NSW Roads and Maritime Services

WOOLGOOLGA TO BALLINA | PACIFIC HIGHWAY UPGRADE

COASTAL EMU MANAGEMENT PLAN

Version 2.0

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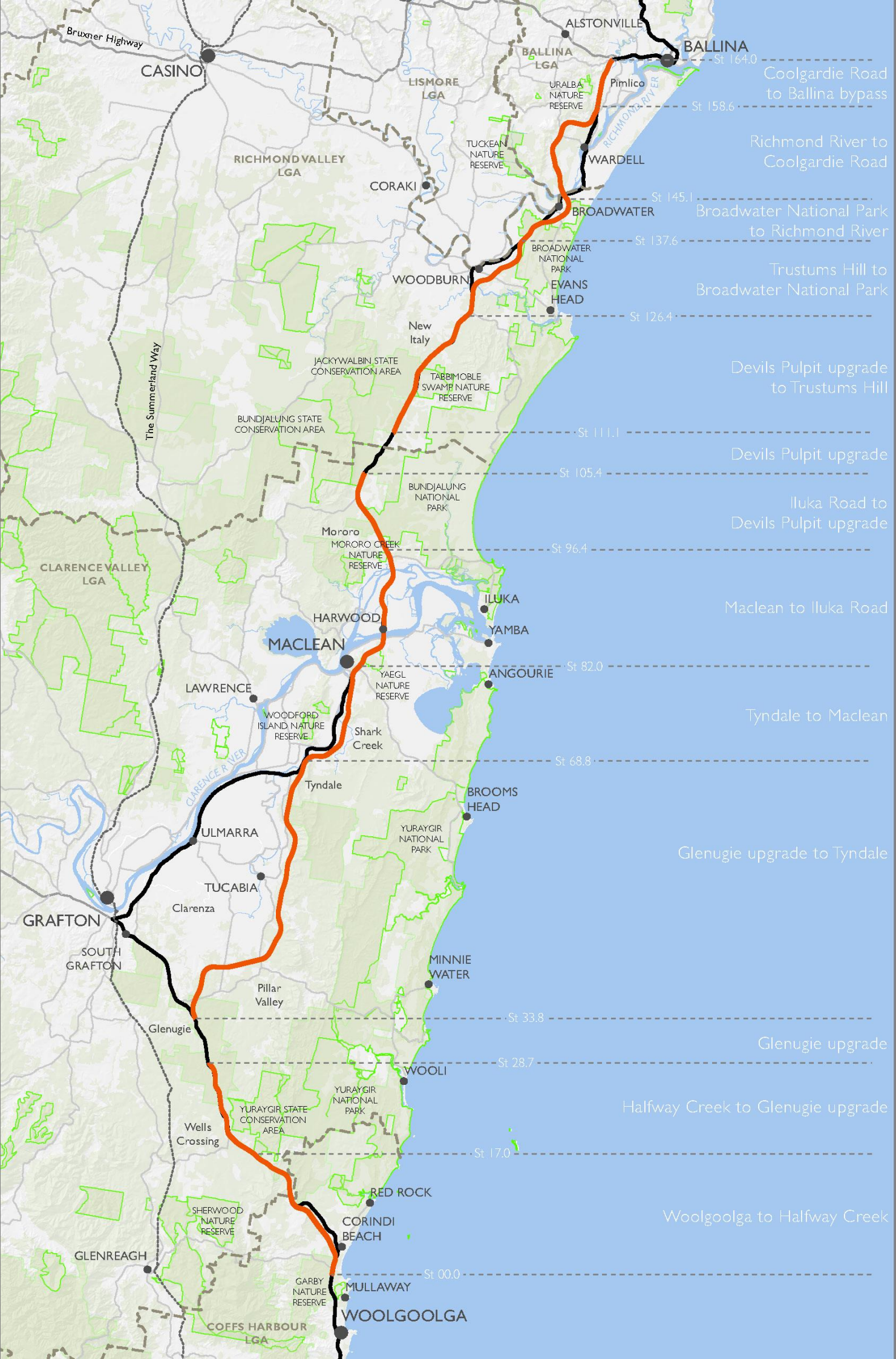
Prepared by: Jacobs Group (Australia)


Bruxner Highway
CASINO
ALSTONVILLE
BALLINA
BALLINA LGA
LISMORE LGA
URALBA NATURE RESERVE
Pimlico
RICHMOND RIVER
St 164.0
Coolgardie Road to Ballina bypass
11
St 158.6
Richmond River to Coolgardie Road
10
TUCKEAN NATURE RESERVE
WARDELL
RICHMOND VALLEY LGA
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 ..... **iii**

1. Introduction **1**

1.1 Project overview 1
1.2 Objectives of the Plan 2
1.3 Management structure and plan updates 4
1.4 Plan author 3
1.5 Expert and agency review 4

2. Coastal Emu population **5**

2.1 Background 5
2.2 Existing knowledge 7
2.3 Population decline and threats 10
2.4 Targeted emu surveys 11

3. Potential impacts and management approach **12**

3.1 Potential impacts associated with the project 12
3.2 Detailed design considerations 13
3.3 Mitigation and monitoring 13
3.4 Effectiveness of mitigation measures 14
3.5 Adaptive management approach 18
3.6 Proposed provisional measures 18

4. Pre-construction management measures **20**

4.1 Potential impacts during pre-construction 20
4.2 Goals for management 20
4.3 Management measures 20
4.4 Performance thresholds and corrective actions 22

5. Construction management measures **24**

5.1 Potential impacts during construction 24
5.2 Goals for management 24
5.3 Management measures 24
5.4 Performance thresholds and corrective actions 33

6. Operational management measures **36**

6.1 Potential impacts during operational phase 36
6.2 Goals for management 36
6.3 Management measures 36
6.4 Performance thresholds and corrective actions 37

7. Monitoring program **39**

7.1 Mitigation and monitoring goals 39
7.2 Emu activity monitoring 40
7.3 Monitoring effectiveness of crossing structures 52
7.4 Exclusion fence monitoring 53
7.5 Emu habitat revegetation monitoring 54
7.6 Evaluation, project review and reporting 55

8. Summary table and implementation schedule 57

9. References 60

Appendix A. Expert and agency comments

Appendix B. Stephen Davies CV

Appendix C. Expert review

Appendix D. Emu fencing strategy

Appendix E. Aerial survey pilot study

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 three waves of construction packaging to suit:
  a) Wave 1- Soft soils works at Harwood
  b) Wave 2- Soft soils works at Whytes Road to Pimlico
  c) Wave 3- Soft soils works between Tyndale and Iluka Road and at 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 3.6 describes provisional measures proposed to investigate design refinements. Details of the emu monitoring program are described in Chapter 7

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.

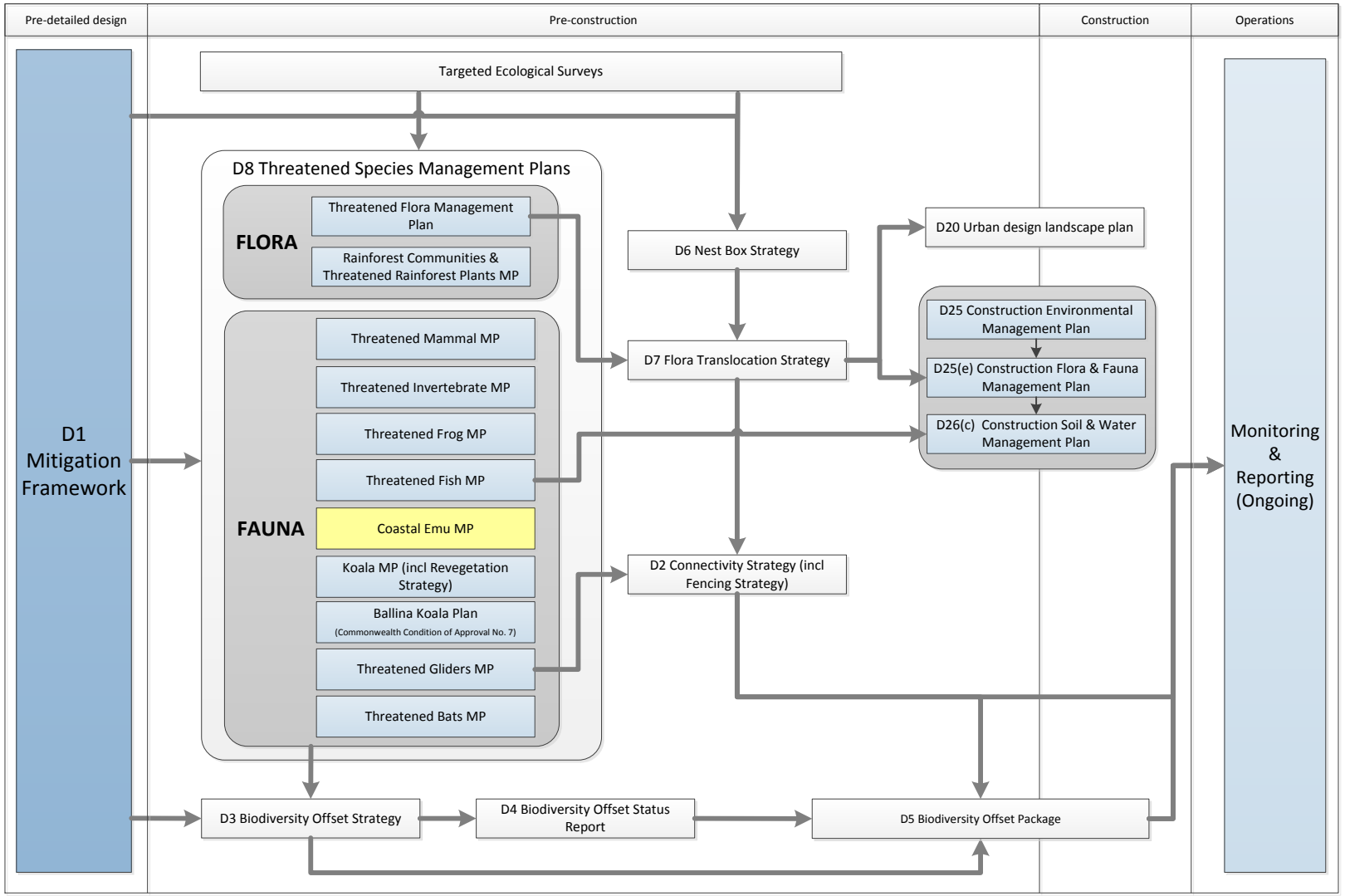
The plan informs future monitoring and reporting and identifies the locations for conducting monitoring of the emu population and the methods, variables and timing of the monitoring program.

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 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 improvement during the different stages of the project. The current version of the plan has been updated to incorporate the results of targeted baseline emu surveys during the pre-construction stage and meets the mitigation and management measures committed to in the Environmental Impact Statement (EIS) and SPIR, and complies with MCoA D8 for the project.

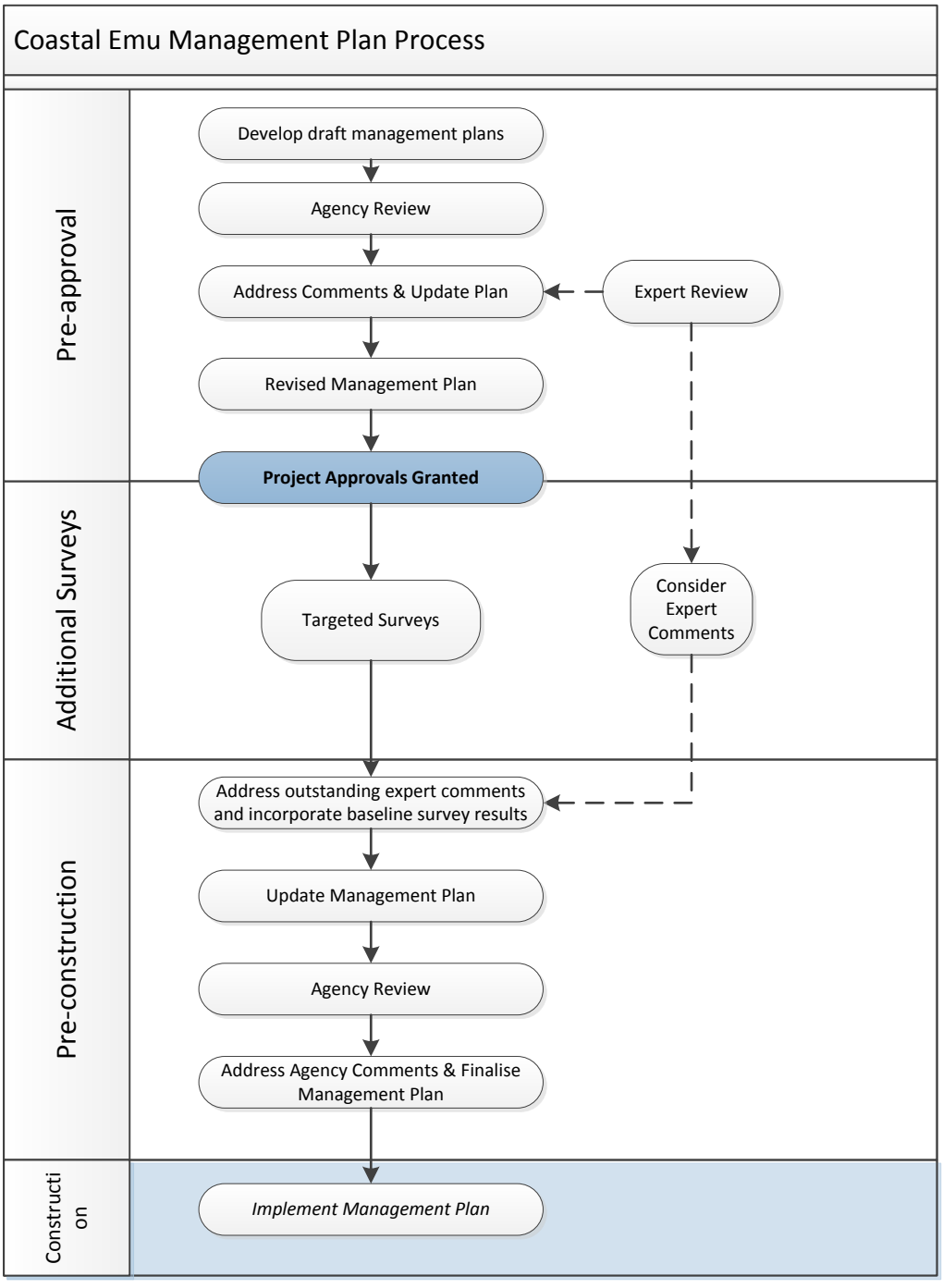
Roads and Maritime propose to update this plan in stages as detailed in the Biodiversity Mitigation Framework (MCoA D1) and the Staging Plan (MCoA A7). This is to reflect the staged nature of construction of the project and also the staggered nature of completing targeted baseline surveys. The first 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) has been 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.**

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

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 (Kerry Cranney pers.comm) 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 1978; 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.

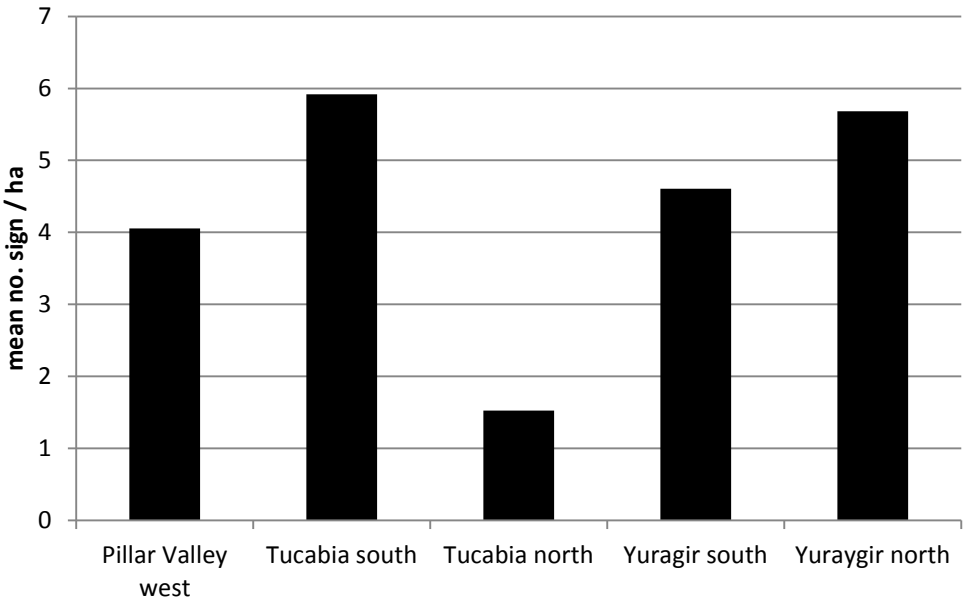


Figure 2-2. Pre-construction density of emu sign (no./ ha) at impact and control sites (November 2013-June2014)

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 Targeted emu surveys

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. This information builds on that presented in the EIS and SPIR. The surveys are focused on collecting baseline information for the monitoring program including impact sites and control sites. 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 in summer at Tucabia south (Section 3) followed by the autumn-winter period for 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 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.

Remote cameras were initially set during the first survey (December 2013). To date images of emus have been captured at 13 of the 20 transects surveyed (65%). 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 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. 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 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 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.

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.

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 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.

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 is yet to be designed and properly assessed for efficacy.

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

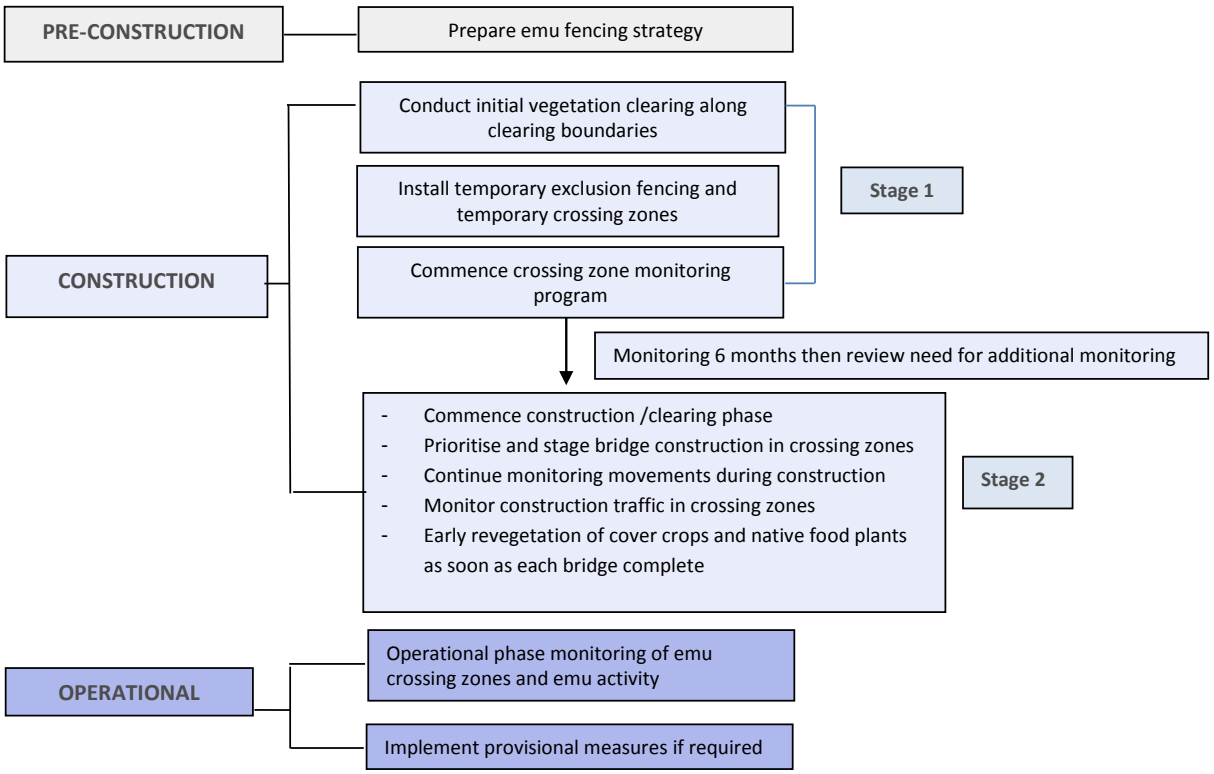
A number of measures to mitigate and monitor the impact of the project on emus during construction and operation of the project were identified in the EIS Biodiversity Working Paper. In general these measures related to:

- A targeted connectivity strategy.
- Provision of exclusion fencing.
- Avoiding impacts to emu habitat outside the road footprint during construction.
- Developing an emu find procedure for dealing with emu encounters during 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 floodplain wetlands is considered critical to the survival of the emu population as is preventing road fatalities on the future highway. In theory access 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 the 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. Exclusion fence monitoring would be implemented during pre-construction and 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 are not 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.

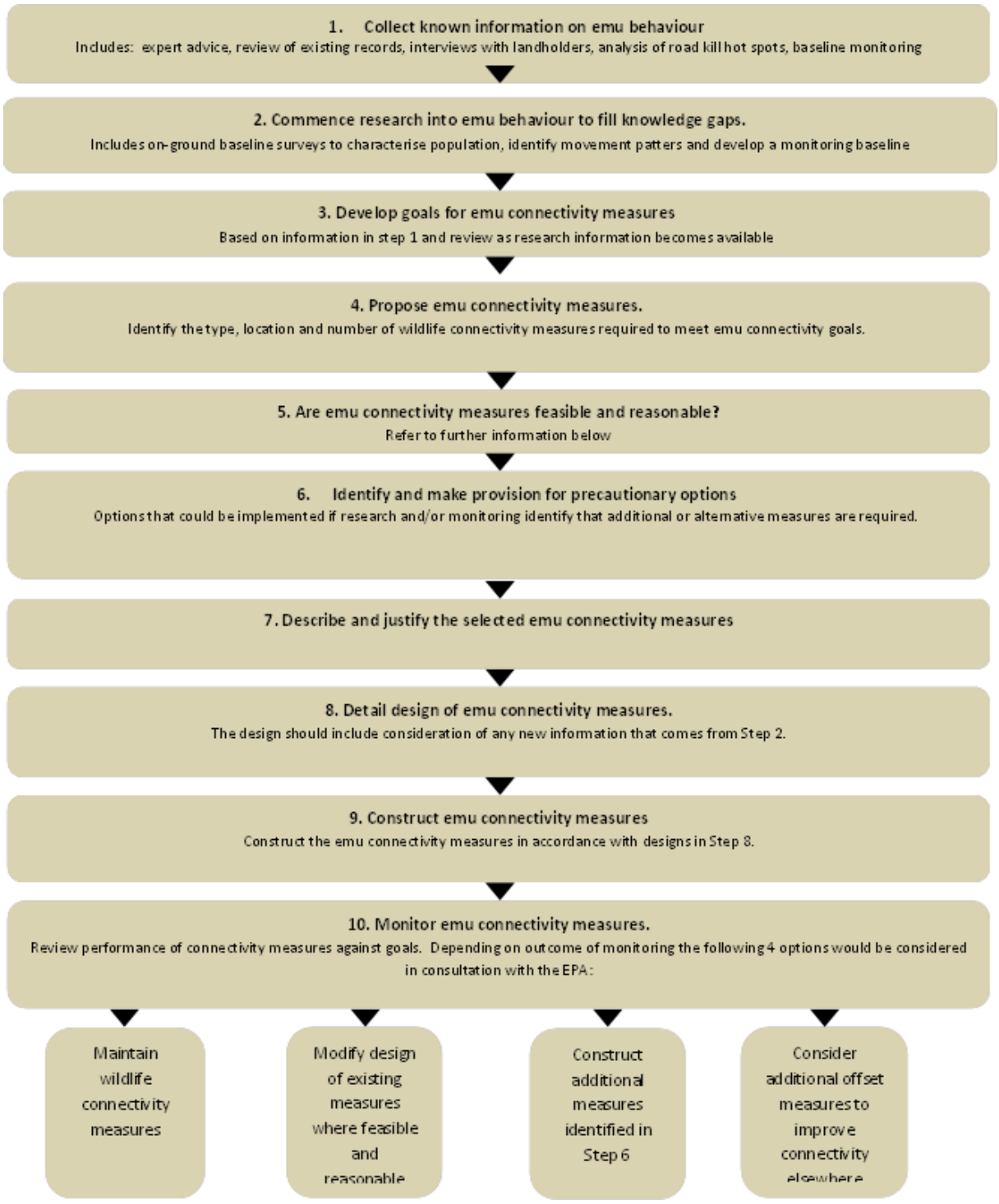
If during the operational phase emus are found to be unable or unwilling to use designated crossing structures provisional options would be developed that could be implemented if research and/or monitoring identify that additional or alternative measures are required.

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**.

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.

4.3.2 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.

4.3.3 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.

4.3.4 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.

4.3.5 Dog policy

The CEMP would include a policy that no domestic dogs are to be brought onto the site during pre-construction and construction activities. All construction personnel to be inducted as part of CEMP.

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

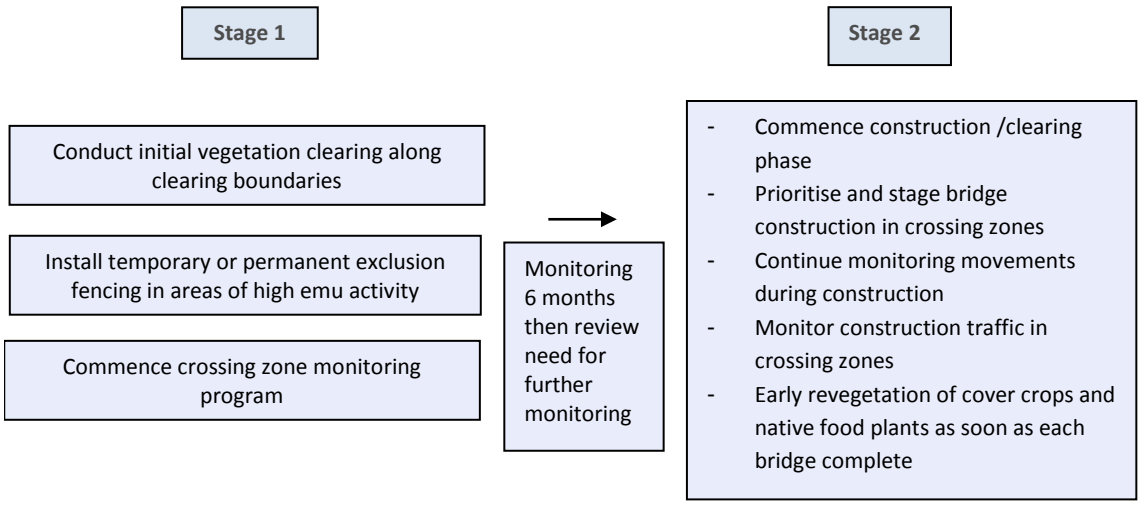
- Impacts during clearing of vegetation.
- Emus entering the construction corridor and becoming trapped in the corridor.
- Emu-vehicle collisions with construction traffic.
- Loss of connectivity and access to important habitats during construction.
- Disturbance and degradation to adjoining emu habitat.
- 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 in **Figure 5-1** below.



5.3.1 Pre-clearing surveys

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 Erect temporary emu exclusion fences

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

- Temporary fencing (pre-construction) to be erected up to 6 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.
- Temporary emu fencing (construction) to be erected in key areas of Section 3 and Section 4 to prevent emus from entering the construction corridor during construction and thereby avoid potential harm to emus from construction traffic and activities.
- The temporary fence design would be used across the length of Section 3 and Section 4 during the stage 2 main construction. It is not required in Section 4 for the stage 1 (early works pre-treatment) construction. This is because traffic activity is expected to be minimal during stage 1 and would be restricted to open country. Emus are regularly observed in cane properties around Shark Creek (Section 4) where they frequent modified habitat and are easy to sight in the open areas. Emu activity would be monitored during stage 1 (early works) and if emus are found to be frequenting the construction corridor during the early works activities, this would trigger a need to erect the modified sturdy temporary fencing as per the design discussed above.

Details on the proposed fence type and location of temporary emu fencing are discussed in the emu fencing strategy (Appendix D).

5.3.3 Staging of construction

Given a potential lengthy construction period for Stages 3 and 4 of the project, the project must make available a number of opening options during construction. Staging is proposed to ensure that emus will have continued opportunities to cross the construction corridor during the construction phase. The objectives are firstly to identify crossing zones by establishing fencing prior to construction and then to maintain functional crossing zones during construction so that at any one time there would be at least one or multiple crossings open.

The first stage of construction would involve identifying clearing limits and removing vegetation along clearing lines followed by installation of either temporary or permanent fencing in places identified by the fencing strategy prior to the commencement of construction. As emus should be allowed the opportunity to cross the construction corridor during the construction period at designated emu crossing zones this will involve placing temporary fencing perpendicular across the construction corridor and maintaining these during the construction phases. **Figure 5-1** shows an example diagram of a crossing zone which represents one of the several bridge locations to be constructed in Sections 3 and 4.

During construction of a bridge(s), this crossing zone would be closed using temporary fencing until completion of the bridge at which point the permanent fencing would be tied into the bridge and plantings completed and the zone open. As there are multiple bridges, construction of these would be staged over time so that there would always be active crossing zones available during construction. It will be important to prioritise rehabilitation of emu crossing zones as soon as a bridge construction is completed.

As it is expected that construction traffic will need to pass through crossing zones on a regular basis, this would occur via controlled vehicle crossing areas (refer Figure 5-1 for example diagram). Controlled access involves speed reduction and erection of emu warning signs as well as the use of temporary gates to be closed outside of construction times to prevent emus entering the construction corridor along the haul road.

5.3.4 Vegetation clearing and emu find procedures

Before clearing commences, ensure that the pre-clearing process as reported in **Chapter 4** 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.

Figure 5-1. Diagrammatic representation of fencing strategy outcomes for crossing zones and haulage routes

5.3.5 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). All vehicles are to remain within the designated construction corridor at all times.

In the case of the emu work would cease and options considered for ensuring 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.

5.3.6 Targeted emu crossing structures

The specific structures for emus would be located in the between chainage 36500 and 66500 (Section 3 and 4 of the project) and include:

- 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.

Specific details of the 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					135.5 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					315.5 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					180.5 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					100.6 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					100.6 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					75.5 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
47.643	3	Pillar Valley Creek 4	BRIDGE					75.5 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					60 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					35.5 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					120.0 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					45.0 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		RCBC	62	1	3.600	3.600		Combined (Emu)	Increase structure to a minimum height of 3.6m (possibly a Bebo Arch) if savings can be found and if practical for property – two separate owners on either side of the alignment	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					52.0 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		ARCH	60			5.500		Combined (Emu)	Consider replacement of culvert with an bridge should savings be identified elsewhere	Chaffin Swamp to Chaffin Hill
54.695	3	Unnamed tributary of Chaffin Creek (near station 54600)	BRIDGE					90 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					88.0 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					75.5 x 10.5	Combined (Emu)	Retain 5m clearance in design for emu	
59.272	3		ARCH	60	1		5.500		Combined (Emu)	Provide 5.5 m clearance for emu if fill batter allows.	
60.802	3		ARCH	60	1		5.500		Combined (Emu)	Provide 5.5 m clearance for emu if fill batter allows.	
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.	

5.3.7 Permanent emu exclusion fencing

Permanent exclusion fencing would progressively replace temporary fencing during construction and completed by the end of construction. 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.

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 in the Brooms Head area, northeast of the study area 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 concrete posts instead of timber and start 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 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.

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.

5.3.8 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.

5.3.9 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.

5.3.10 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.

5.3.11 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.

5.3.12 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 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 during clearing works.	Stop clearing works and consult with emu specialists or NPWS. 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.	• Monthly fauna incident log to be maintained as per FFMP. • Daily exclusion fence monitoring.	Emu injured during construction.	Stop construction and conduct evaluation of exclusion fence strategy and traffic control procedures as appropriate.
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.	• 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.	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.

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). Monitoring of dog activity would be conducted as part of the crossing structure monitoring program (refer Chapter 7). Should underpass monitoring in Section 3 and 4 of the project demonstrate wild dogs to be an issue for emu movement through the crossing zones, the Roads and Maritime would engage with the Northern Rivers Catchment Management Authority, NSW Office of Environment and Heritage (Parks and Wildlife Grafton), and Rural Lands Protection Board (North East) and adjacent landowners.

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 Location of survey transects

Figure 7-1 Location of survey transects

Figure 7-1 Location of survey transects

Figure 7-1 Location of survey transects

Figure 7-1 Location of survey transects

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 site 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 40 camera traps have been placed along the temporary exclusion fence near emu crossing zones, and there are a total of 77 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	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 between 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.	• 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 with controls to determine their effectiveness and inform management decisions, this would include:

- Structure type (raised bridges, versus arch structures).
- Landscape type (cover crops, versus native plantings versus open landscape).
- Attractant type (tethering shiny twirls, 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.

- **Remote surveillance cameras:** 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 would include attachment to the bridge underside and mounted cameras on poles at ground level to obtain alternative side views. Camera 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).
- **Transect surveys**. As per methodology and timing described in **Section 7.2**. Survey to search for emu and dogs scat, tracks and feather surveys and direct emu sightings. Transects would be established at all crossing zones including targeted bridge and arch structures. Data would be collected from the entrance or inside the crossing structure or below the bridge.
- **Mortality survey**: Survey of the emu exclusion fence for 250 metres either side of the structure to identify and report and breaches and report maintenance requirements. Survey of the north and southbound carriageway 500 metres either side of the crossing structure 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 four 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**) to assess emu activity in proximity to structures and identify 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 4 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 24 months to allow plantings to establish. **If no evidence of emu crossings noted in Section 3 after the end of the fourth 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, through evidence of dogs and foxes reported on surveillance cameras and a dead emu found.	• 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.

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 and DP&E 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.

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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

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Note: Appendices to this document are available upon request to Roads and Maritime.