NSW Roads and Maritime Services

WOOLGOOLGA TO BALLINA | PACIFIC HIGHWAY UPGRADE

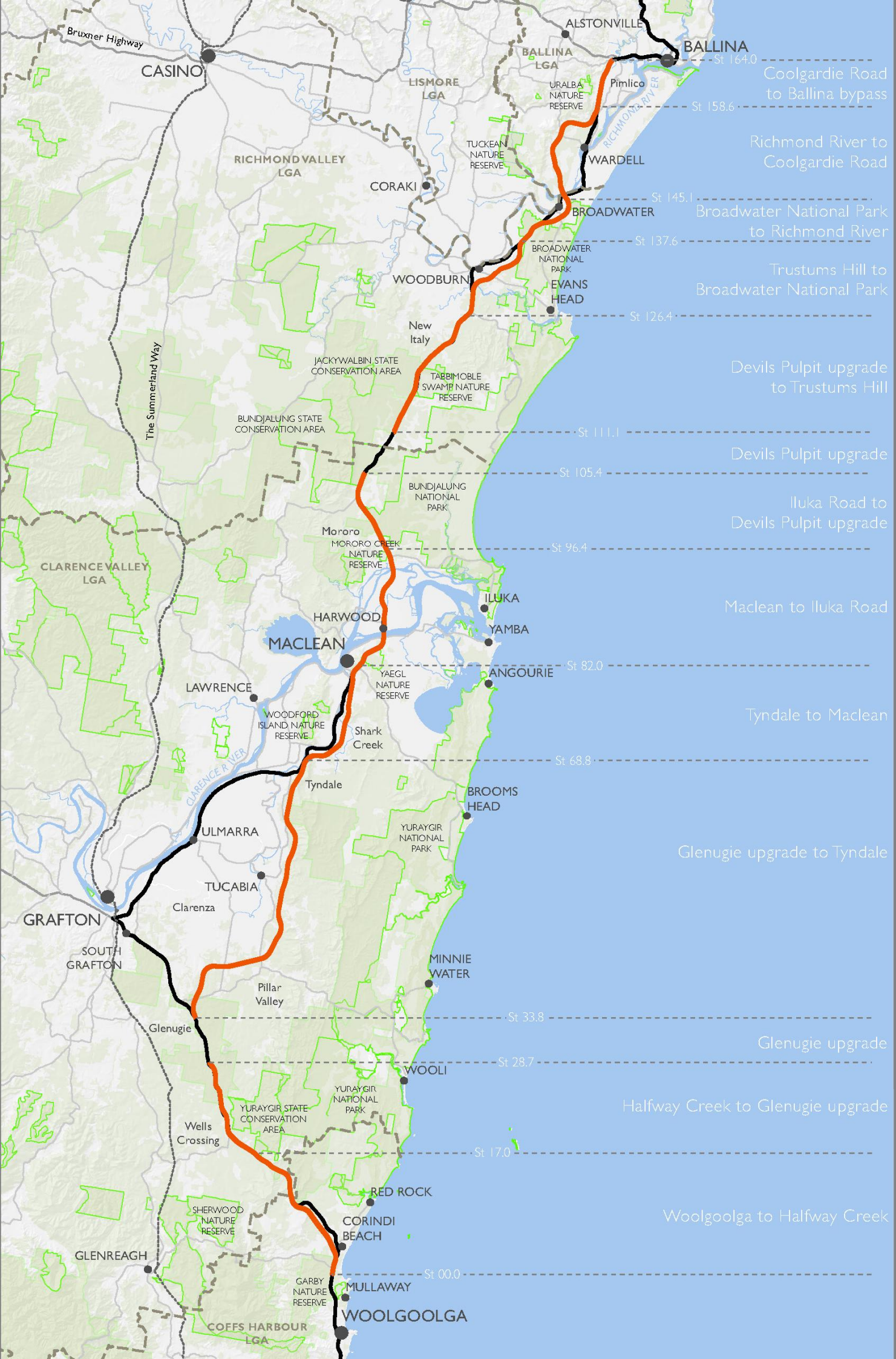
COASTAL EMU MANAGEMENT PLAN

Version 3.1

December 2015

Prepared by: Jacobs

Document Number: W2b-RMS-0-EF-PLN-00036
Revision: 3.1


Bruxner Highway
CASINO
ALSTONVILLE
BALLINA
BALLINA LGA
St 164.0
Coolgardie Road to Ballina bypass
11
LISMORE LGA
URALBA NATURE RESERVE
Pimlico
RICHMOND RIVER
St 158.6
Richmond River to Coolgardie Road
10
RICHMOND VALLEY LGA
TUCKEAN NATURE RESERVE
WARDELL
CORAKI
St 145.1
BROADWATER
Broadwater National Park to Richmond River
9
St 137.6
BROADWATER NATIONAL PARK
Trustums Hill to Broadwater National Park
8
WOODBURN
EVANS HEAD
St 126.4
New Italy
JACKYWALBIN STATE CONSERVATION AREA
TABBIMOBLE SWAMP NATURE RESERVE
Devils Pulpit upgrade to Trustums Hill
7
The Summerland Way
BUNDJALUNG STATE CONSERVATION AREA
St 111.1
Devils Pulpit upgrade
St 105.4
BUNDJALUNG NATIONAL PARK
Iluka Road to Devils Pulpit upgrade
6
Mororo
MORORO CREEK NATURE RESERVE
St 96.4
CLARENCE VALLEY LGA
ILUKA
Maclean to Iluka Road
5
HARWOOD
YAMBA
MACLEAN
St 82.0
ANGOURIE
YAEGL NATURE RESERVE
LAWRENCE
WOODFORD ISLAND NATURE RESERVE
Shark Creek
Tyndale to Maclean
4
St 68.8
CLARENCE RIVER
Tyndale
BROOMS HEAD
YURAYGIR NATIONAL PARK
ULMARRA
Glenugie upgrade to Tyndale
3
TUCABIA
Clarenza
GRAFTON
SOUTH GRAFTON
MINNIE WATER
Pillar Valley
St 33.8
Glenugie
Glenugie upgrade
St 28.7
WOOLI
YURAYGIR NATIONAL PARK
YURAYGIR STATE CONSERVATION AREA
Halfway Creek to Glenugie upgrade
2
Wells Crossing
St 17.0
RED ROCK
SHERWOOD NATURE RESERVE
CORINDI BEACH
Woolgoolga to Halfway Creek
1
GLENREAGH
St 00.0
GARBY NATURE RESERVE
MULLAWAY
WOOLGOOLGA
COFFS HARBOUR LGA

Contents

Glossary and abbreviations

Term	Definition
BACI	Before-After-Control-Impact
CEMP	Construction Environmental Management Plan
CoA	Commonwealth Condition of Approval
Construction footprint	The direct area of the design alignment
CRA	Comprehensive Regional Assessment
DECCW	NSW Department of Environment, Climate Change and Water (now known as EPA)
Direct impact	An impact that causes direct harm within the project boundary (i.e. clearing of vegetation)
DoE	Commonwealth Department of the Environment previously known as the Department of Sustainability, Environment, Water, Population and Communities
DP&E	NSW Department of Planning and Environment (formally known as Department of Planning and Infrastructure)
DPI	NSW Department of Primary Industries
DSEWPaC	The former Commonwealth Department of Sustainability, Environment, Water, Population and Community. Now DoE.
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPA	NSW Environment Protection Authority
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
EIS	Environmental Impact Statement (Biodiversity Assessment Working Paper)
FFMP	Flora and Fauna Management Plan
Indirect impact	An impact that causes harm outside of the project boundary as a result of a direct impact (i.e. edge effects, erosion etc.)
MCoA	Minister's Condition of Approval
NSW	New South Wales
Performance threshold	This is a prescribed outcome that should it be reached, an assessment as to why the objectives are not being met will be undertaken and then appropriate corrective actions implemented.
The Project (aka Project boundary)	Refers to all the proposed works in all eleven sections which includes the construction footprint with a 10 metre construction buffer, ancillary and compound sites and design changes.
Roads and Maritime	NSW Roads and Maritime Services
RTA	Roads and Traffic Authority
SPIR	Submissions / Preferred Infrastructure Report
SSI	State Significant Infrastructure
TSC Act	*Threatened Species Conservation Act 1995*
W2B	Woolgoolga to Ballina Pacific Highway Upgrade

1. Introduction

1.1 Project overview

NSW Roads and Maritime Services (Roads and Maritime) have received approval for the upgrade of the Pacific Highway from Woolgoolga to Ballina (W2B) on the NSW North Coast (the project). An Environmental Impact Statement (EIS) was prepared which assessed the impacts of the project on the endangered coastal emu population (NSW *Threatened Species Conservation Act*, 1995) relevant to Sections 3 and 4 of the project. Approvals were granted under Part 5.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) subject to Ministers Conditions of Approval (MCoA). A key requirement of the EIS and MCoA was the development of a Coastal Emu Management Plan.

The project will upgrade around 155 kilometres of the Pacific Highway and on completion will complete the four-lane divided road program between Hexham and the NSW / Queensland border. For the purposes of the EIS the project has been divided into 11 sections as illustrated in the figure above.

Key features of the upgrade include:

- Duplication of 155 kilometres of the Pacific Highway to a motorway standard (Class M) or arterial road (Class A), with two lanes in each direction and room to add a third lane if required in the future
- Split-level (grade-separated) interchanges at Range Road, Glenugie, Tyndale, Maclean, Yamba / Harwood, Woombah (Iluka Road), Woodburn, Broadwater and Wardell
- Bypasses of South Grafton, Ulmarra, Woodburn, Broadwater and Wardell
- About 40 bridges over rivers, creeks and floodplains, including major bridges crossing the Clarence and Richmond rivers
- Bridges over and under the highway to maintain access to local roads that cross the highway
- Access roads to maintain connections to existing local roads and properties
- Structures designed to encourage animals over and under the upgraded highway where it crosses key animal habitat or wildlife corridors
- Rest areas located at about 50 kilometre intervals at Pine Brush (Tyndale), north of Mororo Road and north of the Richmond River
- A heavy vehicle checking station near Halfway Creek and north of the Richmond River.

Construction and delivery of the project will be undertaken in a number of separate stages. These stages are detailed in the Staging Report prepared to satisfy NSW Minister's Condition of Approval (MCoA) A7. Stage 1 is confirmed and encompasses the following sections of the project:

- Section 1 – Woolgoolga to Halfway Creek
- Section 2 – Halfway Creek to Glenugie
- Soft Soil preload construction undertaken in four waves of construction packaging to suit:
  a) Wave 1- Soft soils works between Koala Drive and Chatsworth Road (Harwood) with material extraction from Tyndale and Green Hill cutting
  b) Wave 2- Soft soils works at Whytes Road to Pimlico
  c) Wave 3- Soft soils works between Tyndale and Maclean
  d) Wave 4- Tuckombil Canal, Woodburn.

The project would be jointly funded by the NSW and Australian governments. Both governments have a shared commitment to finish upgrading the highway to a four-lane divided road as soon as possible. Construction timing for Sections 1 and 2 is estimated for commencement in May 2015 and completion of the entire project is planned for the end of 2020. The project does not include the Pacific Highway upgrades at Glenugie and Devils Pulpit, which are located between Woolgoolga and Ballina. These are separate projects, with Glenugie and Devils Pulpit now complete. Altogether, these three projects would upgrade 164 kilometres of the Pacific Highway. The project does include a partial upgrade of the existing dual carriageways at Halfway Creek.

For a more detailed project description (as approved in late 2014) refer to the Roads and Maritime Services Woolgoolga to Ballina Pacific Highway Upgrade Submissions/Preferred Infrastructure Report (SPIR) dated November 2013 and the W2B Staging Plan.

1.2 Objectives of the Plan

This plan focuses on the potential impacts of the proposed upgrade on the endangered coastal emu (*Dromaius novaehollandiae*) population (TSC Act) occupying portions of Section 3 and 4 in the project area. It aims to outline proposed mitigation and monitoring actions to be undertaken to address the long-term survival of this species in the relevant areas of the W2B upgrade.

The objectives of the management plan are to provide:

- A summary of the locations where the endangered coastal emu population would be likely to be impacted by the project and hence where mitigation is proposed.
- Provide details of proposed mitigation measures to be implemented in the pre-construction, construction and operational stages of the project to minimise and manage impacts to the coastal emu population in Sections 3 and 4 of the proposed upgrade.
- Details of a monitoring program to be implemented pre-construction and during construction and operation of the project to assess changes to distribution and habitat usage and to monitor the effectiveness of the mitigation measures provided for emus.
- An adaptive management framework based on specific goals for mitigation, appropriate monitoring of the performance of these measures against the goals and the identification and implementation of corrective actions to improve mitigation where required. Where shortfalls from the mitigation and adaptive management are identified appropriate provisional and offset measures would be implemented.

The plan has been developed to meet the requirements of the NSW Government Approval MCoA D8 and B11. The requirements of this approval and where it is addressed in this report are detailed in **Table 1-1**.

Table 1-1 Project approval requirements and where addressed.

NSW Approval requirement		Where addressed
MCoA D8	The Applicant shall prepare and implement Threatened Species Management Plans to detail how impacts of the project (referred to as State Significant Infrastructure (SSI)) will be minimised and managed specifically for each species identified as significantly impacted in the documents listed in condition A2 or in accordance with condition D1. The Plans shall be developed from the draft Threatened Species Management Plans included in the documents listed in condition A2(c) (subject to condition D9), in consultation with EPA, DPI (Fisheries) and DoE, and to the satisfaction of the Secretary, and shall include but not necessarily be limited to:	Expert and agency recommendations on the plan are summarised and details as to how they have been addressed are provided in Table 1.2.
	(a) demonstration that adequate surveys have been undertaken to assess the impacts of the SSI with reference to the Mitigation Framework developed under condition D1, including baseline data collected from surveys, undertaken by a suitably qualified and experienced ecologist on threatened species and ecological communities within all habitat areas to be cleared of vegetation for the SSI, that are likely to contain these species and that are likely to be adversely impacted by the SSI (as determined by a suitably qualified expert). The data shall address the densities, distribution, habitat use and movement patterns of these species;	Section 7.2
	(b) identification of potential impacts on each species;	Section 3.1
	(c) details of and demonstrated effectiveness of the proposed avoidance and mitigation and management measures to be implemented for each threatened species including measures to at least maintain habitat values of habitat areas compared to baseline data and maintain connectivity for the relevant species;	Section 3.4
	(d) an adaptive monitoring program to assess the use of the mitigation measures identified in conditions B10 and D2. The monitoring program shall nominate appropriate and justified monitoring periods, performance parameters and criteria against which effectiveness of the mitigation measures will be measured and include operational road kill and fauna crossing surveys to assess the use of fauna crossings and exclusion fencing implemented as part of the SSI;	Section 7.1 to 7.6
	(e) monitoring methodology for threatened flora and fauna adjacent to the SSI footprint,	Section 7.2
	(f) goals and performance indicators to measure the success of mitigation measures, which shall be specific, measurable, achievable, realistic and timely (SMART), and be compared against baseline data;	Section 4.4, 5.4, 6.4, and 7.3
	(g) methodology for the ongoing monitoring of road kill, the species densities, distribution, habitat use and movement patterns, and the use of fauna crossings during construction and operation of the SSI, including the proposed timing, and duration of that monitoring;	Section 7.0
	(h) provision for the assessment of monitoring data to identify changes to habitat usage and whether this can be attributed to the SSI; (i) details of contingency measures that would be implemented in the event of changes to habitat usage patterns, entities, distribution, and movement patterns attributable to the construction or operation of the SSI, based on adequate baseline data;	Section 7.2
	(j) mechanisms for the monitoring, review and amendment of these plans;	Section 1.3 and 7.6
	(k) provision for ongoing monitoring during operation of the SSI (for operation/ongoing impacts) until such time as the use and effectiveness of mitigation measures can be demonstrated to have been achieved over a minimum of three successive monitoring periods, unless otherwise agreed by the Secretary in consultation with the EPA, DPI (Fisheries) and DP&E; and	Chapter 7
	(l) provision for annual reporting of monitoring results to the Secretary and the EPA, DPI (Fisheries) and DP&E, or as otherwise agreed by those agencies.	Section 7.6
MCoA B11	As part of the detailed design the applicant shall further investigate the design refinements for fauna crossings and associated exclusionary measures, between station 41.500 and station 80.000 to improve connectivity for the Coastal Emu. This should be done following baseline surveys for relevant sections.	Section 5.3.7 and Appendix G describes the results of a detailed design workshop to refine emu crossing structures

1.3 Management structure and plan updates

1.3.1 Management structure

This plan is intended to provide a management framework for the coastal emu population occupying the portions of the proposed upgrade (i.e. Sections 3 and 4). The plan provides up-to-date information using the results of targeted surveys outlining the distribution and habitat use by emus within the project area, the likely impacts to emus and proposed mitigation measures to be put in place.

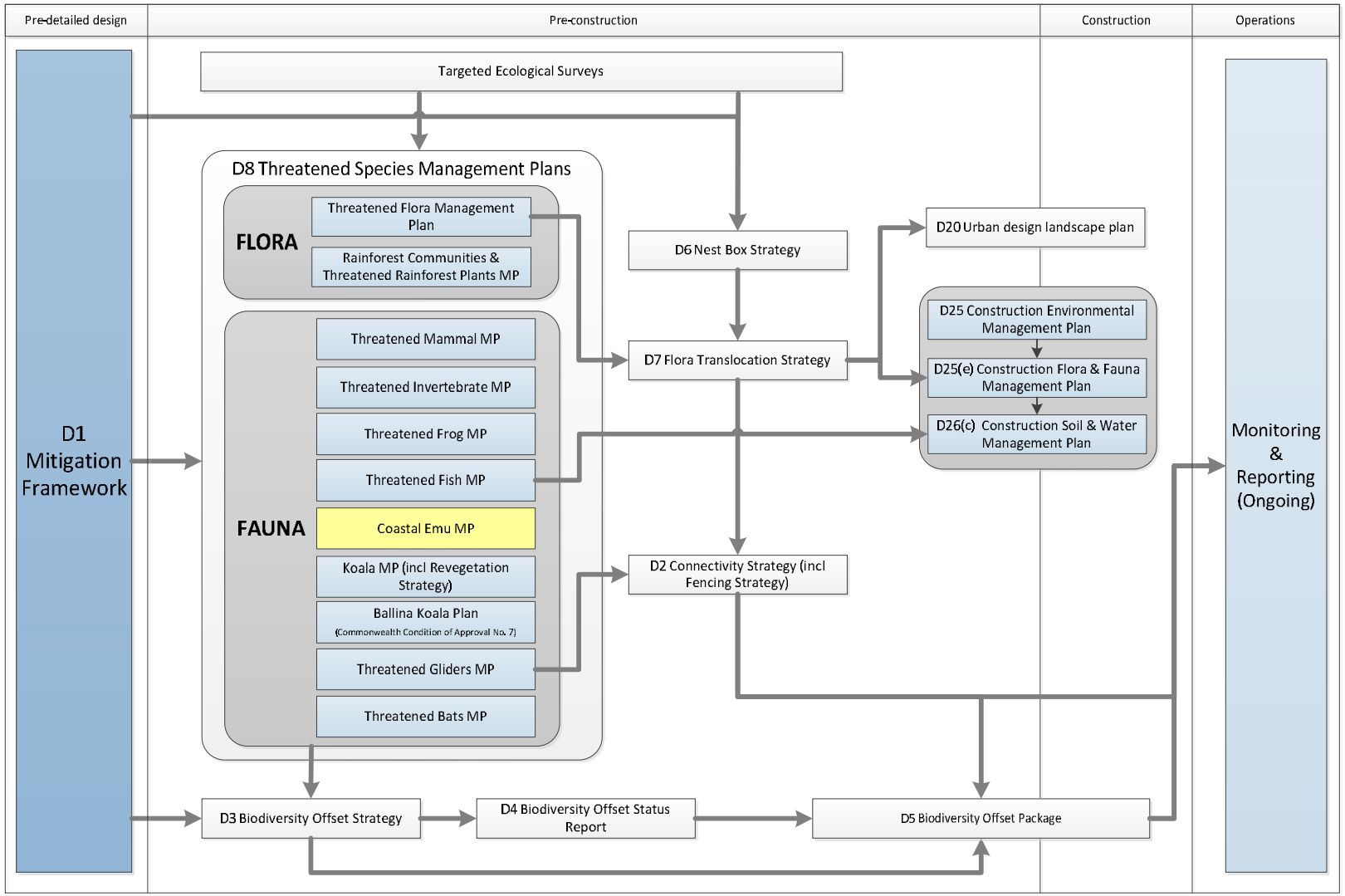
The plan informs future monitoring and reporting and identifies the locations for conducting monitoring of the emu population and the methods, variables and timing of the monitoring program.

The plan operates in conjunction with the Construction Environmental Management Plan (CEMP), project specific flora and fauna management plan (FFMP), Connectivity Strategy and aspects associated with updates and delivery incorporated into the Biodiversity Mitigation Framework. An overview of how this Coastal Emu Management Plan relates to other relevant project documentation is provided in Figure 1-1.

General responsibilities for environmental management will be outlined in the CEMP and FFMP. Responsibilities for implementation of this plan have been described throughout and summarised in **Chapter 8**. Following approval of the plan, the RMS, and/or construction contractor(s) and the contractors ecologists engaged for project sections 3 and 4 would be responsible to oversee implementation of the plan.

Roads and Maritime will update and finalise this plan in consultation with the NSW Department of Planning and Environment (DP&E) and NSW Environment Protection Authority (EPA).

Figure 1-1 Project documentation overview



1.3.2 Plan updates

The Coastal Emu Management Plan is intended to be a dynamic document subject to continual updates during the different stages of the project as required and in light of further information.

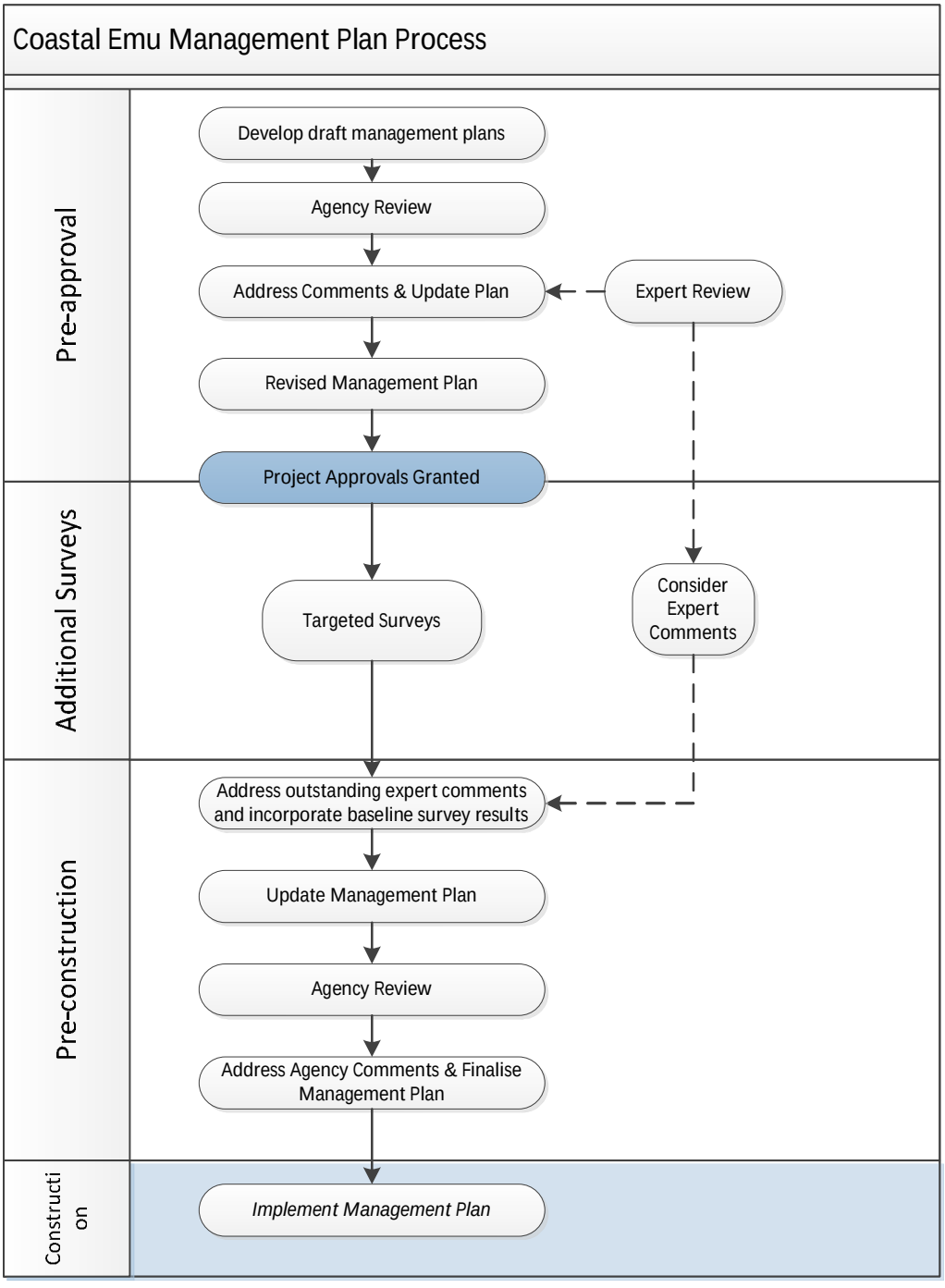
Roads and Maritime will update this plan in stages as detailed in the Biodiversity Mitigation Framework (MCoA D1) and the Staging Plan (MCoA A7). This is to reflect the staged nature of construction of the project and also the staggered nature of completing targeted baseline surveys. The following updates have been made to date.

- The first update (Version 1 of the Plan) incorporated comments from an independent expert review and agency review. This was completed in November 2013 and was included with the submission of the SPIR documentation.
- The second update (Version 2 of the plan) was undertaken to address the approval conditions received, further agency comments provided, subject matter expert comments, and to incorporate results of targeted emu surveys completed in Section 3 and 4 during the pre-construction phase. A summary of the independent expert and agency review comments and how they have been addressed in Version 2 of the plan is detailed in **Appendix A.**
- The third update (Version 3.1) incorporates inputs from a workshop with the delivery partner (Pacific Complete), RMS, Jacobs and the EPA to address a targeted management approach tailored for the Wave 3 early works proposed between Tyndale and Maclean and is reported in Chapter 5. The management actions described are applicable to all works in Section 4. The update also includes a revised construction management approach to allow continued connectivity for emus during construction in Section 3. A second workshop was held to address detailed design of emu connectivity structures in Section 3 by considering the results of the pre-construction emu monitoring work and inputs from the detailed design team. The final update of the plan incorporated the results of design refinements for a number of bridges in Section 3 and followed a design meeting held on 4 December 2015.

A summary of the process for updating the plan is illustrated in Figure 1-2. Specific details for review and amendment of the plan are described in Section 7.6.2,

It is noted that MCoA D8 requires the plan to be submitted and approved by the Secretary prior to commencement of construction of the relevant stages of the action, and implemented prior to commencement of construction of the relevant stages, unless otherwise agreed by the Secretary.

Figure 1-2 Process to develop and update the Coastal Emu Management Plan



1.4 Plan author

This plan has been prepared based on the outcomes of emu surveys, interviews with landowners and the outcomes of a series of workshops held with the Environment Protection Authority (EPA), specifically personnel involved with monitoring the endangered coastal emu population over the last 10+ years and wildlife carers experienced in handling wild emus. Other specialists consulted during the preparation of the plan included researchers with experience in monitoring cassowaries in northern Queensland and Senior Veterinarian and wildlife handlers from Taronga Zoo.

The plan was prepared by Chris Thomson who is an Associate Ecologist at Jacobs with a Bachelor of Applied Science and Graduate Certificate in Natural Resources and eighteen years professional experience in the fields of ecology and natural resource management. He is experienced in the design and implementation of ecological monitoring programs, fauna surveys, threatened fauna management plans and ecological impact assessment. Chris has considerable experience assisting developing outcomes to meet project specific Conditions of Approval in relation to managing and monitoring impacts on biodiversity for large scale infrastructure projects. This includes the preparation and implementation of species specific management plans and monitoring programs. In particular Chris has comprehensive knowledge of fauna monitoring programs, having coordinated numerous targeted fauna surveys and monitoring programs throughout NSW.

Chris has been conducting surveys for the Yuraygir coastal emu population since 2006 associated with the Pacific Highway upgrade and during this time has engaged in extensive consultation with experts, local ecologists, rangers, wildlife carers and landowners to gather knowledge of the coastal emu population. Chris has been engaged to conduct baseline surveys during the pre-construction phase of the Coastal Emu monitoring program. Research has been conducted in collaboration with a range of scientists and experienced personnel and has included investigations into factors affecting emu-vehicle collisions in coastal areas and pilot studies investigating the use of anaesthesia procedures on emus, a trial on the use of GPS tracking technology for coastal emus, methods for collecting DNA samples from emus, aerial surveys using helicopter and monitoring using active search methods and surveillance cameras.

1.5 Expert and agency review

An independent expert review of the plan was undertaken in August 2013 by Professor Stephen Davies. Stephen Davies has been a professional scientist since 1964 and has specialising in Ornithology. As well as an outstanding career as a CSIRO research scientist from 1964-84, Stephen has extensive experience as an academic, lecturing and developing courses in, for example, wildlife management, vertebrate biology, and land care revegetation. As president of Birds Australia, he produced the original Atlas of Australian Birds, a first for Australian ornithology.

Stephen has been the author on about 150 scientific publications, reports and books on Ornithology, this includes the primary author or contributor to four books about emus and seven peer reviewed scientific journal articles on emu biology and ecology.

Curriculum vitae which contains a list of published work on emu's for Stephen Davies is provided in **Appendix B**, and a copy of his review is provided as **Appendix C**.

Roads and Maritime have consulted with NSW Environment Protection Authority (EPA) during the development of this plan. The agency was provided a copy of the Draft Report in November 2014. Feedback received and Roads and Maritime response to issues raised have been included in Appendix A of the report.

A summary of the consultation undertaken in finalising the Coastal Emu Management Plan is outlined in **Appendix A**. The table also identifies how each of the recommendations has been addressed.

2. Coastal Emu population

2.1 Background

The *Coastal Emu population in the NSW North Coast Bioregion and Port Stephens Local Government Area* is listed as an endangered population under the NSW *Threatened Species Conservation Act,* 1995.

The coastal emu population consists of three sub-populations, all in northern NSW, the largest located south of the Clarence River and two smaller populations north of the river. Since the listing on the TSC Act in 2002, information on the size and distribution of the sub-populations as well as the clustering of records has expanded. This has largely occurred due to the efforts of a small number of rangers from the National Parks and Wildlife Service (NPWS) coordinating annual community-based surveys. This information has been used to augment the established scientific data on habitat preferences, diet and current population threats presented in this section. Details on breeding locations are not known, only some movements during breeding and non-breeding periods.

Table 2-1 describes the current status of the three documented sub-populations and their proximity to the project.

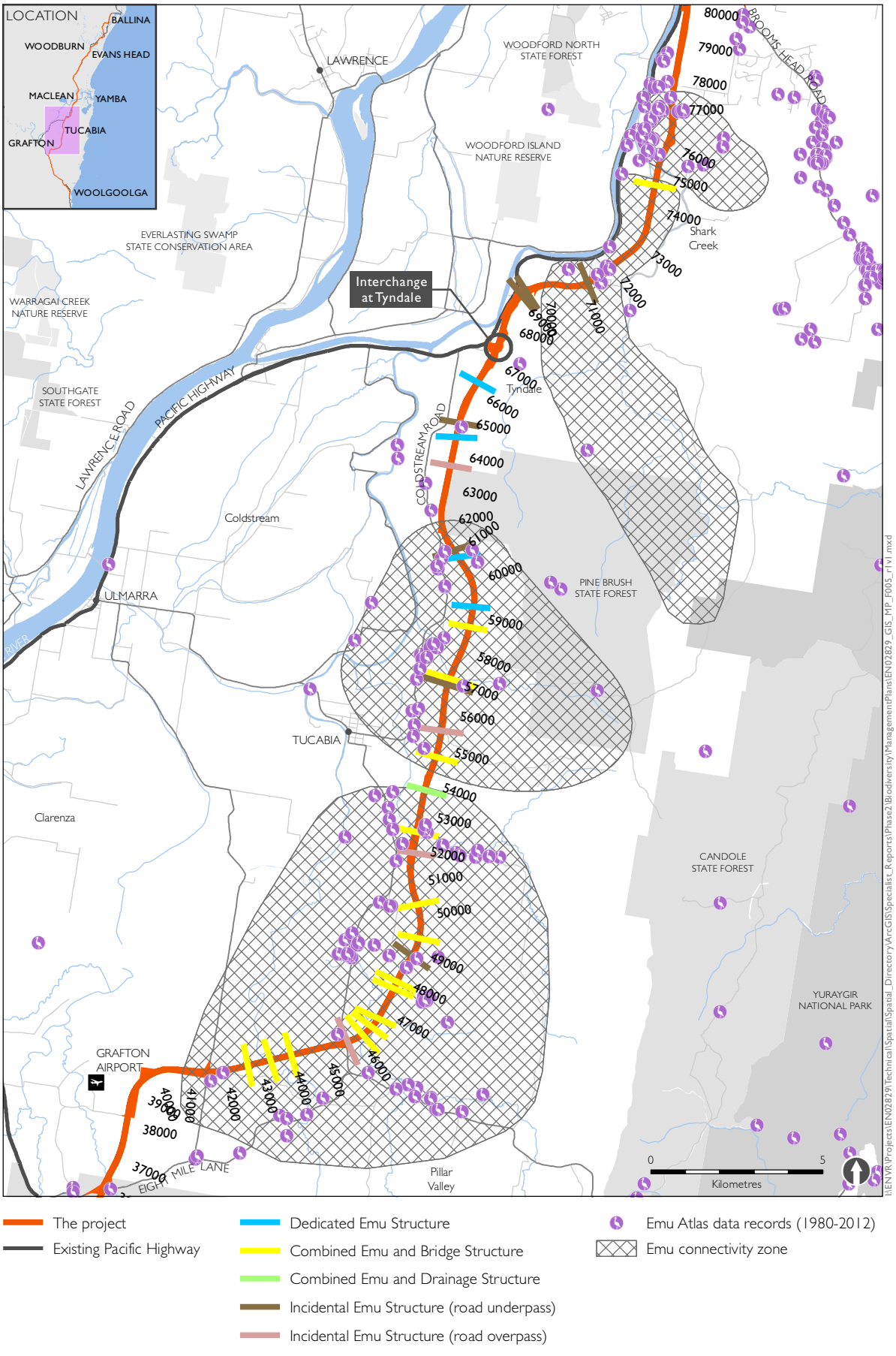
Table 2-1. Details of three described sub-populations in the mid-north coast (source NPWS annual survey results 2002-2014)

Sub-population and range	Predicted sub-population size	Intersection with project corridor
Yuraygir sub-population: South of the Clarence River to Red Rock including Yuraygir National Park in the east and surrounding landscapes such as Clarence River floodplain to the west, north to Gulmarrad-Maclean, and south to Pillar valley and Red Rock through low hills and floodplain.	Largest group estimated at between 50-120 individuals fluctuating from counts over the last 12 years.	The range and habitat of this sub-population intersects with proposed Sections 3 and 4 of the upgrade.
Bundjalung sub population: North of the Clarence River, largely over Bundjalung National Park from Iluka to Evans Head.	Smallest population, only 20 birds estimated in 2006. No emus counted in 2010-2014 censuses, current population unknown and considered possibly extinct.	Not directly affected.
Bungawalbin sub-population: North of the Clarence River and south of the Richmond River. Ranges over Bungawalbin Nature Reserve and National Park, main camp and surrounds.	Estimated at < 60 birds.	Not directly affected, existing highway may be a barrier to connectivity with Bundjalung sub-population.

This plan focuses on the larger Yuraygir sub-population which occupies the coastal strip of Yuraygir National Park to the east of the project, as well as, surrounding contiguous areas in the Sandon and Brooms Head area in the north to Minnie Waters and Red Rock in the south and Tucabia, Tyndale and Shark Creek to Pillar Valley and the lower Clarence River wetlands in the west. The range and habitat of this sub-population intersects with proposed Sections 3 and 4 of the upgrade.

Figure 2-1 below shows the location of the Emu records and proposed habitat connectivity structures in relation to the project.

Figure 2-1 Emu records and connectivity structures



2.2 Existing knowledge

2.2.1 Social groups and range

Knowledge on group movements and their range for the Yuraygir sub-population were based on interpretation and discussion of the annual emu census results from NPWS land managers (Gina Hart NPWS and Matt Clarke formerly NPWS *pers comm.*) and interviews with long-standing property owners in the Pillar Valley, Tucabia and Tyndale area. The anecdotal data suggests that the population is divided by a number of social groups that show fidelity to particular areas and habitat that support important pre and post-breeding life-cycle events. The degree of relatedness and interaction between the groups is not known. The assumptions regarding site fidelity by apparent sub-groups discussed below has not been rigorously investigated.

The majority of the sub-population is centred on Yuraygir National Park including Station Creek to Red Rock, Wooli, Diggers Camp, Minnie Waters, Sandon, Sandon River, Brooms Head, Wooloweyah, James Creek and Taloumbi. These groups range over a considerable distance from the project corridor to the east, north and south with the exception of an additional two groups, which have been predicted to be impacted by the project between the Glenugie Upgrade and Maclean (Sections 3 and 4 of the project). The latter groups include:

1. One ranging within the area south of Tucabia from the Coldstream River wetlands in the west to Pillar Valley and Yuraygir National Park in the east (Section 3 of the project).
2. A second group that is largely found on the agricultural land and forests between Pine Brush and Candole State Forest in the south, Tyndale Swamp and north to Shark Creek and Green Hill and the cane farms around Shark Creek including Byrons Lane and McIntyres Lane at Tyndale (includes portions of Section 3 and 4 of the project).

These two groups frequently access floodplain wetlands and creeks such as Chaffin Swamp and Pillar Valley Creek. They utilise modified agricultural habitats during pre- and post-breeding activities in spring and summer with the cane fields frequently occupied by adult males raising young. There is limited evidence suggesting that nesting occurs above the floodplain further east of the project corridor, for example Chaffin Hill and may extend to the eastern foothills of the Sommervale Range. There has been no reported nesting within the project corridor, however potential habitat occurs and nests have been found in cane fields in other parts of their range (Kerry Cranney pers.comm).

Congregations of emus reportedly occur in mid-autumn to winter prior to nesting and at this time social flocks of breeding birds are infrequently observed in floodplain and agricultural paddocks (Plate 1). The occurrence of such groupings indicates that the birds may travel reasonable distances, as most emu sightings at other times are usually of solitary adults, or of birds in small family groups (Plate 2).

Plate 1. Congregation of breeding Emus in grazing land (pre-nesting)

Plate 2. Small Emu family grazing in sugar cane paddocks in Shar Creek (post-breeding)

2.2.2 Breeding

Anecdotal information on breeding activities suggests that breeding occurs in four broad areas:

1) Station Creek to Red Rock River (south).
2) Wooli - Diggers Camp - Minnie Water - Sandon River (central).
3) Brooms Head - Sandon River - Candole State Forest - Wallaby Lane (north).
4) Pillar Valley around Chaffin Hill and Whites Hill in the western edge of their range (west).

The first three of these areas are in the eastern part of their range within 10 kilometres of the coast and several kilometres from the project. Breeding is evidenced by the presence of young chicks in winter and anecdotal evidence of nest sites in these locations. The full extent of areas used for breeding is not known, as breeding localities have only been identified based on family groups with striped chicks in July to September. These observations may be also skewed as they correlate to coastal villages, public lands and roads where there are more opportunities for viewing emus and their behaviour.

Based on anecdotal evidence, there are no confirmed breeding sites west of the project in the low-lying flood prone areas, and the limited observations of nest sites being reported to the east of the project in higher elevated lands. In the absence of comprehensive surveys it should be assumed that nesting habitat would also be isolated. Emu nests have been located in cane fields in other parts of their range near Brooms Head and there would be potential for birds to nest in cane fields around Shark Creek (Section 4 of the project).

2.2.3 Habitat use

To support the life-cycle activities of feeding and drinking, breeding and nesting, the emus appear to depend on a mosaic of vegetation types including both natural and modified habitats. This includes open forest, heath, woodland, agricultural land (grazing and cropping land), grasslands and wetland fringes. Open paddocks, grazing land and crops are important habitats during both the pre-breeding phase, as social groups gather in these locations, and post-breeding phases for rearing young.

2.2.4 Diet and water requirements

There has been limited study on the diet and water requirements of coastal emus, albeit for an earlier dietary study on the Bungawalbin sub-population (McGrath and Bass 1999). Studies on Emus in open plain habitats in Western Australia indicate that at all times the birds are semi-nomadic, keeping in touch with variation in availability of food (Davies 1976; 1984). Emus are omnivorous relying on insects, seeds, fruits and succulent vegetation (Dawson *et al* 1983) which may include both native and exotic plant species in coastal areas (McGrath and Bass 1999). In any locality in a particular time of year emus exhibit clear food preferences (Davies 1976) a factor which is associated with the typical sporadic and seasonal occurrences of fruits and seeds and this may partly explain their semi-nomadic behaviour and need to travel long distances to access available food sources. In their study of emus in arid landscapes Dawson *et al* (1983) recorded regular daily movements of 10-12 kilometres in autumn and 18 to 25 kilometres in summer reflecting the spatial availability of food. The daily movements and length of travel of the coastal emus is not known however genetic data taken from across the sub-populations range indicates that there is considerable mixing between groups.

The emu's ability to transport many large seeds over long distances could prove an important link between fragments of remnant vegetation by helping to maintain the genetic mix in plant communities (McGrath and Bass 1999). Information obtained from landholder surveys in the Pillar Valley, Tucabia and Tyndale area indicate that the birds regularly feed on crops, in particular soy beans and lablab beans as well as young growth on burnt grass or soft wetland plants. Emus have been observed eating fruit from Bangalow Palm, Native figs and Inkweed and seeds from native sedges and gramminoids (*Gahnia* and *Lomandra* spp.). A total of 11 plant species have been recorded during the pre-construction monitoring surveys including *Gahnia* spp. *Lomandra* spp, Blady Grass (*Imperata cylindrica*), *Styphelia triflora, Dianella* spp*, Pultenaea* spp, *Bangalow Palm* (*Archontophoenix cunninghamiana*) and Native Quince (*Petalostigma pubescens*)

The water requirements of adult emus do not appear high but intake may be limited by the size of the simple gut, resulting in a relatively high frequency of drinking, once per day and occasionally twice per day during hot summer conditions (Dawson *et al* 1983). Drinking rarely occurs during incubation. These data may support the hypothesis that the floodplain wetlands and creeks are critical to emu movements due to the regular supply of water, and the fact that they would be important year round, but particularly in the warmer months.

Evidence in western populations suggests that emus show a high fidelity to particular watering sites which may include artificial dams (Dawson *et al* 1983).

2.2.5 Movements

Emus are semi-nomadic moving in response to the availability of food and water resources. Seasonal access to frequented habitats may be via regular but broad movement pathways across the landscape. Prior to the EIS, there has been no study on the movements of the Yuraygir sub-population in the Clarence Valley and data on movements was based on observations collected as part of the NPWS annual survey. Further work for the EIS looked at targeted scat and feather collections as part of a genetic study as well as anecdotal information from landowner interviews. From the collation of all this data several main emu movement areas were assumed based on regular sightings at the same locations and include:

- Pillar Valley across Wooli Road at Whites Bridge (Pillar Valley Creek) and also south towards Coldstream Wetlands (Section 3 of the project). Congregations of emus have been reported several times on the western side of Tucabia Road around Whites Bridge.
- Sommervale Flats and Tyndale Swamp north to Shark Creek (east and west side of the creek) and north and south of Byrons Lane (Sections 3 and 4 of the project)
- Brooms Head to Green Hill and McIntyres Lane (Section 4 of the project).

The incidence of broad movement pathways suggests that any crossing structures targeting this species need to be closely spaced with multiple structures needing to cover a broad distance. Emus are often observed moving along vehicle tracks and frequent lightly wooded areas and clearings through forest and woodland particularly where they provide access through dense forest and heath, such areas may provide suitable locations for crossing structures or additions to crossing structures.

A pilot study was conducted by Roads and Maritime to determine if GPS-based telemetry data logging devices could be successfully used for monitoring emu movements and secondly to trial a field-based anaesthesia procedure for sedation and handling of emus so that devices could be attached. A secondary objective was to gain insight into the movements and behaviour of captive-reared emus released into the wild population. The data provided insight into the movements of captive-reared and released emus and identified and confirmed threats to their survival including encounters with barbed wire fencing and wild dogs. Monitoring showed wide dispersal, the use of clearings in remnant vegetation and farm land as well as natural habitat, with movements often associated with fence lines.

Studies for the project pre-construction monitoring program has identified emu presence from 13 impact transects and 7 control transects, with signs of emu presence reported on 95% of transects sampled. After the first 6 months of the study the highest density in the impact areas was found in summer at Tucabia south followed by the autumn-winter period for Pillar Valley west where emus were reported on both sides of the road alignment, and particularly near the Coldstream wetlands. The density of emus reported as number of signs per hectare for the control and impact areas is shown in Figure 2-2.

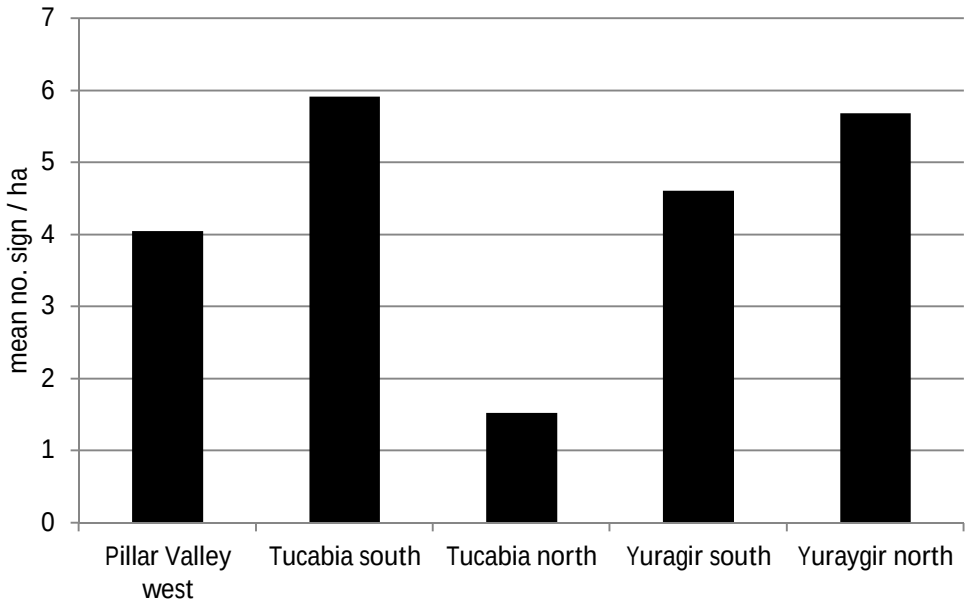


Figure 2-2. Pre-construction density of emu sign (no./ ha) at impact and control sites (November 2013-June2014)

2.3 Population decline and threats

The decline of the coastal emu population is attributed to contracting range and fragmentation of sub-populations due to land development, agriculture and fires (NPWS 1995). Other threats include attack and predation from wild dogs, as confirmed from the radio-tracking study and collisions with vehicles. Over 70 road fatalities have been reported for the coastal emu population in the last 14 years as reported in the NSW Atlas database, incorporating records from OEH and local Wildlife Carers. Other threats as referenced by the NSW Scientific Committee include:

- Risk of local extinction due to small population size and isolation.
- Clearing and fragmentation of habitat for agriculture and urban development.
- Burning of habitat at too frequent intervals.
- Disturbance of nesting birds and predation of birds and young by foxes, dogs and feral pigs.
- Deliberate killing by poisoning and shooting.

The current evidence suggests that the Bundjalung sub-population may have succumbed to a combination of these threats, exacerbated by intense wildfires.

There is no published information on the frequency of vehicle-collisions with emus. In their review of reported animal collisions between 1996 and 2005 throughout western NSW, Ramp and Roger (2008) identify 30 incidents involving emus. Within the range of the coastal emu population on the mid north coast, the NPWS and Clarence Valley WIRES group have logged 70 emu vehicle-collisions between 2000 and 2014 on local roads in the Minnie Waters, Clarence Valley and Iluka areas as a result of fatal collisions with vehicles.

The instances of vehicle collisions with emus in the Clarence Valley can be put into two categories: either, (a) the widespread instances of irregular road kill of single birds, or (b) localities where both multiple road kills occur (usually several chicks from a family group) and/or emus are killed on a regular (annual) basis.

A study of emu-vehicle collisions was reported in the EIS and found emu road-kill sites were typically:

- Where mature forest was present along the roadway (within 10 metres of mature comprising 6-50 per cent canopy cover), as opposed to cleared landscapes and open farmland.
- On single lane dirt roads or larger sealed rural roads but not the existing Pacific Highway.
- Where there was no fence between the forest edge and the road.

- Where there was vegetation two metres or taller within five metres of the edge of the road.

The road speed limit, adjacent speed limits, road gradient, type or condition of paddock fences, shrub and groundcover were identified to not be influential in typical emu road-kill locations.

2.4 Emu monitoring (pre-construction)

In accordance with the mitigation strategies described for pre-construction management in this document (Chapter 4), Roads and Maritime has commissioned targeted emu surveys for the project, commencing with baseline (pre-construction) surveys and monitoring of an exclusion fence and subset of emu crossing zones. This information builds on that presented in the EIS and SPIR and has been used to update the management actions presented in the plan. The surveys are focused on collecting baseline information for the monitoring program including impact sites and control sites as well as trialling behaviour of emus in relation to temporary fences and crossing zones.

Pre-construction surveys commenced in December 2013 and will continue quarterly until construction commences, followed by ongoing quarterly surveys during construction and operation, which includes searches for evidence of emus, collation of sightings and camera trapping. Details of the methods of the targeted surveys are summarised in Section 7.2.

As part of the baseline surveys emu presence was reported from all impact and control sites for the pre-construction surveys, with signs of emu presence reported on 95% of transects sampled. The highest density in the impact areas was found at Tucabia south (Section 3) followed by Pillar Valley west (also Section 3) where emus were reported on both sides of the proposed future road alignment, and particularly near the Coldstream wetlands (Section 3).

The detection rate and occupancy of emus has been reportedly similar between the impact and control areas, with the continual occupancy reported around Mitchell Road and lowest at Tucabia north, which included a broad area from Bostock Road to Pillar Valley State Forest.

Remote cameras were initially set during the first survey (December 2013). To date images of emus have been captured at around 85 % of survey sites . The majority of these have been taken at the control areas of Brooms Head while Tucabia south and Pillar Valley are represented for the impact areas. The remote cameras have proven to be an effective method for detecting emu presence and seasonal activity in combination with the active searches. Photos have been captured for single adults and adult pairs of birds as well as chicks and juveniles and provide a date and time of the observation and evidence of breeding success in the project study area. These results suggest that this technique is likely to valuable in future monitoring during construction and operation of the road to monitor effectiveness of fences and underpass structures and ongoing presence of emus.

Adult pairs were observed in early summer and observations of males with offspring reported in late summer and autumn through to early winter. At these periods the preferred habitats appeared to be sugar cane areas, specifically soybean crops, low-lying pastoral areas adjoining remnant forest surrounding the Coldstream wetlands, Pillar Valley Creek and Black Snake Creek. Activity in the Tucabia south (Mitchell Road) has remained constant throughout the pre-construction period with evidence of breeding in the 2014 and 2015 breeding seasons. Emu occupancy has also remained stable in the Pillar Valley sites over the 18 month pre-construction surveys.

Observations of emus in the Shark Creek cane areas (Section 4) were reported in the first three surveys conducted in summer and autumn. This included one observation of an adult pair, a sighting of an adult male with four juvenile offspring and two observations of solitary adults. In all cases the birds were observed grazing in fields of soybean used by landowners for crop rotation and nitrogen fixing. It is evident that the soybean crops provide an important part of the diet of the local population and account for seasonal visits during the warmer months of the year. There were no emu observed during the winter survey which followed harvesting of the soybean in late autumn.

Monitoring conducted to trial the emu exclusion fence and crossing gaps commenced in December 2014, this included 10 crossing zones that were identified in the EIS. The objective of the trial was to monitoring emu behaviour in relation to the fence and whether emus can be directed to crossing zones or show evidence of using crossing zones. The results have showed evidence of emus moving along the fence and repeated use around 50 % of the crossing zones to date. The results suggest that the proposed crossings zones identified in the EIS are accurate and that that the exclusion fence has been effective at directing emus.

3. Potential impacts and management approach

The following chapter describes the potential impacts to the coastal emu population from the project with reference to the more detailed impact assessment presented in the EIS Biodiversity Working Paper (Roads and Maritime 2012). The impact assessment also takes into consideration the results of additional targeted surveys completed in 2013-14 following submission of the EIS. It describes the potential impacts to the species at specific locations along the upgrade and during the pre-construction, construction and post-construction (operational) stages of the project. The mitigation approach presented in the EIS and documented in **Chapters 4** to **Chapter 6** of the management plan aims to address these predicted impacts.

3.1 Potential impacts associated with the project

3.1.1 Loss of habitat, fragmentation and barrier to movements

The population consists of small numbers of emus that occupy a broad landscape mosaic of both natural and modified habitats. Being predominantly nomadic, non-breeding birds move from place to place without regard to season or direction and depend on resources that occur rarely at the same site. A continuity of resources can be ensured only if birds are able to locate successive favourable areas that are often spatially separated (Davies 2007). In areas where environmental conditions are regular, the movements of emus can appear regular but the birds are still influenced by the same suite of behaviour patterns as are birds in environments that are less consistent (Davies 2007).

Based on the distribution of emu records for the Pillar Valley to Shark Creek group, the evidence suggests that the relatively stable environmental conditions associated with the floodplain wetlands and swamps of the Coldstream River, Chaffin Swamp, Champions Creek, Pillar Valley Creek, Tyndale Swamp and Shark Creek including the associated agricultural land, support reliable food and water resources, both spatially and temporally. These habitats account for observed movements in the pre and post breeding life-cycle periods of birds. The wetlands are currently contiguous with the forest and heath communities to the east of the floodplain via relatively natural and modified habitats, albeit for a network of smaller roads, such as the Tyndale-Tucabia Road, continuing to the coastal lands of Yuraygir National Park and surrounds.

The project in the eastern extent of the lower Clarence floodplain (Section 3 and 4 of the project) would effectively skirt around the Coldstream wetlands, eventually crossing Pillar Valley Creek, Chaffin Creek, Champions Creek and Shark Creek and therefore introduce a physical barrier for emus accessing these important wetland habitats from the east.

Therefore, the impact to the population from the project would include the direct removal, fragmentation and isolation of important habitat. This factor combined with the increased risk of vehicle strike associated with the project, adding to the existing mortality from vehicle strike on local roads, has potential to have significant long-term impacts associated with a cumulative reduction in the population leading to loss of viability. The project would have the greatest impact on the group ranging the Pillar Valley to Tyndale area. The degree of relatedness and interaction of this group to the other identified groups extending to the coast is not known.

3.1.2 Impact of fences

Fauna exclusion fencing is used effectively on other Pacific Highway upgrades for a range of fauna, however there has been no study into the effects of using this fence type on wild emus and it is unknown if the currently used fauna exclusion fence design would be effective in directing emus to crossing locations.

Based on discussions with property owners in the region and the results of the baseline surveys emus are known to and have been observed to easily pass through rural three and four strand wire fences including barbed wire stock fences.

The provision of exclusion fencing on the project would reduce the number of crossing points needed for emus by channelling birds to the designated crossing points. However, there are issues with placing fences in flood prone areas and as is the case near some bridge crossings and also issues preventing cattle exiting private properties but allowing emus to cross through fences to facilitate natural movements to habitat east and west of the project and potentially issues with wild dogs trapping emus along fences.

The fences should also incorporate vertical gaps that are intended to allow emus 'trapped' in the carriageway to run along the fence and be directed through the gap. Given there has been no monitoring of the fencing it is unclear whether the vertical gaps would be effective. It would be possible for the birds to walk along a fence until they come to a break in it, rather than use the underpass structure, although this needs to be tested. An appropriate emu fence will be trialled during the pre-construction phase..

3.2 Detailed design considerations

A number of factors were considered in identifying the key connectivity zones for emus and the types of crossing structures incorporated into the concept design for emus, with the aim of developing these further at the detailed design stage. The factors considered in located and sizing structures included:

- The known distributional range of the Yuraygir sub-population, including all known records of sightings and anecdotal evidence provided by rangers from OEH and land owners.
- The distribution of known habitats and in particular the location of the floodplain wetlands and connectivity of the surrounding landscape to these.
- The body size of the emu standing to 2 metres (bridges were raised to accommodate emu movements rather than minimum hydrology requirements and would not be lowered).

Detailed design in Sections 3 and 4 of the project would consider the appropriate design and location of emu exclusion and directional fencing taking into consideration flood prone areas. Consideration would also be given to fence design around bridges design to exclude domestic stock from exiting a property boundary but allowing emus to pass through and continue to the road crossing point. These details are provided in a separate emu fencing strategy, which is described further in Section 4.3.1.

3.3 Mitigation and monitoring

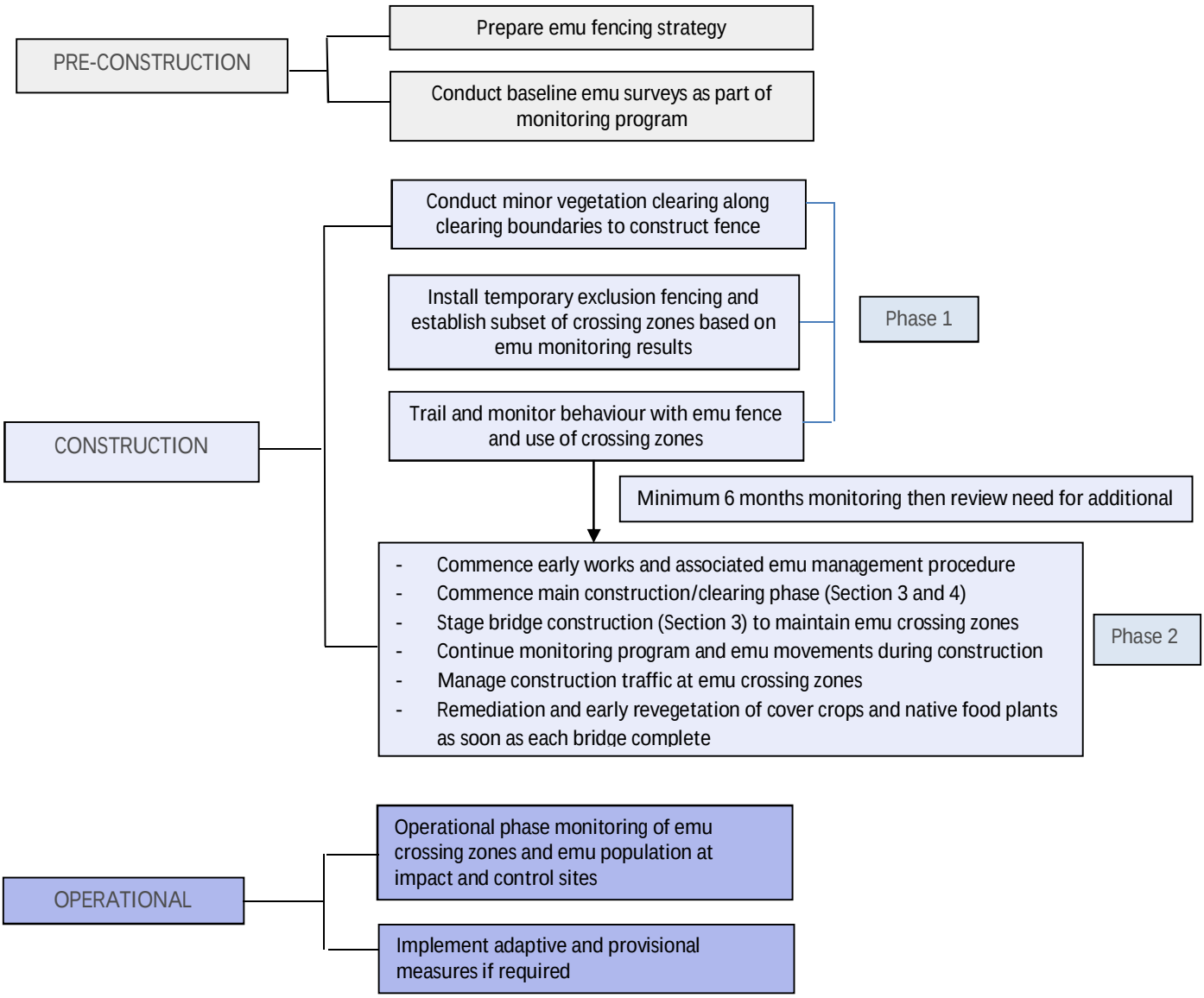
A number of measures to mitigate and monitor the impact of the project on emus during construction and operation of the project were identified in the EIS Biodiversity Working Paper. In general these measures related to:

- A targeted connectivity strategy.
- Provision of exclusion / directional fencing.
- Avoiding impacts to emu habitat outside the road footprint during construction.
- Developing an emu find procedure for dealing with emu encounters during early works and the main construction.
- Providing and trialling attractants to emu crossing points including food plants and other measures
- Re-establishment of emu habitat at approaches to emu crossing structures.
- Develop a monitoring program to monitor impacts on the population and the effectiveness of mitigation measures and incorporate adaptive management actions where impacts are noted.

As a minimum the design of emu targeted crossing structures and fencing would be based on the design principles outlined in the EIS and the process for managing emu connectivity requirements described in the Biodiversity Connectivity Strategy. This includes a comprehensive monitoring program and the inclusion of precautionary options.

The proposed approach to management of potential impacts to the emu population throughout the pre-construction, construction and operational phases is illustrated in **Figure 3-1** below. The management plan addresses these issues in more detail in the following chapters.

Figure 3-1. Proposed staging of management measures



3.4 Effectiveness of mitigation measures

3.4.1 Crossing structures and fencing

Providing continued access to the currently used habitats east and west of the highway f is considered critical to the survival of the emu population as is preventing road fatalities on the future highway. In theory movement across the highway can be provided via appropriately placed and adequately sized crossing structures (i.e. bridges and culverts) in addition to exclusion fencing, which should also act as directional fencing leading to crossing structures. However, there would be a risk in this approach in that it relies on efficacy of these mitigation measures when there is no current scientific evidence to indicate that emus are capable of finding and using crossing structures or can be directed by fencing. In the absence of scientific certainty the benefit of providing crossing structures remains to be proven. There is a need to collect evidence to improve our confidence in this as a mitigation strategy and adequate prediction can be made regarding the impact of the project on the Yuraygir sub-population. This requires a comprehensive monitoring program and the inclusion of provisional and adaptive options if the crossing structures and fences are proven to be ineffective and the movements of emus are restricted by the highway.

Fauna exclusion fencing has been used effectively on other Pacific Highway upgrades, however there has been no study into the effects of fencing on coastal emus and it is unknown if the currently used design would be effective in directing emus to crossing locations. Monitoring of an emu exclusion fence and crossing zones is to be implemented during pre-construction and would continue during construction and operation, further details are provided in **Chapter 7**. An emu exclusion fence would be used in strategic areas which may be incorporated with boundary fence and placed on batter slopes of the road above the flood level where appropriate.

Escape gates may be designed in the exclusion fencing to allow emus trapped in the road corridor to escape, although this is dependent on monitoring of emu activity near the road and the first objective is to adequately prevent emus from entering the road corridor, whereby escape gates would not be required.

An emu fencing strategy has been prepared which outlines the requirements for temporary and permanent fencing in areas frequented by emus or considered within the range of the emu population. The strategy is included as Appendix D.

3.4.2 General measures

A summary of the proposed emu specific mitigation measures and evaluation of their effectiveness based on past experience with other highway upgrades is described in **Table3-1**.

Table 3-1. Mitigation measures and evaluation of their effectiveness

Issue	Mitigation measure	History of success	Effectiveness rating
Emus are curious of new activities and may enter the construction area.	Temporary exclusion fencing to exclude emus from the construction corridor during construction.	Temporary and permanent exclusion fencing used on all Pacific Highway upgrade over the last 10 years with a high rate of success.	Moderate, monitor success and implement corrective actions.
	Develop and implement an emu finds procedure.	Procedure has been developed by Roads and Maritime for unexpected finds such as threatened species, and has been adopted as part of the CEMP for multiple projects.	Unknown, monitor success and implement corrective actions.
	Pre-clearing and clearing procedures.	A standard procedure has been developed by Roads and Maritime and documented in the Biodiversity Guidelines for Construction (RTA 2011). The guidelines were developed in consultation with the NSW Office of Environment and Heritage (OEH), NSW Department of Primary Industries (DPI) (Fisheries), biodiversity specialists and Roads and Maritime staff including project managers, construction personnel and designers. Consultation was facilitated through a number of workshops carried out in 2009. These procedures have been developed using knowledge gained from a long history of upgrades on the Pacific highway and other road projects in NSW.	High
Potentially lengthy disruption to emu movements during construction.	Provide access for emus to cross the road corridor during construction and stage construction at crossing zones to maintain open areas.	Bridges have been prioritised on other projects and this is a feasible approach. Traffic control used on all upgrades by Roads and Maritime to account for local traffic and screening of construction areas. This same method could be adapted for emus.	Unknown, monitor success and implement corrective actions.
Impact to emu habitat outside the construction zone.	Identify exclusion zones and limits of clearing. Revegetation of RMS land adjacent to the corridor post construction.	Standard procedures have been developed by Roads and Maritime and documented in the Biodiversity Guidelines for Construction (RTA 2011). The guidelines were developed in consultation with the NSW Office of Environment and Heritage (OEH), NSW Department of Primary Industries (DPI) (Fisheries), biodiversity specialists and Roads and Maritime staff including project managers, construction personnel and designers. Consultation was facilitated through a number of workshops carried out in 2009. These procedures have been developed using knowledge gained from a long history of upgrades on the Pacific highway and other road projects in NSW.	High
Domestic dogs brought on site by contractor could lead to dog attack.	CEMP to document dog policy.	A standard policy used successfully on all highway upgrade by Roads and Maritime.	High

Emu-vehicle collisions on the highway.	Permanent emu exclusion fencing is to be used throughout the range of the population and potentially escape gates if required.	Permanent fauna exclusion fencing has been used on multiple sections of the Pacific highway to exclude fauna and direct to crossing points. Not been used before for emus.	Unknown, monitor success and implement corrective actions.
Emu-vehicle collisions on the highway.	Maintenance of permanent exclusion fencing, and crossings.	Roads and Maritime routinely conducts maintenance on exclusion fencing along the Pacific Highway both as a standard procedure and in response to a breach in the fence or speight of fauna road kills.	High
Highway creates a barrier to emu movements and access to known habitats, or isolates proportion of the population.	Targeted structures at emu crossing zones including large arches and raised bridges, supported by exclusion fencing and strategic landscaping.	Targeted crossing structures for other fauna have been used on multiple projects in Australia and overseas with high level of success. Raised bridges have been used successfully by cassowaries in north Queensland, however never before targeted at emus.	Unknown, monitor success and implement corrective actions and provisional measures.
Emus attracted to rubbish, or unfamiliar objects around the construction site such as plastic and shiny things.	Waste managed in accordance with procedures in the CEMP.	Roads and Maritime have developed standard procedures for waste management on construction sites as part of the CEMP process with a long history of success as reported in auditing reports	High
Water supply for emus contaminated during construction.	Water quality managed in accordance with procedures in the CEMP.	Roads and Maritime have developed standard procedures for water quality management on construction sites as part of the CEMP process with a long history of success as reported in auditing reports.	High
Increased noise and dust during construction impacting on emu movements and behaviours.	Dust and noise managed in accordance with procedures in the CEMP.	Roads and Maritime have developed standard procedures for noise and dust management on construction sites as part of the CEMP process with a long history of success as reported in auditing reports.	High
Potential for increased wild dog attack at concentrated crossing zones.	Wild dog control.	Roads and Maritime does not conduct wild dog control. Roads and Maritime would engage with stakeholders involved with predator control to identify actions to assist in minimising attacks as required.	High

3.5 Adaptive management approach

This plan has been presented using an adaptive management approach based on firstly identifying specific goals for management, implementation of management actions followed by monitoring of the performance of these measures against the goals and identified thresholds. As a final step the monitoring would evaluate the effectiveness of the management measures using identified thresholds for performance and implementing corrective actions to improve mitigation where required.

To ensure the success of this approach the management goals presented in the plan were based on the following SMART principles:

- **S**pecific.
- **M**easurable.
- **A**chievable.
- **R**esults-based.
- **T**ime-based.

The monitoring program is also adaptive in its approach and details of the proposed monitoring program is described in **Chapter 7** which includes monitoring:

- Change in emu activity in proximity to the project and to the east and west of the project, the methodology includes a Before-After-Impact-Control (BACI) approach.
- The use of crossing zones and crossing structures during pre-construction, construction and during operation of the project.
- The effectiveness of roadside fencing at excluding emus from the road corridor and directing emus to crossing zones.
- The success of emu habitat revegetation.

3.6 Proposed provisional measures

The connectivity strategy provided in the W2B EIS outlined the proposed process for managing emu connectivity requirements. This included monitoring the performance of the connectivity measures against SMART goals as described above. Further information on the proposed monitoring program is provided in **Chapter 7** of this plan.

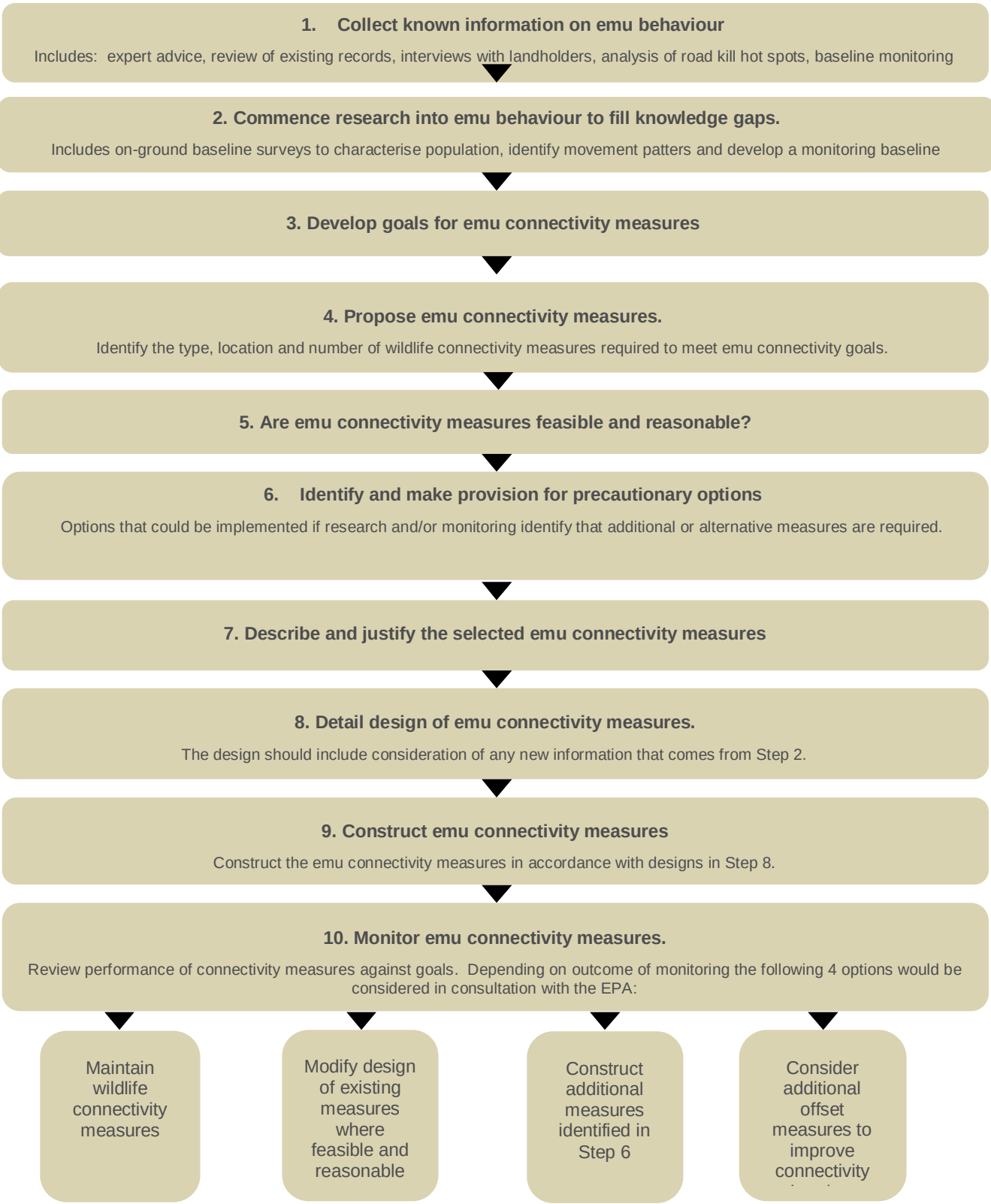
If during the operational phase emus are found to be unable or unwilling to use designated crossing structures provisional options would be developed that could be implemented if research and/or monitoring identify that additional or alternative measures are required.

Depending on the outcome of the monitoring of crossing structures the following four options would be considered in consultation with the EPA:

- Maintenance of the existing connectivity measures.
- Modification of the design of existing measures where feasible and reasonable.
- Construction of additional measures.
- Consideration of additional offset measures to improve connectivity elsewhere.

The location of additional measures is still to be decided and would be based on input from the ongoing emu monitoring program and discussions with the agencies.

Figure 3-2. The process for managing emu connectivity requirements



4. Pre-construction management measures

4.1 Potential impacts during pre-construction

- Location of infrastructure within ancillary facility sites including heavy vehicle access may impact on emu habitat, movements, foraging and behaviour.
- Dog attacks to occur inadvertently by bringing domestic dogs onto the worksite.
- Loss of connectivity and access to important habitats during pre-construction.

4.2 Goals for management

- No damage to emu nests in Section 3 and 4 of the project.
- No damage to emu habitat outside of designated work areas within an ancillary facility in Section 3 and 4 of the project during the pre-construction planning.
- No emu deaths from domestic dog attack on the project.
- Emu fencing strategy completed prior to construction commencing.

4.3 Management measures

Details on the site specific mitigation measures for emus to be implemented during the pre-construction phase are detailed here and summarised in **Table 4-1** along with performance thresholds and corrective actions.

4.3.1 Prepare an Emu fencing strategy

Strategic emu fencing in Section 3 and 4 will enhance the safety of coastal emus near the highway and direct emus to safe crossings provided below the road as dedicated bridges and underpasses or to habitat away from the road. The objectives of the emu fencing strategy are therefore to identify the mitigation required to:

- Identify and formalise crossing zones in areas of high emu activity prior to construction to encourage emus to travel along designated passageways and utilise future crossing zones across the highway prior to the construction and operation of the road.
- Exclude emus from the road corridor during the construction and operational phases of the project.
- Direct emus to designated crossing zones during the construction and operational phases of the project so that birds can access important habitat to the east and west of the road corridor.

Monitoring of crossing points would begin prior to construction and is discussed in **Chapter 7**. An emu fencing strategy was prepared in December 2014 and is provided as **Appendix D**.

4.3.2 Project fencing guidelines

The intention to develop a project wide fencing strategy was reported in the Submissions / Preferred Infrastructure Report (SPIR) and applicable to the entire W2B project (Roads and Maritime, 2012). The fencing strategy for the whole project would be formulated based on standard fence design principles aimed at ensuring the most appropriate solution is identified to cater for the various conditions along the project length. These principles would be implemented where reasonable and feasible and are outlined below. The development of the emu fencing strategy is specific for Sections 3 and 4 of the project and has been guided by the W2B project fencing principles which include:

- Discuss individual fencing needs with affected and adjoining landowners. Fencing requirements for sugar cane farms would be considered as part of the cane farm strategy.

- Develop a design that would combine fauna and boundary fencing (including appropriate stock proof fencing) in consultation with Government agencies.
- Identify opportunities to erect fences within the construction footprint, to avoid the need for additional vegetation clearing.
- Confirm the legal requirements and preferred approach in consultation with Roads and Maritime property and legal branch associated with combining fauna fence and property fence within the construction footprint and not necessarily on the road boundary.
- Develop a hybrid fence design to enable emus to pass and restrict cattle.
- Opportunities for fencing design to tie into culvert structures rather than cross the culvert face would be investigated.
- Where a combined fence design is required for fauna, boundary and stock such as cattle grazing, a fence may need to be erected on the boundary to restrict cattle from passing through culverts. The fence design across the culvert face would need to consider surface water impacts such as flooding/water velocities.
- Identify opportunities to place fauna exclusion fencing on the top of batter in floodplain areas.

4.3.3 Conduct baseline emu surveys

Baseline surveys for the coastal emu commenced in December 2013 during the pre-construction stage to inform the detailed design and monitoring program and provide further data for assessing the impacts on the emu population. Survey data would be used to inform the detailed design and proposed mitigation measures and possible provisional measures. Further details on the methods applied for the baseline surveys are described in Section 7.2.

4.3.4 Identify exclusion zones

An exclusion zone is a designated ‘no-go’ area that is clearly identified and appropriately fenced to prevent damage to native vegetation and fauna habitat. This procedure is documented in the CEMP and conducted along the entire construction corridor for all threatened species and endangered ecological communities.

Habitat exclusion zones and limits of clearing in section 3 and 4 would include consideration of emu habitat, which may include natural and modified habitats and potential sources of water. These zones would be established during the on-ground survey of the road corridor and the commencement of construction to ensure that these activities do not remove protected and roadside vegetation in emu habitat areas.

The identification of exclusion zones may be staged with a priority for early works sites and then remaining areas of the construction corridor. Survey personnel would be inducted to ensure they do not encroach outside the limits of clearing.

Important habitat exclusion zones for coastal emu will be all naturally vegetated areas in Section 3, in particular floodplain swamp forest communities and moist riparian habitats as these comprise reliable food sources and are most frequented as indicated by the monitoring surveys.

4.3.5 Identify sensitive ancillary areas and access roads

The siting of ancillary areas including stockpiles and construction infrastructure would be planned and sited in cleared areas and disturbed vegetation to avoid impacts to vegetation contained within the boundaries of the ancillary site. This would occur across all ancillary sites for each stage of the project and would be documented in the CEMP. The procedure would consider avoiding direct and indirect impacts to emu habitat in Sections 3 and 4 of the project.

4.3.6 Dog policy

No domestic dogs are to be brought onto the site during pre-construction and construction activities. All construction personnel to be informed of this policy.

4.4 Performance thresholds and corrective actions

Table 4-1 below summarises the pre-construction environmental planning measures for coastal emus that would be completed prior to the commencement of construction.

Table 4-1. Mitigation measures, performance measures and corrective actions

Main goals for mitigation	Proposed mitigation measure	Monitoring/timing frequency	Performance thresholds	Corrective actions if deviation from performance thresholds
Emu fencing strategy completed prior to construction commencing.	Detail location of temporary and permanent emu fencing, encourage use of crossing points and direct emus from the road corridor.	Emu fencing strategy to be completed and commence implementation of temporary emu fence 6 months prior to construction commencing on Section 3 and 4 of the project.	Temporary fences not in place 6 months prior to construction.	Delay construction until fencing strategy complete and temporary fencing in place.
No damage to emu nests in Section 3 and 4.	Pre-clearing process.	Report results in the CEMP/EMS.	Emu nest found.	Inform planning and procedures for the staged habitat removal. Monitor nest to determine duration of the nesting period and confirm fledging of young prior to commencing construction
No damage to emu habitat in Section 3 and 4 outside road corridor.	Identify exclusion zones.	Identify clearing limits prior to survey and clearing works to mark and flag exclusion zones. Follow-up inspection after surveying road corridor.	Damage to habitat reported outside limits of clearing in Section 3 and 4.	Supplementary revegetation of disturbed habitat and monitor recovery for period of 12 months.
No damage to emu habitat outside designated ancillary facilities and access.	Construction related infrastructure to be planned and sited within cleared or disturbed areas of the ancillary site. Particularly away from water sources and movements areas.	Detailed plans to be prepared showing the proposed location of construction related infrastructure and signed off prior to commencement of construction.	Plans show facilities located in vegetated areas or outside limits of clearing.	Amend locations if needed until all habitat is shown to be avoided.
No emu deaths from contractors domestic dogs on the project.	CEMP to document policy that prohibits dogs being brought onto the construction site.	Ongoing during construction.	Domestic dog found on site and connected with construction personnel.	Any breach in policy to be reported to EMR and contractors warned and if further breaches would be removed from the project.

5. Construction management measures

5.1 Potential impacts during construction

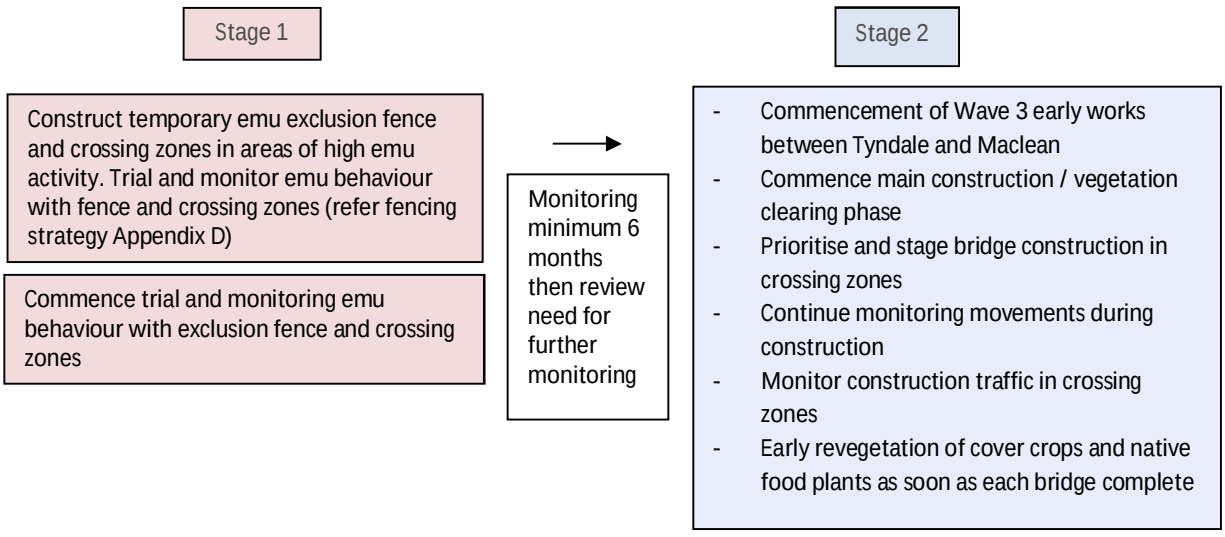
- Impacts during clearing of vegetation.
- Emus entering the construction corridor and becoming trapped in the corridor.
- Emu-vehicle collisions with construction traffic.
- Loss of connectivity and access to important habitats during construction.
- Disturbance and degradation to adjoining emu habitat.
- Ingestion of wire or plastic waste.
- Contamination or isolation of water supplies used by emus.
- Dust and noise impacting on movements and habitat use.

5.2 Goals for management

- No injuries to emus during clearing of vegetation.
- No injuries to emus during construction as a result of emu-construction vehicle collisions.
- No change in pre-construction emu movements across the construction corridor.
- No damage to emu habitat within exclusion zones in Section 3 and 4 of the project during construction.
- Domestic waste managed in accordance with the CEMP.
- Dust and noise managed in accordance with the CEMP.
- Water quality managed in accordance with the CEMP.
- Cover crops established within 3 months of completion of each bridge constructed in emu crossing zones in Section 3 and 4 of the project.
- Methods for rehabilitation of emu habitat adjacent to the road would be documented in the landscape design.
- Erect temporary emu fence in areas of higher emu activity to encourage use of designated crossing zones

5.3 Management measures

In order to minimise impacts to emu movements across the project during construction and to educate emus to use crossing zones prior to construction commencing, it is proposed to stage the construction and placement of infrastructure. This staging approach is illustrated below.



5.3.1 Pre-clearing surveys (Stage 1 and 2)

The pre-clearing process provides a final check for emu nests in the construction corridor prior to the commencement of construction. This may occur at early works sites as a priority and later across the construction corridor according to the priority stages of the upgrade to be determined. The pre-clearing process targets all fauna habitat and is a requirement of the CEMP. Searches of emu activity and emu nests would form a part of this process, and is particularly relevant in Sections 3 and 4 of the project. The results of the pre-clearing process would inform planning and procedures for the staged habitat removal process and have been documented as part of the EMS process.

5.3.2 Wave 3 early works (Stage 2)

The following management section describes the actions required for the Wave 3 early works and will also be applicable to construction in section 4 in general.

Wave 3 early works will occur at stage 2 as shown above and involve clearing of cane crops in fill locations and removal of vegetation and fill material from elevated areas in Section 4. The clearing of vegetation is to follow the procedure in Section 5.3.1. Permanent or temporary exclusion fencing is to be installed where possible on both sides of the cutting at borrow material sites (Tyndale Station 69.200 and Green Hill station 76.000) which is also relevant for the Wave 1 early works. The permanent fence will follow the design described in Section 5.3.8.

For the soft soil treatment areas it is expected that the high visibility in the cleared landscape will result in a low risk of emu-vehicle encounters and negate the need for the temporary emu exclusion fence used on Section 3. There are additional issues with longevity and maintenance of temporary fencing in floodplain areas. Construction of Wave 3 is to be staged according to the following methods to limit impacts to emus:

- Stage 1: Set clearing limits (flagging tape)
- Stage 2: Vegetation clearing (tracked equipment at low speed)
- Stage 3: Swale construction (tracked equipment at low speed)
- Stage 3a: Instrument install
- Stage 4: Place geofabric then drainage or bridging layer by end dumping at low speed
- Stage 4a: Star pickets and plain wire to be erected with flagging and tied to the geofabric or sediment fence. Further details covered in Section 5.3.3
- Stage 4b: Wick drains (low speed excavator mounts)
- Stage 5: Start fill layers (formation at 900 mm before truck movements)

Stages 1 to 4 represent no risk to emus, and stage 5 a low risk. To manage this low risk a purposely designed tall (1200 mm) and robust temporary fence is to be used along the length of the soft soil treatment corridor (refer to Appendix F for design). The star picket fence will include coloured flagging along the top wire for visibility for emus and fauna in general to prevent contact. Where gaps are left in the formation, such as haul road, temporary fence such as ATF is to be established to prevent emus from entering the corridor. This would include closing gaps each evening at the end of work and also on non-work days such as Sundays, wet days and public holidays.

This approach has been developed to avoid and minimise potential entry by emus into the construction corridor. To further manage the low risk of emu encounters in the construction corridor, the following protocol also applies during construction.

- Conduct daily pre-start meeting to maintain awareness of emu presence and report emu finds from previous day. Emu signage to be established if emu's are observed in a particular area.
- Workers on site to actively note and report emu sightings daily by recording number and location of emus on map to be provided. Important to identify time and date, and number of birds including which side of the construction corridor emus sighted.

- As per the threatened species find procedure in the plan (Section 5.3.5) the reporting of a single emu sighting within the boundaries of the construction corridor (which includes the haul road) would trigger the need to stop work within 50 metres of the emu until the emu has left the construction corridor. If the emu continues to stay within the construction corridor for more than 20 minutes, site environmental staff would gently guide the emu out of the construction corridor with assistance from construction staff if required.
- If emus continue to enter the formation (inside sediment fence) on a regular basis (3 observations in a day), the contractor must consult with RMS and EPA to assess the risk to emus and consider establishing a temporary fence, or reduced speed limits.

During the settling period following completion of the wave 3 works, it is expected that construction access will continue on a regular basis and any observations of emus reported within the construction area will be noted and reported.

5.3.3 Erect temporary emu exclusion fences (Stage 1 and 2)

It is proposed to construct temporary exclusion fencing for emus based on the following approach:

Stage 1 - Pre-Construction

- Temporary emu exclusion fencing (pre-construction) to be erected at a minimum 6 months prior to the commencement of the stage 2 construction and targeting areas of high emu activity in Section 3 to encourage emus to locate and use designated crossing zones prior to the commencement of construction and to trial and monitor the effectiveness of the exclusion fence design.

Stage 2 - Construction

- Temporary emu fencing (construction) to be erected in key areas of Section 3 to prevent emus from entering the construction corridor during construction and thereby avoid potential harm to emus from construction traffic and activities. Two Key Areas have been identified, between Wooli Road to North of Mitchell Road, being CH44.5 to CH51.3 and south of Somervale Road (CH55.0) through to CH61.0. This represents a total of 12.8 km of temporary fencing during construction in Section 3.
- In areas of Cut, permanent Emu fence is to be installed where possible. Refer to Section 5.3.8 of this plan.
- In areas of Fill, the temporary fence will be erected as per the below construction methodology:
    - Determine clearing limits and complete clearing
    - Following clearing, erect Sediment and Erosion Controls,
    - Erect temporary Emu exclusion fencing, as per the fence design example shown in Appendix F.

5.3.4 Maintaining connectivity during Stage 2 construction

Given a potential lengthy construction period for Section 3 of the project, the Stage 2 construction phase must make available a number of options for emus to cross the corridor during construction. The objective is to maintain functional crossing zones during construction where possible.

The first stage of construction would involve identifying clearing limits and removing vegetation along clearing lines followed by installation of either the temporary or permanent exclusion fencing in places identified by in the plan. The following approach will be used to establish or maintain connectivity during construction.

- All bridges will be constructed concurrently across Section 3, however it is expected that the shorter bridges will be completed first. As soon as each bridge is completed it will be tied in with the emu exclusion fence and site remediation completed to open up the crossing zone. The bridge would then be used for ongoing haulage.

- During bridge construction temporary fencing would be used to develop an emu passageway or race to direct emus across the entire width of the construction corridor. The race would be established perpendicular to the corridor. Where there is a creek the race would be constructed along the creek and incorporate riparian habitat with a minimum distance of 10 metres either side of the top of the creek bank. Where flatter and wider creeks occur, the area of the creek profile would also be retained inside the race. Where there is no creek, the race should be a minimum of 20 metres wide and set up through the centre of the crossing zone where possible.
- There will be a total of 9 emu races established in key area 1 and associated with the combined emu bridges between Wooli Road and Firth Heinz Road (station 45855 to 50280). These align with 9 temporary crossing zones established in the pre-construction stage which are all known to have been used by emus on at least one occasion during the fence trial. At the start of each work day temporary gates at either side of the race would be closed and then re-opened at the end of each work day. These gates would then also remain open during non-work days such as Sundays, wet days and public holidays.
- The location of the 9 races has been positioned to capture emu activity reported during the baseline surveys up to September 2015. If during the construction monitoring period emu activity is observed to shift north of key area 1, such as key area 2, then an additional race(s) would be provided in the relevant location to facilitate emu movements across the corridor

5.3.5 Vegetation clearing and emu find procedures

Before clearing commences, ensure that the pre-clearing process as stated in Section 5.3.2 would be complete.

Clearing of vegetation would be to ensure that construction works do not go beyond the approved clearing limits in Sections 3 and 4 of the project.

Clearing procedures would be outlined in the CEMP and FFMP, and would be undertaken in accordance with *Biodiversity Guidelines: Protecting and managing biodiversity on RTA Projects* (RTA 2011), in order to minimise impacts on flora and fauna in general.

An ecologist would be present during the clearing works in Sections 3 and 4 of the project and if an emu is encountered during clearing works the Roads and Maritime unexpected finds procedure would be followed.

In the case of the emu a suggested framework would include cease work and employ options for ensuring the safety of the animal. This may include repairing any breeches in exclusion fence before work recommences, or opening the exclusion fence and buffer the area until the emu leaves. A nominated ‘vet-on-call’ to be contacted immediately to facilitate response if an emu is found injured.

5.3.6 Managing emu-vehicle collisions

A licensed ecologist would be present on site during all vegetation clearing and habitat removal activities to redirect emus that may be encountered as discussed above with reference to the unexpected threatened species find procedure.

Following the clearing works and throughout the remainder of the construction period, any observations of emus in the construction corridor would also follow the unexpected threatened species find procedure (RTA 2011). Note specific protocol for Wave 3 and works in Section 4 are described in Section 5.3.2. All vehicles are to remain within the designated construction corridor at all times.

In the case of an emu collision, work would cease and options considered to the safety of the animal. This may include repairing any breeches in exclusion fencing before work recommences. Details of the incident would be reported included the number of emus present, time of day, location and likely entry point from the exclusion fence.

All construction vehicles are to comply with the speed limits set out in the CEMP and to remain within the designated construction corridor.

Given the likely increased traffic on local roads during the construction period due to construction traffic getting to the site, emu awareness signs would be erected on local roads in potential road kill areas to make motorists aware of the potential for emus to cross the road.

5.3.7 Targeted emu crossing structures

Crossing structures targeted at emus were described as part of the concept design / EIS process as being provided between chainage 36.5 and 66.5 (Section 3 and 4 of the project) and included:

- Raised bridges with a minimum height of 3.6 metres to provide targeted crossing points for emus to the Coldstream, Shark Creek and Tyndale wetlands via dry passage retained along both banks of the channel.
- A minimum bank width of 4 metres would be retained in emu habitat / crossing areas to allow emus to walk between an abutment and the creek edge.
- Raised arch structures in emu connectivity zones.
- Purpose built exclusion fencing strategically located in areas surrounding the crossing structures to direct emus and to prevent emus from entering the highway corridor.

In addition to the structures proposed in the concept design the NSW Government Approval Condition MCoA B11 stated that as part of the detailed design the applicant shall further investigate the design refinements for fauna crossings and associated exclusionary measures, between station 41.500 and station 80.000 to improve connectivity for the Coastal Emu. This has now been completed and documented in Version 3.1 of the plan as informed by baseline surveys conducted in Section 3 between December 2013 and December 2015. In order to comply with this condition a workshop was held on 24/07/15 to address detailed design of emu crossing structures. Information gathered from emu monitoring during pre-construction was presented which demonstrated that the proposed crossing zones outlined in the EIS were considered appropriate in term of location and size.
The minutes from the workshop are provided as Appendix G which outlines inputs, the decision process and final outcomes. From this workshop a decision was made to change the 3 arch structures presented in the EIS (CH53.699, 59.272 and 60.802) to plank bridges. Clearance is reduced from 5.5 m to 3.6 m however the overall cross section opening is maintained or increased with 4 m fauna passage maintained on one side. This design change was supported primarily due to the ability of the twin bridge design to allow light penetration into the riparian zone and there facilitate growth of the plants in the riparian zone and provide a more natural crossing zone than the large arches.

A second design meeting was held on 4 December 2015 to discuss proposed changes to a number of bridges in Section 3. Again this decision was informed by the emu fence monitoring work which

resulted in a minor reduction in the length of a number of bridges in Section 3 and an increase in some bridges. Two culverts presented in the SPIR were subsequently upgraded to 20 metre bridges. The overall intention of the changes was to supplement the overall loss in total bridges lengths with the addition of two new bridges in Section 3 such that the gaps between crossings would be reduced, effectively providing more crossing opportunities. The addition of two new bridges in an important emu crossing area was considered to adequately compensate for the overall length on several bridges and considered a better outcome by provided more crossing opportunities (refer Appendix G for meeting minutes).

Specific details of the final proposed dedicated, combined and incidental crossing structures targeted at emus are identified in **Table 5-1.**

Table 5-1. Proposed Emu crossing structures from concept design (SPIR)

Station (km)	Project Section	Name	Structure type	Lgth (m)	Cell no.	RCBC wth (m)	RCBC hgt (m)	Bridge length x width	Functionality	Design Change for Fauna Provisions and notes from agency meeting on Emus 17-9-13	Assumed connectivity
42.522	3	Coldstream River 1	BRIDGE					124 x 10.5	Combined (Emu)	Bridge lifted to at least 3.6 m clearance to soffit for emu clearance	Coldstream wetlands
43.102	3	Coldstream River 2	BRIDGE					350.0 x 10.5	Combined (Emu)	Bridge lifted to at least 3.6 m clearance to soffit for emu clearance	Coldstream wetlands
43.887	3	Coldstream River 3	BRIDGE					194.0 x 10.5	Combined (Emu)	Bridge lifted to at least 3.6 m clearance to soffit for emu clearance	Coldstream wetlands
45.545	3	Wooli Road	BRIDGE OVERPASS					60.5 x 12.5	Incidental (Emu)	nil	
46.055	3	Pillar Valley Creek 1	BRIDGE					80.0 x 10.5 NB and 11.9 SB	Combined (Emu)	Bridge lifted to at least 3.6 m clearance to soffit for emu clearance	Clarence floodplain wetlands to Yuraygir NP
46.325	3	Pillar Valley Creek	BRIDGE					90.0 x 10.5 NB and 11.9 SB.	Combined (Emu)	Bridge lifted to at least 3.6 m clearance to soffit for emu clearance	Clarence floodplain wetlands to Yuraygir NP
46.647	3	Black Snake Creek	BRIDGE					51.0 x 10.5 NB and 11.9 SB	Combined (Emu)	Bridge lifted to at least 3.6 m clearance to soffit for emu clearance	Clarence floodplain wetlands to Yuraygir NP
47.125	3	Floodplain	BRIDGE					20.0 x 10.5	Combined (Emu)	Bridge lifted to at least 3.6 m clearance to soffit for emu clearance	
47.643	3	Pillar Valley Creek 4	BRIDGE					60.0 x 10.5	Combined (Emu)	Bridge lifted to at least 3.6 m clearance to soffit for emu clearance	

47.925	3	Unnamed tributary of Pillar Valley Creek (near station 48000)	BRIDGE					45.0 x 10.5	Combined (Emu)	Bridge lifted to at least 3.6 m clearance to soffit for emu clearance	
48.742	3	Mitchell Road	BRIDGE					29.0 x 10.5 NB and 11.6 SB	Incidental (Emu)	Share access and Emu Crossing. Retain 4.6m clearance	Clarence floodplain wetlands to Yuraygir NP
49.246	3	North of Pillar Valley 1	BRIDGE					83.0 x 10.5 NB and 11.6 SB	Combined (Emu)	Bridge lifted to at least 3.6 m clearance to soffit for emu clearance. Not possible to lift design grade further	Clarence floodplain wetlands to Yuraygir NP
50.280	3	North of Pillar Valley 2	BRIDGE					42.0 x 10.5	Combined (Emu)	Bridge lifted to at least 3.6 m clearance to soffit for emu clearance. Not possible to lift design grade further	Clarence floodplain wetlands to Yuraygir NP
51.419	3		BRIDGE					20.0 x 10.5	Combined (Emu)	Bridge lifted to at least 3.6 m clearance to soffit for emu clearance.	Clarence floodplain wetlands to Yuraygir NP
51.854	3	Firth Heinz Road	BRIDGE					60.6 x 7.2	Incidental (Emu)	ACTION - Allow for future widening by 6.0m for fauna connectivity	Clarence floodplain wetlands to Yuraygir NP
52.427	3	Chaffin Creek	BRIDGE					71.0 x 10.5	Combined (Emu)	Bridge lifted to at least 3.6 m clearance to soffit for emu clearance. Not possible to lift design grade further. Bridge length reduced from 75m to 52 m due to design change in SPIR	Clarence floodplain wetlands to Yuraygir NP
53.699	3		BRIDGE	60			5.500	25.8 x 12.0	Combined (Emu)	Bridge lifted to at least 3.6 m clearance to soffit for emu clearance.	Chaffin Swamp to Chaffin Hill
54.695	3	Unnamed tributary of Chaffin Creek (near station 54600)	BRIDGE					67.0 x 10.5	Combined (Emu)	Bridge lifted to at least 3.6 m clearance to soffit for emu clearance. Not possible to lift design grade further.	Clarence floodplain wetlands to Yuraygir NP
55.486	3	Bostock Road	BRIDGE OVERPASS					60.6 x 7.2	Incidental (Emu)	–Detailed design is to allow for future widening by 6.0m for fauna connectivity i.e. to separate local traffic from emu movements	Clarence floodplain wetlands to Yuraygir NP

56.885	3	Somervale Road	BRIDGE					31.5 x 10.5 and 11.0	Incidental (Emu)	Share access and Emu Crossing. Retain 5m clearance for emu.	Clarence floodplain wetlands to Yuraygir NP
57.014	3	Champions Creek	BRIDGE					78.0 x 10.5	Combined (Emu)	Retain 5m clearance in design for emu (important structure for emu)	Clarence floodplain wetlands to Yuraygir NP
58.626	3	North of Champions Creek	BRIDGE					65.5 x 10.5	Combined (Emu)	Retain 5m clearance in design for emu	
59.272	3		BRIDGE	60	1		5.500	22.7 x 12.0	Combined (Emu)	Bridge lifted to at least 3.6 m clearance to soffit for emu clearance	
60.802	3		BRIDGE	60	1		5.500	60.802 x 12.0	Combined (Emu)	Bridge lifted to at least 3.6 m clearance to soffit for emu clearance	
61.033	3	Property Access	BRIDGE					35.5 x 10.5	Incidental (Emu)	Share access and Emu Crossing	Clarence floodplain wetlands to Yuraygir NP
63.634	3	Property Access	BRIDGE OVERPASS					100.6 x 7.2	Incidental (Emu)	ACTION - Allow for future widening by 6.0m for fauna connectivity	Clarence floodplain wetlands to Yuraygir NP
64.492	3		RCBC	60	1	3.000	3.000		Combined (Emu)	Not an important zone for emu. Reduce arch structure to culvert 3x3m. Retain function for mammal connectivity.	
64.911	3	Crowleys Road Property Access	BRIDGE OVERPASS					60.6 x 6.0	Incidental (Emu)		Clarence floodplain wetlands to Yuraygir NP
66.190	3		RCBC	60	1	3.000	3.000		Combined (emu)	Not an important zone for emu. Reduce arch structure to culvert 3x3m. Retain function for mammal connectivity and cattle to adjacent crown land.	Clarence floodplain wetlands to Yuraygir NP
70.455	4	Tyndale Cane Drain 1	BRIDGE					18 x 11m, 12.5m, 8m	Combined (Emu)		
74.350	4	Shark Creek	BRIDGE					865.0 x 10.5	Combined (Emu)	Increased from 448m to 865m as a result of detailed design for Soft Soils.	

5.3.8 Permanent emu exclusion fencing

Permanent exclusion fencing would progressively replace temporary fencing used during construction and completed by the end of construction. The permanent emu exclusion fence is to be constructed across Section 3 and 4 from Old Six Mile Lane (station 38,250) to the Maclean interchange (station 80,000) a distance of 41.75 km.

Details of the fence type, design and location are documented in the emu fencing strategy (Appendix D) and consider issues such as flooding and directing emus to crossing zones.

In locations of section 3 and 4 where temporary fencing is not been used during construction, and where flooding is not a risk, the construction of permanent fencing will commence after the initial vegetation clearing until progressively completed.

The fence type would be a steel/concrete post (where possible) and wire/mesh fence (specifications below) that can be used as a combined fauna fence and property boundary fence. This fence design has been observed to be effective for directing emus during the pre-construction monitoring and is the same design as the rabbit proof fence in WA which effectively excludes emus.

The specifications of the permanent emu exclusion fence are described below and are similar to the temporary fence design described in RMS (2014a) with the exception of using concrete / steel posts instead of star pickets and closer post spacing as follows:

- 1500 mm high steel/concrete posts
- steel wire netting to 1200 mm high
- 200 mm skirt at ground level on the habitat side to prevent other targeted fauna such as Rufous Bettong and Koala from burrowing underneath.
- The top strand to be plain wire
- Barbed wire may be used in the lower half of the fence. The use of barbed wire would be limited and in negotiation with property owners and may be required to prevent cattle from pushing over and entering the road.
- Fence ends to be tied into the headwall of culverts and bridge abutments or tied into the hybrid fence where required.

This design is expected to prevent injury to emus as well as gliders, brush-tailed phascogale, Rufous bettong and koala. Fencing would be placed along the road reserve boundary and in certain locations combined with property boundaries. Exclusion fencing would avoid blocking access to waterways and artificial dams which represent potentially important emu watering points.

In flood prone areas permanent fencing would be placed on the road batter to prevent flooding damage or collapse. This is particularly relevant to Section 4 in cane fields and parts of the Coldstream River catchment in Section 3.

There has been no prior monitoring to identify effective escape gate designs for emus and there is concern that the provision of openings in the permanent fence may have a negative impact by allowing emus an access point to enter the road corridor. The permanent fence is considered of sufficient length and robust design to exclude emus from the road corridor and therefore escape gates are currently not planned as part of the permanent fence. The need for escape gates in Section 3 and 4 of the project would be reviewed as part of the operational monitoring program to determine if they are required and if so where they should be positioned.

5.3.9 Revegetation of emu crossing zones

Emus prefer to be able to see well ahead of them, ideally a kilometre, so it would be important to have clear, straight leads up to the crossing points and equally important to shield these routes from as much traffic noise, light and movement as possible. Opportunities for trialling construction of dirt tracks would be considered on private land and discussed with landowners. This has evolved from the satellite tracking work which found emus regularly travel along roads and clearings through bushland, and the intention would be to direct emus to crossing points. These tracks could link up with existing tracks, or run parallel to the highway or linking with regular movement pathways. The location of tracks will be informed by the monitoring work documented in **Chapter 7** and depend on negotiation with adjacent landowners.

Revegetation of emu crossing zones (where these have been intersected by the project on Roads and Maritime owned land) would commence immediately on completion of construction activity and to be staged to avoid lengthy disruption to emu movement along the corridor. The aim would be to have an established cover crop within three months of the completion of each bridge.

The revegetation of these areas would include ground cover crops such as soybean, oats, lablab or rye grass to be used initially on disturbed ground around the approaches to the bridges to attract emus to the crossing zone as these represent known food plants. As these are non-native species, sterile cover crops would be used and these areas would be monitored and progressively replaced with native food plants as discussed. This could also be done in the early staging works and documented in the emu fencing strategy.

Where possible, revegetation near crossing zones would commence early during construction in areas that are not expected to be impacted further during construction activities.

Open walking tracks or unsealed vehicle tracks may be incorporated under bridges in densely forest areas as an added attractant for emus to find the crossing structure. This would not be required in open landscapes with clear line of sight.

5.3.10 Emu specific revegetation

The landscape design would be developed to provide specific details for the re-establishment of native vegetation on batters, cut faces, surrounding sediment basins and other areas disturbed during construction including approaches to emu connectivity structures and riparian corridors. Methods for topsoiling, seeding and planting would be in accordance with the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA Projects* (RTA 2011).

The plan would provide due consideration to the landscape requirements of emus which would include natural vegetation and plant types known to be used by emus. This would include revegetation around crossing structures targeted at emus by ensuring that the height and density of vegetation does not obscure the structure and provides a clear open line of sight and revegetation in disturbed areas adjacent to Sections 3 and 4 of the project.

The following specific measures would be implemented during construction:

- Roadside plantings in emu habitat (Section 3 and 4 of the project) would not be within the first 10 metres of the road edge unless there is fauna exclusion fencing in place or as part of the exclusion barrier. In particular, common landscape species such as Lomandra and Dianella spp. would not be used in roadside landscaping as they represent food plants for emus and may attract them to the road edge.
- Final landscape plantings under dedicated and combined bridges in emu crossing zones (Section 3 and 4 of the project) including the approaches to the crossing are to use native grasses or low ground covers suitable to the location and avoid dense plantings of trees and shrubs including low trees such as Acacia or Casuarina. This is to leave the opening and line of sight clear.
- Revegetation in roadside areas disturbed during construction needs to restore the original habitat type at each location. This refers to rehabilitating either the original open forests or swamp forest community or restoration of modified agricultural landscapes which are also known to be used by emus.

Details on monitoring the performance of the revegetation are provided in **Chapter 7**, along with corrective actions.

5.3.11 Managing domestic waste

Wire and plastic, food scraps and other potentially 'attractive' items for emus would be managed in accordance with the waste and refuse protocols of the CEMP.

5.3.12 Managing water quality

Implement procedures for maintenance of water quality included in the CEMP including sediment and erosion control measures. These measures would be critical to maintaining water quality in important emu watering areas. These procedures include:

- Controlled access to watercourses by construction workers and vehicles.
- All refuelling and maintenance to be undertaken in designated bunded areas away from overland flow paths and low-lying areas.
- Specific measures for water detention basins, including appropriate discharge where necessary.

5.3.13 Minimising dust and noise

Dust and noise impacts would be managed in accordance with the CEMP including dust suppression measures and construction noise limit measures.

5.4 Performance thresholds and corrective actions

Table 5-2 below summarises the construction environmental planning measures for coastal emus that would be completed prior to the commencement of construction.

Table 5-2. Mitigation measures, performance measures and corrective actions

Main goals for management	Management measure	Monitoring/timing frequency	Performance thresholds	Corrective actions if performance threshold reached
No injuries to emus during the fence monitoring and crossing gaps (Stage 1 period)	• Trial and monitor use of an appropriate exclusion fence with added crossing zones	• Quarterly monitoring in line with monitoring program	Emu injured or killed during fence monitoring period	Report any emu injury or death to EPA Review the cause of the incident, consult with EPA, RMS, and emu specialist Evaluate situation and appropriate approach on each occasion
No injuries to emus during clearing of vegetation.	• Documented procedure for clearing of vegetation. • Documented procedure for emergency management if emu is encountered during clearing works. • Procedure developed in consultation with WIRES and NPWS. • Project ecologist evaluates situation and approach on each occasion.	• Monitored daily during the clearing works. • Outcome of emu management procedure reported in EMR for review.	Emu injured or killed during clearing works.	Report any emu injury or death to EPA Stop clearing works and consult with RMS, emu specialists or EPA. Update emergency procedure and toolbox talks.
No injuries to emus from collisions with construction vehicles.	• All vehicles to stay within the construction corridor and no entry into exclusion zones. • Comply with construction vehicles speed limits designated in the CEMP. • Implement a daily inspection of emu crossing zones and fence integrity. • Comply with protocol developed for Wave 3 early works (section 4) Section 5.3.2	• Monthly fauna incident log to be maintained as per FFMP. • Daily exclusion fence monitoring.	• Emu injured during construction. • Single emu sighted in Wave 3 early works corridor during construction • 3 emu encounters in one day	• Report any emu injury or death to EPA • Stop construction and conduct evaluation of exclusion fence strategy and traffic control procedures as appropriate. • For early works stop work within 50 m of emu and wait 20 minutes before gently guiding emu out of the work area • After 3 encounters will trigger action to consult with RMS and EPA to assess the risk to emus and consider erecting temporary exclusion fence in Wave 3 works corridor
No damage to emu habitat within exclusion zones in Section 3 and 4 during construction.	• Implement the emu fencing strategy prior to construction. • Fencing to be erected concurrently with clearing procedure in Section 3 and 4.	• Audit fencing outcomes prior to commencement of construction. • Monthly monitoring of exclusion fence and protection zones as part of FFMP	Breach in exclusion zone by construction vehicle of personnel.	Supplementary revegetation of disturbed habitat and monitor recovery for period of 12 months.

No change in pre-construction emu movements across the construction corridor.	• Adopt emu fencing strategy • Construction infrastructure and access tracks located to avoid lengthy interruption to emu movements. • Avoid extended activities in or adjacent to known emu habitat, watering points or crossing zones. • As soon as bridge construction completed, bridge to be tied in with exclusion fence and site remediated to open the crossing zone. • Provide and maintain an emu race across 9 crossing zones between Wooli Road and south of Firth Heinz Road, to be opened outside of work hours	• Daily – monitor construction activities to ensure compliance with emu management plan. • Daily – monitor construction activities to ensure continued access for emus to water supplies and foraging habitat in line with fencing strategy. • Monitor use of crossing zones during construction as per continuous camera stations and inspection and download every three months	After four construction monitoring events there is a demonstrated change from pre-construction emu movements across the project corridor.	Re-evaluate and revise monitoring methodology. Revisit fencing strategy and staging approach for crossing zones and change if practical.
Dust and noise managed in accordance with the CEMP	Implement relevant procedures from the CEMP.	Measures to be undertaken in response to weather and construction conditions.	Monthly reports as part of CEMP including updates on dust and noise control measures.	Increase the frequency of dust and noise measures.
Domestic waste managed in accordance with the CEMP.	Implement waste management procedures from the CEMP.	Ongoing, clean-up of all construction sites to remove potentially hazardous items includes a general daily clean-up of construction areas and rubbish removal	Event based reporting according to CEMP.	Review staff training and waste management training as necessary.
Water quality managed in accordance with the CEMP	Implement water quality procedures from the CEMP.	Weekly and event based monitoring of water quality and erosion controls.	CEMP	Review water and erosion management procedures as necessary.
Cover crops established within 3 months of completion of the bridge construction in Section 3 and 4.	Implement revegetation and rehabilitation to commence immediately on completion of construction activity completion and to be staged to avoid lengthy disruption to emu movement corridors.	Comply with landscape plans performance criteria as regards planting success and revegetation monitoring.	Event based, incident reporting in CEMP	Dead plantings (>30%) to be replaced with equivalent species and maintained until established.
Methods for rehabilitation of emu habitat adjacent to the road is documented in the landscape design.	• Roadside plantings in emu habitat (Section 3 and 4) avoid emu food plants to prevent emus being attracted to road edges. • Landscape plantings under emu crossing zones in Section 3 and 4 to use native grasses or low ground covers suitable to the location and avoid dense plantings of trees and shrubs. • Revegetation in roadside areas disturbed during construction to restore the original habitat type at each location.	Final audit of the landscape design.	Evidence of emu specific revegetation to be captured in the landscape design.	Update landscape design accordingly.

6. Operational management measures

6.1 Potential impacts during operational phase

- Degradation of emu exclusion fence leading to emu-vehicle collisions and road death or emus being trapped in the road corridor.
- Degradation of emu revegetation areas.
- Wild dogs targeting emus at designated crossing zones or along exclusion fence.

6.2 Goals for management

- Zero rate of traffic related emu mortality in Sections 3 and 4 of the project after 10 years.
- Maintain habitat revegetation areas on Roads and Maritime owned land in Section 3 and 4 of the project post-construction until performance threshold has been met.
- Zero or reduced rate of reported deaths from dog attacks in vicinity of crossing structures in Section 3 and 4 of the project in years 1-5.

6.3 Management measures

6.3.1 Maintenance of exclusion fences

The Roads and Maritime would conduct maintenance of exclusion fencing and escape points in emu habitat areas and under emu crossing structures to maintain the integrity of these structures for the life-time of the project. This would include inspections of the fence and structures as part of the standard maintenance requirements at the site for the life-time of the project.

Monitoring would also be conducted in response to observations and reports of emu road kills in the vicinity of exclusion fencing and emu crossing structures. Monitoring would be conducted for five years initially and the need for further five year monitoring periods would be reviewed at the end of this period. The work to be commissioned would include repair of any breaches in the exclusion fence, the slashing of overgrown vegetation that breaches the fence and the removal of large debris or vegetation from arch structure entrances and below bridges.

Conduct fauna mortality surveys with focus on emus in known emu habitat areas and report as per monitoring program discussed in **Chapter 7**.

6.3.2 Maintenance of habitat revegetation

Inspection, monitoring and maintenance of emu habitat revegetation areas would be specified in the landscape design. The recommended monitoring and maintenance schedule for the revegetated areas in the first year is outlined in **Table 6-1**.

Table 6-1 Monitoring and maintenance schedule first year

Monitoring	Timing	Maintenance
Site preparation	Commencement	Weeds and grass controlled within 2 metres of planting locations.
Watering weekly	First month	No plants wilting or with dried foliage.
Monitoring weeds and plant health	3 months	Weeds not smothering plants, plants healthy with active growth, replanting required if plant survival not at required percentage.
Weed control Mulching and fertilising of plants	3 Months	Weeds and grass controlled within 2 metres of planting locations, all plants mulched and fertilised.
Monitoring weeds and plant health	6 months	Weeds not smothering plants, plants healthy with active growth, replanting required if plant survival not at required percentage.

Weed control Mulching and fertilising of plants	6 months	Weeds controlled within 2 metres of planting locations, all plants mulched and fertilised.
Monitoring weeds and plant health	9 months	Weeds not smothering plants, plants healthy with active growth, replanting required if plant survival not at required percentage.
Weed control Mulching and fertilising of plants	9 months	Weeds controlled within 2 metres of planting locations, all plants mulched and fertilised.
Monitoring weeds and plant health	12 months	Weeds not smothering plants, plants healthy with active growth, replanting required if plant survival not at required percentage.
Weed control Mulching and fertilising of plants	12 months	Weeds controlled within 2 metres of planting locations, all plants mulched and fertilised.

6.3.3 Wild dog control

Predators can exploit the channelling function of the fence by hunting near the entrance to the underpass or overpass (Harris et al. 2010) or potentially along the fence itself. Monitoring of dog activity would be conducted as part of the fence trial and crossing zone monitoring programs during construction and operation. Should monitoring in Section 3 of the project demonstrate wild dogs to be a potential issue for emus using the fence or crossing zones, the Roads and Maritime would introduce appropriate action which may include engaging and working with stakeholders to introduce dog control. This may include landowners, the Northern Rivers Catchment Management Authority, NSW Office of Environment and Heritage (Parks and Wildlife Grafton), and Rural Lands Protection Board (North East). Performance monitoring and actions for wild dog control may be appropriate during both construction and operation.

6.4 Performance thresholds and corrective actions

Table 6-2 below summarises the operational environmental planning measures for coastal emus and corrective actions if the measure deviates from the performance criteria.

Table 6-2. Mitigation measures, performance measures and corrective actions

Main goal	Mitigation / control measure	Monitoring/timing frequency	Performance thresholds (triggers for corrective actions)	Corrective actions if deviation from performance criteria
Zero rate of traffic related emu mortality in Sections 3 and 4 of the project after 10 years.	• Periodic monitoring and maintenance of exclusion fencing for the life-time of the project. • Slashing weeds near fences and repair breaches in fence or replace broken fences.	• Conduct emu mortality surveys as per Chapter 7. • The program would include inspections of the fence and structures as part of the standard maintenance requirements at the site for the life-time of the project. • Monitoring would also be conducted in response to observations and reports of emu road kills in the vicinity of exclusion fencing and emu crossing structures. Monitoring would be conducted for five years initially and the need for further 5 year monitoring periods will be reviewed at the end of this period.	• Emu death reported in Section 3 and 4 within operational years 1-10.	• Locate and repair faulty exclusion fence within 3 days of emu death being reported. • Add additional exclusion fencing if a gap has been identified and additional fencing is required

Maintain habitat revegetation areas on Roads and Maritime owned land in Section 3 and 4 post-construction until performance threshold has been met.	• Regular monitoring and reporting on revegetation works and keeping Log Book of Maintenance	• Monitor and report on revegetation works at month three, month nine and month twelve following initial establishment of revegetation area. A Log book of Maintenance shall be prepared. The log book shall report on:
		  • Date of maintenance actions
		  • Results from performance quadrants
		  • Summary of visual inspection
		  • Further soil test information
		  • Any instructions by RMS and response actions from contractor
			• >30% mortality of planted native vegetation sites determined from monitoring quadrants
			• Treatment of weed infestation.
				• Review planting regime and methods. Increase maintenance reporting period until revegetation success rate is achieved.

Zero or reduced rate of reported deaths from dog attacks in vicinity of crossing structures in Section 3 and 4 in years 1-5.	• Conduct ongoing monitoring at crossing zones as per methods in Chapter 7.	• Monitor dog presence and emu-dog kills as part of ongoing crossing structure monitoring program.	• Emu death near crossing zone attributed to dog attached as evidenced by dog activity (as per methods in Chapter 7).	• Engage with stakeholders involved with predator control and identify actions to assist in minimising attacks.

7. Monitoring program

The emu monitoring program is to be conducted in stages as follows:

- Stage 1 – pre-construction (pre-fencing).
- Stage 2 – pre-construction (post-fencing)
- Stage 3 – construction phase
- Stage 4 – operational phase

The Plan aims to provide an adaptive and responsive management approach, whereby information on the distribution of emu activity within and adjacent to the Project area will be used to guide mitigation and ongoing monitoring. Within this monitoring program, adaptive management is a technique that would be utilised to ensure emu declines are recognised if they occur as a result of the Project. Results from the monitoring program would be analysed after each sampling/survey period. Regular analysis of the data is conducted to allow improvements and refinements in the survey design to be incorporated into future monitoring activities. Appropriate triggers for the Program include a notable decline in emu activity or breeding success in the project area compared to control sites.

The program intends to compare the 'before' construction data with 'during' and 'after' construction data and impact sites with control sites. The study will be conducted in the vicinity of the proposed future Section 3 and 4 of the Woolgoolga to Ballina upgrade (specifically from Pillar Valley to Shark Creek). Sites have been selected to survey forest and floodplain swamp habitats as well as modified grazing land and cane farms. Impact sites have been selected within proximity to the project corridor, and particularly near proposed crossing structures provided as mitigation in Section 3. Control sites have been selected in coastal forest habitats which resemble the impact sites and are expected to have regular emu presence.

Other aspects of the study include an experimental trial to test the effectiveness of the temporary fencing used for exclusion and to guide the movements of emus towards crossing zones in areas of high emu activity and to test different hybrid fence types that are designed to exclude cattle but are permeable to emus.

7.1 Mitigation and monitoring goals

The Plan identifies mitigation goals for each phase of the project from pre-construction, through construction and operation. The degree to which these goals are achieved or fail is referred to in the Plan as 'performance' and is measured through monitoring and implementing corrective actions where performance criteria are not met. Both RMS and the construction contractors are responsible for implementing mitigation measures and monitoring their performance.

The monitoring program discussed in this chapter is designed to inform the overall performance of the operational mitigation goals outlined in Chapter 6 and these relate to the effectiveness of the road mitigation at maintaining the viability of the emu population in the study area. The specific mitigation goals relevant to this monitoring program are:

- Zero rate of traffic related emu mortality in Sections 3 and 4 of the project after 10 years.
- Post-mitigation relative density in the Project study area is similar to pre-road construction relative density after 5 years.
- Post-mitigation distribution on both sides of the road is similar to pre-road construction distribution.
- Zero or reduced rate of emu deaths from dog attacks in vicinity of crossing structures in Section 3 and 4 of the project in years 1-5.

The monitoring program aims to determine if the mitigation measures for emus have been effective in the long-term and therefore achieve these mitigation goals. The underlying objectives of the program are to:

- Further understand distribution and habitat use by emus near the road corridor.

- Identify the trend in population density of the local population residing in the Project study area during the different stages of the project.
- Evaluate the success of mitigation measures (crossing structures, fences and habitat revegetation).

The monitoring can be refined, subject to progress against the above matters. In order to fulfil these objectives a number of ecological variables would be monitored, with each variable discussed below.

7.2 Emu activity monitoring

7.2.1 Ground survey

Study area

The emu monitoring study focuses on the Yuraygir emu population which occupies the coastal strip of Yuraygir National Park to the east of the Project, as well as, surrounding contiguous areas from Brooms Head in the north to Minnie Waters in the south and Tucabia, Shark Creek, Pillar Valley and the lower Coldstream wetlands in the west. The surveys have a focus on six study sites:

1) Pillar Valley west, including east and west of the Tucabia-Tyndale Road and portions of the Coldstream wetlands, and lower catchment of Pillar Valley Creek and Black Snake Creek (project Section 3).
2) Tucabia south between Mitchell Road and Firth Heinz Road (project Section 3)
3) Tucabia north from Bostock Road to Somervale Road including Pine Brush State Forest and Stokes Waterholes (project Section 3)
4) Yuraygir south at two locations around Diggers Camp and Minnie Waters (Control)
5) Yuraygir north at two locations around Brooms Head and Taloumbi (Control).
6) Shark Creek floodplain (project Section 4).

Survey transects

A range of different habitat types are present in the study area including pastoral land, grazing land, forest, heath and open wetlands. Evidence of emu activity has been reported in each of these habitats and the study aims to survey a range of impact and control sites with similar characteristics. Transects have been selected to provide even coverage of impact areas with a focus on known regular emu sightings and the location of future mitigation for emus on the highway.

Preliminary surveys determined that a number of site characteristics were important when selecting transects to maximise the chance of finding emu sign. For example transects positioned along fence lines were preferred, particularly well maintained rural fences with barbed wire, due to the fact that emu feathers were frequently found ‘snagged’ on barbed wire by birds passing through or along the fence. The presence of feathers represents a reliable means of detecting emu presence in an area. This situation was not able to be achieved for all transects due to the dominance of plain wire fences and poorly maintained fences in impact areas. In the absence of barbed wire fences, other important site characteristics were sought, these included clearings through forest areas such as power easements and fire trails where emu droppings and footprints could be easily located (Plates 1 and 2), particularly sandy and muddy tracks where emu footprints were readily identifiable. Following a number of preliminary surveys, the transect locations were refined and added.

Control sites were selected that had site characteristics resembling impact sites, this included habitat floristics and structure. In addition as impact sites were located in the general vicinity of existing roads such as the Tucabia-Tyndale Road, Somervale Road and Bostock Road which have a history of emu-vehicle collisions, controls were therefore intentionally placed near to roads, such as Brooms Head Road, Wooli Road and Minnie Water Road where road strike has also been historically reported. The final selection of monitoring sites is centred on five study sites (refer Table 7-1). Surveys in Area 6 (Shark Creek) were targeted in the pre-fencing period only (Stage 1) and were vehicle based only.

Table 7-1. Study sites and details of emu monitoring transects

Study sites	Status	Transect name	Habitat	Transect length (m)	Search area (ha) based on 10 m width	Location relative to future road
1. Pillar Valley West	Impact	PV-A	Grazing / forest	840	0.84	West
	Impact	PV-B	Grazing / wetland	1300	1.30	West
	Impact	PV-C	Grazing / forest	1655	1.65	East
	Impact	PV-D	Grazing / forest	2425	2.42	East
			Total	6220 m	6.2 ha	
2.Tucabia South	Impact	MR-A	Dry open forest	825	0.82	East
	Impact	MR-B	Dry open forest	965	0.96	West
	Impact	MR-C	Dry open forest	755	0.75	West
	Impact	MR-D	Swamp forest	700	0.70	West
	Impact	MR-E	Dry open forest	1400	1.40	East
			Total	4645 m	4.6 ha	
3. Tucabia North	Impact	TN-A	Dry open forest	2080	2.08	West
	Impact	TN-B	Dry open forest	3000	3.00	East
	Impact	TN-C	Dry open forest	1365	1.36	East
	Impact	TN-D	Dry open forest	1370	1.37	East
			Total	7815 m	7.8 ha	
4.Yuraygir South	Control	YS-A	Swamp heath	1155	1.15	-
	Control	YS-B	Swamp heath	1255	1.25	-
	Control	YS-C	Dry open forest	1030	1.03	-
	Control	YS-D	Dry open forest	730	0.73	-
	Control	YS-E	Dry open forest	1250	1.25	-
			Total	5420 m	5.4 ha	
5.Yuraygir North	Control	YN-A	Dry open forest	1850	1.85	-
	Control	YN-B	Dry open forest	1270	1.27	-
			Total	3120 m	3.1 ha	

There are 20 transects in total (13 impact and 7 control) totalling approximately 27 km of transects. Given the importance of having particular characteristics present on transects, it is important that the same transects are sampled for each monitoring event, rather than selection of new random transects for each survey. In this study, the benefits of randomisation do not outweigh the logistical benefits derived by systematic repeat sampling. The other benefit of repeat surveys on the same properties is the opportunity to capture data on emu sightings from landowners between monitoring periods. This was also found to be an effective way of documenting emu presence and abundance in combination with the active and passive search methods used.

FIGURE 7.1 Yuraygir South

FIGURE 7.2 Pillar Valley West

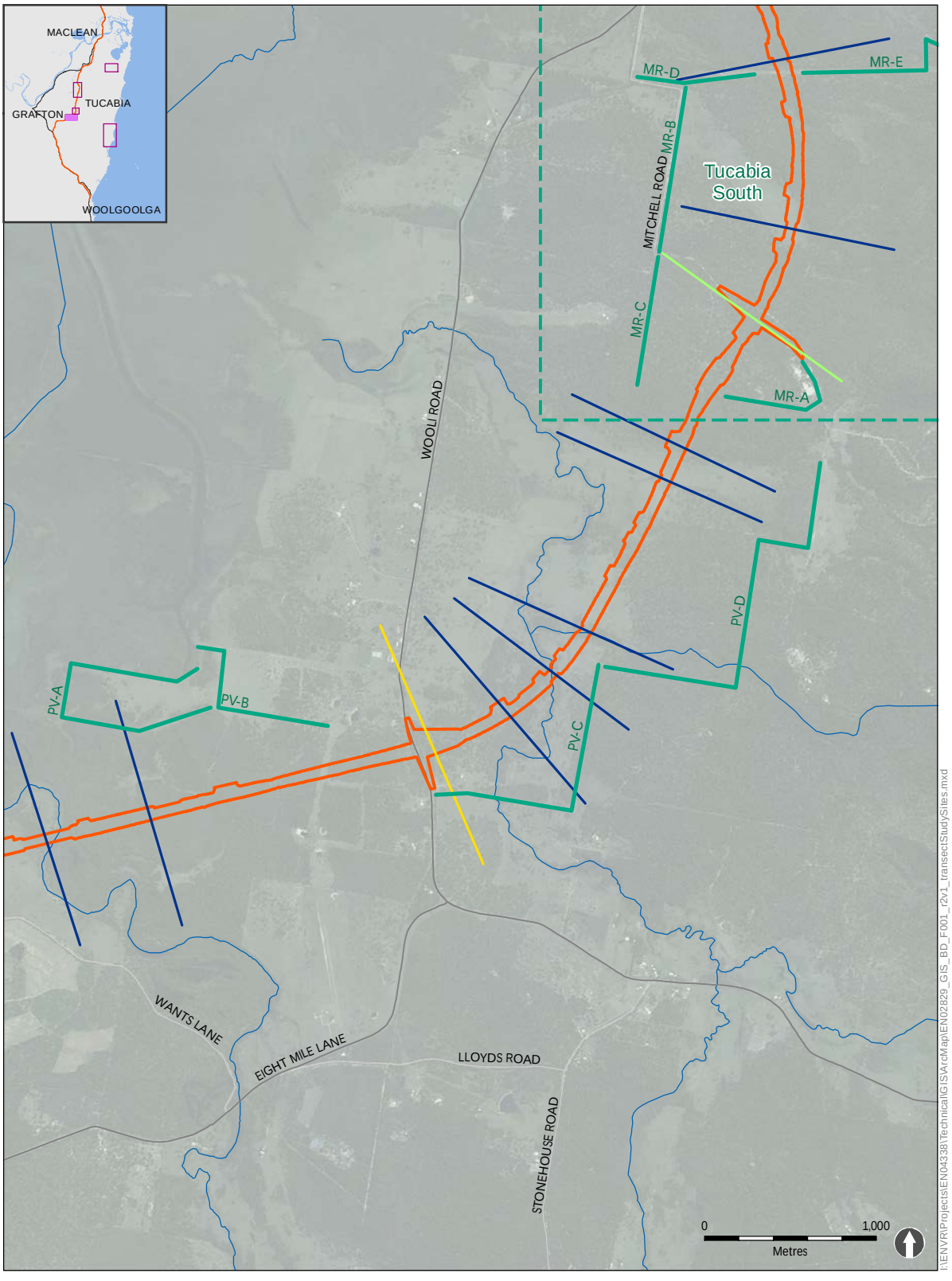


FIGURE 7.3 Tucabia South

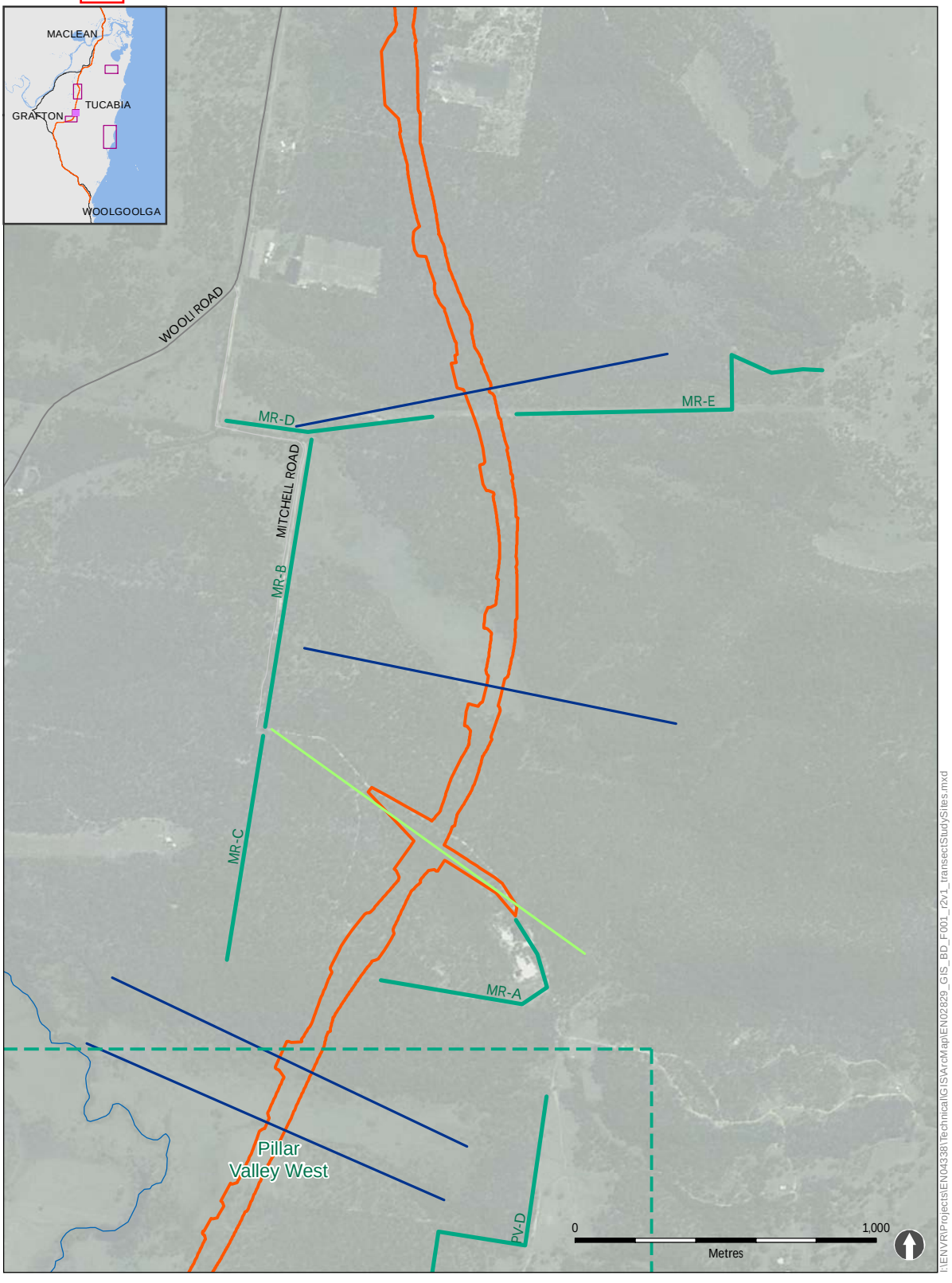


FIGURE 4 7.4 Tucabia North

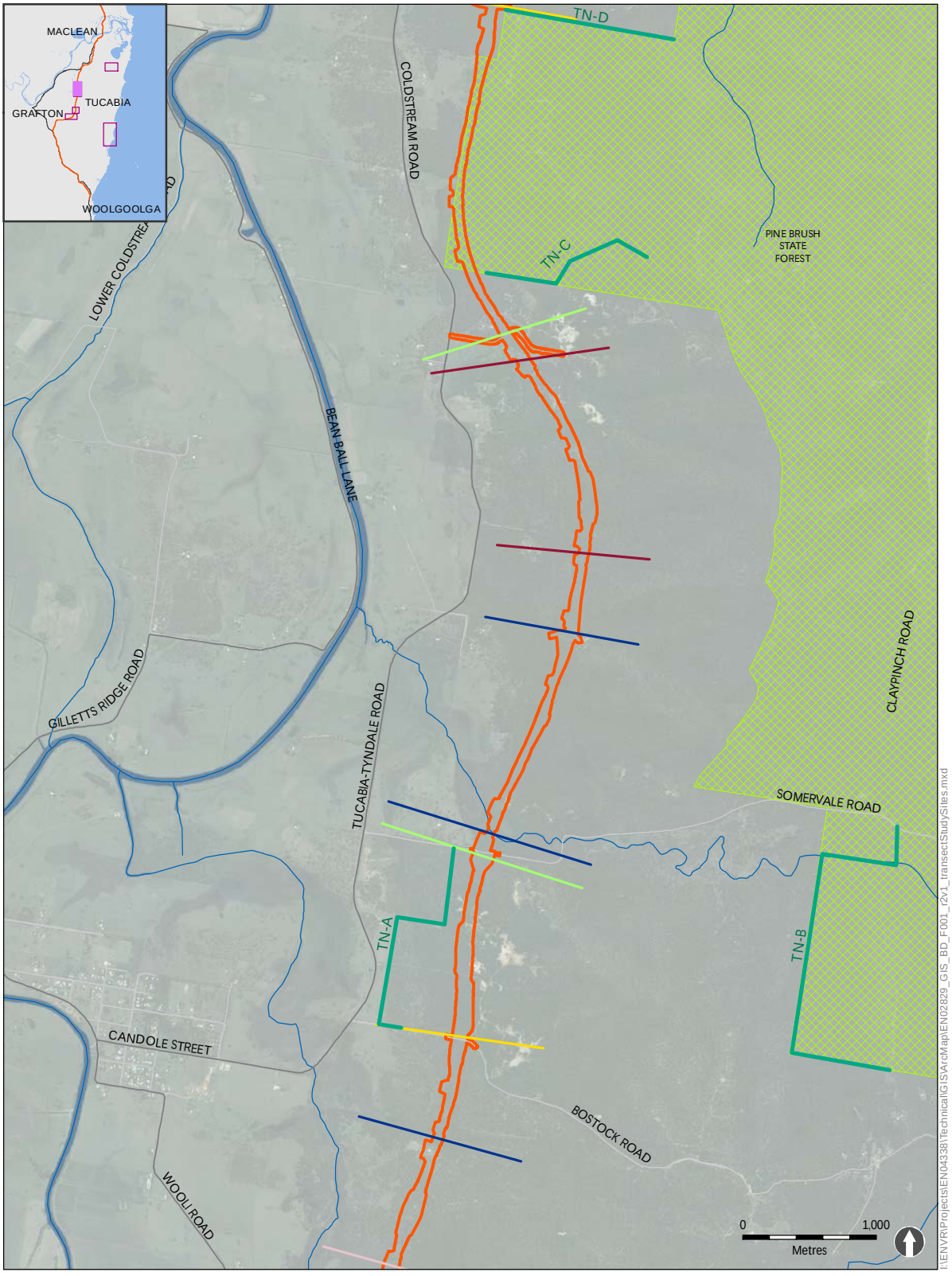


FIGURE 7.5 Yuraygir North

Plate 1. Example of cleared fire break where emu scats and signs could be readily located

Plate 2. Example of cleared power easement through forest habitat with sandy substrate

Timing

The program intends to compare the 'before' construction data with 'during' and 'after' construction data and the impact sites with control sites. Surveys would commence in the pre-construction phase at least 12 months prior to construction and continue seasonally (quarterly) during the pre-construction, construction and operational phases of the project. The length of the operational monitoring will continue for five years after which will be subject to a performance review with possible extension to at least 7 years to monitor corrective actions.

The monitoring program would be adaptive and the timing of surveys and location of transects may change according to the results of the surveys. Performance indicators, thresholds and corrective actions for this component of the monitoring program are discussed in **Section 7.2.2**.

Note it is proposed to commence soft soil treatments in the area from Tyndale to Maclean from late 2015. As there is no emu mitigation measures proposed in this location, it is not critical to complete surveys in this location prior to commencing this activity however some pre-construction surveys have been conducted. A vehicle-based survey was conducted in the Shark Creek area (Section 4) during the summer, autumn and winter 2014 surveys. Each survey was conducted in the late afternoon (commencing 1400-1500) and continued for 2 hours. This involved slowly driving along local roads and private farm access tracks to the north and south of Shark Creek and surrounding cane farms. Where emus were sighted, notes were recorded on the number of birds at each location, their age and gender if known and locations mapped. The vehicle-based survey is not planned to continue due to the absence of planned mitigation in this area for emu crossing and predominance of cropping land.

Active searches for emus and sign

Each transect is surveyed once per season throughout daylight hours (0700 to 1700) and involves one or two observers walking slowly along the designated transect route and actively searching for signs of emu presence (i.e. droppings, feathers, and footprints) concentrated over a 10 metre wide search area, (5 m either side of the transect line) (refer plates 3-6 for examples of emu sign). The number of signs detected are counted and then removed from each transect. For footprints this means raking over sand and mud and for feathers and droppings removing from the transect. This is done in order to capture fresh sign at the next monitoring event. In addition to recording signs, any observations of emus in the vicinity of transects at the time of the survey are recorded and discussions with landowners conducted where possible during the course of the survey to document observations of emus made by the property owner since the previous monitoring event.

When encountered, the contents of scats are recorded and collected to be compared with reference plant material from each location to document dietary items for input into site landscaping plans.

Plate 3. Example of recent emu feathers 'snagged' on barbed wire

Plate 4. Emu dropping with *Gahnia sieberiana* seed

Plate 5. Example of muddy tracks where emu footprints were apparent

Plate 6. Example of sandy tracks where emu footprints were apparent

A description of the attributes used to record data on emus and their sign are described in **Table 7.2**.

Table 7-2 Description of attributes used to record data on emus and their sign during transect surveys

Emu sign	Attribute
Scats	Age of scat ● Very fresh – Dropping wet and sometimes "steaming". ● Fresh – Dropping has a thin dry outer layer but is still very wet underneath. ● Recent – Dropping dry but wet at centre and base. ● Old – Dropping still maintains its shape but has weak structure, and completely dry throughout. ● Very old – Dropping lack structure or baked hard, very dry and deteriorating, consists of exposed seeds or could be germinating.
Footprint	Social structure ● Solitary bird – no chick prints accompany adult footprints or no group structuring. ● Family group – chick prints accompany the adult print. Including number of chicks if discernible from footprints. ● Social group – multiple adult footprints indicating gathering of emus prior to breeding.
Feathers	Age of feather ● Fresh – Feather moist and bends without interaction. ● Old – feather stiff and dry or deteriorating.
Sightings	Social structure ● Family group – adult male and number of chicks. ● Independent adult – adult plumage and size. ● Independent sub-adult – sub-adult plumage or black-head, small size.

Camera trapping

The use of motion-activated cameras provides the opportunity to collect additional information on emu distribution and seasonal presence and habitat use. Camera trapping uses fixed cameras, triggered by motion-activated sensors, to 'trap' images of passing emus. Subject to access constraints and the availability of suitable attachment points facing adequate open ground, up to two traps have been placed semi-systematically along each of the transects, to provide a total of 4-10 cameras per study area and up to 37 permanent camera stations. Cameras would be occasionally moved to new locations along transects during subsequent surveys if found to be unsuccessful from the preceding survey event.

An additional 43 camera traps have been placed along the temporary exclusion fence near emu crossing zones, and there are a total of 80 cameras being used for the monitoring program to date.

Traps have been placed at a height of approximately 1.5 metres above ground and are not baited. Cameras are set to take pictures 12 hours per day in daylight hours only, with a 5 second delay between exposures to minimise repeat photographs of the same animal while allowing continuous recording to capture additional emus in the case of pairs or juveniles. The date and time of each exposure are recorded on the cameras and image and used to determine if multiple pictures were taken of the same animal to discard consecutive observations. Cameras are left in the field continuously and checked at each monitoring event and batteries and storage cards replaced.

Density and habitat use

Two emu density indexes are calculated for comparison within the site over time and use:

- Number of signs for each transect divided by the search area (transect length x 10 m) reported as density of emu signs per hectare.
- Camera trapping rate, defined as the ratio of emu photographs to the number of trap days multiplied by 100. This provides a comparable index of density as individual recognition of photographed emus and hence capture-recapture analysis is unfeasible. Where multiple pictures are taken of the same animal at the same time these are discarded from the trapping rate calculations.

Data on the relative density of emus reported by these two techniques provides a baseline for monitoring emu activity and habitat use at impact and control sites. The emu density indexes for each site would be compared with ongoing surveys at that site to compare before construction data with during construction and post-construction data and impact versus control sites.

Notes on the habitat structure and floristics for each site were taken from series of random points along each transect which aimed to record dominant plant species in the canopy, mid-strata and ground-covers, the soil type and topography, presence of water bodies, and the degree of naturalness or disturbance at the site. Data on presence and relative density of emus was used to determine the importance of the habitat. The location, habitat and date of opportunistic emu observations were also recorded.

7.2.2 Pre-construction fence monitoring

It is proposed to monitor emu behaviour in relation to the pre-construction temporary fence and the gaps in the fence as designated emu crossing points. Monitoring commenced in December 2014 and will focus on the use of remote sensor activated cameras to be stationed at each of the crossing zones and immediately adjacent areas of the temporary fence to capture images of emus passing along the fence or using the gaps provided. Cameras would be checked quarterly in line with the general emu surveys at the locations described in Table 7-3. Scat searches would be conducted along sections of the fence in proximity to the cameras.

Table 7-3. Monitoring locations for pre-construction exclusion fence

Crossing zone	Station	Description / waterway	Approximate opening (to be monitored)
T1	46055 to 46155	Floodway adjacent to Pillar Valley Creek	100 metres
T2	46325 to 46440	Pillar Valley Creek	115 metres
T3	46647 to 46722	Black Snake Creek	75.5 metres
T4	47070 to 47082	Floodway	12 metres
T5	47643 to 47795	Floodway	152 metres
T6	47900 to 47960	Floodway	60 metres
T7	48400 to 48900	Emu hybrid fence trial	50 metres
T8	48740 to 48835	Mitchells Road realignment	95 metres
T9	49246 to 49366	Floodway	120 metres
T10	50280 to 50325	Un-named creek	45 metres

7.2.3 Aerial survey

A peer review of the draft Plan was conducted by emu expert Professor Stephen Davies, who recommended the trial of an aerial survey to supplement the ground-based surveys in determining emu distribution and abundance in relation to the Project. An aerial survey was conducted as a pilot to test the efficacy of the method for the target species and determine if the density of emus in the study area is of sufficient size to statistically analyse and therefore include in the emu monitoring program as an ongoing annual survey. The outcomes of the pilot study are presented in Appendix E

The pilot study included the following objectives:

1) Trial the transect line method to determine its efficacy for the target species in the Project area and for assessing the sightability of emus from the air.
2) Survey east and west of the proposed Pacific Highway road corridor (within sections 3 and 4) to identify emu distribution and abundance in relation to the Project.
3) Trial a random meander search method in the coastal region east of the study area.

4) Determine if sufficient data can be recorded to identify a baseline for ongoing monitoring of change in the density and distribution of emus during and after construction of the Project and therefore provide meaningful input into the adaptive emu management program

The aerial survey was conducted in October 2014, and concentrated over two survey blocks centred on Section 3 between Pillar Valley and Tyndale (Area A) and Section 4 from the Shark Creek wetlands to the cane properties between Tyndale and Maclean (Area B). Both areas include a range of habitats from pastoral and cropping land (cleared), to wetlands and forest. The two survey blocks were chosen to provide even spatial coverage of the Project area and sample these habitat types known to be used by emus. Area A was approximately 20 km x 10 km between Eight Mile Lane in the south to the Clarence River and Tyndale in the north, east to the foothills of the Pillar Valley Range and Shark Creek Range and west to the Coldstream River and surrounding wetlands. Area B was approximately 10 km x 6 km and extends to upper Shark Creek and associated wetlands and the cane lane surrounding Tyndale and Shark Creek.

Details of the methods and results of the aerial survey are provided in RMS (2014b). The results of the survey confirm a low population density of coastal emus in the study area. Despite a search area of 61.2 km^2, only one adult emu was observed. A second emu was observed southwest of Sandon to the northeast of the Project study area using the random meander search method. Both emus were in open habitat on the edge of forested land and were sighted easily and appeared to remain relatively stationary upon observation. The low sample size was insufficient for statistical analysis.

The pilot study identified two important conclusions;

- Firstly that aerial search methods using helicopter and line transect sampling as well as random searches are both effective at identifying emus from the air and that the line transect method proved an effective method at systematically determining the presence and absence of coastal emus.
- Secondly, that the low population density of emus in the Project study area resulted in the data derived from a single survey being insufficient for robust statistical analysis of population density.

In comparison, the ground-based search methods that are being used in the ongoing monitoring program are considered more effective at identifying emu distribution and abundance through seasonal searches of emu signs and use of motion sensor cameras deployed continuously over different seasons. These results reflect the wide-ranging and semi-nomadic movements of coastal emus where low numbers of birds reside over large areas. As such it is not proposed to continue the aerial survey.

7.2.4 Performance thresholds and corrective actions

The objectives of the mitigation measures are to minimise the impacts of habitat loss and fragmentation and the barrier affect created by the project to maintain the long-term viability of the emu population in the locality. The status of the emu population adjacent to the project would be measured and reported following each monitoring event. Performance thresholds and corrective actions are identified in Table 7-1.

Table 7-1. Performance thresholds and corrective actions for emu movement monitoring

Performance thresholds	Timing and corrective actions
• Greater than 15% decline in emu activity (through signs and detection rates) comparing impact and control areas and before and after data. • No evidence of breeding through sightings of chicks and sub-adults between impact and control areas and before and after data.	• The 15% threshold was set prior to conducting baseline surveys. It will be necessary to review this trigger against pre-construction data to identify normal changes in activity that are occur over time irrespective of the highway disturbance. The threshold would be reviewed and revised where required at the end of the pre-construction monitoring. • Emu activity would be compared with the baseline data at the end of each monitoring event during the construction phase. Regular evaluation and review would be conducted at the end of each monitoring event. • If decline noted after the first 12 months of the post-construction (operational) monitoring, review and modify the monitoring program, to consider different monitoring locations. • Review transects locations and cross reference with performance monitoring of the emu crossing structures and fencing strategy. • Investigate emu habitat adjoining the highway and consider improving habitat condition and connectivity. • If decline still noted after a further 12 months operational monitoring (2 years operation) engage with EPA and consider provisional measures. • Further monitoring of provisional measures would be planned at this stage.

7.3 Monitoring effectiveness of crossing structures

7.3.1 Methods, timing, intensity and duration

The monitoring program would be designed to compare a range of crossing types to determine their effectiveness and inform management decisions, this would include:

- Structure type (raised bridges).
- Landscape type (riparian areas, plantings and open landscapes).
- Attractant type (attractants, versus cleared tracks versus no attractants).

Monitoring of emu crossing structures will be undertaken using a combination of techniques deployed at set monitoring periods, as described below and compared with the pre-construction monitoring of crossing zones determined during the fence trial where applicable. The approach would focus on the combined emu crossing structures in Section 3.

- **Camera traps:** stationed at different locations on the structure depending on the situation. For example given the length of the bridges targeted at emus (i.e. up to 400 metres long) camera stations may include attachment to the bridge underside or mounted cameras on poles or tress at ground level to obtain alternative side views. Cameras would operate continuously with batteries replaced and data downloaded every 3 months in both pre-breeding phase (mid-autumn to late winter) (two sessions) and post-breeding phase (spring-summer) (two sessions).
- **Sign surveys**. As per methodology and timing described in **Section 7.2**. Survey to search for signs, including emu and dogs scat, emu tracks and feather surveys and direct emu sightings. This would include repeat survey of the pre-construction transects which are established east and west of the crossing structures. Additional search transects may be established at the emu crossing zone such as below the bridge structures and along the adjacent exclusion fence.
- **Mortality survey**: Survey of the emu exclusion fence for 200 metres either side of the structure to identify and report any breaches and report maintenance requirements. Survey of the north and southbound carriageway 500 metres either side of the combined emu crossing structures in Section 3 for emus hit by vehicles. The survey would continue for the five years of the program. If any emu road kills are identified on the new Section of highway at Sections 3 and 4 over the course of the next five years from public records then this would also trigger the need for corrective actions.

Emu crossing structure monitoring would commence immediately after construction. Monitoring would be undertaken for a period of five years post-construction to monitor the effectiveness of the emu crossing structures, after which time the need for further monitoring would be reviewed in consultation with EPA and extend a further two years as minimum if required.

The monitoring program would integrate with the emu population monitoring program (**Section 7.2**) that is aimed to assess emu activity in proximity to combined emu crossing structures and crossing zones. Additional monitoring or provisional measures may be required in the event the monitoring data suggests that particular emu structure, landscape or attractant type is ineffective or some more effective than others.

7.3.2 Performance thresholds and corrective actions

Monitoring of the emu crossing structures would be undertaken to assess their effectiveness and inform the need for corrective or provisional measures. The main performance thresholds and corrective actions are outlined in Table 7-2.

Table 7-2. Performance thresholds and corrective actions for crossing structures monitoring

Performance thresholds	Timing and corrective Actions
• No evidence of east-west movements across the project corridor after 5 years post-construction. • Emus found on western side of the highway but no evidence of using crossing structures (i.e. isolation).	If no evidence of emu crossings noted in Section 3 after the end of first year post-construction then: • Review and modify the monitoring methods considering increasing frequency, intensity and duration or a different technique to ensure individuals using crossing structures are identified and not being missed. Compare with data from monitoring transects to see if emus are picked up east and west of the road but not using the crossings and consider concentrating monitoring in those areas as necessary. • Check fauna exclusion fencing and fauna crossing structures for damage/blockage and rectify. • Monitor for a further 12 months. If no evidence of emu crossings noted in Section 3 after the end of the second year post-construction and after change in monitoring method then: • Investigate habitat and plantings / landscape adjoining and under each underpass/bridge in Section 3. Consider improving habitat condition and connectivity where necessary including supplementary plantings and weed or dog control. • Consider use of other artificial attractants to crossing zones to arouse interest and attract emus. • Monitor for a further 36 months to allow plantings to establish. If no evidence of emu crossings noted in Section 3 after the end of the fifth year then: • Review location and type of crossing structures and fauna exclusion fencing and engage provisional measures as outlined in the EIS. • Extend the monitoring program a further 2 years as a minimum to monitor the provisional measures
• A single dog or fox attack reported in proximity to a crossing structure or along the exclusion fence, through evidence of dogs and foxes reported on surveillance cameras and / or a dead emu found.	• RMS to engage with stakeholders involved with predator control and identify actions to assist in minimising attacks.

7.4 Exclusion fence monitoring

7.4.1 Methods, timing, intensity and duration

Operational monitoring would focus on two aspects:

- Monitoring of all hybrid fence gap locations (n=7) to determine their effectiveness in line with an adaptive management approach. The method would apply motion-activated cameras to monitoring movements through the crossing zone and search for signs, on a quarterly basis in line with the broader emu operational monitoring framework.

- Monitoring of the exclusion fence in the vicinity of crossing zones to determine use of crossing zone and movements along the fence.

Monitoring cameras would be installed as a means of trialling the effectiveness of the fence and hybrid fence design. The number and locations of cameras and frequency and timing of the camera monitoring would be determined after construction of the fence, and could be revised during the program in light of any additional information from the emu activity monitoring program.

Cameras would be attached to the fence at strategic locations to ensure sampling of a range of conditions. Cameras would be sensor activated and run continuously, with data collected at the seasonal (quarterly) monitoring events. Sign surveys along the fence are described in Section 7.3.

7.4.2 Performance thresholds and corrective actions

Monitoring of the emu exclusion fences would be undertaken to assess their effectiveness and inform the need for corrective or provisional measures. The main performance thresholds and corrective actions are outlined in Table 7-3.

Table 7-3. Performance thresholds and corrective actions for exclusion fencing monitoring

Performance Indicator	Corrective actions
• Evidence of an emu injured by the exclusion fencing or hybrid fence. • Evidence of an emu breaching the exclusion fencing system and entering the roadway. • Evidence that the hybrid fence is ineffective through the camera monitoring program. • A single road fatality recorded on the highway in Section 3 and 4 of the project during 10 years operation.	• Review monitoring methods, considering further monitoring and assessment. • Survey the area of the breach to determine if the fence has been compromised and then repair • Modify the type of fence being breached. • Repair breach in fence within 5 days of identifying the problem • Modify the hybrid fence if found to be ineffective.

7.5 Emu habitat revegetation monitoring

7.5.1 Methods, timing, intensity and duration

The objective of the emu habitat revegetation is to restore the habitat surrounding the construction footprint and road boundary in Section 3 and 4 of the project to a high condition based on establishing different habitat zones. As emus are known to use both natural and modified habitats, the revegetation is aimed at restoring the original pre-construction condition of the vegetation.

After the first year of development of emu revegetated areas (refer to **Section 5.3.7**), annual monitoring would be undertaken using the BioBanking assessment methodology (DECC, 2008) to evaluate the progress of revegetation against benchmark data for the target vegetation community. This method would only apply for natural revegetation areas and would be based on undertaken an initial 'benchmark' survey prior to construction. The restoration of modified agricultural landscapes would also be based on a benchmark survey although would be based on photo monitoring plots.

BioBanking is a site-based, quantitative and therefore repeatable assessment procedure that provides a numeric score of the condition of native vegetation. Permanent monitoring plots (100 metres x 50 metres) would be established in revegetation areas and assessed for nine site-based vegetation attributes as follows (note the attribute 'number of large trees with hollows' has been removed as revegetation will be from scratch):

1. Native plant species richness.
2. Native over storey cover.
3. Native mid-storey cover.
4. Native ground cover (grasses).
5. Native ground cover (shrubs).

6. Native ground cover (other).
7. Exotic plant cover.
8. Proportion of over-storey species occurring as regeneration.
9. Total length of fallen logs.

Revegetation criteria for the site-based attributes would be developed, derived from benchmark data for each biometric vegetation type for the different vegetation communities and habitats present to the east and west of the project in Sections 3 and 4.

Monitoring of revegetation areas would commence one to two years after initial establishment and would occur annually (in Spring/Summer) for a period of five monitoring events post-construction or until success of the revegetation has been achieved against criteria. The following information would be collected:

- Record of treatments used, including topsoil source, soil treatment, seeding and planting rates and mixes.
- Photographs of the revegetation areas from permanent photographic points.
- BioBanking site-based vegetation attributes from permanent monitoring plots.
- Slope and erosion.
- Any failure of revegetation works.

7.5.2 Performance thresholds and corrective actions

The following table outlines the monitoring program, performance indicators and corrective actions if monitoring finds poor outcomes as measured by performance indicators. Performance indicators and corrective actions are identified in Table 7-4.

Table 7-4. Performance thresholds and corrective actions for emu habitat revegetation

Performance indicator	Corrective actions
Revegetation criteria not been achieved after 5 consecutive monitoring periods post-construction.	Undertake revegetation maintenance, i.e. replanting, fertiliser treatment, erosion control, weed control.

7.6 Evaluation, project review and reporting

7.6.1 Review and amendment of the management plan

The contractor engaged to undertake the emu population monitoring would be responsible for evaluation of impacts from the project on Coastal Emus during the construction and operational stages of the project and annual reporting of the results of the monitoring program. The results of ongoing monitoring will be reviewed after each monitoring event and will be used to inform the effectiveness of the management actions. Depending on the results of the monitoring, updates and amendments to the Management Plan may be required during the construction and operational stages of the project and are the responsibility the contractor engaged to conduct the Coastal Emu monitoring program. The triggers for review should include where Coastal Emus are located during future surveys and clearing. In such instances, an assessment of the connectivity requirements should be undertaken and measures implemented, as required.

Roads and Maritime are responsible for annual review of the plan content and its effectiveness taking into consideration the factors described above. As such, monitoring needs to be proactive, rigorous and focused on identifying the triggers identified for corrective actions as outlined in Chapters 4, 5 and 6 of the plan.

7.6.2 Timing

Annual reports would be prepared to inform the adaptive management and monitoring program. Reports would be prepared by the contractor for distribution to Roads and Maritime, the EPA and DPE and document the methods and results from each monitoring period.

7.6.3 Identify and implement provisional measures

The connectivity strategy provided in the EIS outlined the proposed process for managing emu connectivity requirements. This included monitoring the performance of the connectivity measures against goals.

If during the operational phase emus are found to be unable or unwilling to use designated crossing structures as per the performance measures outlined in this plan then provisional options would be developed. Depending on the outcome of the monitoring of crossing structures the following four options would be considered in consultation with the EPA:

- Maintenance of the existing connectivity measures.
- Modify design of existing measures where feasible and reasonable.
- Construct additional measures.
- Consider additional offset measures to improve connectivity elsewhere.

8. Summary table and implementation schedule

Table 8-1 provides an overall example summary of the actions proposed in the above plan. It also identifies the person responsible for the actions and the estimated timing of the project.

.

Table 8-1: Summary table and implementation schedule of management plan.

No.	Task	Responsibility	Pre-construction	Construction	Operational years									
					1	2	3	4	5	6	7	8	9	10
1.	Pre-construction management													
1.1	Prepare emu fencing strategy	Ecologist and design team	X											
1.2	Pre-clearing survey	Ecologist	X											
1.3	Identify exclusion zones	Contractor	X											
1.4	Identify sensitive ancillary areas	Contractor	X											
1.5	Develop dog policy	Contractor	X	X										
2.	Construction management													
2.1	Develop emus finds procedure	Roads and Maritime		X										
2.2	Vegetation clearing procedure	Ecologist		X										
2.3	Designate temporary emu crossing zones and erect temporary exclusion fence (pre-construction)	Contractor		X										
2.4	Prioritise construction of bridges to minimise disruption to emu movements	Contractor		X										
2.5	Install temporary exclusion fencing (construction)	Contractor		X										
2.6	Revegetation using cover crops at crossing zones	Contractor		X										
2.7	Emu specific revegetation in areas disturbed by construction including crossing zones	Contractor		X										
2.8	Managing domestic waste	Contractor		X										
2.9	Ongoing management of water quality	Contractor		X										
2.10	Ongoing management of dust and noise	Contractor		X										
3. Operational management														
3.1	Maintenance of exclusion fence and hybrid fence	Roads and Maritime			X	X	X	X	X	X	X			
3.2	Maintenance of habitat revegetation	Roads and Maritime			X	X	X	X	X	X	X			
3.3	Contribute to predator control if required	Roads and Maritime			X	X	X	X	X					
4. Monitoring program														
4.1	Emu activity monitoring	Ecologist	X	X	X	X	X	X	X	X	X	X	X	X

No.	Task	Responsibility	Pre-construction	Construction	Operational years									
					1	2	3	4	5	6	7	8	9	10
					review	review	review	review	review	review	review	review	review	review
4.2	Effectiveness of crossing structures	Ecologist		X	X review	X review	X review	X review	X review	X review	X review	X review	X review	X review
4.3	Exclusion fencing monitoring	Ecologist		X	X	X review	X review	X review	X review	X review	X review	X review	X review	X review
4.4	Habitat revegetation monitoring	Ecologist		X	X	X	X							
4.6	Evaluation and reporting	Ecologist	X	X	X	X	X	X	X	X	X	X	X	X

9. References

Department of Environment and Climate Change NSW (DECC) (2008) *BioBanking Assessment Methodology.*

Department of Environment, Climate Change and Water NSW (DECCW) (2010) *Rehabilitation of Protected Fauna Policy.*

Davies, S.J.J.F. (1972). Results of 40 hours' continuous watching at five waterpoints in an Australian desert. Emu, 71, 8-12.

Davies, S.J.J.F. (1976). Studies of the flowering season and fruit production of some arid zone shrubs and trees in Western Australia. J. Ecol. ,64, 665-87.

Davies, S.J.J.F. (1984). Nomadism in response to desert conditions in Australia. *J. Arid Enviro,* 7, 183-93.

Dawson, T.J, Read, D., and Russell, E.M. (1983). Seasonal variation in daily activity patterns, water relations and diet of emus. *Emu,* 93. 17-25.

Harris, I.M., Mills, H.R. and Bencini, R. (2010) Multiple individual southern brown bandicoots (*Isoodon obesulus fusciventer*) and foxes (*Vulpes vulpes*) use underpasses installed at a new highway in Perth, Western Australia. *Wildlife Research* 37: 127-133.

Hayes, I.F. and Goldingay, R.L. (2009) Use of fauna road-crossing structures in north-eastern New South Wales. *Australian Mammalogy* 31: 89-95.

McGrath, R.J., and Bass, D. 1999. Seed dispersal by Emus on the New South Wales North-east coast. *Emu* 99, 248-252.

Roads and Traffic Authority (2011) *Biodiversity Guidelines – Protecting and managing biodiversity on RTA projects,* Roads and Traffic Authority of New South Wales.

Roads and Maritime Service (2012). Upgrading the Pacific Highway Woolgoolga to Ballina Upgrade Working paper: Biodiversity Assessment. November 2012.

RMS (2014a). Pacific Highway Upgrade Woolgoolga to Ballina Emu Fencing Strategy for Sections 3 and 4. Report prepared by Jacobs Group (Australia).

RMS (2014b). Pacific Highway Upgrade Woolgoolga to Ballina Coastal Emu Monitoring Study: aerial survey of emus in Section 3 and 4: a pilot study. Report prepared by Jacobs Group (Australia).

SMEC (2007) *Review of mitigation measures used to deal with the issue of habitat fragmentation.* Department of the Environment and Water Resources. Symonston. ACT.

Taylor, B.D. and Goldingay, R.L. (2003) Cutting the carnage: wildlife usage of culverts in the north-eastern New South Wales. *Wildlife Research* 30(5): 529-537.

van der Ree, R., van der Grift, E., Gulle, N., Holland, K., Mata, C., and Suarez, F. (2007). Overcoming the barrier effect of roads – how effective are mitigation strategies? An international review of the use and effectiveness of underpasses and overpasses designed to increase the permeability of roads for wildlife. In *Proceedings of the International Conference on Ecology and Transportation*. (Eds C. L. Irwin, D. Nelson and K. P. McDermott.) pp. 423–433. (Center for Transportation and the Environment, North Carolina State University: Raleigh, NC.)

Veage, L. and Jones, D.N. (2007) *Breaking the Barrier: Assessing the Value of Fauna-friendly Crossing Structures at Compton Road.* Report for Brisbane City Council. Centre of Innovative Conservation Strategies, Griffith University, Brisbane, Qld, Australia.

Woolgoolga to Ballina Planning Alliance (2012) *Upgrading the Pacific Highway Woolgoolga to Ballina Upgrade Working paper: Biodiversity Assessment.* November 2012

Appendix A. Expert and agency comments and participation

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

ID No	Review	Recommendation / Participation.	How recommendation would be addressed
CeMP1	Expert	It would benefit the monitoring program to fly (about 400 feet above the ground) one or two hour surveys over the flood plain and along the coast in the pre- and post-breeding seasons to complement the land–based monitoring.	Adopted- plan updated December 2014 Version 2. Refer Section 7.3.2 Aerial survey and Appendix E which details the outcomes
CeMP2	Expert	Emus can be controlled by normal rabbit proof fencing with three barbs on top, giving a total height of 1.3 metres. There is no need to have solid fencing as in emu farms, but a vehicle track along the fences will help emus to move along it. I recommend that an exclusion fence of similar design be used along the alignment.	Adopted- however RMS has adopted a 1.5 m high fence design with 1.2 m of mesh on the lower two-thirds and plain or barbed wire on top depending on the location. Refer details in Appendix D emu fencing strategy.
CeMP3	Agency (EPA)	The rabbit proof fencing design mentioned in Version 1 of the plan is not consistent with the design proposed by the RMS in the following document: W2BEW-IFD-20-0000-GE-20140528_GE_FENCING_DETAILS_01. This design utilises plain wire on the top 2 strands and is 1.8m high. The EPA understands the permanent fencing is also designed with consideration of additional threatened species requirements as discussed in section 2.2 of the emu fencing strategy.	The expert review recommended a 1.3 m high fence. RMS has adopted a 1.5 m high fence design with 1.2 m of mesh on the lower two-thirds and plain or barbed wire on top. EPA have reviewed the emu fencing strategy and provided comment, which was incorporated into the fencing strategy. RMS and EPA undertook a site visit of the emu fence on the 10/12/14 no concerns were noted from EPA.
CeMP4	Agency (EPA)	The EPA recommends that fauna fencing is located as close as possible to the road edge thus increasing the amount of available habitat to fauna. Combined fences also reduce the need for duplicate fencing.	For section 3 and 4 in flood prone areas the emu fencing strategy describes that the fence will be placed on the batter, there will be no habitat between the road edge and fence in this instance. Combined fencing is proposed throughout wherever feasible, and explained in the project fencing strategy
CeMP5	Agency (EPA)	Table 6-1 should include the commitment to improve mitigation or include additional offsets; provisional measures etc. if the population is shown to be in decline.	Corrective actions are provided in Table 7-1 as part of the population monitoring approach and explain the need for provisional measures. The form of provisional measures is illustrated in Section 3.6
CeMP6	Agency (DPE)	Section 1.1. It is unclear by whom the project description has been approved, if the approval was given in late 2014 and includes the Staging Plan. It would be useful if the staging plan could be provided.	Section 1.1 also states *Approvals were granted under Part 5.1 of the Environmental Planning and Assessment Act 1979 (EP&A Act) and the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) subject to Ministers Conditions of Approval (MCoA).* RMS has prepared a staging report. Following sign off RMS will provide to agencies for their information.
CeMP7	Agency (DPE)	Section 2.1-2.3. These sections are as per Appendix K of the SPIR. Have the surveys discussed in section 2.4 not provided any additional information that requires updating of this discussion?	The surveys conducted during the pre-survey period support this information. Sections 2.1 to 2.3 provide an overview of the distribution and habitat use by emus over several years of monitoring in the region. Further information has been added from the pre-construction surveys into Section 2.2.4 diet and Section 2.2.5 movements.

CeMP8	Agency (DPE)	Table 3-1. Further to the above, has additional research undertaken on Emu population provided any further indication about the effectiveness of some of these measures (this table is the same as the SPIR but for minor confirmation regarding proposed fencing measures)?	It Is too early to comment on this, the surveys have been conducted over 12 months during the pre-construction phase only. The only mitigation measure adopted is a temporary exclusion fence and monitoring has commenced at fence gaps, although nothing to report in the management plan.
CeMP9	Agency (DPE)	Mitigation Framework Table 5-5. On this point, the Department notes that the conclusion of the Mitigation Framework that '[t]he incorporation of results of the emu surveys allows for more targeted management measures which will increase the effectiveness of the management effort and decrease the impact of the project on the coastal emu.' This comment should directly link to the parts of the Framework that identify out these measures.	The results of the pre-construction emu surveys have provided an indication of areas frequented by emus in proximity to the project corridor in Sections 3 and 4, since summer 2013. These data were used in identifying the appropriate location for the temporary exclusion fence and trial of fence type and fence gaps at crossing zones. Reference to this information in the management plan is found in the emu fence strategy (Appendix D). The results of ongoing quarterly surveys will inform the effectiveness of the fence design and also aid in refining the location of the crossing zones and is providing valuable information on the diet of the coastal emu that will be used in landscape plantings. At this early stage in the monitoring program there are still limitations to the data, as this provides us with a brief snapshot in time and the areas frequented by emus are likely to change over time. Hence any changes to mitigation measures would be applied following ongoing monitoring.
CeMP10	Agency (DPE)	Section 5.3. It is noted that procedures for clearing and setting no-go zones, and mitigation measures for traffic (construction vehicle speeds), waste, water quality, dust and noise, are deferred to the CEMP. Given the requirements of condition D8(c)—details of and demonstrated effectiveness of the proposed avoidance and mitigation and management measures to be implemented—these measures should be detailed in the Plan. The Department reiterates that the alternative is for approval and implementation of the Plan to be deferred until approval of the relevant CEMP documentation.	The coastal emu management plan provides adequate details on the proposed avoidance and mitigation measures to be implemented for the emu, as well as a dedicated section on the effectiveness of these measures where known. The CEMP is a spate document and plan to the coastal emu plan however there are some overlaps with regard to marking no-go zones and avoiding impacts to habitat outside the construction zone.
CeMP11	Agency (DPE)	Section 4.3.2. On this point, the Department considers that the purpose of the Mitigation Framework is to have identified sufficient information to allow finalisation of management measures. As such, it is critical that RMS clarify the statement in this section that '[s]survey data would be used to inform the detailed design and proposed mitigation measures and possible provisional measures'.	The management plan proposes the use of SMART goals and adaptive management measures. Granted the mitigation framework does identify finalise management measures however continued monitoring may assist where emus are found to be unable to or unwilling to use the dedicated crossing structures over time. This was the basis of including the proposed provisional measures which are illustrated in Section 3.6. Continual monitoring surveys may also provide additional data to assist with design refinements of fencing type and location and specifics of the fauna fence design in areas frequented by emus. The whole process of the management structure for emus and other threatened species management plans is based on SMART goals and an adaptive management approach

CeMP12	Agency (DPE)	Section 4.3.3. Further, guidance should be provided on the location of exclusion zones.	This will be provided in the CEMP. In addition added sentence in Section 4.3.3 of the plan Important exclusion zones for coastal emu habitat will be all naturally vegetated areas in Section 3, in particular floodplain swamp forest communities and moist riparian habitats as these comprise reliable food sources and are most frequented as indicated by the monitoring surveys.
CeMP13	Agency (DPE)	Chapter 5. Following on from comment 6, the plan must provide the baseline data against which RMS will measures its commitments, such as 'no change in pre-construction emu movements across the construction corridor.' This would include, for example, the emu density indexes discussed in 7.2.1.	The intention is to report emu density in the annual monitoring reports for coastal emu monitoring and not in this management plan, that way the plan does not need to be updated annually in line with the results.
CeMP14	Agency (DPE)	Table 6-2. What is a 'performance quadrant'?	Changed text to monitoring quadrat
CeMP15	Agency (DPE)	Table 6-2. The dotpoints below this table don't seem to link to the table.	Dot points are the same as provided in Table 7-1 as part of the overall monitoring program. Removed from footnote of Table 6-2 and retained in Table 7-1.
CeMP16	Agency (DPE)	The term 'monitoring period' appears to take a few different meanings, and should be clarified to ensure measurement against the requirements of sub-condition (k).	Plan has been updated to remove any ambiguity
CeMP17	Agency (DPE)	Table 7.2. The corrective action in the first row is only triggered after 3 years. Given the monitoring to date, more information is required to demonstrate: • how this timing has been determined based on the baseline data, and • how the use and effectiveness of the mitigation measures can be demonstrated to have been achieved during any monitoring periods during those three years if no movement is detected.	Table 7.2 has been updated to reduce the trigger response time to 12 months on the first instance, then 2 years and then four years in line with the regular accounts of emus in the study area as determined by the pre-construction monitoring. The overall length before provisional measures are implemented has been shortened to 4 years. Movements of emus in the study area may be influenced by longer term environmental factors other than the road and so the length of time that emus may be found using crossing structures is likely to be measured in years rather than months
CeMP18	Agency (DPE)	Section 7.5. When will these revegetation criteria be developed?	The paragraph has been updated; the benchmark scores for habitat condition would be derived from the already established OEH biometric vegetation type's database and not survey.
CeMP19	Agency (DPE)	Chapter 8. What is likely to change as part of an update 'following a review of the approval and project timelines'	This sentence has been removed.
CeMP20	Agency (DPE)	Appendix A, Appendix C. It is critical that the plan address in detail the requirement that: *recommendations provided for each draft plan in the documents listed in condition A2(c) have been addressed, including detailed justification of any variance from the recommendations of the expert reviewer of the management plans, including analysis of potential risk to the threatened species.* Response to the agency comments provided on previous versions of the plan should be detailed.	Appendix A has been updated with more detail, which addresses the expert comments from Appendix C and the agency comments
CeMP21	Agency (DPE)	Appendix A (CeMP3). Evidence of the approval of fence design by EPA should be provided.	EPA have reviewed the emu fencing strategy and provided comment, which was incorporated into the fencing strategy. RMS and EPA undertook a site visit of the emu fence on the 10/12/14 no concerns were noted from EPA.
CeMP22	Agency (DPE)	Chapter 1.1. Construction of sections 1 and 2 is now scheduled to commence in May 2015. Devils Pulpit has been completed and is now operational.	Changed from April to May 2015 Updated to indicate that Devils Pulpit is now operational

CeMP23	Agency (DPE)	Chapter 1.3.2 and Figure 1-2. The Plan is only updated up to the commencement of construction of the project. The Plan should be amended to include details on the process for monitoring, reviewing and amending the Plan during construction and operation of the project, including the responsibilities for updating and approving the revised plan, the propose timeframe for review (e.g. annually) and any factors which may trigger a review. Triggers for review should include where Coastal Emus are located during future surveys and clearing. In such instances, an assessment of the connectivity requirements should be undertaken and measures implemented, as required.	ADDED: The Coastal Emu Management Plan is intended to be a dynamic document subject to continual improvement during the different stages of the project. Section 7.6.1 has been updated to include the following *The contractor engaged to undertake the emu population monitoring would be responsible for evaluation of impacts from the project on Coastal Emus during the construction and operational stages of the project and annual reporting of the results of the monitoring program. The results of ongoing monitoring will be reviewed after each monitoring event and will be used to inform the effectiveness of the management actions. Depending on the results of the monitoring, updates and amendments to the Management Plan may be required during the construction and operational stages of the project and are the responsibility the contractor engaged to conduct the Coastal Emu monitoring program. The triggers for review should include where Coastal Emus are located during future surveys and clearing. In such instances, an assessment of the connectivity requirements should be undertaken and measures implemented, as required.* *Roads and Maritime are responsible for annual review of the plan content and its effectiveness taking into consideration the factors described above. As such, monitoring needs to be proactive, rigorous and focused on identifying the triggers identified for corrective actions as outlined in Chapters 4, 5 and 6 of the plan.* This process is also now referenced in Section 1.3.2
CeMP24	Agency (DPE)	Table 3-1. Crossing zones would be identified to provide safe access across the road corridor and fencing installed to direct Emus to these crossings. Are the crossing zones located at the permanent crossing (bridge/underpass) locations? Will bridge construction activities frighten Emus from these crossings? The discussion on the history of success of the dust and noise mitigation measures refers to water quality management in the CEMP. This should refer to dust and noise management measures.	Yes the crossing zones are located at the permanent crossing (bridge/underpass) locations. There is a likelihood that the bridge construction activities will temporarily disrupt emu movements, and this is the basis for developing a staged approach to construction of the bridges as discussed in Section 5.3.3. Table 3-1 amended to refer to noise and dust management instead of water.
CeMP25	Agency (DPE)	Chapter 5.3.6. Targeted emu crossings are briefly discussed in this chapter. However, no detail is provided of the number of crossings and why these are suitable and appropriate for Emus. A figure showing the proposed crossing locations should be provided and the justification for the type of structure and its location provided. Such detail has been provided for other threatened fauna management plans. The Department acknowledges detailed design for sections 3 and 4 has not commenced. However, such detail must be provided (it may be appropriate that the management Plan is updated and submitted for the Secretary's approval following detailed design.	Section 3.1.1 of the management plan describes in detail important areas of habitat and land for the coastal emu in relation to intersection with the project corridor, and is used as the basis for justifying the type and location of the emu crossing structures. Section 3.2 and 5.3.6 describes the proposed crossing structures and these are illustrated on Figure 2-1. An additional table has been added (Table 5-1) that identifies all proposed crossing structures targeted for emus as presented in the concept design (SPIR)
CeMP26	Agency (DPE)	Chapter 6.2. First dot point provides goal of zero traffic related mortality after 7 years. Change to 10 years to be consistent with 10 year period nominated elsewhere in the Plan (Table 6-2 and Chapter 7).	Updated to 10 years for consistency. Also updated Table 8-1.

CeMP27	Agency (DPE)	Chapter 7.6. Annual monitoring reports to be provided to DP&E.	Annual reports would be prepared to inform the adaptive management and monitoring program. Reports would be prepared by the contractor for distribution to Roads and Maritime and DP&E and document the methods and results from each monitoring period. Have updated section 7.6.2 to include DP&E. All references to OEH have been changed to EPA.
CeMP28	Agency (EPA)	EPA participated in a meeting held on 2 July 2015 to develop a targeted management procedure and protocol for the Wave 3 early works between Tyndale and Maclean	Section 5.3.2 was added and included a procedure for managing the low risk of emu encounters in the construction corridor and protocol to be adopted during construction to further avoid and manage emu encounters
CeMP29	Agency (EPA)	Detailed design workshop held on 24 July 2015 and attended by RMS, Pacific Complete (delivery partner), Jacobs, and EPA. Purpose was to analyse the emu connectivity structures put forward in the concept design / EIS in light of up to date emu survey information gathered during pre-construction.	Section 5.3.7 and Appendix G was updated to discuss inputs and outcomes of the detailed design workshop.
CeMP30	Agency (EPA)	Table 3.1 Mitigation measures and their effectiveness (and 5.3.8 and as a general note). In the section on Emu-vehicle collisions: Permanent emu exclusion fencing is to be continuous over sections 3 and 4. In this situation the absence of escape gates can be supported unless monitoring suggests their necessity. The extent of permanent exclusion fencing is not made clear throughout the document. The EPA believes the intent has been to fence the entirety of section 3 and 4 and strongly supports this.	Section 5.3.8 of the plan has been updated to clearly articulate the objective of constructing permanent fencing across all of section 3 and 4 (refer text) The permanent emu exclusion fence is to be constructed across Section 3 and 4 from Old Six Mile Lane (station 38,250) to the Maclean interchange (station 80,000) a distance of 41.75 km.
CeMP31	Agency (EPA)	5.3.4 Maintaining Connectivity during stage 2 construction. The staging of construction mentioned in the first paragraph needs to be expanded. For example the July workshop contained discussion around the possibility of early construction of accessible plank bridges. No further mention or resolution to this proposal has been received.	Section 5.3.4 has been updated to reflect the outcomes of the workshop and phone meeting held on 22 October 2015.
CeMP32	Agency (EPA)	5.3.3 temporary emu fences during construction. Temporary emu fencing is restricted to approximately 13 kms of section 3. The EPA therefore encourages a commitment to install permanent fencing throughout section 3 and as soon as possible during or before construction. Please include this commitment in the plan text.	Any areas of cut or fill where flooding is not an issue will include permanent fencing to be progressively constructed after clearing and during construction (refer text added) In locations of section 3 and 4 where temporary fencing is not been used during construction, and where flooding is not a risk, the construction of permanent fencing will commence after the initial vegetation clearing until progressively completed
CeMP33	Agency (EPA)	5.3.8 Permanent emu exclusion fencing. 1) Posts are stated to be concrete or hardwood. Previous versions of the plan have had concrete or steel posts in the permanent fencing. The EPA endorses the use of concrete posts for permanent fencing. If there is a structural/functional reason to include hardwood as a post option please communicate this to stakeholders for consideration. 2) Once again the extent of permanent fencing is never explicitly stated. Neither is it in the fencing strategy in appendix D. The closest reference is it will be in 'Emu habitat'. Survey work to date indicates this is the total area of section 3 and 4 to varying degrees of usage. The EPA has been under the impression that the entirety of section 3 and 4 is to be permanently fenced, this needs to be confirmed in the plan.	Changed to concrete or steel Section 5.3.8 of the plan has been updated to clearly articulate the objective of constructing permanent fencing across all of section 3 and 4 (refer text) The permanent emu exclusion fence is to be constructed across Section 3 and 4 from Old Six Mile Lane (station 38,250) to the Maclean interchange (station 80,000) a distance of 41.75 km.

CeMP34	Agency (EPA)	7.6.2 Timing. Annual reports should also be distributed to the EPA	EPA added
CeMP35	Agency (EPA)	Some references used in the text are missing from the reference list. For example those of Davies (1978;1984), McGrath and Bass (1999) and Dawson et al (1983), from section 2 of the plan	Added
CeMP36	Agency (DPE)	Chapter 5.3.2. 2nd paragraph Permanent exclusion fencing is to be installed where possible on both sides of the cuttings at Tyndale and Green Hills. What type of fencing is to be installed at these two sites? 3rd paragraph Reference is made to Figure 5-2 for design of the sediment fence to be used in the soft soil treatment corridor. There is no Figure 5-2. It is noted that the design of temporary emu exclusion fencing is shown in Appendix F. How will construction areas be secured at the end of the day to prevent emus from entering the construction site?	Added. *The permanent fence will follow the design described in Section 5.3.8.* *Figure 5-2 was in a previous version of the plan and was superseded with a detailed description of the connectivity measures to be adopted during construction. (Section 5.3.4). This has now updated to say refer Appendix F for figure of fence.* Added. *Where gaps are left in the formation, such as the haul road, temporary fence such as ATF is to be established to prevent emus from entering the corridor. This would include closing gaps each evening at the end of work and also on no-work days such as Sundays, wet days and public holidays.*
CeMP37	Agency (DPE)	Chapter 5.3.3. Stage 1 - Pre-construction: temporary exclusion fencing is to be erected at a minimum of 6-months prior to the commencement of Stage 2 construction and targeting areas of high emu activity in section 3. Has the temporary exclusion fencing in Stage 2 work areas (Tyndale and Green Hill cuts in section 4) been erected 6 months prior to Stage 2 (Wave 3 works) commencing? Need to amend the timing to reflect commencement of Wave 3 (part) construction. Stage 2 – Construction: include an additional dot point for the Wave 3 work in section 4 and measures to minimise impacts on emus. This chapter is silent on measures to exclude emus from the construction corridor when main construction commences and fill material is being hauled from the cut to the fill sites.	No, section 5.3.3 refers to the main construction of the upgrade and not the wave 3 works. The temporary fence and crossing zone trial commenced in Section 3 in December 2014. The intention of early deployment was to educate emus on the location of crossing points and trial the effectiveness of the fence at directing emus. The temporary fence for wave 3 works will be installed immediately before the work begins
CeMP38	Agency (DPE)	Chapter 5.3.4. Will the emu crossing locations be closed during the construction hours? Are emus likely to want to cross the corridor during daytime construction? Will the crossings be opened should emus want to cross?	Yes, section 5.3.4 has been amended to make it clearer the process for opening and closing the crossing zones during construction
CeMP39	Agency (DPE)	Chapter 5.3.7 and Table 5-1. It is noted that the final emu crossing structures will be contained in the Fauna Connectivity Strategy required under Condition D2, and which will take into account the detailed design of the project.	Noted
CeMP40	Agency (DPE)	Chapter 5. Separate section should discuss measures to monitor the construction areas and fencing should there be a period of construction inactivity following the completion of soft soil treatment/cutting and the commencement of main construction.	No formal monitoring is proposed at this location, however it is expected that there will be regular activity at this location during the settling period and that the presence of emus would be noted and any issues reported. Added. *During the settling period following completion of the wave 3 works, it is expected that construction access will continue on a regular basis and any observations of emus reported within the construction area will be noted and reported.*

CeMP41	Agency (EPA)	Section 5.3.7. Detailed design workshop held on 4 December 2015 and attended by RMS, Pacific Complete (delivery partner), Jacobs, and EPA. Purpose was to discuss design refinements to a number of bridges in Section 3 considering emu monitoring data for the temporary exclusion fence and fence gaps. analyse the emu connectivity structures put forward in the concept design / EIS in light of up to date emu survey information gathered during pre-construction.	Section 5.3.7 has been amended to reflect minor changes to bridges, this included a reduction in length for a number of bridges and the upgrading of two culverts to 20 metre bridge structures targeted at emus.

Appendix B. Stephen Davies CV

from STEPHEN DAVIES

WATERS UPTON
MOUNT HELENA
WESTERN
AUSTRALIA

S.J.J.F. DAVIES - BIOGRAPHICAL DETAILS

Born	26th. April 1935 at Sydney, N.S.W.
Childhood	Mainly at Castle Hill, near Sydney, but with two years at Thursday Island, Queensland.
Education	The King's School, Parramatta, N.S.W. (1943-1952) and The Elms School, Colwall, Malvern, England (1948).
Undergraduate	Emmanuel College, Cambridge, 1953-1956. Graduated with 2.1 honours in Part II Zoology in 1956. I attended courses in Botany (2 years), Organic Chemistry (1 year) and Biochemistry (1 year). I attended a marine course at Bangor, Wales, in 1955, two bird biology courses at Oxford (1955,1956) and visited Swedish Lapland in 1955 as a member of the Cambridge Lapland Expedition 1955. Most of my vacations were spent with my uncle in rural Shropshire.
Post-graduate	I joined the Wildlife Survey Section of CSIRO in 1956 and studied the behaviour and ecology of Magpie Geese at Darwin 1956-1959. During and after those years I carried out a number of experimental studies on the behaviour of captive Magpie Geese. In 1959 I moved to Western Australia to begin studies of the pattern of movement of Emus in north-western Australia and of White-tailed Black Cockatoos in south-western Australia.
PhD Course	1961-1964 at the Sub-department of Animal Behaviour, Madingley, Cambridge, England under the supervision of Professor W.H. Thorpe, FRS, on studies of the behaviour of *Streptopelia* doves and their hybrids in captivity. I attended the 1961 (Germany) and 1963 (Holland) International Ethological Congresses and the Paris Symposium on Antarctic Biology in 1963. I assisted with the running of a freshwater biology course at Slapton Ley Field Studies Centre in 1963, and at Scolt Head Island in 1964. I visited Corsica on fieldwork in 1963. I visited Skolholm Island, Wales with a Ministry of Agriculture, Fisheries and Food field party to study rabbits in 1962.
1964-1975	With CSIRO, Division of Wildlife Research, continuing studies of the movement patterns of Emus, which led into studies of the environmental variables of the mulga zone, and studies of other arid zone organisms. Officer-in-Charge of the Helena Valley Laboratories of the Division 1969-1983, where a programme developed relating the ecology and behaviour of various bird species. I continued work on the behaviour of *Streptopelia* doves leading to the recognition of the critical relationship between the bird's display and its nest-building activities as a mechanism for the stimulation of ovulation in the hen. In 1966 I visited Macquarie Island with the Australian National Antarctic Research Expedition. In 1973 I was a member of the Australian delegation to the third US/Australian Workshop in Range Science at Tuscon, Arizona, U.S.A. In 1974 I was appointed to the Western Australian Wildlife Authority on whose committees I had served since 1971. I was a member of the Australian Committee of the 16th. International Ornithological Congress in Canberra in 1974 and of its Scientific Programme Committee. In 1975 I attended the Association of Animal Behaviour

meeting in Aberdeen, Scotland, and the British Ornithologists Union Conference at Wexford, Ireland, and inspected waterfowl conservation in Ireland.

1976-1998 Officer-in-Charge, CSIRO Helena Valley, until 1983. Director, Royal Australasian Ornithologists Union 1984-1989. Adjunct Professor, School of Environmental Biology, Curtin University of Technology from 1989, and concurrently, Adjunct Professor Environmental Science Murdoch University from 2003. Research Liaison Officer, Division of Environmental Science, Murdoch University, 1990-1999. Other RAOU offices: President , RAOU, 1975-1978; Chairman Research Committee 1975-1984; Fellow 1980; Chairman, WA Group of the RAOU 1970-1984. President, Gould League of WA, 1982-1983. President Royal Society of WA, 1983-1984. Patron, Avicultural Society of WA, 1979-1984. Member, International Ornithological Committee, 1974-1982. Member, Scientific Programme Committee, International Ethological Congress, 1983. Member Western Australian Wildlife Authority, 1974-1984. Member, Conservation Programme Committee of World Wildlife Fund Australia 1978-1984; Trustee 1984-1990; Goverrnor 2007 - present. One of three international speakers invited to "Birds and Man" Symposium in Johannesburg in April 1983. I visited the Percy Fitzpatrick Institute of African Ornithology and the Oudtshoorn district where I visited Ostrich farms and processing facilities. Chairman, Accreditation Panel, Degree of Master of Applied Science in Environmental Science, Western Australian Institute of Technology, January 1985. In November 1985 I was the non-government member of the Australian Delegation to the Third Consultative Meeting of the Japan-Australia Migratory Bird Agreement in Tokyo. from 1986 to 1993 I was a member of the Editorial Committee of the *Fauna of Australia* (ANPWS). In 1986-1987 I was Chairman of the Management Committee of the Ngangganawilli Community Emu Farm at Wiluna, WA. In 1986 I was appointed to the WA Department of Conservation and Land Management, Herdsman Lake Management Advisory Committee and have been Chairman since 1991. I attended and spoke at the International Ornithological Congress at Ottawa, Canada, in June 1986, and was appointed to the IOC Committee on Applied Ornithology, became a member of the Working Group on Birds as Indicators of Environmental Change and was appointed Chairman of that Working Group in 1998. Attended the IOC meeting in Vienna, Austria, in 1994. I was appointed by the Victorian Department of Conservation, Forests and Lands to the Review Committee on the Possession and Trade in Wildlife from 1987-1989. I was elected a Corresponding Member of the British Ornithologists Union in 1987-97. I was made an Honorary Member of the Emu Farmers Federation of Australia in 1989 and was Chairman of its Research and Information Committee 1995-8. I was appointed to the Board of Whiteman Park, WA in 1991. In 1992 99 I was elected to the national committee of the Australian Rare and Minority Breeds Association; vice-president 1993-99. I was a member of the WA Rhodes Scholarship Selection Committee in 1994-1996. Appointed to the WA Recovery Team for Carnaby's Cockatoo in 2003 and the WA and National Recovery Teams for Malleefowl in 2004.

Sc.D. I was admitted to the ScD. degree by Cambridge University in 1988.

Scholarships 1953-1956 Broughton and Forrest Exhibition from The Kings School, Parramatta, to Cambridge. 1961-1964 CSIRO Overseas Studentship to the Sub-department of Animal Behaviour, Cambridge.

Teaching From 1969-1972 I gave an annual course on Animal Behaviour to the honours school of the Department of Psychology in the University of Western Australia. From 1984 to 1988 I lectured in Wildlife Management at the School of Agriculture and Forestry, Melbourne University, and in 1986 gave two courses on Wildlife Management at Footscray College of Technical and Further Education (Victoria). In 1989 I contributed twelve lectures and six practicals to the 202 second year vertebrate biology course at Curtin University of Technology; from 1997 I have contributed six lectures and three practicals to this course. From

1991 I have been Course Coordinator for the Landcare Revegetation Unit of the Graduate Diploma in Landcare offered by Curtin University of Technology. I have given several series of extension lectures on animal behaviour and on birds for the University of Western Australia. I have demonstrated at the Murdoch University Ecology Camp from 1992, and lectured in Management of Aquatic Systems and Monitoring Fauna units. I have supervised 26 honours, 4 masters and 13 PhD students, all of whom have completed their degrees.

Valuations — I have been a registered valuer of Biological Material with the Cultural Gifts and Bequests Programs (and precursors) since 1985.

Consulting — Scientific Consultant to Iluka Resources Ltd Capel Wetlands Centre, since 1989. Ecological Consultant to Mundaring Christian School, 1992-1993. Ornithological Consultant to Government House, Perth, Grounds Maintenance Advisory Committee 1994-97. Prepared fauna survey reports for Cobra Station, Gascoyne (1984), Trickle Creek, Parkerville (1989), Koobabbie Farm, Coorow (1990) (this farm was runner-up in the Greening Western Australia, John Tonkin Award (private landholder) 1994). Conducted bird surveys at Kangaroo Hills and Calooli Timber Reserves, Coolgardie (CALM 1991), Innering Catchment (Carnamah LCDC, 1992), Western Reefs Mt. Farmer prospects (1995) and conducted biological survey of unmade road reserves in the Shire of Dumbleyung, 1993 (this survey was part of the winning entry in the Greening Western Australia John Tonkin Award (Local Government) 1994). Prepared a Management Plan for the Churchmans Bushland Association (Churchman Regional Open Space) 1996-98. Conducted weekend workshops on Wildlife on Farms at Birralee, Kukerin (1990), at Wybalena, Kojonup, (1990) and on Farm Dams at Tincurrin, 1992. Flora surveys of the Marchagee, Waddy Forest and Wilton Well Catchments for the National Heritage Trust 1999-2000. Conducted search for new populations of a rare plant *Chorizema humile* in WA in 2000 (CALM) Undertook a consultancy "Coast and Catchment" on Carnaby's Cockatoo for the Moore Catchment Council, 2001. Surveyed the vegetation structure and bird communities of the Latham Land Conservation District, 2001. Undertook biological survey of the Mullewa Land Conservation District, 2001-2002. Advice to the NSW Roads and Maritime Service on the realignment of the Pacific Highway around Grafton. December 2007. External Triennial Review of the Department of Environment and Conservation Ethics Committee, March 2011.

Hobbies Include breeding Shropshire sheep of which I have maintained a stud since 1969; I exhibit the sheep regularly in the Perth Royal Show and Wagin Woolarama.

LIST OF PUBLICATIONS BY S.J.J.F. DAVIES, Sc.D.

Ambrose, S.J. and S.J.J.F. Davies. (1989). The social organisation of the White-browed Scrubwren *Sericornis frontalis* Gould (Acanthizidae) in arid, semi-arid and mesic environments of Western Australia. *Emu* **89**:40-46.

Bamford, A.R., S.J.J.F. Davies and R. van Delft. (1989). Model boats: their effects on waterbirds at Herdsman Lake. *RAOU Report* No. **48**.

Bamford, A.R., Davies, S.J.J.F. and van Delft, R. (1990). The effects of model power boats on waterbirds at Herdsman Lake, Perth, Western Australia. *Emu* **90**:260-265.

Bamford, M. and Davies, S. (1991). Waterbird usage of the lakes at the AMC Wetlands Centre, Capel, Western Australia, December 1986 to August 1989. *AMC Wetlands Centre Technical Report* No. **13**:1-33.

Bamford, M.J., S.J.J.F. Davies and P.G. Ladd. (1991). *Biological Survey of Kangaroo Hills and Calooli Timber Reserves, Coolgardie, Western Australia.* 108 pp. Perth.

Barratt, B., Davies, S., Garstone, R. and Graham, M. (1994). *Birds of the Great Southern.* Dongalocking Corridors Project. (2 copies).

Beutel, P.M., S.J.J.F. Davies and W.C. Packer. (1983). Physical and physiological measurements of Emu eggs and chicks. *Intern. Zoo Handbook* **23**:175-181.

Blakers, M., S.J.J.F. Davies and P.N. Reilly. (1984). *Atlas of Australian Birds.* Melbourne, Melbourne University Press. 738pp.

Brown, R.J., Brown, M. N., Davis, M. J. and Davies, S. J. J. F. (2005) Observations on the changes in status and movements of birds at the Middlesex Field Study Centre, Manjimup, Western Australia, based on twenty-five years of daily records. *Curtin University of Technology, Department of Environmental Biology Bulletin* No. **26**.

Busby, J.R. and S.J.J.F. Davies. (Eds) (1977). *Distribution of Birds on the Australian Mainland: Dr. Serventy's Maps.* Melbourne, CSIRO. 355pp.

Calver, M. C., Davies, S. J. J. F., and Brown, C. (1997). A search for new species of phorids (Diptera: Phoridae) in south-western Australia. *Myrmecia*, **November 1997**, 6-8.

Cowling, S.J. and S.J.J.F. Davies. (1983). Status of Australian birds with special reference to captive breeding. *Victorian Dept. of Conservation, Forests and Lands, Fisheries and Wildlife Service, Field Management Branch, Tech. Rep. Ser.* No. **1**:1-21.

Davies, S.J. (1952) Unusual bird visitors. *Wildlife and Outdoors* **16**:268.

Davies, S.J.J.F. (1957). The gosling of the Magpie Goose. *Emu* **57**:354-355.

Davies, S.J.J.F. (1958). The breeding of the Meadow Pipit in Swedish Lapland. *Bird Study* **5**:184-191.

Davies, S.J.J.F. (1959). A note on the shearwaters breeding on the Tollgates Island, N.S.W. *Emu* **59**:287-288.

Davies, S.J.J.F. (1960). A note on two small mammals of the Darwin area. *J. Roy. Soc. W.A.* **43**:61-66.

Davies, S.J.J.F. (1961). The orientation of pecking in very young Magpie Geese. *Ibis* **103a**:277-283.

Davies, S.J.J.F. (1961). Magpie Goose behaviour. *Australian Museum Magazine* **13**:314-318.

Davies, S.J.J.F. (1961). Some aboriginal sites in the Murchison district of Western Australia. *W. Aust. Nat.* **8**:1-5.

Davies, S.J.J.F. (1962). The response of the Magpie Goose to aerial predators. *Emu* **62**:51-55.

Davies, S.J.J.F. (1962). The nest-building behaviour of the Magpie Goose. *Ibis* **104**:147-157.

Davies, S.J.J.F. (1963). Emus. *Australian Natural History* **14**:225-229.

Davies, S.J.J.F. (1963). Aspects of the behaviour of the Magpie Goose, Anseranas semipalmata. *Ibis* **105**:76-98.

Davies, S.J.J.F. (1964). Behaviour studies of Antarctic animals. *1st. Symposium on Antarctic Biology. Paris, 1962.* (Hermann, Paris). pp 395-400.

Davies, S.J.J.F. (1966). The movements of the White-tailed Black Cockatoo (*Calyptorhynchus baudinii*) in south-western Australia. *W. Aust. Nat.* **10**:33-42.

Davies, S.J.J.F. (1967). Measurements of some *Streptopelia* doves and their hybrids. *Bull. Brit. Orn. Club* **67**:81-86.

Davies, S.J.J.F. (1967). Sexual dimorphism in the Emu. *Emu* **67**:23-26.

Davies, S.J.J.F. (1968). Aspects of a study of Emus in semi-arid Western Australia. *Proc. Ecol. Soc. Aust.* **3**:160-166.

Davies, S.J.J.F. (1969). An aerial survey of inland Western Australia. *Tech. Memo. Div. Wild. Res. CSIRO, Aust.* No. **1**.

Davies, S.J.J.F. (1970). Patterns of inheritance in the behaviour of *Streptopelia* doves and their hybrids. *Behaviour* **36**:197-214.

Davies, S.J.J.F. (1970). A list of plants and animals found at Mileura, Western Australia. Lat. 26° 22'S, Long. 117° 20'E. *Tech. Memo. Div. Wild. Res. CSIRO, Aust.* No. **3**.

Davies, S.J.J.F. (1972). Results of 40 hours' continuous watch at five waterpoints in an Australian desert. *Emu* **72**:8-12.

Davies, S.J.J.F. (1972). Emu. pp. 666-667 *in* Friedhoff, H. (Ed.) *Encylopedia of the Animal World.* London, Elsevier.

Davies, S.J.J.F. (1973). Environmental variables and the biology of native Australian animals in the mulga zone. *Trop. Grasslands* **7**:127-134.

Davies, S.J.J.F. (1973). Application of co-ordinated research on birds to Australian conditions. *Emu* **73**:217-221.

Davies, S.J.J.F. (1974). The interpretation of the function of avian display. *Emu* **74**:18-26.

Davies, S.J.J.F. (1974). Studies of the three coo calls of the male Barbary Dove. *Emu* **74**:18-26.

Davies, S.J.J.F. (1974). The breeding season of captive Barbary Doves, *Streptopelia risoria*, at Helena Valley, Western Australia. *Aust. Wildl. Res.* **1**:85-88.

Davies, S.J.J.F. (1975). Land use by Emus and other wildlife species in the arid shrublands of Western Australia. *Proc. 3rd. Workshop US/Aust. Rangelands Panel, Tuscon, Arizona,* **1973**:91-98.

Davies, S.J.J.F. (1976). Studies of the flowering season and fruit production of some arid zone shrubs and trees in Western Australia. *J. Ecol.* **64**:665-687.

Davies, S.J.J.F. (1976). The natural history of the Emu in comparison with that of other ratites. *Proc. 16th. Intern. Ornith. Cong.*:109-120.

Davies, S.J.J.F. (1976). Environmental variables and the biology of birds of the Australian arid zone. *Proc. 16th. Intern. Ornith. Cong.*:481-488.

Davies, S.J.J.F. (1977). The timing of breeding by the Zebra Finch *Taeniopygia castonotis* at Mileura, Western Australia. *Ibis* **119**:369-372.

Davies, S.J.J.F. (1977). Man's activities and birds' distribution in the arid zone. *Emu* **77**:169-172.

Davies, S.J.J.F. (1978). The food of Emus. *Aust. J. Ecol.* **3**:411-422.

Davies, S.J.J.F. (1979). The breeding seasons of birds in south-western Australia. *J. Roy. Soc. W.A.* **62**:53-64.

Davies, S.J.J.F. (1980). A bird census of Garden Island. *W. Aust. Nat.* **14**:220-224.

Davies, S. (1981). The Atlas of Australian Birds – Its Implications for Australian Ornithology: the Crosbie Morrison Lecture, 1981. *Trees and Victoria's Resources* **24**:28-32.

Davies, S.J.J.F. (1982). Behavioural adaptations of birds to environments where evaporation is high and water is in short supply. *Comp. Biochem Physiol.* **71A**:557-566.

Davies, S.J.J.F (1982). Harry Frith – an appreciation. *Emu* **82**:123-4.

Davies, S.J.J.F. (1982). Counting bush birds at Eyre. *RAOU Report* No. **3**:43-52.

Davies, S.J.J.F. (Ed.) (1982). *Bushbirds in Captivity.* Perth, Avicultural Society of W.A. 40pp.

Davies, S.J.J.F. (1983). Emus in Western Australia. In Riney, T. (Ed.) *Wildlife Management in the 80's.* Melbourne: Graduate School of Environmental Science, Monash University:240-247.

Davies, S.J.J.F. (1984). Nomadism as a response to desert conditions in Australia. *J. Arid Environ.* **7**:183-193.

Davies, S.J.J.F. (1984). *The Wildlife Potential of Cobra Station.*

Davies, S.J.J.F. (Ed.) (1984). Methods of Censusing Birds in Australia. *RAOU Report* No. **7**:1-63.

Davies, S.J.J.F. (1985). Nest function. In Campbell, B. and E. Lack (Eds). *A Dictionary of Birds.* Calton, T. and A.D. Poyser :388-389.

Davies, S.J.J.F. (1985). The significance of nest-building behaviour in Magpie Geese to the role of nests in avian courtship. *Proc. Symp. Birds and Man, Johannesburg* **1983**. :225-245.

Davies, S.J.J.F. (1985). Emus and Cassowaries. pp. 24-27 *in* Perrins, C.M. and Middleton, A.L.A. (Eds.).*The Encyclopedia of Birds.* Oxford, Equinox.

Davies, S.J.J.F. (1985). Regenrating mobile sand dunes at Eyre. *RAOU Report* No. **9**:66-72.

Davies, S.J.J.F. (1986). A biology of the desert fringe. *J. Roy. Soc. Western Australia.* **68**:37-50.

Davies, S.J.J.F. (1986). Barefoot Biology. pp 152-156, *in* Williams, R. (Ed.) *Science Show II.* Melbourne, Nelson.

Davies, S.J.J.F. (1987). Obituary; Dr. Julian Ford. *Emu* **87**:132.

Davies, S.J.J.F. (1987). Wiluna's Fashion Farm. *Landscope* **2**:18-23.

Davies, S. (1988). Case History - How the conservative RAOU moved to modern fund raising. *Australian Direct Marketing* Vol. **1**, No. **5**:38-47.

Davies, S.J.J.F. (1989). Nomadism in the Australian Gull-billed Tern. *Proc. 19th. Intern. Ornith. Congr.*: 744-753.

Davies, S.J.J.F. (1989). Obituary; Dr. Dominic Louis Serventy (1904-1988). *Ibis* **131**:448-450.

Davies, S.J.J.F. (1989). *An appraisal of the wildlife potential of Trickle Creek, Parkerville*. Made at the request of Terry Giles.

Davies, S.J.J.F. (1990). *Report on a survey of the wildlife of Koobabbie, Coorow.* Prepared for A. & J. Doley.

Davies, S.J.J.F. (1990). *An appraisal of the wildlife potential of Koobabbie, Coorow.* Prepared for A. & J. Doley.

Davies, S.J.J.F. (1990). *An appraisal of the wildlife potential of Lot 283, Mundaring.* Prepared for Swan Christian School.

Davies, S.J.J.F. (1990). *Report on a survey of the wildlife of Koobabbie, Coorow.* 47pp.

Davies, S.J.J.F. (Ed.) (1990). *Landcare Revegetation, 501.* Unit Guide. Curtin University of Technology. (Revised and reprinted yearly to 2002)

Davies, S.J.J.F. (1990). An Australian perspective on New Zealand Ornithology. pp 146-7 in Gill, B.J. and Heather B.D. (eds) *A Flying Start*. Auckland: Random Century.

Davies, S.J.J.F. (1991). Obituary: Glen Milton Storr. *Emu* **91**:66.

Davies, S.J.J.F. (1992). An appreciation: Harry Frith. *Emu* **92**:123-124.

Davies, S.J.J.F. (1995). Adaptations of birds to arid Australia. *Wingspan* **5**:12-13.

Davies, S. (1997). Twelve years on: conservation and industry at Capel, WA. *Wingspan*, **7**, 6-9.

Davies, S.J.J.F. (1998). Ratites and tinamous. pp. 46-49 *in* Forshaw, J. (Ed.). *Encyclopedia of Birds*. Sydney, Weldon Owen.

Davies, S. (2000). Survey in search of new populations of *Chorizema humile* (Fabaceae) in the Western Australian Wheatbelt. *Report to CALM, Moora.* 15pp.

Davies, S. (2001). Learning from the past. *Wingspan* **11**, No. 2:8-11.

Davies, S. (2001). Birds of the century. *Wingspan* **11**, No. 2:12-17.

Davies, S. J. J. F. (2002). The Capel Wetlands Centre: A survey of its historical developments, significance and research results. *Curtin University of Technology, Department of Environmental Biology Bulletin* No. **22.**

Davies, S.J.J.F. (2002). *Ratites and Tinamous*. Oxford, Oxford University Press.310pp.

Davies, S. (2002). *Interim report on a biological survey of the Mullewa Land Conservation District - 2001 - 2002*. Perth.

Davies, S. J. J. F. (Ed.) (2003). The Moore River Catchment Forum 2000: Thinking beyond today. *Curtin University of Technology, Department of Environmental Biology Bulletin* No. **24.**

Davies, S. (2004). Obituary – Stephen Marchant 1912-2003. *Emu* **104**:89-90.

Davies, S. (2005). *Usage of Artificial Nest Boxes by Carnaby's Cockatoo: Assessment of Status 2004*. Report to WWF and Men of the Trees, Perth.

Davies, S. (2005). *Information on the White-faced Heron and its status on Lot 49, Wright Road, Forrestdale, W.A.* Prepared for Bowtell Clark + Yole.

Davies, S. J. J. F. (Ed.) (2005). The Drummond Symposium. *Curtin University of Technology, Department of Environmental Biology Bulletin* No. **27.**

Davies, S. J. J. F. (Ed.) (2008). Katanning National Malleefowl Forum 2007, Proceedings. *Curtin University of Technology, Department of Environmental Biology Bulletin* No. **28.**

Davies, S. (2008). Obituary – Vincent Noel Serventy: an Appreciation. *Wingspan* **18**:45.

Davies, S. (2008). In search of a field station for naturalists. *In* de Rebeira, A. (Ed.) *Eyre's Sand Patch to Eyre Bird Observatory*. Perth: 6.

Davies, S. (2009). Pebble-mound mice. *Western Wildlife* **13**:11 and 13.

Davies, S.J.J.F. (2010). Long-term indices of density of ten woodland passerines at Eyre Bird Observatory. *Corella* **34**:1-6.

Davies, S.J.J.F. (2010). Review of "Boom and Bust: bird stories for a dry continent" Robin, L., Heinsohn, R and Joseph, L. (Eds.) *Pacific Conservation Biology*. **16**:70-71.

Davies, S.J.J.F. (2010). Five weeks with Lapland Birds – An account of the Cambridge Lapland Expedition 1955. *Curtin University of Technology, Department of Environment and Agriculture Bulletin* No. **30**.

Davies, S.J.J.F., M. Bamford and M.J. Bamford. (1988). The Night Parrot: a search in the Lake Disappointment area, September 1987. *RAOU Report* No. **49**.

Davies, S.J.J.F., M. Bamford, S. McNee and C. Watkins. (1993). *A Survey of Unformed Roads in the Shire of Dumbleyung, Western Australia.* Prepared for the Shire of Dunbleyung. (2 copies).

Davies, S., Bamford, M. J. and Bamford, A. R. (1995). *Western Reefs Ltd. Golden Wing and Gilbey's Prospects (Dalgaranga area): Site Assessment, Fauna.*

Davies, S.J.J.F. and Beck, M.W.R. (1968). A nesting record of the Painted finch, *Zonaeginthus pictus* on Mount Hale, Murchison District, W.A. *W.A. Naturalist* **11**:71-72.

Davies, S.J.J.F., M.W.R. Beck and J.P. Kruiskamp. (1971). The results of banding 154 Emus in Western Australia. *CSIRO Wildl. Res.* **16**:77-79.

Davies, S.J.J.F. and R. Carrick, (1962). On the ability of the Crested Tern, Sterna bergii, to recognise their own chicks. *Aust. J. Zool.* **10**:171-177.

Davies, S.J.J.F., D.P. Congreve and P. Congreve. (1985). More counts of bush birds at Eyre. *RAOU Report* No. **9**:93-108.

Davies, S.J.J.F. and G.S. Chapman. (1975). The status of birds on Peron Peninsula and Dirk Hartog Island, Shark Bay, W.A. *Emu* **75**:55-59.

Davies, S. J. J. F. and Creese, S. (2009). Studies of two species of bat (Microchiroptera) in the Murchison District of Western Australia, 1960-2007. *Curtin University of Technology, Department of Environmental Biology Bulletin* No. **29.**

Davies, S. and Douglas, T. 2010. Techniques in Bird Studies Course – 29th. November – 5th. December 2009. *W A Bird Notes* No.**133**:26-7.

Davies, S. and Douglas, T. 2011. Field Techniques in Bird Studies Course, Eyre Bird Observatory – November – December 2010 – Course Report and Summary of Results. *W A Bird Notes* No.**138**:18-19.

Davies, S. and Douglas, T. 2012. Field Techniques in Bird Studies Course, Eyre Bird Observatory – November – December 2011 – Course Report and Summary of Results. *W A Bird Notes* No.**141**:33-35.

Davies, S. and Douglas, T. 2013. Field Techniques in Bird Studies Course, – November – December 2012 – Report on the course and Summary of Results. *W A Bird Notes* No.**145**:43-44.

Davies, S.J.J.F. and C.H. Fraser Rowell. (1956). Observations on the Redwing in Swedish Lapland. *Bird Study* **3**:242-248.

Davies, S.J.J.F. and C.H. Fraser Rowell. (2010). Ornithological Report of the Cambridge Lapland Expedition 1955. *In* Davies, S.J.J.F. (2010). Five weeks with Lapland Birds – An account of the Cambridge Lapland Expedition 1955. *Curtin*

University of Technology, Department of Environment and Agriculture Bulletin No. **30**:2-33.

Davies, S.J.J.F. and H.J. Frith. (1964). Some comments on the taxonomic position of the Magpie Goose. *Emu* **63**:265-272.

Davies, S. and Kenny, S. (2008). Techniques in bird studies – Eyre course report and summary of results, 2007. *WA Bird Notes* No. **125**:11-13.

Davies, S.J.J.F., T.A. Knight, G.H. Pfitzner and C.P.S. de Rebeira. (1977). Ejah Breakaways, Mileura, Cue, as an aboriginal home. *W. Aust. Nat.* **13**:177-183.

Davies, S. and Ladd, P. (2000). A survey of the flora remnants within the Waddy Forest Land Conservation District. *Report to Waddy Forest LCDC.* 69pp.

Davies, S. and Ladd, P. (2000). A survey of the flora of remnant vegetation within the Marchagee Catchment. *Report to the Marchagee Catchment Group of the Coorow Land Conservation District.* 76pp.

Davies, S., Ladd, P. and Loomes, D. (2001). A survey of the flora of remnant vegetation within the Wilton Well catchment. *Report to the Wilton Well Catchment Group of the Three Springs Land Conservation District.* 43pp.

Davies, S., Ladd, P. and Loomes, D. (2001). A survey of the flora of remnant vegetation within the Marchagee Catchment - second report. *Report to the Marchagee Catchment Group of the Coorow Land Conservation District.* 45pp.

Davies, S, T. Lloyd and D. Lloyd. (1991). Rural roadside bird counts - summer 1990/1991. *WA Bird Notes* No. **60**:2-3.

Davies, S., Loomes, D., Simmons, T. and Edward, K. (2001). Surveys of the vegetation structure and the bird communities in eighty sites on remnants in the Latham Land Conservation District, February 2001. *Report to the Latham Land Conservation District Committee.* 50pp.

Davies, S. and Loomes, D. (2002). *Carnaby's Cockatoo - Coast and Catchment- Draft Final report on the project.* Perth.

Davies, S., Metcalf, B and Clinch, M. (2003). *Report on a biological survey of the Mullewa Conservation District - 2001-2002.* Report for the Mullewa LCDC.

Davies, S. and Silberstein, M. (1984). Mapping a Continent's Birds – The Australian Atlas. *BTO News* No. **133**:6-7.

Davies, S.J.J.F., G.T. Smith and F.N. Robinson. (1982). The Noisy Scrub-bird in Western Australia. in Grove, R.H. and W.D.L. Ride (Eds). *Species at Risk: Research in Australia.* Canberra, Australian Academy of Science: 117-127.

Davies, S.J.J.F. and T.F.M. Walsh. (1979). Observations on the regeneration of shrubs and woody forbs over a ten year period in grazed quadrats on Mileura Station, Western Australia. *Aust. Rangel. J.* **1**:215-224.

Doyle, F. W., and Davies, S. J. J. F. (1999). Creation of a wetland ecosystem from a sand mining site: a multidisciplinary approach. In *Wetlands for the Future*. (eds. McComb, A. J., and Davis, J. A.) pp 761-72.

Frith, H.J. and S.J.J.F. Davies. (1958). The Magpie Goose. *Australian Museum Magazine* **12**:348-351.

Frith, H.J. and S.J.J.F. Davies. (1958). Wild geese and rice cultivation in the Northern Territory. *South Pacific*. May-June **1958**:1-7.

Frith, H.J. and S.J.J.F. Davies. (1961). Ecology of the Magpie Goose, *Anseranas semipalmata*. *CSIRO Wildlife Research* **6**:91-141.

Frith, H.J. and S.J.J.F. Davies. (1961). Breeding seasons of birds in sub-coastal Northern Territory. *Emu* **61**:97-111.

Fullagar, P.J., K.W. Lowe and S.J.J.F. Davies. (1989). Intracontinental migration of Australian birds. *Proc. 19th. Intern. Ornith. Congr.*: 791-801.

Gleadell, E. R., Bamford, M. J., Bowen, B. J., and Davies, S. J. J. F. (1999). An annotated list of Walmajari and Mangala names for natural features, plants and animals in the Great Sandy Desert, Western Australia. *W. A. Naturalist*, **22**, 199-204.

Higgins, P., and Davies, S.J.J. F. (Eds.) (1996). *Handbook of Australian, New Zealand and Antarctic Birds*. Vol. 3. Oxford University Press, Melbourne. 1028pp.

Jellie, A. B. and Davies, S.J.J.F. (1961). *The Jellies of Warrnambool*. Geelong, the Authors. 20pp.

Knight, T.A. and S.J.J.F. Davies. (1975). An electrical counter for the coo-calls of the Barbary Dove, *Streptopelia risoria*. *Tech. Memo. Div. Wildl. Res. CSIRO, Aust.* No. **9**.

Mella, V.S.A., Cooper, C.E. and Davies, S.J.J.F. (2010). Ventilatory frequency as a measure of the response of tammar wallabies (*Macropus eugenii*) to the odour of potential predators. *Aust. J. Zool.* **58**:16-23.

Mella, V.S.A., Cooper, C.E. and Davies, S.J.J.F. (2010). Predator odour does not influence trappability of southern brown bandicoots (*Isoodon obesulus*) and common brushtail possums (*Trichosurus vulpecula*). *Aust. J. Zool.* **58**:267-272.

Metcalf, B.M., Davies, S.J.J.F. and Ladd, P.G. (2000). Adaptation of behaviour by two bird species as a result of habituation to humans. *The Australian Bird Watcher*. **18**:306-312.

Nicholls, F.M., and Davies, S.J.J.F. (1990). Techniques for developing wetland habitats at AMC Wetlands Centre, Capel, Western Australia. In *Environmental Workshop 1990*, Vol. **I**, pp 67-83. Australian Mining Industries Council, Wollongong.

Parsons, M. H., B. B. Lamont, B. Kovacs, S. J. J. F. Davies (2007). Effects of novel and historic predator urines on semi-wild western grey kangaroos. *Journal of Wildlife Management* **71**: 1225-1228.

Simojoki, S. and Davies, S.J.J.F. (2013). Analysis of breeding data of the Welcome Swallow *Hirundo neoxena* near Manjimup, Western Australia. *Corella* **37**:36-40.

Tyndale-Biscoe, C.H., Calaby, J.H. and Davies, S.J.J.F. (1995). Harold James Frith 1921-1982. *Historical Records of Australian Science*. **10**:247-263.

Williams, M. and Davies, S.J.J.F. 2008. Comparison of habitat selection of the Nankeen Kestrel and Black-shouldered Kite in the Perth Metropolitan area. *WA Bird Notes* No. **127**:1-3.

Appendix C. Expert review

REVIEW OF THE WOOLGOOLGA TO BALLINA / PACIFIC HIGHWAY UPGRADE
DRAFT COASTAL EMU MANAGEMENT PLAN – Version 0.3

by Stephen Davies

I have examined the Draft Coastal Emu Management Plan – Version 0.3 - prepared by NSW Roads and Maritime Services, Aurecon and Sinclair Knight Mertz, together with the notes from the telephone discussion of August 23, 2013, the Agency Comments on the Plan and the responses from the authors of the Draft Plan.

I consider the Plan is sound, thorough and workable.

Specifically:

1. Figure 2.1 illustrates a satisfactory number of crossing points for emus to pass between the flood plain and the coastal habitat.
2. The early construction of emu exclusion fencing, prior to the commencement of construction work, along the highway alignment except at emu crossing points is strongly endorsed (5.3.2).
3. The need to control vehicle and emu movement at crossing points during the construction phase in Zones 3 and 4 is necessary and practical (5.3.3).
4. Raised bridges with a minimum height of 3.6 metres will give satisfactory clearance for emus to pass through (5.3.6).
5. The provision of food for emus – soy beans and laplap – at the entrances to bridges is strongly endorsed (5.3.8).
6. Giving emus a clear view toward and through the bridges is important (5.3.8).
7. The methods of monitoring the movement of emus to and from the floodplain are acceptable (7.2; 7.3). but would be improved by some aerial monitoring (see below)

DETAILED COMMENTS ON THE PLAN

1.3 It is excellent that the plan is regarded as a dynamic document.

2.2 The Victorian road maintenance authority – I do not know its present name – has kept records of road kills of Emus on the Sturt Highway, and these should be available.

3.1 I agree about the importance of limiting vehicle strike.

Emus will locate open gates as they walk up and down fences. They do so on the 1000 km Emu Fence in Western Australia.

3.4 The Western Australian Emu fence directs Emus well, often for hundreds of kilometres. Stock fences will not deflect Emus.

5.3.2 I endorse this paragraph as Emus are well known to be inquisitive.

5.3.8 I endorse this paragraph, particularly the straight leads; traffic noise will be continual and this will be less disrupting than sudden bursts of noise. The early revegetation with known food plants, even though not native, is very sensible.

RCOMMENDATIONS

1. In Western Australia aerial surveys in a high-winged monoplane (Cessna 182 or 206) have been effective in counting Emus when flown at about 400 feet above the ground. Emus would be easily visible on the open flood plain and looking at the aerial photos of the open woodland of the W2B study areas 3 and 4 that show the projected flood levels in the plan document (Appendix B), Emus should be visible there too. It would benefit the monitoring program to fly one or two hour surveys over the flood plain and along the coast in the pre- and post-breeding seasons to complement the land–based monitoring. This

should indicate if shifts in the population do occur. There is an airport at Grafton and it is likely that a Cessna could be chartered there for a short flight.

2. Emus can be controlled by normal rabbit proof fencing with three barbs on top, giving a total hight of 1.3 metres. It works well in the Western Australian Emu Fence. From 350 Emus banded outside the fence only one was found inside the fence and that was thought to have been shot outside the fence but the address of the shooter was inside the fence. There is no need to have solid fencing as in emu farms, but a vehicle track along the fences will help emus to move along it. I recommend that an exclusion fence of similar design be used along the alignment. Further information can be obtained from Emily Lewis, WADFA Coordinator of the Esperance Emu Fence Extension Emily.Lewis@agric.wa.gov.au

SUGGESTIONS

1. There are various methods of catching wild Emus. That illustrated in Rowley (1974). Bird Life. Collins. p 256 is very effective but no longer practical with current OHS rules. A Western Australian sheep station Wogarno has devised a water trap that catches Emus, although it was built to catch goats. Their address is David and Lesley-Jane Campbell, Wogarno Homestead, P.O. Box 525, Mount Magnet 6638, Western Australia and the phone number is (08) 9963 5846. The e-mail is wogarno2@bigpond.com but I would suggest a phone call first. It may be worth seeking their advice.

2. One general point relates to the whole approach taken by the plan, set out in 1.2 – Purpose and Objectives. In this it is stated that the plan "… outlines the most appropriate mitigation and monitoring actions to be taken to address the long-term survival of this species in the relevant areas of the W2B upgrade." The plan does this by dealing in detail with the means of ensuring that the emus are able to cross the new highway safely, but mentions only briefly aspects related to the breeding of the birds. Of the three coastal Emu populations in the area, one is already thought to be extinct, and both the others are estimated to be small, less than 60 birds and between 80 and 120 birds. In order to ensure the

survival of the populations consideration should also be given to enhancing the breeding potential of the existing populations. The bird can produce large clutches and rear them successfully if the food supply during the pre-breeding period (January-March) is good and plenty of food is available for the chicks in their early weeks (July-August). It is particularly desirable that breeding should be successful during the construction and early operational phases of the project, when road casualties are likely to occur (over 60 have been reported in the last ten years (2.3 and 3.1), that is half the number of birds estimated in the largest surviving population). It may therefore be desirable to enhance the breeding potential of the surviving population by providing supplementary food for the birds in the suspected breeding areas during the pre-breeding and early chick periods. The birds are known to eat soy beans and laplap beans (2.2.4) and if weekly feeds of these cereals were provided in identified breeding areas it could greatly enhance the reproductive potential of the population.

It will be said that this introduces an artificial treatment to a natural population. From the Emu's point of view the whole situation is artificial, although fires undoubtedly occurred in pre European times, there were no roads, no vehicles and no substantial clearing in those days. The population can clearly adapt to artificial changes as nests have been found in cane fields (2.2.2). If the population is to survive this help may be of great benefit and a low additional cost compared with the engineering works proposed in the plan. It can be considered as an Off-set, the possible use of which is noted in the plan already (7.6.3).

3. It would be good if revegetation in roadside areas disturbed during construction contained native food plants that produce fruit such as figs (5.3.9).

Appendix D. Emu fencing strategy

Pacific Highway Upgrade
Woolgoolga to Ballina

NSW ROADS AND MARITIME SERVICES

Emu Fencing Strategy for Sections 3 and 4

Final

October 2015

JACOBS

JACOBS

Pacific Highway Upgrade Woolgoolga to Ballina

Project no:	EN04338
Document title:	Emu Fencing Strategy
Revision:	Final
Date:	28 October 2015
Client name:	Roads and Maritime
Client no:	Client Reference
Project manager:	Chris Thomson
File name:	I:\ENVR\Projects\EN04338\Deliverables\Fence strategy\Final draft\Emu fencing strategy_Final_101114_ISSUE.docx

Jacobs Group (Australia) Pty Ltd
ABN 37 001 024 095
710 Hunter Street
Newcastle, NSW, 2302, AUSTRALIA
www.jacobs.com

Important note about your report

The sole purpose of this report and the associated services performed by Jacobs is to identify a fencing strategy for emus on the W2B project in accordance with the scope of services set out in the contract between Jacobs and the Client. That scope of services, as described in this report, was developed with the Client. In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from information sourced from the Client (if any) and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context. This report has been prepared on behalf of, and for the exclusive use of, Jacobs's Client, and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and the Client. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party

Document history and status

Revision	Date	Description	By	Review	Approved
Rev01	27/05/14	Draft report	C.Thomson	C.Thomson	J.Wall
Rev01	03/06/14	Draft	C.Thomson	RMS	J.Wall
Rev01	7/11/14	Final Draft	C.Thomson	RMS	C.Thomson
Final	27/11/15	Final	C.Thomson	RMS	C.Thomson

Contents

Contents

1. Introduction

1.1 Background

NSW Roads and Maritime Services (Roads and Maritime) have approval to upgrade the Pacific Highway from Woolgoolga to Ballina on the mid and far north coast of NSW (the project). An Environmental Impact Statement (EIS) was produced which assessed the potential impacts of the project on the endangered coastal emu population in Sections 3 and 4 of the project. A key input to the EIS was the development of a Coastal Emu Management Plan. This Emu Fencing Strategy has been prepared as a requirement of the management plan.

Vehicle strike is a significant threat to coastal emus with multiple road fatalities reported in the Clarence Valley and surrounds over the last decade. Wle there is no published information on the frequency and factors of vehicle-collisions with emus in this region, the NPWS and Clarence Valley WIRES have logged 71 emu vehicle-collisions between 2000 and 2014 on local roads in the Minnie Waters, Clarence Valley and Iluka areas. Analysis of this emu-vehicle collision data was reported in the Woolgoolga to Ballina EIS and found that emu road-kill sites were typically:

- Where mature forest was present along the roadway (within 10 metres of mature forest), as opposed to cleared landscapes and open farmland.
- On single lane dirt roads or larger sealed rural roads.
- Where there was no fence between the forest edge and the road.
- Where there was vegetation two metres or taller within five metres of the edge of the road.

These data report a higher incidence of road kill where fences are absent, particularly in forested environments and this highlights the importance of a fencing strategy for the highway upgrade as a key mitigation measure for emus to avoid future road-kill on the highway and to direct emus to targeted crossing structures below the road.

1.2 Objectives of the emu fencing strategy

Strategic emu fencing in Section 3 and 4 will enhance the safety of coastal emus near the highway and direct emus to safe crossings provided below the road as dedicated bridges and underpasses or to habitat away from the road. The objectives of the emu fencing strategy are therefore to identify the mitigation required to:

- Identify and formalise crossing zones in areas of high emu activity prior to construction to encourage emus to travel along designated passageways and utilise future crossing zones across the highway prior to the construction and operation of the road.
- Exclude emus from the road corridor during the construction and operational phases of the project.
- Direct emus to designated crossing zones during the construction and operational phases of the project so that birds can access important habitat to the east and west of the road corridor.

1.3 Project fencing guidelines

The intention to develop a project wide fencing strategy was reported in the Submissions / Preferred Infrastructure Report (SPIR) and applicable to the entire Woolgoolga to Ballina project (Roads and Maritime, 2012). The fencing strategy for the whole project would be formulated based on standard fence design principles aimed at ensuring the most appropriate solution is identified to cater for the various conditions along the project length. These principles would be implemented where reasonable and feasible and are outlined below. The development of this emu fencing strategy is specific for Sections 3 and 4 of the project and has been guided by the W2B project fencing principles which include:

- Discuss individual fencing needs with affected and adjoining landowners. Fencing requirements for sugar cane farms would be considered as part of the cane farm strategy.
- Develop a design that would combine fauna and boundary fencing (including appropriate stock proof fencing) in consultation with Government agencies.

- Identify opportunities to erect fences within the construction footprint, to avoid the need for additional vegetation clearing.
- Confirm the legal requirements and preferred approach in consultation with Roads and Maritime property and legal branch associated with combining fauna fence and property fence within the construction footprint and not necessarily on the road boundary.
- Develop a hybrid fence design to enable emus to pass and restrict cattle.
- Opportunities for fencing design to tie into culvert structures rather than cross the culvert face would be investigated.
- Where a combined fence design is required for fauna, boundary and stock such as cattle grazing, a fence may need to be erected on the boundary to restrict cattle from passing through culverts. The fence design across the culvert face would need to consider surface water impacts such as flooding/water velocities.
- Identify opportunities to place fauna exclusion fencing on the top of batter in floodplain areas.

2. Emu Fence Design and Location

2.1 Background

It is proposed to construct both temporary and permanent fencing to exclude emus based on the following approach:

- Temporary fencing (pre-construction) to be erected up to 12 months prior to the commencement of construction and targeting areas of high emu activity in Section 3 to encourage emus to locate and use designated crossing zones prior to the commencement of construction (Section 2.2).
- Temporary emu fencing (construction) to be erected in two key areas of Section 3 and at the wave 3 works areas for Section 4 to prevent emus from entering the construction corridor during construction and thereby avoid potential harm to emus from construction traffic and activities (Section 2.3).
- Permanent emu fencing (operation) to be erected as a long-term operational mitigation measure to prevent emu-vehicle collisions and to guide emus to designated safe crossing zones below the road so that birds can access important habitat to the east and west of the road corridor (Section 2.4). Permanent fencing will be placed along the length of Section 3 and 4 from Old Six Mile Lane to the Maclean interchange.

Construction will be divided into two phases; firstly relating to 'early works' which are to be conducted in soft soil areas as a pre-treatment measure, and secondly the main construction which involves the clearing of vegetation from the road corridor and construction of the road and bridge structures. It will be necessary to prevent emus from entering the construction corridor in high emu activity areas during the main construction but continue to have opportunity to access habitat either side of the construction corridor over a potentially lengthy construction period. This is hoped to be achieved through the early construction of emu fencing and staging of construction at emu crossing zones as described further in Section 2.5 and the Coastal Emu Management Plan.

Further to this, there are a few instances in Section 3 and Section 4 of the project where there will be a need to position property boundary fences across the proposed emu crossing zones. In these instances a hybrid (emu/cattle) fence is proposed that would effectively restrict cattle while being permeable to emus and other native fauna needing to use the crossing zone, further details provided in Section 2.6.

At all stages of pre-construction, construction and operation there will be monitoring of fences and crossing zones in areas frequented by emus to determine the effectiveness of the fence at excluding and directing emus and this forms part of the adaptive emu management plan. Further details on the monitoring approach are described in Section 3.0 and the Coastal Emu Management Plan.

2.2 Temporary fencing (pre-construction)

The objective of constructing an emu exclusion fence prior to the main construction of the project is detailed in the Coastal Emu Management Plan, and is for the purposes of educating emus to find and use the designated crossing zones for a period of up 12 months prior to construction, with these locations eventually becoming formal emu crossing zones below the road (bridges). The aim is to ensure that emus are accustomed to these crossing points well in advance of construction to minimise disturbance and interruption during construction. Permanent fencing will eventually replace temporary fencing in these locations. The trial will also investigate the effectiveness of the fence design at excluding emus from the road corridor and directing emu movements along the fence.

The intent was, where possible, that the permanent exclusion fence would be erected on the road boundary (in cleared areas) although the management plan acknowledges that this may be difficult in floodplain areas as the permanent fence will need to be placed on the batter above the flood level. Hence a temporary fence will be used and be removed and replaced with the permanent fence at the end of construction.

The placement of the fence was to be determined following review of the emu baseline surveys and therefore target the areas of highest emu activity. The fence will target the area in Section 3 between station 45855 to station 50555 (4,700 metres) and covering 10 openings (refer **Table 1** for detail and figure in **Appendix A**). A

combined emu / cattle hybrid fence will be trialled at one of these locations (station 48400) to trial a fence that will allow emus to pass through, but exclude cattle, further details are described in Section 2.6.

Following completion of the temporary fence, the openings (gaps in the fence) will be monitored for a period of 6-12 months, to monitor emu activity, and to begin to record where possible, emus passing through the openings, in addition to emu response and behaviour to the fences, including the hybrid fence design.

The fence will be wire mesh construction similar to the proposed permanent emu exclusion fence (Section 2.4), with the exception of star pickets and timber strainers to be used instead of concrete posts. The fence design is shown in **Appendix C**, and is a five strand (1500 mm high) fence with wire mesh on the lower 1200 mm. Barbed wire is to be used adjacent to the mesh to prevent cattle from pushing the fence over. Additional smaller gaps, up to 3-6 metres wide will be included for farm vehicle access, and these would eventually be removed following construction.

The timing for installation of the temporary fence (pre-construction) is dependent on the progress of property acquisition and access to each property and is currently planned to commence in November-December 2014.

Table 1. Location of temporary fence (pre-construction) and fence gaps (crossing zones)

Crossing zone (gas in the fence)	Station	Description / waterway	Approximate opening (to be monitored)
T1	46055 to 46155	Floodway adjacent to Pillar Valley Creek	100 metres
T2	46325 to 46440	Pillar Valley Creek	115 metres
T3	46647 to 46722	Black Snake Creek	75.5 metres
T4	47643 to 47795	Floodway	152 metres
T5	47900 to 47960	Floodway	60 metres
T6	48400 to 48900	Emu hybrid fence trial	50 metres
T7	48740 to 48835	Mitchells Road realignment	95 metres
T8	49246 to 49366	Floodway	120 metres
T9	49450 to 49471	Floodway	21 metres
T10	50280 to 50325	Un-named creek	45 metres

2.3 Temporary fencing (construction)

Temporary fencing is used as a standard RMS procedure at the limits of a construction corridor for the protection of sensitive environments by identifying ‘no-go zones’ for construction vehicles and personnel. Where emus are reported in Sections 3 and 4 of the project, this temporary fencing (construction) will also need to prevent emus from entering the construction corridor during construction.

It is proposed to construct temporary exclusion fencing for emus based on the following approach:

- Temporary emu fencing (construction) to be erected in key areas of Section 3 to prevent emus from entering the construction corridor during construction and thereby avoid potential harm to emus from construction traffic and activities. Two Key Areas have been identified, between Wooli Road to North of Mitchell Road, being CH44.5 to CH51.3 and south of Somervale Road (CH55.0) through to CH61.0. This represents a total of 12.8 km of temporary fencing during construction in Section 3.
- In areas of Cut, permanent Emu fence is to be installed where possible. Refer to Section 2.4.
- In areas of Fill, the temporary fence will be erected as per the below construction methodology:
    - Determine clearing limits and complete clearing
    - Following clearing, erect Sediment and Erosion Controls,

- Erect temporary Emu exclusion fencing, as per the fence design example shown in **Appendix B**.

Wave 3 early works will involve clearing of cane crops in fill locations and removal of vegetation and fill material from elevated areas in Section 4. Permanent or temporary exclusion fencing is to be installed where possible on both sides of the cutting at borrow material sites (Tyndale Station 69.200 and Green Hill station 76.000). A purposely designed tall (1200 mm) and robust temporary fence is to be used along the length of the soft soil treatment corridor (refer to **Appendix B** for design). The star picket fence will include coloured flagging along the top wire for visibility for emus and fauna in general to prevent contact. Where gaps are left in the formation, such as haul road, temporary fence such as ATF is to be established to prevent emus from entering the corridor. This would include closing gaps each evening at the end of work and also on non-work days such as Sundays, wet days and public holidays.

2.4 Permanent fencing (operation)

Permanent fauna exclusion fencing is used effectively on a number of Pacific Highway upgrades and targets a range of fauna species as a means of excluding fauna from the road and directing them to dedicated and incidental fauna crossing zones. The design of fauna exclusion fencing varies according to the target fauna and specific property requirements and may combine property boundary fences in some instances.

Based on observations from the pre-construction baseline emu surveys and discussions with local property owners, emus are known to easily pass ‘through’ three and four strand wire stock fences including plain and barbed wire fences. Therefore fences designed to exclude emus during operation of the road will need to be impermeable (wire mesh) and be of suitable height to prevent emus from attempting to pass over and potentially sustaining injury. In specific areas where emus and other significant fauna co-occur, including threatened species such as Squirrel Glider, Rufous Bettong, Brush-tailed Phascogale and Koala, the fence design would need to consider these additional target species.

Permanent emu fencing (operation) would progressively replace the temporary fencing used during pre-construction and construction and is to be completed by the end of construction. The fence type will be a concrete/steel post and wire mesh fence (specifications below) that can be used as a combined fauna fence and property boundary fence. This fence design has been observed to be impermeable to emus during the pre-construction surveys and is the same design as the rabbit proof fence in WA which effectively excludes emus (for example refer to plate 2).

Plate 2. Example of emu exclusion fenced trialled during pre-construction

The specifications of the permanent emu exclusion fence are described below and shown in **Appendix C** as follows:

- 1500 mm high steel/concrete posts
- steel wire netting to 1200 mm high
- 200 mm skirt at ground level on the habitat side to prevent other targeted fauna such as Rufous Bettong and Koala from burrowing underneath.
- The top two strands to be plain wire
- Barbed wire may be used in the lower half of the fence positioned behind the mesh on the road side of the fence. The use of barbed wire would be limited and in negotiation with property owners and may be required to prevent cattle from pushing over and entering the road.
- Fence ends to be tied into the headwall of culverts and bridge abutments or tied into the hybrid fence where required.

This design is expected to prevent injury to emus as well as gliders, brush-tailed phascogale, Rufous bettong and koala. Fencing would be placed along the road reserve boundary and in certain locations combined with property boundaries. Exclusion fencing would avoid blocking access to waterways and artificial dams which represent potentially important emu watering points. The emu exclusion fence would be specific to emu habitat areas in Section 3 and 4 of the project from Old Six Mile Lane (station 38250) to the Maclean interchange (station 80000).

In flood prone areas permanent fencing would be placed on the road batter to prevent flooding damage or collapse. This is particularly relevant to Section 4 in cane fields and parts of the Coldstream River catchment in Section 3.

In addition to the permanent fence, the coastal emu management plan describes the need to consider an appropriate design and location of ‘escape points’ or openings to mitigate for emus that become trapped in the road corridor during operation. There has been no prior monitoring to identify effective escape gate designs for emus and there is concern that the provision of openings in the permanent fence may have a negative impact

by allowing emus an access point to enter the road corridor. The permanent fence is considered of sufficient length and robust design to exclude emus from the road corridor and therefore escape gates are currently not planned as part of the permanent fence. The need for escape gates in Section 3 and 4 of the project would be reviewed as part of the operational monitoring program to determine if they are required and if so where they should be positioned.

2.5 Maintaining emu crossings zones during construction

Given a potential lengthy construction period for Section 3 of the project, the Stage 2 construction phase must make available a number of options for emus to cross the corridor during construction. The objective is to maintain functional crossing zones during construction where possible.

The first stage of construction would involve identifying clearing limits and removing vegetation along clearing lines followed by installation of either the temporary or permanent exclusion fencing in places identified by in the Coastal Emu Management Plan. The following approach will be used to establish or maintain connectivity during construction by using temporary fencing.

- During bridge construction temporary fencing would be used to develop an emu passageway or race to direct emus across the entire width of the construction corridor. The race would be established perpendicular to the corridor. Where there is a creek the race would be constructed along the creek and incorporate riparian habitat with a minimum distance of 10 metres either side of the top of the creek bank. Where flatter and wider creeks occur, the area of the creek profile would also be retained inside the race. Where there is no creek, the race should be a minimum of 20 metres wide and set up through the centre of the crossing zone where possible.
- There will be a total of 8 emu races established in key area 1 and associated with the combined emu bridges between Wooli Road and Firth Heinz Road (station 45855 to 50280). These align with 8 temporary crossing zones established in the pre-construction stage which are all known to have been used by emus on at least one occasion during the fence trial. At the start of each work day temporary gates at either side of the race would be closed and then re-opened at the end of each work day. These gates would then also remain open during non-work days such as Sundays, wet days and public holidays.
- The location of the 8 races has been positioned to capture emu activity reported during the baseline surveys up to September 2015. If during the construction monitoring period emu activity is observed to shift north of key area 1, such as key area 2, then an additional race(s) would be provided in the relevant location to facilitate emu movements across the corridor

2.6 Hybrid fence design

A hybrid fence is required where crossing zones occur at the same location where there are different property owners on either side of the road. The purpose of the hybrid fence is to provide a fence across the crossing zone that will enable emus to pass through, while preventing stock (cattle) from leaving the property. Three designs have been proposed for the hybrid fence as shown in **Appendix D**. These are to be monitored post-construction to determine their effectiveness and include a:

- standard four strand wire stock fence (two plain and two barbed strands)
- metal squeeze stile (narrow gap that excludes cattle)
- steel bollards in replace of wire across a 600 mm span of fence.

A hybrid fence is also proposed to be trialled as part of the temporary fence (pre-construction) at one location (station 48400), to monitor these three designs prior to construction and may inform the final preferred design. The location of the hybrid fences to be installed at the end of construction, are detailed in Table 3.

Table 3. Location of hybrid fences to be installed at the end of construction

Hybrid crossing zone	Station	Property details

H1	43100 to 43400	Lot 1 DP 393766
H2	51400	Lot 168 DP751365 / Lot 133 DP751365
H3	52425 to 52477	Lot 44 DP751365
H4	57050 to 57138	Lot 19 DP751365 / Lot 7004 DP1128077
H5	64150	Lot 137 DP751389 / Lot 381 DP117618
H6	64500	Lot 138 DP751389 / Lot 381 DP117618
H7	76450	Lot 1 DP327815 / Lot 8 DP751372

3. Monitoring the emu fence

The emu management plan outlines monitoring objectives designed to evaluate the success of mitigation measures for emus. Monitoring is therefore required to determine the effectiveness of the temporary and permanent fencing at excluding emus and directing emus to crossing zones and provide input into any refinement of the fence design to avoid injuries to emus. It will be important to identify any problems or injuries to emus from the temporary and permanent fences. Monitoring would occur during the:

- pre-construction stage to monitor the temporary fence (pre-construction) in Section 3 and the single hybrid fence
- construction stage to monitor the temporary (fence) construction
- operational stage, as part of the monitoring of crossing zones and adjacent fences.

3.1 Pre-construction monitoring

It is proposed to monitor emu behaviour in relation to the pre-construction temporary fence and the gaps in the fence as designated emu crossing points. Monitoring would focus on the use of remote sensor activated cameras to be stationed at each of the crossing zones and immediately adjacent areas of the temporary fence to capture images of emus passing along the fence or using the gaps provided. Cameras would be checked quarterly in line with the general baseline pre-construction emu surveys at the locations described in Table 4. Scat searches would be conducted along sections of the fence in proximity to the cameras.

Table 4. Indicative monitoring locations for pre-construction exclusion fence

Crossing zone	Station	Description / waterway	Approximate opening (to be monitored)
T1	46055 to 46155	Floodway adjacent to Pillar Valley Creek	100 metres
T2	46325 to 46440	Pillar Valley Creek	115 metres
T3	46647 to 46722	Black Snake Creek	75.5 metres
T4	47643 to 47795	Floodway	152 metres
T5	47900 to 47960	Floodway	60 metres
T6	48400 to 48900	Emu hybrid fence trial	50 metres
T7	48740 to 48835	Mitchells Road realignment	95 metres
T8	49246 to 49366	Floodway	120 metres
T9	49450 to 49471	Floodway	21 metres
T10	50280 to 50325	Un-named creek	45 metres

3.2 Construction monitoring

During construction of Section 3 and 4 of the project, the temporary fence (construction) would be routinely checked and monitored as a requirement under the construction environmental management plan (CEMP). Any breach of the fence by emus would be covered by the unexpected finds procedure as documented in the RMS biodiversity guidelines (RTA 2011).

3.3 Operational monitoring

Operational monitoring would focus on two aspects:

- Monitoring of all hybrid fence locations (n=7) to determine their effectiveness in line with the adaptive management approach outlined in the emu management plan. The method would apply remote sensor activated cameras and search for signs, on a quarterly basis in line with the broader emu operational monitoring framework.
- The operational monitoring program for emus has a focus on identifying if emus are using the designated crossing zones in Section 3 by using remote sensor cameras and searches for signs. Opportunities to monitor the exclusion fence will be investigated at this point by extending the survey along the adjacent areas of the permanent fence.

Appendix A. Location of temporary emu fence (pre-construction)

Pacific Highway Upgrade - Woolgoolga to Ballina

Section 3 - Emu Fencing

START EMU FENCE CH45855

END EMU FENCE CH50555

T1 (A,B,C,D,E)

T2 (F,G,H,I,J)

T3 (K,L,M,N)

T4 (O), P removed

T5 (Q,R,S,T,U,V)

T6 (W,X,Y,Z)

T7 (AA,BB,CC,DD)

T8 (EE,FF,GG,HH,II,JJ)

T9 (KK,LL,MM,NN,OO,PP)

T10 (QQ,RR,SS,TT)

Ancillary Site 4

Ancillary Site 5

2m Offset from Project Boundary

100.6m Opening CH46055-46155

115.0m Opening CH46325-46440

3.6m Gate on existing track CH46550

75.5m Opening CH46647-46722

12m Opening CH47070

3.6m Opening CH47180

152.0m opening CH47643-47795

3.6m gate on existing track

60m opening CH47900-47960

3.6m gate on existing track

Emu Entry Structure CH48400

95m opening CH48740-48835

3.6m Opening CH49070

3.6m Opening on existing track CH49800

120m Opening CH49246-49366

21.6m Opening CH49450-49471

45m Opening CH50280-50325

3.6m Opening on existing track

3.6m Opening on existing track CH50040

WOOLI RD

MITCHELL RD

PILLAR VALLEY CK

JEFFERIES

PRESTON

FLINDALL & EMERY

FRANKLIN

CHARD

NILAND

BENNETT & AVIDOR

WIDIN & PATANE

RYAN

SOMMER & HARRISON

W2B PIR Project Boundary (13/11/2013)	PrimaryRoad
W2B PIR EIS Boundary (20131018)	ArterialRoad
Start/End Proposed Emu Fence	SubArterialRoad
Proposed Emu Fence	LocalRoad
Emu Entry Structure	UrbanServiceLane
Gate / Opening	Track-Vehicular
Cadastre	Property Access Tracks
Rivers	PIR Design
Ancillary Sites SPIR	

Transport Roads & Maritime Services

NSW GOVERNMENT

1:14,000

0 80 160 320 480 640 800

Metres

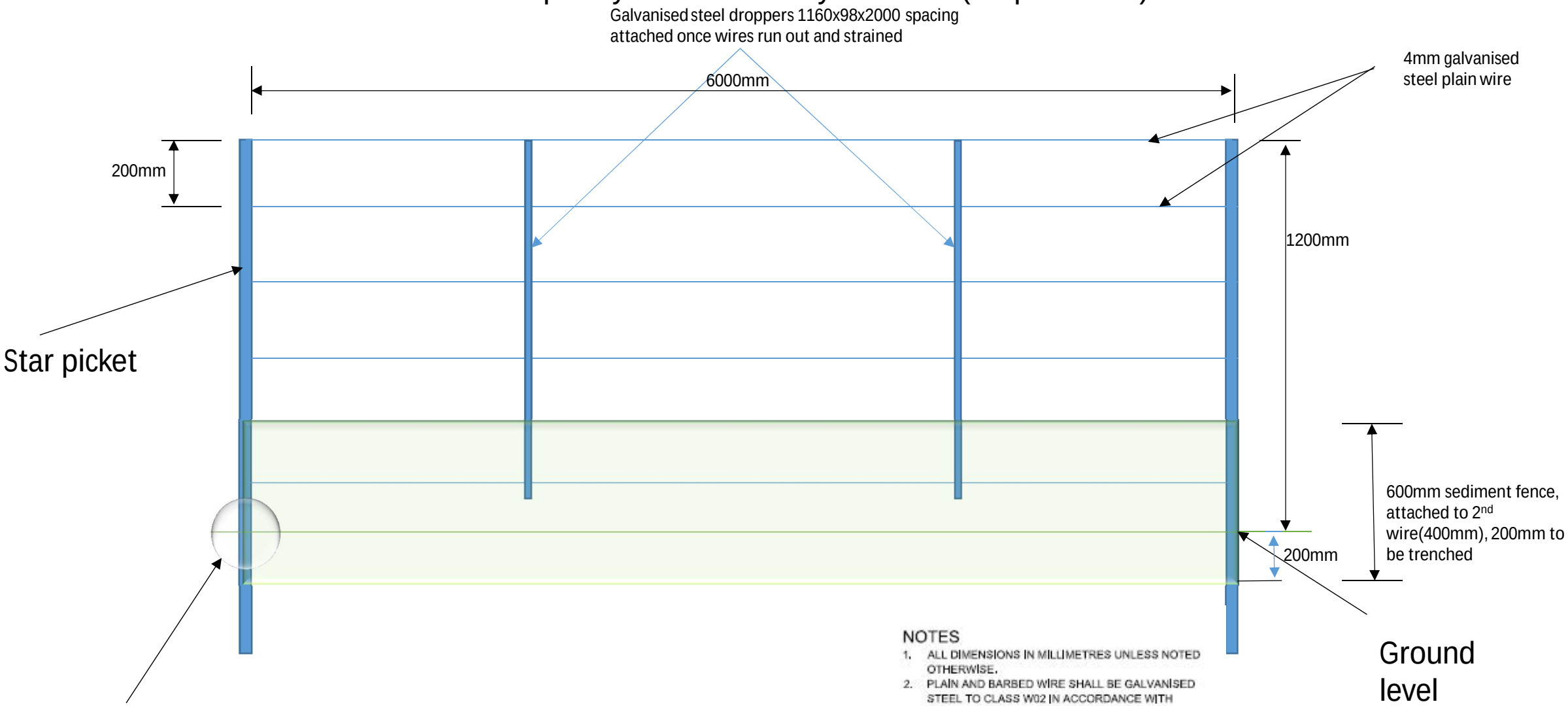
Print Date: 2/10/2014

Map produced by Pacific Highway Branch, Infrastructure Development, RMS, by SYMONDSJ

Path: G:\W2B\14_GIS\02_Maps\03_MXD\D00395_0132_EmuStudyA3_S3_v6e.mxd

Appendix B. Temporary emu fence to be used during construction

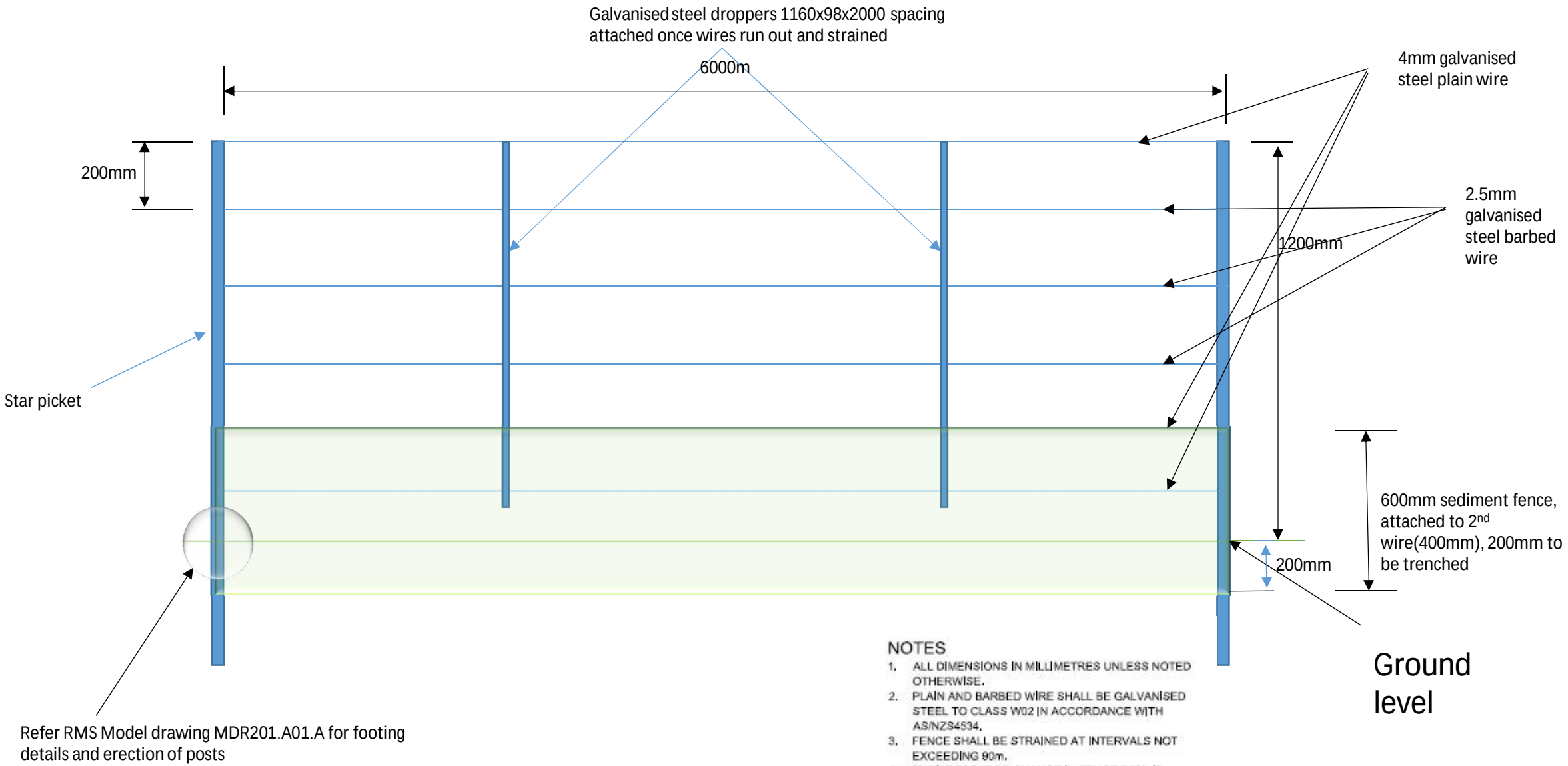
Temporary Emu Fence – Tyndale Cut (6 x plain wire)



NOTES

1. ALL DIMENSIONS IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. PLAIN AND BARBED WIRE SHALL BE GALVANISED STEEL TO CLASS W02 IN ACCORDANCE WITH AS/NZS4534.
3. FENCE SHALL BE STRAINED AT INTERVALS NOT EXCEEDING 90m.
4. MAXIMUM GRADE CHANGE IN FENCE 7.5%, IF GREATER STRAINER POST AND STRUT REQUIRED.
5. REFER TO RMS STD MODEL DRG MD,R201,A04,A FOR MATCHING GATE DETAILS.
6. REFER TO RMS STD MODEL DRG MD,R201,A03,A FOR WIRE FASTENING DETAILS.

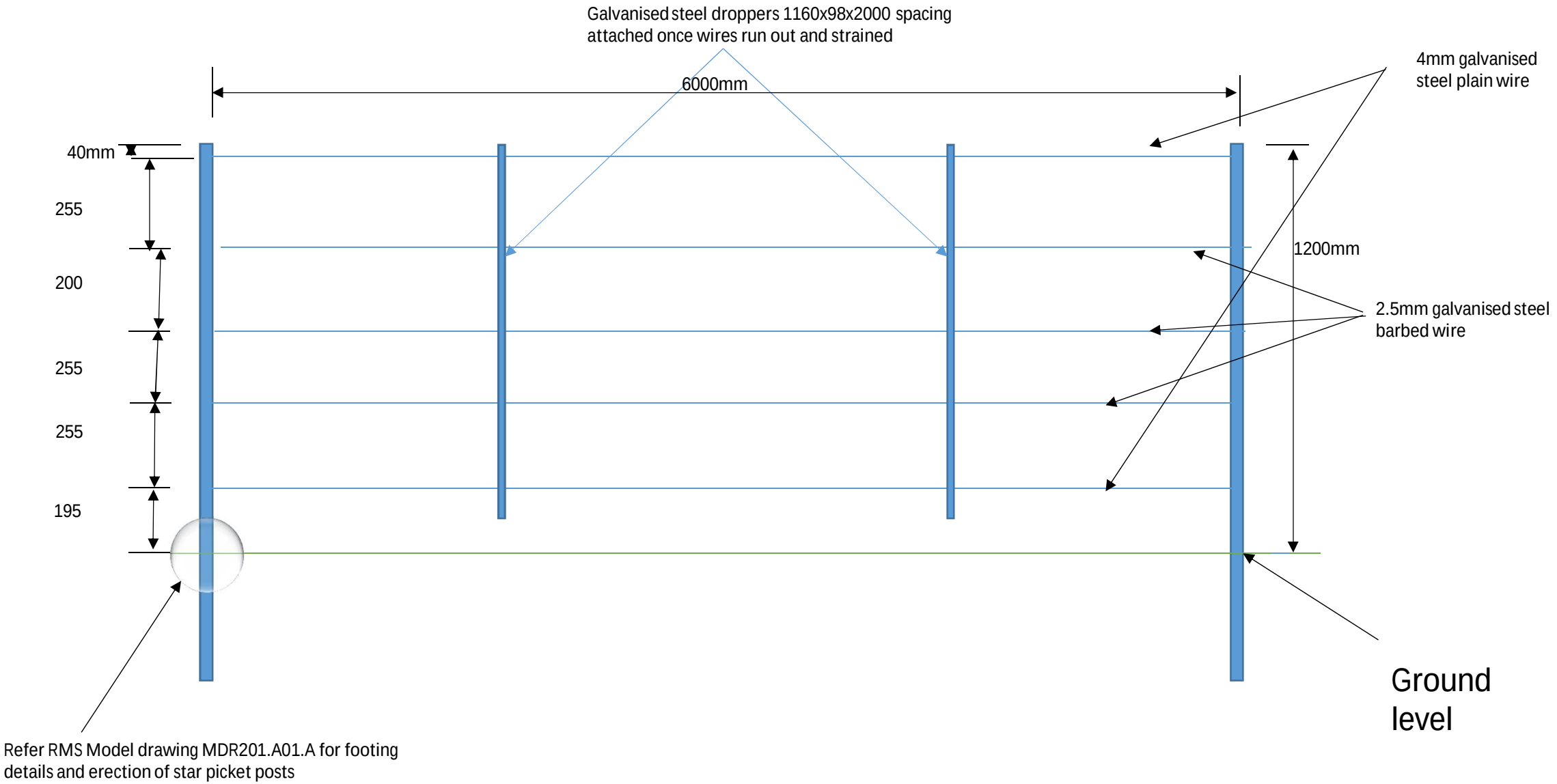
Temporary Emu/Stock Fence –(APO 125) Greenhill Cut (3 x plain wire, 3 x Barbed)



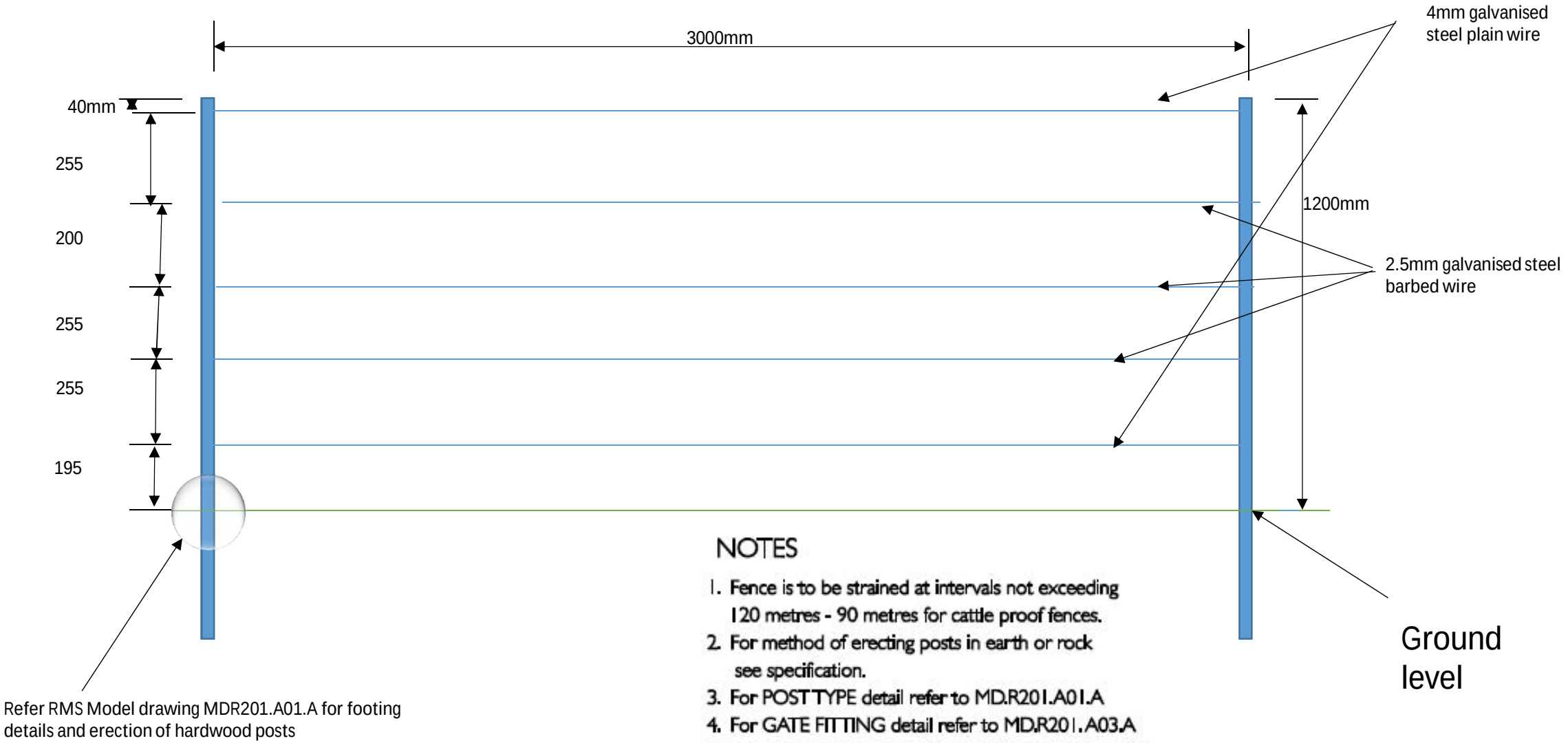
NOTES

1. ALL DIMENSIONS IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. PLAIN AND BARBED WIRE SHALL BE GALVANISED STEEL TO CLASS W02 IN ACCORDANCE WITH AS/NZS4534.
3. FENCE SHALL BE STRAINED AT INTERVALS NOT EXCEEDING 90m.
4. MAXIMUM GRADE CHANGE IN FENCE 7.5%, IF GREATER STRAINER POST AND STRUT REQUIRED.
5. REFER TO RMS STD MODEL DRG MD,R201,A04,A FOR MATCHING GATE DETAILS.
6. REFER TO RMS STD MODEL DRG MD,R201,A03,A FOR WIRE FASTENING DETAILS.

Temporary Stock Fence– APO 168 (2 x plain wire, 3 x barbed wire)



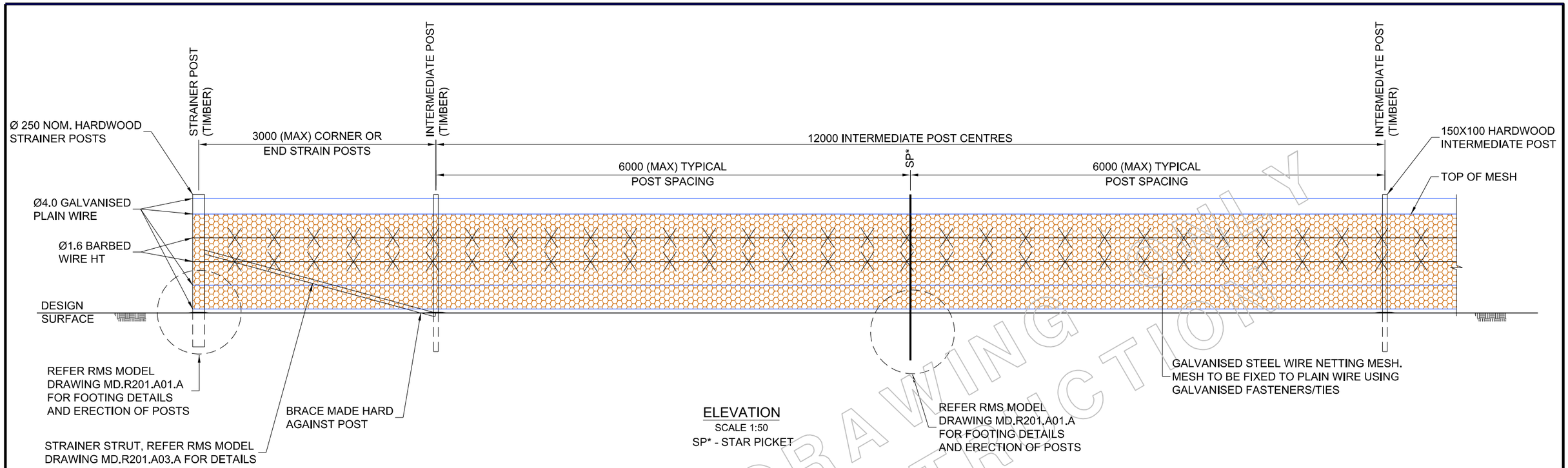
Permanent Stock Fence–APO169(2 x plain wire, 3 x barbed wire)



NOTES

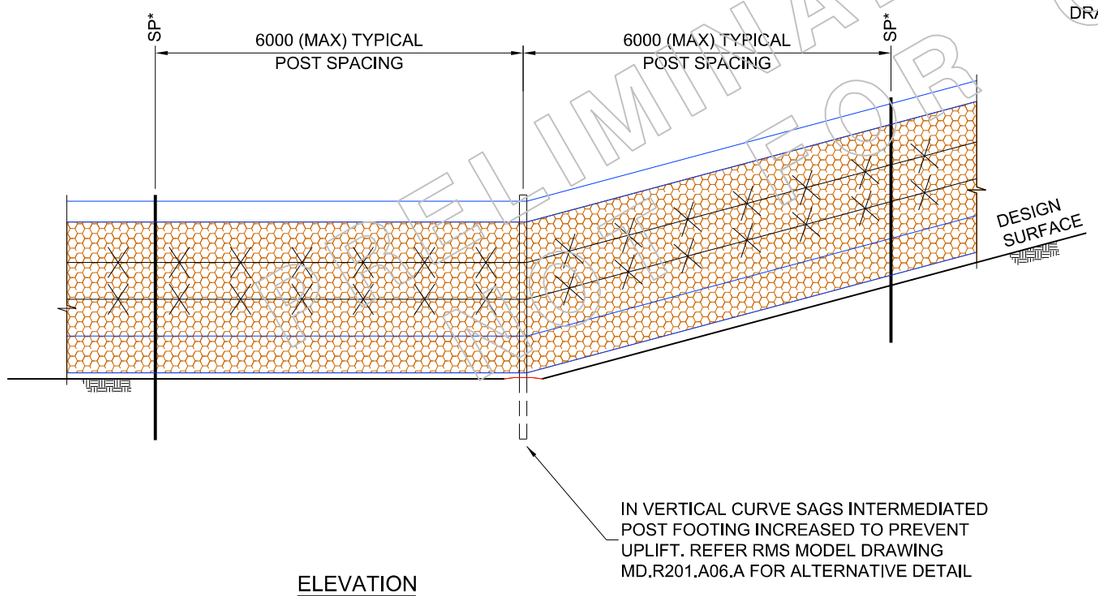
1. Fence is to be strained at intervals not exceeding 120 metres - 90 metres for cattle proof fences.
2. For method of erecting posts in earth or rock see specification.
3. For POST TYPE detail refer to MD.R201.A01.A
4. For GATE FITTING detail refer to MD.R201.A03.A
5. For FASTENING wire detail refer to MD. R201.A04.A
6. Fencing materials are to be in accordance with specification - R 201

Appendix C. Permanent exclusion fence design



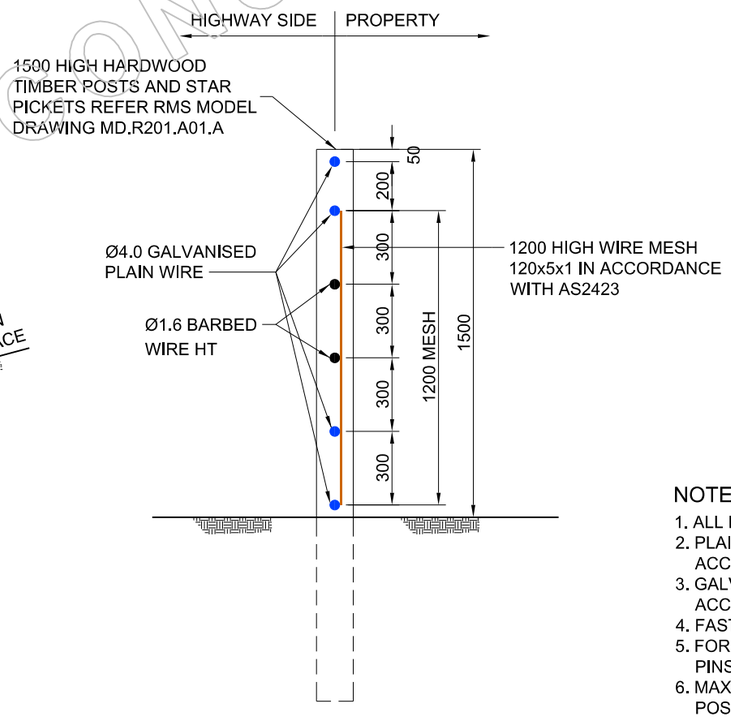
ELEVATION
SCALE 1:50

SP* - STAR PICKET

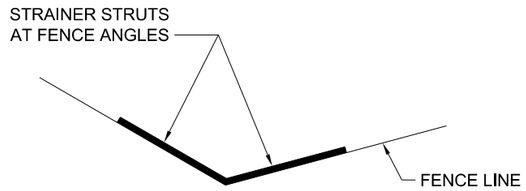


ELEVATION
INTERMEDIATE POST AT LOW POINT
SCALE 1:50

SP* - STAR PICKET



SIDE ELEVATION
SCALE 1:25



NOTE: MIN. INTERNAL ANGLE 135 DEGREES TO PREVENT FAUNA TRAPPING

PLAN OF FENCE ANGLE
SCALE 1:25

NOTES:
1. ALL DIMENSIONS IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. PLAIN WIRE SHALL BE GALVANISED STEEL TO CLASS W02 IN ACCORDANCE WITH AS/NZS4534.
3. GALVANISED STEEL WIRE NETTING TO CLASS W02 IN ACCORDANCE WITH AS/NZS4534.
4. FASTENING PINS INSTALLED AT 1200 INTERVALS.
5. FOR LOOSE SANDY SOILS MIN. 350mm GALVANISED FASTENING PINS MUST BE USED.
6. MAXIMUM GRADE CHANGE IN FENCE 7.5%, IF GREATER STRAINER POST AND STRUT REQUIRED.

No.	Amendment Description	Initials	Date

SCALES
0 0.25 0.50 0.75 1.00 1.25
SCALE 1:25m
0 0.5 1.0 1.5 2.0 2.5
SCALE 1:50m

Transport Roads & Maritime Services
NSW GOVERNMENT

SETOUT REVIEW
NAME .....
SIGNED ..... DATE .....

ROADS AND MARITIME SERVICES

PACIFIC HIGHWAY UPGRADE
WOOLGOOLGA TO BALLINA
INFORMATION DOCUMENT
TEMP. FENCING DETAILS - TYPE 1
COMBINED FAUNA/EMU/STOCK FENCE

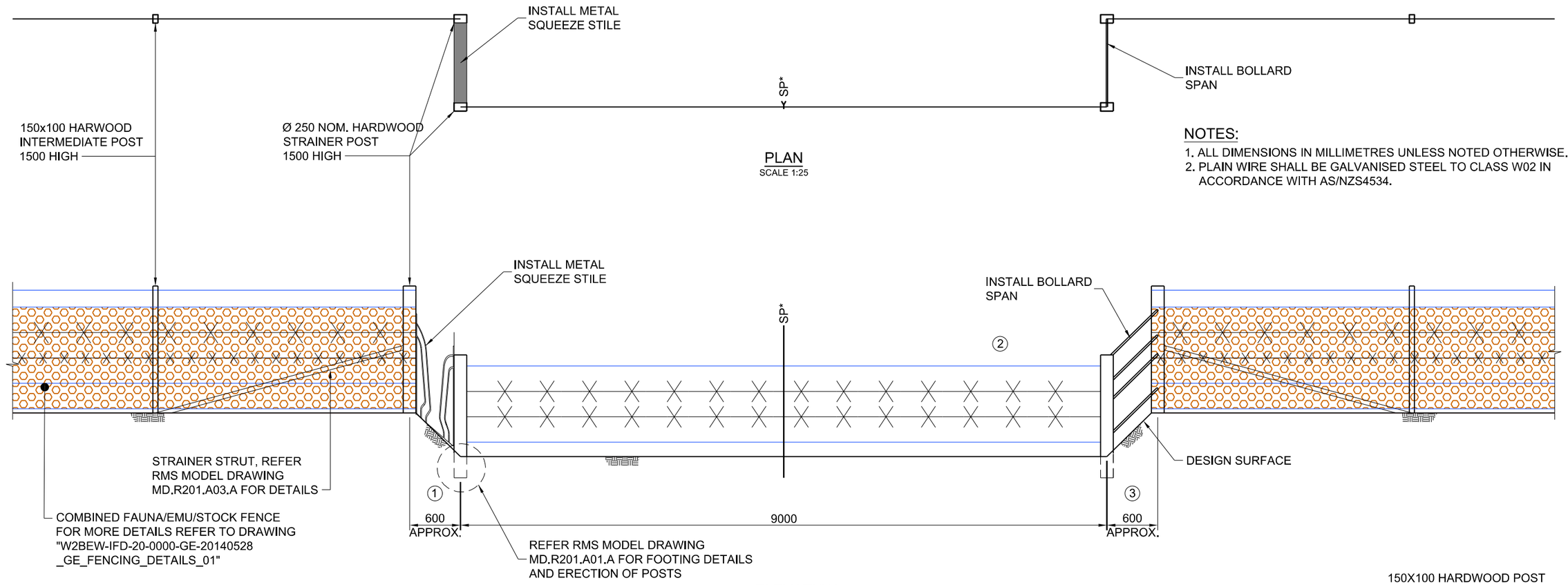
FILE No.	DRAWING	PRINTED DATE	SHEET No.
XXX	ID3_EMU_01_V1.dgn	25/09/2014	1

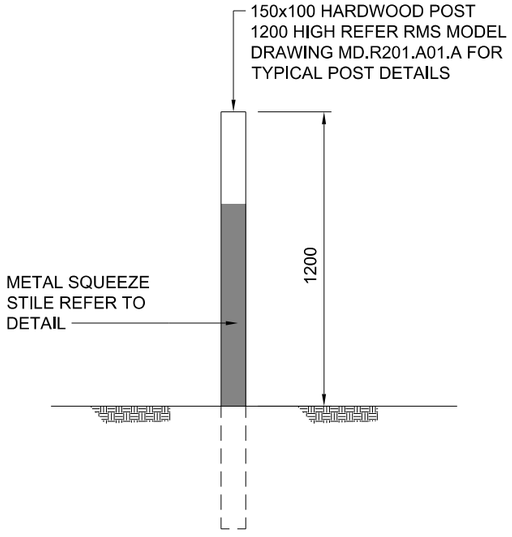
REGISTRATION NUMBER
INFO DOC ONLY

A3 original | This sheet may be prepared using colour and may be incomplete if copied | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D.

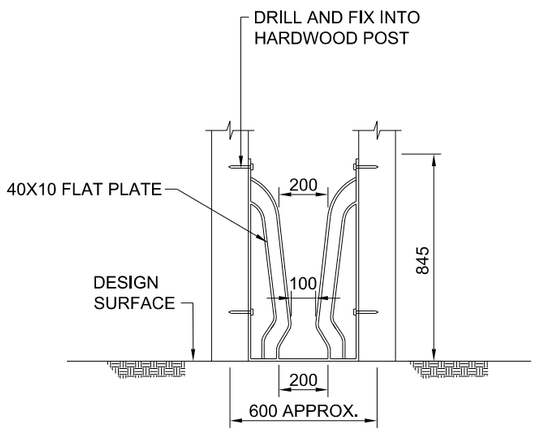
PRODUCED: 25/09/2014 AT 11:23:24 AM USER: harribje
FILE PATH: K:\PROJECTS\10_PACIFIC HIGHWAY\HW10 WOOLGOOLGA TO BALLINA\Drawings\Concept\PDS\Info Docs\140909 Temp Emu Fence\V3\ID3_EMU_01_V1.dgn
PLOT DRIVER: d:\data\Bentley\WorkSpace\Standards\plotdrv\PDF-wc2u.pltcfg
PEN TABLE: d:\data\Bentley\WorkSpace\Standards\tables\pen\TEXT_SUBSTITUTIONS_FOR_COLOUR.tbl

Appendix D. Hybrid fence design

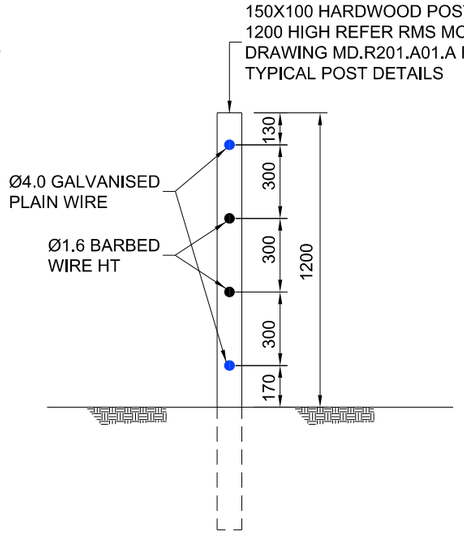




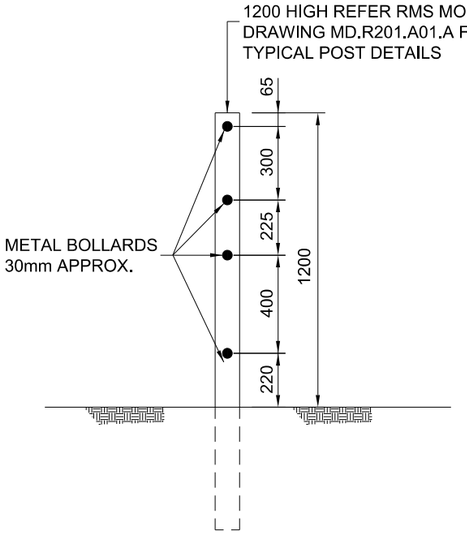
SIDE ELEVATION①
SCALE 1:25



METAL SQUEEZE STILE DETAIL
SCALE 1:25



SIDE ELEVATION②
SCALE 1:25



SIDE ELEVATION③
SCALE 1:25

No.	Amendment Description	Initials	Date

SCALES
0 0.25 0.50 0.75 1.00 1.25
SCALE 1:25m
0 0.5 1.0 1.5 2.0 2.5
SCALE 1:50m

Transport Roads & Maritime Services
NSW GOVERNMENT

SETOUT REVIEW
NAME .....
SIGNED ..... DATE .....

ROADS AND MARITIME SERVICES

PACIFIC HIGHWAY UPGRADE
WOOLGOOLGA TO BALLINA
INFORMATION DOCUMENT
TEMP. FENCING DETAILS - TYPE 2
EMU HYBRID FENCE

FILE No.	DRAWING	PRINTED DATE	SHEET No.
XXX	ID3_EMU_02_V1.dgn	25/09/2014	2

REGISTRATION NUMBER
INFO DOC ONLY

A3 original | This sheet may be prepared using colour and may be incomplete if copied | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D.

PRODUCED: 25/09/2014 AT 11:24:01 AM USER: harrisje
FILE PATH: K:\PROJECTS\10_PACIFIC HIGHWAY\HW10 WOOLGOOLGA TO BALLINA\Drawings\Concept\PDS\Info Docs\140909 Temp Emu Fence\V3\ID3_EMU_02_V1.dgn
PLOT DRIVER: d:\data\Bentley\WorkSpace\Standards\plotdrv\PDF-wc2u.pltcfg
PEN TABLE: d:\data\Bentley\WorkSpace\Standards\tables\pen\TEXT_SUBSTITUTIONS_FOR_COLOUR.tbl

Appendix E. Aerial survey pilot study

Pacific Highway Upgrade Woolgoolga to Ballina Coastal Emu Monitoring Study

ROADS AND MARITIME SERVICES

Aerial survey of emus in Sections 3 and 4: a pilot study

Final

20 February 2015

JACOBS

Coastal Emu Pre-construction Survey Requirements

Project no:	EN04338
Document title:	Aerial survey of emus in Section 3 and 4: a pilot study
Revision:	Final
Date:	20 Feb 2015
Client name:	NSW Roads and Maritime Services
Author:	Chris Thomson
File name:	v.2

Jacobs Group (Australia) Pty Limited
ABN 37 001 024 095
710 Hunter Street
Newcastle West NSW 2302 Australia
PO Box 2147 Dangar NSW 2309 Australia
T +61 2 4979 2600
F +61 2 4979 2666
www.jacobs.com

Important note about your report

The sole purpose of this report and the associated services performed by Jacobs is to monitor emu activity and habitat use for the W2B project environmental monitoring program in accordance with the scope of services set out in the contract between Jacobs and the Client. That scope of services, as described in this report, was developed with the Client.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from information sourced from the Client (if any) and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context. Some project specific limitations exist in relation to permission to enter private properties that are outside the project corridor.

This report has been prepared on behalf of, and for the exclusive use of, Jacobs's Client, and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and the Client. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party

Document history and status

Revision	Date	Description	By	Review	Approved
V1	03/12/14	Draft review	J.Carr	Practice	C.Thomson

Contents

Executive Summary

This report describes the methods and outcomes of an aerial emu survey pilot study conducted in Sections 3 and 4 of the Woolgoolga to Ballina Pacific Highway Upgrade (W2B) during the pre-construction phase of the project. The aim of the pilot study was to determine the efficacy of conducting an aerial survey for emus as a means of supplementing ground-surveys which report on emu presence, movements, habitat use and relative density. The pilot study included the following objectives:

1) Trial the transect line method to determine its efficacy for the target species in the Project area and for assessing the sightability of emus from the air for the different habitat strata.
2) Survey east and west of the proposed Pacific Highway road corridor (within sections 3 and 4) to identify emu distribution and abundance in relation to the Project.
3) Determine if sufficient data can be recorded to identify a baseline for ongoing monitoring of change in the density and distribution of emus during and after construction of the Project and therefore provide meaningful input into the adaptive emu management program.

The aerial survey concentrated over two survey blocks centred on Section 3 of the W2B project between Pillar Valley and Tyndale (Area A) and Section 4 from the Shark Creek wetlands to the cane properties between Tyndale and Maclean (Area B). Both areas include a range of habitats from pastoral and cropping land (cleared), to wetlands and forest. The two survey blocks were chosen to provide even spatial coverage of the Project area and sample the habitat types known to be used by emus. The technique used distance sampling to count emus along transect lines from a helicopter (Bell 206 BIII) flown at 250 feet (76 m) above ground with a ground speed of 50 knots (93 km h^{-1}). The pilot used a global positioning receiver (GPS) with pre-recorded start and end points to navigate along each transect. Two observers sat in the rear seat and counted emus from either side of the transect centre line. A third observer sat in the front seat. Emu sightings were noted and placed into 25 m distances classes, up to 150 m perpendicular to the transect line and recorded on to a dictaphone for later transcribing and analysis of data. This allowed a search width of 300 metres along each transect. A pole attached to the helicopter at either side was used to delineate the distance classes. Distances were calibrated by test flight over measured distances on the ground.

Despite a search area of 61.2 km^2, only one adult emu was observed in the Project area. The bird was located in Area A to the east of the road alignment in the upstream areas of Black Snake Creek. A second emu was observed southwest of Sandon to the northeast of the Project study area using a random meander search method.

The low sample size was found to be insufficient for statistical analysis of emu density however the survey method was found to be effective at sighting emus in addition to a wide range of other native fauna, which included macropods, waterbirds and terrestrial birds. This included a diversity of large and medium-sized birds which were easily identified at 650 feet, including Brolga (*Grus rubicunda*), Black-necked Stork (*Ehippiorhynchus asiaticus*) and Pacific Heron (*Ardea pacifica*) indicating good sightability for large birds. Based on these observations, the results from the survey are likely indicative of a very low emu presence and density in the Project area at the time of survey rather than an ineffective survey method.

Based on these results it is evident that the aerial survey method for emus is likely to yield low results when conducted over a single survey and that repeated surveys over multiple days may be required to obtain more robust data for analysis of emu density in the survey area. This is due to the low-population density, the commonly reported presence of single birds or pairs and the widespread habits of the species. Given these constraints and costs involved with aerial surveys the use of repeated surveys over multiple days is not considered an efficient or cost effective method of survey of emus in the Project area compared with the repeated ground surveys.

1. Introduction

1.1 Background

A coastal emu management plan (the Plan) was prepared as part of the W2B Pacific Highway Upgrade (the Project) with the objective of outlining mitigation measures targeted at coastal emus to be implemented during the different phases of the project. To determine the effectiveness of the mitigation the Plan details a program for monitoring emus and habitat use using ground surveys that record emu presence and signs and compare the results of impact versus control sites during pre-construction, construction and operation. A peer review of the Plan was conducted by Professor Stephen Davies, who recommended the trial of an aerial survey to supplement the ground-based surveys for determining emu distribution and abundance in relation to the Project.

This report describes the methods and outcomes of the aerial pilot study conducted in Sections 3 and 4 of the Project during the pre-construction phase. The aerial survey was conducted as a pilot to test the efficacy of the method for the target species and determine if the density of emus in the study area is of sufficient size for robust statistical analysis. The validity of continuing this technique in the ongoing emu monitoring program is discussed.

Aerial surveys have been used in Australia for wildlife management for decades. In a few instances these have included emus as a secondary target species (Caughley and Grice 1982; Grice *et al* 1985; Wilson *et al* 1987 and Pople *et al* 1991), and at least one study reported a targeted aerial survey of emus in central Australia (Hone and Short 1988). The technique is well suited to large animals with a choice of survey platforms depending on the size of the survey area and cost restrictions. These include fixed-wing aircraft, helicopter or ultralight. Helicopters are preferred over fixed-wing aircraft in smaller areas because speed and altitude can be altered to achieve improved sightability (Clancy 1999). The small area targeted for the current survey (approximately 250km^2), low population density of emus and expected low sightability in forest habitats is considered best suited to a helicopter survey over fixed-wing aircraft.

Wilson *et al*. (1987) observed that densities of emus from an aerial survey in semi-arid habitat did not change substantially between late winter and spring, and reported no significant effects of time of day of the survey (early morning versus late afternoon). Similarly, Hone and Short (1988) reported no significant correlations between cloud cover, temperature and time of day on observed densities of emus over two seasons from an aerial survey. These data contrast with kangaroo surveys where temperature and cloud cover (Bayliss and Giles 1985; Short and Bayliss 1985) and time of day (Hill *et al.* 1985) have been shown to influence sightability of kangaroos. Generally emus are considered less inclined to shelter during the middle of the day in contrast to kangaroos and hence survey time of day is not restrictive.

The survey season selected for the pilot is spring to coincide with peak movements of birds around the Coldstream and Shark Creek floodplains and presence of chicks. This timing also coincides with the annual ground-based community emu surveys conducted annually by NPWS which occur over the broader distribution of the population and therefore provide input to this work. The aerial survey was conducted on 8-9 October, around 4 weeks after the community-based emu survey.

1.2 Aim and Objectives

The aim of the survey was to determine the efficacy of the technique for supplementing the ground-survey program which reports on emu movements, habitat use and relative density. The pilot study included the following objectives:

4) Trial the transect line method to determine its efficacy for the target species in the Project area and for assessing the sightability of emus from the air for the different habitat strata.
5) Survey east and west of the proposed Pacific Highway road corridor (within sections 3 and 4) to identify emu distribution and abundance in relation to the Project.
6) Determine if sufficient data can be recorded to identify a baseline for ongoing monitoring of change in the density and distribution of emus during and after construction of the Project and therefore provide meaningful input into the adaptive emu management program.

2. Methods

2.1 Study area

The aerial survey concentrated over two survey blocks centred on Section 3 between Pillar Valley and Tyndale (Area A) and Section 4 from the Shark Creek wetlands to the cane properties between Tyndale and Maclean (Area B). Both areas include a range of habitats from pastoral and cropping land (cleared), to wetlands and forest. The two survey blocks were chosen to provide even spatial coverage of the Project area and sample these habitat types known to be used by emus (**Figure 1**).

Area A is approximately 20 km x 10 km between Eight Mile Lane in the south to the Clarence River and Tyndale in the north, east to the foothills of the Pillar Valley Range and Shark Creek Range and west to the Coldstream River and surrounding wetlands. Area B is approximately 10 km x 6 km and extends to upper Shark Creek and associated wetlands and the cane land surrounding Tyndale and Shark Creek.

2.2 Stratification and transects

The study area contains a mix of agricultural land on which crops are grown, pastoral land running cattle, and forests, some of which are used for commercial timber production. There is considerable variation in topography from the low-lying Coldstream floodplain in the west to the Somervale Range (220 m ASL) in the east.

The placement and length of transects considered the topography as the primary strata and the need to fly at a constant altitude along transects. Therefore the steeper escarpment of the Somervale Range and Shark Creek Range were avoided. Transects were then stratified according to the dominant habitat types 1) forest, 2) cleared (floodplain, cane and open wetlands). The soil types reflect the topography, with alluvial soils over the floodplain and wetlands and sandy soils in the low hills and ridges occupied by forest. Refer to Figure 1 for habitat strata and transect arrangement.

A total of 15 parallel north-south transects were placed perpendicular along the long axis of Area A using a 1km grid pattern. Transect lengths vary from 4 km to 19 km and avoid steep and densely forested terrain and urbanised areas of Tucabia. The north-south orientation allowed transects to be placed east and west of the future road corridor and evenly between cleared and forested land. Of the 15 transects 8 sampled cleared land and 7 sampled forested habitat. The total transect length for Area A was 159 km.

A total of 11 parallel east-west transects were positioned perpendicular to the short axis of Area B. Transects were placed 1 km apart and range from 3 to 8 km in length and aimed to sample separately the cleared cane properties (6 transects) and floodplain forests (5 transects). The total transect length for Area B was 45 km.

Transect identification, length and search areas are outlined in Table 1 and transects shown on Figure 1. The search area was based on a 300 metre wide strip transect as discussed in Section 2.3. In total the survey covered 204 km of transects and around 61.2 square kilometre search area.

FIGURE 1 | FLIGHT TRANSECTS

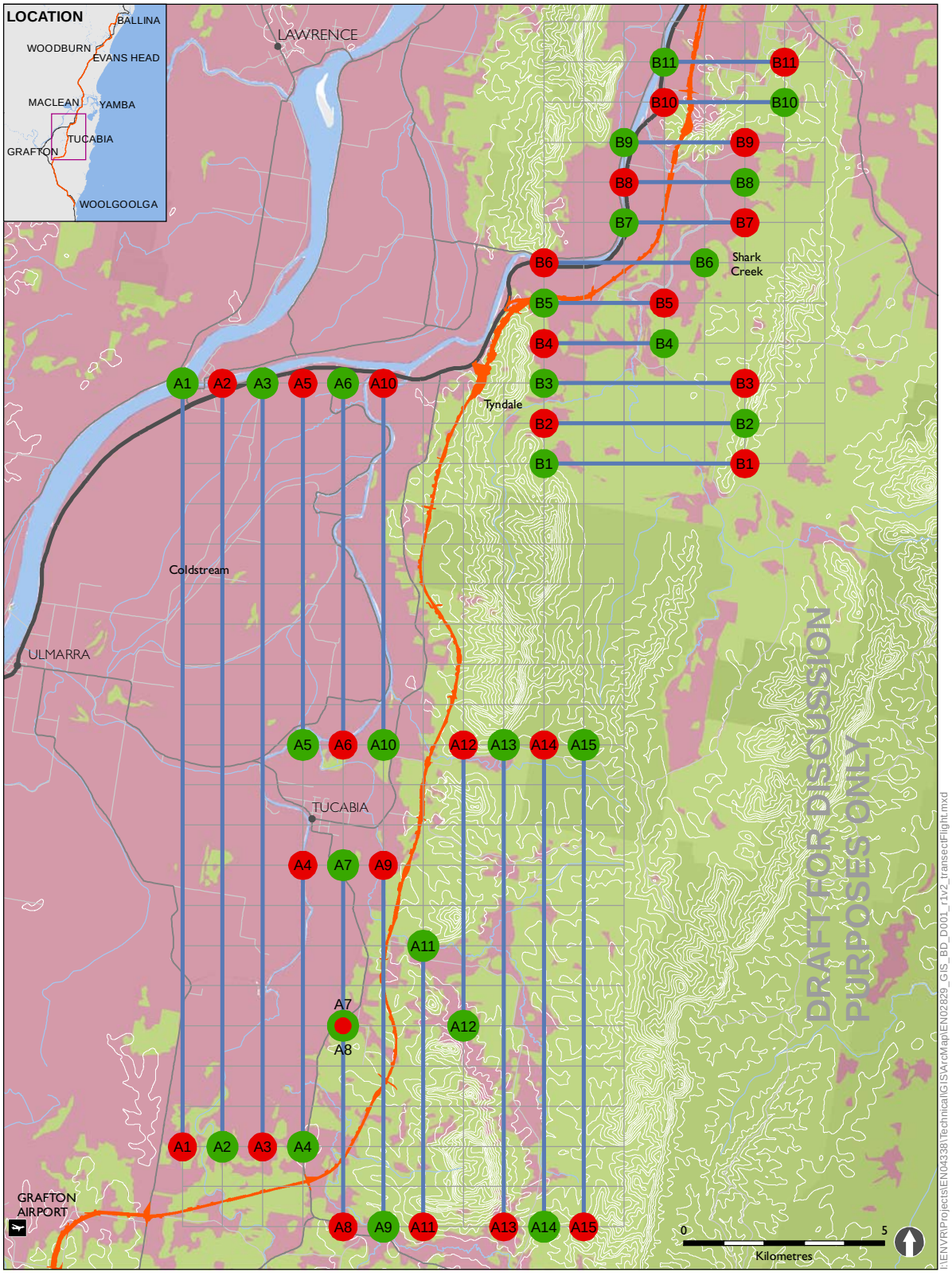


Table 1. Transect identification, strata, length and search area

Survey Block	Transect	Strata	Transect length (km)	Search area (km^2) based on 300 m transect width
Area A	A1	Cleared	19	5.7
	A2	Cleared	19	5.7
	A3	Cleared	19	5.7
	A4	Cleared	7	2.1
	A5	Cleared	9	2.7
	A6	Cleared	9	2.7
	A7	Cleared	4	1.2
	A8	Forest	5	1.5
	A9	Forest	9	2.7
	A10	Cleared	9	2.7
	A11	Forest	7	2.1
	A12	Forest	7	2.1
	A13	Forest	12	3.6
	A14	Forest	12	3.6
	A15	Forest	12	3.6
	Total Area A		*159 km*	*47.7 km^2*
Area B	B1	Forest	5	1.5
	B2	Forest	5	1.5
	B3	Forest	5	1.5
	B4	Cleared	3	0.9
	B5	Cleared	3	0.9
	B6	Cleared	4	1.2
	B7	Cleared	3	0.9
	B8	Cleared	8	2.4
	B9	Forest	3	0.9
	B10	Forest	3	0.9
	B11	Cleared	3	0.9
	Total Area B		*45 km*	*13.5 km^2*
	Total search area		**204 km**	**61.2 km^2**

2.3 Survey method

The technique used distance sampling to count emus along each transect line from a helicopter (Bell 206 BIII) flown at 250 feet (76 m) above ground with a ground speed of 50 knots (93 km h^{-1}). The pilot used a global positioning receiver (GPS) with pre-recorded start and end points to navigate along each transect.

Two observers sat in the rear seat and counted emus from either side of the transect centre line. A third observer sat in the front seat. Emu sightings were noted and placed into 25 m distances classes, up to 150 m perpendicular to the transect line and recorded on to a dictaphone for later transcribing and analysis of data. This allowed a search width of 300 metres. A pole attached to the helicopter at either side was used to delineate the distance classes (example shown on **Plate 1**). Distances were calibrated by test flight over measured distances on the ground.

Figure 1. Example of pole used to delineate distances of observations from the transect

Transects were surveyed over two days on 8-9 October 2014, and were conducted by Chris Thomson (Jacobs), Simon Wilson (RMS), Gina Hart (NPWS) and Scott Lawrence (RMS). Flights were made within 6 hours of first light under low to moderate wind conditions, with no rain. Transect were completed over 2.5 hours for Area A and 1 hour for Area B.

In addition to the systematic survey an additional 1.5 hours were spent searching other known habitat areas to the northeast and southeast of the Project corridor using a random meander search technique. The random search flight covered parts of Gulmarrad to Brooms Head and Sandon and Minnie Waters to Pillar Valley.

2.4 Data analysis

In the line-transect method, observers count individuals sighted in each of a series of parallel strips, demarcated by a grid positioned between the viewer and the ground. The shape of the curve of numbers seen plotted against distance from the line is the basis of calculations that lead to an estimate of density in the total area viewed. This can then be scaled up to the whole survey area. Comprehensive descriptions of line-transect methods and analytical method can be found in Buckland *et al.* (1993). All data was collected on electronic voice recorders for input and analysis via the computer software program Distance 6.0®.

The locations and numbers of emus relative to the highway corridor were recorded using GPS to provide positional data in relation to monitoring the effectiveness of the emu crossing structures.

3. Results and Discussion

Despite a search area of 61.2 km^2, only one adult emu was observed in the Project area. The bird was located in Area A (transect A12) to the east of the road alignment in the upstream areas of Black Snake Creek. A second emu was observed southwest of Sandon to the northeast of the Project study area using the random meander search method. Both emus were in open habitat on the edge of forested land and were sighted easily from the helicopter and appeared to remain relatively stationary upon observation. The low sample size was found to be insufficient for statistical analysis of emu density.

The line transect survey method was found to be very effective at sighting a wide range of native fauna in addition to emus, which included macropods, waterbirds and terrestrial birds. This included a diversity of large and medium-sized birds which were easily identified at 650 feet, including Brolga (*Grus rubicunda*), Black-necked Stork (*Ehippiorhynchus asiaticus*) and Pacific Heron (*Ardea pacifica*) indicating good sightability for large birds. Based on these observations, the results from the survey are likely indicative of a very low emu presence in the Project area at the time of survey rather than an ineffective survey method.

Sightability was greatest in the cleared land, as well as wetlands and cane land. Observability of emus is likely to be greater in the sparsely covered habitats (cleared and cropped) suggesting that true emu densities may be higher than determined in forested habitats. Groups of macropods were observed in forested habitats indicating good sightability to ground level. However Samuel and Pollock (1981) reported that sightability bias in aerial surveys for some species may be related to group size, wherein the probability of an observer seeing a larger group is higher than that of seeing a smaller group. Most accounts of macropods in the forest habitats were indeed of groups of animals while observations of emus in the study area from ground surveys are typically of single individuals or pairs rather than groups and this may have an effect on the sightability of emus in forested areas.

The pilot study identified two important conclusions;

- Firstly that aerial search methods using helicopter and line transect sampling as well as random searches are both effective at identifying emus from the air and that the line transect method proved an effective method at systematically determining the presence and absence of coastal emus from the Project area.
- Secondly, that the low population density of emus in the Project study area resulted in the data derived from a single survey being insufficient for robust statistical analysis and ongoing comparison of population density.

In comparison, the ground-based search methods that are being used in the ongoing monitoring program are considered more effective at identifying emu distribution and abundance through seasonal searches of emu signs and use of motion sensor cameras deployed continuously over different seasons. These results reflect the wide-ranging and semi-nomadic movements of coastal emus where low numbers of birds reside over large areas.

Based on these results it is evident that the aerial survey method for emus is likely to yield low results when conducted over a single survey and that repeated surveys over multiple days may be required to obtain robust data for analysis of density. This is due to the low-population density, the commonly reported presence of single birds or pairs and the widespread habits of the species. Given these constraints and costs involved with aerial surveys the use of repeated surveys over multiple days is not considered an efficient or cost effective method of survey of emus in the Project area compared with the repeated ground surveys .

4. References

Bayliss, P., and Giles, J. (1985). Factors affecting the visibility of kangaroos counted during aerial surveys. *Journal of Wildlife Management* **49,** 686–692.

Hill, G. J. E., Barnes, A., and Wilson, G. R. (1985). Time of day and aerial counts of grey kangaroos. *Journal of Wildlife Management* **49**, 843–849.

Buckland, S. T., Anderson, D. R., Burnham, K. P., and Laake, J. L. (1993). 'Distance Sampling.' (Chapman and Hall: London.)

Caughley, G., and Grice, D. (1982). A correction factor for counting emus from the air, and its application to counts in Western Australia. *Australian Wildlife Research.* **9,** 253-259.

Clancy, T.F (1999). Choice of survey platforms and technique for broad-scale monitoring of kangaroo populations*. Australian Zoologist* 31(1) 267-74.

Grigg, G.C., Pople, A.R. and Beard, L.A. (1997). Application of an ultralight aircraft to aerial surveys of kangaroos on grazing properties. *Wildlife Research* **24**, 359-372.

Wilson, G.R., Hill, G.J and Barnes, A. (1987). An aerial survey of feral pigs and emus in south-eastern Queensland. *Australian Wildlife Research*, **14**, 515-520.

Pople, A., Cairns, S.C, and Grigg, G.C. (1991). Distribution and abundance of Emu *Dromaius novaehollandiae* in relation to the environment in the South Australian pastoral zone. *Emu*, 91, 222-229.

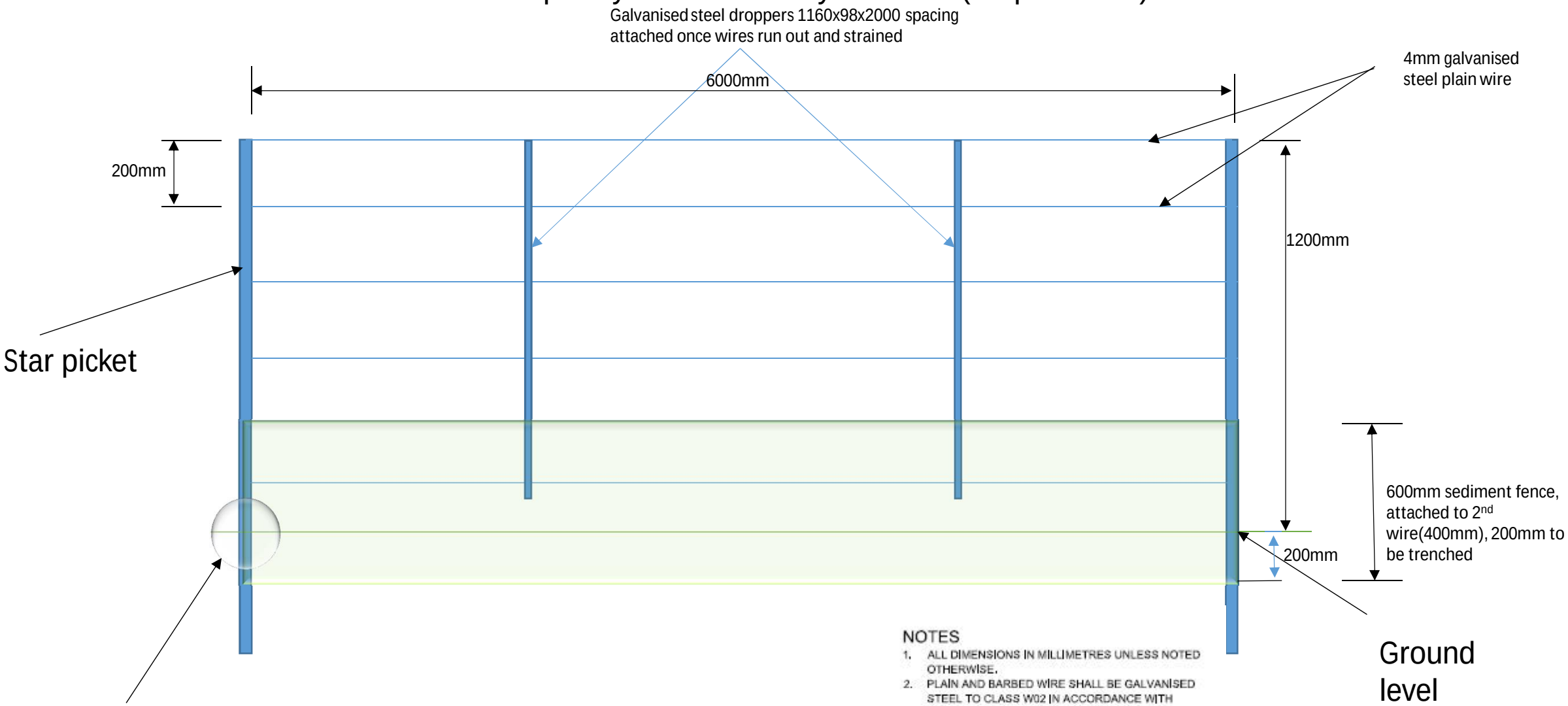
Hone, J., and Short, J. (1988). A note on the sightability of emus during an aerial survey. *Australian Wildlife Research*, **15**, 647-9.

Samuel, M. D., and Pollock, K. H. (198 1). Correction of visibility bias in aerial surveys where animals occur in groups*. J. Wildl. Manage*. 45, 993-7.

Short, J., and Hone, J. (1988). Calibrating aerial surveys of kangaroos by comparison with drive counts. *Australian Wildlife Research* **15,** 277–284.

Appendix F. Temporary exclusion fence to be used during construction

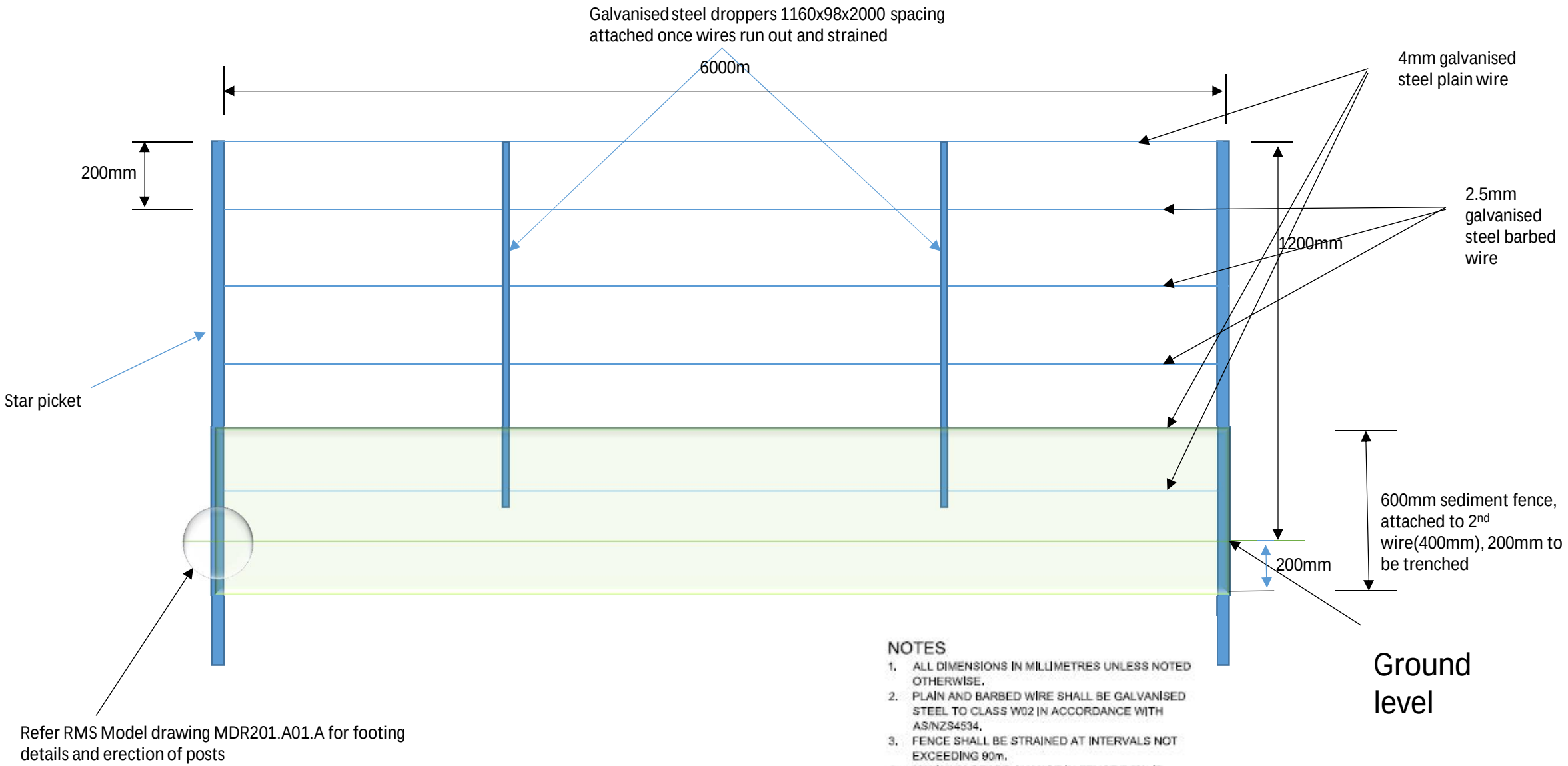
Temporary Emu Fence – Tyndale Cut (6 x plain wire)



NOTES

1. ALL DIMENSIONS IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. PLAIN AND BARBED WIRE SHALL BE GALVANISED STEEL TO CLASS W02 IN ACCORDANCE WITH AS/NZS4534.
3. FENCE SHALL BE STRAINED AT INTERVALS NOT EXCEEDING 90m.
4. MAXIMUM GRADE CHANGE IN FENCE 7.5%, IF GREATER STRAINER POST AND STRUT REQUIRED.
5. REFER TO RMS STD MODEL DRG MD,R201,A04,A FOR MATCHING GATE DETAILS.
6. REFER TO RMS STD MODEL DRG MD,R201,A03,A FOR WIRE FASTENING DETAILS.

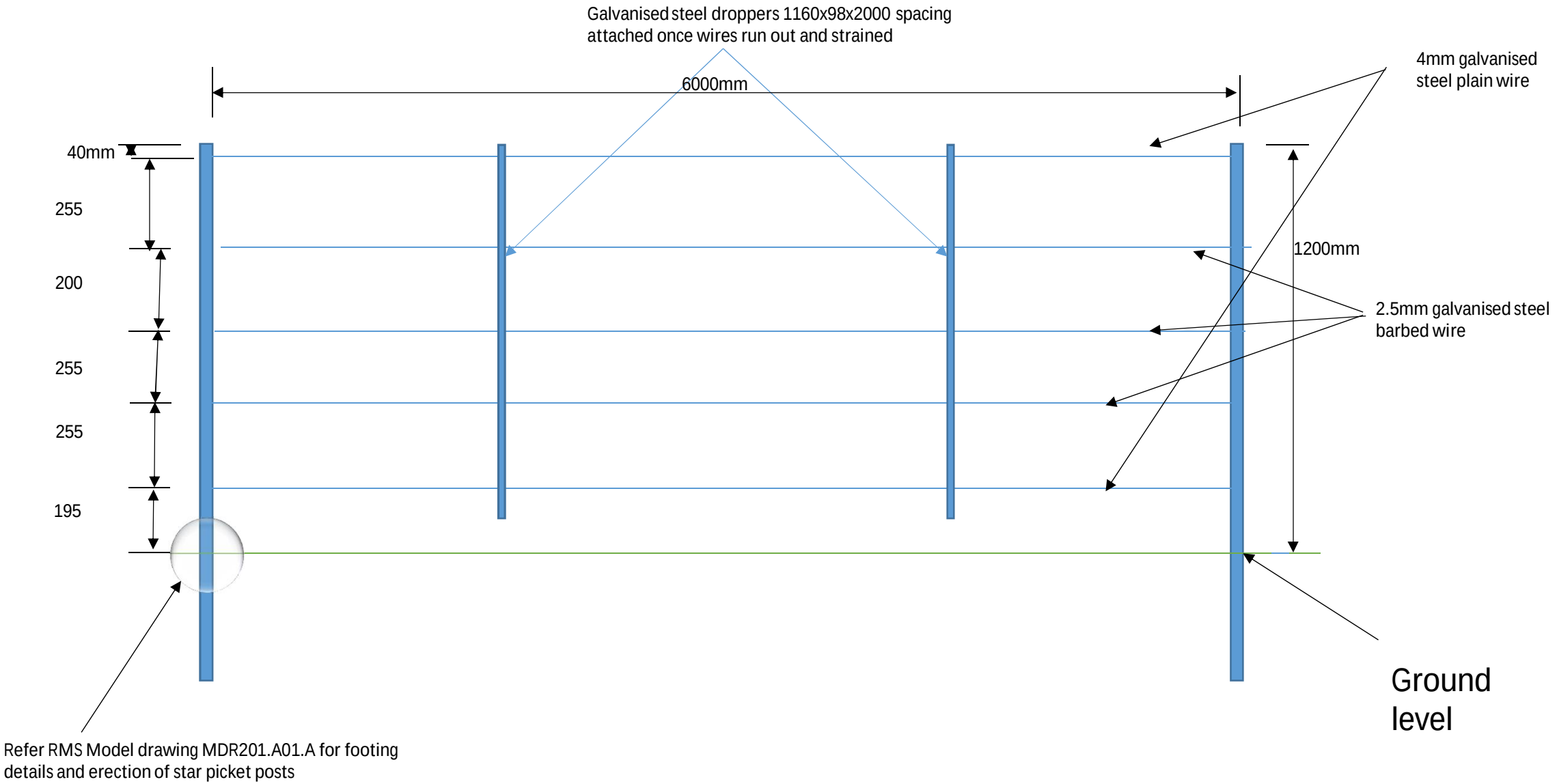
Temporary Emu/Stock Fence –(APO 125) Greenhill Cut (3 x plain wire, 3 x Barbed)



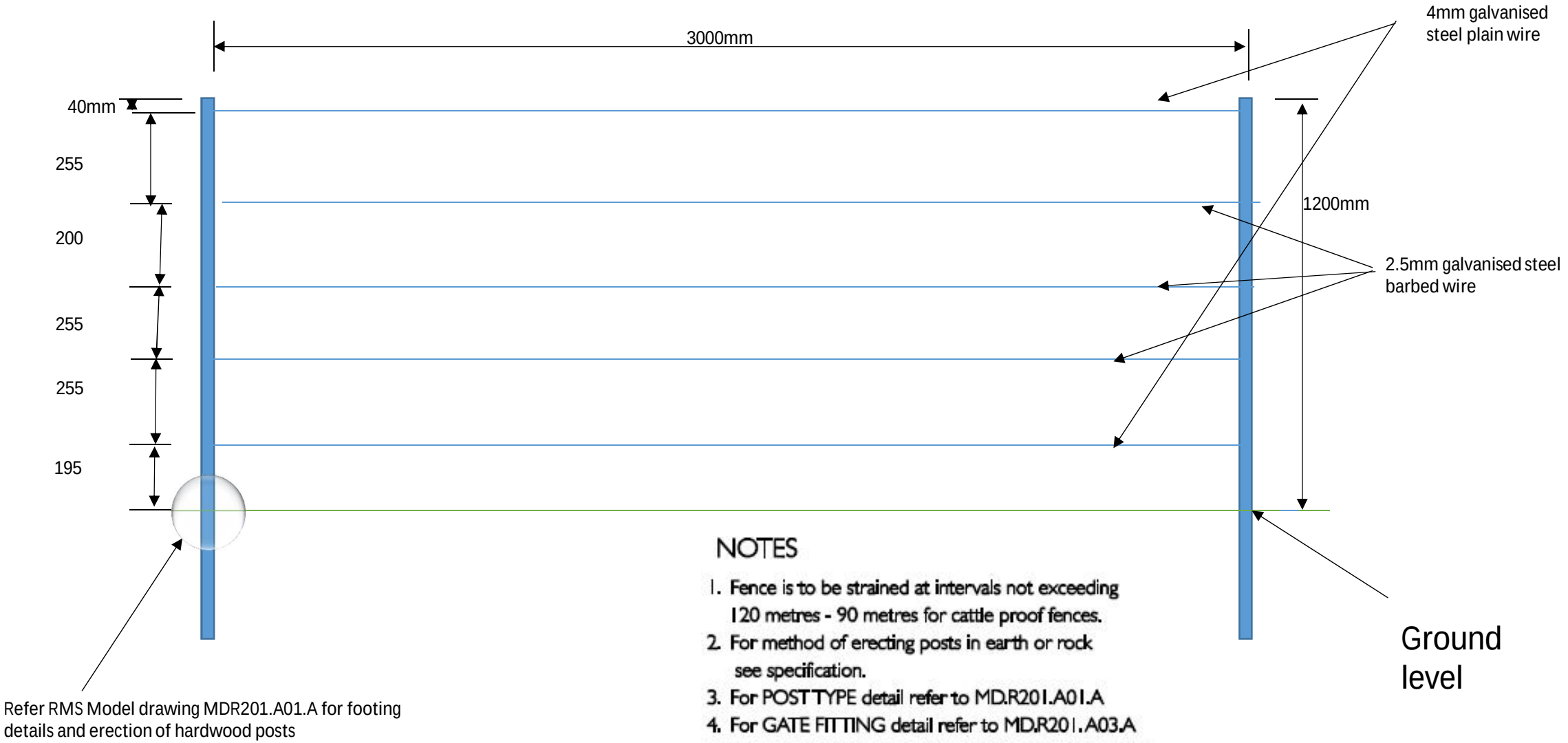
NOTES

1. ALL DIMENSIONS IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. PLAIN AND BARBED WIRE SHALL BE GALVANISED STEEL TO CLASS W02 IN ACCORDANCE WITH AS/NZS4534.
3. FENCE SHALL BE STRAINED AT INTERVALS NOT EXCEEDING 90m.
4. MAXIMUM GRADE CHANGE IN FENCE 7.5%, IF GREATER STRAINER POST AND STRUT REQUIRED.
5. REFER TO RMS STD MODEL DRG MD,R201,A04,A FOR MATCHING GATE DETAILS.
6. REFER TO RMS STD MODEL DRG MD,R201,A03,A FOR WIRE FASTENING DETAILS.

Temporary Stock Fence– APO 168 (2 x plain wire, 3 x barbed wire)



Permanent Stock Fence–APO169(2 x plain wire, 3 x barbed wire)



NOTES

1. Fence is to be strained at intervals not exceeding 120 metres - 90 metres for cattle proof fences.
2. For method of erecting posts in earth or rock see specification.
3. For POST TYPE detail refer to MD.R201.A01.A
4. For GATE FITTING detail refer to MD.R201.A03.A
5. For FASTENING wire detail refer to MD. R201.A04.A
6. Fencing materials are to be in accordance with specification - R 201

Appendix G. Minutes and correspondance from detailed design emu connectivity workshops / meetings

Woolgoolga to Ballina: Emu Workshop

Date:	24 July 2015
Time:	10:00 – 2.00PM
Location	21 Prince Street, Grafton, Pacific Highway Conference Room
Chairperson:	Scott Lawrence

Attendees:

Scott Lawrence (SL)	RMS
Bob Higgins (BH)	RMS
Simon Wilson (SW)	RMS/Pacific Complete
Mike Bulmer (MB)	RMS/Pacific Complete
Mark Woods (MW)	RMS/Pacific Complete
Brett Nudd (BN)	EPA
Peter Higgs (PH)	EPA
Gina Hart (GH)	NPWS
Chris Thomson (CT)	Jacobs
Greg Cook (GC)	Pacific Complete
Hugh Madden (HM)	Pacific Complete
Kenny Frain (KF)	Pacific Complete
Peter Rees (PR)	Pacific Complete

Notes

Item No.	Subject
1.	**Introductions and Objectives** SL – Objectives for the workshop is to provide an update on the pre-construction emu monitoring and confirm proposed emu connectivity structures. The outcomes of the workshop will assist Pacific Complete as they progress into the detailed design and addressing MCoA D8 and B11 and ultimately Connectivity Strategy required under MCoA D2 All - All parties introduced themselves around the table.
2.	**Background and Investigations to date** CT - Provides an overview of emu surveys undertaken for the EIS/SPIR and development of the emu connectivity strategy and design principles. CT – Provides update on pre-construction emu monitoring including trial emu fence; • Monitoring commenced December 2013 • Trial fence established December 2014 • Purpose: o establish a subset of crossing zones prior to construction o educate emus to use proposed crossing points o test accuracy or propose crossing points o observe behaviours with proposed exclusion fence and hybrid fence design • Emu presence detected at all crossing zones and around 60% of crossing points have a confirmed crossing. • Results indicate higher emu activity around Tucabia south than Tucabia North. This may be a result of higher rainfall over the past few years. • Emus observed walking past the hybrid fence however no crossing attempts. Action – SW to attach material (flagging tape, cd's) to the hybrid fence to attract emus. Action – RMS to consider trialling another hybrid fence design if other solutions are identified. • Results indicate crossing zones are accurate and exclusion fence is effective.
3.	**Review of connectivity structures** PR – Explained connectivity structures for sections 3 and 4 and any proposed changes from the SPIR. • GC – Pacific Complete are investigating options to combine Coldstream bridges 1, 2 and 3. Benefits may include construction efficiencies, time and cost. After feedback from an emu connectivity perspective: o PH,SW,CT,GH - Combining all structures into one structure with no net increase in structure length is not ideal from a fauna connectivity perspective because only provides connectivity for that habitat type/fauna corridor. o SL, SW – Raised concerns about the sensitive waterway/wetland at Coldstream bridge 1. Creek realignment most likely not supported. o Action - Pacific Complete to advise if any changes are proposed to Coldstream bridges.

	• GC - Pacific Complete are investigating options to combine Pillar Valley bridges 1, 2, 3, 4 and 5. Benefits may include construction efficiencies, time and cost. After feedback from an emu connectivity perspective: o PH,SW,CT,GH - Combining all structures into one structure with no net increase in structure length is not ideal from a fauna connectivity perspective because only provides connectivity for that habitat type/fauna corridor. o CT – Important to maintain connectivity for the different habitat types with Pillar Valley bridges 4 and 5. o SW - Need to consider landowner access commitments under bridges. o Action - Pacific Complete to advise if any changes are proposed to Pillar Valley Bridges. • CT – 120m bridge at chainage 49.250 (adjacent to Mitchell Road) is important for emu connectivity with high activity recorded. Priority structure. • PR - Pacific Complete is proposing to change the 3 Arch structures (ch 53.699, 59.272, 60.802) to plank bridges. Clearance is reduced from 5.5m to 3.6m however the overall cross section opening is maintained or increased. 4m fauna passage is also maintained on one side. The bridge design enables light penetration into the median. o General support from all. o Action – EPA to confirm if support change from arch to bridge on week starting 27/7. • PR – The 3.6 x 3.6m RCBC at chainage 51.400 has been reduced in length from 62m – 48m • PR - Shark Creek Bridge has been increased in length from 450m to 865m for hydrological reasons. • PR – Discussion about scour protection options. Agreed by all that it is important to maintain natural materials under bridges as much as possible. Soft scour treatments with Lomandra plantings could attract emus to crossing structures. • No further changes to remainder of structures and general support for connectivity structures. **Emu connectivity during construction** All – Open discussion about potential issues and solutions with maintaining emu connectivity from west – east for the construction period. • CT/GH – It is important to maintain emu connectivity for the 3 year construction period. • SW/SL/CT - Permanent exclusion fence should be established early in areas where flooding is not an issue. Temporary fence arrangement could be used in flooded areas until the permanent fence can be established on the batter. Emus are inquisitive and may cross through designated openings during construction • BH - Constructing bridges early may be an option to allow emu connectivity early pending Pacific Complete investigation into staging/procurement • SW - Allowing emu connectivity in out of hours, wet days, holidays and Sundays, another option. • Providing designated emu crossing points across the construction corridor with appropriate fencing and signage for construction plant, should be

	considered. • Action – GC to confirm construction staging and potential solutions. • Action – CT to update the Emu Management Plan with proposed approach including a construction emu connectivity protocol.
4.	**Summary Actions:** • Action – SW to attach material (flagging tape, cd's) to the hybrid fence to attract emus. • Action – RMS to consider trialling another hybrid fence design if other solutions are identified. • Action - Pacific Complete to advise if any changes are proposed to Coldstream bridges following hydraulic investigations • Action - Pacific Complete to advise if any changes are proposed to Pillar Valley Bridges following hydraulic investigations • Action – EPA to confirm if support change from arch to bridge on week starting 27/7. • Action – GC to confirm construction staging and potential solutions for emu connectivity during construction. • Action – CT to update the Emu Management Plan with proposed approach including a construction emu connectivity protocol.

Hi Simon and others,

In reference to the Emu connectivity meeting last Friday 4/12/15 the EPA notes the following:

- Hydrological design and standardisation review has resulted in the net reduction (of 97 metres) of bridging in section 3 and 4, in comparison to SPIR design and draft Emu management Plan (finer detail as included in e-mail below and table attached). Generally the reductions have been achieved via a small reduction of the overall bridge length in each location.
- The reduction in overall bridge length equates to a reduction in available area for emu connectivity. The bridges subject to these reductions are generally in areas established as important, or hot spots, for Emu connectivity
- The 12 bridges with the proposed reductions are generally lengthy bridges ranging from 35 to 140 metres in length. Proposed reductions are relatively small in comparison to initial bridge length and remaining apertures are generally large, with an average bridge length of approximately 64m (after the proposed reductions). If the 3 bridges that have been lengthened are included in this calculation the average bridge length after proposed changes is approx. 90m.
- In compensation for this loss of connectivity, Pacific Complete propose to upgrade two (SPIR) culverts to 20m plank bridges (details in e-mail below). Both bridges will be designed to provide a minimum 3.6m high aperture for Emu passage.
- Consultant Ecologist Chris Thompson stated that the reduction in aperture size on some bridges that is represented by this redesign is adequately compensated for ecologically by the proposed 2 plank bridge upgrade/additions, for the following reasons:

1. Monitoring to date demonstrates that Emu's are using apertures in the trial fencing freely and seemingly independent of size, i.e. a twelve metre aperture is being as well utilised as much larger gaps.
2. The 2 new proposed structures are optimally placed in key corridor the primary Emu area. One of the structures halves what was previously a 2 km gap between connectivity structures. Chris Thompson when asked could not suggest more appropriate placement for these 2 new structures.

In response the EPA provide the following comments:

- In principle agreement that the revised proposals will deliver a balanced conservation outcome, on the understanding that :

1. The proposed additional plank bridges are well placed in primary Emu usage areas based on currently available monitoring and information.
2. That shortening already quite long bridges will not significantly alter their potential utility as connectivity structures.

- The EPA understands that the revised proposals will deliver net financial savings and would appreciate the opportunity to discuss options for redirecting some of these savings into the mitigation strategies embedded in the Emu Strategy.
- In this context the EPA notes the value in delivering a co-ordinated feral reduction program in this area, which is also supported by other key stakeholders. The value of co-ordination is highlighted by the fact that several disparate feral reduction programs are currently being planned in the local region, including RMS feral reduction programs for offset properties.
- The EPA would appreciate the opportunity to comment on the draft Emu Management Plan, once these changes are incorporated.

Happy to discuss the above

Regards

Peter

Peter Higgs
Senior Threatened Species Officer-North Coast Region
North Branch, NSW Environment Protection Authority
+61 2 66598223 +61 402 149 302

Peter.Higgs@epa.nsw.gov.au www.epa.nsw.gov.au @EPA_NSW

Appendix H. Phase 1 Emu monitoring report

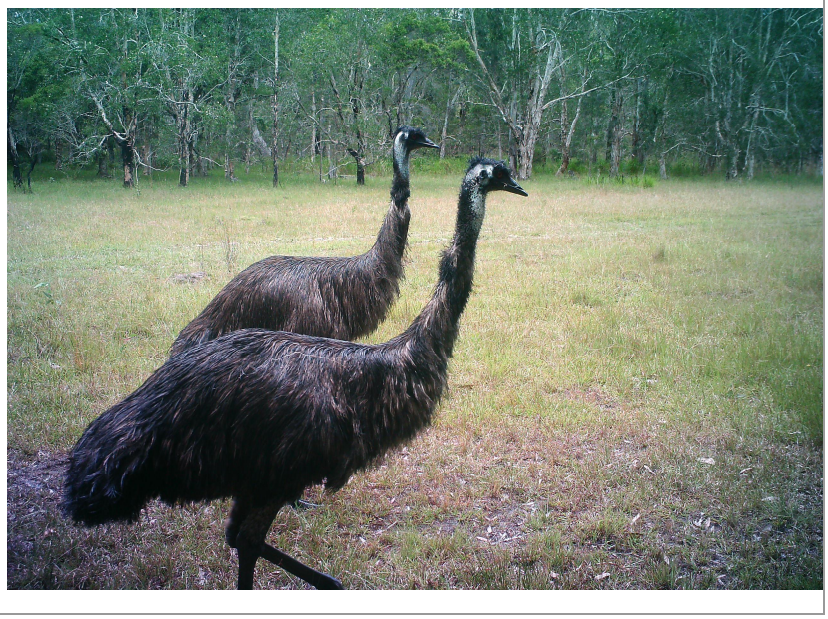
Pacific Highway Upgrade Woolgoolga to Ballina Coastal Emu Monitoring Study

ROADS AND MARITIME SERVICES

Phase 1: Pre-construction Survey Report (pre-fencing)

FINAL

01 November 2014



JACOBS®

Coastal Emu Pre-construction Survey Requirements

Project no:	EN04338
Document title:	Coastal Emu Baseline Survey Report
Document no:	FINAL
Revision:	FINAL
Date:	01 November 2014
Client name:	NSW Roads and Maritime Services
Client no:	
Project manager:	Chris Thomson
Author:	Chris Thomson
File name:	v.3

Jacobs Group (Australia) Pty Limited
ABN 37 001 024 095
710 Hunter Street
Newcastle West NSW 2302 Australia
PO Box 2147 Dangar NSW 2309 Australia
T +61 2 4979 2600
F +61 2 4979 2666
www.jacobs.com

Document history and status

Revision	Date	Description	By	Review	Approved
V1	19/08/14	Draft review	J.Carr	Practice	C.Thomson
V2	01/11/14	Final review	A.Carty	Practice	C.Thomson

Contents

Executive Summary

The report details the methods and results of emu surveys conducted during the first six months of the pre-construction phase of the W2B Project. The first stage focused on establishing monitoring locations and gathering baseline data to inform the adaptive management program for Project sections 3 and 4 of the upgrade.

The monitoring program aims to determine if the mitigation measures for emus have been effective in the long-term and therefore achieve the mitigation goals in the Plan. The underlying objectives of the program are to:

- Further understand distribution and habitat use by emus near the road corridor.
- Identify the trend in population density of the local population residing in the Project study area during the different stages of the project.
- Evaluate the success of mitigation measures (crossing structures, fences and habitat revegetation).

The surveys have focused on six study sites:

1. Pillar Valley west, including east and west of the Tucabia-Tyndale Road and portions of the Coldstream wetlands, and lower catchment of Pillar Valley Creek and Black Snake Creek (project Section 3).
2. Tucabia south between Mitchell Road and Firth Heinz Road (project Section 3)
3. Tucabia north from Bostock Road to Somervale Road and Pillar Valley State Forest, including Champions Creek and the associated floodplain (project Section 3)
4. Yuraygir south at two locations around Diggers Camp and Minnie Waters (Control)
5. Yuraygir north at two locations around Brooms Head and Taloumbi (Control).
6. Shark Creek floodplain (project Section 4).

This first stage report, discusses the establishment of survey sites and transects, and the survey method which included active searches for emus and emu sign and camera trapping.

Emu presence was reported from all impact and control study sites, with signs of emu presence reported on 95% of transects sampled. The highest density in the impact areas was found in summer at Tucabia south followed by the autumn-winter period for Pillar Valley west where emus were reported on both sides of the road corridor, and particularly near the Coldstream wetlands Remote cameras were initially set during the first survey (December 2013), and in the six months following this images of emus have been captured at 68% of transects surveyed.. The majority of these have been taken at the control areas of Diggers Creek, Minnie Waters and Brooms Head while Tucabia south and Pillar Valley are represented for the impact areas.

The initial results of the first six months of the program report on baseline conditions relating to emu activity across six study sites. These data show indications of emu density in relation to season and habitats at impact and control areas. Further baseline surveys will help to develop knowledge on emu distribution and abundance. . The highest density in impact areas was reported in the pastoral lands and forests on sandy and alluvial soils associated with Pillar Valley creek and Black Snake Creek and nearby unnamed tributaries of the Coldstream River wetlands. Comparatively lower activity was reported in the Tucabia to Tyndale area, although this was reported over a brief period and would potentially shift between years. Emus frequented sugar cane properties both for pre- and post-breeding activities and this habitat is likely to be important for raising young.

This first annual monitoring report presents the methods and results of the initial emu surveys conducted over 6 months and involved pilot investigations over a large number of transects, not all of which are described in the report. Several transects which showed no past evidence of emu activity were removed from the program and it is intended to refine and add additional transects to the program over the next 2-3 survey periods until a final suite of transects is established. The 2015 annual report will identify and map the final suite of monitoring

transects and likely include a more complete picture of the current emu distribution and activity and the bearing this has on the location of connectivity structures.

Important note about your report

The sole purpose of this report and the associated services performed by Jacobs is to monitor emu activity and habitat use for the W2B project environmental monitoring program in accordance with the scope of services set out in the contract between Jacobs and the Client. That scope of services, as described in this report, was developed with the Client.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from information sourced from the Client (if any) and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context. Some project specific limitations exist in relation to permission to enter private properties that are outside the project corridor.

This report has been prepared on behalf of, and for the exclusive use of, Jacobs's Client, and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and the Client. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party

1. Introduction

1.1 Background

Roads and Maritime Services (RMS) is upgrading the Pacific Highway from Woolgoolga to Ballina (the Project). The project was approved in June and August 2014 under the *Environmental Planning and Assessment Act,* 1979 and the Environment Protection and Biodiversity Conservation Act, 1999 respectively.. This report documents the results of the first stage of pre-construction monitoring of the endangered coastal emu population listed under the NSW *Threatened Species Conservation Act*, 1995.

The report details the methods and results of emu surveys conducted during summer, autumn and winter of 2013-14, in the pre-construction phase of the Project prior to installation of exclusion fencing and a proposed fence experimental trial. Details of the monitoring program are outlined in the Coastal Emu Management Plan (the Plan) (RMS 2013) and this first stage focused on establishing monitoring locations and gathering baseline data to inform the adaptive management program for Project sections 3 and 4 of the upgrade between Chainage 36500 and Chainage 66500.

1.2 Overview of the study

The emu monitoring program is to be conducted in stages as follows:

- Stage 1 – pre-construction (pre-fencing), current stage.
- Stage 2 – pre-construction (post-fencing)
- Stage 3 – construction phase
- Stage 4 – operational phase.

The Plan aims to provide an adaptive and responsive management approach, whereby information on the distribution of emu activity within and adjacent to the Project area will be used to guide mitigation and ongoing monitoring. Within this monitoring program, adaptive management is a technique that would be utilised to ensure emu declines are recognised if they occur as a result of the Project. Results from the monitoring program would be analysed after each sampling/survey period. Regular analysis of the data is conducted to allow improvements and refinements in the survey design to be incorporated into future monitoring activities. Appropriate triggers for the Program are consistent with those documented in the draft management plan and include a notable decline in emu activity or breeding success in the project area compared to control sites.

The program intends to compare the ‘before’ construction data with ‘during’ and ‘after’ construction data and impact sites with control sites. The study is being conducted in the vicinity of the proposed future Section 3 and 4 of the Woolgoolga to Ballina upgrade (specifically from Pillar Valley to Shark Creek). Sites have been selected to survey forest and floodplain swamp habitats as well as modified grazing land and cane farms. Impact sites are to be selected within proximity to the project corridor, and particularly near proposed crossing structures provided as mitigation in Section 3. Control sites are to be selected in coastal forest habitats which resemble the impact sites and are expected to have regular emu presence.

Other aspects of the study include an experimental trial to test the effectiveness of fencing used for exclusion and to guide the movements of emus towards crossing zones and to test different hybrid fence types that are design to exclude cattle but are permeable to emus. This work would be reported in later stages.

1.3 Mitigation and monitoring goals

The Plan identifies mitigation goals for each phase of the project from pre-construction, through construction and operation. The degree to which these goals are achieved or fail is referred to as ‘performance’ and is measured through monitoring and implementing corrective actions where performance criteria are not met. Both

RMS and the construction contractors are responsible for implementing mitigation measures and monitoring their performance.

The monitoring program discussed in this report is designed to inform the overall performance of the operational mitigation goals outlined in the Plan and these relate to the effectiveness of the road mitigation at maintaining the viability of the emu population in the study area. The specific mitigation goals relevant to this monitoring program are:

- Zero rate of traffic related emu mortality in Sections 3 and 4 of the project after 10 years.
- Post-mitigation relative density in the Project study area is similar to pre-road construction relative density after 5 years.
- Post-mitigation distribution on both sides of the road are similar to pre-road construction distribution.
- Zero or reduced rate of emu deaths from dog attacks in vicinity of crossing structures in Section 3 and 4 of the project in years 1-5.

The monitoring program aims to determine if the mitigation measures for emus have been effective in the long-term and therefore achieve these mitigation goals. The underlying objectives of the program are to:

- Further understand distribution and habitat use by emus near the road corridor.
- Identify the trend in population density of the local population residing in the Project study area during the different stages of the project.
- Evaluate the success of mitigation measures (crossing structures, fences and habitat revegetation).

2. Methods

2.1 Study area

The emu monitoring study focuses on the Yuraygir emu population which occupies the coastal strip of Yuraygir National Park to the east of the Project, as well as, surrounding contiguous areas from Brooms Head in the north to Minnie Waters in the south and Tucabia, Shark Creek, Pillar Valley and the lower Coldstream wetlands in the west. The surveys have focused on six study sites:

1. Pillar Valley west, including east and west of the Tucabia-Tyndale Road and portions of the Coldstream wetlands, and lower catchment of Pillar Valley Creek and Black Snake Creek (project Section 3).
2. Tucabia south between Mitchell Road and Firth Heinz Road (project Section 3)
3. Tucabia north from Bostock Road to Somervale Road and Pine Brush State Forest, including Champions Creek and the associated floodplain (project Section 3)
4. Yuraygir south at two locations around Diggers Camp and Minnie Waters (Control)
5. Yuraygir north at two locations around Brooms Head and Taloumbi (Control).
6. Shark Creek floodplain (project Section 4).

The Plan suggests the potential survey of up to six search areas across the range of the Yuraygir emu population, with up to five transects (approximately 1km in length) sampled in each search area. Preliminary surveys were conducted during December 2013 and February and April 2014, with the aim of testing transect locations and lengths. Up to 30 transects were traversed to investigate their suitability for ongoing monitoring, this included a wide range of sites between Pillar Valley and Tyndale including upper Shark Creek and Firth Heinz Road, as well as Sandon, Brooms Head, Minnie Waters and Diggers Camp for control areas. Ranges of different transect locations, lengths; habitats and site characteristics were investigated for emu signs. The results confirmed low emu density in the study area and a difficultly in locating emu sign in all areas, particularly densely forested areas and large open grazing land.

The location of the preliminary transects were subsequently refined and in some cases shorter transects were combined in order to cover a larger spatial area within the same habitat type. This resulted in fewer transects than suggested in the Plan although longer transect lengths that vary from 1 to 7 km with a focus on sampling between to 3 to 6 ha of each study site. Refer Figure 1-5 for location of survey transects. Access to private properties was restricted to those affected by the Project corridor and to landowners willing to assist in the long-term study as well as State Forests and National Parks and this also influenced the number and location of impact and control sites that could be established.

Surveys in Shark Creek concentrated on the floodplain sugar cane properties and involved a number of vehicle-based surveys aimed at recording emu presence from actual sightings rather than emu signs. The long-term monitoring of emu presence, signs and population density focuses on study sites 1-5 to account for the proposed mitigation in Section 3. No targeted crossing structures are proposed at Shark Creek and the monitoring program in area six does not extend beyond the initial pre-construction investigations reported herein.

2.2 Methods

2.2.1 Establishing survey transects

A range of different habitat types are present in the study area including pastoral land, grazing land, forest, heath and open wetlands. Evidence of emu activity was noted in each of these habitats and the study aimed to select a range of impact and control sites with similar characteristics. Transects were selected to provide even coverage of impact areas with a focus on known regular emu sightings and the location of future mitigation for emus on the highway.

FIGURE 1 | Yuraygir South

FIGURE 2 | Pillar Valley West

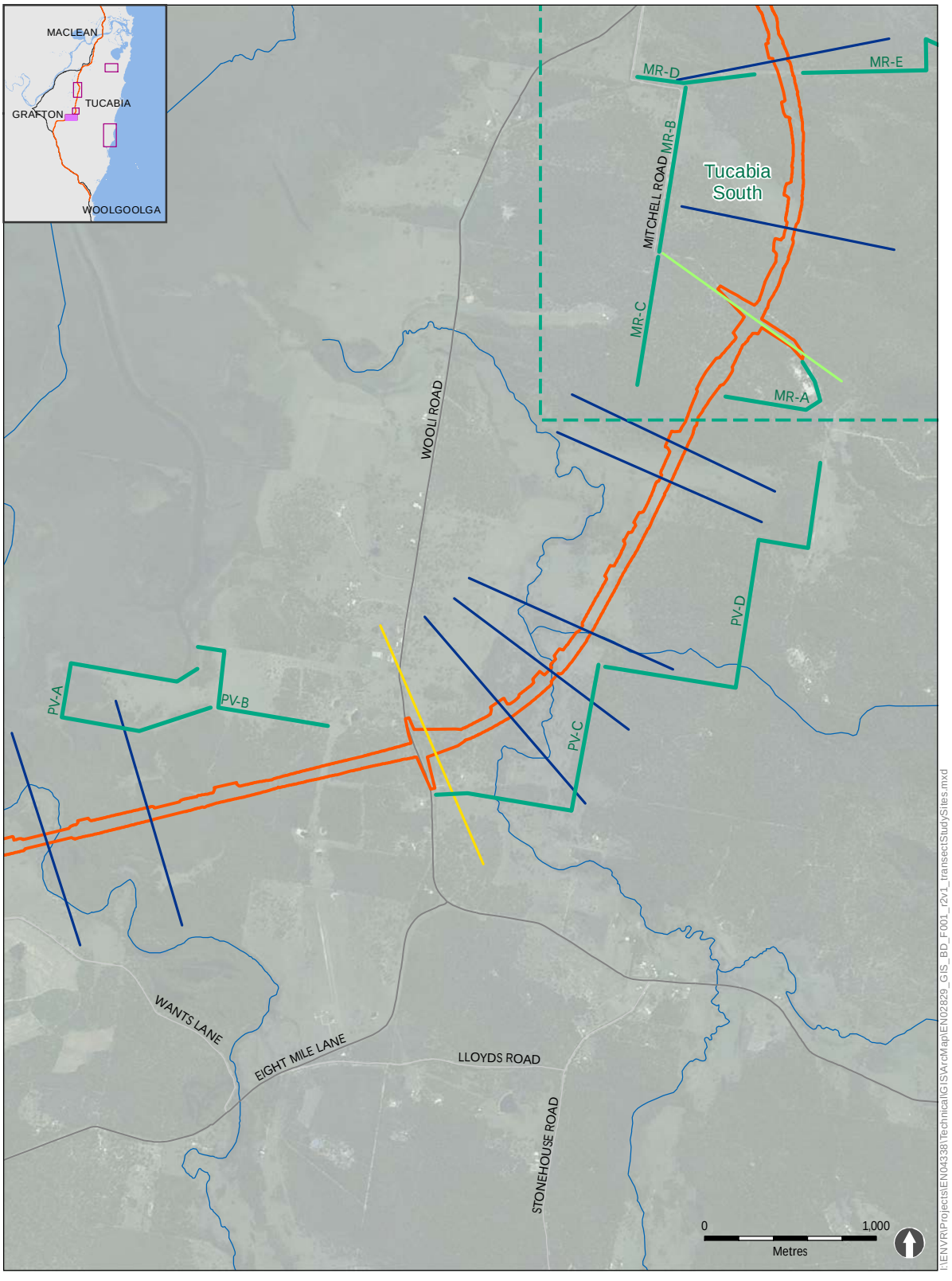


FIGURE 3 | Tucabia South

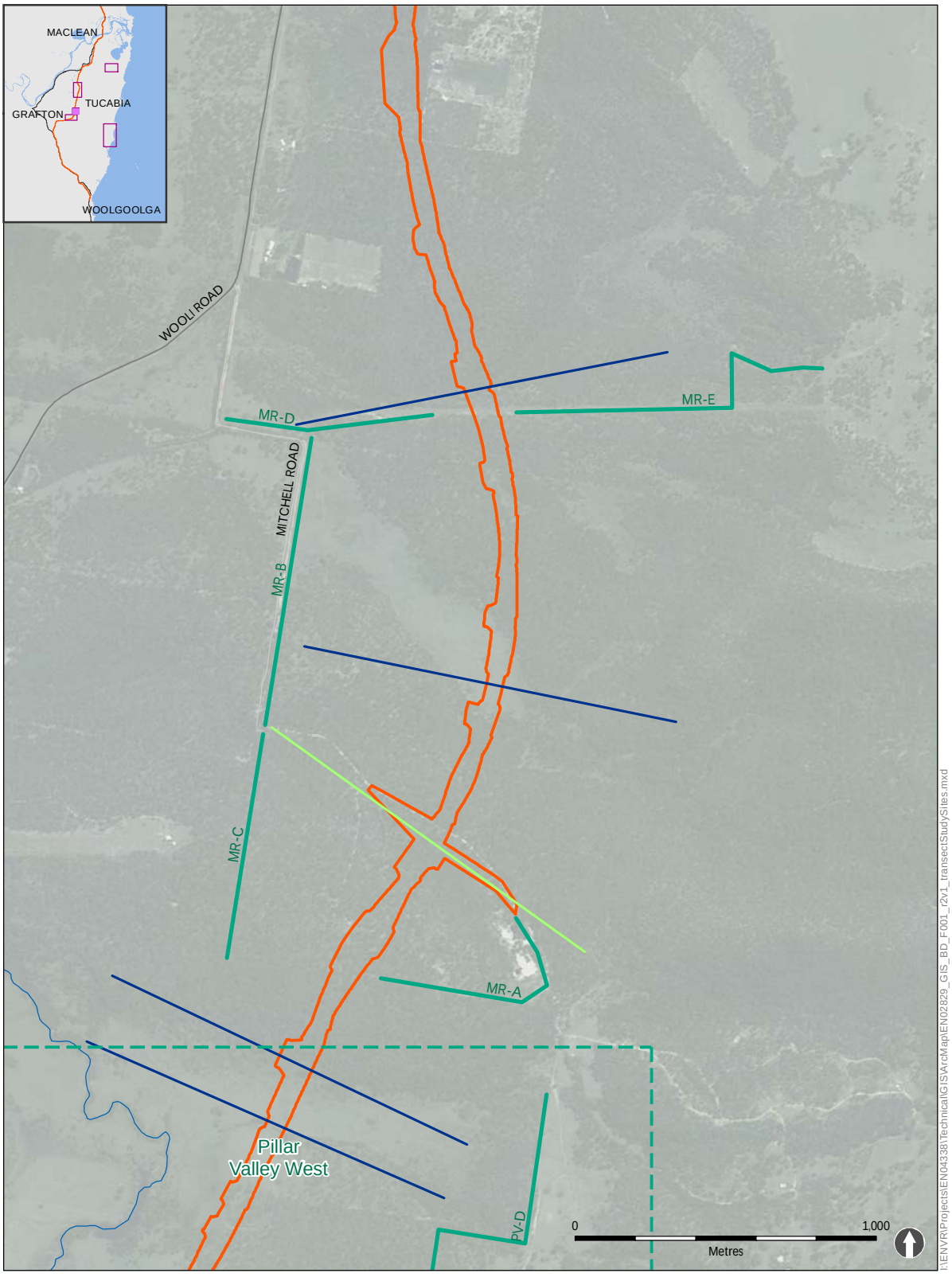
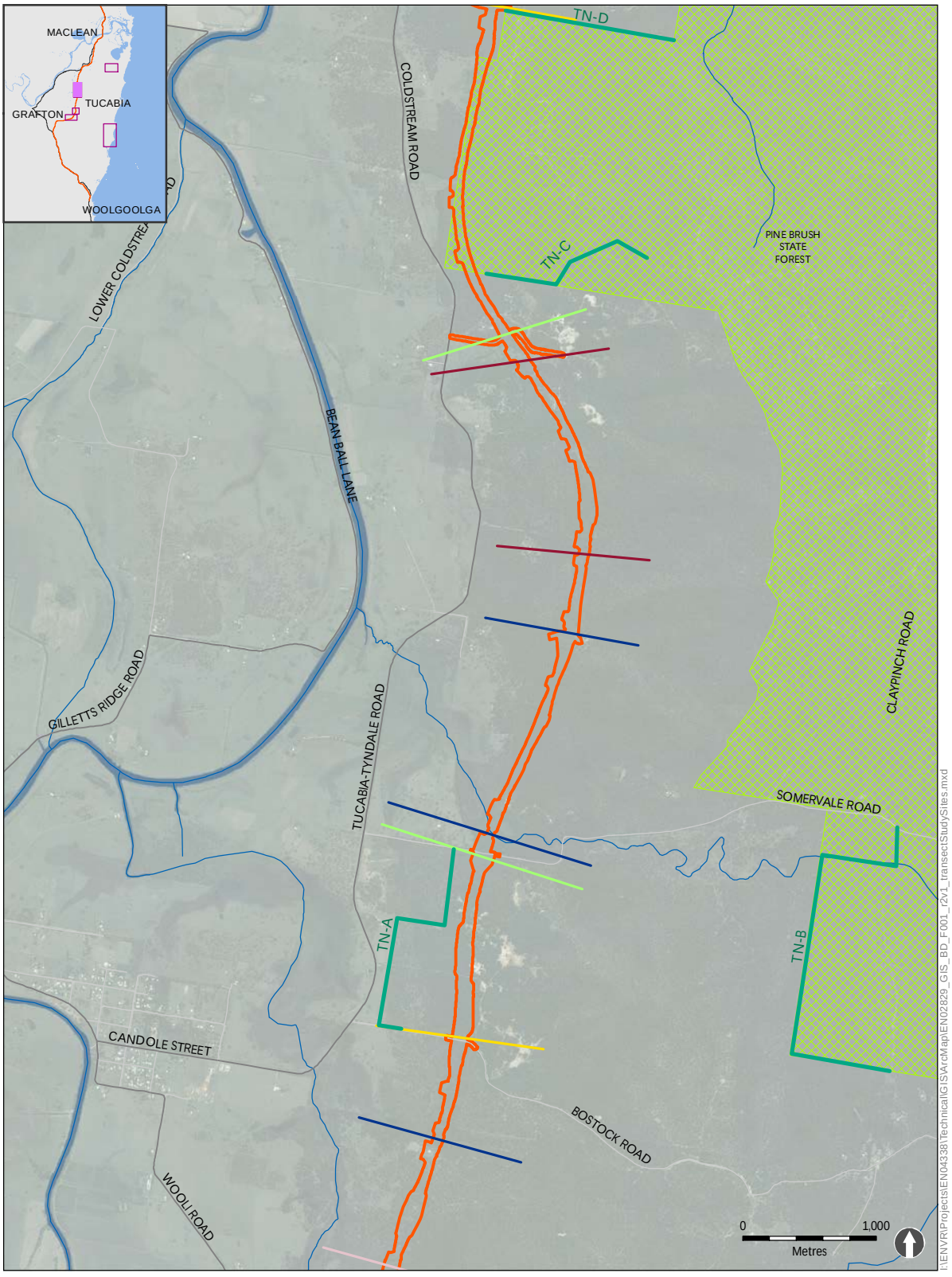


FIGURE 4 | Tucabia North



Highway upgrade
Existing Pacific Highway
Transect
Combined Emu and Bridge Structure
Combined Emu and Drainage Structure
Dedicated Emu Structure
Incidental Emu Structure (road overpass)
Incidental Emu Structure (road underpass)

FIGURE 5 | Yuraygir North

The preliminary surveys determined that a number of site characteristics were important when selecting transects to maximise the chance of finding emu sign. For example transects positioned along fence lines were preferred, particularly well maintained rural fences with barbed wire, due to the fact that emu feathers were frequently found 'snagged' on barbed wire by birds passing through the fence. The presence of feathers represented a reliable means of detecting emu presence in an area. This situation was not able to be achieved for all transects due to the dominance of plain wire fences and poorly maintained fences in impact areas. In the absence of barbed wire fences, other important site characteristics were sought, these included clearings through forest areas such as power easements and fire breaks where emu droppings and footprints could be easily located (Plates 1 and 2), particularly sandy and muddy tracks where emu footprints were readily identifiable. Following the preliminary surveys, a number of transects were removed due to the absence of emu signs and difficultly finding these site characteristics, this included several sites at Upper Shark Creek, and Champion Creek flats (Somervale Road) and several controls in Yuraygir National Park.

Control sites were selected that had site characteristics resembling impact sites, this included habitat floristics and structure. In addition as impact sites were located in the general vicinity of existing roads such as the Tucabia-Tyndale Road, Somervale Road and Bostock Road which have a history of emu-vehicle collisions, controls were therefore intentionally placed near to roads, such as Brooms Head Road, Wooli Road and Minnie Water Road where road strike has also been historically reported. The final selection of monitoring sites is centred on five study sites (refer Table 1).

Table 1. Study sites and details of emu monitoring transects

Study sites	Status	Transect name	Habitat	Transect length (m)	Search area (ha) based on 10 m width	Location relative to future road
1. Pillar Valley West	Impact	PV-A	Grazing / forest	840	0.84	West
	Impact	PV-B	Grazing / wetland	1300	1.30	West
	Impact	PV-C	Grazing / forest	1655	1.65	East
	Impact	PV-D	Grazing / forest	2425	2.42	East
			Total	6220 m	6.2 ha	
2.Tucabia South	Impact	MR-A	Dry open forest	825	0.82	East
	Impact	MR-B	Dry open forest	965	0.96	West
	Impact	MR-C	Dry open forest	755	0.75	West
	Impact	MR-D	Swamp forest	700	0.70	West
	Impact	MR-E	Dry open forest	1400	1.40	East
			Total	4645 m	4.6 ha	
3. Tucabia North	Impact	T-A	Dry open forest	2080	2.08	West
	Impact	T-B	Grazing / wetland	645	0.64	West
	Impact	T-C	Dry open forest	1365	1.36	East
			Total	4090 m	4.1 ha	
4.Yuraygir South	Control	YS-A	Swamp heath	1155	1.15	Control
	Control	YS-B	Swamp heath	1255	1.25	Control
	Control	YS-C	Dry open forest	1030	1.03	Control
	Control	YS-D	Dry open forest	730	0.73	Control
	Control	YS-E	Dry open forest	1250	1.25	Control
			Total	5420 m	5.4 ha	
5.Yuraygir North	Control	YN-A	Dry open forest	1850	1.85	Control
	Control	YN-B	Dry open forest	1270	1.27	Control
			Total	3120 m	3.1 ha	

Given the importance of having particular characteristics present on transects, it is important that the same transects are sampled for each monitoring event, rather than selection of new random transects for each survey. In this study, the benefits of randomisation do not outweigh the logistical benefits derived by systematic sampling. The other benefit of repeat surveys on the same properties is the opportunity to capture data on emu sightings from landowners between monitoring periods. This was also found to be an effective way of documenting emu presence and abundance in combination with the active and passive search methods used.

Plate 1. Example of cleared fire break where emu scats and signs could be readily located

Plate 2. Example of cleared power easement through forest habitat with sandy substrate

2.2.2 Site habitat descriptions

A description of the habitat characteristics at each site and specific transect is provided in Appendix A

2.2.3 Timing

Surveys during the pre-construction period commenced in December 2013, followed by a February, April and June survey (2014) for a total of 40 field-person days (Table 3). The autumn survey was conducted in late April to target the start of the breeding season with a second breeding survey conducted in June 2014. Due to the late timing of engagement of the contract, two surveys were planned and conducted in the initial summer season. Surveys are planned to sample for seasonal variability and peak activity times, with time as a factor in assessing the impacts on emu presence and movements.

Table 3. Survey periods and weather conditions

Timing	Survey dates	Season	Weather conditions
Pre-construction (PC1)	16-20 December 2013	Summer	Mean daily maximum temperatures 28^{0}C and minimum 17.5^{0}C. Total of 3.8 mm of rain early in the week and 37.3 mm the previous week. Winds slight to moderate.
Pre-construction (PC2)	10-14 February 2014	Summer	Mean daily maximum temperatures 24.8^{0}C, and minimum 20^{0}C. No rain, winds slight to moderate, mostly from the east and north east.
Pre-construction (PC3)	28 April-2 May 2014	Autumn	Mean daily maximum temperatures 22.6^{0}C, and minimum 14.8^{0}C. Total of 22.2 mm of rain. Winds slight to moderate north and west.
Pre-construction	23 – 27 June 2014	Winter	Mean daily maximum temperatures 22.3^{0}C, and minimum

(PC4)			6.6^{0}C. Total of 6.1 mm of rain, winds slight to moderate westerly and northeast.

2.2.4 Active searches for emus and sign

Each transect was surveyed once over a week long survey period. Transects were sampled throughout daylight hours (0730 to 1700) and involved a single observer walking slowly along the designated transect route and actively searching for signs of emu presence (i.e. droppings, feathers, and footprints) concentrated over a 10 m wide search area, (5 m either side of the transect line) (refer plates 3-6 for examples of emu sign). The number of signs detected was counted and then removed from each transect. For footprints this meant raking over sand and mud and for feathers and droppings removing from the transect. This was done in order to capture fresh sign over the following survey period. In addition to recording signs, any actual observations of emus in the vicinity of transects were recorded and discussions with landowners were conducted where possible during the course of the survey week to document any observations of emus made by the property owner since the last monitoring period.

When encountered, the contents of scats were recorded and collected to be compared with reference plant material from each location to document dietary items. An updated list of plant species recorded in the diet of emus will be provided in each monitoring report for input into the revegetation and planting design.

A vehicle-based survey was conducted in the Shark Creek area (Section 4) during the December, February, April and July surveys. Each survey was conducted in the late afternoon (commencing 1400-1500) and continued for 2 hours. This involved slowly driving along local roads and private farm access tracks to the north and south of Shark Creek and surrounding cane farms. Where emus were sighted, notes were recorded on the number of birds at each location, their age and gender if known and locations mapped.

Plate 3. Example of recent emu feathers 'snagged' on barbed wire

Plate 4. Emu dropping with *Gahnia sieberiana* seed

Plate 5. Example of muddy tracks where emu footprints were apparent

Plate 6. Example of sandy tracks where emu footprints were apparent

2.2.5 Camera trapping

The use of remote cameras provided the opportunity to collect additional information on emu distribution and seasonal presence and habitat use. Camera trapping used fixed cameras, triggered by infra-red sensors, to 'trap' images of passing emus. Subject to access constraints and the availability of suitable attachment points facing adequate open ground, up to two traps were placed semi-systematically along each of the transects, to provide a total of 4-8 cameras per study site. Cameras were occasionally moved to new locations along transects during subsequent surveys if found to be unsuccessful from the preceding survey period. The number of traps used was increased at each survey as further transects were added resulting in a total of 33 cameras being deployed at PC4. Details on camera trapping effort are provided in Table 4.

Traps were placed at a height of approximately 1.5 metres above ground and were not baited, in some instances we trialled the use of a reflective object (compact disk) tied to a nearby tree to attract interest by passing emus and this technique is still being trialled. Cameras were set to take pictures 12 hours per day in daylight hours only, with a 10 second delay between exposures to minimise repeat photographs of the same animal while allowing continuous recording to capture additional emus in the case of pairs or juveniles. The date and time of each exposure were recorded on the cameras and used to determine if multiple pictures were taken of the same animal to discard consecutive observations. Cameras were left in the field continuously during each monitoring period and batteries and storage cards replaced at each survey. Camara trapping rate was defined as the ratio of emu photographs to the number of trap days and multiplied by 100.

Table 4. Pre-construction camera trapping effort at the six survey sites

Timing	Pre-construction surveys	Impact			Control	
		Pillar Valley west	Tucabia south	Tucabia north	Yuraygir south	Yuraygir north
Period 1 (summer) 20.12.13 to 10.02.14	Camera trapping days	49	49	49	49	49
	Successful cameras	3	6	3	7	4
	Camera broken/stolen	0	0	0	0	0
	Total camera trap effort (days)	147	294	147	343	196
Period 2 (summer- autumn) 14.02.14 – 28.04.14	Camera trapping days	70	70	70	70	70
	Successful cameras	3	10	3	7	4
	Camera broken/stolen	0	0	0	0	0
	Total camera trap effort (days)	210	700	210	490	280

Period 3 (autumn-winter) 02.05.14 – 23.06.14	Camera trapping days	49	49	49	49	49
	Successful cameras	7	10	3	6	4
	Camera broken/stolen	0	0	0	1	0
	Total camera trap effort (days)	343	490	147	245	196

2.2.6 Density and habitat use

We correlated trapping rates of emus with densities estimated from counts of signs made along the search transects. Two emu density indexes were calculated using:

- Number of signs for each transect divided by the search area (transect length x 10 m) reported as density of emu signs per hectare.
- Camera trapping rate, defined as the ratio of emu photographs to the number of trap days multiplied by 100. This provided a comparable index of density as individual recognition of photographed emus and hence capture-recapture analysis is unfeasible. Where multiple pictures were taken of the same animal at the same time these were discarded from the trapping rate calculations.

Data on the relative density of emus reported by these two techniques provides a baseline for monitoring emu activity and habitat use at impact and control sites. The emu density indexes for each site would be compared with future surveys to compare before construction data with during construction and post-construction data and impact versus control sites.

Notes on the habitat structure and floristics for each site were taken from series of random points along each transect which aimed to record dominant plant species in the canopy, mid-strata and ground-covers, the soil type and topography, presence of water bodies, and the degree of naturalness or disturbance at the site. Data on presence and relative density of emus was used to determine the importance of the habitat. The location, habitat and date of opportunistic emu observations were also recorded.

3. Results

3.1 Distribution and density

Emu presence was reported from all impact and control study sites for the pre-construction surveys, with signs of emu presence reported on 95% of transects sampled. The highest density in the impact areas was found in summer at Tucabia south followed by the autumn-winter period for Pillar Valley west where emus were reported on both sides of the road alignment, and particularly near the Coldstream wetlands. The density of emus reported as number of signs per hectare for the control and impact areas is shown in Table 5 and Figure 6.

Table 5. Pre-construction density of emu sign (no./ha) located at each study site

Study site	Timing	Emu sign			Total sign	No. sign / ha
		Feathers	Droppings	Footprints		
Pillar Valley west (impact)	PC1 (summer)	15	0	1	16	2.57
	PC2 (summer)	23	0	0	23	3.69
	PC3 (summer/autumn)	22	0	0	22	3.53
	PC4 (autumn/winter)	31	7	2	40	6.43
	mean	22.75	1.75	0.75	25.25	4.05
Tucabia south (impact)	PC1 (summer)	8	15	7	30	6.46
	PC2 (summer)	21	21	3	45	9.69
	PC3 (summer/autumn)	18	7	2	27	5.81
	PC4 (autumn/winter)	3	5	0	8	1.72
	mean	12.5	12	3	27.5	5.92
Tucabia north (impact)	PC1 (summer)	0	0	0	0	0
	PC2 (summer)	0	0	0	0	0
	PC3 (summer/autumn)	14	3	0	17	4.15
	PC4 (autumn/winter)	5	3	0	8	1.95
	mean	4.75	1.5	0	6.25	1.52
Yuraygir south (control)	PC1 (summer)	1	21	8	30	5.53
	PC2 (summer	0	6	18	24	4.42
	PC3 (summer/autumn)	0	7	14	21	3.87
	PC4 (autumn/winter)	0	9	16	25	4.61
	mean	0.25	10.75	14	25	4.60
Yuraygir north (control	PC1 (summer)	3	0	1	4	1.28
	PC2 (summer)	13	1	2	16	5.12
	PC3 (summer/autumn)	13	1	1	15	4.80
	PC4 (autumn/winter)	34	0	2	36	11.53
	mean	15.75	0.5	1.5	17.75	5.68

The density of emus was similar between the impact and control areas, with the highest density reported around Mitchell Road and lowest at Tucabia north, which included a broad area from Bostock Road to Pillar Valley State Forest. The long-term seasonal activity will be an important aspect of the study and should be viewed with some caution in this original report. This is because the number of signs reported in the first survey (PC1) represents an undetermined period of time prior to the survey, particularly for accumulation of emu sign.. After this initial survey these signs were removed and so the accumulation of new signs relates to the specific seasonal survey period.

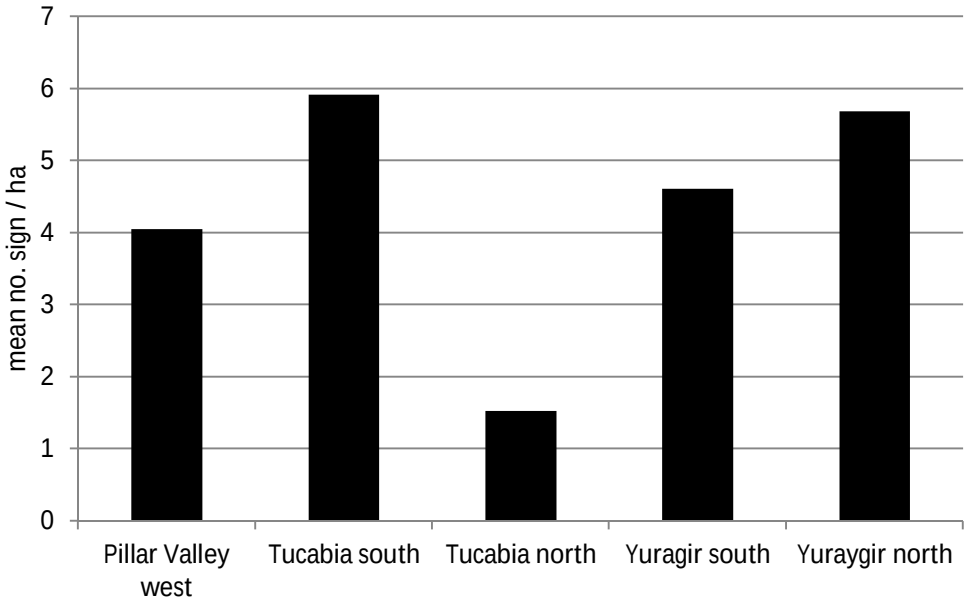


Figure 6. Pre-construction density of emu sign (no./ ha) at impact and control sites

Remote cameras were initially set during the first survey (December 2013), in the six months following this images of emus have been captured at 13 of the 19 transects surveyed (68%). The majority of these have been taken at the control areas of Diggers Creek, Minnie Waters and Brooms Head while Tucabia south and Pillar Valley are represented for the impact areas (Table 6).

The trap rate reports the number of emus photographed per 100 camera trap days. For Yuraygir north this was represented by around 2-3 birds with a peak in the autumn season. A similar autumn peak was recorded in Yuraygir south and Pillar Valley west, the latter associated with the Coldstream wetlands, while activity for Tucabia south had peaked in summer and dropped off in late autumn and winter (Figure 7).

Table 6. Pre-construction count of emu photographs and mean trap rate per study site

Study site	Timing	Summer	Summer/autumn	Autumn/winter	Mean trap rate (pre-construction)
Pillar Valley west	Count of individuals	0	2	2	
	No. camera trap days	147	210	343	
	Trap rate	0.0	0.95	0.58	0.51
Tucabia south	Count of individuals	4	6	1	
	No. camera trap days	294	700	490	
	Trap rate	1.36	0.86	0.20	0.80
Tucabia north	Count of individuals	0	0	0	
	No. camera trap days	147	210	147	
	Trap rate	0.0	0.0	0.0	0.0
Yuraygir south	Count of individuals	0	13	5	
	No. camera trap days	342	490	245	
	Trap rate	0.0	2.65	2.04	1.56
Yuraygir north	Count of individuals	0	11	4	
	No. camera trap days	196	280	196	
	Trap rate	0.0	3.93	2.04	1.99

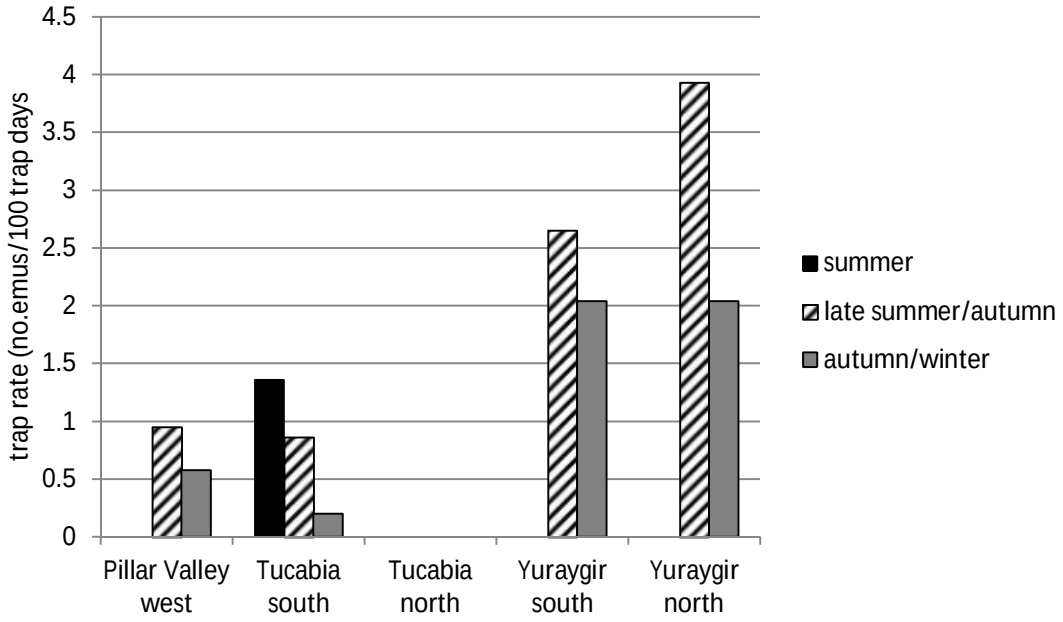


Figure 7. Pre-construction emu trap rates per season at impact and control sites

The remote cameras have proven to be an effective method for detecting emu presence and seasonal activity in combination with the active searches. Photos have been captured for single adults and adult pairs of birds as well as chicks and juveniles (Plates 7-10) and provide a date and time of the observation, and in most cases direction of travel. These initial results suggest that this technique is likely to valuable in future monitoring during construction and operation of the road to monitor effectiveness of fences and underpass structures.

Plate 7. Adult pair in Tucabia south summer

Plate 8. Chick photographed in Tucabia south in summer

Plate 9. Single bird in autumn Yuraygir south

Plate 10. Male and juvenile Pillar Valley west in autumn

Adult pairs were observed in early summer and observations of males with offspring reported in late summer and autumn through to early winter. At these periods the preferred habitats appeared to be sugar cane areas, specifically soybean crops, low-lying pastoral areas surrounding the Coldstream wetlands and Pillar Valley Creek. Activity in the Tucabia south (Mitchell Road) area peaked around mid to late summer and gradually declined into the cooler months, however emus remained present over all survey periods. While emu presence in the Pillar Valley west remained stable between summer and the autumn/winter periods.

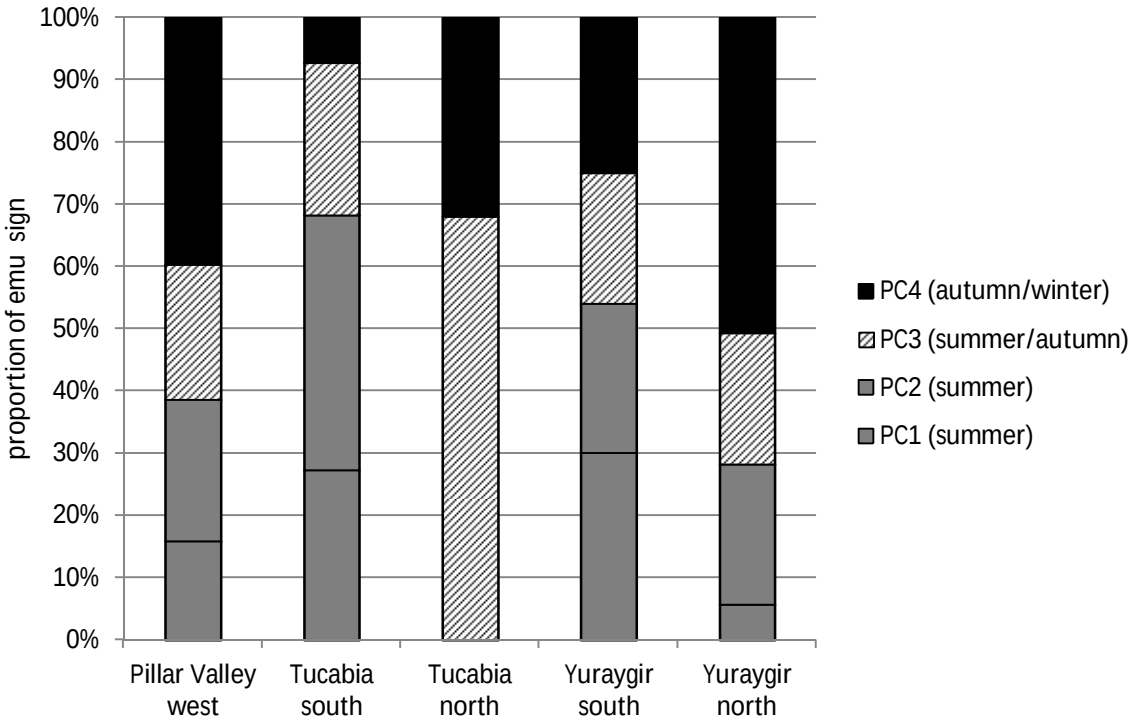


Figure 8. Frequency of emu sign in relation to season (two summer periods are combined)

Observations of emus in the Shark Creek cane areas (Section 4) were reported in the first three surveys conducted in summer and autumn. This included one observation of an adult pair, a sighting of an adult male with four juvenile offspring and two observations of solitary adults. In all cases the birds were observed grazing in fields of soybean used by landowners for crop rotation and nitrogen fixing. It is evident that the soybean crops provide an important part of the diet of the local population and account for seasonal visits during the warmer

months of the year. There were no emu observed during the winter survey which followed harvesting of the soybean in late autumn. Emu observations in the Shark Creek area are illustrated on Figure 9 and presented in Table 7.

Table 7. Pre-construction emu observations from the Shark Creek vehicle-based survey (Section 4)

Survey	Date	Sighting 1	Sighting 2	Total birds
Summer	19/12/2013	adult pair		2
Summer	12/02/2014	1 solitary adult	adult male and 4 juveniles	6
Autumn	30/04/2014	1 solitary adult	-	1
Winter	26/06/2014	-	-	0

3.2 Breeding activity

The current baseline data supports evidence of post-breeding activity in the impact areas around Pillar Valley west, and Tucabia south. This is associated with observations of adult males with offspring on the west side of the future road alignment around the Coldstream wetlands in late spring 2013, mid-summer and late autumn 2014. A male and two juveniles were also reported near Mitchell Road (Tucabia south) in early summer (December 2013) and an adult pair was also observed at this time. Adult pairs were regularly observed in the Brooms Head and Taloumbi in the late summer, autumn and winter surveys and adult males with offspring were reported at Shark Creek in summer.

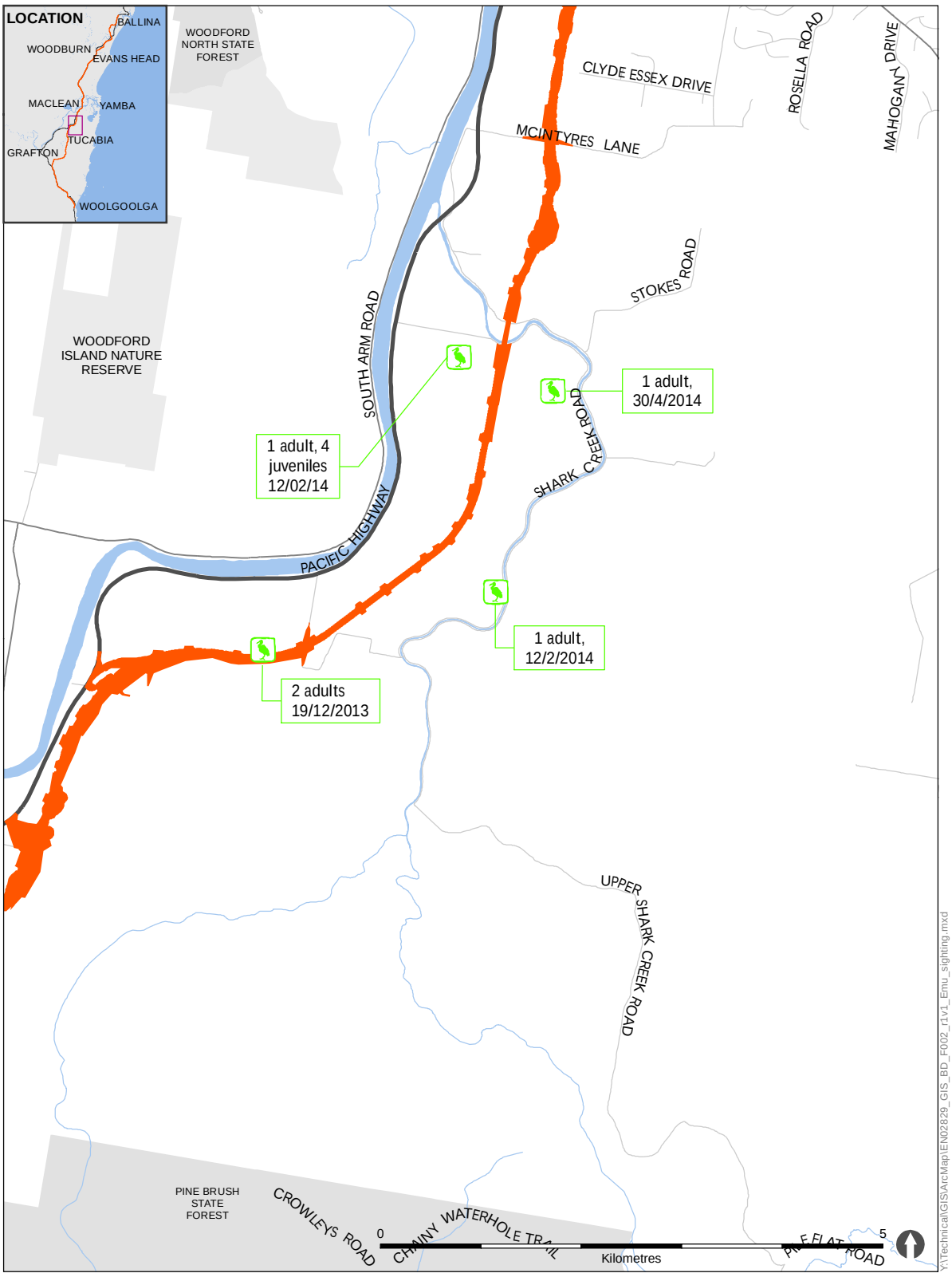
3.3 Diet and habitat use

A total of 11 plant species were confirmed as dietary items from observation of 62 droppings. These items are shown in Table 8 as number of scats containing these items. A number of additional unknown seeds were collected for later analysis.

Table 8. Dietary items recorded from scat search combined for all study sites

Dietary item	Plant name	Scientific name	Presence (no. of scats)		
			Summer	Autumn	Winter
Fruit	Native Quince	*Petalostigma pubescens*		1	2
Fruit	Bangalow Palm	*Archontophoenix cunninghamiana*	1	1	
Seed	Red-fruit Saw Sedge	*Gahnia sieberiana*	2	4	5
Seed	Rough Saw-Sedge	*Gahnia aspera*		2	1
Buds	Styphelia	*Styphelia triflora*		2	2
Grass	Blady Grass	*Imperata cylindrica*			2
Seed	Mat rush	*Lomandra longifolia*			2
Seed capsule	Turpentine	*Syncarpia glomulifera*			1
Fruit	Dianella	*Dianella spp*			1
Buds and leaves	Bitter Pea	*Daviesia sp*			1
Leaves	Bush-pea	*Pultenaea sp*			1
Grass	Grass (Poa spp)	unknown		1	9
Seed	Seed A	unknown			3
Seed	Seed B	unknown			3
Seed	Seed C	unknown		1	4
Charcoal				2	5
Insect material			2		1
Total			5	14	43

FIGURE 9 | OBSERVATIONS OF EMUS FROM THE VEHICLE - BASED SURVEY IN THE SHARK CREEK SUGAR CANE AREA



4. Discussion

The monitoring Program uses a Before-After-Control-Impact design (Underwood 1991; Green 1993) to investigate the impact of the construction and operation of the Woolgoolga to Ballina upgrade on the endangered coastal emu population and provide input into design refinements and mitigation measures. Data was collected and analysed for the first six months of the program representing the pre-construction and pre-fencing phases of the project. Emu fencing is due to start in late 2014 and early work construction around the Shark Creek area in late 2015. The date for commencement of construction in Section 3 and 4 has not been determined.

The initial results of the first six months of the program report on the baseline conditions relating to emu activity across six study sites, including the Shark Creek area over different seasons. These data show preliminary indications of emu density in relation to season and habitats at impact and control areas. Further surveys as planned will help to provide a clearer picture of the distribution and abundance of emus in the study area. . The highest density in the impacts areas was reported in the pastoral lands and forest on sandy and alluvial soils associated with Pillar Valley creek and Black Snake Creek and nearby unnamed tributaries of the Coldstream River wetlands. Comparatively lower activity was reported in the Tucabia to Tyndale area, although this was reported over a brief period and would potentially shift between years. Emus frequented sugar cane properties both for pre- and post-breeding activities and this habitat is likely to be important for raising young.

The analyses of data would be conducted after each survey period and focus on monitoring temporal changes within each study site over time. The density of emus varied between sites and some reporting of shifts in emu activity between sites may be apparent over time.

A number of items have been reported in the diet of emus over the study period relating to soybean crops, native pasture grasses and the fruits and seeds of native shrubs and small trees. Further work is required to determine the origin of several seeds collected in this study.

No congregations of emus were reported during the monitoring period.

The Environment Protection Agency (EPA) has provided comments on an earlier draft of this annual report, which are provided in Appendix B along with a written response. In summary it is proposed to continue quarterly monitoring during the pre-construction phase until such time as construction begins. This first annual monitoring report presents the methods and results of the initial emu surveys conducted over 6 months and involved pilot investigations over a large number of transects, not all of which are described in the report. Several transects which showed no past evidence of emu activity were removed from the program and it is intended to refine and add additional transects to the program over the next 2-3 survey periods until a final suite of transects is established. The 2015 annual report will identify and map the final suite of monitoring transects and likely include a more complete picture of the current emu distribution and activity and the bearing this has on the location of connectivity structures.

5. References

Green, R.H. (1993). The application of repeated measures designs in environmental impact and monitoring studies. *Australian Journal of Ecology*. 18, 81-98.

Roads and Maritime Services, (2013). Woolgoolga to Ballina, Pacific Highway Upgrade, Coastal Emu Management Plan. Prepared by RMS, and SKM.

Underwood, A.J. (1991). Beyond BACI: Experimental designs for detecting human environmental impacts on temporal variations in natural populations. Australian Journal of Marine and Freshwater Research 42(5) 569-587.

Appendix A. Site descriptions

Table 2. Details of the habitat and floristics at each study site and specific transect area

Study site	Description of site characteristics
Pillar Valley west	PV-A is on semi-cleared grazing land on the floodplain of the Coldstream River occupying a transitional zone between open forest and swamp sclerophyll forest. Swamp box (*Lophostemon suaveolens*) and Forest Red Gum (*Eucalyptus tereticornis*) comprise the overstorey with dense stands of Swamp Oak (*Casuarina glauca*). Prickly-leaved Paperbark (*Melaleuca nodosa*) and *Baeckea* sp. are dominant in the understorey. A range of grasses and herbs, especially modified pasture species such as Couch (*Cynodon dactylon*), Carpet Grass (*Axonopus fissifolius*) were common in groundcover. Other native species recorded close to the River include Ivy-leaved Violet (*Viola hederacea*) *Juncus usitatus* and Water Ribbon (*Triglochin procera*).
	PV-B is on semi-cleared grazing land on an ecotone where higher sandy soils meet alluvial soils on the floodplain. Habitat types are similar to PV-B and comprise a mix of open eucalypt forest, coastal floodplain forest and swamp oak forest. Grey Ironbark (*Eucalyptus siderophloia*), Red Bloodwood (*Corymbia gummifera*), Scribbly Gum (*Eucalyptus signata*) dominate the overstorey on sandy soils with a sparse shrub strata comprising regenerating *Eucalyptus* sp. and Red Ash (*Alphitonia excelsa*). The groundcover is highly diverse with native grasses and herbs mostly dominated with Weeping Grass (*Microlaena stipoides*), Purple Wiregrass (*Aristida ramosa*), Blady grass (*Imperata cylindrica*), Mat-rush (*Lomandra multiflora*) and Whiteroot (*Pratia purpurascens*). The exotic Carpet Grass (*Axonopus fissifolius*) dominates in areas of open grazing pasture. In coastal floodplain forest, Forest Red Gum, Red Bloodwood and Black she-oak (*Allocasuarina littoralis*) intergrade with Swamp Oak and Prickly-leaved Paperbark on the edge of the floodplain. Habitats open into disturbed swamp oak forest where grazing and land use activity have cause major dieback in Swamp Oak and Prickly-leaved Paperbark.
	PV-C has a mix of grazing land and intact bushland. Transitional zones occur along creeks and floodplains where sandy eucalypt forest intergrade with swamp oak forest and swamp sclerophyll forest. Most of the site is sandy and regularly burnt in grazing land and is composed of Scribbly Gum, Red Bloodwood, Rough-barked Apple (*Angophora floribunda*) and Narrow-leaved Ironbark(*Eucalyptus crebra*) in the canopy and Black she-oak, Coastal Banksia (*Banksia integrifolia*), Red Ash and some occurrences of Quinine tree (*Petalostigma pubescens*) in the mid-storey. The groundcover mostly consists of Blady Grass in burnt areas and pasture species Kikuyu (*Pennisetum clandestinum*) in wetter grazing land.
	PV-D has habitats varying from open eucalypt forest, swamp oak forest and semi rainforest in around Black Snake Creek. Part of the site is sandy and regularly burnt in grazing land. The canopy species comprise Scribbly Gum, Red Bloodwood, Rough-barked Apple (*Angophora floribunda*) and Narrow-leaved Ironbark(*Eucalyptus crebra*) and Black she-oak, Coastal Banksia (*Banksia integrifolia*), Red Ash and some occurrences of Quinine tree (*Petalostigma pubescens*) in the mid-storey. Along Black Snake Creek, riparian vegetation of Swamp Box, Bruch Box (*Lophostemon confertus*), Grey Myrtle (*Backhousia myrtifolia*) and a range of rainforest species in the mid-storey including Bangalow Palm (*Archontophoenix cunninghamiana*) and Lilly Pilly (*Acmena smithii*). The understorey consists of False Bracken Fern (*Calochlaena dubia*) and common Maidenhair fern (*Adiantum aethiopicum*) with some invasion of Lantana (*Lantana camara*).
Tucabia south	MR-A is in sandy dry eucalypt forest with adjoining swamp forest habitat. The site is grazed by cattle but habitats remain in good condition with a high diversity of plant species. The overstorey generally comprises of Scribbly Gum, Tallowwood, Red Bloodwood, *Angophora robur*, Grey Ironbark, Blackbutt and Stringy barks. The mid-storey has a diverse structure with Black she-oak and Red Ash in the upper strata. Old man Banksia (*Banksia serrata*), *Leucopogon lanceolatus*, Tantoon (*Leptospermum polygalifolium*), Slender Rice Flower (*Pimelea linifolia*) and various *Acacia* and Heath species (*Ericaceae*) species dominate in the lower strata. The sandy track of Mitchell Road has some introduced species such as Carpet Grass and Fireweed (*Senecio madagascariensis*). The groundcover has a mix of native grasses and herbs (Blady Grass, Purple Wiregrass, Barbed wire grass (*Cymbopogon refractus*), *Hibbertia vestita*, *Pomax umbellata*. Saw Sedges (*Gahnia sieberiana*), Spiny-head Mat Rush (*Lomandra longifolia*) and Bracken Fern

	(*Pteridium esculentum*) are also common.
	MR-B is in sandy dry forest on semi grazed land. Open eucalypt forest is comprised of Scribbly Gum, Tallowwood and Rough Barked Apple. The mid-storey is sparse with Coastal Banksia and Prickly-leaved Paperbark. Swamp Oak occurs less commonly in lower elevated areas along a drainage line dominated with pasture grasses and Frogmouth (*Philydrum lanuginosum*). The groundcover is dominated with native grasses such as Blady Grass, Weeping Grass, Purple Wiregrass and Barbed wire grass and introduced Whiskey Grass (*Andropogon virginicus*).
	MR-C is similar to MR-B transect, however it crosses a swamp forest comprising Swamp Mahogany (*Eucalyptus robusta*) on boggy dark clay loamy soils. On more elevated lands, a bench of white sand is present with Scribbly Gum, Tallowwood, Rough-barked Apple and Red Bloodwood. Red Ash, Old man Banksia, Coastal Banksia and Tantoon dominate the mid-storey. The groundcover supports tall Australian reed (*Baloskion tetraphyllum* subsp. *meiostachyum*) and Saw Sedges in wet areas and is generally dominated with Blady Grass and Bracken Fern in sandy areas.
	MR-D begins on the flats and slowly rises up slope to grey loamy sand. The habitat is a mixed forest type comprising Scribbly Gum, Tallowwood and Rough-barked Apple and Red Bloodwood in a sparse overstorey. Broad-leaved Paperbark is widely abundant in the sub canopy and is also dominated with Prickly-leaved Paperbark, Swamp Oak, and Black she-oak mixed in the mid-storey. The groundcover is grassy (Blady Grass and Whiskey Grass) and is often dominated with Bracken Fern.
	MR-E is similar to MR-D transect but with a greater mix of forest canopy species. This site is on an elevated slope of sand and clay. On the lower slope the overstorey is sparse with Scribbly Gum, Red Bloodwood and *A. robur*. The mid-storey is dominated by Broad-leaved Paperbark and Coastal Banksia and comprises of a grassy groundcover with Kangaroo Grass (*Themeda triandra*), Whiskey Grass, Blady Grass and Three-awned Grass (*Austrostipa* sp.). *Hibbertia vestita*, Sender Rice Flower, Yellow Buttons (*Chrysocephalum apiculatum*), *Cheilanthes sieberi* and fireweed are also common. Upper slopes have similar canopy cover but different tree composition comprising Forest Red Gum, Tallowwood and Grey Ironbark. This is likely due to changing soils on the slope. Mid-storey and groundcover species composition remains consistent throughout the slope. Part of the site drains into a pond where Broad-leaved Paperbark and *Melaleuca alternifolia* are common. It supports sub-aquatic plants such as Potamogeton (*Potamogeton tricarinatus*) and Water Ribbon, and wetland plant species *Eleocharis* sp., Frogmouth, *Baumea* sp., and *Juncus* sp. The pond is heavily grazed and trampled around the edges by cattle.
Tucabia north	TN-A is on a range of low to heavy grazing regimes and near intact bushland blocks which have a diverse mix of habitat types. The site is situated on the upper edge of the Coldstream floodplain in a combination of loamy clay and sandy soils. Dry clay forests vary in condition and have a sparse canopy cover comprising Swamp Box, Forest Red Gum, Red Bloodwood, Grey Ironbark and *A. robur*. The mid-storey is absent in some patches where the land use regime is affected by regular slashing and burning. Some examples of dry forest have regenerating and intact mid-storey and include Coastal Banksia, Black She-oak, Red Ash and dense growth of pioneer *Acacia* species'. In open areas of high grazing impact, the groundcover is dominated with introduced pasture species such as Carpet Grass, Whiskey Grass, Setaria sp. and Paspalum (*Paspalum dilatatum*), including abundant introduced herbs Paddy's Lucerne (*Sida rhombifolia*) Verbena (*Verbena rigida*) and Fleebane (*Conyza* sp.). In forested areas, Blady Grass, Purple Wiregrass and Bracken fern are common and weeping grass is less common. There are sandy dry forests which intergrade with swamp forest around natural drainage lines and creeks. Overstorey composition includes Red Mahogany (*Eucalyptus resinifera*), Scribbly Gum, Red Bloodwood, Swamp Box, Turpentine (*Syncarpia glomulifera*) and Narrow-leaved Ironbark. A structurally diverse understorey occurs on the ecotone of dry and swamp forests. The upper strata comprise Tantoon, Prickly Tea Tree (*Leptospermum juniperinum*), Flaky-barked Tea Tree (*Leptospermum trinervium*), *Melaleuca sieberi*, Broad-leaved Geebung (*Persoonia levis*), *Acacia ulicifolia*, *Banksia oblongifolia*, Lilly Pilly and Blueberry Ash (*Elaeocarpus reticulatus*) and a low abundance of Hard Corkwood (*Endiandra sieberi*). The lower strata is dominated by Australian Reed and different ferns, Bracken Fern, False Bracken Fern, Coral fern (*Gleichenia dicarpa*) Water fern (*Blechnum* sp.) and vines Scrambling Lily (*Geitonoplesium cymosum*), Sweet Sarsaparilla (*Smilax glyciphylla*) and Wonga Wonga Vine (*Pandorea pandorana*).
	TN-B is on the Coldstream floodplain, close to large open wetlands on flat grazing pasture land. The site is mostly cleared with large scattered Forest Red Gum and Swamp Oak.

	The mid-storey has sparsely regenerating with Broad-leaved Paperbark and Prickly-leaved Paperbark. The groundcover is dominated by weeds such as Setaria sp., Paspalum and Couch.
	TN-C is in Pine Brush State Forest and has a diverse range of high quality habitats. Sandy dry forest is most common and has interconnecting natural drainage lines with transitions of Swamp Forest. Canopy species vary in composition in dry forest with Red Bloodwood, Turpentine and Tallowwood being most common and Rough-barked Apple, Forest Red Gum, White Mahogany, Blackbutt and Needlebark (*Eucalyptus planchoniana*) occur in low abundance in different areas. The mid-storey is structurally complex, mostly dominated with Axe breaker (*Trochocarpa laurina*), Forest Oak (*Allocasuarina torulosa*) and *L. lanceolatus*. Other species occur less frequently and in different compositions include Old man Banksia, Coastal Banksia, Hairpin Banksia (*Banksia spinosa*) Red Ash, Christmas Bush (*Ceratopetalum gummiferum*), *Xanthorrhoea* sp. and *Acacia* species. The groundcover has a highly diverse range of native grasses, herbs, orchids and vines, including *Lepidosperma laterale*, Blady Grass, Weeping Grass, *Entolasia stricta*, *Austrostipa* sp., *Panicum* sp., *Digitaria* sp., Settlers Flax (*Gymnostachys anceps*), *Cordyline stricta*, and orchids *Acianthus* sp. and *Pterostylis* sp. In Swamp Forest, Swamp Mahogany is most dominant with Red Mahogany occurring on the fringes in sandy dry forest. The understorey generally comprises Saw sedges (*Gahnia aspera* and *G. sieberiana*), Australian Reed, *Cassytha glabella*, *Hydrocotyle* sp. and *Gonocarpus* sp.
Yuraygir south	YS-A is along a Diggers Camp power easement on swampy flat sands within Yuraygir National Park. Open forest and low open wet heathland dominate the site before reaching the coast. Open forest comprises of Rough-barked Apple in the canopy with Broad-leaved Paperbark in the sub-canopy. The understorey has Black she-oak, Old man Banksia, Hairpin Banksia and *Melaleuca* regrowth *Xanthorrhoea* sp. Moist soils occur further south where low open heathland is dominated with Heath Banksia (*Banksia ericifolia*) and Broad-leaved Paper and a high diversity of heathland shrubs. Sedges and Saw sedges such as G. *sieberiana* and Australian reed are also common.
	YS-B is along a regularly slashed fire trail on flat wet sandy soils. The site is a treeless wet heathland with a high cover of tall Heath Banksia and structurally and species diverse understorey. The upper strata comprises Old Banksia, Leptospermum spp., Prickly-leaved Paperbark, Hairpin Banksia and Blueberry Ash is less common. The low strata is highly diverse with Pultenaea spp., *Dilwynia* sp., *Xanthorrhoea* sp., *C. glabella,* Coral fern, *Woollsia pungens*, *Styphelia triflora* and other Ericaceae spp. The ground cover is also very diverse with herbs and sedges comprising *Gahnia sieberiana*, *Dampiera stricta*, Australian Reed, Sun-dew (*Drosera* sp.), *Tetratheca* sp., *Gonocarpus* sp. and *Eleocharis* spp.
	YS-C is similar to YS-B with wet heathland. The site intergrades into swamp forest and rises up slope to open woodland over a peak and back into flat swamp forest. The wet heathland is mostly treeless with scattered Swamp Mahogany and Broad-leaved Paperbark which has a highly diverse understorey and groundcover. A complex ecotone occurs where the flats meet the slope and there is an abrupt transition from Heath to Swamp Forest and Open Forest from changes with moisture levels. Smooth-barked Apple (*Angophora costata*), Swamp Box and Blackbutt dominate the overstorey with a rich species diverse mid-storey comprising Broad-leaved Paperbark, Black she-oak, Old man Banksia, Blueberry Ash and Leptospermum spp. The groundcover transitions from sedges (Australian Reed) to grasses (Kangaroo Grass and Blady Grass). On more elevated slopes and up to the peak, open forest has a different composition of canopy species such as Narrow-leaved Ironbark, Red Bloodwood and Forest Red Gum. The understorey comprises *Acacia* spp., Large-leaf Hop Bush, Rice Flower (*Ozothamnus diosmifolius*), Broad-leaved Geebung and noxious weeds Lantana and Bitou Bush (*Chrysanthemoides monilifera* subsp. *rotundata*) occur on the peak. Forest Red Gum, Swamp Box and Broad-leaved Paperbark dominate back into Swamp Forest on the lower slopes.
	YS-D is in National Park at Minnie Water along a power easement. The site is on undulating forested sand dunes. The upper slopes and crest dunes contain dry open forest and the lower slopes and gullies support sandy swamp forest. The dominate canopy species in dry forest comprise Blackbutt, Red Bloodwood and Needlebark. The understorey is structurally diverse rich with native species from the Ericaceae family. Old man Banksia, Native Cherry (*Exocarpos cupressifolia*), Black she-oak, Flaky-barked Tea Tree, *Persoonia* and *Acacia* species dominate the upper mid-storey. The lower mid-storey is very species diverse comprising, Tantoon, *Monotoca* sp. Pine Heath (*Astroloma pinifolium*), *S. triflora*, *L. lanceolata*, *Dodonaea triquetra*, *Acacia suaveolens*, *Correa reflexa, Hibbertia vestita*, *Dillwynia* sp., *Bossiaea* sp. and *Pimelea* sp. The ground cover is grassy comprising Kangaroo Grass, Blady Grass, Wiregrasses, Weeping Grass, Barbed-wire Grass, and Echinopogon sp. Other ground species comprise *Dianella longifolia* and Mat-rush, and in wetter habitats Australian Reed, *Baumea* sp., *Drosera* sp. and Cyperus species are dominate. The swamp forest is dominated by Broad-lead Paperbark, *M.*

	sieberi, Prickly-leaved Paperbark, *Hakea sericea*, Heath Banksia and *B. oblongifolia*.
	YS-E is on the same power easement as YS-D and comprises the same habitats and plant species composition. Smooth-barked Apple is more dominant on this site compared to YS-D.
Yuraygir north	YN-A is on the western boundary of National Park on relatively flat sandy soils. Dry open forest dominates the site and a patch of swamp forest/wet heath is also present. In dry forest, the overstorey comprises a mix of Blackbutt, Grey Gum (*Eucalyptus punctata*), Red Bloodwood, Turpentine, Tallowwood and Scribbly Gum. Two-veined Hickory (*Acacia binervata*), *L. lanceolata*, *D. triquetra*, Forest Oak, Broad-leaf Geebung, Old man Banksia and other less common shrubs such as Red Ash, Blueberry Ash and *M. sieberi.* The southern part of the site has a high level of ground cover regrowth in response to recent bush fire burning. The groundcover is rich with grasses and herbs with the most dominate comprising *Lepidosperma laterale*, Entolasia stricta, Austrostipa sp. and *H. vestita*, including some vines Wombat Berry and Hairy Apple Berry (*Billardiera scandens*). On the edges of swamp forest, small stands of Scribbly Gum and Needlebark become less frequent and Swamp Mahogany and Swamp Box are more dominate. Saw sedges dominate in the understorey along a narrow creek. On slightly elevated soils adjoining the creek, sands are constantly moist and support a highly diverse open wet heath habitat. This habitat is treeless and comprises of *Leucopogon lanceolata*, *Epacris pungens*, Flaky-barked Tea Tree, Prickly Tea Tree, *Daviesia* sp. *Boronia* sp. and *Banksia oblongifolia*. In the ground cover Saw sedges are present including a high cover of *Ptilothrix deusta*.
	YN-B is at Brooms Head on a private bushland block. A range of habitats are present which include swamp forest and high quality open forest. One patch of swamp forest on sand comprises regrowth of dominant Broad-leaved Paperbark, *M. sieberi*, *B. oblongifolia* and *Pultenaea villosa*. The groundcover is dominated with *P. deusta*. A second patch of mature swamp forest is also dominated by tall Broad-leaved Paperbark, and there is an occurrence of Swamp Oak and Red Mahogany. The open forest has an overstorey comprising Scribbly Gum, Needlebark and Red Bloodwood. There is also a small patch of Broad-leaved Ironbark (*Eucalyptus fibrosa*) and Spotted Gum where there is likely a clay cap. Black she-oak dominates the mid-storey in all open forest types with *Hakea dactyloides* occurring less frequently. The lower mid-storey comprises *Daviesia ulicifolia*, *B. oblongifolia*, Hairpin Banksia, *A. ulicifolia, L. lanceolata* and *Epacris pungens*. The groundcover is highly diverse but is mostly dominated with *Entolasia stricta* and other native grasses.

Appendix B. EPA comments and responses

ENVIRONMENT PROTECTION AUTHORITY - COMMENT SHEET

Project:	Pacific Hwy Upgrade – *Woolgoolga to Ballina*		
Document title:	*Coastal Emu Monitoring Study Phase 1 August 2014*		
Revision No.:	August 2014		
Reviewer name:	Craig Harré, Brian Tolhurst and Gina Hart	Review date:	12 September 2014

Thankyou for the opportunity to comment on the *Woolgoolga to Ballina Coastal Emu Monitoring Study Phase 1.* The EPA has reviewed the Study and has outlined key areas of concern and recommendations in the table below:

Reference	EPA Comments	RMS Response
Exec summary	To assist with EPA understanding of the following point from the report - "*These data show indications of emu density in relation to season and habitats*" please provide a detailed map of these data to illustrate clearly where emus were detected, at what densities and the different habitat types. Ideally the map would be overlaid on imagery showing the alignment including mitigation structures.	Improved mapping at a better scale to be provided in the next annual report
1.2	The pre-construction monitoring should ideally be undertaken quarterly until construction begins. It is stated in this report that construction commencement for sections 3 and 4 are unknown at present. The data collected now and until construction begins will form the basis for all future comparisons and as such should be as robust as possible. The monitoring objective from the Emu Management Plan states that *"Monitoring is to provide reliable information such that sound conclusions can be drawn in relation to the management of the species".* Given the low density of the emu population seasonal movements will obviously only be captured after surveying for a number of years. We have gained a significant increase in knowledge of local emu presence and habitat preferences from this first round of surveys. We have also seen an initial shift in distribution of emus from these surveys which will now require further clarification over a number of seasons. Also consider that the report states	It is proposed to continue quarterly monitoring until such time as construction begins

	"further baseline surveys will help to develop knowledge on emu distribution and abundance". At no point does the Emu Management Plan limit stage 1 survey to 12 months. Can the RMS confirm if it intends to continue with baseline surveys until such time as constructions begins? Alternatively, continue surveys until results are consistent between survey periods allowing confidence in future comparisons. As stated in the report it is also necessary to continue with surveys to remove the bias from the first round of emu passive observations in transects. The proceeding survey results may be vastly different.	
1.3	The project study area is not clearly defined. It is important that the study area is defined on a map so the EPA can understand how the local population near the road is defined. The map should also show transects and camera traps. This is particularly important at the impact sites. Gaining an understanding of the study area will also assist when contemplating the mean density of emus for a given area. Figure 1 is too broad to gather this information.	Maps showing the location of transects have been updated to include new transects and an improved scale. It is not intended to show camera locations on the map for security reasons, however these are described in the report.
2.1	The Emu Management Plan called for approximately 30km of transects across the Yuraygir emu population however the monitoring has delivered approximately 23km of transect. The EPA understands the constraints stated in the report and refinements made to accommodate this however given the uncertainty surrounding emu movement and the low density of the population it would be ideal to consider opportunities to identify potential new survey sites (likely no need for additional control sites). Given the unknown start date, there remains opportunity to collect additional baseline data. This is particularly the case in habitat areas surrounding and immediately north of Tucabia. The results appear to be inconsistent with previous NPWS understanding of emu activity in this area. Could lower survey effort contribute to this result? Please expand on the reasons why Somervale Road was excised from survey.	The first annual monitoring report presents the methods and results of the initial emu surveys conducted over 6 months and involved pilot investigations over a large number of transects. Transects which showed no evidence of emus were removed from the program and new ones sampled. The pilot investigations have resulted in new transects being added to the program over time. The annual report to be prepared in 2014 will report on a total of 13 impact transects and 7 control transects totalling 31.2 km. There is a total of 37 camera traps on survey transects and 44 camera traps of the emu exclusion fence
2.2.5	In this section it is stated that 33 cameras were deployed at PC4. PC4 represents the June 2014 transect surveys. However Table 4 illustrates camera use throughout the entire monitoring period. As already commented above, it would be ideal to understand where cameras were placed, timing and results on a map.	Revised mapping to be provided in the 2015 annual report that shows all transect locations. The position of cameras is described in the report rather than shown on mapping to protect security of cameras.

3	The low density survey results highlight the deficiencies with the mitigation objectives described in the Emu Management Plan. Of particular concern to the EPA is the allowance for 'similar' emu population density post-construction compared to baseline population density. Given the reported low density from these surveys, a lower density result in the future of say 0.5 could be viewed as 'similar' and therefore not trigger contingency measures. Following additional rounds of baseline surveys the EPA would welcome the opportunity to discuss these trigger values so there is a definitive decision point.	
Discussion	Can the report expand on the implications of the new knowledge that has been gained. Have we missed important areas in our surveys and can the RMS provide suggestions or other potential survey areas? How far into the Coldstream wetlands do the transects and contemporary emu records extend? Does the data highlight the importance of maintaining access to grazing and cropping land? Does it appear that connectivity structures are well located? Does Breeding west of alignment appear to be likely, and is this supported by the data?	The first annual report provides data from initial investigations conducted over a 6 month period including pilot investigations. The information requested by EPA will be provided in the 2015 annual report which provides a further 12 months of data and therefore provides a more complete understanding of emu presence and activity and the bearing this has on the location of connectivity structures. Additional survey areas have been informed by the baseline work and added to the program. The location of survey transects are limited to properties that are affected by the pacific highway upgrade, with the exception of control sites. Transects at Pillar Valley west extent to the Coldstream Wetland and will be shown on the revised mapping to be provided in the 2015 annual report.
General	How does the RMS consider annual emu count census data and incorporate other sources of data? For example regular sightings of emus in cane paddocks around?	A separate database has been devised for ongoing opportunistic sightings of emus in the study area and surrounding localities including the cane paddocks. It is intended to maintain this through the remainder of the monitoring program. The annual emu count data was not discussed in the 2014 annual report, however has been obtained by OEH in late 2014 and will be discussed in the 2015 annual report.

Appendix I. Exclusion fence monitoring progress reports

WOOLGOOLGA TO BALLINA PACIFIC HIGWAY UPGRADE: COASTAL EMU MONITORING PROGRAM - PHASE 1: PRE-CONSTRUCTION (POST-FENCE MONITORING) - PROGRESS REPORT MARCH 2015

Chris Thomson – Associate Ecologist Jacobs: chris.thomson@jacobs.com

Introduction

This progress report provides a brief summary of the methods and results of coastal emu monitoring associated with the temporary 'emu exclusion fence' installed in the pre-construction phase of the Woolgoolga to Ballina Pacific Highway Upgrade. Installation of the temporary emu exclusion fence was completed in December 2014 in two locations in Section 3, between Chainage 45855 and 49070 and Chainage 49800 and 50555. Monitoring commenced immediately following with the installation of motion-activated camera traps placed strategically at emu crossing zones. Monitoring was designed for consistency with the methods outlined in the W2B Coastal Emu Management Plan and focuses on the collection of seasonal data on emu presence and activity in proximity to purpose built gaps in the exclusion fence. The gaps have been placed at future emu crossing zones below the road. The objective of the early placement of the fence is to educate emus on the location of the future crossing zones well in advance of construction of the road with monitoring being used to inform the effectiveness of the fence design and use of the gaps.

Sampling design

The fence monitoring program compliments the emu baseline pre-construction data that has been gathered at impact and control sites since December 2013. In this regard the temporary exclusion fence was deliberately positioned close to the intersection with Wooli Road and continuing to the north east of Mitchell Road to target the area and habitat most frequented by emus within the project corridor as informed by the baseline monitoring. At one location (Chainage 48400) a hybrid gap was constructed to trial the exclusion of cattle but allow emus to pass through the gap, further details are provided in the Coastal Emu Management Plan and Emu Fence Strategy.

A series of camera trapping stations were placed at each gap in the fence with the density of cameras reflecting the size of the gap being monitored (refer Table 1). The number and configuration of cameras at each gap aimed to determine 1) if emus are present near fence gaps and 2) the location and frequency of emu passes through a fence gap. To achieve this, paired cameras were placed east and west of the gap within 30 metres of the fence to allow for spatial coverage of photo images across the gap. For larger gaps (> 12 metres) or densely vegetated areas with lower camera range additional cameras were placed on the fence itself at the start and end of each opening. The cameras were set for continuous operation in daylight hours between 0500 and 2000 hours and set to take still imagines with a trigger interval of 5 seconds in attempt to capture direction of travel and groups of emus. The four motion-activated cameras used at the hybrid gate were set to record video for 10 second duration. For the first phase of the monitoring period camera traps were set over two days (17-18 December 2014) and revisited on 3-4 February 2015 (32 days), at this time all photos and video image were downloaded and SD cards and batteries replaced to commence the second monitoring period.

Table 1 – Emu fence monitoring locations and camera trap arrangement

Crossing zone	Station	Description / waterway	Fence opening monitored (m)	Camera traps
T1	46055 to 46155	Floodway adjacent to Pillar Valley Creek	100.0	5
T2	46325 to 46440	Pillar Valley Creek	115.0	5
T3	46647 to 46722	Black Snake Creek	75.5	4
T4	47070 to 47082	Floodway	12.0	2
T5	47643 to 47795	Floodway	152.0	6
T6	47900 to 47960	Floodway	60.0	4
T7	48400 to 48900	Emu hybrid fence trial	50.0	4
T8	48740 to 48835	Mitchells Road realignment	95.0	6
T9	50280 to 50325	Un-named creek	45.0	4
		TOTAL	704.5 metres	40

During the camera checks in February, sections of the fence adjacent to the gaps were walked to search for fresh signs of emu activity (scats, tracks and feathers).

Results

Several periods of heavy rain in the weeks between the fence installation and the inspection are likely to have had an effect on the results in terms of finding evidence of emus and the sensitivity of the cameras. We have found that emu tracks and scats can be removed after heavy rain and local flooding. Data was collected for the first 32 days following completion of the emu fence. Evidence of emu presence was noted at five of the nine fence gaps (55 %), which included confirmed crossing by emus through a gap at two locations. These observations are described below:

- Ch45055 (T1) – (14/01/2015). Solitary adult emu passing through the gap travelling in a northerly direction (14/01/2015)
- Ch46325 (T2) – (28/01/2015). Pillar Valley Creek solitary adult emu passing through the gap travelling in a northerly direction (28/01/2015)
- Ch46647 (T3) – (03/02/2015). Solitary adult emu observed on the east side of the fence gap.
- Ch48400 (T7) – (23/12/2014). (Hybrid gate) video of adult male and chick walking past the eastern side of the hybrid gate but did not attempt to pass through the gap or show interest in the structure. Footage was captured of a calf pushing through the three strand barbed wire hybrid gate.
- Ch50555 (T9) - Two emu scats found along the exclusion fence approximately 50 metres south of the fence opening suggesting an emu walked along the fence.

Five cameras experienced problems with nesting ants which is related to sheltering from the very wet conditions and easy access to the inside of the camera, this problem has now been rectified. Care needs to be taken with setting the sensitivity of the cameras and ensuring no obstruction, as some cameras were triggered easily resulting in filling up the memory card and a reduced monitoring period. Similarly cattle were observed to be frequently using some fence gaps also leading to reduced monitoring periods.

Recommendations

Due to issues with timing of property acquisition, the temporary emu exclusion fence was not installed between Ch49070 and Ch50040, a distance of 970 metres and covering two emu crossing zones (120 metres and 21.6 metres). As a consequence there has been no monitoring of these two fence gaps. Monitoring on this property to the west of the fence during the monitoring period has continued to identify emu presence in the area around Mitchell Road.

It is likely that installation of the fence across this property would encourage emus to find and use the crossing zones. Monitoring of the fence gaps at T8 and T9 north and south of the unfenced property has shown no evidence of emus passing through these gaps for the first period of post-fence monitoring. This may suggest that any east-west movements in this location are currently occurring through the 'unfenced' section.

Continual monitoring of the fence may inform a decision to fence across the newly acquired property pre-construction. For example if T7, T8 and T9 continue to show no evidence of emus passing through the gap, but emus continue to be detected at the monitoring transects to the west of these (MRC, MRB and MRD), then there is some evidence to suggest that emus are using the 'unfenced' section instead of the gaps (intended crossing zones).

The intent of the fence gaps is to concentrate emu movements to narrower crossing zones and learning to do this before construction may be critical in obtaining future evidence that the crossing zones are being frequented and this should be considered.

WOOLGOOLGA TO BALLINA PACIFIC HIGWAY UPGRADE: COASTAL EMU MONITORING PROGRAM - PHASE 1: PRE-CONSTRUCTION (POST-FENCE MONITORING) - PROGRESS REPORT 2: JUNE 2015

Chris Thomson – Associate Ecologist Jacobs: chris.thomson@jacobs.com

Introduction

This progress report provides a brief summary of the methods and results of the coastal emu monitoring associated with the temporary 'emu exclusion fence' installed in the pre-construction phase of the Woolgoolga to Ballina Pacific Highway Upgrade. Installation of the temporary emu exclusion fence was completed in December 2014 in two locations in Section 3, between Chainage 45855 and 49070 and Chainage 49800 and 50555. The third and final section was completed in May 2015 between Chainage 49246 and 49366.

Monitoring of emu activity commenced immediately following the fence construction in December for the first two sections using motion-activated camera traps placed strategically at emu crossing zones. Additional cameras were placed at the final fence gap in May 2015. Monitoring was designed for consistency with the methods outlined in the W2B Coastal Emu Management Plan and focuses on the ongoing collection of data on emu presence and activity in proximity to the purpose built gaps in the exclusion fence. The gaps have been placed at future emu crossing zones to be placed below the road. The objective of the early placement of the fence is to educate emus on the location of the future crossing zones well in advance of construction of the road with monitoring being used to inform the effectiveness of the fence design and crossing of the gaps by emus.

Sampling design

The fence monitoring program compliments the emu baseline pre-construction data that has been gathered at impact and control sites since December 2013. In this regard the temporary exclusion fence was deliberately positioned close to the intersection with Wooli Road and continuing to the north east of Mitchell Road to target the area and habitat most frequented by emus within the project corridor as informed by the baseline monitoring. At one location (Chainage 48400) a hybrid gap was constructed to trial the exclusion of cattle but allow emus to pass through the gap, further details are provided in the Coastal Emu Management Plan and Emu Fence Strategy.

A series of camera trapping stations were placed at each gap in the fence with the density of cameras reflecting the size of the gap being monitored (refer Table 1). The number and configuration of cameras at each gap aimed to determine 1) if emus are present near fence gaps and 2) the location and frequency of emu passes through a fence gap. To achieve this, cameras have been placed systematically across the fence gap to obtain spatial coverage of photo images across the entire gap. For larger gaps (> 12 metres) or densely vegetated areas with lower camera range additional cameras were placed on the fence itself at the start and end of each opening. The cameras were set for continuous operation in daylight hours between 0500 and 2000 hours and set to take still imagines with a trigger interval of 5 seconds in attempt to capture direction of travel and groups of emus. Two motion-activated cameras used at the hybrid gate were set to record video for 10 second duration.

For the second period of monitoring camera traps were set over two days (3-4 February 2015) and revisited on 5-6 May 2015 (92 days), at this time all photos and video image were downloaded and SD cards and batteries replaced to commence the third monitoring period. An additional 6 cameras were set at T9 on 6 May 2015.

Table 1 – Emu fence monitoring locations and camera trap arrangement

Crossing zone	Station	Description / waterway	Fence opening monitored (m)	Camera traps
T1	46055 to 46155	Floodway adjacent to Pillar Valley Creek	100.0	5
T2	46325 to 46440	Pillar Valley Creek	115.0	5
T3	46647 to 46722	Black Snake Creek	75.5	4
T4	47070 to 47082	Floodway	12.0	1
T5	47643 to 47795	Floodway	152.0	6
T6	47900 to 47960	Un-named creek	60.0	4

T7	48400 to 48900	Emu hybrid fence trial	50.0	4
T8	48740 to 48835	Mitchells Road realignment	95.0	6
T9	49246 to 49366	Floodway	120.0	6
T10	50280 to 50325	Un-named creek	45.0	4
		TOTAL	824.5 metres	45

During the camera checks in May, sections of the fence adjacent to the gaps were walked to search for fresh signs of emu activity (scats, tracks and feathers).

Results

Periods of heavy rain in the week prior to the May inspection are likely to have had an effect on the results in terms of finding evidence of emus and the sensitivity of the cameras. We have found that emu tracks and scats can be removed after heavy rain and local flooding. Individual camera trap effort ranged between 2-93 days (mean 60 days). One camera malfunctioned due to nesting ants accessing the housing and one camera was stolen from near Mitchell Road (T8).

Evidence of emu presence in the autumn period was noted at seven of the nine fence gaps monitored (77 %), which included confirmed crossing by emus through a gap at two locations. These observations are described below:

- T3 – One photo of solitary adult emu observed on the east side of the fence gap.
- T4 – Two confirmed photos of emu passing through the narrow gap in the fence on different days
- T5 – Two photos confirming emu passing through the fence gap, likely the same animal although on different days
- T6 – three photos of emus in the riparian habitat associated with the gap at T6, one photo shows emu walking down fence line from the west toward the gap and other two photos confirm likely crossing through the gap.
- T7 – (Hybrid gate) eleven photos and video in total of adult pair walking past the eastern side of the hybrid gate but not attempting to pass through the gap. Scats and tracks also observed
- T8 – three photos in total showing individuals and pair in area of fence gap. The pair would be the same birds as photographed at T7
- T10 – one photo of adult emu walking in direction of the gap along track from eastern side.

The trap rate (number of emu photos captured per 100 days) between the first and second monitoring periods is shown in Figure 1. This is not an indication of emu abundance but rather activity in proximity to the fence gaps. Note that monitoring at T9 commenced in May, hence there are no results at this gap to date, however emu tracks were observed along the fence line less than 50 metres from the fence gap at T9. The data shows emu activity reported new observations at T3, T6 and T8 and no observations at T1 and T2 where emus were observed in the previous summer period.

Plate 1. Emu pair at hybrid gate (T7)

Plate 2. Emu crossing T4, camera on fence post

Discussion

The emu fence monitoring data shows that emu activity has been recorded at 100 % of the sites surveyed (n=9) in the first 6 months since installation of the temporary fence. There has been increase activity noted at the hybrid fence (T7) in the autumn period by the resident adult pair although no confirmation of using the emu gate. Observations of emu scats and tracks as well as camera footage show emus moving along the fence between chainage 47900 and 49200. There is evidence of repeat crossings though three gaps (T4, T5 and T10) over the two monitoring periods.

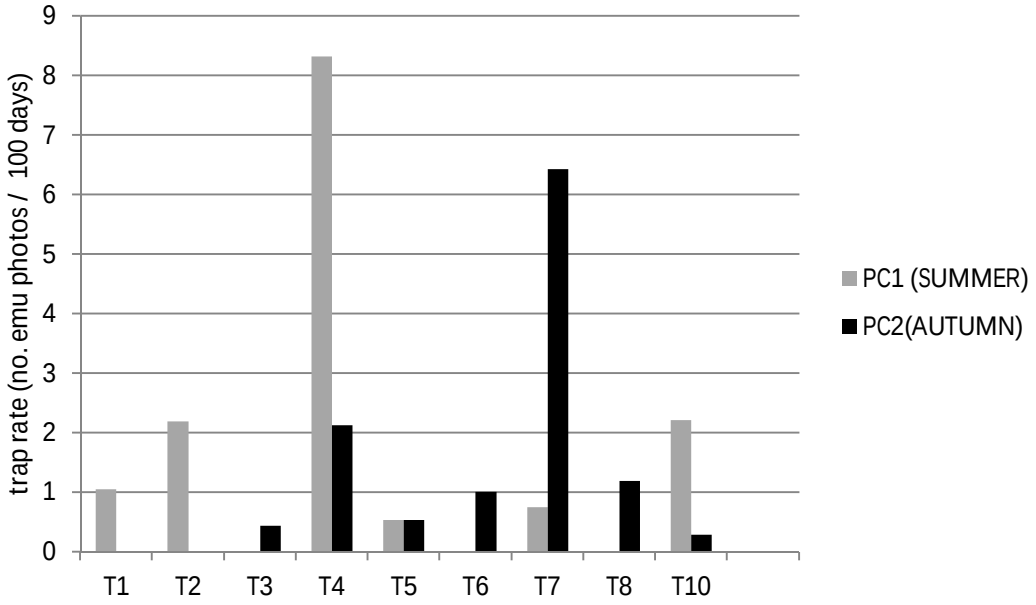


Figure 1. Camera trap rate (no. emu photos / 100 trap days) at each fence gap over the two monitoring periods. PC refers to pre-construction monitoring period

The configuration of the camera traps was changed in PC2 in attempt to obtain confirmation of emus crossing through the gaps rather than just observed in proximity to the gap. The paired trap arrangement was replaced with a linear arrangement, using the same number of cameras, aimed at covering all possible passes through the gap.

The camera traps also recorded wild dog activity at all fence gaps, which was largely associated with dingo or dingo hybrids. The number of individual dogs observed at each site during the two monitoring periods is shown below in Table 2. This is not a measure of dog abundance, as many of the photographs show the same individuals moving across different cameras.

The data from the fence and transect monitoring indicate that wild dogs are common in the study area, and their presence is frequently observed in locations where emus occur. The data is being collected to monitor trends in emu presence and activity over time and comparison with dog activity.

Table 2 – Count of wild dog observations near fence gaps

Fence gap	Count of individual dogs	
	PC1 (summer)	PC2 (autumn)
T1	4	0
T2	2	3
T3	0	10
T4	1	3
T5	0	4
T6	0	5
T7	0	4
T8	7	4
T10	12	7