal of plant and equipment, from areas of known pathogens.

Performance Indicators

- Implementation of the Chytrid Fungus Disinfectant Protocol
- No increase in the prevelance of Chytrid Fungus

2.3.3 Myrtle Rust Management Measures

All occurrences of Myrtle Rust will be reported to the Environment Manager immediately upon positive identification and infected areas will be considered contaminated and treated accordingly.

Timing

Surveys for Myrtle Rust as part of pre-clearing checks will be completed daily in known areas of Myrltle as advised by project ecologist. The Environment Manager is to report all occurrences to the NSW DPI within 7 days of positive identification and obtain advice on the most suitable control method.

Performance Indicators

- Pre-clearing surveys for myrtle rust completed daily in known areas of Myrltle as advised by project ecologist
- All occurrences of Myrtle Rust reported to the Environment Manager immediately upon positive identification
- Environment Manager report all occurrences of Myrlte Rust to the NSW DPI within 7 days of positive identification

2.3.4 Phytopthora Cinnamomi Management Measures

Where necessary, the introduction and spread of Phytophthera cinnamomi will be managed using a combination of the following measures, where applicable and necessary:

- Training of staff on the risk of, and controls to be implemented for, working in or adjacent to Phytophthera cinnamomi infested areas.
- Establishment of No-Go zones where works within infested areas can be avoided.
- Maintainance of natural barriers between construction activities and infested areas, where possible.
- Scheduling activities in non-infested areas before moving to infested areas.
- Scheduling activities for periods with the highest likelihood of dry soil conditions to minimise the spread of the pathogen, where possible.
- Ensuring vehicles, material and footwear are clean upon entry into, and exit from, infested areas.
- Minimisation of the amount of water discharged into infested areas.
- Restricted movement of soil from infested areas and implementation of local stockpiling and demarcation of infested soils within infested areas.

- Implementation of hygiene protocols where working across infested and non-infested areas cannot be avoided.

2.4 TOPSOIL

Refer to the **Spoil and Fill Management Procedure (QMS# 025-E002-2602)** for the appropriate weed control measures relating to stockpiles. Topsoil management measures will be implemented in a manner that minimises the spread of weeds.

2.5 AQUATIC WEEDS

2.5.1 Overview

All noxious weeds are listed under the NSW *Noxious Weeds Act 1993*. Aquatic plants will only be controlled when they interfere with the use of particular aquatic environments or where there is a statutory obligation. All weeds will be disposed offsite to an appropriately licensed facility to accept that kind of waste.

The following management approach for aquatic weeds is taken from the NSW DPI (Primefact 30, NSW DPI, November 2008). To select the most appropriate management option, it is essential that the plant is correctly identified. An ecologist should undertake an assessment of any aquatic weeds.

2.5.2 Overall Management Measures

Where possible preventative measures will be implemented. These measures include:

- Monitoring and early detection of new infestations.
- The use of booms and fences to prevent the spread (a permit under the Fisheries Management Act 1994 is needed if a boom is likely to impact fish movement).
- Hygienic practices when moving nets and traps from one waterbody to another.
- Proper management of a waterbody and uses of its surrounding land to minimise nutrient loads and disturbances to banks and riparian vegetation.

Timing

Weeds will be controlled during the clearing and grubbing program.

Performance Indicators

All classified weed material disposed of lawfully and controlled in accordance with staturtory requirements.

2.5.3 Mechanical Removal of Weeds

Mechanical removal involves the removal of the plant biomass from the water body using specially designed harvesters or equipment. Physical control includes the removal of plant material by hand. Mechanical and physical removals are often a good first option, particularly where the water is used for animal or human consumption and herbicide control is undesirable.

Example of mechanical removal will include:

- Excavator/harvester
- Strategic use of seasonal slashing for select weed species in association with chemical application (i.e. spring slashing of easements and verges followed by chemical application to reduce seeding opportunities in Giant Parramatta Grass).

Timing

Weeds will be removed during the clearing and grubbing program.

Performance Indicators

If required, all noxious weeds removed mechanically are done so in accordance with the Noxious Weeds Act.

2.5.4 Environmental Control

Control can be achieved by altering the water body in some way to limit the growth of aquatic plants.

- For submerged plants, lowering the water level to expose them to the sun can be effective.
- Dredge or excavate to a depth where the plants will not grow, or will only grow at reduced densities due to lack of light. This approach is most successful in very turbid water.
- Limit the inflow of nutrients by diverting effluent from stockyards or feeding areas.
- Do not allow stock direct access to waterways; provide a watering point below the catchment area.
- Provide a buffer zone around waterways and between water storages by way of long, dense grass or a strip of native shrubs and trees. This can impede or trap the movement of aquatic plants from one water source to another.

Timing

Weeds will be removed during the clearing and grubbing program.

Performance Indicators

If required, all noxious weeds controlled using environmental controls are done so in accordance with the Noxious Weeds Act.

2.5.5 Chemical Control

. In the event of chemical control, the following approach will be adopted:

- Select a herbicide registered for use in water and for the specific plant. Take particular note of toxicity to other plants, fish or wildlife, residual activity and withholding periods for treated water.
- Make an accurate measure of the water volume or surface area to be treated in order to calculate the correct application rate and volume of herbicide to be used.
- Infestations should be treated in sections so that the risk of water contamination is minimised, and the decay of smaller amounts of vegetation will not reduce oxygen levels in the water sufficiently to kill fish.

Timing

All Noxious weeds chemical application will be carried out within 7 days of clearing operations within known noxious weeds populations and will be undertaken by suitably qualified persons. Further chemical control will be carried out as required. An example of where chemical control may need to be carried out is to ensure the plants do not seed ahead of the clearing and grubbing program.

Performance Indicators

- Herbicide application administered by authorised personnel only, with ChemCert Accreditation AQF 3 (in accordance with Workcover requirements).
- Noxious weeds treated in accordance with the herbicide specific to each species, as listed in the Noxious and Environmental Weed Control Handbook (DPI 2011).

2.5.6 Stockpiling and Disposal

Weed infested materials will not be stockpiled adjacent to native vegetation wherever possible during topsoiling stripping operations. Under no circumstances will weeds or exotic species be used to make up any shortfall of mulch.

All classified weed material will be disposed of, in accordance with the requirements of the local council, by burial or disposal at an appropriate waste management facility following positive identification.

Timing

Weeds will be stockpiled and disposed of removed during the clearing and grubbing program.

Performance Indicators

- All classified weed material disposed of lawfully;
- No stockpiling of weed infested materials adjacent to native vegetation;
- No use of weed infested mulch for Landscaping purposes.

3.0 INSPECTION AND MONITORING

3.1 WEED AND PATHOGEN MONITORING PROGRAM

The frequency and duration of weed monitoring will be specific to the site and adjoining areas and have the flexibility to respond to changes in the environment. As a minimum, weed inspections will be undertaken on a monthly basis for the first six months after commencement of construction (or as necessary responding to seasonal and climatic conditions). Inspections will then be undertaken at least every two months until construction completion.

The following items will be included in monthly environmental reporting (included in the Project Monthly Report) on weed management:

- Locations and approximate areas (m^2) where weed management was carried out;
- Number of hours spent in weed control works in total and at each area;
- Number of staff carrying out weed control works;
- Treatment methods applied in each area;

The program will be guided by the results and recommendations of the baseline Noxious Weed surveys completed in June 2014. Initial or baseline data points will be used to document the following:

- Location, type, approximate area and extent/cover
- Proposed management action

The works shall be regularly reviewed and inspected by the Project Engineer, Superintendent/ Foreman and Environment Manager to ensure compliance with this Plan. This will identify inappropriate weed and pathogen management actions and identify more suitable control measures. Observations on the success of control measures and results of each monitoring inspection will be made against the weed management objectives and activities outlined in this Plan.

3.2 PATHOGEN MONITORING

3.2.1 Chytrid

Chytrid monitoring will be undertaken before and after construction of the K2K upgrade by Roads and Maritime. Mitigation measures will focus on the areas known to contain the threatened Giant Barred Frog and Green-thighed Frog. They include Smiths Creek, Pipers Creek, main cut area at ch. 33650 and Maria River.

Baseline pre-construction chytrid surveys have been performed as part of the collection of baseline data for the Ecological Monitoring program. The results identified Chytrid in 2 of the 12 Giant Barred Frogs at Smiths Creek but at no other site.

3.2.2 Phytophthora cinnamomi

In the event Phytophthora is identified on the K2K project, monitoring will be guided by procedures previously used by the Department of Conservation and Land Management (DCLM) for the control of Phytophthora cinnamomi and disease caused by it (DCLM 1999).

In principal the monitoring would comprise one or more of the following:

- Marking of 'disease fronts'
- Tagging of live and dead plants
- Sampling of leaf material for phosphite concentration
- Photo points

The use of control area would also be explored depending on the severity of disease and at the advice of the RMS.

3.2.3 Photography

Photographs taken from fixed points will be used as a general indicator of changes in plant health.

3.3 OTHER INSPECTIONS AND MONITORING

Section 8 of the CEMP outlines the requirements for all environmental inspections, monitoring, and auditing on the project.

3.4 PERFORMANCE INDICATORS

The following performance indicators have been established for the management of weed and pathogen impacts during the Project:

- No increase in distribution of weeds currently existing within the Project areas; and
- No new weeds introduced to the Project areas.