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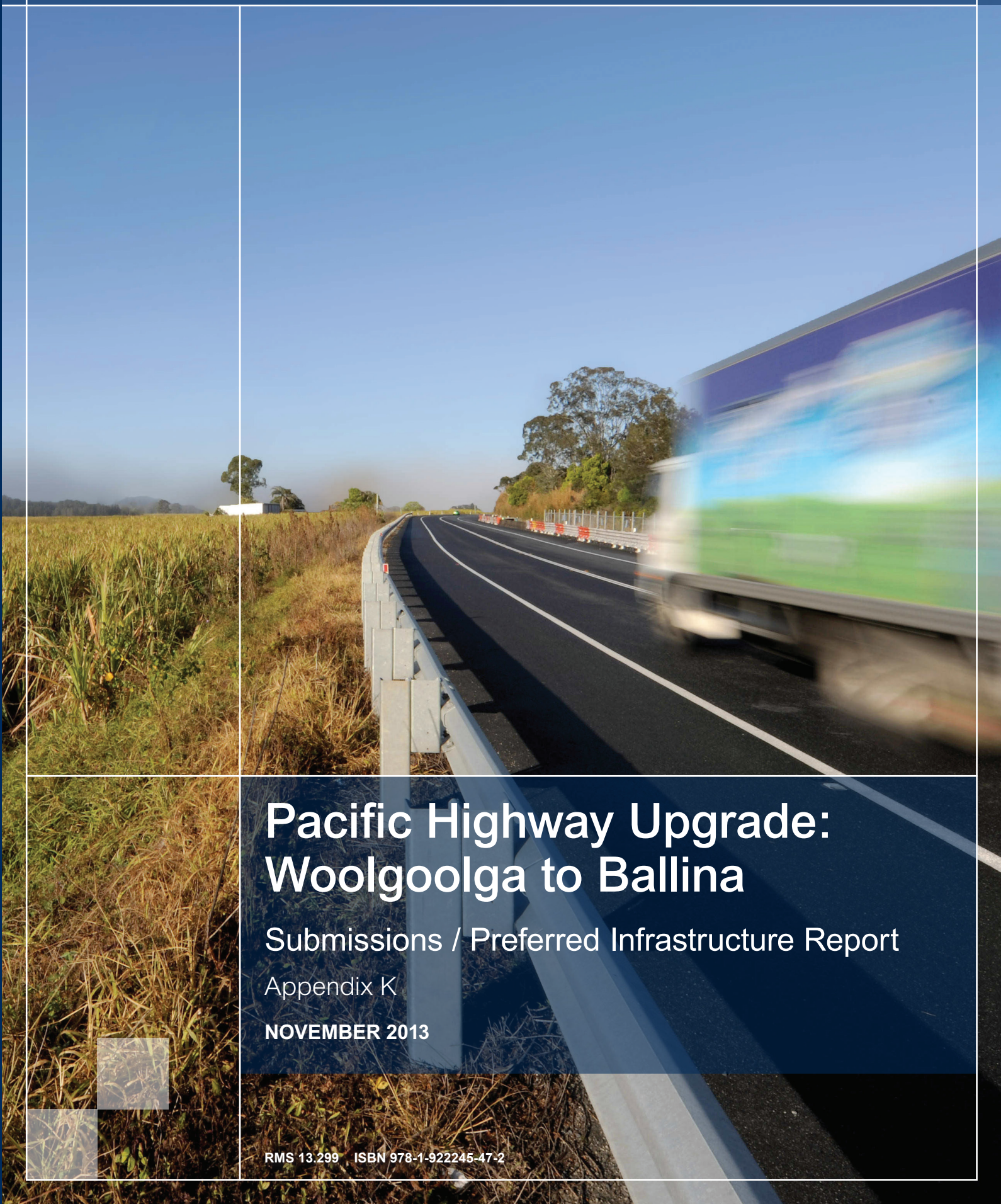

Pacific Highway Upgrade: Woolgoolga to Ballina

Submissions / Preferred Infrastructure Report

Appendix K

NOVEMBER 2013

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NSW Roads and Maritime Services

WOOLGOOLGA TO BALLINA | PACIFIC HIGHWAY UPGRADE

SUBMISSIONS / PREFERRED INFRASTRUCTURE REPORT

Appendix K Threatened species management plans

Version 1.1

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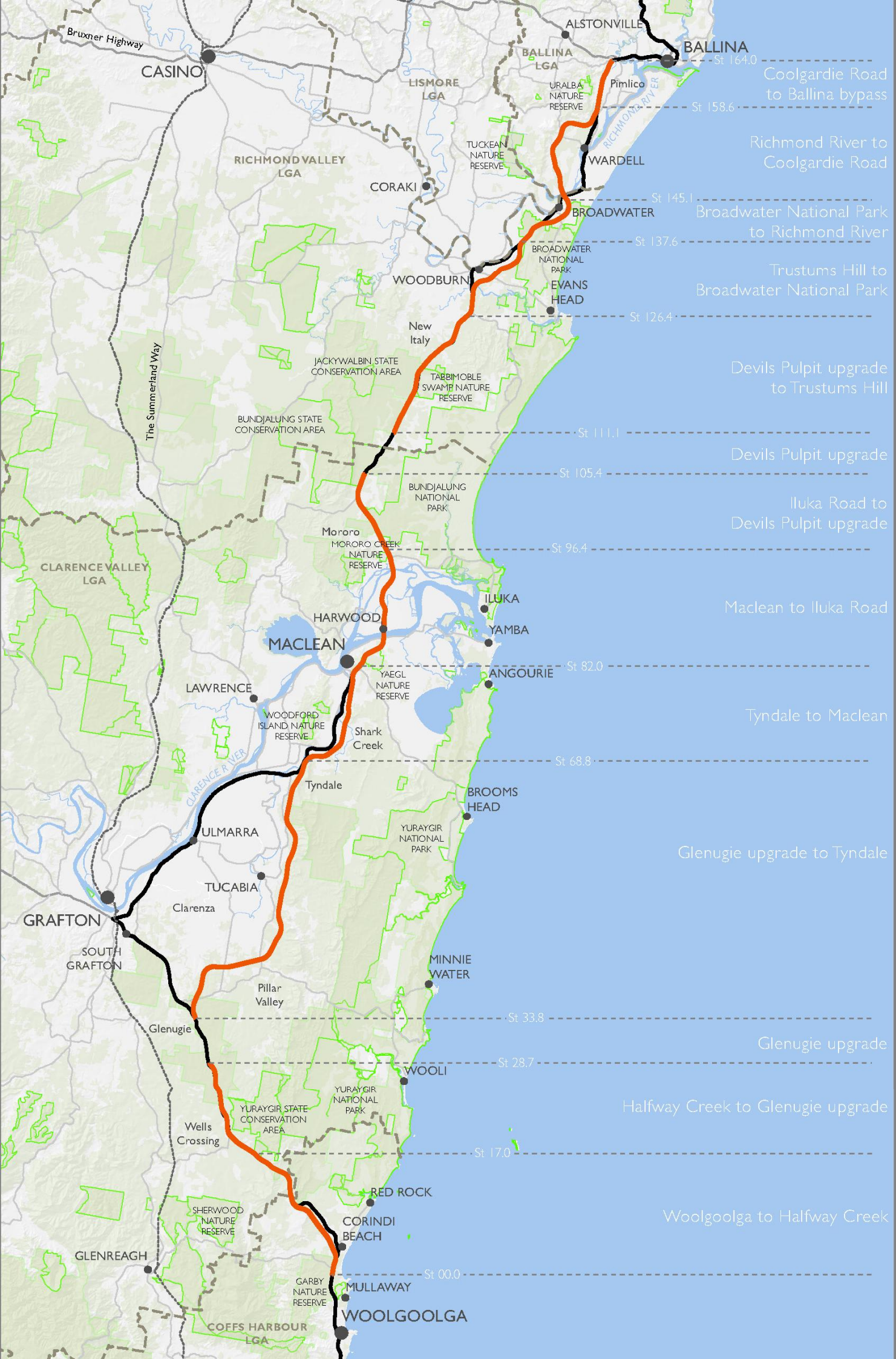
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Appendix K Threatened species management plan

Ecological monitoring program

Rainforest communities and threatened rainforest plants management plan

Threatened flora management plan

Threatened mammal management plan

Coastal emu management plan

Threatened frog management plan

Threatened fish management plan

Koala management plan

Threatened invertebrates management plan

Threatened gliders management plan

NSW Roads and Maritime Services

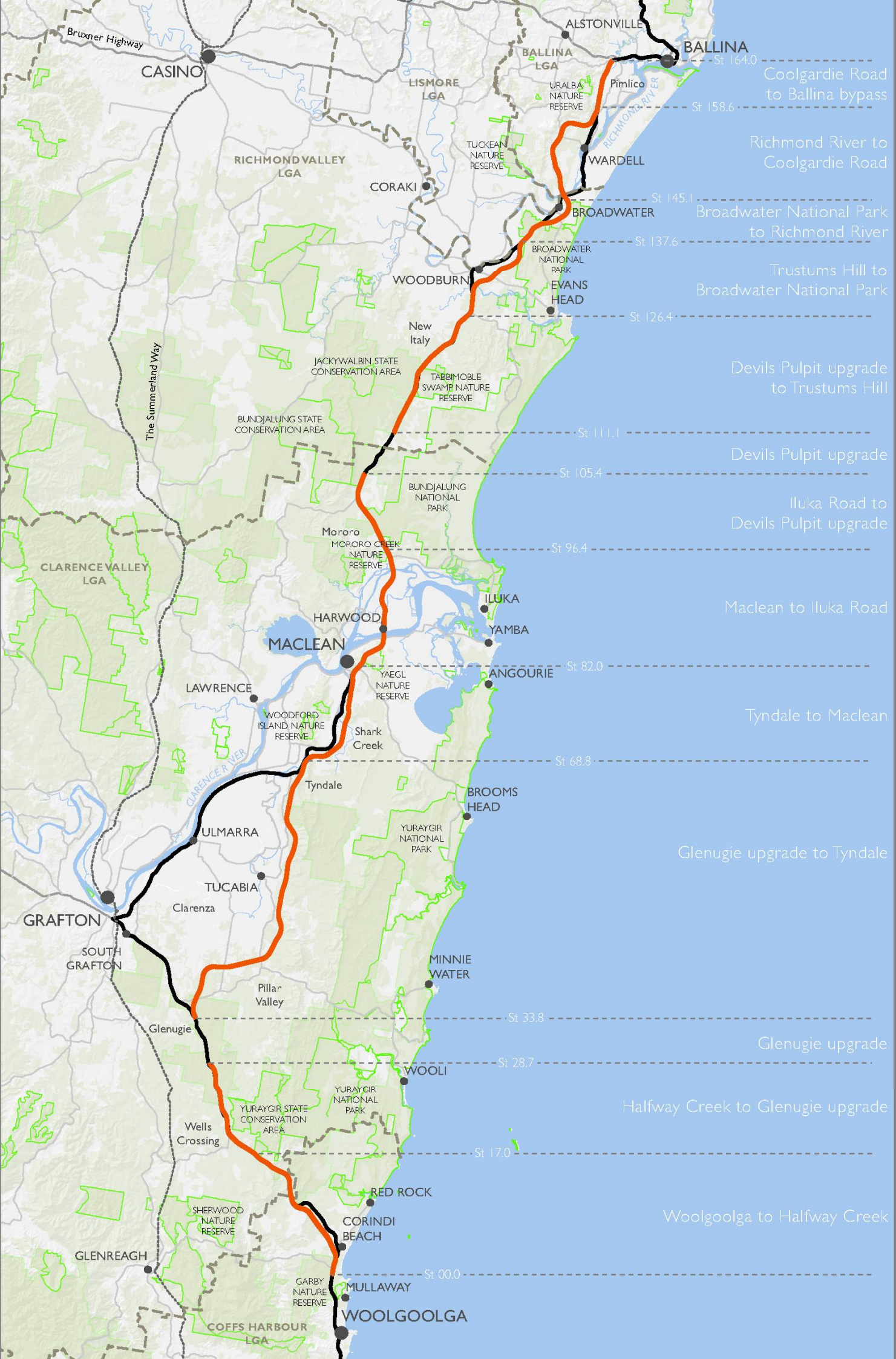
WOOLGOOLGA TO BALLINA | PACIFIC HIGHWAY UPGRADE

ECOLOGICAL MONITORING PROGRAM

Version 1.0

November 2013

Prepared by: NSW Roads and Maritime Services, Aurecon and Sinclair Knight Merz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Contents

1. Introduction

1.1. Project overview

NSW Roads and Maritime Services (Roads and Maritime) is seeking project approval for the Woolgoolga to Ballina (W2B) Pacific Highway upgrade project (the project) which is located on the NSW North Coast. The approval is sought under Part 5.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and under the Commonwealth environmental assessment requirements of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The project would upgrade around 155 kilometres of highway, forming a major part of the overall Pacific Highway Upgrade Program. The project would provide a four-lane divided carriageway from around five kilometres north of Woolgoolga to around six kilometres south of Ballina. The delivery of the project has potential to be staged based on 11 staging sections as shown in the figure above.

This Ecological Monitoring Program (EcMP) has been prepared to provide the framework for monitoring the biodiversity mitigation measures proposed for the project, as part of an adaptive management process.

The program is dealing with multiple stages of upgrade associated with the entire W2B project. Mitigation measures, like pre-clearing and clearing works, nest box management and weed management are applicable to all stages of the project. Other mitigation measures specific to threatened species or specific stages of upgrade have been detailed in the relevant threatened species management plans. A description of the overall biodiversity management and monitoring framework is provided in **Section 1.2**.

1.1. Purpose and objectives

The purpose of the EcMP is to provide details of the biodiversity mitigation measures and monitoring requirements that are not specific to threatened species but cover general flora and fauna, such as those relating to the pre-clearing and clearing process, nest box management, riparian and aquatic habitat protection including groundwater dependent ecosystems and weed management.

The EcMP objective is to provide an adaptive monitoring program that assesses the effectiveness of the proposed mitigation measures and allows an adaptive management process if necessary. The monitoring would:

- 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.
- Provide clear goals that are SMART (Specific, Measurable, Achievable, Realistic and Timely) to monitor and assist in demonstrating the effectiveness of biodiversity mitigation measures implemented as part of the project and inform an adaptive management approach.
- Provide reporting details including provision for annual reporting of monitoring results to relevant agencies.

1.2. Biodiversity management and monitoring framework

An overview of the ecological management and monitoring framework for the project and how this program fits has been described in the following sections and summarised in the flow chart below.

Ecological monitoring program

The EcMP presents an adaptive monitoring program to assess the effectiveness of the general biodiversity mitigation measures and allow their modification if necessary. The monitoring program includes targets against which effectiveness would be measured and aims to prescribe monitoring parameters for reporting on the outcomes of:

- Pre-clearing and clearing procedures.
- Nest box management.
- Aquatic and riparian habitat protection.
- Weed management.
- Groundwater dependent ecosystem protection.

As a targeted species approach has been used for the monitoring of fauna connectivity structures within the project (including fauna exclusion fencing), details of the monitoring of fauna crossing structures have been outlined in the relevant threatened species management plans.

The EcMP provides a framework for any part of the proposed upgrade between Woolgoolga to Ballina and would be updated as required for staged project sections. The EcMP is intended to be a dynamic document subject to continual improvement. The EcMP would be updated as required to meet the mitigation and management measures committed to in the relevant project reports and any Conditions of Approval for the project. Prior to implementation, the EcMP would also be updated following independent expert review to incorporate any necessary changes that arise from that review (refer to **Table 1-1** below). The final EcMP would be specific to each project section, stage, program of works or singular element of infrastructure which makes-up the overall Woolgoolga to Ballina upgrade.

The EcMP would operate in conjunction with the Construction Environmental Management Plan (CEMP), project specific flora and fauna management plan (FFMP), and Threatened Species Management Plans. **Section 1.4** outlines the relationship with these documents.

General responsibilities for environmental management would be outlined in the CEMP and FFMP. Responsibilities for implementation of the EcMP have been described throughout. Roads and Maritime would finalise the EcMP in consultation with the NSW Department of Planning and Infrastructure (DP&I) and relevant agencies. Following approval of the EcMP the construction contractor and the contractor's ecologist(s) engaged for the relevant project sections would be responsible to oversee implementation of the plan.

Threatened species management plans

Where specific mitigation measures have been identified for target threatened species they have been outlined in the threatened species management plans. For example this includes targeted surveys during the pre-construction phase and the use of fauna crossing structures and exclusion fencing.

Specific mitigation measures, performance measures and contingencies for target threatened communities, species and populations are provided in a series of management plans prepared for those target species identified as being at greatest risk from the project. These plans aim at providing mitigation and monitoring measures for implementation during pre-construction, construction and operation. The plans include:

- Threatened frog management plan.
- Koala management plan.
- Coastal Emu management plan.
- Rainforest communities and threatened rainforest plants management plan.
- Threatened flora management plan.
- Threatened glider management plan.
- Threatened mammal management plan.
- Threatened fish management plan.
- Threatened invertebrate management plan.

These plans have been prepared in consultation with experts for the target threatened species. The plans provide a strategy for the protection of threatened species adjacent to the project and a means of monitoring the effectiveness of mitigation measures using an adaptive management framework.

The monitoring program provided in each plan describes the monitoring parameters for reporting on the outcomes of:

- Specific goals for mitigation.
- Protection and monitoring of *in situ* threatened species populations.
- Monitoring the effectiveness of mitigation measures including but not limited to fauna crossing structures (targeted species approach), fauna exclusion fencing and widened medians.
- Riparian and aquatic habitat condition monitoring in habitats for threatened fish and frogs.
- Monitoring change to habitat usage.
- Monitoring the success of habitat revegetation in areas disturbed by construction.

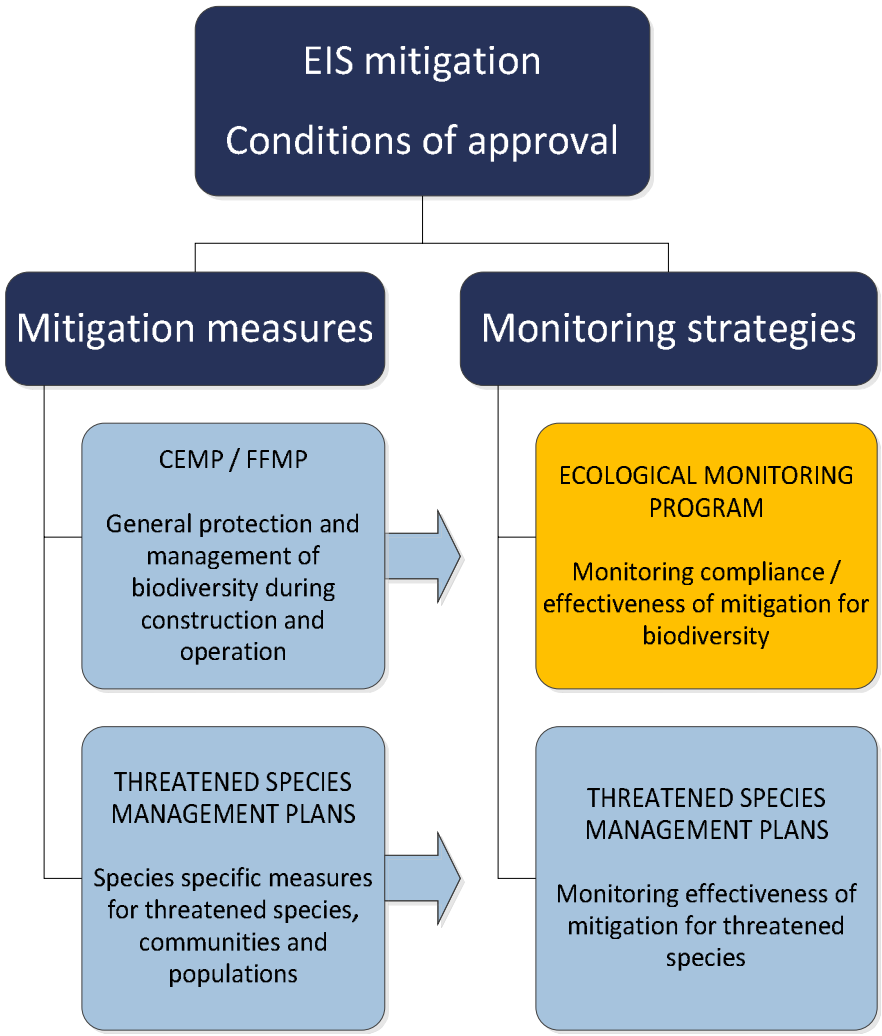

Figure 1-1: Biodiversity monitoring framework

Expert review

An expert review of the plan was undertaken in August 2013 by Dr Rodney van der Ree. Dr van der Ree is the Deputy Director and Manager, Ecological Sciences of the Australian Research Centre for Urban Ecology (ARCUE) and responsible for conducting high quality scientific research on the impacts of human activities on wildlife. His current research projects are diverse, and broadly cover the effects of habitat loss and fragmentation due to the construction of cities and towns as well as other infrastructures, particularly major roads.

Rodney has successfully undertaken consultancy projects for a range of clients in Victoria and New South Wales, including the New South Wales National Parks and Wildlife Service, VicRoads, and the Albury-Wodonga Development Corporation. The research included studies of the distribution and abundance of Squirrel Gliders in New South Wales and Victoria and the development of mitigation measures to facilitate the crossing of major roads by fauna.

Rodney has is an active member a number of professional organisations and has been invited to sit on a number of expert scientific committees across Australia. In addition, he has published more than 60 reports and popular articles, given in excess of 70 presentations at conferences, workshops, community groups and more than 20 media appearances, including TV, radio, and newspaper.

A curriculum vitae for Dr Rodney van der Ree is provided in **Appendix A** and a copy of his review is provided as Appendix B. The recommendations provided in this review have been summarised in **Table 1-1**. The table also identifies how each of the recommendations has been addressed. Recommendations have been addressed in one of three ways:

- Adopted - plan updated.
- Adopted - plan to be updated prior to implementation.
- To be reviewed - recommendation to be reviewed further by Roads and Maritime prior to implementation.

Table 1-1 Summary of recommendations from the expert review and how addressed in this plan

ID no	Section	Comment / Recommendation	How recommendation would be addressed
EcMP1	General	Formal surveys of weeds be undertaken periodically to ensure they are detected and detected early enough to be treated. The design of these surveys will be based on the biology of known problematic weed species that are likely or potentially a problem in the region.	Adopted- plan to be updated prior to implementation
EcMP2	2.1	Convene some workshops with experts on the monitoring programs, to discuss and design monitoring programs to achieve the goal, as stated in 1.1: "to provide an adaptive monitoring program that assesses the effectiveness of the proposed mitigation measures and allows an adaptive management process". Most ecological monitoring is often a waste of time and money, and rarely achieves its goals, and needs to be designed with input from experts in the formulation of relevant questions, appropriate and rigorous scientific study design, an understanding of how the ecological system works and the ability and track record to complete monitoring through to the end.	To be reviewed.
EcMP3	General	Biodiversity offset strategy: Corrective actions in the subsequent sections needs to contain a link back to updating the offset strategy if the initial mitigation is found to be ineffective.	Adopted- plan updated
EcMP4	General	Habitat features suitable for redistribution: Ensure that decayed and hollow logs are also redistributed.	Adopted- plan to be updated prior to implementation
EcMP5	2.1.2	Will need more than 1 person be present during tree clearing just in case animals need to be taken into care immediately. Can't halt clearing while the lone ecologist drives off to the vet / wildlife carer. I would also suggest that ecologists on site be able to euthanize on site if conditions / animal health requires it.	Adopted- plan to be updated prior to implementation
EcMP6	2.6	Objectives: The objectives for the general connectivity mitigation measures be revised to be more specific and measurable.	To be reviewed.
EcMP7	2.6.1	Ensure the distance that fencing extends past the crossing structures is based on the ecology / movements of the target species	
EcMP8	2.6.1	Ensure that wildlife mortality surveys at the ends of each section of fence begin when the road is opened to traffic, as most mortality will occur immediately after opening and will likely occur at fence ends.	
EcMP9	2.6.2	Fauna underpasses: Revise the objectives of mitigation and ensure the monitoring measures a parameter that is as close to the goal as possible. For example, the goal of culverts is to facilitate some amount of animal movement across the road, which	

ID no	Section	Comment / Recommendation	How recommendation would be addressed
		cannot be evaluated by the number of roadkills.	
EcMP10	2.6.3	Widened medians: The monitoring program should evaluate the effect of widened medians on other species, both in terms of mortality and increased crossing rates, because we don't want the perverse situation where widened medians increase crossing by species X and increased mortality by species Y.	
EcMP11	2.6.5	Arboreal crossings: Goals for mitigation are too vague and need to be re-worked significantly. I won't repeat what is in the threatened gliders plan in too much detail, but the specifics of the impacts need to be clearly articulated, the goals of mitigation can then be developed, from which a robust and useful monitoring program can be designed!	
EcMP12	3.1.3	First dot pot point: How can you tell if the assessment of number of hollows is accurate? I recommend that a sub-sample of trees to be felled are surveyed for hollows before felling and then inspected once felled to determine the accuracy of the ground-counts of hollows to ensure the number of required nest boxes is accurately determined.	Adopted- plan to be updated prior to implementation
EcMP13	3.2	I recommend that the nest boxes be installed to answer a research question(s), as well as mitigate the impact of the loss of hollows. For example, the plan states that the aspect of boxes could be changed due to thermoregulatory issues. I suggest that some outstanding questions/hypotheses around box design and/or placement be identified, and that the deployment of boxes test the hypothesis/answer the question. It may be as simple as "do nest boxes on smooth barked trees have fewer of species X" or it could be much more elegant and scientifically robust. For almost no extra cost, this mitigation and monitoring program could answer some outstanding nest box questions. This has relevance for future deployment of nest boxes on Roads and Maritime and other projects where boxes are routinely deployed to ensure the maximum benefit of boxes can be obtained.	To be reviewed.
EcMP14	3.3.3	Don't rely solely on photo points to assess the condition of the terrestrial habitat.	Adopted- plan updated
EcMP15	3.4	Review of the weed management plan based on the specific weed species that may be encountered with respect to their invasiveness, extent, risk of spread, sensitivity of adjacent landscapes etc.	Adopted- plan updated

1.3. Relationship with other documents

The relationship with the threatened species management plans has been outlined in **Section 1.2** above. The relationship with other relevant project documents has been outlined below.

Environmental Impact Statement

The assessments of the projects impact on threatened species, populations and ecological communities was undertaken as part of the project Environmental Impact Statement (Roads and Maritime 2012) and Submissions / Preferred infrastructure report (Roads and Maritime 2013).

Construction Environmental Management Plan

A template for the Pacific Highway Upgrade – Woolgoolga to Ballina Construction Environmental Management Plan (CEMP) is to be developed and would describe the Environmental Management System (EMS) for works within all sections of the upgrade. A CEMP would be developed for each stage section of the project and would be designed to meet the Roads and Maritime Statement of Commitments and any Conditions of Approval. The CEMP's would provide the systems and processes to ensure that construction contractors establish and maintain appropriate controls to manage environmental impacts during construction.

The EcMP would operate in conjunction with the CEMP.

Construction Flora and Fauna Management Plan

The construction Flora and Fauna Management Plan (FFMP) would be prepared as part of the CEMP and would detail how impacts and risks to native vegetation, fauna species and fauna habitat would be managed. It includes a description of measures to be implemented during construction to mitigate potential impacts on the significant species of flora, fauna and vegetation communities.

The EcMP would operate in conjunction with the FFMP for construction related monitoring measures.

Landscape Management Plan

The Landscape Management Plan is prepared as part of the CEMP. The primary objective of a landscape management plan is to encourage the establishment of local native plant species and focus on the more dominant and impact species within a project. The landscape management plan outlines the maintenance of the whole areas of planting maintenance and the subsequent suppression of weed species. Therefore the landscape management plan sets out an approach to the maintenance of landscape plantings, both in technique and frequency including monitoring the success of revegetation.

Biodiversity Offset Strategy

The objective of the Biodiversity Offset Strategy is to deliver a Biodiversity Offset Package that achieves a net regional biodiversity benefit as a result of the project. The Biodiversity Offset Strategy identifies the impacts of the upgrade, and details the management of biodiversity impacts, following the principles of avoiding, mitigating and offsetting impacts, and presents the decision-making framework for determining offset measures.

2. Mitigation measures

The EcMP focuses on five general mitigation measures that are outlined in the EIS and Roads and Maritime Biodiversity Guidelines and are applicable to all future stages of the upgrade:

- Pre-clearing and clearing procedures.
- Nest boxes management.
- Riparian and aquatic habitat protection.
- Weed management.
- Ground-water dependent ecosystems.

These mitigation procedures would be documented in detail in the project FFMP and have been summarised in the sections below to provide context for the monitoring program.

The monitoring of fauna crossing structures as part of a targeted species approach is provided in the relevant threatened species management plans. A section on fauna crossing structures has, been included at the end of this chapter to provide details on which specific threatened species plans contains this information and an initial pre-section of structures included in the program.

2.1. Pre-clearing and clearing process

Guide 1: Pre-clearing process of the *Roads and Maritime Biodiversity Guidelines, Protecting and managing biodiversity on RTA projects* (RTA 2011) provides the basis for the process to be followed during pre-clearing activities. The objective of this guide is to provide guidance for the pre-clearing process that is to be conducted before any clearing takes place to minimise the impact on native flora and fauna in all staged sections of the project.

The pre-clearing process would be guided by information gathered during flora and fauna surveys conducted for the EIS and subsequent targeted surveys to be undertaken during the pre-construction phase of the project.

The pre-clearing process would be implemented before clearing begins to:

- Confirm the location of biodiversity features identified during the environmental assessment process.
- Check for the presence of flora and fauna species and habitat on a site immediately before clearing begins.
- Provide input into identifying appropriate exclusion zones (see Guide 2: Exclusion zones of the Roads and Maritime Biodiversity Guidelines).
- Locate nearby habitat suitable for the release of fauna that may be encountered during the pre-clearing process or habitat removal.
- Inform planning and procedures for the staged habitat removal process (see *Guide 4: Clearing of vegetation and removal of bushrock*).
- Ensure that the location of any threatened flora species, threatened ecological communities and habitat are mapped.
- Identify any additional management measures that may need to be incorporated into the Construction Environmental Management Plan (CEMP).

2.1.1. Pre-clearing surveys

Refer to the FFMP for the pre-clearing survey procedure. In summary prior to the commencement of clearing works for each separate staged section of the upgrade, a qualified ecologist would identify all areas within the proposed clearing limits of the project that contain:

- Nests, dreys and termataria that would be likely to be occupied by fauna at the time of clearing.
- Hollow-bearing trees.

- Habitat features suitable for redistribution.

Identification and marking of nests, dreys and termitaria

Within seven days of the proposed under scrubbing works commencing (Stage 1 Clearing), all nests, dreys and termitaria likely to be occupied by fauna would be marked using the following procedure:

- Plotted using a hand held GPS using the GDA 94 format.
- Flagged with flagging tape.
- Spray painted with a number (i.e. H1, H2) and a ring around the tree in the event the flagging tape is removed.

The objective of this approach would be to ensure each habitat feature has been easily distinguished and avoided by the clearing and grubbing contractors.

Identification and marking of hollow bearing trees

The project limits of clearing would be surveyed as part of preparing a nest box plan of management (refer to **section 2.2**) for each staged section of the project. The location of each hollow bearing tree would be marked using the following procedure:

- Plotted using a hand held GPS using the GDA 94 format.
- Flagged with flagging tape.
- Spray painted with a number (i.e. H1, H2) and a ring around the tree in the event the flagging tape was removed.
- Plotted on project survey plans to advice on site works.

In addition to this, data would be collected as to whether the tree was dead or alive, the number and size of hollows per tree, tree species, height, diameter at breast height (DBH), position of hollows in the tree (i.e. trunk, limb) and their estimated size classes (Small = <50 mm; Medium = 50-150 mm; Large = >150 mm) so the suitability of each resource can be assigned to various fauna groups (i.e. microchiropteran bats, scansorial mammals, gliders, possums, birds etc).

The data collected during this survey would be used to inform the nest box management plan (refer to **Section 2.2**).

Habitat features suitable for re-distribution

Field surveys would involve a thorough search of the project limits of clearing to identify and mark habitat features considered suitable for re-distribution into areas adjacent to the clearing footprint. This would include but would not be limited to large fallen logs (>300 mm diameter and not in advanced stage of decay) and large rocks with each features location:

- Plotted using a hand held GPS using the GDA 94 format.
- Flagged with flagging tape.
- Spray painted with a number (i.e. H1, H2) and a ring around the feature in the event the flagging tape is removed.

2.1.2. Clearing procedure

The main objective of this procedure would be to allow sufficient time for resident hollow-dependent fauna time to evacuate the tree prior to its felling.

Habitat features would be cleared in the following two stage process:

- Stage 1 – Under scrubbing and non-habitat trees removed.
- Stage 2 – Habitat trees removed ≥24 hours after Stage 1.

The following procedure would be followed 24 hours before clearing:

- A licensed ecologist would capture and/or remove fauna that have the potential to be disturbed, injured or killed as a result of clearing activities. Relocate captured fauna into pre-determined habitat identified for fauna release (refer to *Guide 9: Fauna handling* of the Roads and Maritime Biodiversity Guideline (RTA 2011)).
- The project manager and/or environment manager would inform clearing contractors of any changes to the sequence of clearing if required. Carry out staged habitat removal, as outlined in *Guide 4: Clearing of vegetation and removal of bushrock* of the Roads and Maritime Biodiversity Guideline (RTA 2011), where fauna habitat features (such as hollow-bearing trees, habitat trees and bushrock) have been identified and marked.

A suitably qualified and experienced ecologist (with wildlife handling training) would be present to observe the removal of each habitat tree. The ecologist would inspect each felled tree and record tree hollow characteristics (hollow depth, entrance diameter) and evidence of habitation. Should injured fauna be collected a wildlife carer would be contacted or the animal transported to a veterinarian. The FFMP contains a list of wildlife carers and local veterinarians in each the area. The wildlife carer would manage any injured or displaced fauna residing in felled trees. The ecologist would be responsible for the relocation and release of any displaced fauna that are not injured. Refer to the FFMP for a description of the appropriate handling process for fauna and injured fauna.

Unexpected finds procedure

The unexpected finds procedure is outlined in Guide 1: *Pre-clearing process of the Roads and Maritime Biodiversity Guidelines, Protecting and managing biodiversity on RTA projects* (RTA 2011). This procedure would be used if threatened flora or fauna species are unexpectedly encountered on site during the clearing surveys, and/or at any other times throughout construction of the project.

2.2. Nest box management

Nest boxes would be installed to compensate for the loss of hollow-bearing trees from the project. Installation and maintenance would be in accordance with the *Guide 8: Nest Boxes of the Roads and Maritime Biodiversity Guidelines* (RTA 2011).

The number and type of nest boxes required would be determined during the pre-clearance surveys based on the number, quality and size of the hollows that would be removed and the target species inhabiting the area (refer to **Section 2.1**). Following this a Nest Box Management Plan would be prepared for each project section detailing specifications for nest box dimensions, installation requirements, locations of nest boxes and ongoing monitoring and maintenance. The plan would consider placement in adjacent habitats and focus initially on areas of naturally low abundance of hollows.

Seventy per cent (70%) of the nominated nest boxes would be installed prior to or during the clearing works with the objective of providing temporal refuge habitat for those hollow dependant fauna displaced during clearing operations. The remaining 30 per cent (30%) of nest boxes would be installed once a final tally of functional trees 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 would also facilitate the final number and types of nest boxes being installed.

The EcMP details the consistent monitoring approach to be adopted for nest box monitoring and maintenance across all sections of the upgrade.

2.3. Aquatic and riparian habitat protection

A total of 344 water crossing structures (bridges, culverts and pipes) would be constructed across the project. The large majority of these (68 per cent) would be constructed across shallow ephemeral drainage lines consisting of a class 3 or class 4 waterway. The remaining structures would be built across 20 class 1 waterways (10 per cent) and seventy-four class 2 waterways (22 per cent).

The project design principles state that all Class 1 Waterways should be bridges. All watercourses which provide known habitat for Oxleyan Pygmy Perch have been classified as Class 1 Waterways. Further design of the structures as per the design principles would be undertaken during detailed design.

The mitigation measures proposed to protect aquatic and riparian habitats within and surrounding construction areas across waterways include:

- Erosion and sediment controls such as the use of geotextile materials, temporary sedimentation basins etc. Erosion and sediment control procedures including type and location would be outlined in the CEMP.
- Use of exclusion zones to keep construction activities away adjoining riparian habitats outside the construction area.
- Use of temporary watercourse crossings to facilitate construction access. Temporary watercourse crossings may include bridges, arches, multi-celled culverts, box culverts and pipe culverts. All temporary water crossings and culverts would be constructed in accordance with *Guidelines for Controlled Activities Watercourse Crossings* (DWE, 2008) and *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (NSW Fisheries, 2003) and with consultation of OEH, DPI (Fisheries) and DSEWPaC such that there are no barriers or impedances to instream fish movement
- Revegetation of riparian areas disturbed by construction. The landscape design would include details of the revegetation methods, species and maintenance schedules.

Permanent watercourse crossings (bridges and culverts) would be designed and constructed to be consistent with Witheridge (2002) where the use of bridges or bebo arch is the preferred structure for Class 1 (major fish habitat waterways). Culvert structures have been proposed for waterways not classified as Class 1.

Permanent creek realignments have been proposed at Picaninny Creek (Section 3) and Eversons Creek (Section 9). Detailed design of the realignment would meet requirements for waterway design, watercourse diversions and specific environmental management measures including development of a rehabilitation plan. Stranded fish would be captured and translocated following the relevant DPI Fisheries Guidelines.

In addition, permanent spill basins would be placed at key sensitive receiving environment to manage water quality from the road during operation.

2.4. Weed management

Guide 6: Weed management of the Biodiversity Guidelines: protecting and managing biodiversity on RTA project (RTA 2011) provides the requirements for weed management on all Roads and Maritime projects. The *Introductory Weed Management Manual* (Natural Heritage Trust 2004) also provides guidance for developing weed management plans.

In summary, Guide 6 of the Roads and Maritime Biodiversity Guidelines would require a site weed assessment to be undertaken prior to construction for each staged section of the project. Data collected during the assessment would be used to develop a weed management plan, which would include details on the weed monitoring program. The requirements of the weed management plan would be incorporated into relevant plans for the project (eg landscape management plan, CEMP or work method statements).

A separate weed management plan would be developed for each staged section of the upgrade, as part of the CEMP to provide guidance for preventing or minimising the spread of noxious and environmental weed species during pre-construction, construction and operation. While the FFMP would outline weed management measures to be implemented during construction, this plan outlines weed management measures to be implemented post-construction.

In general, weed management plans include descriptions and mapping of major weed infestations identified during pre-clearing surveys, with appropriate management actions outlined to be implemented for each infestation. The details in the weed management plans would most likely vary for each section of the project but would include:

- Taxa and potential sources of the weed species.
- Weed management priorities and objectives.
- Sensitive environmental areas within or adjacent to the site.
- Location of weed infested areas.
- Treatment and removal methods for all weed species of national significance.
- Mechanical weed control methods such as slashing or mowing, as well as a range of herbicides to avoid the development of herbicide resistance.
- Measures to prevent the spread of weeds.
- A monitoring program to measure the success of weed management.
- Appropriate disposal of weed infested materials and soils to be identified in the CEMP.
- Communication strategies to improve contractor awareness of weeds and weed management.

In addition to the above general guidance, the NSW Department of Planning and Infrastructure (DPI) have expressed concern over the known presence of Alligator Weed within the project. This species has been identified previously in Tuckombil Canal (Section 8 of the project). Early detection of this species would be necessary during the preparation of CEMP and targeted surveys are recommended in Sections 7 to10 of the project. If present, the CEMP would reference the DPI Alligator Weed control manual (van Oosterhout 2007).

2.5. Groundwater dependent ecosystems

Several vegetation communities occur adjacent to the project, which are groundwater dependent ecosystems (GDEs). These comprise vegetation occurring in waterways and on floodplains which are likely to be reliant on groundwater particularly during drier drought periods and also endangered ecological communities (EEC) (TSC Act) located in floodplain areas including:

- Freshwater wetlands.
- Sub-tropical coastal floodplain forest.
- Swamp sclerophyll forest.
- Swamp oak floodplain forest.
- Lowland rainforest (on alluvial soils).

Road crossings of these GDEs can impact on the subsurface flows by blocking drainage passages and groundwater flows. The greatest impacts to GDEs would be likely to occur within freshwater wetlands located in low lying floodplain areas which have been intersected or would be located adjacent to the project including the Upper Coldstream Wetland (Section 3), Clarence River Estuary (Section 5), Bundjalung National Park Wetlands (Section 6) and the wetlands of the Tabbimoble Creek and overflow area including Tabbimoble Swamp Nature Reserve (Section 6).

Groundwater inflows to cuttings resulting from the interception of the groundwater table would manifest in the form of localised seepage and potential instability of batter faces. These impacts can usually be managed through engineering mitigation measures such as drainage blankets. Groundwater seepage into the cuttings can also be collected in a subsurface drainage system (with possible treatment if required) transported to the nearest waterbody and/or GDE area such as wetlands, therefore not reducing the supply of groundwater that may currently flow towards these areas.

Monitoring of groundwater levels and water quality would be done using extensive groundwater monitoring infrastructure to be installed prior to construction. This monitoring would aim to identify potential impacts to GDEs near the project particularly where substantial cuttings may intersect the water table and affect groundwater levels, and where road crossings would be through floodplain groundwater dependent ecosystems.

2.6. Connectivity mitigation measures

The EIS and Biodiversity Connectivity Strategy describe the provision of fauna connectivity mitigation measures. The location and type of mitigation measures proposed have been outlined in the threatened species management plans (refer to **Section 1.2** and **Appendix B**). These structures would be reviewed following the targeted surveys and refined as required during the detailed design.

The objective of fauna crossing structures would be to maintain fauna movements and access to habitat. This would be achieved by the placement of fauna exclusion fencing to direct fauna to crossing structures. Connectivity mitigation measures proposed for the W2B project include:

- Fauna exclusion fencing.
- Dedicated and combined fauna underpasses.
- Widened medians.
- Dedicated overpasses.
- Canopy rope crossings.

2.6.1. Fauna exclusion fencing

The proposed locations for fauna exclusion fencing have been outlined in the following threatened species management plans (refer to **Section 1.2**):

- Koala management plan.
- Coastal Emu management plan.
- Threatened mammal management plan.
- Threatened glider management plan.
- Threatened frog management plan.

Fauna exclusion fencing would be used to direct fauna for at least 200 metres either side of each designated fauna crossing structure. Specific details on fencing types to be used have been outlined in the threatened species management plans. In general the following fauna fencing design requirements would be considered:

- Construction of fencing on both sides of the carriageway, which generally extends at least 200 metres either side of designated crossing structures.
- Continuous fencing with a 'return area' at their end to guide animals back into habitat rather than across the carriageway or to other local roads.
- Fences designed to prevent fauna from digging underneath, or passing through points where fencing crosses drainage lines.

The effectiveness of fauna exclusion fencing would be determined by the absence of road mortalities for the targeted threatened fauna in the immediate vicinity of the fauna fencing and crossing structures. The monitoring of road mortalities would occur following the opening of the road and methods, timing and frequency reported in the threatened species management plans.

2.6.2. Fauna underpasses

Dedicated and combined underpasses have been identified for targeted threatened species. The location and size of dedicated and combined underpasses have been outlined in the EIS and Biodiversity Connectivity Strategy and the following threatened species management plans:

- Koala management plan.
- Threatened mammal management plan.
- Threatened frog management plan.

The location and size of fauna underpasses were identified in the EIS and would be refined as required during the detailed design. The effectiveness of fauna underpasses would be determined by the absence of road mortalities for the targeted threatened fauna, and use of structures using remote camera monitoring and other indirect means. For some target fauna species this would include monitoring of presence and activity in the vicinity of the structure to identify that populations have access to structures.

2.6.3. Widened medians

The proposed locations for widened medians have been outlined in the Biodiversity Connectivity Strategy and the following threatened species management plans:

- Threatened glider management plan.
- Threatened mammal management plan.

The location of widened medians were identified in the EIS and would be refined as required during the detailed design. Widened medians can act as a measure to mitigate the loss of continuous habitat and increase the chance of safely crossing roads by providing stepping-stone connectivity and are targeted at threatened gliders and will also include underpass structures. The effectiveness of widened medians would be determined by the absence of road mortalities for the targeted threatened fauna, and use of structures using remote camera monitoring and evidence of glider activity. For gliders this would include monitoring of presence and activity in the vicinity of the structure to identify that populations are within area of widened median.

2.6.4. Overpass structures

Dedicated overpass structures (land bridges) have been identified in the Biodiversity Connectivity Strategy and following threatened species management plans:

- Koala management plan.
- Threatened glider management plan.
- Threatened mammal management plan.

The location and type of structures to be used would be reviewed following the targeted surveys and refined as required during detailed design. The effectiveness of fauna underpasses would be determined by the absence of road mortalities for the targeted threatened fauna, and use of structures using remote camera monitoring and other indirect means. For some target fauna species this would include monitoring of presence and activity in the vicinity of the structure to identify that populations have access to structures.

2.6.5. Arboreal crossings

The location of arboreal crossings have been outlined in the threatened glider management plan (refer to **Section 1.2**). The location of arboreal structures would be reviewed following the targeted surveys and refined during detailed design. Canopy rope bridges have been proposed for the concept design as these represent the greatest value for a range of arboreal fauna. The effectiveness of arboreal crossing structures would be determined by the absence of road mortalities for the targeted threatened fauna, and use of structures using remote camera monitoring. This would include monitoring of presence and activity in the vicinity of the structure to identify that populations have access to the structure.

3. Monitoring program

The following provides details of the ecological monitoring program proposed for upgrade. Where specific monitoring requirements such as targeted surveys for threatened species have been identified these have been included in the relevant threatened species management plan as detailed in **Section 1.2**.

3.1. Pre-clearing and clearing works

3.1.1. Timing

Clearing works would use the information gathered during the pre-clearing flora and fauna surveys to minimise potential impacts to threatened species during the clearing works. Active searches of fauna habitat immediately prior to Stage 1 removal of vegetation would be undertaken. Habitat trees would be subject to inspection during the Stage 2 clearing stage, ie 24 hours before clearing. **Section 2.1** describes the procedures to be followed during clearing works for vegetation removal and habitat tree removal.

3.1.2. Monitoring methods

For the purposes of the clearing works a field proforma would be used to record the following information:

- Type, number and general health of fauna captured and relocated as part of Stage 1 clearing works (i.e. under scrubbing).
- Type, number and general health of fauna captured and relocated as part of Stage 2 clearing works (removal of flagged habitat trees).
- Tree hollow characteristics including hollow type, hollow depth, size of entrance, signs of occupancy.
- Relocation points for each species and the release approach (i.e. bat released at dusk).
- Fauna injuries and actions undertaken.

3.1.3. Performance indicators and corrective actions

The performance of the clearing works would be assessed against the following parameters:

- Accurate assessment of tree hollow numbers being removed.
- Reduced number of fauna injuries/mortality as a result of the clearing operations.
- The capture and release of all fauna displaced during the clearing operations.
- Rapid processing, treatment and release of injured fauna.
- Data collation and reporting of these measures.

Corrective actions to be implemented should the clearing works be deemed ineffective are identified in **Table 3-1**.

Table 3-1 Clearing works performance monitoring and corrective action plan

Mitigation measure	Performance indicators	Corrective actions	Responsibility
Implementation of the clearing procedures	Not all fauna habitat features identified. Clearing of undocumented threatened species and habitat trees.	Notify project environmental manager. 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. Review pre-clearing data and identify how difference could be accounted for to inform further pre-clearing surveys within the subsequent project sections.	Roads and Maritime through construction contractor responsible for engaging suitably qualified ecologists and wildlife carers to undertake the clearing works.
	Multiple occurrences of fauna injury and mortality reported over a day.	Stop clearing works and notify environmental manager. Ecologist and contractor to review clearing procedures being implemented. Modify habitat tree retention times and/or Stage 2 (habitat tree felling) clearing procedures.	
	Koala to be displaced by clearing works not captured and released 24 hours before clearing works is undertaken.	Notify environmental manager. Stop clearing works and allow a further 24 hours for Koala to move. Capture and relocate as per Koala management plan. Project ecologist to relocate and release fauna into suitable adjoining habitat.	
	A suitability qualified ecologist and licensed wildlife carer not present /available during clearing works as per the clearing procedures as documented in the FFMP.	Stop clearing works and review the clearing procedure being implemented to ensure it meets the Roads and Maritime Biodiversity Guideline requirements and minimises impacts to fauna.	
	Reporting not undertaken within four weeks of clearing works being undertaken per section.	Contractor to discuss report with ecologist and prioritise completion of the report.	

3.2. Nest box monitoring

3.2.1. Site selection

Monitoring would be undertaken for the sites where nest boxes have been located.

3.2.2. Timing and frequency

Monitoring would be undertaken 12 months after the installation of nest boxes followed by a summer or winter census to account for seasonal variation in the use of the nest boxes. Annual monitoring and maintenance would be undertaken until the effectiveness of the nest boxes has been proven over three consecutive monitoring periods.

3.2.3. Monitoring methods

The Nest Box management plan for each upgraded section would detail the number and type of nest boxes required for each section of the project. Monitoring would be required to determine the usage of nest boxes by the target species and inform any maintenance requirements.

During each monitoring event, a visual inspection of each nest box would be conducted to collect the following data using a field proforma (refer to **Appendix D** for an example 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?
- Has the surrounding landscape changed (i.e. clearing, partial clearing, fauna mitigation devices such as underpass)?

Visual inspection would enable the observer to perform a close inspection for signs of feathers, droppings/scats, hair, nesting material or individuals themselves. At this time some maintenance considerations/actions could be undertaken. For example, changing the aspect of a nest box to address thermoregulatory considerations.

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. Damaged boxes geographic co-ordinate would need to be reported.
- Repositioning, re-erection or relocation of dysfunctional nest boxes.
- Checking each box is not holding water or leaking.
- Removing excess nesting material as this may impede access over time.

3.2.4. Performance indicators and corrective actions

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 target species by those species (i.e. Brush-tailed Phascogale nest box being used by this species).
- Low rates of exotic fauna using nest boxes.
- Reduced maintenance requirements.

Corrective actions to be implemented should the nest boxes be deemed ineffective are identified in **Table 3-2**.

Table 3-2 Nest box performance monitoring and corrective action plan

Mitigation measure	Performance indicator	Corrective actions	Responsibility
Nest boxes	Nest box not being used by target species. Poor uptake/usage rate by native fauna.	Review the location, type and number of nest boxes used.	Roads and Maritime responsible for engaging suitably qualified ecologists to undertake the monitoring and suitably qualified contactors to undertake the maintenance.
	Nest boxes become occupied by exotic or invasive fauna.	Review/change nest box design and/or placement on tree to exclude undesirable species, treat if applicable or relocate those nest boxes to another location.	
	Nest boxes deteriorating rapidly and requiring maintenance.	Identify causes of nest box failure, modify design and construct accordingly.	

3.3. Aquatic and riparian habitat monitoring

3.3.1. Selection of sites

Aquatic and riparian habitat monitoring and water quality monitoring would be undertaken pre-construction to collect baseline data at all water crossing sites within the project. The sites to be monitored during construction and operation would be informed by the baseline survey findings.

Aquatic and riparian habitat monitoring during construction and operation would be undertaken at sites that do not contain Oxleyan Pygmy Perch as per this plan. Known and potential Oxleyan Pygmy Perch habitat would be monitored as per the Threatened fish management plan.

Fish surveys would be undertaken at locations where threatened fish have been identified. Fish sampling and monitoring requirements have been outlined in the Threatened fish management plan.

3.3.2. Timing and frequency

Collection of baseline data including aquatic habitat, water quality and fish surveys would be undertaken pre-construction at all water crossing sites within the project. Monitoring of aquatic habitat and water quality would be undertaken during construction once riparian revegetation has developed sufficient cover. Monitoring of aquatic habitat and water quality would be undertaken annually during operation. Monitoring would continue post-construction until the mitigation measures have proven successful, after which the need for further monitoring would be reviewed in consultation with the relevant agencies.

3.3.3. Monitoring methods

Habitat condition

A general description of the habitat characteristics of each monitoring site would be undertaken documenting riparian vegetation characteristics and condition, stream substrate composition and profile, areas of bank erosion and sedimentation, and overall habitat condition. The methods described in Pusey, Kennard & Arthrington (2004) formed the basis of habitat descriptions.

Photographs would be taken facing upstream and downstream from a permanent photographic point. The location of the photographic monitoring point as well as upstream and downstream site boundaries and significant features (e.g. hollow-bearing or mature trees) would be recorded with a hand-held GPS to allow re-positioning during repeat sampling.

At each monitoring site the following in-stream habitat features would be recorded as the main determinants of habitat suitability for the target fish species:

- Average water depth from three points in each site.
- Average stream width from three points in each site.
- Per cent cover of large woody debris (>150 millimetres stem diameter), small woody debris and leaf litter from 12 points in each site.
- Per cent cover of submerged and emergent macrophytes from 12 points in each site. Species of aquatic vegetation were also recorded.
- Substrate composition from 12 points in each site in percentage cover of mud, sand, fine gravel (2-16 millimetres), coarse gravel (16-64 millimetres), cobble (64-128 millimetres, rock and bedrock.
- Per cent of bank classified as undercut (30 cm overhang within 10 centimetres of surface), or as root masses averaged from four transects at each site.
- Per cent cover of riparian vegetation averaged from four transects at each site.
- Flow rates.

To survey structural habitat, three transects would be positioned perpendicular to stream flow and the substrate composition, debris cover and vegetative cover would be estimated in four 0.5 metres squared quadrats randomly positioned along each transect. Wetted width and depth would be measured at each of these transects. Additionally, four transects, representing a total of 20 per cent of wetted stream perimeter, would be randomly positioned along each bank and estimates of root masses, bank and vegetation overhangs and riparian cover would be made along each transect. At some sites, the steepness of the banks and depth of the water may make it difficult to lay and interpret quadrats. On such occasions, and on others where the wetted width of the stream is less than 2.5 metres, the full complement of 12 quadrats would not be not utilised.

In addition to the above structural habitat descriptions an inventory of aquatic plants at each site would be compiled.

Water quality

Water quality monitoring (including surface and groundwater monitoring) has commenced pre-construction for the W2G Pacific Highway upgrade. The monitoring being undertaken involves two main initial stages. Stage 1 requires the preparation of a protocol for water quality monitoring. Protocols have been developed for the Woolgoolga to Glenugie, Glenugie to Devils Pulpit and Devils Pulpit to Ballina sections of the W2B project. Protocol development required consultation with relevant government agencies, and agency and Roads and Maritime concurrence prior to the commencement of the next stage. Stage 2 involves 12 months of water quality monitoring, in accordance with the approved protocol. In general, the baseline water quality monitoring (pre-construction) would be undertaken at impact and control sites to document the pre-existing condition so as water quality objectives can be developed prior to the installation of waterway crossing structure(s).

Water quality sampling and analysis would be undertaken in accordance with the *Australian Standard AS/NZS 5667.1.1998 – Water Quality Sampling Guidance and ANZECC/ARMCANZ* (2000) Australian Guidelines for Water Quality Monitoring and Reporting. Trends in water quality data would be compared over time and against relevant standards. Refer to the CEMP Surface and Groundwater Water Quality Monitoring Protocols for a detailed description of the sampling sites, regime and parameters. At each monitoring site, the following minimum physio-chemical water quality parameters would be measured in surface water to determine the suitability of the water for target species: temperature, conductivity, dissolved oxygen, pH and turbidity. Observations of surface films and debris would also be made.

This monitoring is being undertaken in order to monitor and manage the impacts of the proposed Pacific Highway upgrade on local water bodies, both during and post construction. The pre-construction monitoring program would establish baseline water quality information that can be used to assess compliance with the water quality objectives and monitor the effectiveness of the mitigation measures to be implemented during construction and operation. It should be noted that water quality monitoring would continue post-construction until the mitigation measures have been proven successful, after which the need for further monitoring would be reviewed in consultation with the relevant agencies.

3.3.4. Performance indicators and corrective

Performance indicators of mitigation success would include:

- Emergent macrophyte cover would not decline by greater than 25 per cent of baseline values at two or more stations, and as a result of road construction works.
- Noted decline in water quality between impact site and control site as a result of road construction or operation.
- Noted dieback of plants located on the bank or within the riparian zone adjacent to the construction corridor.

Corrective actions to be implemented should the riparian and aquatic habitat mitigation measures be deemed ineffective are identified in **Table 3-3**.

Table 3-3 Aquatic habitat corrective actions

Mitigation measure	Performance indicator	Corrective actions	Responsibility
Watercourse crossings (temporary and permanent) and creek realignments.	Emergent macrophyte cover declined by greater than 25 per cent of baseline values at two or more impact sites. Noted decline in water quality between impact site and control site as a result of road construction or operation. Noted dieback of plants located on the bank or within the riparian zone.	Undertake rehabilitation maintenance, i.e. riparian replanting, erosion, sediment and weed control. Undertake aquatic weed and pest control as required. Check potential sources of contamination upstream, restore riparian vegetation. Investigate cause of macrophyte reduction. Implement measures to restore. Investigate cause of plant death and implemented measures to restore.	Roads and Maritime responsible for engaging suitably qualified ecologists to undertake the monitoring and suitably qualified contractors for the maintenance.

3.4. Weed management

As noted in **Section 2.4**, the FFMP would outline weed management measures to be implemented during construction. This plan outlines weed monitoring measures to be implemented post-construction. The noxious weeds and environmental weed infestations monitored during construction would inform the operational weed monitoring locations.

Weed management within and in close vicinity of threatened plant populations would be monitored as part of the threatened species management plans.

3.4.1. Site selection

The sites to be monitored post-construction would be informed by the noxious weed and environmental weed infestations identified pre-construction/construction. A visual assessment of each upgraded section would be undertaken to identify additional noxious weeds and environmental weed infestations within the project.

3.4.2. Timing and frequency

Post-construction monitoring of weeds would commence in Year 1 after completion of the project. Inspection of the project would be undertaken twice a year to identify weed infestations. In addition, the establishment of any noxious weeds would be identified during Roads and Maritime's regular maintenance activities within the road reserve. Weeds identified during maintenance activities would be treated within three weeks of being identified.

3.4.1. Monitoring methods

A visual assessment (including photographs) of the project would be undertaken to identify noxious weeds and environmental weed infestations. This visual assessment would include the previously identified noxious weeds and environmental weed infestations. Transects would be used to record the cover and abundance of noxious weeds and environmental weed infestations.

Noxious weeds identified within the project would be treated in accordance with the methods described in the *Noxious and Environmental Weed Control Handbook* (NSW DPI 2007) and in consultation with the relevant council. Particular attention would be given to weed infestations that have been identified in proximity to drainage lines. If required for control, a herbicide and/or pesticide suitable for use in or near watercourses would be used.

No specific treatments are proposed for other species as these are generally herbaceous, not noxious and not highly invasive. Such species are generally not considered to pose a threat to the ecological functioning within the project.

3.4.2. Performance indicators and corrective

Performance of effective weed management would be measured by achievement of the following:

- No spread of weeds onto land adjoining the project.
- Prompt treatment of any noxious weeds identified within the project.

Corrective actions to be implemented should the weed management mitigation measures be deemed ineffective are identified in **Table 3-4**.

Table 3-4 Weed management corrective actions

Mitigation measure	Performance indicator	Corrective actions	Responsibility
Regular maintenance activities during operation to manage weed management. Twice yearly inspections to identify noxious and environmental weed infestations.	Evidence of noxious weed invasion controlled or eradicated.	Report noxious weeds to the project environmental manager and implement relevant noxious weed management protocols. Prompt treatment of any noxious weeds within the project. Wherever possible, removal of weeds should be undertaken prior to seed developing (during the warmer months for most species). Where this is not possible weed removal must include the removal of any seeds from the plant. If noxious weeds have been identified in adjoining land, treat weeds on adjoining land in consultation with the land owner.	Roads and Maritime responsible for engaging suitably qualified ecologists to undertake the monitoring and suitably qualified contractors for the maintenance.

3.5. Groundwater dependent ecosystems

Changes to the condition of GDE's would be identified by monitoring groundwater quality before and after construction. Groundwater monitoring infrastructures have been set up and installed for the W2B Pacific Highway upgrade.

As described in **Section 3.3.3**, water quality monitoring (including groundwater monitoring) has commenced pre-construction for the W2B Pacific Highway upgrade. Refer to the Surface and Groundwater Quality Monitoring Protocols for each section of the project for details on the water quality monitoring being undertaken pre, during and post construction. It should be noted that water quality monitoring would continue post-construction until the mitigation measures have been proven successful, after which the need for further monitoring would be reviewed in consultation with the relevant agencies.

As noted in **Section 2.5**, monitoring groundwater levels and quality using the groundwater monitoring infrastructure installed for the W2B Pacific Highway upgrade would be undertaken for the freshwater wetlands and ground dependent ecosystems.

3.6. Connectivity mitigation measures

The monitoring, performance indicators and corrective actions for connectivity mitigation measures specific to targeted threatened species have been outlined in the following threatened species management plan:

- Koala management plan.
- Coastal Emu management plan.
- Threatened mammal management plan.
- Threatened glider management plan.
- Threatened frog management plan.

4. Reporting

4.1. Pre-clearing and clearing works

A report would be prepared and submitted to the project environmental manager after the clearing works have been finalised and would include:

- A detailed description of the methods used during the pre-clearing and clearing procedures.
- Results of pre-clearing and clearing procedures including lists of fauna species displaced by clearing, species captured, species released, any wildlife mortalities resulting either directly or indirectly from the clearing operations and number, type and new location (GPS coordinates) of natural habitat features relocated from within clearing limits.
- Hollow bearing tree register presenting data collected during clearing supervision and compare this with the nest box plan of management. The objective is to assess the adequacy of nest boxes installed and its mitigative role in offsetting the loss of functional tree hollows.
- Discussion on the effectiveness of those methods employed.
- Recommendations for any refinements to pre clearing and clearing procedures for future clearing operations within other sections of the project.

4.2. Annual reporting

Annual reporting of all other monitoring results associated with the Ecological Monitoring Program to the Director General and relevant agencies (or as otherwise agreed by those agencies) and the project environmental manager and would include:

- A detailed description of the monitoring methodology employed, sites and geographic co-ordinates.
- Results from the monitoring events, including timing of the monitoring period, weather conditions, and data analysis.
- Discussion of results, including how the results compare against performance measures, if any modifications to timing or frequency of monitoring periods or monitoring methodology would be required and any other recommendations.
- If corrective actions or contingency measures should be or were implemented.
- Review of the effectiveness of mitigation measures (as appropriate) to the monitoring period.

4.3. Threatened species reports

Reporting requirements for the targeted threatened species has been outlined in the threatened species management plans. Refer to the following plans for these requirements:

- Koala management plan.
- Coastal Emu management plan.
- Rainforest communities and threatened rainforest plants management plan.
- Threatened flora management plan.
- Threatened glider management plan.
- Threatened mammal management plan.
- Threatened frog management plan.
- Threatened fish management plan.
- Threatened invertebrate management plan.

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Appendix A – Dr R. van der Ree CV

Curriculum Vitae

PERSONAL DETAILS

Dr Rodney van der Ree
32 St David's Drive
Wantirna, VIC, 3152
0412 562 429
rvdr@unimelb.edu.au

EDUCATION

1995 – 2000 Ph.D. School of Ecology and Environment, Deakin University "Ecology of arboreal marsupials in a network of remnant linear habitats".

1994 Bachelor of Science (1st Class Honours), Deakin University. "The distribution and abundance of mammals in 1939 and 1983 regrowth *Eucalyptus regnans* (Mountain Ash) forests in the Central Highlands of Victoria".

1991 – 1993 Bachelor of Applied Science, Deakin University, with majors in Biology, Terrestrial Ecology, Earth Sciences and Environmental Science.

EMPLOYMENT HISTORY

2009-present: Deputy Director and Manager, Ecological Sciences: Australian Research Centre for Urban Ecology (ARCUE)

Employment history at ARCUE:
2001 – 2004 Post-Doctoral Research Fellow
2004 – 2006 Ecologist
2006 – 2008 Senior Ecologist

ARCUE is a research division of the Royal Botanic Gardens Melbourne and is also part of the School of Botany at The University of Melbourne. I am responsible for conducting high quality scientific research on the impacts of human activities on wildlife as well as managing the commercial and collaborative research partnerships and consultancies between ARCUE and our clients. My research projects are diverse, and broadly cover the effects of habitat loss and fragmentation due to the construction of cities and towns as well as other infrastructures, such as roads, and agricultural activities. For example, I am leading a team of scientists and postgraduate students researching the effects of roads and traffic on flora, fauna and ecological processes. This is a 8-year project with initial support from the ARC via the Linkage Projects scheme, with VicRoads and the NSW Roads and Maritime Service as major industry partners. I am also leading a team of scientists, postdocs and postgraduate students on another ARC Linkage Project to understand the impacts of urbanisation on insectivorous bats. In addition, I am responsible for the day to day management of all aspects of numerous small research and consulting projects.

In my role as Deputy Director I am responsible for the recruitment and supervision of staff and students on my projects (i.e. setting tasks, reviewing progress, managing expectations), as well as the management of multiple projects (up to 20) - including setting and monitoring budgets, liaison with clients, report writing - and co-ordinate the often competing demands on equipment, staff time and other resources. I supervise multiple students and postdoctoral fellows, write scientific papers, grant applications and review student theses, papers and reports. An important part of my role is engaging with project partners to financially and logistically support projects.

Throughout the year I frequently undertake higher duties when the ARCUE Director is on leave or travelling. In this capacity, I am fully responsible for all the functions and operations of ARCUE, including approval of expenditure, signing contracts, project management and staff supervision.

2001 – 2004 **Consultant Ecologist**
I have successfully undertaken consultancy projects for a range of clients in Victoria and New South Wales, including the New South Wales National Parks and Wildlife Service, VicRoads, and the Albury-Wodonga Development Corporation. The research included studies of the distribution and abundance of Squirrel Gliders in New South Wales and Victoria and the development of mitigation measures to facilitate the crossing of major roads by fauna. I have contributed to the design of a strategy to conserve biodiversity in the Thurgoona district of Albury, an agricultural area being rapidly developed for housing. As an environmental consultant, I was required to establish my own business, undertake field research and literature reviews, be responsible for budgeting and accounting, report writing and working to deadlines.

1994 – present **Lecturer, Tutor and Demonstrator - Deakin University, The University of Melbourne**
I regularly lecture and in undergraduate ecology classes at Melbourne Uni and have taught classes in Biology, Environmental Management and Conservation Biology at Deakin University.

1999 **Ecologist - Department of Natural Resources and Environment**
Consultancy to investigate the spatial organisation of the endangered Brush-tailed Phascogale within a highly fragmented and cleared agricultural landscape in northern Victoria. The consultancy involved project planning and budgeting, fieldwork (trapping, radiotracking), data analysis and report writing.

Supervision of postdoctoral fellows and students

Current

Dr Fiona Caryl (Post Doc). Australian Research Centre for Urban Ecology and University of Melbourne. Habitat models of insectivorous bats in urban Melbourne.

Dr Pia Lentini (Post Doc). Australian Research Centre for Urban Ecology and University of Melbourne. Population viability of insectivorous bats under different urbanisation scenarios.

Dr Cheryl Krull (Post Doc). University of Auckland, New Zealand. Is the grass greener on the other side? Applying road ecology to invasive species management in New Zealand.

Kylie Soanes (PhD). Australian Research Centre for Urban Ecology and University of Melbourne. Assessing the use and effectiveness of wildlife crossing structures for the endangered Squirrl Glider.

Caroline Wilson (PhD). Australian Research Centre for Urban Ecology and University of Melbourne. The foraging and roosting requirements of insectivorous bats in an urban environment.

Tanja Straka (PhD). Australian Research Centre for Urban Ecology and University of Melbourne. The role of waterbodies and perceptions of the public to urban bats.

Chris Stewart (PhD). Australian Research Centre for Urban Ecology and University of Melbourne. Investigating the effects of roads on wildlife populations using simulation modelling.

Jody Taylor (PhD) Monash University. Landscape connectivity in fragmented habitat: Lizard-eyed views of remnant vegetation in Victoria.

2007 Silvana Cesarini (PhD). Monash University. Quantifying and mitigating the barrier effect of roads on the Squirrel Glider, *Petaurus norfolcensis.*

2007 Natasha Kreitals (1st Class Hons). Australian Research Centre for Urban Ecology and University of Melbourne. Using stable isotopes to identify food sources for Spectacled Flying-foxes.

2006 Micaela Main (1st Class Hons). Australian Research Centre for Urban Ecology and University of Melbourne. Living life on the edge: abundance and diversity of lizards on roadsides.

2006 Nadine Gulle (1st Class Hons). Australian Research Centre for Urban Ecology and University of Melbourne. The effects of roads on the movement patterns of the Common Brushtail Possum.

2006 Shannon Troy (1st Class Hons) Australian Research Centre for Urban Ecology and University of Melbourne. Quantifying source-sink dynamics in Yellow-footed Antechinus.

2006 Sarah McCall (1st Class Hons). Australian Research Centre for Urban Ecology and University of Melbourne. Modelling the survival of Squirrel Gliders adjacent to major roads.

2005 Ashley Herrod (1st Class Hons) Monash University. Quantifying a barrier effect of a major freeway to Yellow-footed Antechinus occurring in roadside habitat in northern Victoria, using genotypic analyses.

2005 Katrina Thompson (1st Class Hons). Australian Research Centre for Urban Ecology and University of Melbourne. Spatial organisation of the Sugar Glider in urban bushland remnants.

2005 Hayley Broecker (1st Class Hons). Australian Research Centre for Urban Ecology and University of Melbourne. Modelling detectability of small mammals during surveys.

2005 Michael Harper (PhD). Australian Research Centre for Urban Ecology and University of Melbourne. 'The distribution and development of tree hollows and the ecology of hollow-dependent fauna along an urbanisation gradient in Melbourne.'

2003 Carolina Cordeiro (H2A Hons). Australian Research Centre for Urban Ecology and University of Melbourne. 'Relationship between activity levels of predators and prey in patches of remnant Red Gum woodland along an urban-rural gradient.'

2001. Michael Harper (1st Class Hons). Australian Research Centre for Urban Ecology and University of Queensland. 'Assessing trees for tree hollows: a comparison of techniques.'

1999. Mark Venosta (3rd Year Research Project) Deakin University. 'Time budget and related aspects of the foraging and habitat use of the Brush-tailed Phascogale *Phascogale tapoatafa* within fragmented habitat near Euroa, Victoria.'

1998. Daniel Gilmore (3rd Year Research Project) Deakin University. 'The influence of isolation of the occurrence of arboreal marsupials in small patches of woodland in an agricultural landscape.'

1998. Greg Holland. (1st Class Hons) Deakin University. 'Time budget and related aspects of the foraging behaviour and habitat use of the Squirrel Glider *Petaurus norfolcensis.'*

1997. Luke Murphy (1st Class Hons) Deakin University). 'Ecology of the Common Brushtail Possum (*Trichosurus vulpecula* KERR, 1792) in roadside corridors in north east Victoria.'

ACADEMIC and PROFESSIONAL ACTIVITIES

I am an active member of the following professional organisations: Australasian Wildlife Management Society, Ecological Society of Australia, International Association for Landscape Ecology, Infra-Eco Network of Europe, International Conference of Ecology and Transportation and the Australian Mammal Society.

I have been invited to sit on a number of expert scientific committees across Australia. In 2004 I was a member of the Grey-headed Flying-fox Reference Group to provide advice to the Victorian Minister for the Environment on issues relating to the management of this nationally threatened species. In 2009-12 I advised the Royal Botanic Gardens Trust (Sydney) on management of the Grey-headed Flying-fox. In 2013 I was invited to be a scientific expert for the web-based company "MyRoadkill.com" who donate proceeds from their sales to wildlife conservation organisations. I have been appointed to expert committees for the International Conference on Ecology and Transportation (USA) and the Infra-Eco Network of Europe conferences in 2010, 2011 and 2012. In 2012 I was appointed to the Leadbeater's Possum Recovery Team. From 2005 – 2007 I was a member of the Environmental Advisory Committee for the City of Knox, advising them on a wide range of environmental issues. In 2001, I was invited to sit on the panel to judge applications for the National Banksia Environmental Awards. I have acted as a judge of student presentations at > 10 national and international conferences within Australia and overseas, including the 2004 meeting of the Society for Conservation Biology in the U.S.A. and the 2002 meeting of the Australian Mammal Society.

I have refereed manuscripts for numerous international scientific journals, including Journal of Applied Ecology, Acta Oecologia, Acta Theriologica, Austral Ecology, Animal Conservation, Ecological Management and Restoration, Journal of Environmental Management, Journal of Zoology, Wildlife Research, Landscape and Urban Planning, Landscape Ecology, Forest Ecology and Management, Biological Conservation, Urban Ecosystems, Australian Mammalogy, as well as manuscripts for various books. I have reviewed grant applications for the National Science Foundation (USA), Natural Sciences and Engineering Council (Canada), Killam Research Fellowship (Canada), and the Foundation for Research, Science and Technology (New Zealand). I have assessed four PhD, two Masters and >10 Honours theses from various universities across Australia and overseas.

I have made it a priority to give lectures and seminars about my research to a variety of audiences, including universities, research institutes, and special interest and community groups (see below for a selection of seminars). I have given Plenary lectures at the Infra-Eco Network of Europe Conference in Potsdam, Germany (October 2012), Society for Conservation Biology meeting in India (August 2012), International Conference on Ecology and Transportation, USA (May 2007). In 1999, I received a professional enhancement award from National Aeronautics and Space Administration (NASA) and Michigan State University to attend the Congress of the International Association of Landscape Ecology in Colorado, USA. In 2000, I received the Bolliger Award for the best spoken paper by a student at the annual conference of the Australian Mammal Society in Alice Springs.

I have organised numerous specialist symposia as part of national and international ecological conferences, as well chaired the organising committees for national conferences. The specialist symposia include:

- "Wildlife Management in Urban Areas", 3rd International Wildlife Management Congress, Christchurch, New Zealand, December 2003.
- "Ecological Effects of Roads, Traffic and Infrastructure Corridors", Ecological Society of Australia Adelaide, December 2004.
- "Effects of roads and traffic on wildlife populations and landscape function", International Association for Landscape Ecology Conference, The Netherlands, July 2007.

PUBLICATIONS (refereed)

Ascensao, F., S. LaPoint, van der Ree R. (in press). Roads and traffic: big problems for small mammals. Ecology of roads: an international practitioners guide. R. van der Ree, D. J. Smith and C. Grilo. London, Wiley.

D'Angelo, G. J. and R. van der Ree (in press). Use of wildlife reflectors and whistles to prevent wildlife-vehicle collisions. Ecology of roads: an international practitioners guide. R. van der Ree, D. J. Smith and C. Grilo. London, Wiley.

Jones, D., H. Bekker, van der Ree R (in press). Road ecology in an urbanising world. Ecology of roads: an international practitioners guide. R. van der Ree, D. J. Smith and C. Grilo. London, Wiley.

Milton, S. J., R. Dean, van der Ree R et al. (in press). The function and management of roadside vegetation. Ecology of roads: an international practitioners guide. R. van der Ree, D. J. Smith and C. Grilo. London, Wiley.

Reck, H. and R. van der Ree (in press). Insects, snails and spiders: the role of invertebrates in road ecology. Ecology of roads: an international practitioners guide. R. van der Ree, D. J. Smith and C. Grilo. London, Wiley.

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van der Ree, R., D. J. Smith, et al., Eds. (in press). Ecology of roads: An international practitioners guide. London, Wiley.

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Caryl F, Thompson K, van der Ree R. (2013). Permeability of the urban matrix to arboreal gliding mammals: Sugar gliders in Melbourne, Australia. Austral Ecology **38**, 609 - 616.

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McCall, S., R. van der Ree, et al. (2010). "Highway living reduces survival of Squirrel Gliders." Ecology and Society 15(3). [online] URL: http://www.ecologyandsociety.org/vol15/iss3/art27/

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Harper M. J., Mccarthy M. A. & van der Ree R. (2008). Landscape resources influence possum abundance. *Austral Ecology* **33**, 243.

Holland, G., A. F. Bennett, et al. (2007). "Time-budget and foraging behaviour of the Squirrel Glider, *Petaurus norfolcensis*, in remnant linear habitat " Wildlife Research **34**(4): 288 – 295.

van der Ree, R., A. F. Bennett, et al. (2006). "Nest tree selection by the threatened brush-tailed phascogale *Phascogale tapoatafa* (Marsupialia: Dasyuridae) in a highly fragmented agricultural landscape." Wildlife Research **33**: 113-119.

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Williams N. S. G., McDonnell M. J., Phelan G. K., Keim L. and van der Ree R. (2006). Range expansion due to urbanisation: increased food resources attract Grey-headed Flying-foxes (*Pteropus poliocephalus*) to Melbourne. Austral Ecology **31**, 190 - 198.

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van der Ree R., McDonnell M. J., Temby I. D., Nelson J. and Whittingham E. (2006). The establishment and dynamics of a recently established urban camp of flying foxes outside their geographic range. Journal of Zoology (London) **268**, 177-185.

van der Ree R., Ward S. J. and Handasyde K. (2004). Distribution and conservation status of possums and gliders in Victoria. In 'The Biology of Australian Possums and Gliders'. (Eds. RL Goldingay and S Jackson) pp. 91-110, (Surrey Beatty and Sons PTY LTD: Chipping Norton).

Harper, M.J., McCarthy, M.A., & van der Ree, R. (2005). The abundance of hollow-bearing trees in urban dry sclerophyl forest and the effect of wind on hollow development. Biological Conservation **122**, 181 - 192.

van der Ree, R. (2004). The impact of urbanisation on the mammals of Melbourne - do atlas records tell the whole story or just some of the chapters? In 'Urban Wildlife: more than meets the eye'. (Eds. D. Lunney and S. Burgin.) pp. 195-204, (Royal Zoological Society of New South Wales: Mosman, NSW).

Claridge A. W. and van der Ree R. (2004). Recovering endangered populations in fragmented landscapes: the squirrel glider *Petaurus norfolcensis* on the south-west slopes of New South Wales. In 'Conservation of Australia's Forest Fauna' (second edition), (Ed. D Lunney) pp. 678-687, (Royal Zoological Society of New South Wales: Mosman, New South Wales).

Harper, M. J., McCarthy, M. A., van der Ree, R., and Fox, J. C. (2004). Overcoming bias in ground-based surveys of hollow-bearing trees using double sampling. Forest Ecology & Management **190**, 291-300.

McCarthy, M. A., Parris, K. M., van der Ree, R., McDonnell, M. J., Burgman, M. A., Williams, N. S. G., McLean, N., Harper, M. J., Meyer, R., Hahs, A., and Coates, T. (2004). The habitat hectares approach to vegetation assessment: An evaluation and suggestions for improvement. Ecological Management and Restoration **5**, 24-27.

van der Ree, R., Bennett, A. F. and Gilmore, D. C. (2003). Gap-crossing by gliding marsupials: thresholds for use of isolated woodland patches in an agricultural landscape. Biological Conservation **115**, 241-249.

van der Ree, R., and Bennett, A. F. (2003). Home range of the Squirrel Glider *Petaurus norfolcensis* in a network of linear habitats. Journal of Zoology (London) **259**, 327-336.

van der Ree, R. (2003). The occurrence of the yellow-footed antechinus *Antechinus flavipes* in remnant linear habitats in north-eastern Victoria. Australian Mammalogy **25**, 97-100.

van der Ree, R. (2002). The population ecology of the Squirrel Glider *Petaurus norfolcensis*, within a network of remnant linear habitats. Wildlife Research **29**, 329-340.

van der Ree, R. and Loyn, R. H. (2002). The influence of time since fire and distance from the fire boundary on the distribution and abundance of arboreal marsupials in *Eucalyptus regnans*-dominated forest in the Central Highlands of Victoria. *Wildlife Research,* **29**, 151-158.

van der Ree, R. and Bennett, A. F. (2001). Woodland remnants along roadsides - a reflection of pre-European structure in temperate woodlands? Ecological Management and Restoration*,* **2**, 226-228.

van der Ree, R., Soderquist, T. R. and Bennett, A. F. (2001). Home range use by the Brush-tailed Phascogale *Phascogale tapoatafa* (Marsupialia: Dasyuridae) in high-quality, spatially limited habitat. Wildlife Research*,* **28**, 517-525.

Bennett, A. F., and van der Ree, R. (2001). Roadside vegetation in Australia: conservation and function of a linear habitat network in rural environments. In 'Hedgerows of the world: their ecological functions in different landscapes', (Eds. C. Barr and S. Petit.) pp. 231-240, (IALE (UK)).

van der Ree, R. (1999). Barbed wire fencing as a hazard for wildlife. The Victorian Naturalist **116**, 210-217.

In addition, I have published more than 60 reports and popular articles, given in excess of 70 presentations at conferences, workshops, community groups and > 20 media appearances, including TV, radio, and newspaper.

Appendix B - Expert review

Review of Draft Ecological Monitoring program for Woolgoolga to Ballina, Pacific Highway Upgrade

Version 0.4, August 2013.

By Dr Rodney van der Ree, Australian Research Centre for Urban Ecology.

27th August 2013 and revised 11 September 2013

Overview

It is pleasing to see a wide ranging ecological monitoring program for major road projects, that attempt to integrate and co-ordinate numerous species and issues into one program. This monitoring program is a significant advance on previous projects across Australia, where monitoring programs begin to be thought about after construction has been completed. The opportunity provided by this current approach and program has the potential to actually provide important information about the effectiveness of the measures implemented to eliminate and mitigate the various negative effects of the Pacific Highway upgrade on a range of ecological matters.

Unfortunately, the potential outcomes provided by this plan are still unlikely to be achieved if the monitoring proceeds according to the details contained within this draft ecological monitoring program. I hope that my advice and recommendations enable Roads and Maritime and its contractors to revise the monitoring strategy and thus fulfil their commitments to be able to properly assess the impacts of the highway on ecological matters and confidently assess the effectiveness of mitigation and offset measures.

I have given my comments in two sections. The first is a response to the specific question detailed by SKM to be considered in my review, and the second part contains detailed comments that relate to specific sections of the EcMP.

PART 1: RESPONSE TO SPECIFIC QUESTIONS DETAILED BY SKM TO BE CONSIDERED DURING REVIEW

a) is the design of the monitoring project appropriate for the species?

Generally yes, although modifications to various aspects is required, as noted in detailed comments below.

b) is the frequency and timing of mitigation adequate?

Yes

c) is the management plan clear on what basis the monitoring locations would be selected?

Partially. The EcMP gives general information about the basis from which monitoring plots will be selected. For example, the EcMP states that all waterway crossings will be monitored, which is good, but does not specify if all nest boxes will be surveyed. As for weed management, the EcMP states that sites for weed management will be selected based on observations of weed infestations pre- and during-construction.

RECC 1: I recommend that formal surveys of weeds be undertaken periodically to ensure they are detected and detected early enough to be treated. The design of these surveys will be based on the biology of known problematic weed species that are likely or potentially a problem in the region.

d) are appropriate goals being set?

Not applicable – goals have not been set for the monitoring program

e) Are the mitigation and management actions sufficiently targeted for the species?

Generally yes. See detailed comments below

f) Are the objectives, performance measures, corrective actions and thresholds for corrective actions in accordance with SMART principles?

Generally yes, but they need to be smarter, in that the performance indicators need to be more specific and measurable, and the corrective actions need to actually be a corrective action. Further details on this in detailed comments below.

g) do the management measure objectives, performance indicators, thresholds and corrective actions link sufficiently to allow effective implementation?

Generally yes, but thresholds need to be better defined. For example, Table 3-2 has a performance indicator of "poor uptake of nest boxes by native fauna" without defining "poor". In addition, there are no objectives or performance indicators, threshold or corrective actions described for 3.5, ground water dependent ecosystems. Other examples of this are highlighted in detailed comments below.

h) has the Management Plan provided sufficient evidence where the proposed mitigation has previously been effective?

No.

i) Does the Management Plan describe and discuss contingencies, should the proposed measures be ineffective?

Partially. Detailed comments below highlight some of the contingencies which require further explanation or refinement.

j) If we can't demonstrate mitigation proposed will be effective, can we demonstrate that corrective actions will be effective?

Most corrective actions have not been demonstrated within the EcMP that they are likely to be effective. Most corrective actions have just been listed without justification or demonstration that they are likely to be effective.

k) Where there is no known research / evidence of the effectiveness of the specific measure proposed – have relevant alternative contingencies been committed to?

Unknown – I cant determine from the detail within the EcMP if the proposed mitigation measures are supported by research or evidence that demonstrates their efectiveness

l) Have indirect impacts been addressed in the Management Plan, as relevant?

No

m) Are qualifications and experience of authors in subject field relevant?

Not applicable – details of the authors and their experience not given for this EcMP.

DETAILED COMMENTS

1.2: the EcMP is presented as an "adaptive monitoring program". I do not see anything within this document that convinces me the monitoring program is actually adaptive. Adaptive monitoring is a relatively new concept, and one that needs at least a few components: i) well-defined, tractable questions; ii) underpinned by rigorous statistical design; iii) be based on a conceptual model of how the ecosystem might work (or how the parts of the ecosystem that we are interested in – e.g. nest boxes, glider, threatened birds might work); and iv) driven by a need to know what the impacts of the disturbance (in this case Pac Hwy upgrade) on ecological matters. Additionally, and importantly, is the feedback loop, such that the answers from our monitoring feedback to the start of the process, either by "answering our questions" or by "refining our questions" or "posing new ones". The most important step in any monitoring program is the development of the right questions, which I don't think this plan has done very well. More on this later.

It is quite possible that what is actually meant is an adaptive management program, which is quite different. I would propose that the adaptive monitoring framework be adopted, and be embraced by Roads and Maritime to ensure that the mandated monitoring you must do, is actually useful and helpful for this Pac Hwy project, and indeed other road projects in NSW, Australia and elsewhere. In its current form, I don't think the monitoring will be able to maximise the amount of valuable and necessary info that is required.

This concern is also evident in the threatened gliders management plan (which I also reviewed), and although I have not seen the other plans, I suspect they also are equally deficient.

RECC 2: My advice would to convene some workshops with experts on the monitoring programs, to discuss and design monitoring programs to achieve the goal, as stated in 1.1: "to provide an adaptive monitoring program that assesses the effectiveness of the proposed mitigation measures and allows an adaptive management process". Most ecological monitoring is often a waste of time and money, and rarely achieves its goals, and needs to be designed with input from experts in the formulation of relevant questions, appropriate and rigorous scientific study design, an understanding of how the ecological system works and the ability and track record to complete monitoring through to the end.

Flow diagram: there are no feedback loops. If mgt and/or monitoring is meant to be adaptive, there needs to be explicit identification of the multiple feedback loops, the timing of those feedback loops and who/how those feedbacks are initiated and the likely triggers in performance that will trigger a response.

Biodiversity offset strategy: How does the offset strategy take into account the potential findings that the mitigation measures are ineffective and modifications to the mitigations will also likely remain ineffective? This specifically relates to issues that are discovered after 3 or 5 or XX years of monitoring as being unmitigatble impacts.

RECC 3: Corrective actions in the subsequent sections needs to contain a link back to updating the offset strategy if the initial mitigation is found to be ineffective.

2. Mitigation measures: I am not able to comment specifically on the actions for each of the five general mitigation measures, because these are detailed in other documents which I was not provided. Further, I am not an expert on weed management, ground-water dependent ecosystems or protection of riparian areas.

2.1.1: Identification and marking of nests, dreys and termitaria: the objective should be placed before the methods. Also, clarify how long the clearing contractors will 'avoid" the marked habitat feature.

Identification and marking of HBTs: clarify if the size classes refer to the entrance size of the hollows. If an ecologist is going to the trouble of identifying and measuring every hollow in every tree, will the ecologist also record evidence of use by different species? Such as collecting fur samples, scats for visual or genetic identification.

SUGGESTION 1: I strongly encourage Roads and Maritime to engage with a research organisation to value-add to the already expensive procedure of identifying and measuring every hollow in every HBT and record hollow use. This would probably be the single largest study of natural hollow use in Australia. But, to avoid mindless monitoring, this potential project needs some careful thought to identify ecologically meaningful questions to ensure that this does not become "mindless monitoring". This is a suggestion, not a formal recommendation, as it is not central to the task of upgrading the Pacific Highway.

Habitat features suitable for redistribution: Clarify "advanced stage of decay" – because we don't want only pristine logs with zero decay to be placed, as skinks and inverts will require logs in varying stages of decay and we cant expect them to sit around waiting for a non-decayed log to begin to decay and form hollows.

RECC 4: ensure that decayed and hollow logs are also redistributed.

2.1.2: stage 2. Clarify up to how long after 24 hrs the subsequent clearing will happen. It is quite possible that hollow-dependent species may return to hollows in standing trees amongst cleared areas if it takes too long between the two stages of clearing.

RECC 5: Will need more than 1 person be present during tree clearing just in case animals need to be taken into care immediately. Can't halt clearing while the lone ecologist drives off to the vet / wildlife carer. I would also suggest that ecologists on site be able to euthanize on site if conditions / animal health requires it.

2.4: there is insufficient information here to be able to assess the monitoring of the weed management mitigation measures, because it says it will appear in the weed management plan, which is yet to be developed.

2.5.: Groundwater dependent ecosystems. I am not qualified to review the methods to monitor GDEs, not the appropriateness or otherwise of mitigation measures. In addition, performance thresholds and corrective actions are not specified in the EcMP. There is insufficient information in this ½ page that summarises the potential impacts that would allow a monitoring program to be devised. For example, how much deviation from current water quality levels or water height levels is acceptable?

2.6: Connectivity mitigation measures: As for the threatened gliders monitoring plan, the effects of reduced connectivity and increased mortality are two different impacts and need to be addressed separately. In some cases the mitigation may be the same or the mitigation may be complementary, but in other cases they may be quite different. In some situations, mortality may be the problem, not reduced connectivity, or vice versa.

Objectives: The objectives of the fauna fencing and crossing structures need to be ecologically sensible and SMART. The broad definition of "maintain fauna movements" and "access to habitats" is ok as a broad, overarching goal, but this broad definition is not specific enough to begin to develop the monitoring plan. If 1 individual makes it across 1 bridge – is that success?

RECC 6: the objectives for the general connectivity mitigation measures be revised to be more specific and measurable.

2.6.1: effectiveness of fencing "absence of road mortality for the targeted threatened fauna in the immediate vicinity of the fencing and crossing structures": need to define what is meant by immediate. Also – what if mortality occurs in areas without mitigation? Surely this is a big concern and if targeted threatened species start becoming roadkill outside of the immediate vicinity then a response and retrofit would be required?

What is the basis of the "200 m" either side of a crossing structure for fencing? For some species this may be enough, while for others it is likely to be very insufficient. This distance needs to be based on what we know of the ecology of species in the area and should be accompanied with monitoring to evaluate if roadkill occurs at fence ends or further away.

RECC 7: ensure the distance that fencing extends past the crossing structures is based on the ecology / movements of the target species

RECC 8: Ensure that wildlife mortality surveys at the ends of each section of fence begin when the road is opened to traffic, as most mortality will occur immediately after opening and will likely occur at fence ends.

2.6.2 Fauna underpasses: how can road mortality be used as a definitive measure of the success of a fauna underpass? Road mortality is an important measure – but the perfectly built underpass may be ineffective because the fauna exclusion fence was compromised. And how much use of underpasses is enough? Is it 1 animal per week / per year / over the duration of monitoring? What if mortality rates 1 km down the road is so high that the population declines such that there are not enough animals to even go near the structure. If you only measure rate of use with cameras, then you will not be able to assess effectiveness because the structure may be effective, but the local population is now extinct, so you cant measure use with cameras…..

Why are you only measuring “presence and activity in vicinity” for some species of target fauna. Given my example above, the presence/abundance of most species adjacent to the highway/crossing structures should be assessed to measure performance using crossing structures.

RECC 9: revise the objectives of mitigation and ensure the monitoring measures a parameter that is as close to the goal as possible. For example, the goal of culverts is to facilitate some amount of animal movement across the road, which can not be evaluated by the number of roadkill!

2.6.3: Widened medians: Widened medians will likely impact other species too, including birds, bats, and underpasses across widened medians will necessarily be longer – and will the target species use longer underpasses?

RECC 10: The monitoring program should evaluate the effect of widened medians on other species, both in terms of mortality and increased crossing rates, because we don’t want the perverse situation where widened medians increase crossing by species X and increased mortality by species Y.

Again, the goals against which effectiveness of medians will be assessed are too vague and wont help design an ecologically sensible monitoring program.

2.6.5: Arboreal crossings: as per above

RECC 11: goals for mitigation are too vague and need to be re-worked significantly. I wont repeat what is in the threatened gliders plan in too much detail, but the specifics of the impacts need to be clearly articulated, the goals of mitigation can then be developed, from which a robust and useful monitoring program can be designed!

3.1.2: Add some specificity around the “general health” of fauna to be recorded during clearing.

3.1.3: first dot pot point: How can you tell if the assessment of number of hollows is accurate?

RECC 12: I recommend that a sub-sample of trees to be felled are surveyed for hollows before felling and then inspected once felled to determine the accuracy of the ground-counts of hollows to ensure the number of required nest boxes is accurately determined.

3.1.3. 2nd dot point: How to tell if the number of fauna injuries is “reduced” ie compared to what?

3.1.3. 3rd dot point: What about the survival of the released fauna?

Table 3-1. 2nd performance indicator: How many is “multiple”? I suggest that injury or mortality of any threatened species is sufficient to trigger as response.

3.2.2: Need to define what the effectiveness of nest boxes is

3.2.3: Need to add in some statement that the number and type of boxes to be deployed will be broadly representative of the number and size of hollows having been destroyed.

Clarify if “visual inspection” involves a camera on a pole or climbing and inspection, or either/both. Also clarify the frequency of inspection.

Ensure the number of individuals within a box is also recorded

It is unclear how the changes to the surrounding landscape will be measured and what types of changes will be monitored.

RECC 13: I recommend that the nest boxes be installed to answer a research question(s), as well as mitigate the impact of the loss of hollows. For example, the plan states that the aspect of boxes could be changed due to thermoregulatory issues. I suggest that some outstanding questions/hypotheses around box design and/or placement be identified, and that the deployment of boxes test the hypothesis/answer the question. It may be as simple as “do nest boxes on smooth barked trees have fewer of species X” or it could be much more elegant and scientifically robust. For almost no extra cost, this mitigation and monitoring program could answer some outstanding nest box questions. This has relevance for future deployment of nest boxes on Roads and Maritime and other projects where boxes are routinely deployed to ensure the maximum benefit of boxes can be obtained.

3.2.4. Performance indicators and corrective actions:

Performance indicators are too vague – what is “a range of fauna”, what is a low rate of use by exotic species, etc?

Table3-2. what is “poor uptake” defined as?

3.3.2: Define what is meant by “riparian vegetation which has developed sufficient cover”

3.3.3: Use of photo points. Photo points are good for before/after comparisons, but they are difficult to use in a rigorous scientific way because of slight variation in camera and lenses used, different heights and angles of the camera to ensure subsequent photos are comparable, changes in vegetation cover next to camera that obscures the area of interest. The plan should also specify what sort of measurements will be made from the photos and how the data will be stored, managed and analysed.

RECC 14: Don’t rely solely on photo points to assess the condition of the terrestrial habitat.

Table 3-3. 3rd performance indicator: Dieback is not noted on the previous page as one of the variables to be recorded at each site, so it will be difficult to detect a change in dieback levels. This table should also reflect all the aspects being measured as described in the text.

3.4.1/3.4.2: Is there a certain time of year when some weed species are not detectable? I suggest including a list of likely / notable weed species here to ensure the worst are actually looked for.

RECC 15: I suggest a review of the weed management plan based on the specific weed species that may be encountered with respect to their invasiveness, extent, risk of spread, sensitivity of adjacent landscapes etc.

3.4.1 X2: there is a repeat of 3.4.1 and 3.4.2.

Table3-4, 2nd mitigation measure: I don’t think inspections for weed infestations is a mitigation measure.

4.1, 2nd dot point: include number of individuals displaced, age/sex of individuals, and any steps taken to follow their survival.

4.1, 3rd dot point: clarify that the objective of the nest box plan is to provide a nest box of similar size for each hollow that was destroyed.

Appendix C: Clearly this is a cut and paste proforma from another job – as I don’t think you plan to stagwatch all hundreds of nest boxes…also add in that hair samples and scats etc from within boxes will be collected and identified to identify species occurrence.

Appendix C – Summary of fauna crossing structures for the concept plan

The information contained in the table below was sourced from the W2B EIS (Roads and Maritime 2012). This table would be reviewed and updated as required following the targeted surveys and during the detailed design.

Table C-1 pre-selected list of fauna crossing structures, identified for targeted monitoring program

Station		Crossing structure					
(km)	Project Section	Structure type	Length (m)	Cell no.	RCBC width (m)	RCBC height (m)	Bridge length x width (m)
1.5	1	ARBOREAL CROSSING	65	-	-	-	-
3.545	1	BRIDGE	-	-	-	-	90.5 x 10.5
4.685	1	BRIDGE	-	-	-	-	75.5 x 10.5
6.78	1	FAUNA CROSSING - RCBC	48	1	3	3	-
7.285	1	RCBC	65	1	3	3	-
8.51	1	FAUNA CROSSING - RCBC	70	1	3	3	-
11.785	1	FAUNA CROSSING - RCBC	71	1	3	3	-
12.75	1	ARBOREAL CROSSING	65	-	-	-	-
12.885	1	RCBC	43	1	3	3	-
13.315	1	RCBC	25	2	3	3	-
13.315	1	RCBC	35	2	3	3	-
13.835	1	RCBC	68	1	3	3	-
14.28	1	RCBC	68	2	3	3	-
17.02	2	ARBOREAL CROSSING	-	-	-	-	-
20.65	2	RCBC	48	4	3	2.4	-
20.718	2	BRIDGE	-	-	-	-	50.5 x 11
20.88	2	RCBC	43	1	3	2.4	-
21.29	2	RCBC	50	1	3	3	-
22.373	2	BRIDGE	-	-	-	-	60.5 x 11
23.125	2	RCBC	22		3	2.4	-
23.125	2	RCBC	22		3	2.4	-
24.575	2	RCBC	46	1	3	2.4	-
24.665	2	RCBC	53	1	3	1.8	-
25.95	2	RCBC	45		3	2.4	-
27.42	2	RCBC	104	1	3.6	2.4	-
35.23	3	RCBC	65	2	2.4	2.4	
36.398	3	BRIDGE					75.5 x 11 to 16.1
37.32	3	RCBC	69	2	2.4	2.4	-
39.69	3	RCBC	28	11	3	1.2	-

Station		Crossing structure					
(km)	Project Section	Structure type	Length (m)	Cell no.	RCBC width (m)	RCBC height (m)	Bridge length x width (m)
42.541	3	BRIDGE	-	-	-	-	135.5 x 10.5
43.121	3	BRIDGE	-	-	-	-	315.5 x 10.5
43.906	3	BRIDGE					180.5 x 10.5
46.074	3	BRIDGE	-	-	-	-	100.6 x 10.5 NB and 11.9 SB
46.344	3	BRIDGE	-	-	-	-	100.6 x 10.5 NB and 11.9 SB.
46.666	3	BRIDGE	-	-	-	-	75.5 x 10.5 NB and 11.9 SB
47.662	3	BRIDGE	-	-	-	-	75.5 x 10.5
48.1	3	FAUNA CROSSING - ROPE	65	-	-	-	-
49.265	3	BRIDGE	-	-	-	-	120.0 x 10.5 NB and 11.6 SB
50.299	3	BRIDGE	-	-	-	-	45.0 x 10.5
50.5	3	FAUNA CROSSING - ROPE	65	-	-	-	-
51.43	3	RCBC	62	1	2.4	3.6	
52.438	3	BRIDGE	-	-	-	-	75.0 x 10.5
52.605	3	RCBC	60	6	3.6	2.1	-
53.71	3	RCBC	63	1	3.6	3.6	-
53.85	3	ARBOREAL CROSSING	65	-	-	-	-
54.706	3	BRIDGE	-	-	-	-	90 x 10.5
57.027	3	BRIDGE	-	-	-	-	88.0 x 10.5
58.639	3	BRIDGE	-	-	-	-	75.5 x 10.5
59.285	3	ARCH	60	1	-	5.5	-
60.815	3	ARCH	60	1	-	5.5	-
64.505	3	ARCH	60	1	-	5.5	-
66.19	3	ARCH	60	1	-	4	-
70.455	4	BRIDGE	-	-	-	-	18 x 11m, 12.5m, 8m
74.755	4	BRIDGE	-	-	-	-	448.6 x 10.5
75.88	4	ARBOREAL CROSSING	65	-	-	-	-
75.92	4	ARBOREAL CROSSING		-	-	-	-
99.73	6	FAUNA CROSSING - RCBC	45	1	3	2.4	-
101.1	6	FAUNA CROSSING - RCBC	38	1	3	2.4	-
101.541	6	BRIDGE	-	-	-	-	132.0 x 10.5
111.55	7	ARBOREAL CROSSING	-	-	-	-	-
113.92	7	BRIDGE	-	-	-	-	15 x 11
115.272	7	BRIDGE	-	-	-	-	88.0 x 10.5
116.4	7	ARBOREAL	65	-	-	-	65.0 x 0.4

Station		Crossing structure					
(km)	Project Section	Structure type	Length (m)	Cell no.	RCBC width (m)	RCBC height (m)	Bridge length x width (m)
		CROSSING					
118.828	7	LAND BRIDGE	-	-	-	-	72.6 x 12.2
131.066	8	BRIDGE	-	-	-	-	75.5 x10.5
134.6	8	RCBC	41	1	1.8	1.2	-
136.666	8	BRIDGE					18.5 x 11.0
138.43	9	FAUNA CROSSING - RCBC	85	1	1.2	1.2	-
138.796	9	LAND BRIDGE	-	-	-	-	90.4 x 12.2
139.44	9	FAUNA CROSSING - RCBC	85	1	1.2	1.2	-
139.918	9	LAND BRIDGE	-	-	-	-	80.3 x 12.2
140.62	9	ARBOREAL CROSSING	150	-	-	-	-
142.24	9	BRIDGE	-	-	-	-	15 x 11.0 NB x 11.3 SB
144.29	9	RCBC	45	1	1.8	3	-
144.77	9	RCBC	46	2	3.3	3	-
145.106	10	BRIDGE	-	-	-	-	75.5 x 10.5 NB and 75.5 x 10.5-12.5 SB
145.287	10	BRIDGE	-	-	-	-	789.3 x 11.5 x 2 (Stitched)
146.36	10	RCBC	44	2	3	3	-
146.6	10	RCBC	52	1	3	3	-
147.6	10	LAND BRIDGE	-	-	-	-	-
148.6	10	RCBC	-	-	3	3	
151.933	10	BRIDGE	-	-	-	-	18.0 x 11.0
156.1	10	LAND BRIDGE	-	-	-	-	62.0 x 12.2
156.305	10	RCBC	52	4	3.3	1.2	-

Appendix D – Example nest box proforma

Observers name:					
Date:				Time:	
Weather conditions:					
Box type	**Box no.**	**Occupied? (Y/N)**	**Internal/external observations (condition, presence of pest species etc)**	**Species observed or assumed based on evidence**	**Comments/actions required (eg maintenance)**