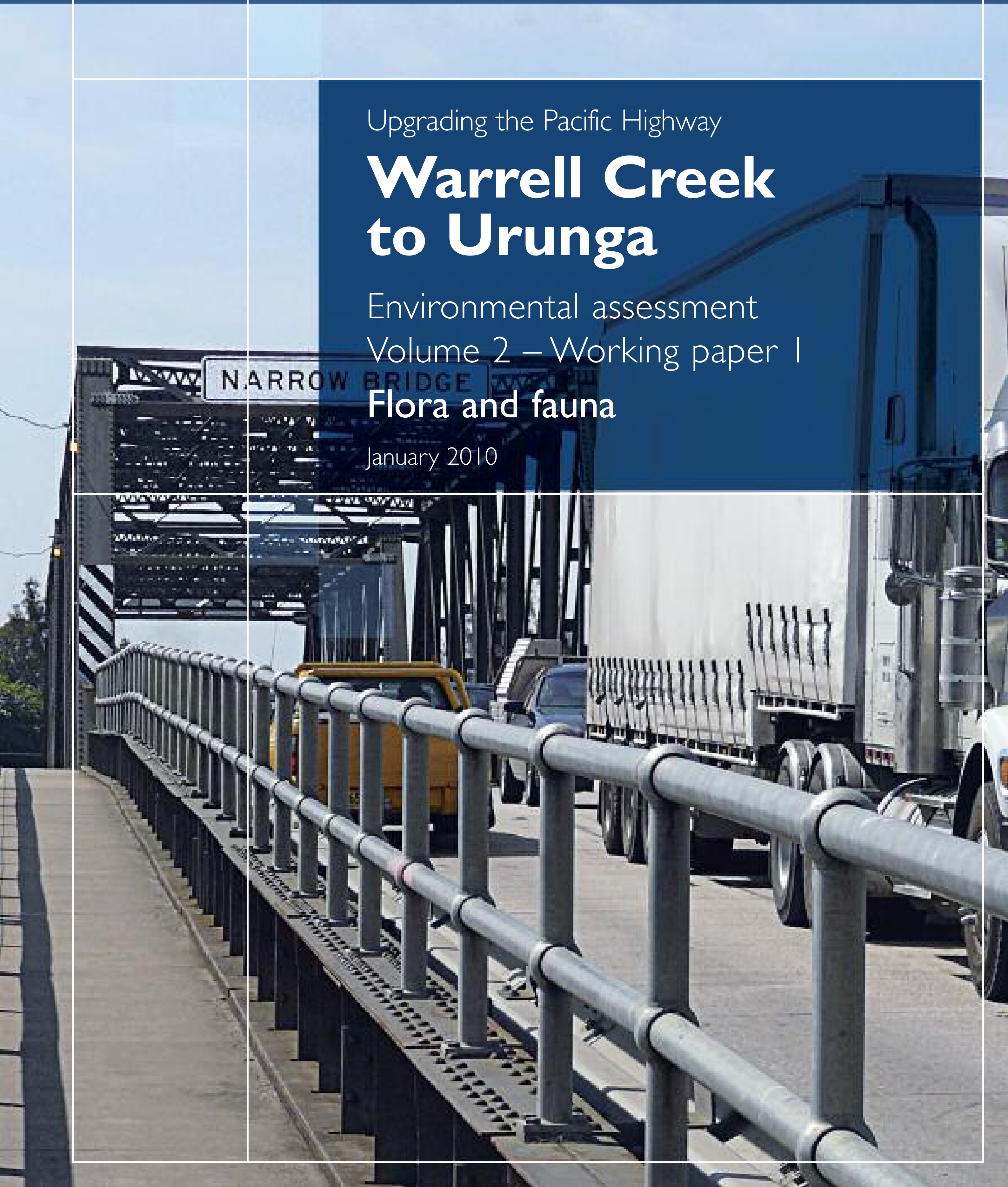
Upgrading the Pacific Highway

Warrell Creek to Urunga

Environmental assessment
Volume 2 – Working paper 1

Flora and fauna

January 2010



Warrell Creek to Urunga Upgrading the Pacific Highway

WORKING PAPER NO 1 - FLORA AND FAUNA

Final

- 13 January 2010

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Acknowledgements

Sinclair Knight Merz acknowledges the contribution, through the provision of data and information, of the following people in preparing this report:

- John Murray and Brian Tolhurst (Department of Primary Industries: NSW State Forests, now part of Department of Industry and Investment)

Abbreviations

AUSRIVAS	Australian Rivers Assessment System
CAMBA	China Australia Migratory Bird Agreement
DECC	NSW Department of Environment and Climate Change
DECCW	NSW Department of Environment, Climate Change and Water
DEHWA	Commonwealth Department of Environment, Heritage, Water and the Arts
DEH	Commonwealth Department of Environment and Heritage
DII	Department of Industry and Investment
EP&A Act	NSW Environmental Planning and Assessment Act, 1979
EPBC Act	Commonwealth Environment Protection and Biodiversity Conservation Act, 1999
FM Act	Fisheries Management Act, 1994
GIS	Geographic Information System
GPS	Geographic Positioning System
JAMBA	Japan Australia Migratory Bird Agreement
MNES	Matters of National Environmental Significance
NPWS	NSW National Parks and Wildlife Service
ROTAP	Rare or Threatened Australian Plant
RTA	NSW Roads and Traffic Authority
SEPP	State Environmental Planning Policy
sp.	Species (singular)
spp.	Species (plural)
subsp.	Subspecies
TSC Act	NSW Threatened Species Conservation Act, 1995
TSR	Travelling Stock Route
var.	variety
WIRES	Wildlife Rescue Emergency Service

Executive summary

This working paper presents a technical report on the ecological impacts associated with the Pacific Highway Upgrade Warrell Creek to Urunga Project as part of the Environmental Assessment (EA). The document reports on the methods and results of investigations into the terrestrial & aquatic flora and fauna associated with the study area, the prediction of impacts, their magnitude and significance and outline of mitigating measures to minimise impacts on biota.

Investigation into the ecological values of the study area, including landscape, baseline and habitat data were collected over the period 2003-08, commencing with survey during the route options development phase (2003-06) followed by the EA (2007-08). Seasonal surveys were conducted with the objective of assembling quantitative and qualitative data on the flora and fauna diversity and the distribution of vegetation and habitat associated with the project corridor with a focus on acknowledging the key issues identified in the Director Generals requirements.

In total, 590 terrestrial plant species from 132 families were identified including one nationally vulnerable species (*Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)), also listed as endangered in NSW (*Threatened Species Conservation Act 1995 (*TSC Act)) and one state listed vulnerable species (TSC Act). A further two recognised rare species (RoTAP) and five regionally significant species were identified. Of the flora identified 17 per cent represent introduced species.

A total of 203 terrestrial fauna species were identified (125 bird species, 36 mammal species, 24 reptile species and 18 amphibian species) including one nationally vulnerable species (EPBC Act), also listed as endangered in NSW (TSC Act) and a further 13 state listed species.

Vegetation characteristic of the following listed Endangered Ecological Communities (TSC Act) were identified:

- Subtropical Coastal Floodplain Forest of the NSW North Coast bioregion.
- Freshwater Wetlands on Coastal Floodplains of the NSW North Coast bioregion.
- Lowland Rainforest on floodplain of the NSW North Coast bioregion.
- Swamp Oak Floodplain Forest of the NSW North Coast bioregion.
- Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast bioregion
- Coastal Saltmarsh of the NSW North Coast bioregion.

Direct impacts from the Proposal on the identified vegetation and species habitat were calculated from the road design footprint, including an additional 10 m buffer, equating to a construction corridor of 431 ha. Of this corridor 255 ha (59 per cent) is occupied by native vegetation, the remaining 176 ha (41 per cent) consists of cleared land (agricultural or rural residential), hardwood plantations and river crossings. The proportion of this impact on Endangered Ecological Communities is reported.

The methods and results of targeted surveys for threatened flora and fauna species are reported. Of these several populations of the slender milkvine (*Marsdenia longiloba*) (Vulnerable: EPBC Act; Endangered: TSC Act) were identified in the vicinity of the corridor (i.e. 500 m search area) comprising in total 156 individuals. The Proposal would directly impact on an estimated 12 plants (approximately 8 per cent of the subject populations) and indirectly impact on an additional 32 individuals (20 per cent) that would remain within 30 m of the corridor and therefore subject to expected altered biophysical conditions. A single rusty plum (*Amorphospermum whitei)* (Vulnerable: TSC Act) located in riparian vegetation along Boggy Creek would be removed. No other threatened flora, as identified by the Director General's requirements, were located in the study area.

Targeted fish surveys were undertaken upstream and downstream of where the Proposal crosses waterways. A total of twelve species comprising 273 fish were recorded from the 13 freshwater sites and a total of 4836 fish across 17 species within the estuarine sites. No species listed under the *Fisheries Management Act 1994* or *EPBC Act 1999* were encountered during the targeted surveys.

The Proposal would directly impact on a portion of the habitat available for several threatened fauna populations including eight mammal and four bird species. Additional threatened species potentially impacted by the Proposal, although not directly identified during the field surveys include six plant species, five bird species, one frog and one mammal species.

General and specific impact mitigation measures and long-term management and monitoring strategies are identified to minimise and monitor impacts to flora and fauna. These would form the basis of a Flora and Fauna Management Plan (FFMP) to be prepared as a supplementary plan to the Construction Environmental Management Plan (CEMP) and the Operation Environmental Management Plan (OEMP) for the Proposal. The FFMP would identify the areas of ecological conservation significance to be protected, advise appropriate methods for vegetation and habitat protection and management during construction and outline species monitoring protocols.

1. Introduction

1.1. Overview

Sinclair Knight Merz (SKM) has been commissioned by the New South Wales (NSW) Roads and Traffic Authority (RTA) to conduct an environmental assessment (EA) of the Proposal for the Pacific Highway upgrade between Warrell Creek and Urunga, which forms part of the RTA's Pacific Highway Upgrading (PHU) Program. The Proposal corridor is located in the Mid-North Coast region of NSW and extends for approximately 42 km from the northern end of the existing Allgomera deviation, south of Warrell Creek, to the southern end of the existing Raleigh deviation, north of Urunga.

Flora and fauna is identified as a key issue in the Department of Planning (DoP) (now part of the Department of Planning & Local Government) Director-General's requirements. A detailed flora and fauna assessment of the Proposal was undertaken as part of the broader EA process and to assist with the concept design and is presented in this working paper.

This working paper documents the methods and results of an investigation of the terrestrial flora and fauna along the proposed road, the prediction of impacts and their significance and outline of mitigating measures to minimise impacts on biota. Data from targeted surveys along the preferred route in 2007-08 have been utilised to assess the ecological impacts of the Proposal, together with previous flora and fauna surveys and assessment gathered from the route selection phase of the Proposal (2003-06).

The study area has been split into four sections as shown in **Figure 1-1**. These include:

- Section 1 – Allgomera Deviation to Nambucca River.
- Section 2 – Nambucca River to Nambucca Heads.
- Section 3 - Nambucca Heads to Ballards Road.
- Section 4 - Ballards Road to Raleigh Deviation.

1.2. Assessment requirements

The Director-General's Requirements, Department of Primary Industries (DPI, now part of the Department of Industry and Investment) and the Department of Environment and Climate Change (DECC, now the Department of Environment, Climate Change and Water (DECCW)) identified key requirements which needed to be addressed regarding the impacts on terrestrial and aquatic flora and fauna associated with the Proposal, these are listed in **Table 1-1** along with reference to discussion on these issues throughout the report.

Figure 1-1 : The Proposal

GDA 94 MGA Zone 56

SKM SINCLAIR KNIGHT MERZ

RTA

Warrell Creek to Urunga - Upgrading the Pacific Highway

June 1, 2009

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Table 1-1: Environmental assessment requirements

Environmental assessment requirement	Sections where addressed
Director-General's Requirements, Department of Planning (now part of the Department of planning & Local Government)	
Threatened terrestrial species, populations, ecological communities and/or critical habitat including erosion of genetic stock.	Sections 5.2.1, 5.2.3, 5.2.4, 6.2.1, 6.2.3, 6.2.4
Targeted surveys of threatened flora and fauna species including slender milkvine (*Marsdenia longiloba*), rusty plum (*Amorphospermum whitei*), Newry golden wattle (*Acacia chrysotricha*), scented acronychia (*Acronychia littoralis*) and milky silkpod (*Parsonsia dorrigoensis*).	Sections 2.4.2, 4.4
Terrestrial habitat and biodiversity including native vegetation loss, habitat fragmentation, weed infestation, wildlife and riparian corridors, riparian habitat, and groundwater-dependent communities.	Sections 5.2.1, 5.2.2, 5.2.6, 5.2.7, 5.2.8, 5.2.9, 5.2.10, 6.2.1, 6.2.4, 6.2.5, 6.2.6
Regional scale cumulative impacts and the significance of the impacts of the Proposal in context of the Pacific Highway Upgrade Project (PHUP).	Sections 5.2.11, 6.2.7
Aquatic habitat and biodiversity including wetlands, mangroves and seagrass including consideration of the NSW Fisheries document *Policy and Guidelines for Aquatic Habitat Management and Fish Conservation 1999*.	Sections 3.2, 3.5, 3.6, 3.7, 3.8, 3.9
Department of Primary Industries (now part of Department of Industry and Investment (DII))	
Further targeted surveys and assessment of terrestrial flora and fauna associated with the refined route is included in the scope of the EA and the approach is supported. All existing information and the results of the additional work as well as adjacent land uses should be considered in refining the concept design in relation to flora and fauna protection measures.	Section 2, 5.1, 6.2
The EA should clearly identify the risk to aquatic habitats, any likely impacts, the extent of impacts and any mitigation or compensation strategies put in place to achieve no net loss of fish habitat.	Section 5.2.12
Detailed risk assessment of all potential impacts on fish and fish habitat during and after works. Include consideration of impacts on the oyster industry, commercial fisheries and any recreation fishery issues.	Sections 3.2.5, 5.21
Description of measures and initiatives to avoid, minimise, manage and mitigate impacts of the project to waterways and fish habitat.	Sections 6.1, 6.25, 6.26, 6.2.11, 6.2.12, 6.2.13
The EA should consider the potential staging and timing of works (such as the winter movements of the Australian Bass)	Sections 5.2.13, 5.3, 5.6
Department of Environment and Climate Change (now Department of Environment, Climate Change and Water (DECCW))	
The EA should include threatened biodiversity field surveys and assessments following the steps listed in the *NSW Threatened Species Survey and Assessment Guidelines June 2006*. These surveys and assessments, specifically in the preferred route corridor, should be carried out under ideal seasonal and climatic conditions (include survey methodologies and results). The Guideline states 'if suitable habitat exists, and it is not possible to survey for potentially present threatened species during appropriate seasons and weather conditions, it must be assumed that these	Section 2, 5.2.4

Environmental assessment requirement	Sections where addressed
species occur in the study area'.	
The EA should describe, quantify and address likely direct and indirect impacts associated with the Proposal to threatened biodiversity, their habitats and native vegetation distribution, including cumulative impacts and a qualitative and quantitative landscape impact assessment of the Proposal for the length of the Pacific Highway Upgrade known as the 'declared project'. Where such impacts are unable to be demonstrably mitigated or otherwise avoided, these should be described and quantified in sufficient detail to determine the extent to which compensatory habitat or other offsets will be required. Consideration should be given to applying the DECC Biobanking Credit Calculator to quantify these offsets. The calculator is currently in draft form and will be available from the DECC website in early 2008 (not available 14 November 2008).	Sections 5 and 6
The environmental assessment should identify whether the Proposal or aspects of the Proposal constitute Key Threatening Processes (KTPs) under the Threatened Species Conservation Act 1995 (TSC Act). Where KTPs are identified, relevant threat abatement measures proposed to be implemented are required. Reference to nominated and preliminary listing of KTPs is also encouraged.	Section 5.2.12, 6.2.7, 6.2.8
The environmental assessment should describe the objectives and assess the feasibility of implementing appropriate flora and fauna mitigation measures during both construction and operational phases of the Proposal, making specific reference to the nature and extent of the expected impacts. Where appropriate feasible mitigation measures are identified, the EA should seek to define and commit to these measures to ensure impacts to threatened species and biodiversity are managed in accordance with current environmental best practice. Where fauna crossing structures are proposed the EA must consider the suitability of such structures by gaining a thorough understanding of pre-development threatened fauna population dynamics including a habitat assessment of the adjacent landscape. Any proposed mitigation measures should be evaluated against a clearly defined and measurable goal.	Section 6
The Project Application Report (PAR) indicates that no threatened flora species listed under NSW or Commonwealth legislation were recorded within the investigation area for the Proposal. DECC records indicate that the following species have been recorded in or near the preferred route: slender milkvine (*Marsdenia longiloba*), rusty plum (*Amorphospermum whitei*), Newry golden wattle (*Acacia chrysotricha*), scented acronychia (*Acronychia littoralis*) and milky silkpod (*Parsonsia dorrigoensis*). It is imperative that flora survey work target these and any additional threatened flora species that are known or predicted to occur in the preferred route corridor.	Sections 2.4.2, 4.4
The PAR indicates that the preferred route will bisect a number of EEC's including: swamp sclerophyll forest on coastal floodplains, freshwater wetlands on coastal floodplains, river-flat eucalypt forest on coastal floodplains, subtropical coastal floodplain forest and swamp oak floodplain forest. These contain indigenous plant and animal assemblages that are generally poorly conserved in the region and are subject to further fragmentation and erosion of their genetic stock. The EA must evaluate and propose mitigation options for direct and indirect impacts on these EECs.	Sections 4.2, 4.3, 5.2.3, 6.2.2
The preferred route has the potential to impact on SEPP 14 wetlands through the alteration of hydrological regimes, particularly near Gumma Swamp south of Nambucca River, Newee Creek, Deep Creek complex near Boggy and Cow Creeks, and wetlands west of Urunga and Newry Island. Direct and indirect impacts to these wetlands must be fully explored, along with proposed options to mitigation these impacts. This assessment must also evaluate the impacts of altered hydrological regimes on EEC's associated with the SEPP 14 wetlands.	Section 6.2.6

1.3. Legislative context

The Proposal is assessed under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act). In addition the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) has been considered in the assessment of the Proposal.

Further state legislation and planning policies relevant to the protection of biodiversity include:

- *Threatened Species Conservation Act 1995.*
- *Native Vegetation Act 2003.*
- *Fisheries Management Act 1994.*
- *National Parks and Wildlife Act 1974.*
- *State Environmental Planning Policy No. 44 – Koala Habitat Protection.*

Although licences and approvals under these State Acts and policies are not required in addition to approval under Part 3A of the EP&A Act, consideration has been given to their intent.

1.3.1. Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)

The EPBC Act protects the environment, particularly matters of National Environmental Significance. It streamlines the national environmental assessment and approvals process, protects Australian biodiversity and integrates management of important natural and cultural places. The EPBC Act identifies seven matters of national environmental significance:

- World Heritage properties.
- National heritage places.
- Wetlands of international importance (Ramsar wetlands).
- Threatened species and ecological communities.
- Migratory species.
- Commonwealth marine areas.
- Nuclear actions (including uranium mining).

1.3.2. Environmental Planning and Assessment Act 1979 (NSW)

The EP&A Act details the development assessment system in NSW. The consent and/or determining authority must consider the effects of a proposed development or activity on threatened species, populations and ecological communities as listed under Schedules 1, 1A and 2 of the *Threatened Species Conservation Act 1995* and determine if there is likely to be a significant impact. This document identifies matters which are relevant to the assessment of impacts to threatened species, populations, or ecological communities, or their habitats arising the Proposal under the *Guidelines for Threatened Species Assessment* (Part 3A) (NSW Department of Environment and Conservation and Department of Primary Industries 2005).

1.3.3. Threatened Species Conservation Act 1995 (NSW)

The NSW *Threatened Species Conservation Act 1995* (TSC Act) identifies threatened species, populations and ecological communities as listed under Schedules 1, 1A and 2 which are to be addressed in assessing the significance of impacts arising from a proposal assessed by the EP&A Act.

1.3.4. Fisheries Management Act (1994)

The objectives of the NSW *Fisheries Management Act 1994* (FM Act) are to conserve, develop and share the fishery resources of the State for the benefit of present and future generations. Objectives of the Act also include the conservation of fish stocks, key fish habitats, threatened species, populations and ecological communities of fish and marine vegetation. Ecologically sustainable development is promoted by conservation of biological diversity through the promotion of viable commercial fishing, recreational fishing and aquaculture industries. The FM Act applies to all waters that are within State jurisdiction. It seeks to prevent the extinction of threatened species by protecting their critical habitat. Any action that has an impact on threatened species, populations and ecological communities of fish and marine vegetation must be properly assessed to ensure conservation through the implementation of co-operative management. Endangered species, populations and ecological communities listed in the Act, as well as their distribution is provided in **Appendix I**. In relation to the FM Act, there are four threatened fish species that have been recorded in the vicinity of the study area. The grey nurse shark (*Carcharias taurus*) has been sighted at the mouth of the Nambucca River. The green sawfish (*Pristis zijsron*) has been recorded at South West Rocks. Black cod (*Epinephelus daemelii*) has been recorded at the mouth of the Nambucca River and at Boambee Creek (approximately 20km north of the study area).The green turtle (*Chelonia mydas*) and leatherback turtle (*Dermochelys coriacea*) have also been spotted in the area.

1.4. Assessment approach

The principal aim of the terrestrial and aquatic flora and fauna assessment was to identify, describe and map the biological features of the proposed road corridor to provide baseline data to be utilised in the prediction of impacts and determination of monitoring and management actions for features of conservation value The specific objectives of the assessment were devised in accordance with the ecological assessment requirements referred to in **Table 1-1**, and included:

- Identification and description of the flora and fauna species, communities and populations of local, regional, state and national conservation significance (as defined under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), the NSW *National Parks and Wildlife Act 1974* (NP&W Act), *Fisheries Management Act 1999* (FM Act) and *Threatened Species Conservation Act 1995* (TSC Act), and their habitats, which are known or considered likely to occur in the study area.
- Provide baseline ecological data to a standard that can be used to predict and assess the significance of impacts of the Proposal on flora and fauna of conservation significance as provided by the statutory requirements of the EPBC Act, the TSC Act and the EP&A Act.
- Targeted surveys for threatened flora and fauna known or considered to potentially occur in the study area.
- Targeted surveys of aquatic flora and fauna species and communities including macroinvertebrates in the study area
- Investigation and description of the vegetation associations, terrestrial fauna habitats, aquatic habitats and inventory of species occurring in the study area.
- Identification of the regional impacts of potential erosion of genetic stock.
- Regional scale cumulative impacts and the significance of these with regard to the entire Pacific Highway Upgrade (PHU) Program.
- Quantifying impacts by identifying the extent of native vegetation loss and habitat fragmentation, impacts from weed infestation, severance to wildlife and riparian corridors, and impacts on riparian habitat and groundwater-dependent communities.
- Development of appropriate mitigation and monitoring measures to be incorporated into the construction and operational phases of the Proposal to minimise and monitor impacts.
- To outline appropriate mitigation measures to reduce the risk of impact on marine and freshwater flora and fauna species with due consideration of the NSW Fisheries document ‘Policy and guidelines for aquatic habitat management and fish conservation, 1999’ (sections 6.4 and 6.5 specifically).

2. Methodology

2.1. Definitions

The following definitions are used in the working paper to describe the specifications of the Proposal:

- Footprint: the footprint of the Proposal has been calculated as the limits of the design footprint plus a 10 m buffer to account for edge effects and other disturbances. Additionally various impact scenarios have been produced for the Proposal including the proposed road design with 3 m, 5 m and 10 m buffers.
- Study area: the design footprint and any proximal areas that could potentially be affected by the Proposal which was identified as a 150 m corridor along the route alignment. However, areas of ecological significance outside the 150 m corridor were inspected where applicable such as SEPP14 wetlands, riparian zones and other areas of targeted surveys for threatened plant species.
- Locality: the area within 10 km of the design centreline.
- Landscape: the area within 20 km of the design centreline.
- Region: a bioregion defined in a national system of bio-regionalisation. For this study this is the NSW North Coast bioregion as defined in the Interim Biogeographic Regionalisation for Australia (Thackway & Cresswell 1995).

2.2. Literature and database review

As a preliminary phase of the assessment a review of relevant ecological literature, consultation with key stakeholders and government maintained databases pertaining to the study area and locality was undertaken. From the review a list of threatened flora and fauna species was compiled and assessed to determine the potential presence of threatened biota in the study area. Available database records of aquatic species previously documented in the region, including waterway dependent reptiles and mammals are provided in Appendix K (SKM 2004). The data sources used in this review included but were not limited to the following:

- Atlas of NSW Wildlife Database (DECCW).
- NPWS (1999a, 1999b) Threatened Species Management Guidelines for the NSW North Coast.
- NSW Natural Resources Atlas (http://www.nratlas.nsw.gov.au).
- Records published in scientific journals, specialist ecological reports in the locality and general flora and fauna distribution texts.
- DECCW’s Draft Sea Level Rise Policy Statement (February 2009).
- Results of local environmental studies, including studies prepared by consultants, local government authorities, biological organisations, universities and other sources.

- Discussions with personnel from the Department of the Environment, Climate Change and Water (DECCW) and the Department of Industry and Investment, including the Aquatic Habitat Protection Unit and NSW State Forests.
- Anecdotal reports from authorities and local ecologists / naturalists.
- Feedback from discussion with members of ecological interest groups, such as the Nambucca Valley Conservation Group.
- Threatened Species, Population and Ecological Communities of NSW (http://www.threatenedspecies.environment.nsw.gov.au/index.aspx).
- Protected Matters Search Tool (http://www.environment.gov.au/erin/ert/epbc/index.html).
- Aquatic ecology studies undertaken by The Ecology Lab (1998), Gibbs et al (1999), Llewellyn (1983) and Bishop (1993).

2.3. Landscape assessment

The potential impacts of the Proposal on the landscape were assessed using a qualitative and quantitative strategic assessment of ecosystem values, focusing on lands covering the study area and up to 20 km from the Proposal centre line. The assessment involved a review and analysis of the following datasets:

- Aerial photographs of the study area.
- NSW Landscapes (Mitchell 2003). The NSW Landscapes coverage is a state-wide map of landscapes, mapped at a scale of 1: 250 000, describing land attributes considered to drive ecosystem processes. Definition of the landscapes emphasises geologic, geomorphic and pedologic factors.
- Key habitats and corridors (NSW National Parks and Wildlife Service 2001). The key habitats map layer is a regional representation displaying the likelihood of occurrence of key habitats for fauna consolidated at the regional scale. This is combined with a layer of regional and subregional linking corridors for fauna of the Upper North East (UNE) and Lower North East (LNE) NSW RFA regions.
- Climate Change Wildlife Corridors for North-east NSW (NSW DECC 2007). This project was conducted on behalf of the Northern Rivers Catchment Management Authority (NRCMA) to help identify land areas for strategic conservation efforts to aid adaptation to the potential adverse effects of climate change for wildlife.
- Lower North East (LNE) Forest Ecosystems (NSW National Parks and Wildlife Service 1998).
- A visual analysis of vegetation patches and connectivity across the landscape.

2.4. Assessment team

The team associated with the completion of this assessment is listed in **Table 2-1**, together with details of their qualifications and role. All work was carried out under the appropriate scientific investigation licences as required under Clause 22 of the *National Parks and Wildlife Regulations* 2002, Section 132C of the *National Parks and Wildlife Act* 1974 and Section 37 of the FM Act, in addition to animal research authority under the DII.

▪ **Table 2-1 Assessment team**

Name	Qualification	Role
Chris Thomson	BAppSc	Ecologist - Team Leader, fauna survey and assessment
Andrew Carty	BEnvSc	Botanist – field surveys, targeted threatened flora surveys, reporting, GIS
Dr. Julie-Anne Harty	BAppSc; PhD	Zoologist – field surveys
Martin Sullivan	BSc	Botanist – field surveys, reporting, condition assessment
Sarah Foy	BSc; MEnvStud	Aquatic Ecologist – field surveys, reporting
Vanessa Bain	BEnvSc	Ecologist – fauna field surveys
Adam Cohen	BEnvSc; PhD	Ecologist – Team Leader Aquatic Ecology, fish surveys and impact assessment
Peta Johnston	BMarSc	Aquatic ecologist - field surveys

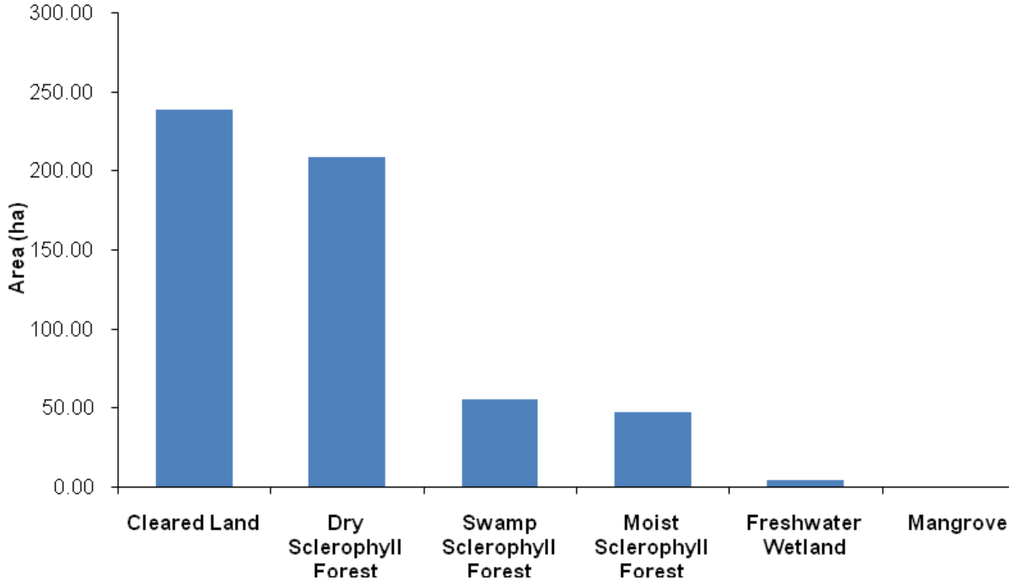
2.5. Terrestrial field surveys

Investigation into the ecological values of the study area, including landscape, baseline and habitat data were collected over the period 2003-08, commencing with survey during the route options development phase (2003-06) followed by the EA (2007-08). Survey was conducted during all four seasons with the objective of assembling quantitative and qualitative data on the flora and fauna diversity and the distribution of vegetation and habitat associated with the study area. The extent of survey effort and techniques used for the detailed survey of the study area were conducted with reference to *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities* - working draft (DECC 2004).

2.5.1. Stratification

Aerial photographs, vegetation mapping from the route selection phase of the Proposal (RTA 2005) and topographic maps (1: 25,000) were used to stratify vegetation and habitats into individual units and identify appropriate sampling sites according to the extent of each unit. The stratification units are based on broad groupings of vegetation map units such as dry forest, moist forest, swamp forest, wetlands etc. The study area was stratified on the basis of existing field data from previous surveys and biophysical attributes (predominantly soil type and elevation) from which stratification units were delineated based on broad vegetation groupings (e.g. wet and dry sclerophyll forests, swamp forests, wetlands etc).

Stratification was based on a 150 m wide corridor (the study area) to account for the footprint and adjacent edge effects (see **Figure 2-1**). The majority of the study area is represented by cleared agricultural land and wood plantations (235 ha). The stratification units comprised dry sclerophyll forest (209 ha), swamp sclerophyll forest (55 ha) and moist sclerophyll forest (47 ha). Portions of two small freshwater wetlands occur within the study area (4 ha) and the remaining areas comprise small fragments of mangrove forest.



- **Figure 2-1: Proportion of land cover categories (habitat strata) in the study area**

2.5.2. Terrestrial flora

The survey aimed to provide baseline data concerning the presence of threatened species, populations and communities in the study area to provide a basis for the prediction of impacts and refinement of the concept design announced in September 2007 where feasible. The survey effort was determined through the stratification of the study area and the level of variability observed in each stratification unit. The survey focused on identifying flora species impacted by the study area.

In some circumstances the distribution of threatened flora species was also investigated outside the study area, in particular for slender marsdenia. Targeted threatened flora searches were focussed on but not limited to the slender marsdenia, rusty plum, Newry golden wattle, scented acronychia and milky silkpod, as specified in the Director-General’s requirements. Also included in the targeted surveys were red bopple nut (*Hicksbeachia pinnatifolia*), *Maundia triglochinoides* and brown fairy-chain orchid (*Peristeranthus hillii*).

The flora surveys utilised a combination of general traverses or transects, plot-based quadrat assessments and targeted surveys for threatened flora species. Flora survey locations are shown in **Figures 2-2** to **2-5.**

2.5.2.1. Transects and traverses

The distribution and extent of vegetation communities in the study area was initially identified through field surveys and desktop assessments undertaken for the route selection phase of the Project (RTA 2005). As part of the detailed ecology surveys for the Proposal, this existing vegetation mapping was ground-truthed and refined to finer scale. Transect sampling was conducted in targeted areas to refine vegetation community boundaries in proximity to the footprint. The number of transects sampled was proportional to the size of the stratification units identified with up to two 100 m transects sampled per 2-50 ha of each stratification unit and three 100 m transects sampled per 51-250 ha of stratification unit (Department of Environment and Conservation 2004). A hand-held GPS unit was used to record vegetation community boundaries, the location of threatened species and any other items of interest such as habitat trees.

Digital mapping of vegetation community boundaries was conducted using the ArcGIS software package. A combination of field data, aerial photograph interpretation and biophysical data such as elevation and soil type were used to map the boundaries of vegetation communities. Description of the vegetation communities was based on their structure and dominant canopy species (Specht 1981) and correlated with Keith (1994) for comparison with final determination advice on Endangered Ecological Communities (*TSC Act*).

2.5.2.2. Plot-based surveys

Quantitative data on species richness were collected from quadrats ($400m^2$) replicated across each vegetation association. Quadrat data was used to determine the floristic composition and structure of vegetation associations, and the ecological condition of the vegetation including disturbances and weed abundance. Data collected in each sample plot included:

- Dominant species in each structural layer.
- Heights of structural layers (i.e. canopy, sub-canopy, shrub and groundcovers).
- A cover abundance score of each layer (based on a modified Braun Blanquet cover scale).
- Landscape features (i.e. slope, gully, aspect etc).
- Soil features (soil type, rocks, organic matter etc).
- Geographical coordinates and a photographic record.

- Species richness and abundance.
- An inventory of all species in the plot.
- The presence and abundance of weed species.
- The condition of the vegetation including past and present disturbances such as fire, grazing, logging, etc.
- The presence, abundance and geographic coordinates of rare and threatened plants species.

The number of quadrats sampled was proportional to the size of the stratification unit and the degree of variation in the stratification unit resulting in a total of 38 quadrats sampled (refer **Figure 2-2** to **2-5** for location of flora survey sites). The number of quadrats and transects sampled in each stratification unit are listed in **Table 2-1.**

- **Table 2-1: Flora survey effort per habitat stratification unit**

Habitat	Area (ha)	Survey Sites	
		Quadrat	Traverses
Dry Sclerophyll Forest	222.98	12	41
Moist Sclerophyll Forest/Rainforest	93.17	14	35
Swamp Sclerophyll Forest	37.92	8	16
Wetlands	3.15	3	5
Mangroves	0.6	0	2
Saltmarsh	0	1	1
Cleared	299.84	0	4
Total Vegetation	357.82		
TOTAL	**657.66**	**38**	**104**

Additional to these quadrat assessments and general traverses, rapid plot-based assessments were undertaken recording dominant floristic species and vegetation structure to aid vegetation mapping. Any species which could not be identified in the field were collected for later identification or for lodgement with the National Herbarium.

2.5.2.3. Targeted surveys

Threatened flora species which potentially occur in the study area were targeted in separate surveys in areas of suitable habitat. Targeted surveys comprised random meanders through areas of suitable habitat, which allows for greater coverage than plot-based techniques. Where threatened flora species were located data was recorded for habitat condition, population size and range, reproductive status, existing threatening processes and habitat disturbances, age structure and land use. Threatened flora species were also recorded opportunistically during general traverses and quadrat assessments. Targeted threatened species searches were focussed on, but not limited to, the species listed in **Table 2-2**.

- **Table 2-2: Details of targeted flora surveys**

Threatened species	Legislative status		Targeted areas
	Cwlth	NSW	
Acacia chrysotricha Newry golden wattle	-	E	In the study area gully areas in State Forests and on private property with quartzite soils were targeted.
Acronychia littoralis scented acronychia	E	E	Preferred habitat is littoral rainforest on sand which does not occur in the study area. Included in targeted searches for other threatened rainforest species.
Amorphospermum whitei (*Niemeyera whitei*) rusty plum	-	V	Wet sclerophyll forests and rainforests areas in the study area.
Hicksbeachia pinnatifolia red bopple nut	-	V	Wet sclerophyll forests and rainforest areas in the study area.
Maundia triglochinoides	-	V	Grows in shallow freshwater 30-60 centimetres deep on heavy clay with low nutrients. Freshwater wetlands, creeks and dams in the study area were targeted.
Marsdenia longiloba slender marsdenia	V	E	Wet sclerophyll forests and rainforests areas in the study area. Additional targeted searches were conducted up to 250m from the Proposal centre line were this species was found.
Parsonsia dorrigoensis milky silkpod	E	V	Wet sclerophyll forests and rainforest areas in the study area.
Peristeranthus hillii brown fairy-chain orchid	-	V	Wet sclerophyll forests and rainforest areas in the study area.

Where a threatened plant species was found in the study area additional surveys were conducted within a 500 m corridor surrounding the construction alignment to provide additional data to assist refinement of the footprint design. This was undertaken for *Marsdenia longiloba* where it was found during searches conducted 250 m either side of the construction corridor.

2.5.3. Terrestrial vertebrate fauna

The assessment of impacts on terrestrial fauna has utilised quantitative and qualitative data sourced from field surveys conducted during the route option and EA phases of the Proposal, during the period 2003 to 2008. Data was collected on the type and distribution of fauna habitats and fauna species richness, distribution and abundance focusing on threatened species listed under the TSC Act and EPBC Act. This included all threatened fauna species identified previously in the regional area from the search of the Atlas of NSW Wildlife (DECC 2007).

2.5.3.1. Site selection

Fauna survey sites were selected to sample the range of habitat types identified by the initial stratification (i.e. dry forests, moist forests and swamp forests) (refer **Table 2-3**). Where possible surveys were conducted across a range of floristic types associated with these units. Pasture, young regrowth and aquatic habitats (creeks, dams and wetlands) provided additional incidental data. This regime resulted in sampling 89 sites in total (refer **Figure 2-6** to **Figure 2-9**).

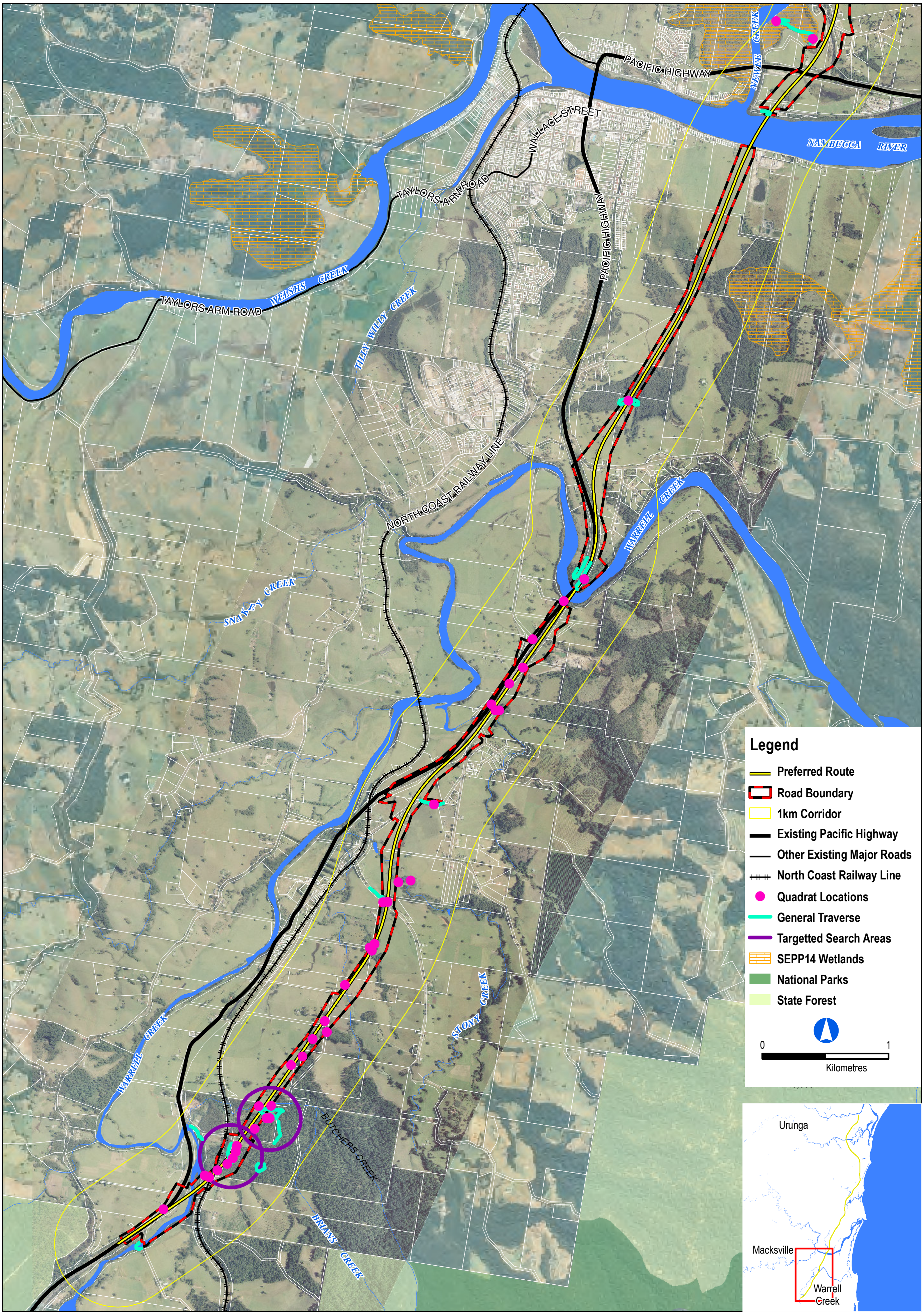


Figure 2-2 : Location of flora surveys

GDA 94 MGA Zone 56

Warrell Creek to Urunga - Upgrading the Pacific Highway

June 1, 2009
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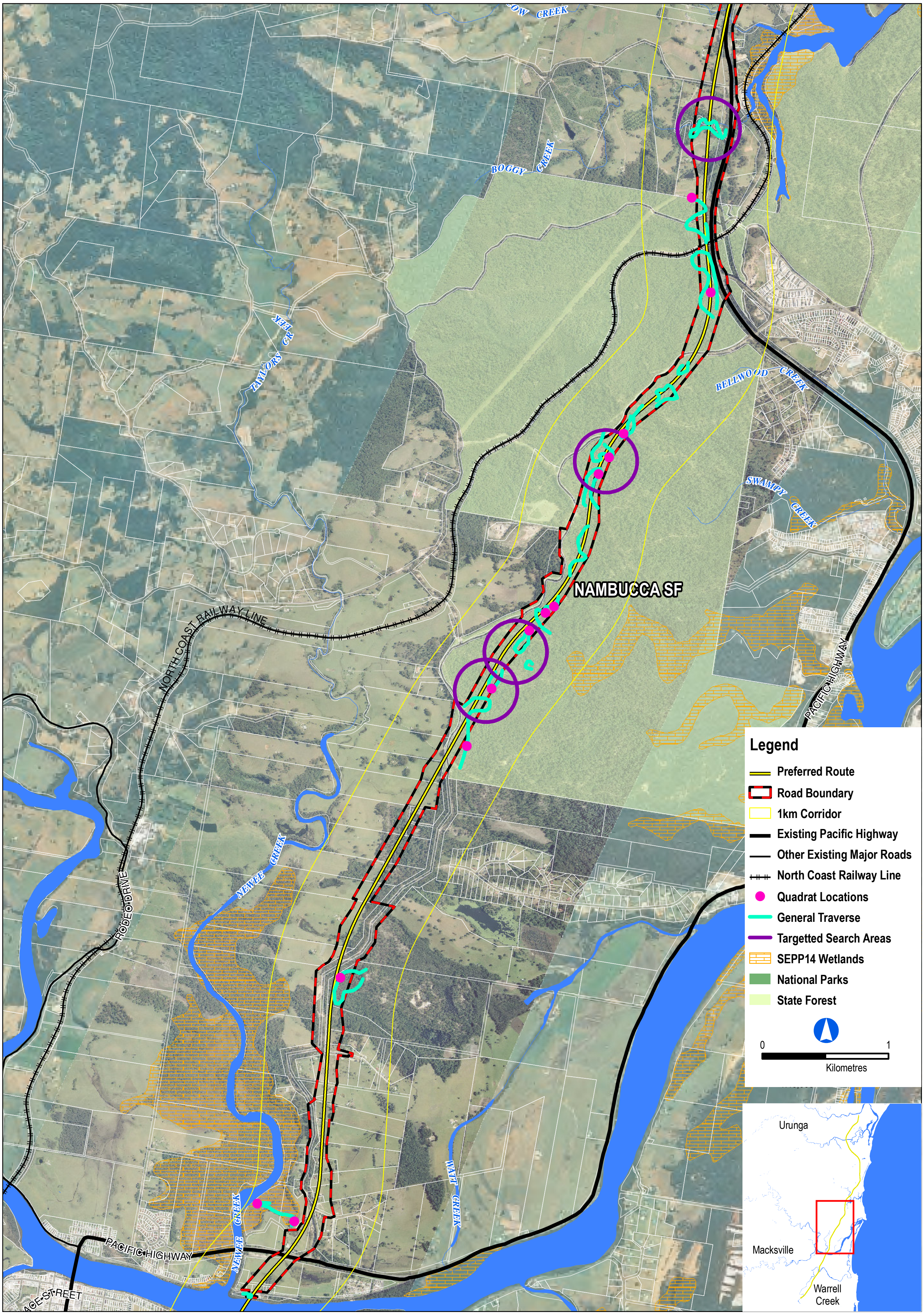

Figure 2-3 : Location of flora surveys

GDA 94 MGA Zone 56

Warrell Creek to Urunga - Upgrading the Pacific Highway

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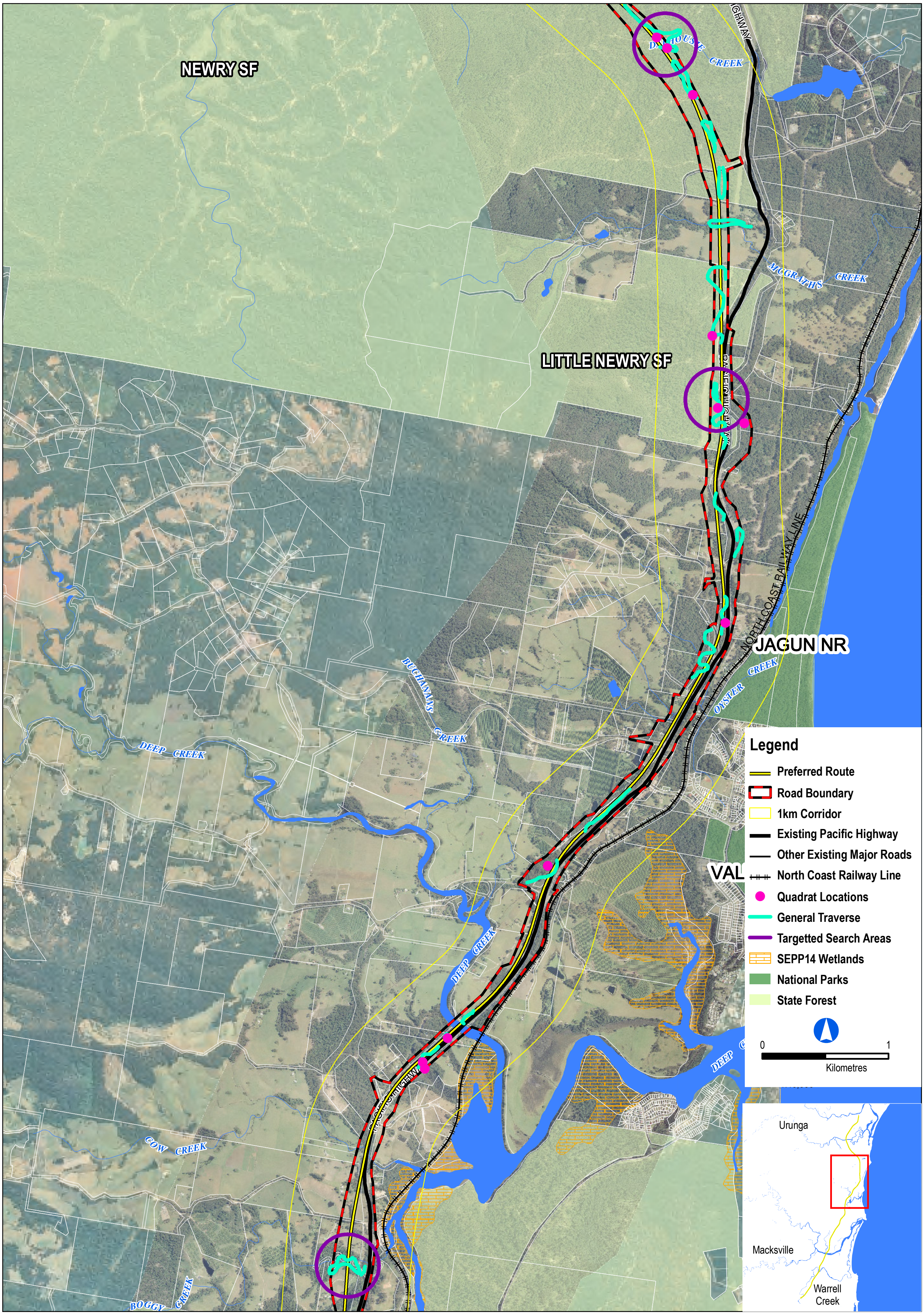

Figure 2-4 : Location of flora surveys

GDA 94 MGA Zone 56

Warrell Creek to Urunga - Upgrading the Pacific Highway

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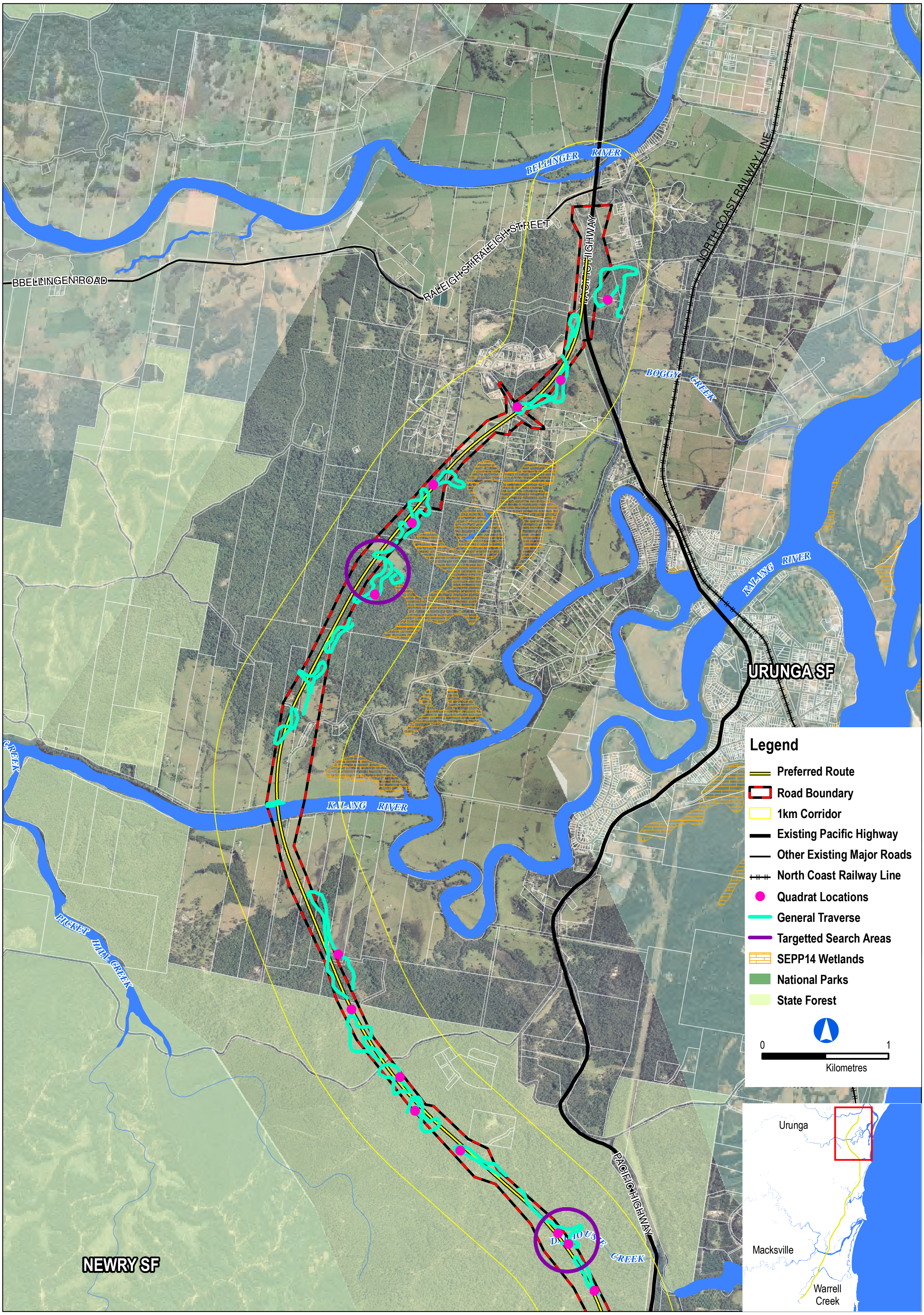

Figure 2-5 : Location of flora surveys

GDA 94 MGA Zone 56

Warrell Creek to Urunga - Upgrading the Pacific Highway

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▪ **Table 2-3: Fauna survey effort per habitat stratification unit**

Habitat	Area (ha)	Survey sites			Total
		Baseline	Supp harp traps	Habitat assessment	
Dry Sclerophyll Forest	222.98	13	1	27	**41**
Moist Sclerophyll Forest/Rainforest	93.17	8	2	12	**22**
Swamp Sclerophyll Forest	37.92	4	1	8	**13**
Wetlands	3.15	-	1	5	**6**
Mangroves	0.6	-	-	1	**1**
Cleared	299.84	-	-	6	6
TOTAL	**657.66**	**25**	**5**	**54**	**89**

Baseline survey sites were sampled during January 2005 (n=10) and between November 2007 and June 2008 (n=15). A combination of sampling techniques was employed at all 25 baseline survey sites in general accordance with the *Draft Threatened Biodiversity Survey and Assessment Guidelines* (NSW Department of Environment and Conservation 2004) which included diurnal and nocturnal census and opportunistic observations. Details of survey techniques, effort and localities are provided below. Habitat assessment sites were sampled during both survey periods (2005 and 2007) and aimed to provide a landscape assessment of the habitats in the study area. The location of fauna survey sites are presented in **Figure 2-6** to **2-9.**

2.5.3.2. Survey conditions

Surveys were conducted over three seasons (i.e. winter, spring and summer). Details of the specific temperatures and rainfall during the field surveys were recorded and detailed below. The survey period was considered optimum for the detection of the majority of the target species. Periodic rainfall was experienced during the first survey period although not during the specific survey days.

▪ **Table 2-4: Survey weather conditions**

Dates	Mean Temp (°C)		Moon	Average winds	Weekly total (mm)
	Min	Max			
10-14 Jan 2005	21.2	32.4	Last quarter to no moon	Slight -moderate SE and NE	None
24-28 Jan 2005	19.6	27.4	Third quarter to full moon	Moderate SE	202
11-16 Nov 2007	13.8	23.8	Last quarter to no moon	Moderate SE tending NE	5.2
25-30 Nov 2007	16.9	24.9	Third quarter to full moon	Moderate SE tending NE	19
9-14 Dec 2007	19.5	25.9	Second quarter	Moderate SSW tending NE	39.8
13-18 Jan 2008	20.7	26.3	Last quarter	Moderate north-northeast	87.2
2-6 June 2008	12.8	21.9	First quarter	Moderate E turning SSE	25

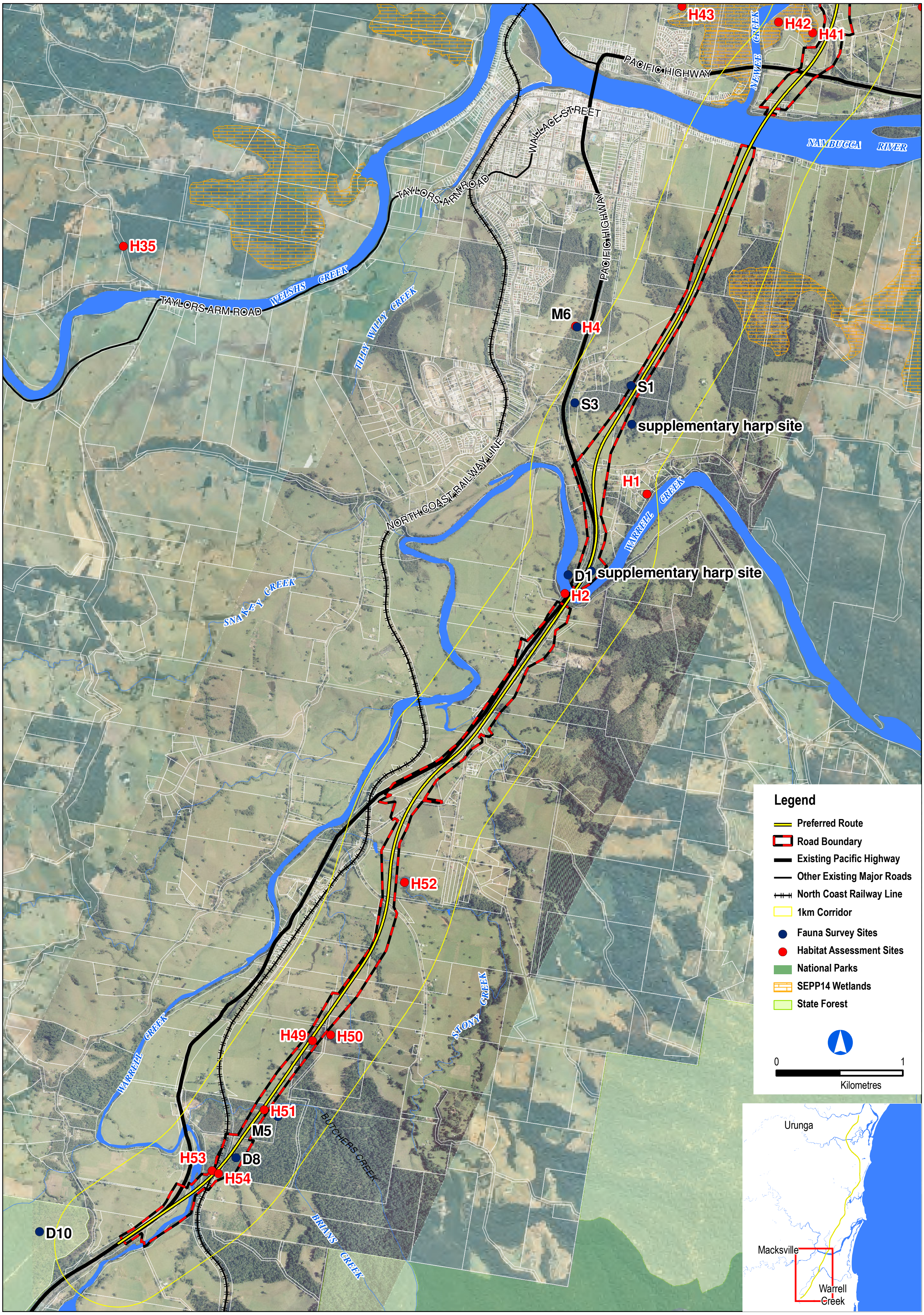

Figure 2-6 : Location of fauna survey sites

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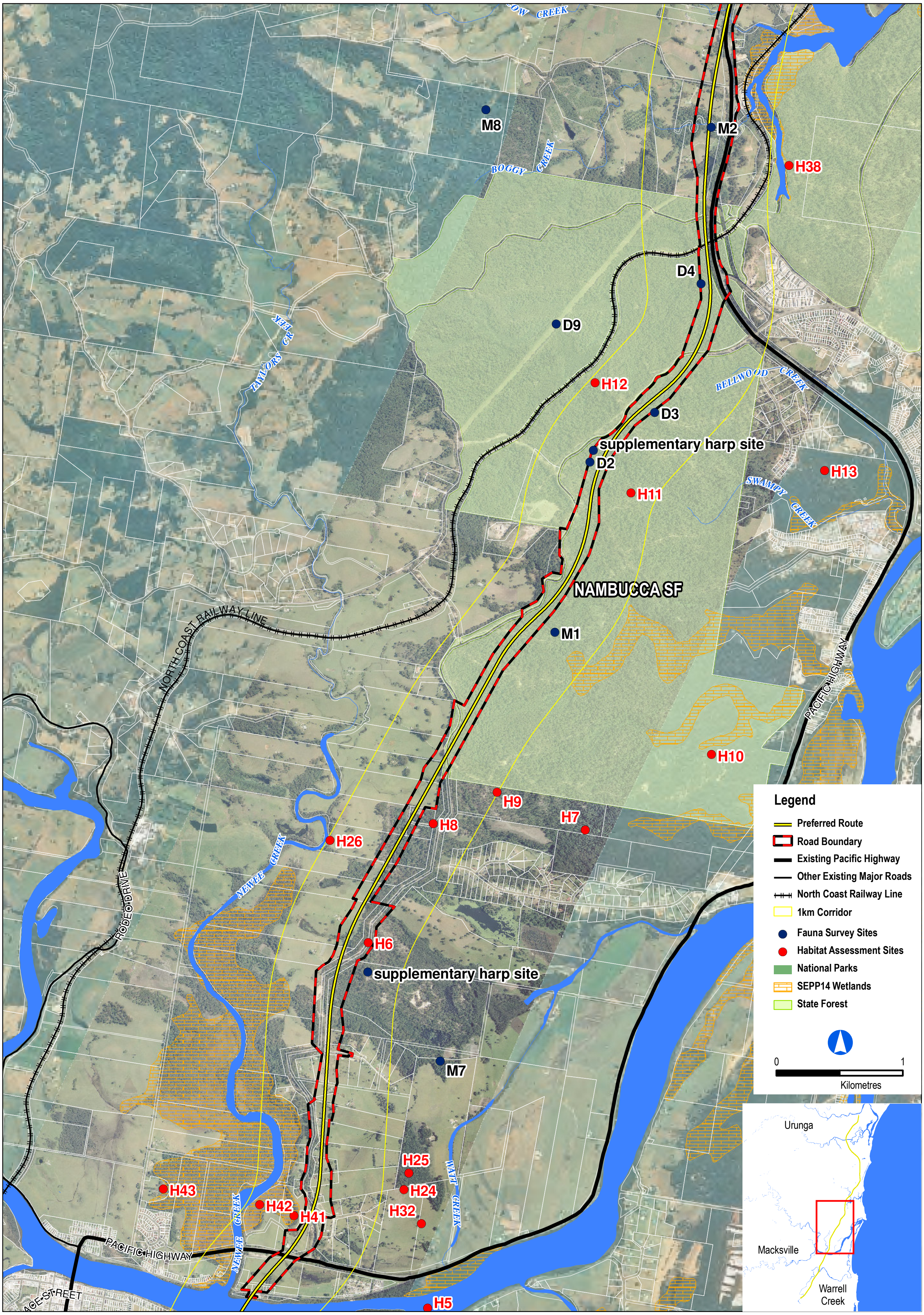

Figure 2-7 : Location of fauna survey sites

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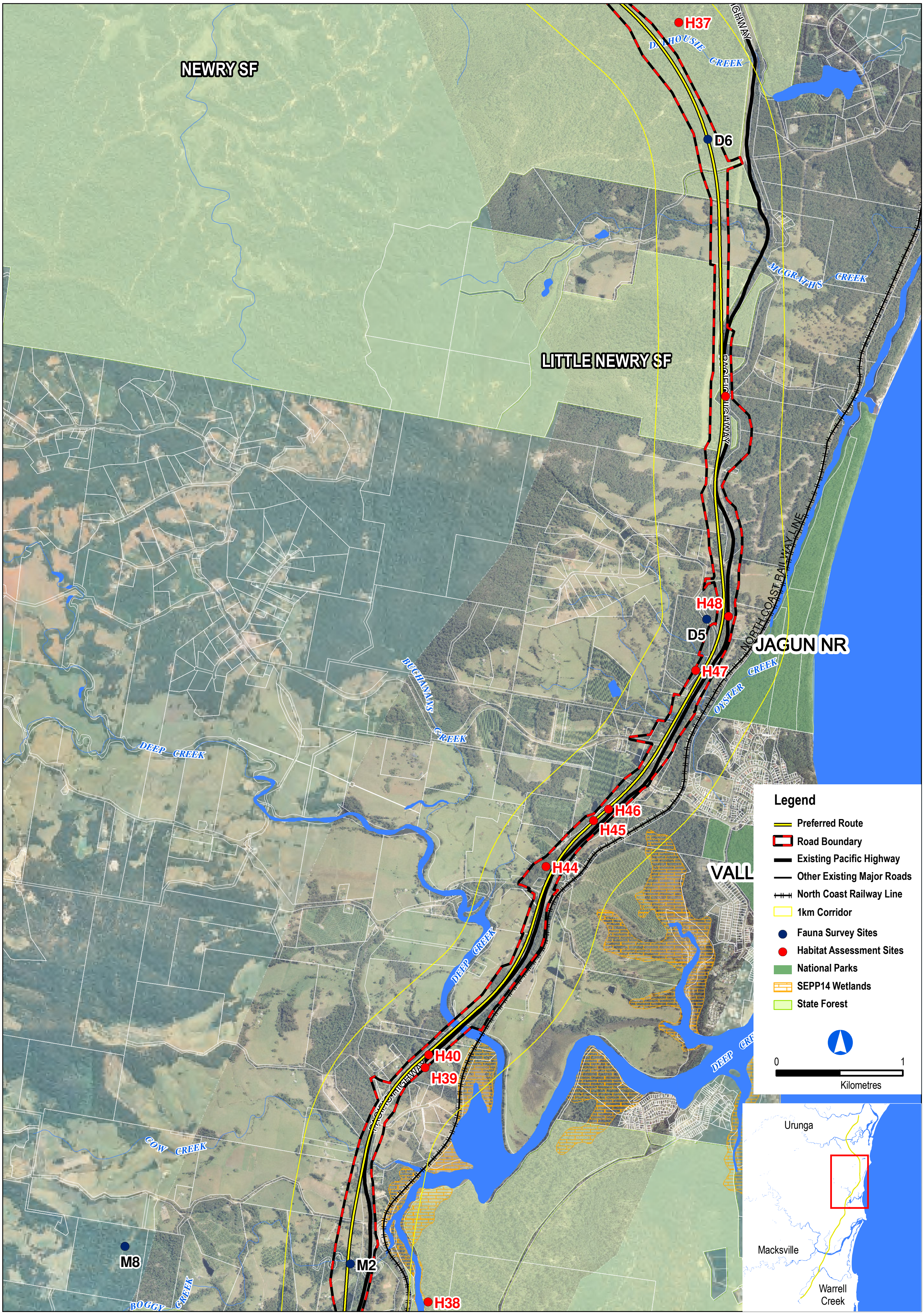

Figure 2-8 : Location of fauna survey sites

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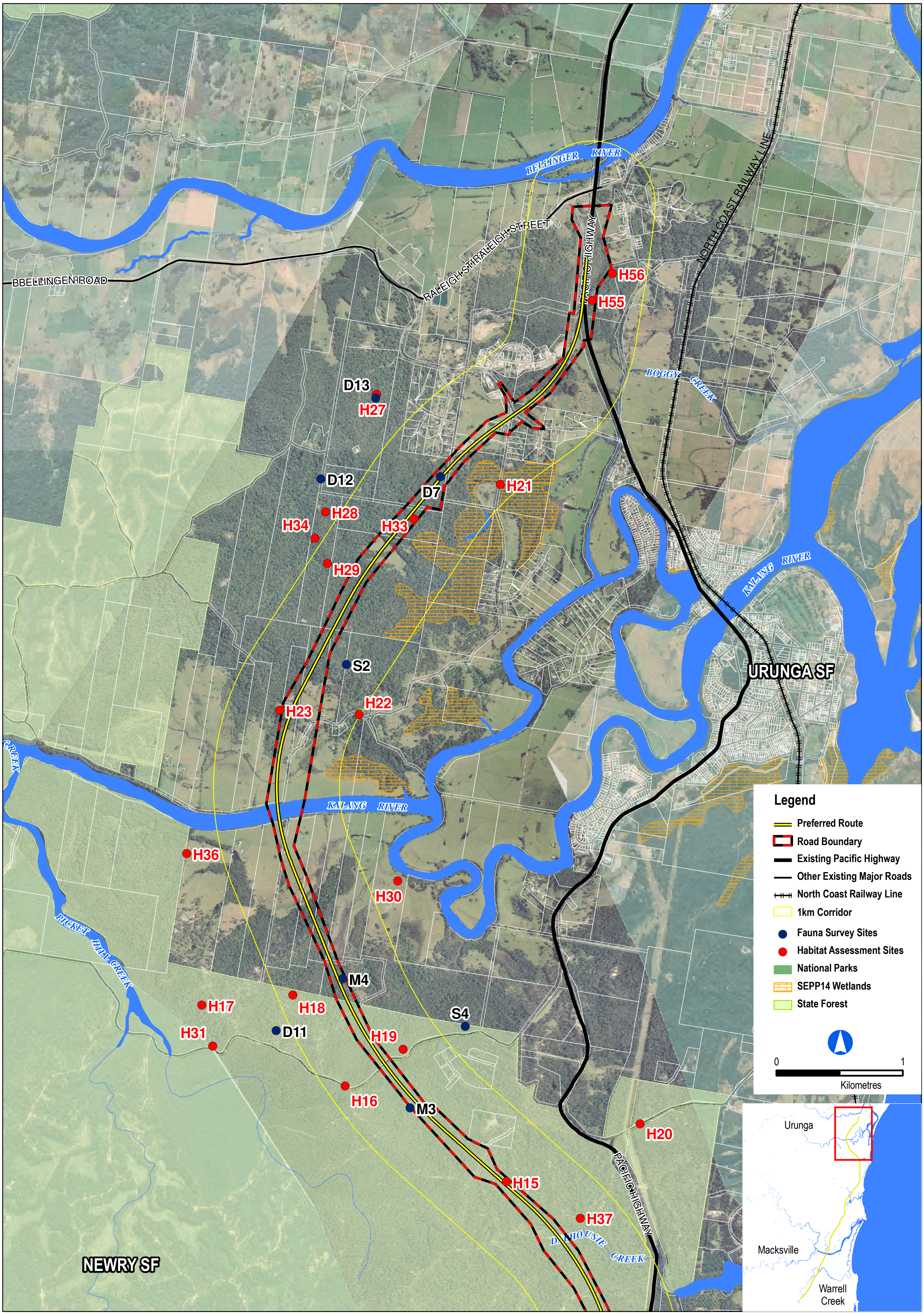

Figure 2-9 : Location of fauna survey sites

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2.5.3.3. Ground-dwelling mammals

Live-trapping of small to medium sized ground-dwelling mammals was conducted at the baseline survey sites during January 2005 (n=10) and November 2007 to June 2008 (n=15). A standardised parallel transect arrangement was used (2 x 100 m) separated by 50 m and delineated by 20 Elliott type A, 33 x 10 x 9 cm, aluminium folding traps) placed 10 m apart with a cage trap (wire 30 x 30 x 60 cm) placed at opposite ends. All traps were baited with peanut butter, rolled oats and honey and cage traps were baited with tinned sardines. Traps and cages were placed in or under cover wherever possible. Traps were opened for a three-night period (96 hours) at each site and were checked each morning. Captured animals were measured, weighed, identified and released. The species and location of mammal scats, scratches and other evidence of fauna presence when encountered was noted to provide locality records for native and exotic species.

Hair sampling tubes were used to supplement the live-trapping program and targeted small to medium sized mammals, particularly the spotted-tailed quoll (*Dasyurus maculatus*). This consisted of six small ground tubes (opening diameter 60 mm) and six large tubes (diameter 120 mm) placed at each trap site for a total of three nights. Small hair-tubes were baited with peanut butter and rolled oats and the larger hair-tubes were baited with chicken meat. Double sided tape was used in the rim of the tube to collect hair samples from the neck or back of the animal and hair samples were sent to a specialist for analysis.

2.5.3.4. Arboreal mammals

Live-trapping of arboreal mammals was conducted at the baseline survey sites during January 2005 (n=10) and November 2007 to June 2008 (n=15). The method involved two traps placed along each of the ground trapping transect (i.e. 4 traps at each site) spaced 50 m apart. At each point a trap (Elliott type B, 15 x 16 x 45 cm aluminium folding trap) was mounted on a platform attached to the trunk of a tree at a height of 3.5 metres. Each trap was baited with a mixture of peanut butter, rolled oats and honey and the trunk of the tree adjacent to the trap sprayed with a mixture of water and honey to act as an attractant. Traps were inspected each morning and the tree re-sprayed with the honey-water mixture. Any animals captured were measured, weighed, identified and released at the capture site the following night. Each trap grid was active for three consecutive nights (96 hours).

Spotlighting and dusk census for arboreal mammals was conducted at all baseline sites during the trapping periods. Spotlighting was foot-based and comprised a general traverse across the site and adjacent tracks or forest edges, utilising 50W hand-held spotlights powered by 12V batteries. Two observers conducted the survey for a minimum period of one hour per site. All fauna heard or observed were recorded to species level. Observations of fauna were aided by the use of binoculars. Counts were taken on the number of fauna heard and observed.

Hair sampling tubes were used to supplement the live-trapping program and targeted gliders (*Petaurus* species) and brush-tailed phascogale (*Phascogale tapotafa*). This consisted of three hair tubes (opening diameters 60 mm) at each trap site, attached to trees approximately two metres above the ground for three nights. The trunk of the tree was sprayed daily with a honey and water mixture to act as an attractant.

2.5.3.5. Koala census and habitat survey

Searches for evidence of koalas (*Phascolarctos cinereus)* were conducted at each baseline survey site. The method included searching for koala droppings (scats) in a randomly selected 50m^2 quadrat. Searches were conducted around the base of trees greater than 20 cm diameter at breast height, until a total of 20 trees were searched. Where several tree species occurred in the quadrat, preference was given to known koala browse species, including forest red gum (*Eucalyptus tereticornis)* and tallowwood (*E.microcorys).*

2.5.3.6. Call playback for mammals

Pre-recorded calls of the koala (*Phascolarctos cinereus*) and yellow-bellied glider (*Petaurus australis*) were played through a portable cassette player and megaphone during spotlighting at each of the baseline survey sites. Calls were played at the start of the spotlighting session for a total of 5 minutes for each species and followed with quiet listening and spotlighting.

2.5.3.7. Bats

Standard two-bank 4.2m^2 harp traps were used to sample for microchiropteran bats. Harp traps were used during the baseline surveys in January 2005 and November 2007 to June 2008. The location of each harp trap was chosen to sample the range of different habitat types. Where possible harp traps were placed in the vicinity of primary survey sites (n = 20) with the remaining supplementary harp sites (n = 4) selected throughout the study area where suitable bat flyways were not found at a primary site. Harp traps were placed in forested areas along narrow gaps such as vehicle and walking tracks. Such locations are generally associated with natural flyways for microchiropteran bats. Harp traps were placed at each location for two nights. Captured bats were collected early the following morning, identified and measured. Captured individuals were held that day and released at the capture point that night.

A stationary ultrasonic bat call detector (Anabat II, Titley Electronics) was used with a storage ZCAIM unit to record bat calls at 21 baseline sites. Calls were recorded continuously between 1800 and 0500 hours for two nights at each site. Calls were identified to genus or species level where possible using computer frequency analysis software (Analook v.4.0).

Spotlighting and listening for calls of megachiropteran bats (*Pteropus* spp) was conducted during spotlighting activities.

2.5.3.8. Birds

The survey method for birds was replicated across each of the baseline sites in January 2005 and November 2007 to June 2008. Line transects were undertaken by a single observer moving along a fixed route and recording the birds seen and heard on either side of the route (Gibbons *et al*. 2000). Each transect was a fixed 200 m long and 100 m wide, generating a two ha search area centred around the mammal trap site. The survey aimed to record all birds seen or heard within 50 m either side of the transect over a minimum 20 minute period. The time spent searching is an important factor in the number of species that would be detected, so the decision to stop surveying beyond the 20 min minimum is determined as the point where no new species have been detected in the previous five minutes. This technique is known as the species-time curve approach. Birds were also recorded opportunistically during all other site visits and field surveys activities. Binoculars were carried in the field at all times to assist in identification.

2.5.3.9. Targeted survey for swift parrot and regent honeyeater

Potential habitat for the targeted species was identified from aerial photography, topographic maps and vegetation survey data derived from SKM (2005) (report provided in Appendix H). Potential habitat was identified on the basis of the dominant eucalypt species in the canopy, in particular the presence of wet lowland forests with winter flowering species (i.e. swamp mahogany *E. robusta*). Vegetation comprising forest red gum (*E.tereticornis*) and red bloodwood (*Corymbia maculata*) were also targeted, although these species occurred in very low densities and were scattered throughout the study area.

Surveys were conducted during the period 15-19 August 2005. An attempt was made to visit all properties comprising suitable habitat, however due to difficulties contacting all landholders prior to the visit some properties were not accessed. These were assessed based on previous knowledge of the study area. A total of 16 sites were visited providing a representative sample of the preferred habitats in the study area which included several locations in Newry and Nambucca State Forests (refer to report in Appendix H).

Bird census was conducted at each property during morning periods, which involved a random search listening for calls of the target species and obtaining visual identification of all bird species. Greater survey effort was concentrated around individuals and groups of flowering trees where encountered. Trees with copious flowers were re-visited on consecutive days. Aggregations of other nectarivorous birds, particularly scaly-breasted lorikeet (*Trichoglossus chlorolepidotus*) and rainbow lorikeet (*T.haematodus*), which could often be heard from a distance, were also used as a guide to locate flowering trees and search for the target species. Swift parrots are often found in cohort with these other nectarivorous species.

Sites where regent honeyeater and swift parrot have been recorded previously outside of the study area were visited during the survey period to investigate if birds were present during the survey period, as well as to assess resource availability and the condition of these habitats relative to those present in the study area and in proximity to the proposed route. Sites were visited at Moonee Beach Nature Reserve north of Coffs Harbour as both species have been recorded from this location in recent years (NPWS, Coffs Harbour office, *pers.comm*), and Nambucca Heads.

2.5.3.10. Call playback for birds

Call playback was used to survey the following species at each baseline site:

- Powerful owl (*Ninox strenua).*
- Barking owl (*Ninox connivens)*.
- Masked owl (*Tyto novaehollandiae).*
- Sooty owl (*Tyto tenebricosa)*.
- Bush stone curlew (*Burhinus grallarius*).

Pre-recorded calls were broadcast via a portable cassette player and megaphone for a period of five minutes for each species, followed by a five minute listening period. Spotlighting was conducted briefly between calls and then following completion of the call playback series for a period of 10 minutes. Quiet listening for dusk calls of each large forest owl species was also undertaken whilst conducting other field activities such as spotlight searches.

2.5.3.11. Reptiles and amphibians

Both nocturnal and diurnal herpetological surveys were conducted at each baseline site. Nocturnal herpetofauna was surveyed for during spotlighting surveys and included the survey of the margins of wet areas and dams for active frogs and reptiles. Systematic frog searches were also carried out at farm dams and creeks where present in proximity to fauna survey sites. Nocturnal surveys for frogs were conducted by two persons using Lightforce spotlights (50W) and battery powered head torches to survey along drainage lines, around freshwater wetlands and dams.

Frogs were identified by call, and/or visual characteristics. All active frogs were captured, where possible, identified and immediately released. At potentially suitable locations throughout the study area, a period of listening for the calls of frog species was undertaken, especially at dusk on moist and warm nights. The conditions were considered optimal for the survey of frogs particular during the January 2005 survey where 200 mm of rain fell immediately prior to and during the survey and the mean nightly temperature was 19^{o}C.

The diurnal component of the reptile surveys consisted of hand searches for active and resting individuals under rocks, logs, bark, leaves and timber and artificial debris when encountered. Specific reptile census was conducted for 30 minutes at each of the baseline survey sites. Opportunistic observations were also recorded during the carrying out of other survey activities.

2.5.3.12. Call playback for amphibians

Call playback was used to survey for threatened frog species considered to potentially occur in the study area on the basis of suitable habitat, including southern barred frog (*Mixophyes balbus*), giant barred frog (*Mixophyes iteratus*). The habitat was not considered suitable for other threatened frog species whose distributional range covers the study area. Call playback was only used at potential habitat sites close to the primary survey sites.

Call playback was not used for the green and golden bell frog or the green-thighed frog. However, for both of these species spotlighting, diurnal searches and species specific surveys were undertaken during favourable seasons and weather conditions. Since the green-thighed frog can call without stimulation, call playback is of limited use.

2.5.3.13. Fauna survey effort

The total fauna survey effort per technique and habitat unit is summarised below in **Table 2-5**.

- **Table 2-5: Summary of fauna survey effort (2005 and 2007/08)**

Technique	Target group	Survey effort *			
		Dry Sclerophyll Forest	Moist Sclerophyll Forest	Swamp Sclerophyll Forest	Total effort
Mammal traps (tree-mounted)	Phascogales and gliders	156[1]	96[1]	48[1]	300 trap nights
Mammal traps (small ground)	Small terrestrial mammals	570[1]	360[1]	180[1]	1110 trap nights
Mammal traps (large ground)	Medium terrestrial mammals	144[1]	90[1]	36[1]	270 trap nights
Cage traps	Larger ground-dwelling mammals (e.g. quolls)	93[1]	60[1]	27[1]	180 trap nights
Hair-tubes (large ground)	Larger ground-dwelling mammals (e.g. quolls)	144[1]	144[1]	72[1]	360 tube nights
Hair-tubes (small ground)	Small terrestrial mammals	90[1]	90[1]	45[1]	225 tube nights
Hair-tubes (tree-mounted)	Phascogales and gliders	36[1]	36[1]	18[1]	90 tube nights
Harp-traps	Microchiropteran bats	22[1]	16[1]	8[1]	46 trap nights
Bat call recording	Microchiropteran bats	10[3]	6[3]	4[3]	20 sites (480 hrs)

Technique	Target group	Survey effort *			
		Dry Sclerophyll Forest	Moist Sclerophyll Forest	Swamp Sclerophyll Forest	Total effort
Spotlighting	All groups	14[2]	10[2]	5[2]	29 person hours
Diurnal birds	Diurnal birds	13[3]	8[3]	4[3]	25 sites
Call playback	Large Forest Owls	13[3]	8[3]	4[3]	25 sites
Call playback	Threatened Frogs	-	3[3]	1[3]	4 sites
Reptile searches	Reptiles	13[2]	8[2]	4[2]	25 person hours
Stagwatch survey	Arboreal mammals, owls and bats	1[2]	1[2]	-	2 person hours
Scat search	koala	13[3]	8[3]	4[3]	12 person hours

* 1 = trap nights; 2 = person hours; 3 = number of sites where census was conducted

2.5.3.14. Data use and analysis

Replication of the survey methods at each survey site was designed to generate spatial and temporal data on species richness, abundance, distribution and community composition at each of the sites and habitat units. Data for mammals and birds were combined to compare species richness and abundance relative to each site.

2.5.3.15. Habitat assessment

Habitat assessment data were collected during the route option phase (2003-05) and EA phases (2007-08) of the Proposal in order the gather information on the type and condition of fauna habitat presented across the landscape. Fifty-four (54) habitat assessment sites were sampled in total comprising 26 sites in dry sclerophyll forest, 11 sites in moist sclerophyll forest, seven sites in swamp sclerophyll forest, five sites in wetlands, one site in mangroves and four sites in cleared agricultural land. The location of habitat assessment sites are shown on **Figure 2-6** to **Figure 2-9**. At each site a 2500 m^2 quadrat was used to record fauna habitat features, by assessing the condition and abundance of a set of habitat criteria listed below. Additionally, general meanders were undertaken in the vicinity of the quadrats to assess fauna habitat quality and the continuity of adjacent areas. The criteria used were considered to represent minimum attributes required for reasonable habitat health and viability and included:

- Type and structure of the vegetation, including an assessment of the 'naturalness' in terms of the presence of native remnant vegetation or planted and regrowth areas and the extent of logging.
- Presence and frequency of large mature trees, tree hollows and their size classes, standing dead trees (stags) and logs or boulders.

- Dominant flora species and a subjective assessment of floristic diversity at different structural layers, flowering and fruiting resources.
- Presence of significant keystone species and critical habitat elements for threatened fauna.
- Representation of the habitat type on a local and regional scale.
- Disturbance regimes, both past and ongoing including fire regime and weed abundance.
- Density of each vegetation strata (structural diversity).
- Presence and quality of wet areas or waterbodies, significant aquatic habitats where present.
- Size of remnant patches and extent of connectivity, movement corridors and refuge value.

The data was used in combination with field survey results to identify habitats of conservation value for fauna, in particular threatened fauna recorded from the region.

2.6. Aquatic field surveys

Twelve permanent water courses (estuarine and freshwater) present in the study area were sampled during the field survey with samples typically collected upstream and downstream of The Proposal. **Table 2-6** provides a summary of the field surveys conducted.

Table 2-6 Summary of field surveys conducted

	Site Code	Water Quality	Electrofishing	Bait Trapping	Fyke Nets	Macro-invertebrates	Gill Nets	Seine Nets
Freshwater								
Butchers Creek	W2a	✓	✓	✓	✓			
	W2b	✓	✓	✓	✓	✓		
Rosewood Creek	W3a	✓		✓	✓			
	W3b	✓		✓	✓			
Stony Creek	W4a	✓	✓	✓	✓	✓		
	W4b	✓	✓	✓	✓			
Williamson Creek	1a	✓	✓	✓	✓			
	1b	✓	✓	✓	✓			
Boggy Creek	4b	✓	✓	✓	✓	✓		
Cow Creek	5a	✓	✓	✓	✓	✓		
	5b	✓		✓	✓			
Oyster Creek	7a	✓	✓	✓	✓			
	7b	✓	✓	✓	✓	✓		
Estuarine								
Warrell Creek	2a	✓		✓				
	2b	✓		✓				

	Site Code	Water Quality	Electrofishing	Bait Trapping	Fyke Nets	Macro-invertebrates	Gill Nets	Seine Nets
Nambucca River	3a	✓		✓			✓	
	3b	✓		✓			✓	
Deep Creek	6a	✓		✓			✓	✓
	6b	✓		✓			✓	✓
Kalang River	9a	✓		✓			✓	✓
	9b	✓		✓			✓	✓
Bellinger River*	10a	✓		✓			✓	✓
	10b	✓		✓			✓	

Note; the Bellinger River is located beyond the study area.

Sites were selected upstream and downstream of the freshwater creeks and estuaries associated with the proposal. A total of fourteen freshwater and ten estuarine sites were selected. The locations sampled are detailed in **Table 2-6** and graphically depicted in Appendix J. Fish field surveys associated with the proposal for sites 1 to 10 were undertaken from 26 to 30 November 2007. Additional fish surveys were undertaken in the Warrell Creek section (sites W2-W4) between 14 and 17 July 2008.

Five freshwater sites (Butchers Creek, Stony Creek, Boggy Creek, Cow Creek and Oyster Creek) were selected for the assessment of freshwater macroinvertebrates. The selected locations were the only sites which contained suitable edge habitat for AusRivAS assessment. Boggy Creek, Cow Creek and Oyster Creek were sampled during the spring AusRivAS season from 22 to 24 October 2007. Due to access constraints the Warrell Creek section sites (Butchers Creek and Stony Creek) were not sampled until 14 to 17 July 2008.

2.6.1. Water quality

Water quality was measured in situ at each of the freshwater sites using a TPS 90FLMV multi-parameter water quality meter. A range of parameters were measured including dissolved oxygen (DO), pH, conductivity (µS/cm – mS/cm) and temperature (°C). Also a TPS WP88 single parameter water quality meter was used to measure turbidity (NTU). The water quality meter was calibrated prior to fieldwork being undertaken. Sites within the Warrell Creek section were measured using a Yeokal-611 multi-parameter water quality probe. Resultant data were compared with the historic water quality data collected at each site (see Appendix L).

2.6.2. Fish sampling

Freshwater fish communities were sampled at each site using a combination of backpack electro-fishing, bait traps and fyke nets. Estuarine fish communities were sampled at each site using a combination of bait traps, seine nets and gill nets.

2.6.3. Freshwater electro-fishing

Backpack electro-fishing is limited in its use to sites where conductivity is less than 1500 µS/cm. Backpack electro-fishing was used to survey wadeable habitats at each site where access and electrical conductivity levels permitted. Three replicate shots of 300 seconds 'power on' time was undertaken at each site with catch data for each shot being recorded separately. Electro-fishing temporarily stuns the fish, whereupon they float to the surface and can be identified and counted. Backpack electro-fishing was undertaken at all sites except for Cow Creek (5b) due to high conductivity and associated safety concerns and Rosewood Creek (W2a &b) sites because of property access constraints

2.6.4. Bait traps

At freshwater sites, five bait traps (unbaited) (45 × 25 × 25 cm) were set overnight in shallow habitats at each site. At estuarine sites the five bait traps were baited with a small handful of catfood and set for 1.5 hours. Where possible, traps were set in stands of emergent vegetation, areas with submerged vegetation, or snag piles, as these areas are likely to have a greater diversity and abundance of small bodied fish. The bait traps were set overnight and retrieved the following morning. Plate 2-1shows a bait trap set in shallow water near submerged vegetation.

- **Plate 2-1 Bait trap**

2.6.5. Fyke nets

A large single fyke net with a six metre leader was set overnight in freshwater littoral habitats (>0.4 m deep), at each site. The fyke nets were used to trap mobile, large bodied fish. The nets were set with a float in the cod end to provide an air pocket for any turtles or diving birds and mammals, which may become trapped.

2.6.6. Seine netting

A 30 metre seine net was used at sites where sections of the river or creek were at a wadeable depth (less than one metre). The net was deployed from the bank and dragged through the river/creek in a loop by one of the researchers. The net is then dragged into the bank to record the catch. The seine was repeated at each of the sites, 15 minutes later. **Plate 2-2** shows an example of a seine net being deployed.

- **Plate 2-2 Seine net**

2.6.7. Gill netting

Between two to three gill nets were set for one hour at each of the upstream and downstream sites. The three nets used were 30 metres long and 1.2 metres wide. The mesh sizes utilised were 5.5mm, 8mm, 10mm, 12mm and 13 mm. The nets were deployed from a boat in water depths of two to five metres. **Plate 2-3** shows an example of a gill net set in an estuary.

- **Plate 2-3 Gill net**

2.6.8. Fish species measurements

All fish captured were identified to species and the following information recorded:

- Abundance.
- Size of fish (total length in mm).
- Sampling technique.

2.6.9. Macroinvertebrate sampling

AUSRIVAS samples were collected at Boggy Creek, Cow Creek and Oyster Creek by AusRivas accredited personnel during the Spring sampling period (15 September – 15 December) using NSW AusRivAS protocols summarised below (Turak *et al.* 2004). Due to access constraints the Warrell Creek section sites (Butchers Creek and Stony Creek) were not sampled until 14 to 17 July 2008, just outside of the Autumn sampling period (15 March - 15 June).

2.6.10. AusRivAS sampling methodology

The sampling area at each site was determined as a length of 100m or 10x the mode width (whichever is larger). At each sample site macroinvertebrate samples were collected from edge habitats (creek bank in areas of little or no flow, including alcoves and backwaters, with abundant leaf litter, fine sediment deposits, macrophyte beds and overhanging bank vegetation) (Turak *et al.* 2004). Riffle habitats were not sampled due to a lack of suitable habitat (riffle habitat consists of areas of broken water with rapid current (Turak *et al.* 2004)). Samples were collected from 10m of representative edge sub-habitats using a kicknet (0.25mm mesh size) to dislodge macroinvertebrates, whilst noting physical habitat at the location. Care was taken to ensure all sub-habitats within the site were represented within the sample.

Existing water quality was assessed at each AusRivAS sampling location. Temperature, conductivity, turbidity, dissolved oxygen, salinity and pH were measured using a YeoKal 611 water quality probe. Alkalinity ($CaCO_3$) was determined using Total Alkalinity titration kits. In addition to providing habitat predictor variables used in the AusRivAS model, water chemistry can be compared to the ecological health SIGNAL scores and macroinvertebrate taxa presence to determine variables impacting upon macroinvertebrate communities. The assessment of water quality in this report is made in accordance with default trigger values in slightly disturbed estuarine and lowland river ecosystems in south-east Australia as outlined in the National Water Quality Management Strategy (ANZECC/ARMCANZ 2000).

Chemical and physical habitat variables (environmental data) were recorded onto AusRivAS datasheets at each site and used as predictor variables in the AusRivAS modelling program.

Samples were live sorted by trained staff shortly after collection and placed into separate, labelled jars containing 70 per cent ethanol. A minimum sorting time of 40 minutes applied after which sorting time depended upon whether a new taxon had been recently collected. The maximum sorting time allowed was 60 minutes. Debris remaining after sorting was returned to the creek from where it was collected.

2.6.11. Macroinvertebrate identification

The live picked macroinvertebrate samples were sent to the NATA accredited, Australian Water Quality Centre in South Australia for identification. All macroinvertebrates were to be identified to the family level of taxonomic resolution, except for Chironomidae which was identified to subfamily as required by the AusRivAS model. If large crustaceans were found they were identified to species level due to the high level of endemism.

2.6.12. AusRivAS modelling

Identified macroinvertebrate data was entered into the AusRivAS modelling program. The program uses mathematical models to predict the aquatic macroinvertebrate fauna expected to occur at modelled locations with similar habitat which have minimal or no impact from most human activity (reference condition) and compares these results with fauna actually collected, providing a measure of biological impairment. Predictor variables (including physical habitat variables, latitude, longitude, altitude, slope and distance from source) are used to determine the modelled reference condition of similar type against which to compare macroinvertebrate assemblages.

The AusRivAS model software outputs specify the Observed (macroinvertebrates collected during sampling) to Expected Ratios (macroinvertebrates which are predicted to occur in reference conditions). The ‘Observed’ (O) macroinvertebrates are calculated for all macroinvertebrates which were observed with a predicted probability of occurrence greater than 50percent. The ‘Expected’ (E) variable is calculated as the sum of all modelled probabilities greater than 50percent. An O/E value close to 1 indicates that the macroinvertebrate fauna found are similar to those of the predicted reference streams, and a value close to zero indicates severe impairment compared to reference condition. Based upon these ratios, a band ranking indicating the ecological health of the river is assigned as follows:

- Band X: Macroinvertebrate assemblage is more biologically diverse than reference sites.
- Band A: Site is in reference condition with most/all of the expected families found.
- Band B: Site is significantly impaired, indicating a potential impact either on water quality and/or habitat quality which has resulted in a loss of taxa.
- Band C: Site is severely impaired; indicating a loss of biodiversity due to substantial impacts on water and/or habitat quality.
- Band D; Site is extremely impaired; few expected taxa remain, indicating extremely poor water and/or habitat quality resulting in a highly degraded waterway.

The model also calculates the expected and actual SIGNAL score for each site. SIGNAL is a biotic index that allocates a value to each macroinvertebrate family based largely upon their sensitivity to pollution (a value of 10 indicates high sensitivity, 1 represents high tolerance) (Chessman, 1995). The SIGNAL scores were used to grade water quality into the following categories:

- Signal score > 6: Healthy habitat.
- Signal score 5-6: Mild pollution.
- Signal score 4-5: Moderate pollution.
- Signal score <4: Severe pollution.

2.6.13. Water way classification

An assessment of riparian and instream habitat at each of the freshwater and estuarine sites sampled was undertaken in accordance with the Anderson Riverine Habitat Audit Procedure (Anderson, 1993). The method adopted was referenced from Section 13, Appendix 1 of Anderson (1993). The datasheets and survey procedures were used to assess each of the sites. The sheets utilised were as follows:

- Sheet 1 – Sub-section element.
- Sheet 3 – Site description.
- Sheet 4 – Reach environs – temporal and spatial.
- Sheet 10 – Aquatic habitat.

The assessment of the riparian and instream habitat at each study site is outlined in **Section 3.**

2.7. Limitations

The list of flora and fauna species recorded from this study should not be seen to be fully comprehensive, but an indication of the species present at the time of the surveys. A period of several seasons or years is often needed to identify all the species present in an area, especially as some species are only apparent at certain times of the year for short periods (e.g. orchids or migratory birds) and require specific weather conditions for optimum detection (e.g. frogs and reptiles). The conclusions of this report are therefore based upon available data and the field surveys and are merely indicative of the environmental condition of the site at the time of the surveys. It should be recognised that site conditions, including the presence of threatened species, can change with time. However considering ecological surveys have been conducted for the Proposal from 2005-2008 during several seasons the ecological assessment is considered to be adequate for the EA and has adequately adhered to the DGRs.

3. Results

The terrestrial and aquatic ecology surveys were undertaken in accordance with the ecological assessment requirements identified in the DGRs and the Recommended Information Requirements from the DECCW and DII (refer to section 1.3).

3.1. Terrestrial landscape context

The study area lies within the NSW North Coast (NNC) Bioregion which encompasses an area of 5,694,360 ha along the coast and eastern slopes from Port Macquarie to the Queensland border (Thackway and Creswell 1995). Two hundred and two flora species found in the North Coast Bioregion are listed in the schedules of the *TSC Act*. Of these, 108 are endangered, 89 are vulnerable and five are considered extinct in the bioregion (NSW NPWS 2001). One hundred and fifty-seven fauna species recorded in the North Coast Bioregion are listed in the schedules of the *TSC Act* (NSW NPWS 2001). Of these, 36 are listed as endangered and 121 are listed as vulnerable.

A major factor which contributes to this high species diversity is the location within the MacPherson-Macleay Overlap Zone. This zone is defined as that area of eastern Australia where the Tropical and Temperate Zones overlap (Burbridge 1960). It includes part of south-east Queensland and part of north-east NSW. In this area tropical elements predominate in the wetter habitats of the eastern slopes of the ranges and temperate elements in the drier or cooler and more open sites. Bassian (or south-eastern Australian) and Torresian (or northern Australian) species overlap with the former being at the northern extent of their range, the latter being at the southern extent of their range.

The NNC Bioregion has the second highest proportion of lands under conservation reserves of the NSW bioregions. In total 1,061, 709.61 hectares or 18.65 per cent of the bioregion is conserved. The following conservation reserves are located within 20 km of the Proposal centre line.

- Bongil Bongil National Park
- Yarriabini National Park
- Bindarii National Park
- Dorrigo National Park
- Jaaningga Nature Reserve
- Jagan Nature Reserve
- Valla Nature Reserve
- Bollanolla Nature Reserve
- Bowraville Nature Reserve
- Gaynay Nature Reserve
- Ngambaa Nature Reserve
- Fishermans Bend Nature Reserve

A number of State Forests are located within the landscape, these properties are managed primarily for forestry activities although also have some conservation values. There are numerous records of the threatened flora and fauna species in these state forests. The conservation values of these state forests are recognised through their identification as key habitats (NSW NPWS 2002). Nambucca State Forest, Newry State Forest, and Little Newry State Forest are located in the study area and would be directly intersected by the Proposal alignment. A number of other state forests are located within 20 km of the Proposal centreline which include Ingalba State Forest, Way Way State Forest, Viewmont State Forest and Mistake State Forest.

A review of threatened flora and fauna species present in conservation reserves of the region is presented in **Table 3-1** and the location of threatened flora and fauna records within 10 km of the Proposal is shown in **Figures 3-1** and **3-2.**

Table 3-1: Threatened flora and fauna present in regional conservation reserves

Common name	Species	Status*	Bongil Bongil NP	Yarriabinni NP	Bindarii NP	Dorrigo NP	Jaaningga NR	Jagan NR	Valla NR	Bollanolla NR	Bowraville NP	Ngambaa NR
Threatened Fauna												
Green-thighed frog	*Litoria brevipalmata*	V	•			•						
Giant barred frog	*Mixophyes iteratus*	E1			•					•		•
Sphagnum frog	*Philoria sphagnicolus*	V			•	•						
Boorolong frog	*Litoria boorolongensis*	V				•						
Glandular frog	*Litoria subglandulosa*	V				•						
Pouched frog	*Assa darlingtoni*	V				•						
Stuttering frog	*Mixophyes balbus*	E1				•						
Osprey	*Pandion haliaetus*	V	•									
Black bittern	*Ixobrychus flavicollis*	V	•			•						•
Beach stone-curlew	*Esacus neglectus*	E1	•									
Glossy black-cockatoo	*Calyptorhynchus lathami*	V	•	•	•	•	•	•				•
Barred cuckoo-shrike	*Coracina lineata*	V	•	•								
Black-necked stork	*Ephippiorhynchus asiaticus*	E1	•						•			
Wompoo fruit-dove	*Ptilinopus magnificus*	V	•	•	•	•	•					•
Rose-crowned fruit-Dove	*Ptilinopus regina*	V	•			•						
Superb fruit-dove	*Ptilinopus superbus*	V	•									

Common name	Species	Status*	Bongil Bongil NP	Yarriabinni NP	Bindarii NP	Dorrigo NP	Jaaningga NR	Jagan NR	Valla NR	Bollanolla NR	Bowraville NP	Ngambaa NR
Sooty oystercatcher	*Haematopus fuliginosus*	V	•									
Pied oystercatcher	*Haematopus longirostris*	V	•									
Comb-crested jacana	*Irediparra gallinacea*	V	•									
Little tern	*Sterna albifrons*	E1	•									
Powerful owl	*Ninox strenua*	V	•		•	•						•
Barking owl	*Ninox connivens*	V										•
Sooty owl	*Tyto tenebricosa*	V	•	•	•	•						
Masked owl	*Tyto novaehollandiae*	V				•						
Yellow-bellied glider	*Petaurus australis*	V	•	•	•	•						•
Squirrel glider	*Petaurus norfolcensis*	V	•									
Koala	*Phascolarctos cinereus*	V	•		•	•	•			•	•	•
Grey-headed flying-fox	*Pteropus poliocephalus*	V	•			•		•	•			•
Common blossom-bat	*Syconycteris australis*	V	•									
Little bentwing-bat	*Miniopterus australis*	V	•		•							•
Eastern bentwing-bat	*Miniopterus schreibersii oceanensis*	V	•		•	•						
Olive whistler	*Pachycephala olivaceae*	V			•							
Eastern pygmy possum	*Certcartetus nanus*	V			•	•						
Spotted-tailed quoll	*Dasyurus maculatus*	V			•	•		•				•

Common name	Species	Status*	Bongil Bongil NP	Yarriabinni NP	Bindarii NP	Dorrigo NP	Jaaningga NR	Jagan NR	Valla NR	Bollanolla NR	Bowraville NP	Ngambaa NR
Parma wallaby	*Macropus parma*	V			●							
Greater broad-nosed bat	*Scoteanax rueppelli*	V			●							●
Large-footed myotis	*Myotis macropus*	V			●							
Brush-tailed phascogale	*Phascogale tapotafa*	V				●						●
Brush-tailed rock wallaby	*Petrogale penicillata*	E1				●						
Long-nosed potoroo	*Potorous tridactylus*	V				●						
Stephens banded snake	*Hoplocephalus stephensii*	V				●						●
Square-tailed kite	*Lophoictinia isura*	V							●			
Threatened flora												
Slender marsdenia	*Marsedenia longiloba*	E1	●		●				●			●
Sand spurge	*Chamaesyce psammogenton*	E1	●									
Arrow-head Vine	*Tinospora tinosporoides*	V	●									
Floyd’s grass	*Alexfloydi repens*	E1	●									
Scented acronychia	*Acroynchia littoralis*	E1	●									
Rusty plum	*Amorphosporum whitei*	V	●		●	●	●					
Milky silkpod	*Parsonsia dorrigoensis*	V			●	●	●					●
Red-flowered king	*Oberonia titania*	V			●							

Common name	Species	Status*	Bongil Bongil NP	Yarriabinni NP	Bindarii NP	Dorrigo NP	Jaaningga NR	Jagan NR	Valla NR	Bollanolla NR	Bowraville NP	Ngambaa NR
Ravine orchid	*Sarochilus fitzgeraldii*	V			●	●						
Dorrigo daisy bush	*Olearia flocktoniae*	E1				●						
Woodland babingtonia	*Babingtonia silvestris*	E1				●						
Newry golden wattle	*Acacia chrysotricha*	E1					●					

- Status – E1 Endangered Species; V Vulnerable Species (TSC Act)

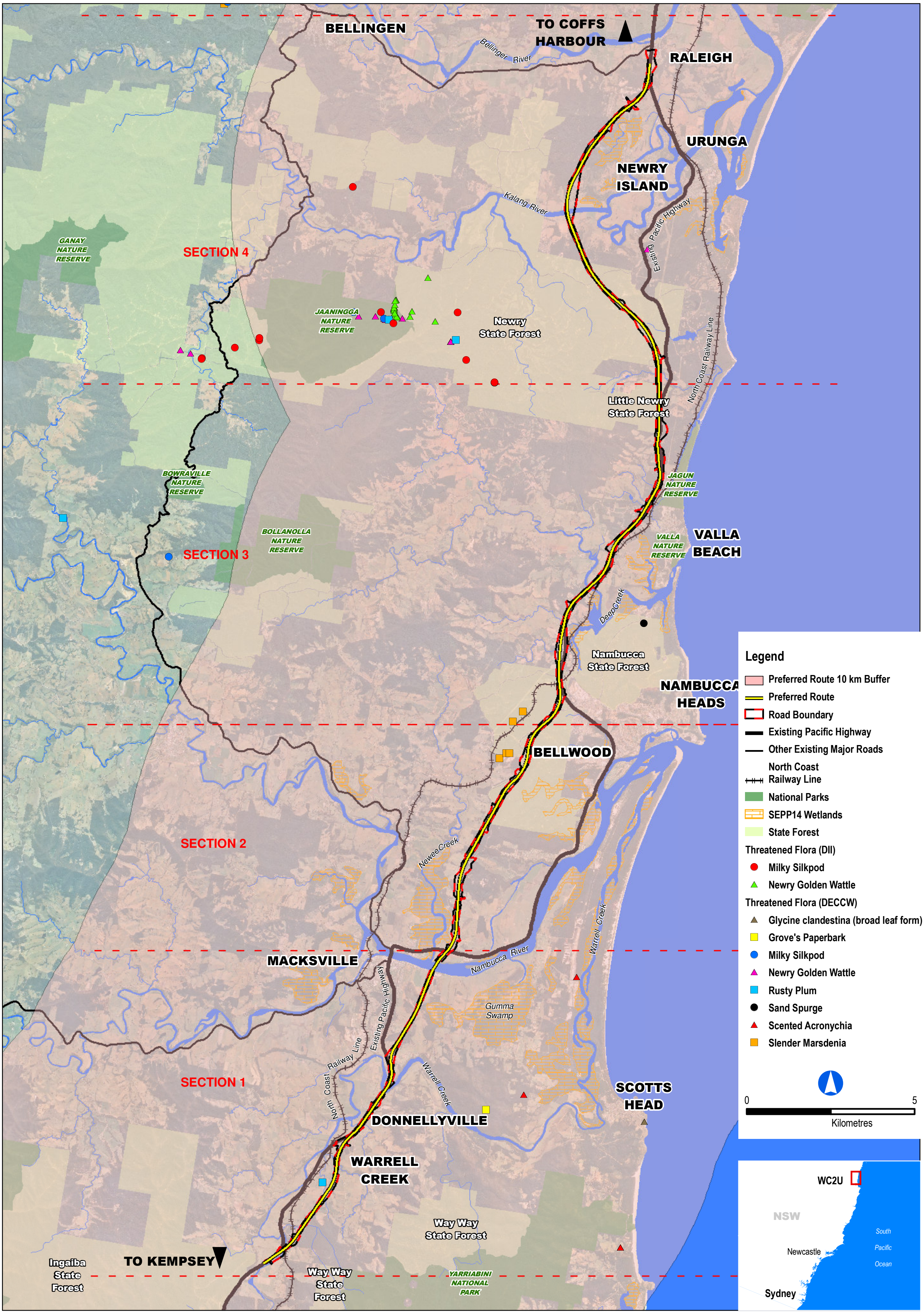

Figure 3-1 : Threatened Flora Records (DECCW and DII)

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Figure 3-2 : Threatened Fauna Records (DECCW and DII)

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3.1.1. Mitchell landscapes

The Landscapes of NSW were mapped at a broad scale (1: 250,000) using land systems, geology, geomorphology and elevation data (Mitchell 2003). The study area lies in the coastal strip identified by Mitchell (2003) as the Manning-Macleay region. These data identify two landscape types present across the study area (refer Figure 3-3). These include:

- Manning-Macleay Coastal Alluvial Plains.
- Ingalba Coastal Hills.

3.1.1.1. Manning-Macleay Coastal Alluvial Plains

This landscape is associated with the wide valleys, channels, alluvial floodplains, swamps and terraces of rivers and creeks in the Manning and Macleay region extending across the lower reaches of coastal waterways from Port Macquarie in the south to Kempsey in the north. Based on the *BioMetric Assessment Tool* (NSW Department of Environment and Conservation 2005) approximately 57 per cent of the historical vegetation has been cleared across this landscape.

In the study area this landscape is present on the alluvial floodplains of the Nambucca and Kalang Rivers and smaller creeks such as Deep Creek, Boggy Creek and Oyster Creek. Characterised by Quaternary alluvium, with a general elevation of 0-50 m, and local relief of 15 m. Soils include dark organic loams and silty clays on the floodplain, gradational brown loams and yellow-brown texture-contrast soil on terraces, and organic silty mud in swamps.

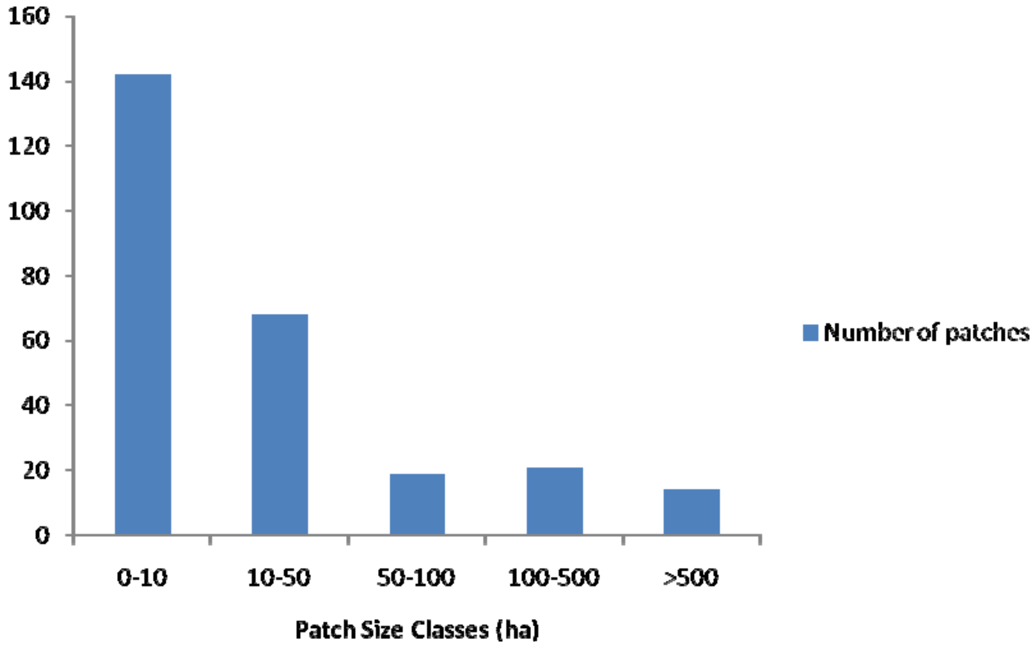
3.1.1.2. Ingalba Coastal Hills

Associated with the coastal hills and slopes on lower Permian slate, phyllite, schistose sandstone and schistose conglomerate with a general elevation of up to 830 m, and local relief of 350 m. Characteristic soil types represented include thin, stony gradational loam and sandy loam on the slopes grading to yellow-brown texture-contrast soils on lower slopes and in valleys. In the study area the Ingalba Coastal Hills can be identified as the hills and slopes rising above the floodplain reaches of the Nambucca and Kalang Rivers. Remnant forested areas are dominated by dry sclerophyll forests with moist sclerophyll forests in gullies.

Based on the *BioMetric Assessment Tool* (NSW Department of Environment and Conservation 2005) approximately 39 per cent of the historical vegetation has been cleared across this landscape.

3.1.2. Vegetation patch network

The size and abundance of vegetation patches within a 20 km radius of the Proposal centreline were quantified and the results displayed in **Figure 3-2**. The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands. The largest areas of continuous vegetation in the surrounding area are located in Newry, Little Newry and Nambucca State Forests. Portions of each of these properties would be traversed by the Proposal resulting in further fragmentation of large vegetation patches. The vegetation patches identified in a 20 km radius from the Proposal centreline are shown in **Figure 3-3**.



- **Figure 3-3: Mosaic of vegetation patches identified in the landscape surrounding the Proposal (i.e. 20 km radius)**

3.1.3. Key habitats and corridors

Current datasets available in relation to key habitats and wildlife corridors identified in the study area were examined for relevance to impacts from the Proposal. These data include the *Key Habitats and Corridors* (NSW Department of Environment and Climate Change 2003) which is based on broad-scale vegetation data and focused on a range of flora and fauna reference species and *Climate Change Corridors* (NSW Department of Environment and Climate Change 2007a) which identifies broad landscape corridors required for species to adapt to climate change. The focus of the latter is on species considered at greatest risk from climate change.

- **Table 3-2: Climate change corridors located in the study area**

Corridor type	Description	Feature	Reference species	Area (ha)
Moist corridors	Urunga - Escarpment	east-west stepping stone consolidation	Rose-crowned Fruit Dove and giant barred frog	12,300
	Oyster Creek – Escarpment	east-west reserve buffers and linkages	Little Bent-wing Bat and giant barred frog	10,240
	Yarrahappinii-Escarpment	east-west reserve buffers and linkages	grey-headed flying-fox and Wompoo Pigeon	4,630
Coastal corridors	Bellinger-Nambucca	north-south linkage across the floodplain	grey-headed flying-fox and coastal shorebirds	14,120
	Nambucca-Macleay	north-south coastal connector	Eastern blossom bat and grey-headed flying-fox	15,365
Dry corridors	Macleay River-Collombattii	east-west reserve buffers and linkages	brush-tailed phascogale	63,013

The majority of ‘key habitats and corridors’ identified by NSW Department of Environment and Climate Change (2003) in the study area relate to large vegetation patches contained in the Nambucca, Newry and Little Newry State Forests and associated with the Ingalba Hills landscape (Mitchell 2003). These habitats provide a strategic link in the landscape between the coastal lowlands and the larger habitats to the west including conservation reserves and other state forests.

3.2. Literature and database review

The conservation significance of terrestrial flora and fauna species and Endangered Ecological Communities is discussed in the national context with reference to the Commonwealth *EPBC Act*, Briggs & Leigh (1996) (*Rare or Threatened Australian Plants – RoTAP*) and in the State context with reference to Schedules 1 and 2 of the TSC Act. The result of the background investigation into listed biodiversity relevant to the study locality is discussed in the following section.

Available database records of aquatic flora and fauna species previously documented in the region, including waterway dependent reptiles and mammals provided background information into species relevant to the study locality (Section 3.2.3). A full list of aquatic species is provided in Appendix K (SKM 2004). These studies were undertaken by The Ecology Lab (1998), Gibbs et al (1999), Llewellyn (1983) and Bishop (1993). Literature relevant to estuarine habitats including wetlands, commercial fisheries & oyster farming, was also reviewed as required by the Director-General.

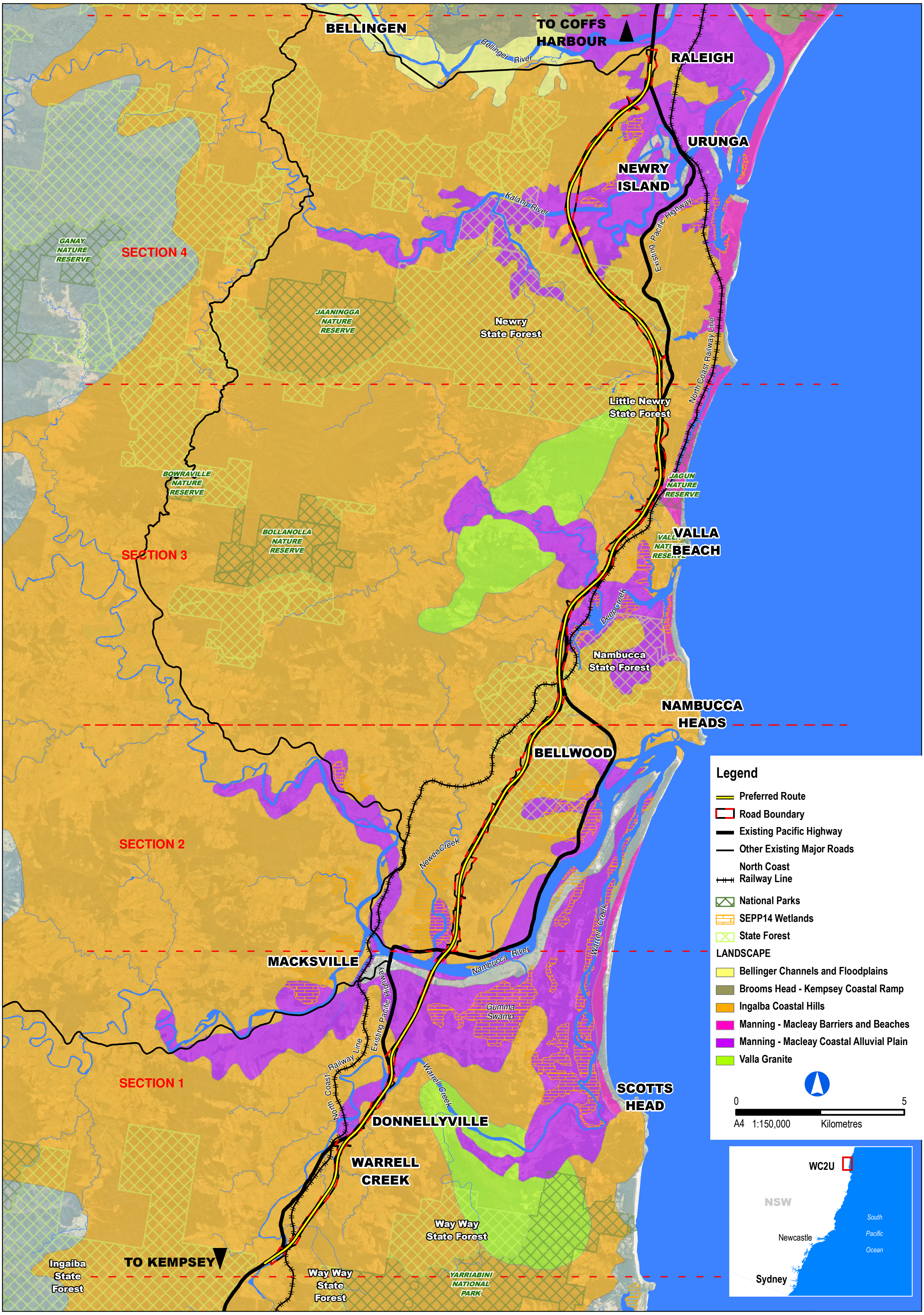


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Figure 3-4 : Landscape context for the proposal

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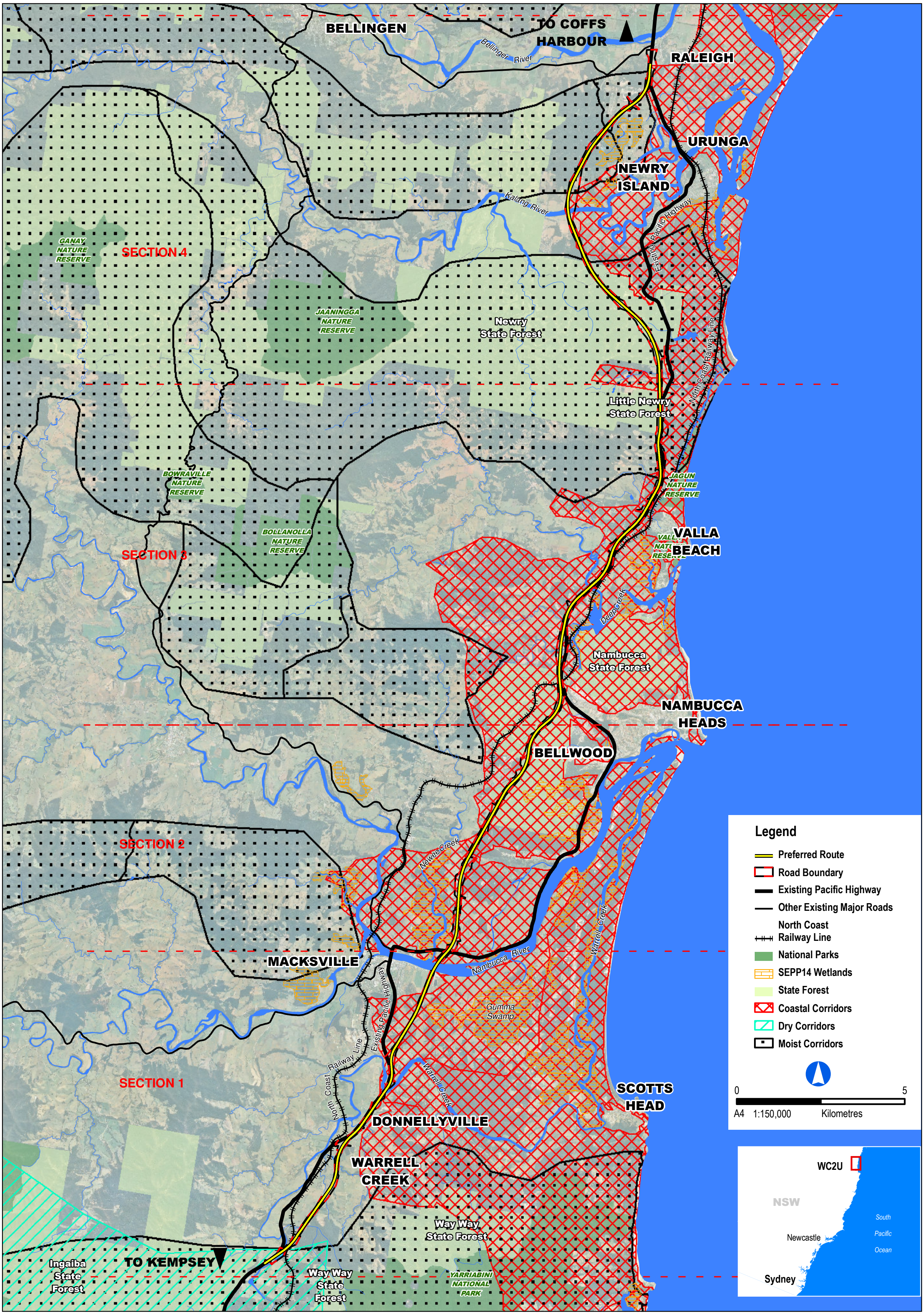

Figure 3-5 : Regional, sub-regional and climate change corridors

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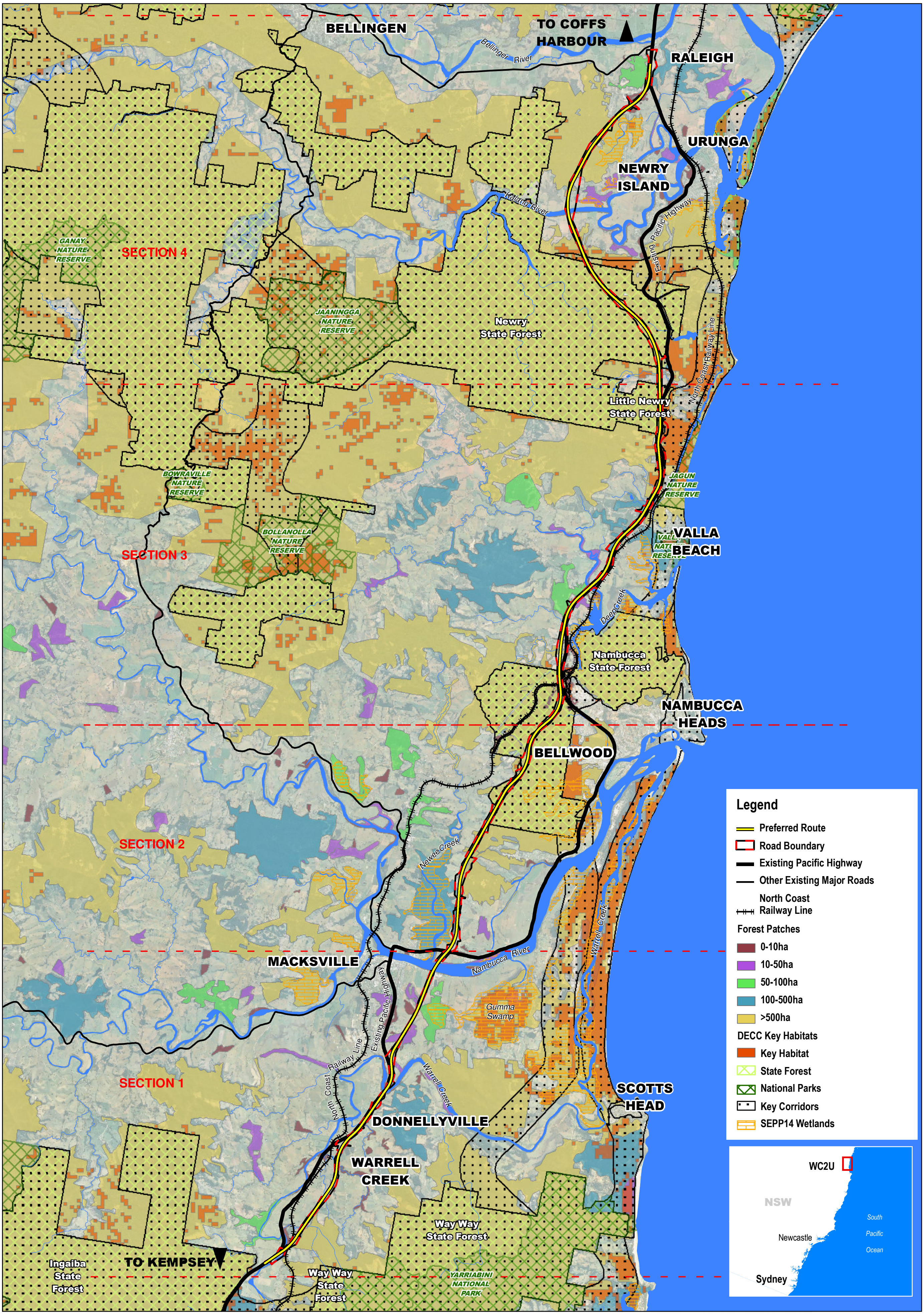

Figure 3-6: Landcape network of forest patches

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3.2.1. Endangered Ecological Communities

Much of the pre-European vegetation of the lowland floodplain in the study area would have comprised lowland rainforest, swamp forests, wetlands and wet floodplain eucalypt forests. The vast majority of this vegetation has been cleared due to the fertile soil types for agriculture and proximity to the river and coast for transport and settlement. Fragments of vegetation remaining on the floodplain are characteristic of vegetation associations of the NSW North Coast Bioregion which have been scheduled as Endangered Ecological Communities (EECs) under Part 3 of Schedule 1 of the TSC Act. The following EECs were identified in and adjacent to the study area:

Vegetation characteristics of the following EECs were identified in the detailed flora investigations for the Proposal:

- Subtropical Coastal Floodplain Forest of the NSW North Coast bioregion.
- Freshwater Wetlands on Coastal Floodplains of the NSW North Coast bioregion.
- Lowland Rainforest on floodplain of the NSW North Coast bioregion.
- Swamp Oak Floodplain Forest of the NSW North Coast bioregion.
- Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast bioregion.
- Coastal Saltmarsh of the NSW North Coast bioregion.

Targeted surveys were undertaken for the EA to confirm the presence and distribution of these communities in the study area, in addition to identifying the potential presence of additional EECs not previously identified.

3.2.2. Threatened species

The results of the literature and database review have identified records for threatened fauna species in the study locality. The potential presence of these species was considered by comparing the preferred habitat attributes of each species with the habitat attributes identified in the study area. This resulted in a list of potential subject species (refer Appendix A) of 12 threatened flora species and 25 threatened fauna species targeted in field surveys and addressed in assessing the significance of impacts from the Proposal.

3.2.3. Fish communities of the Nambucca and Bellinger River systems

During a study in 1999, fish and macroinvertebrates were sampled on several occasions from three sites in the Nambucca River, about 6km from the mouth of the river and downstream of the study area. Gibbs *et al.* (1999) used the Nambucca River as a control to assess the effects of flood mitigation works on fish communities. Three sites were sampled with 56 species of fish being recorded including several species of commercial importance. None of the species currently listed on the threatened species schedules were recorded by Gibbs *et al.* (1999).

The Ecology Lab (1998) sampled fish and macroinvertebrates within a 3km freshwater reach of the Nambucca River at Bowraville to assess the effects of a proposed water extraction augmentation scheme on the ecology of the Nambucca River (Note this area is located upstream of the present study area). Seventeen species of fish were recorded, including several migratory species. No scheduled species were reported (SKM, 2004).

There have been several studies of the freshwater reaches of the Bellinger River. These studies have reported 25 species, which is greater than numbers recorded in the freshwater reaches of the Nambucca River and may reflect greater effort and/or different methods used to sample the Bellinger River. No scheduled species listed currently under the *FM Act* 1994 were recorded in either of those studies (SKM, 2004).

Further details of the fish communities identified in the field surveys are provided in Section 3.5 onwards.

3.2.4. Wetlands

Mangroves occur within the study area, and in some instances are located directly in the path of the Proposal. Based on existing maps and ground truthing field surveys, all seagrasses that occur in the estuaries occur outside the alignment of the current Pacific Highway. Even though saltmarsh habitats are scattered throughout the river systems, none occur in close proximity to the Proposal (SKM, 2004). Adam *et al*. (1985) mapped the distribution of SEPP 14 wetlands within NSW. A total of eight SEPP 14 wetlands have borders that fall within the region of the Proposal (SEPP14 Wetlands 388, 383, 386, 351, 353, 383, 386 and 353). Site visits made by SKM to these wetlands during routine water quality monitoring found no water at SEPP Wetlands 383,353 and 386. No seagrasses were observed at any of the wetlands, with the only aquatic flora sited being dense mats of Duckweed Lemnacae at the SEPP Wetland 351 (off Southarm Road).

3.2.5. Commercial fisheries and oyster farming

Finfish and crabs account for most of the commercial production of the Nambucca River. There are currently 84 commercial fishers who potentially fish the Nambucca River. The value of the commercial fishing catch in the Nambucca River was reported to be $228,000 in 2001/2002 with annual figures between 1997/98 – 1999/2000 showing the value of catch and production in the Nambucca River as being relatively steady (SKM, 2004).

Methods of commercial fishing permitted within Nambucca River are those typically used in other estuaries throughout NSW and include hauling, fish and crab trapping, mesh netting, hand lining, dip and scoop net, hand gathering and prawn netting. These methods are permitted in estuarine waters of Nambucca River upstream of Stuarts Island and include parts of the study area (SKM, 2004). The whole of Bellinger River, Kalang River and Deep Creek were closed to commercial fishing in May 2002 after these river systems were declared Recreational Fishing Havens (SKM, 2004).

Oyster farming of the Sydney rock oyster (*Crassostrea commercialis*) is centred in the middle and lower reaches of the Nambucca River with approximately 40 leases. The latest data (September 2008) shows there to be 40 leases, the majority of which are located along the main arm of Nambucca River, with priority lease areas clustered to the east of Goat Island, downstream of the proposal. There are currently 51 oyster leases in the Bellinger and Kalang Rivers (pers comm. Relene Atkinson DPI 25th September 2008). Oyster cultivation in the Nambucca River estuary was worth $484,181 in the 2000-2001 fiscal year or less than 2% of the total NSW Sydney rock oyster production (SKM, 2004). The value of oyster production in this estuary was $257,504 or less than one percent of NSW production in 2001/2002. Most of the oyster leases located in Kalang River occur within waters of the study area, whilst leases in Bellinger River are located downstream of the Old Pacific Highway crossing at Raleigh (SKM, 2004).

3.3. Terrestrial flora

3.3.1. Vegetation communities

Seven vegetation structural types are represented in the study area, these include:

- Dry sclerophyll forest.
- Moist sclerophyll forest.
- Rainforest.
- Swamp sclerophyll forest.
- Freshwater wetlands.
- Estuarine vegetation.
- Modified communities.

A brief description of the biophysical and floristic characteristics of vegetation types associated with these is described below. Detailed floristic descriptions provided in **Appendix E** and the distribution of vegetation communities along the study area is provided in **Figure 3-7** to **3-10**. Discussion as the conservation significance and legislative status of the described vegetation communities in detailed in Chapter 4.

3.3.1.1. Dry sclerophyll forests

Dry sclerophyll forest associations occupy upper slopes and crests of the study area. The vegetation structure comprises a canopy dominated by Eucalypts with a diversity of sclerophyll shrubs, grasses and forbs. The structure and diversity of the understory varies depending on the fire regime and degree of disturbance of each area.

Map Unit 1: Blackbutt open forest

The majority of the vegetation of the study area consists of dry sclerophyll forest which is associated with elevated hills and slopes. Blackbutt Open Forest is generally associated with Permian metasediments of the Newry soil landscape. This forest type is dominated by blackbutt (*Eucalyptus pilularis*) with tallowwood (*E.microcorys*), grey gum (*E.propinqua*) and pink bloodwood (*Corymbia intermedia*) occurring as co-dominants in areas. In more sheltered gullies and some south facing slopes this community more closely resembles a wet sclerophyll forest with turpentine (*Syncarpia glomulifera*) often occurring with several mesic species forming an open subcanopy, including cheese tree (*Glochidion ferdinandi*), red ash (*Alphitonia clande*) and scentless rosewood (*Synoum glandulosum*), along with forest oak(*Allocasuarina torulosa*) which is a common component throughout the community.

This open forest exhibits a moderate diversity of shrub and groundcover species particularly in older regrowth and areas less disturbed from fire. The more common species include native indigo (*Indigofera australis*), gorse bitter-pea (*Daviesia ulicifolia*), sickle wattle (*Acacia falcata*), rough guinea-flower (*Hibbertia aspera*), elderberry panax (*Polyscias sambucifolia*) and yellow tea-tree (*Leptospermum polygalifolium*). Conversely areas impacted from frequent fires have a higher abundance of blady grass (*Imperata clandestine*), bracken fern (*Pteridium esculentum*) and kangaroo grass (*Themeda australis*) and in some areas dense thickets of hop bush (*Dodonaea triquetra*) are present. Species commonly found in all areas include wiry panic (*Entolasia stricta*), purple twining-pea (*Hardenbergia violacea*), climbing guinea-flower (*Hibbertia scandens*), white root (*Pratia purpurascens*) and twining glycine (*Glycine clandestine*).

Weeds are generally present in disturbed areas of this community such as on the edges of the existing highway where exotic grass and herb species are common including South African pigeon grass (*Setaria sphacelata*), whiskey grass (*Andropogon virginicus*) and blue billygoat weed (*Ageratina houstonianum*). Some trails in State Forests are dominated by broad-leaf paspalum (*Paspalum wettsteinii*) and lantana (*Lantana camara)* is abundant in sheltered areas where there is higher soil moisture content. Bitou bush (*Chrysanthemoides monilifera*) was recorded in portions of Newry State Forest.

Blackbutt Open Forest occurs throughout significant portions of Nambucca, Newry and Little Newry State Forest and has been substantially modified from logging and a frequent fire regime. Several smaller areas of this community are present on private lands adjacent to the existing highway between Nambucca Heads and Urunga.

3.3.1.2. Moist sclerophyll forests

Moist forest associations occupy sheltered gullies and riparian areas adjoining Blackbutt Open Forest on the slopes and hills. The structure comprises a canopy dominated by Eucalypts with a dense subcanopy of mesic species and high diversity of mesic shrubs, vines and groundcovers resembling rainforest.

Map Unit 2: Mixed floodplain forest

This association occupies gullies in low elevated areas and floodplain areas of the study area on alluvial soils and Permian metasediments (Newry and Nambucca River soil landscapes) mostly below 10 metres elevation. Examples of this community occur in Newry and Little Newry State Forest and on private land adjacent to existing highway north of Nambucca Heads. This community also occurs in the riparian zones of Warrell Creek, the Kalang River, Boggy Creek and Oyster Creek. Some sites have been impacted from logging and frequent fires and may exhibit gaps in the canopy facilitating the invasion of *Lantana camara*. This community is distinguished from White Mahogany / Grey Gum / Ironbark Open Forest (Map Unit 3) by the lower elevated position and from Flooded Gum Open Forest (Map Unit 4) by the mixed dominance of the canopy and lower abundance of Flooded Gum (*Eucalyptus grandis*).

The canopy generally comprises a mixed composition of several species including pink bloodwood (*Corymbia intermedia*), flooded gum (*Eucalyptus grandis*), white mahogany (*E.acmenoides*), grey ironbark (*E.siderophloia*), small-fruited grey gum (*Eucalyptus propinqua*), brush box (*Lophostemon confertus*) and red mahogany (*E.resinifera*). A dense subcanopy is common in areas excluded from fire which supports a diversity of rainforest species. Common species in the subcanopy include cabbage tree palm (*Livistonia australis*), cheese tree (*Glochidion ferdinandi*), rose walnut (*Endiandra discolor*), bangalow palm (*Archontophoenix cunninghamiana*), red ash (*Alphitonia excelsa*), native guava (*Rhodomyrtus psidioides*), prickly-leaved paperbark (*Melaleuca styphelioides*), scentless rosewood (*Synoum glandulosum*), common acronychia (*Acronychia oblongifolia*) and yellow carabeen (*Sloanea woollsii*).

This association also supports a high diversity of rainforest shrub species including banana bush (*Tabernaemontana pandacaqui*), bolwarra (*Eupomatia laurina*), tree heath (*Trochocarpa laurina*), narrow-leaf palm-lily (*Cordyline stricta*), forest maple (*Cryptocarya rigida*) and green native cascarilla (*Croton verreauxii*). The groundcover is relatively sparse consisting of several fern, grass and herb species including basket grass (*Oplismenus* spp.), gristle fern (*Blechnum cartilagineum*) and pastel flower (*Pseuderanthemum variable*). There is a moderate diversity of vine species with some large lianes present in rainforest areas. Common vine species include five-leaf water vine (*Cissus hypoglauca*), common silkpod (*Parsonsia straminea*), native yam (*Dioscorea transversa*) and morinda (*Morinda jasminoides*).

Lantana camara is abundant in several areas, and is particularly dense in the ecotonal areas where there is more sunlight reaching the shrub layer and increased soil drainage. *Lantana camara* generally occurs in lower abundance where a dense cover of rainforest species occurs.

This association is characteristic of Subtropical Coastal Floodplain Forest an EEC listed under the *TSC Act.* This community supports a diversity of rainforest species in areas, which form a dense subcanopy in places and therefore it also has affinities to Lowland Rainforest (EEC), however the presence of a mixed Eucalypt canopy more closely aligns this community with Subtropical Coastal Floodplain Forest.

Map Unit 3: White Mahogany / Grey Gum / Ironbark open forest

This association occupies mid-slope areas and minor gullies in the central parts of Newry State Forest and on private properties on the northern side of the Kalang River. This community is associated with Permian metasediments of the Pine Creek soil landscape. Dominant species include white mahogany (*Eucalyptus acmenoides*), grey gum (*E.propinqua*) and grey ironbark (*E.siderophloia*), interspersed with several other Eucalypt species in localised areas. Other canopy species include turpentine (*Syncarpia glomulifera*), pink bloodwood (*Corymbia intermedia*), tallowwood (*E.microcorys*), flooded gum (*E. grandis*) and red mahogany (*E.resinifera*). A subcanopy of forest oak (*Allocasuarina torulosa*) and blackwood (*Acacia melanoxylon*) may be present. Understorey species include a diversity of mesic species including banana bush (*Tabernaemontana pandacaqui*), basket grass (*Oplismenus* spp.), soft bracken fern (*Calochlaena dubia*), settlers flax (*Gymnostachys anceps*), saw-sedge (*G.clarkei*) and lawyer vine (*Smilax glyciphylla*).

The density of invasive weeds is low, although *Lantana camara* occurs in moderate abundance with a greater prevalence in disturbed edges of this community.

Map Unit 4: Flooded Gum open forest

This association occupies mid-slope areas and minor gullies around Nambucca State Forest and the Warrell Creek area. This community occurs on slightly higher elevated areas and is associated with Permian metasediments (Newry, Nambucca River and Pine Creek soil landscapes). The community is dominated by flooded gum (*E. grandis*), and other canopy species generally occur in low abundance including turpentine (*S.glomulifera*), pink bloodwood (*C.intermedia*), red mahogany (*E.resinifera*), blackbutt (*E. pilularis*) and tallowwood (*E. microcorys*). A dense to open subcanopy is present in some areas of this community dominated by several rainforest trees including callicoma (*Callicoma serratifolia*), blueberry ash (*Elaeocarpus reticulatus*), cheese tree (*Glochidion ferdinandi*), red ash (*Alphitonia excelsa*), brown bolly gum (*Litsea reticulata*) and common acronychia (*Acronychia oblongifolia*).

Understorey species include a diversity of mesic ferns, vines, sedges and herbs including pastel flower (*Pseuderanthemum variable*), soft bracken fern (*Calochlaena dubia*), gristle fern (*Blechnum cartilagineum*), native yam (*Dioscorea transversa*) and morinda (*Morinda jasminoides*). mat-rush (*Lomandra longifolia*) and saw-sedge (*Gahnia clarkei*) are common along some creek lines in this community.

The density of invasive weeds is relatively high particularly in disturbed areas of this community in the Warrell Creek area. *Lantana camara* occurs in moderate abundance throughout the majority of the community with a greater prevalence in disturbed edges. Areas of this community in Nambucca State Forest are moderately to highly infested with *Lantana camara*, which forms dense thickets in gullies, particularly where disturbances such as logging and fires have thinned the canopy allowing additional light into the understorey.

3.3.1.3. Rainforests

Areas of rainforest are generally limited to the southern end of the study area in the Warrell Creek area, comprising small patches of gallery rainforest surrounding creeklines in cleared agricultural landscapes. Rainforest vegetation is also present in several areas north of Warrell Creek forming a dense subcanopy beneath Eucalypt emergents along creeks in Mixed Floodplain Forest including areas in Newry State Forest and on private land north of the Kalang River. As a result of historical land clearing practices throughout the investigation area most patches of rainforest that remain are relatively small and occur as isolated bands along creek gullies or road verges.

Map Unit 5: Lowland Rainforest

Relatively isolated stands of this community occur in the Warrell Creek area on alluvial soils and Permian metasediments (Warrell Creek, Newry and Nambucca River soil landscapes). The stands are generally in a poor condition, due to prior and current practices of grazing and general agriculture with most patches being highly-moderately infested with camphor laurel (*Cinnamonum camphora*). Representative species includes crabapple (*Schizomeria ovata*), fig species (*Ficus* spp.), water gum (*Tristaniopsis laurina*), red ash (*Alphitonia excelsa*), brush kurrajong (*Commersonia fraseri*), hard quandong (*Elaeocarpus obovatus*), guioa (*Guioa semiglauca*), grey myrtle (*Backhousia myrtifolia*) and lilypily (*Acmena smithii*). Better quality examples of rainforest vegetation are present in several small patches in Newry State Forest in gully areas connected to major floodplain areas.

A majority of the Mixed Floodplain Forest (Map Unit 2) and Flooded Gum Open Forest (Map Unit 4) also supports a dense subcanopy of rainforest species with Eucalypt emergents. These areas support a suite of rainforest trees, shrubs and vines, however the presence of a mixed Eucalypt canopy suggest this community has closer affinities to moist sclerophyll forest types. Rainforest vegetation in the study area does not conform to recognised rainforest classification groups as described by Floyd (1990). Considering the degree of past disturbances from clearing, frequent fires and logging it is difficult to determine which sub-alliance as described by Floyd (1990) the rainforest vegetation in the study area has affinities to. It is likely that more than one sub-alliance may be represented, and separation of sub-alliances may be difficult due to complex integrations of these communities.

As a result of its scarcity, Lowland Rainforest is listed as an endangered ecological community under the *TSC Act*.

3.3.1.4. Swamp sclerophyll forests

Swamp communities occur in low-lying areas on water-logged soils adjoining creeks, wetlands and river flats. The better intact examples of swamp forest in the locality occur outside the study area, including Bellwood Swamp in Nambucca State Forest and east of the study area between Raleigh and the Kalang River, in particular vegetation traversed by South Arm Road. Several smaller remnants occur in the study area adjacent to the existing Pacific Highway and on private property adjoining the northern end of Newry State Forest. These communities are listed as EECs under the TSC Act.

Map Unit 6: Swamp Mahogany / Paperbark

This association occurs on Permian metasediments of the Bowra Creek soil landscape and peat accumulations on Holocene alluvial of the Clybucca soil landscape and is characteristic of the EEC ‘Swamp Sclerophyll Forest on Coastal Floodplains’ listed under the *TSC Act*.

This association often merges with moist forests and therefore may include a suite of mesophilic rainforest species in the understorey. Generally characterised by dense stands of broad-leaved paperbark (*Melaleuca quinquenervia*) and weeping bottlebrush (*Callistemon salignus*), in the mid to lower canopy but also occasionally present in the upper canopy. The canopy is dominated by swamp mahogany (*Eucalyptus robusta*) and to a lesser degree red mahogany (*E.resinifera*). Other indicative species include prickly-leaved paperbark (*Melaleuca styphelioides*) and snow-in-summer (*Melaleuca linariifolia*). The understorey varies according to the depth and duration of flooding. Areas subject to a high degree of water logging and persistent surface water frequently exhibit tall sedge (*Carex appressa*), common reed (*Phragmites australis*), swamp water-fern (*Blechnum indicum*) and saw-sedge (*Gahnia clarkei*). Drier sites include a higher diversity of understorey flora including native lassiandra (*Melastoma affine*), rough green wattle (*Acacia irrorata*), bleeding heart (*Omalanthus populifolius*), harsh ground-fern (*Hypolepis muellerii*), christella (*Christella dentata*), angled lobelia (*Lobelia alata*), and panicled goodenia (*Goodenia paniculata*).

Apart from a moderate abundance of *Lantana camara* in localised areas, this association is relatively free of invasive weed species. No weeds are present in highly water-logged areas subject to extended inundation.

Map Unit 7: Swamp Oak

Small fragments of this association are represented in the study area in areas subject to occasional inundation from brackish water and low-lying lands adjacent to tidal creeks. The majority of sites consist of small remnants retained along the edge of the existing Pacific Highway and in agricultural landscapes. This community is present along the edges of Warrell Creek, Deep Creek and the Nambucca River. Several larger remnants are present in agricultural land surrounding Raleigh and along the edges of the power easement at the northern end of the study area. Early stages of regeneration were noted at several sites were cattle have been removed in the Raleigh area.

Many areas have been historically cleared for agriculture resulting in this community being listed as an EEC, ‘Swamp Oak Forest on Coastal Floodplains’ under the TSC Act. This association often adjoins stands of mangroves and merges with other swamp and riparian forest types. The canopy is generally represented as monospecific stands of swamp oak (*Casuarina glauca*), although occasional paperbarks (*Melaleuca* spp.) may be present. The understorey varies according to the degree of disturbance, and the frequency and duration of flooding. In highly water-logged areas this comprises a sparse cover of sedges, rushes and reeds such as saw-sedge (*Gahnia clarkei*), slender twig-rush (*Baumea juncea*) and common reed (*Phragmites australis*). Sites with better drainage support fern and grass species such as harsh ground-fern (*Hypolepis muellerii*) and margined panic (*Entolasia marginata*).

Several areas adjacent to the existing highway have dense thickets of *Lantana camara* and other weeds such as wild tobacco (*Solanum mauritianum*) and cassia (*Senna pendula*) prevalent on disturbed edges. Sites on agricultural properties have dense cover of pasture grasses and weeds. Weeds are generally absent in very wet areas with surface water.

3.3.1.5. Wetlands

In general there are very few wetland areas in the study area, and consist only of several small wet areas generally in cleared or modified agricultural land. Several of the larger wetlands in the locality occur on river flats adjoining the Nambucca and Kalang River as well as Deep Creek and are often within or associated with wetlands listed under SEPP 14. ‘Freshwater Wetlands’ are listed as an EEC under the TSC Act.

Map Unit 8: Freshwater Wetland

Sites are characterised by macrophytes, mainly emergent sedges and rushes forming dense stands in shallow surface water and fringing habitats. Dominant species vary according to the frequency and duration of flooding, disturbance, depth of water, saline influences and soil substrates. These include species from the plant Genuses *Eleocharis, Cyperus, Baumea, Juncus* and *Schoenoplectus*. Native rush (*Phragmites australis*) and cumbungi (*Typha orientalis*) may also occur. Floating macrophytes occur in areas of deeper water include water primrose (*Ludwigia peploides* subsp. *montevidensis*), water lily (*Nymphaea* spp.), river buttercup (*Ranunculus inundatus*) and water-milfoil (*Myriophyllum* spp.).

Sites occurring in grazed paddocks often exhibit exotic pasture species such as South African pigeon grass (*Setaria sphacelata*), vasey grass (*Paspalum urvillei*) and carpet grass (*Axonopus affinis*). Areas inundated for long periods are generally free of exotic species.

3.3.1.6. Estuarine vegetation

Estuarine vegetation consists of narrow bands (1-5 m) of mangroves surrounding tidal creeks such as Newee and Deep Creek and large portions of the Kalang and Nambucca River foreshores. Mangrove communities are recognised for providing significant habitat for estuarine fish and are protected as important fish habitat under the *Fisheries Management Act 1991*.

Map Unit 9: Mangrove

This association occurs along banks of tidal estuaries subject to inundation by salt-laden water. Two species are represented, grey mangrove (*Avicennia marina*) and river mangrove (*Aegiceras corniculatum*). Understorey vegetation is generally absent, however in some areas a number of species associated with saltmarsh and swamp communities are present such as samphire (*Sarcocornia quinqueflora*), New Zealand spinach (*Tetragonia tetragonioides*) and saltwater couch (*Sporobolus virginicus*). Exotic species are generally absent from this community.

3.3.1.7. Modified communities

The long history of settlement and agriculture in the region has resulted in extensive clearing of remnant vegetation and the proliferation of cleared pastures with scattered trees and small fragments of regrowth.

Cleared grassland and introduced pasture

Cleared grassland and introduced pasture dominates the fertile alluvial soils, with the majority of these being associated with the floodplains of Warrell Creek and the Nambucca River in the south and Deep Creek and the Kalang River through the central and northern parts of the study area. These habitats contain limited remnant vegetation and are characterised by a low diversity of native plant species, albeit for scattered and isolated remnant trees and small fragments of native vegetation included planted windrows and gardens. Pastures are dominated by exotic species such as South African pigeon grass (*Setaria sphacelata*), vasey grass (*Paspalum* *urvillei*), carpet grass (*Axonopus affinis*), paspalum (*Paspalum dilatatum*), rhodes grass (*Chloris gayana*) and kikuyu (*Pennisetum clandestinum*).

Hardwood plantation

Even-aged stands of blackbutt (*Eucalyptus pilularis*) and flooded gum (*Eucalyptus grandis*) have been planted in two major areas comprising areas of private land between Newry State Forest and the Kalang River and near Upper Warrell Creek. These areas are traversed by the Proposal. The understorey contains a mix of native and exotic species including *Lantana camara*.

Softwood plantations

This vegetation type occurs as narrow strips within farmland properties near the corner of Rosewood Drive and Alberts Drive in the Warrell Creek section. The dominant species is the exotic slash pine (*Pinus elliottii*). The understorey is generally dominated by exotic grasses and herbs.

3.3.1.8. Vegetation communities surrounding the study area

Scribbly Gum / Bloodwood open forest

This community type is generally positioned in elevated areas in similar locations to the Dry blackbutt dominated communities, although on poorer soils. The largest stands in the study area were located on the ridgelines in the centre of the Nambucca State Forest and the forested portion just to the south. This community exhibits a generally young age structure as a result of the removal of blackbutt in most locations, although there appears to be areas containing larger and more mature trees outside the State Forest boundary. Scribbly gum (*Eucalyptus signata*) dominates this forest type with scattered individuals and small stands of both blackbutt (*Eucalyptus pilularis*) and red bloodwood (*Corymbia gummifera*). The community merges into both the blackbutt (*Eucalyptus pilularis*) dominated communities and the open forest dominated by smooth-barked apple (*Angophora costata*). The understorey typically comprises numerous shrub species, particularly wattles (*Acacia* sp.).

Coastal Saltmarsh

Saltmarsh is the most highly restricted community recorded in the local area and is limited to small patches and isolated pockets. Occupying tidal areas generally on the landward side of mangrove communities it is restricted to areas of both the Kalang and Nambucca Rivers and some of the lower portions of their associated tributaries. The saltmarsh patches are characterised by species including samphire (*Sarcocornia quinqueflora*), New Zealand spinach (*Tetragonia tetragonioides*) and saltwater couch (*Sporobolus virginicus*). Coastal Saltmarsh communities are listed as an EEC under the TSC Act.

3.3.2. Species diversity

In total, 590 different plant species from 132 families were identified during field investigations along the Study area. This total comprises 166 species of monocotyledon, 390 species of dicotyledons, 27 fern species, two cycad species and three conifer species. Included in this total are two threatened species, two RoTAP species and five species which are considered to be regionally significant in the local area. Exotic species are dominant along roadsides, cleared paddocks and areas of disturbed vegetation. Of the 590 flora species recorded, 99 (17 per cent) are introduced species, and the remaining 83 per cent are native species indigenous to the local area. The complete list of flora recorded in the study area is provided in **Appendix D**.

3.3.3. Introduced species

Introduced flora species are generally dominant along disturbed roadsides, cleared paddocks and areas of disturbed vegetation. A high abundance of *Lantana camara* is present in some areas of intact bushland, particularly along creeks and in depressions where soil moisture and fertility are higher. Introduced species were generally absent in intact areas of dry sclerophyll forest, although a low-medium abundance of *Lantana camara* is present in some areas particularly where there has been disturbance from logging and grazing. Of the 995 introduced flora species recorded in the study area, nine of these are declared noxious weeds in the control area of Nambucca, these are listed below in **Table 3-3**.

- **Table 3-3: Declared noxious flora species recorded in the study area**

Noxious species	Noxious class and legal requirements
Ageratina adenophora (crofton weed)	Class 4 -The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority
Baccharis halimifolia	Class 3 -The plant must be fully and continuously suppressed and

(groundsel bush)	destroyed
Chrysanthemoides monilifera subsp. *rotunda* (bitou bush)	Class 4 -The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority
Cinnamonum camphora (camphor laurel)	
Lantana camara (lantana)	
Ligustrum sinense (small-leaved privet)	
Rubus fruticosus (blackberry)	
Salvinia molesta (salvinia)	Class 3 -The plant must be fully and continuously suppressed and destroyed
Senecio madagascariensis (fireweed)	Class 4 -The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority

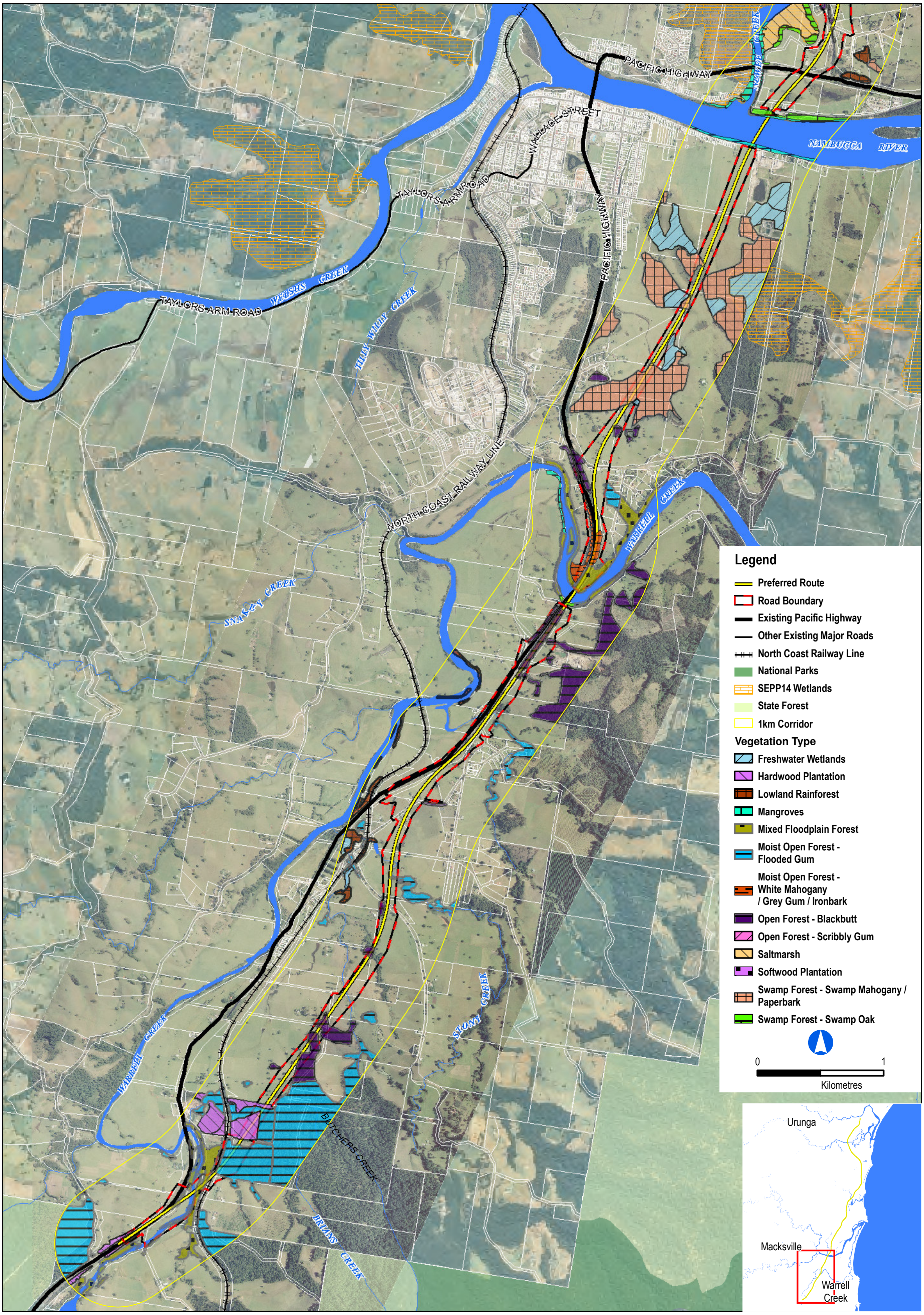

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Figure 3-7 : Vegetation Communities

GDA 94 MGA Zone 56

Warrell Creek to Urunga - Upgrading the Pacific Highway

June 2, 2009

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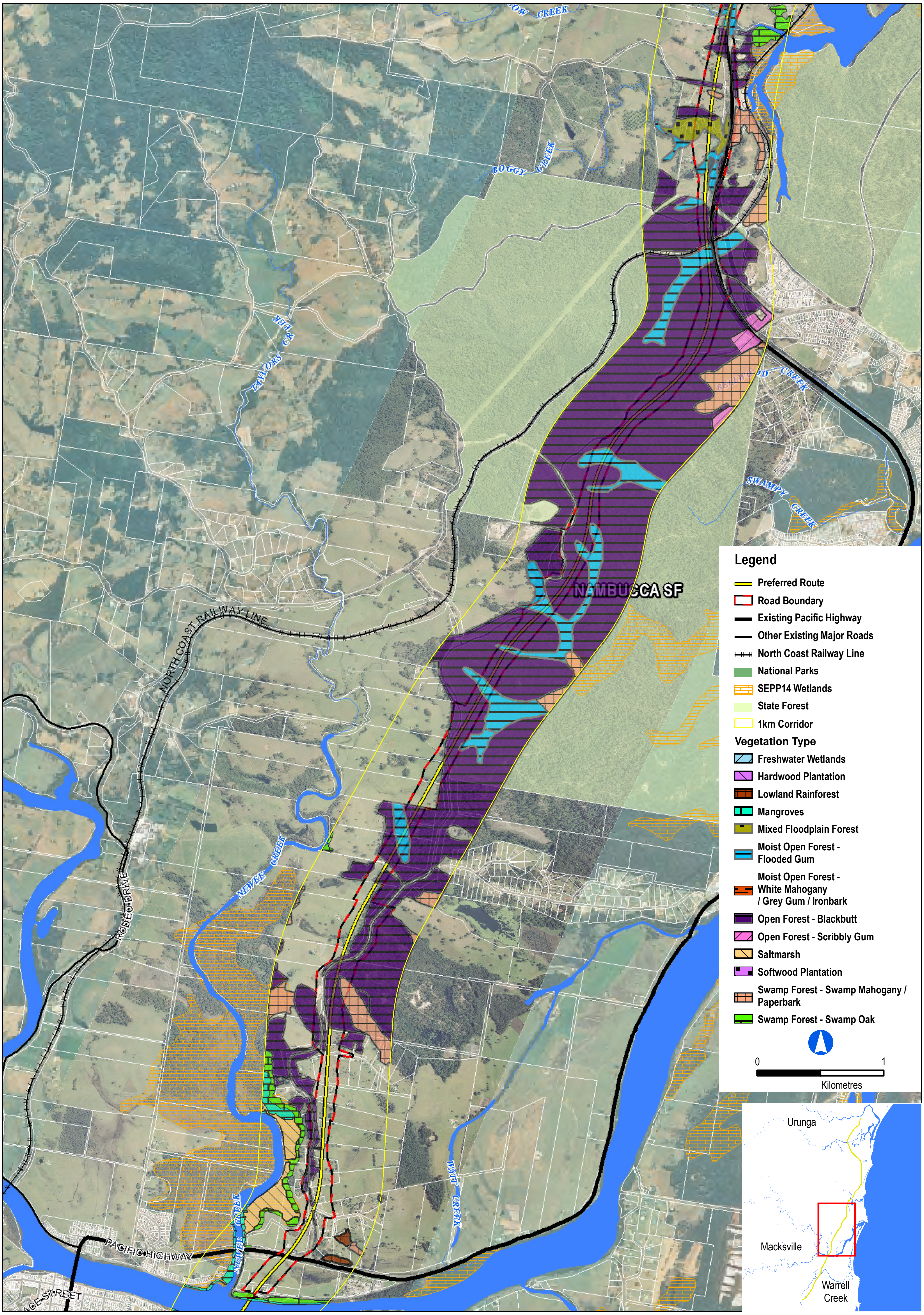

Figure 3-8 : Vegetation Communities

GDA 94 MGA Zone 56

Warrell Creek to Urunga - Upgrading the Pacific Highway

June 2, 2009
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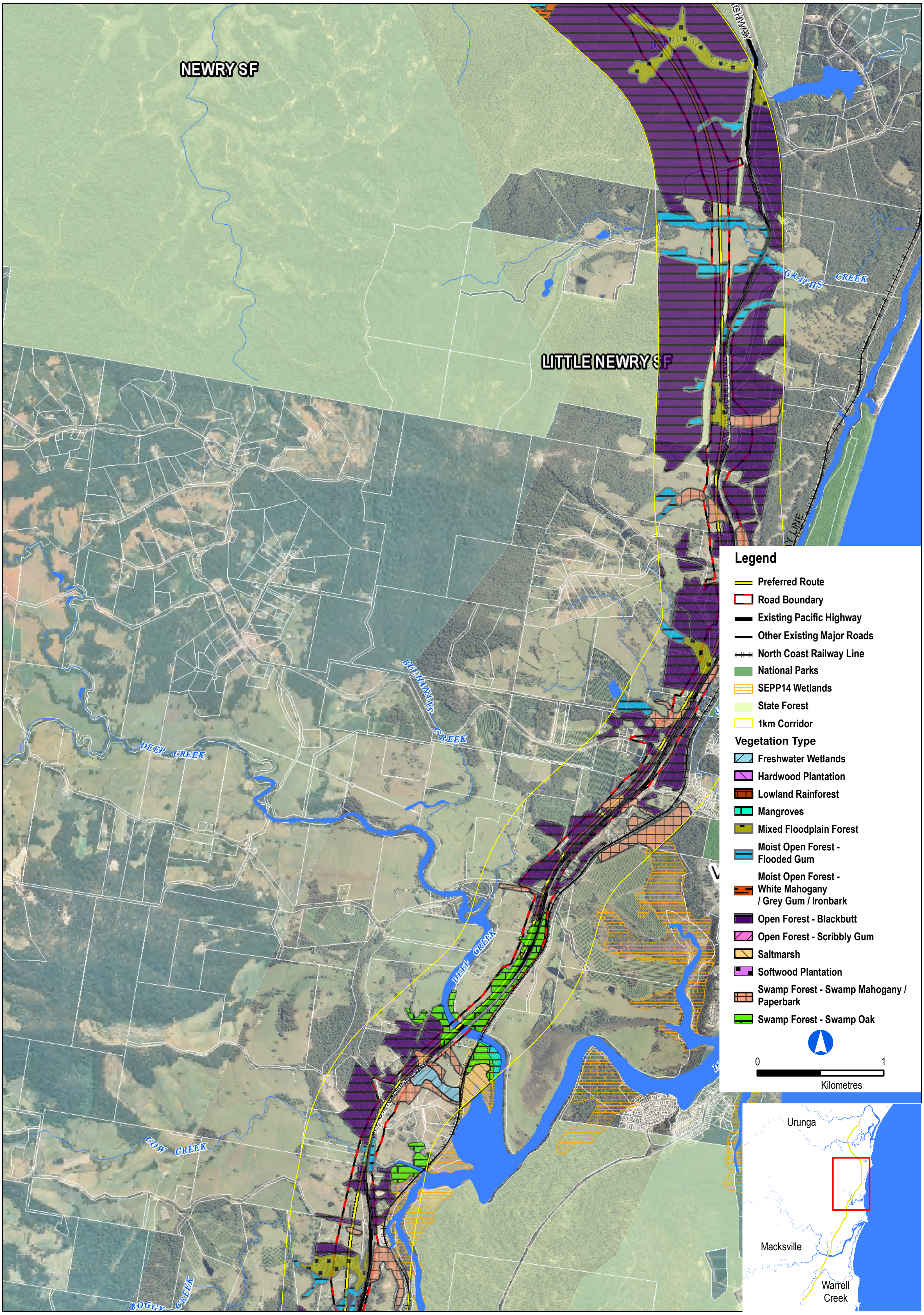

Figure 3-9 : Vegetation Communities

GDA 94 MGA Zone 56

Warrell Creek to Urunga - Upgrading the Pacific Highway

June 2, 2009

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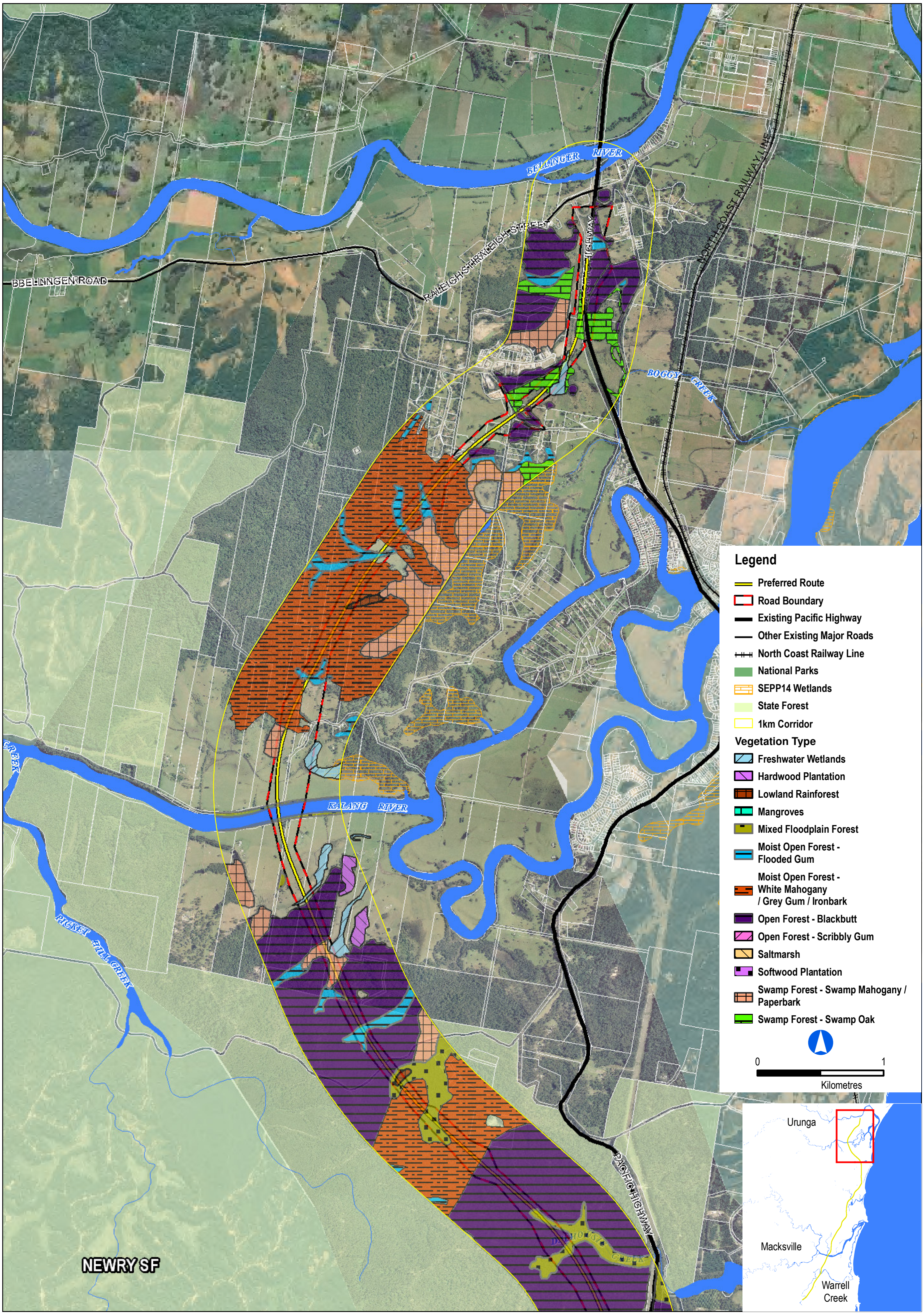

Figure 3-10 : Vegetation Communities

GDA 94 MGA Zone 56

Warrell Creek to Urunga - Upgrading the Pacific Highway

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3.4. Vertebrate fauna

3.4.1. Habitats

Five fauna habitat types are represented in the study area in association with the structural vegetation types described above, these include:

- Dry open forests.
- Moist forests.
- Swamp forests.
- Freshwater aquatic and estuarine habitats.
- Modified habitats.

These are presented in **Figures 3-11** to **3-14.**

3.4.1.1. Dry open forests

Dry open forest habitats are proportionally well represented in the study area occupying approximately 144 ha of the proposed impact area and consist of blackbutt Open Forest (MU1) described above. These are largely contained in Nambucca, Newry and Little Newry State Forests although also on privately owned lands north of the Kalang River up to the Raleigh industrial estate. All dry forest habitats represented in the corridor have been modified and degraded to differing degrees as a result of logging and altered fire regimes. Other associated disturbances include grazing and track formation leading to localised erosion and weed invasion.

As a result of the large extent of dry forest habitat present in the locality there is a range of microhabitat features present including shelter and food resources capable of supporting breeding populations and refuge for a diversity of sedentary and transient fauna including several listed threatened species. Of particular importance is the diversity of canopy plant species which provide seasonal food and shelter resources for nectarivorous and foliovorous birds and mammals. Additional features of importance include varying densities of logs and dense understory providing sheltering and breeding opportunities for reptiles and small to medium sized ground dwelling mammals.

There is a general lack of senescence typically represented in the dry forest habitats of the study area resulting from a long history of logging and fire. This has reduced the habitat value to a degree particularly the habitat structure and scarcity of tree hollows resulting in fewer nesting and sheltering opportunities for hollow-dependent fauna.

The dry open forests support species rich populations of birds (i.e. 70 species) represented from several families dominated by cockatoos, parrots, cuckoos, honeyeaters, thornbills, whistlers and allies. Other fauna represented within this habitat type included 28 mammal species, dominated by rodents, microchiropteran bats, gliders and possums, and 13 reptile species dominated by skinks. Diversity and abundance was disproportional across different open forest sites and reflected the degree of disturbance, particularly fire frequency and intensity experienced in the study area.

3.4.1.2. Moist forests

Smaller linear fragments and regrowth moist forests occur in sheltered gullies and riparian areas and occupy approximately 15 per cent of the study area. Generally the moist forest habitats adjoin and merge with open forest habitats and as such the majority of fauna occurring in these areas would utilise both habitat types and are not exclusively linked to either. However, the moist forest habitats tend to exhibit a higher floristic diversity, density and structure and may comprise a greater percentage of food resources (i.e. fruits and nectar) which are particularly important for specialist fauna groups. Similarly a larger percentage of dead standing trees and mature trees with hollow cavities were found to occur in the moist gully sites where fire had been suppressed. As such hollow-dependent fauna may be more reliant on gully areas for shelter, breeding and refuge. In some instances these habitats were found in association with ephemeral creeks providing habitat for stream dwelling frog species. It is apparent that these moist forest habitats are limited in extent and provide essential habitat for a small range of threatened fauna species and as such are of high conservation value. Despite their smaller size the moist forest habitats were found to support a species rich assemblage of birds (i.e. 63 species) dominated by whistlers, bowerbirds, honeyeaters, scrub birds and thornbills. Other fauna represented included 26 mammal species mostly microchiropteran bats, possums, gliders and bandicoots, 11 species of frogs dominated by stream-dwelling species and 11 reptile species predominantly skinks and snakes (elapids).

3.4.1.3. Swamp forests

Swamp forest habitat refers to the vegetation retained or established in low-lying areas adjoining creeks, wetlands and rivers. Along the study area, the best-preserved areas of swamp forest occur around the lower reaches of creeks and as small fragments on the floodplains. The dominant species vary from individual stands of one tree species to combinations of species which may include swamp mahogany, red mahogany, paperbarks or swamp oak. The swamp forest habitats are generally characterised by high structural diversity and provide dense cover for ground-dwelling mammals and birds. Swamp mahogany is a winter flowering eucalypt and important food resource for nectarivorous fauna. Other important habitat features present include large trees, tree hollows and logs, and persistent surface water in poorly drained areas providing important refuge habitat for frogs. The swamp forests support the most species rich populations of frogs (i.e. 14 species) represented by both ground-dwelling and tree frogs. Other fauna represented included 28 bird species, mainly small cover-dependent birds such as wrens and thornbills, 11 species of mammals and six reptile species.

3.4.1.4. Freshwater aquatic and estuarine habitats

Permanent and ephemeral creeks, freshwater wetlands and farm dams provide valuable habitat dependent fauna and often represent significant features in the landscape, particularly in modified agricultural and floodplain landscapes. Such areas provide important habitat for frogs, some reptiles and several common wader and waterbird species and can exhibit a comparatively species rich habitat despite their small size and often isolated locations. Riparian and estuarine habitats may also provide important fauna movement corridors and refuge during fire and drought events.

The Proposal crosses the Nambucca River in the south and the Kalang River in the north. These river channels provide significant estuarine fauna habitats including open water, intertidal sandflats, sandy shores and oyster leases and provide important habitat for bird groups such as waders, waterfowl, cormorants, pelicans, herons, oystercatchers and their allies. This includes the osprey (*Pandion haliaetus)*, a threatened raptor that requires extensive areas of open water for fishing, frequenting fresh and saline habitats and adjacent coastal forests with tall trees for nesting. Several osprey nest sites were recorded on the Nambucca and Kalang River floodplains across the study locality. Fauna represented in freshwater and aquatic habitats included 19 species of birds, 10 frog species and four reptile species.

3.4.1.5. Modified habitats

Modified fauna habitats comprise former forested communities that have been cleared for grazing and subsequently exist as grassy paddocks with small isolated fragments of disturbed tree cover. Such open habitats provide few important habitat features for fauna and generally comprise lower faunal diversity as a result of the degree of disturbance. In general, these areas lack significant vegetation or habitat for threatened species and are dominated by common and introduced fauna, particularly those tolerant of modified landscapes. Although the value of isolated mature remnant trees has been documented previously in terms of their ability to provide food and sheltering resources for mobile fauna species (Law *et al* 2000), these features particularly large dead trees, are often selected as preferred nest sites for raptors including the threatened osprey (Clancy 1991) as a result of their absence from forest habitats.

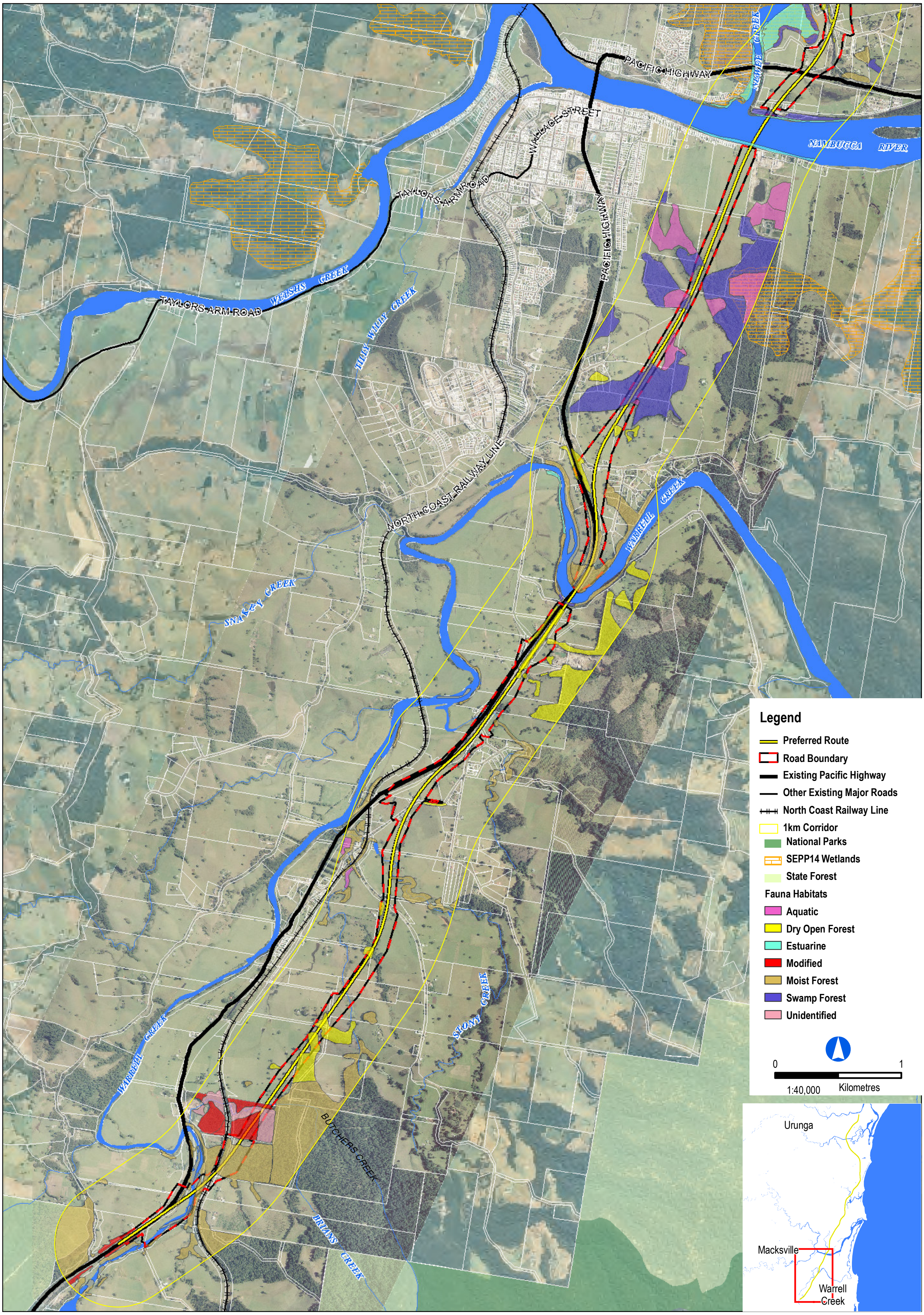

Figure 3-11 : Fauna Habitats

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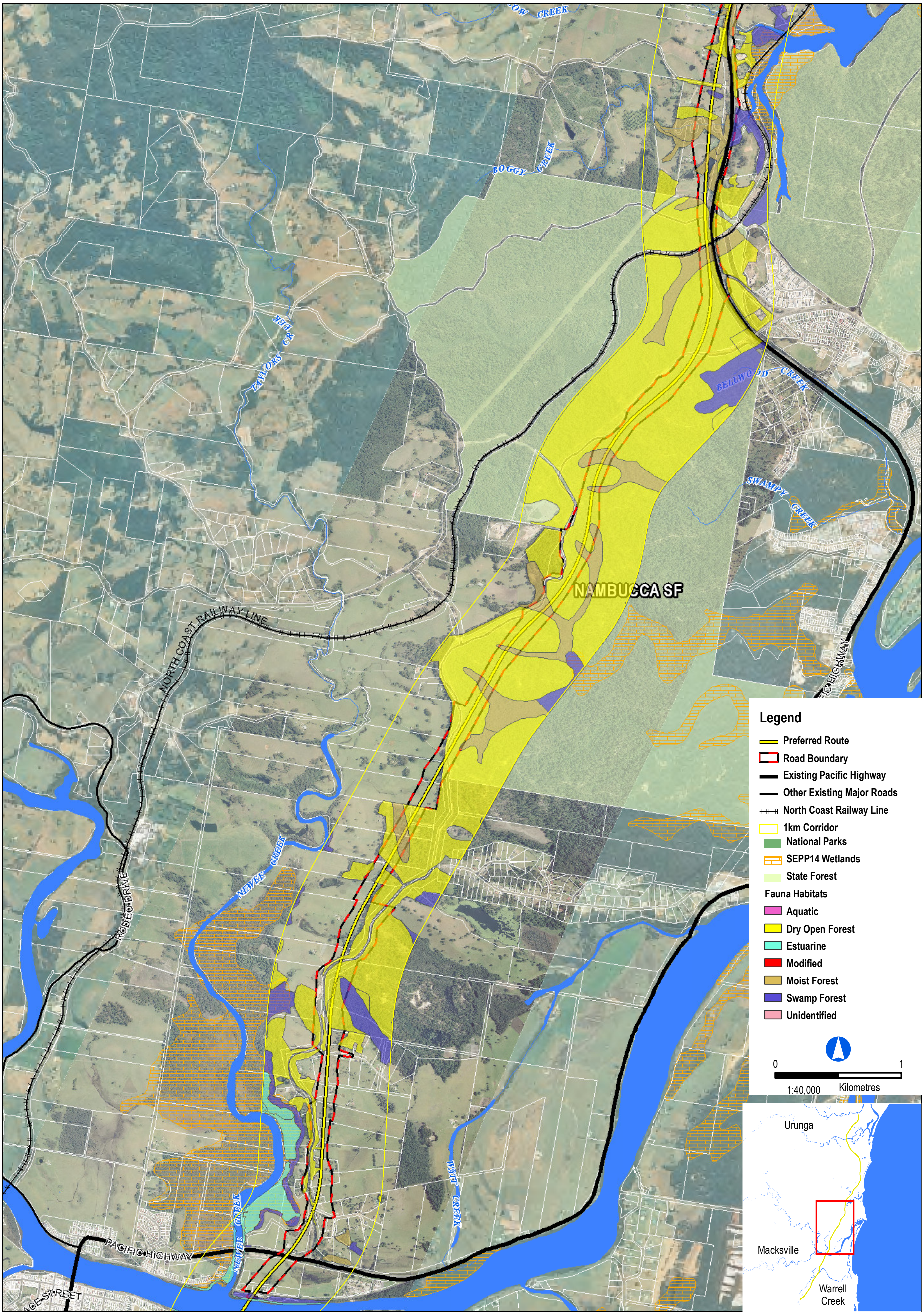

Figure 3-12 : Fauna Habitats

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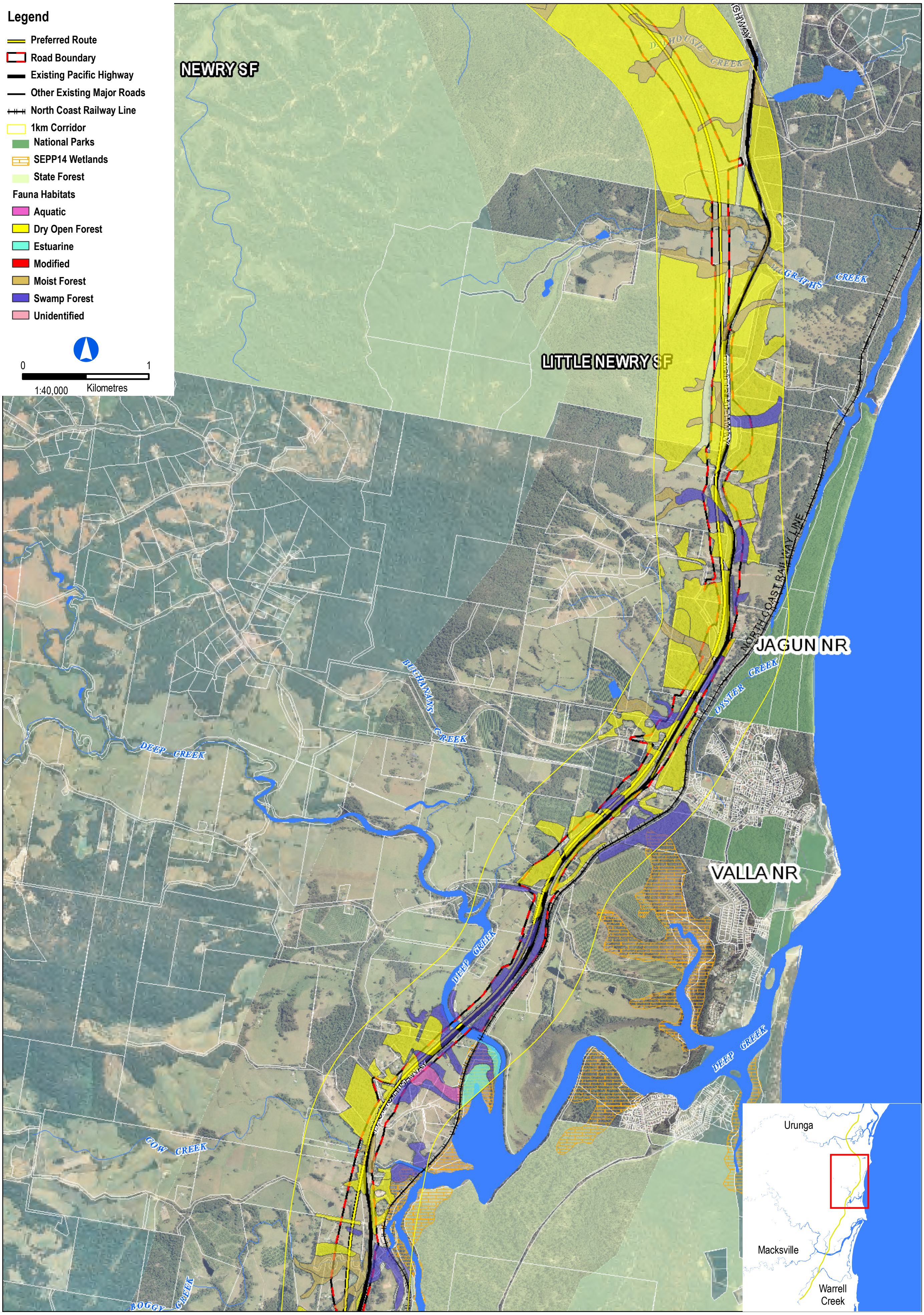

Figure 3-13 : Fauna Habitats

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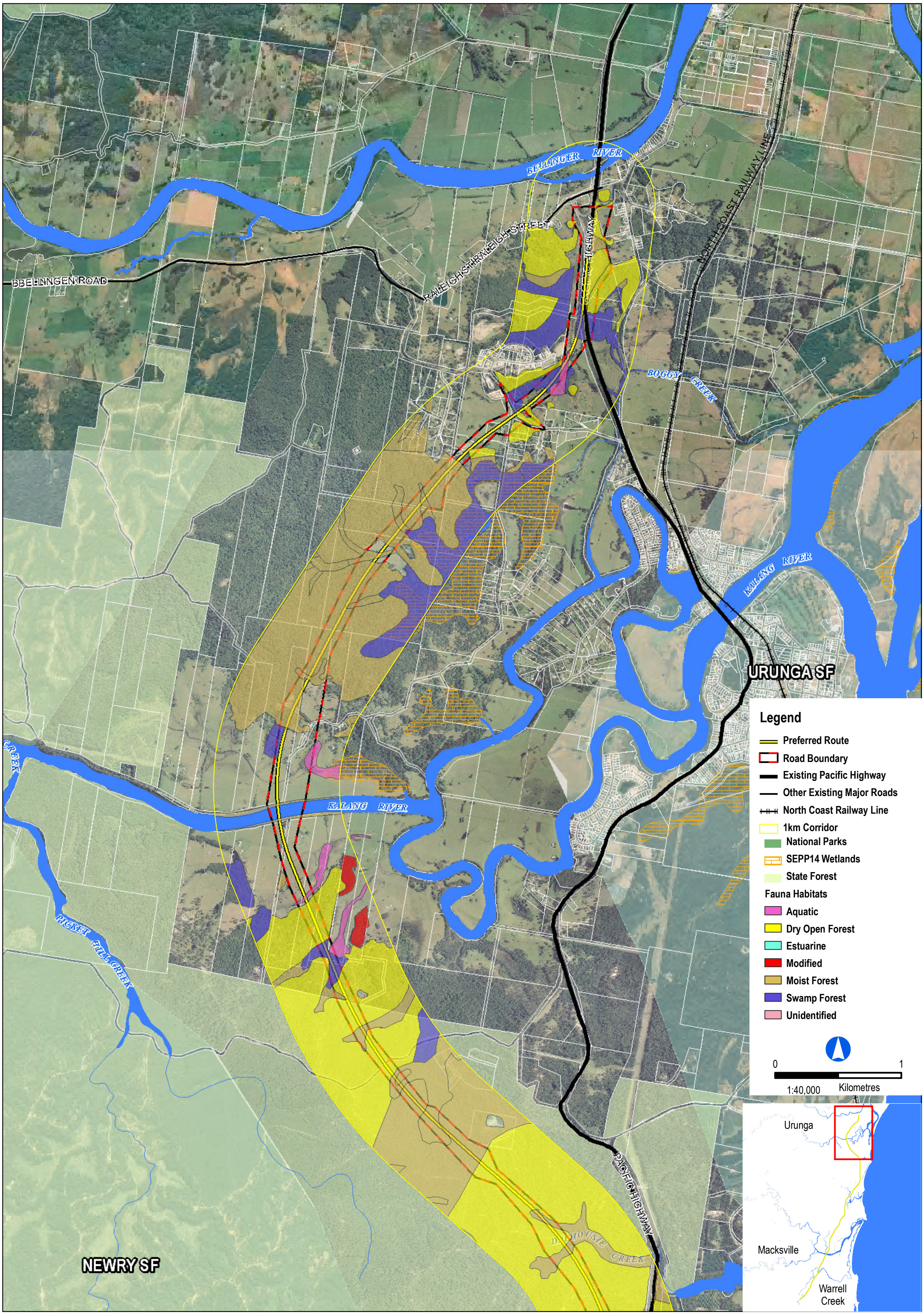

Figure 3-14 : Fauna Habitats

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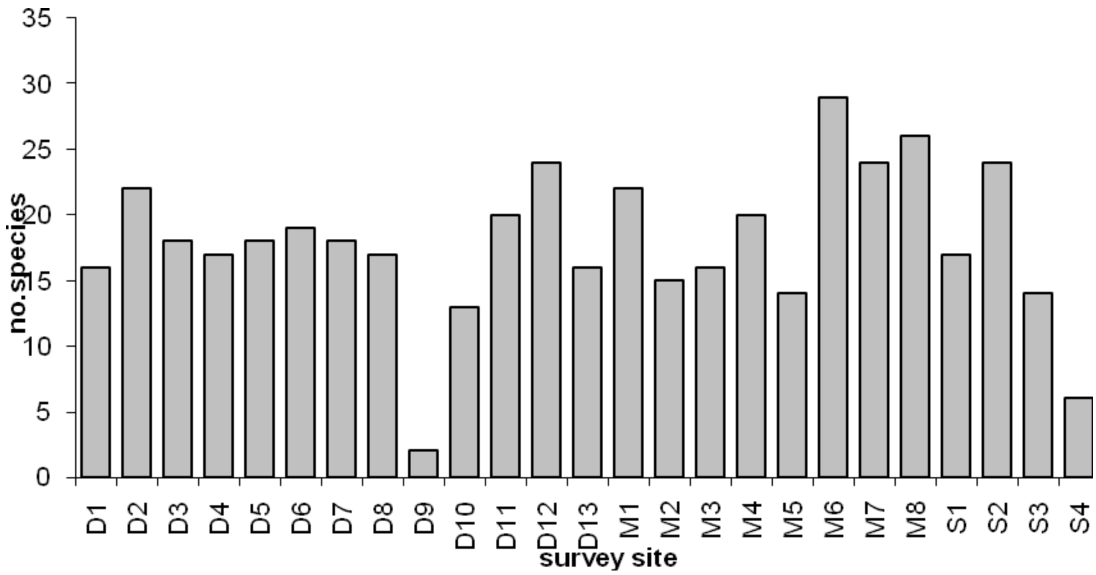
3.4.2. Species diversity

A total of 203 fauna species were recorded in the study area, comprising 125 bird, 36 mammal, 24 reptile and 18 amphibian species. The list of species identified is provided as **Appendix F**. Additional threatened species expected to occur in the study area have been included in the list based on a review of records from the DECCW Atlas of NSW Wildlife and other ecological reports and knowledge of the habitats represented.

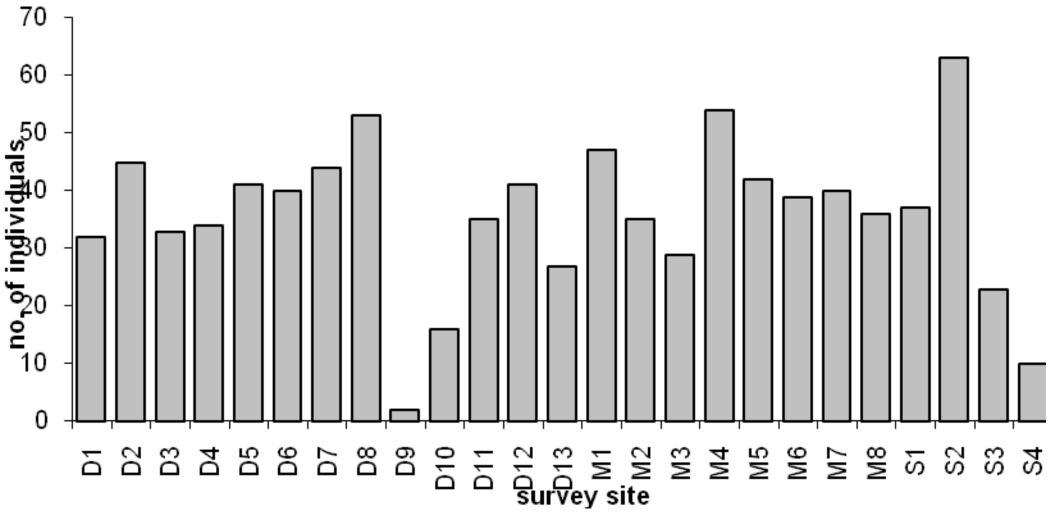
Mammal and bird species richness was found to be slightly higher at sites in moist forest habitats (mean 20.8 ±SE) then dry forest (16.9±SE) and swamp forest (15.3±SE). This may be attributed to the higher floristic and structural diversity and greater number of mature trees and tree hollows through favourable soil moisture conditions and fire suppression. The most species rich sites included tall moist forest sites adjacent to Macksville Golf Course (M6) and in Nambucca State Forest (M8) and swamp forest habitat near South Arm Road (S2) and dry forest habitat on private land north of the Kalang River (D12) (refer **Figure 3-15**).



- **Figure 3-15: Species richness for mammals and birds at replicate sites (D=dry forest sites; M=moist forest sites; S=swamp forest sites).**

The abundance of mammals and birds recorded was also slightly higher in the moist forest habitats (mean 40.3±SE) then dry forest habitat (34.1±SE) and swamp forest (mean 33.3±SE). The highest abundance was recorded in a large fragment of moist forest (5-100 ha) with rainforest elements on the Nambucca River floodplain (M9) followed by swamp forest near

South Arm Road (S2) and private property between Newry State Forest and the Kalang River (M4) (refer **Figure 3-16**).



- **Figure 3-16: Abundance of mammals and birds at replicate sites (D=dry forest sites; M=moist forest sites; S=swamp forest sites).**

3.4.2.1. Ground-dwelling mammals

The ground mammal trapping effort yielded a total of 119 captures identifying six mammal species (four native and two introduced) (**Table 3-4**). One additional ground-dwelling species, the long-nosed bandicoot (*Perameles nasuta*) was not trapped although confirmed via spotlighting in dry and moist sclerophyll habitats.

- **Table 3-4: Small mammal trapping results**

Species	DSF	SSF	MSF	No.ind	%
Bush rat (*Rattus fuscipes*)	35	9	16	60	50.4
Brown antechinus (*Antechinus stuartii*)	18	2	13	33	27.7
Fawn-footed melomys (*Melomys cervinipes*)	9	1	7	17	14.3
Black rat (*Rattus rattus**)	1	0	4	5	4.2
House mouse (*Mus musculus**)	2	0	1	3	2.5
Northern brown bandicoot (*Isoodon macrourus*)	1	0	0	1	0.8
Total captures	**66**	**12**	**41**	**119**	**100.0**
Per/habitat (%)	**55.5**	**10.1**	**34.5**		

*introduced species

In general the survey yielded a low to moderate trap success rate, expressed as a percentage of 8.2 animals for every 100 trap nights. Trapping success was closely correlated with ground cover, in particular sites comprising a density of fallen trees, leaf litter, shrubs and/or rocks rather than habitat type. This was evident at sites D5, M2, D7 and S2 which recorded the highest capture rates for small mammals. Moist habitats with dense ground cover and abundant logs were favoured by fawn-footed melomys (*M.cervinipes*). Sites with apparent longer fire intervals were favoured by the northern brown bandicoot (*Isoodon macrourus*), whereas bush rat (*Rattus fuscipes*) were found across all sites regardless of fire history. Small mammals were only captured at 16 of the 25 trap sites (64 per cent) which may be a reflection of the lack of ground cover at some sites in the form of low vegetation and logs resulting from high fire frequency, or physical removal of understorey and grazing and high levels of disturbance.

Macropods were considered scarce, with only two species recorded, the swamp wallaby (*Wallabia bicolor*) and eastern grey kangaroo (*Macropus giganteus).* Swamp wallabies were observed in forested habitats, mainly swamp and wet forests near open paddocks. Diggings and scats attributed to the echidna (*Tachyglossus aculeatus*) were observed at several dry sclerophyll forest sites.

3.4.2.2. Arboreal mammals

The tree-trapping, spotlighting and scat search methods recorded a total of seven arboreal mammal species (**Table 3-5**). The diversity of arboreal mammals was highest in dry open forest (n=5), followed by moist forest (n=4) and swamp forest (n=2). Higher diversity was associated with a greater density of mature trees and tree hollows as well as larger continuous habitat in the State Forests rather than smaller isolated fragments of habitat located on the floodplain. The richness of arboreal mammal species along the study area is probably a reflection of the diversity of Eucalypt species present, which provide an abundance of habitat resources (seasonal nectar, foliage and insect abundance).

- **Table 3-5: Arboreal mammal identifications**

Species	DSF	SSF	MSF	No. ind
Common brushtail possum (*Trichosurus vulpecula*)	0	4	0	**4**
Short-eared possum (*Trichosurus caninus*)	0	0	3	**3**
Common ringtail possum (*Pseudocheirus peregrinus*)	1	0	0	**1**
Yellow-bellied glider (*Petaurus australis*)	2	0	2	**4**
Sugar glider (*Petaurus breviceps*)	4	0	1	**5**
Feathertail glider (*Acrobates pygmaeus*)	2	0	2	**4**
Koala (*Phascolarctos cinereus*)	1	1	1	**3***
Total	**10**	**5**	**7**	**22**

*identified from scats

Yellow-bellied gliders (*Petaurus australis*) were reported in low abundance at one site only, associated with a moist forest gully and adjacent drier slopes near Bellwood Forest Drive in Nambucca State Forest. Scats of the koala (*Phascolarctos cinereus)* were collected in Nambucca State Forest, the west of the railway line outside the road corridor.

3.4.2.3. Bats

The total number of microchiropteran bat species recorded using a combination of both techniques is 16 species from three genera. This included nine species positively identified from 25 captures (**Table 3-6**) and additional seven species identified from call analysis (**Table 3-7**).

All species captured were members of the family Vespertilionidae, and are predominantly tree-roosting species which are dependent on hollow cavities in trees for shelter and breeding. The Eastern and little bentwing-bat are predominantly recorded roosting in caves and tunnels (Churchill, 1998) although the latter has also been recorded roosting in tree hollows (Schulz, 1997). Artificial structures such as farm sheds may provide temporary roost sites for bats.

- **Table 3-6: Results of bat trapping survey**

Species	DSF	MSF	SSF	Total
Southern forest bat (*Vespadelus regulus*)	2	4	-	6
Eastern broad-nosed bat (*Scotorepens orion*)	-	4	-	4
Gould's long-eared bat (*Nyctophilus gouldii*)	-	2	1	3
Eastern forest bat (*Vespadelus pumilus*)	-	3	-	3
Little forest bat (*Vespadelus vulturnus*)	2	-	-	2
Large forest bat (*Vespadelus darlingtoni*)	-	2	-	2
Lesser long-eared bat (*Nyctophilus geoffroyi*)	1	-	-	1
Eastern bentwing-bat (*Miniopterus schreibersii oceansis*)	1	-	-	1
Chocolate wattled bat (*Chalinolobus morio*)	-	1	-	1
No.individuals	**6**	**16**	**1**	**23**

The distribution of bat captures was primarily a function of the presence of better quality trap sites in moist forest habitats due to the closed canopy along narrow tracks and does not accurately reflect the distribution of roosting and foraging habitat for bats. The use of bat call detectors indicated that activity is more evenly distributed across the study area with bats recorded at all sites particularly near water and open areas adjoining forest.

Recording of bat calls resulting in the collation of 1,110 calls of which approximately 40 per cent were of sufficient quality to analyse. The residual calls were either too short in sequence, non-search phase calls (i.e. feeding buzzes, excited or social calls) or influenced by insect noises. The analysis resulted in positive identification of 6 species including calls of a long-eared bat (*Nyctophilus* spp). Calls attributed to the genus *Nyctophilus* cannot be separated from the species *N. geoffroyi* or *N. gouldii*. However, both species were captured using harp traps and presence is therefore confirmed. Call recordings of a further four probable species were tentatively identified on the basis of close similarities between call structure and frequency and the difficultly associated with separating species (refer **Table 3-7**), this particularly the case for species in the Genus *Scotorepens*, *Falsistrellus*, *Scoteanax* and *Vespadelus.*

- **Table 3-7: Bat species recorded by ultrasonic call recording**

Species	DSF	MSF	SSF
Eastern freetail-bat (*Mormopterus* sp 2)	De	De	Pr
White-striped freetail bat (*Tadarida australis*)	De	-	-
Little bentwing-bat (*Miniopterus australis*)	-	Pr	-
Long-eared Bat (*Nyctophilus* spp.)	De	De	-
Gould's wattled bat (*Chalinolobus gouldii*)	De	De	Po
Yellow-bellied sheathtail-Bat (*Saccolaimus flaviventris*)	-	De	-
Greater broad-nosed Bat (*Scoteanax ruepellii*)	Po	-	-
Eastern false pipistrelle (*Falsistrellus tasmaniensis*)	Po	Po	-
Eastern broad-nosed bat (*Scotorepens orion*)	Pr	Pr	-
Forest bat (*Vespadelus* spp.)	De	De	-
Eastern forest bat (*Vespadelus pumilus*)	Pr	Pr	-
Little forest bat (*Vespadelus vulturnus*)	Pr	Pr	-

Key. De – Definite identification, Pr – Probable identification, Po – Possible identification

As mentioned previously, the bat assemblage comprises both tree-roosting and cave-roosting species, the latter including the little bent-wing bat *(Miniopterus australis)* and large bent-wing bat (*Miniopterus australis*). The cave roosting species inhabit a wide variety of caves and mines (Churchill 1998), which may include abandoned shafts and buildings. No potential cave roosting habitats were identified along the study area.

One megachiropteran species, the grey-headed flying-fox *Pteropus poliocephalus* was recorded during spotlighting surveys in dry and swamp forest habitats. Foraging habitat for this species is widespread and no roosting colonies have been identified in the study area.

3.4.2.4. Birds

A total of 125 bird species were recorded, representing moderately high species richness. This richness can be attributed to the size of the study area, diversity of habitats available, topographic variation and floristic diversity. The diversity of habitats present provides sufficient shelter, foraging and breeding resources to support several bird groups and provides significant refuge given the extent of clearing which has occurred throughout the floodplain.

The dominant bird groups noted included nectarivores and foliage insectivores, also present were granivores, diurnal and nocturnal raptors, aerial foragers and several waterfowl. Lorikeets (*Psitticidae*) and honeyeaters (*Meliphagidae*) were particularly abundant. Several common birds were recorded as widespread and abundant in all forest habitats and could be considered generalists this included the grey fantail, spotted pardalote, striated thornbill, golden whistler, noisy miner, yellow-faced honeyeater and scarlet honeyeater. The eastern whipbird, black-faced monarch and eastern yellow robin were also common although restricted to moist forest habitats. Single observations were made of the black-necked stork, powerful owl, rufous fantail, grey goshawk, square-tailed kite and wompoo fruit-dove.

Several birds present are of conservation significance in NSW, these include the black-necked stork , powerful owl, square-tailed kite, wompoo fruit-dove, glossy black-cockatoo and osprey. More information on the distribution and abundance of these species is provided later in the report. A number of nocturnal bird species were recorded from dry and moist forest habitats including the Australian owlet nightjar, tawny frogmouth, southern boobook and powerful owl. These nocturnal species roost predominantly in tree hollows, although may also roost in dense foliage.

3.4.2.5. Reptiles and amphibians

A total of 24 reptile species were recorded from the field surveys in the study area. All reptiles identified are considered common and widespread species in eastern NSW. The reptile diversity was dominated by skinks (Family Scincidae) representing 58 per cent of the total species. Of these, a number of species are generalists found in a variety of forested habitats with an adequate cover of trees, leaf litter and logs. This includes *Cryptoblepharus virgatus, Lampropholis delicata, Ctenotus robustus, Egernia striolata* and *Egernia major.* Lace monitors (*Varanus varius)* were widespread and abundant throughout all forested habitats and eastern water dragons (*Physignathus lesuerii)* were restricted primarily to the dam and creek habitats on the floodplain.

A total of 18 frog species were recorded across all habitat types. The most widespread and abundant species were associated with the Family Hylidae (tree-frogs) and included the eastern dwarf tree frog (*Litoria fallax*), Tyler’s tree frog (*L.tyleri*) and Peron’s tree frog (*L.peroni*).

These species were found occupying a greater diversity of habitats then all other species ranging from flowing creeks to farm dams, flooded soaks in wet paddocks and the dry fringes of swamps. In contrast, several ground-dwelling frogs (Family: Myobatrachidae) were also common although more restricted in distribution occupying creeks, pools, dams and swamps. These included great barred frog (*Mixophyes fasciolatus*), rocket frog (*L.nasuata*), revealed frog (*L.revelata*) and red-backed toadlet (*Pseudophryne coriacea*).

3.4.3. Introduced species

Seven introduced vertebrate fauna species were identified, consisting of 3 bird and 4 mammal species. The most abundant species recorded were the black rat (*Rattus rattus*) in both dry and moist forest habitats. Conversely house mouse (*Mus musculus*) were very scarce. Red fox (*Vulpes vulpes*) and rabbit (*Oryctolagus cuniculus)* were generally associated with farm land and disturbed riparian areas. Introduced birds included spotted turtle-dove (*Streptopelia chinensis*), common myna (*Acridotheres tristis*) and common starling (*Sturna vulgaris*). These were most commonly found near small farmland remnants and isolated trees.

3.5. Freshwater waterways

The following section summarises the results of the fish and macroinvertebrate sampling program undertaken in freshwater ecosystems associated with the Proposal. A description has been provided on each site based on the methods provided in Anderson (1993). The location of each site is depicted in **Appendix J.**

3.5.1. Butchers Creek

Butchers Creek is located in the southern most end of the Warrell Creek section originating off Mount Yarrahapinni. Butchers Creek flows into Warrell Creek just north of the southern Warrell Creek crossing of the Pacific Highway. Two sites were sampled at Butchers Creek.

3.5.1.1. Butchers Creek upstream the Proposal (Site W2a)

Site W2a, Butchers Creek is located upstream of the Pacific Highway, at Easting 489895, Northing 6594912 (**Plate 3-1**). Butchers Creek was sampled approximately 500 metres upstream of the Pacific Highway crossing. Butchers Creek was at a very low level at the time of sampling consisting of dry channels with a few deep pools containing water. The channel pattern was irregular with significant bank erosion and undercutting at meanders indicating a prominent flood channel. Adjacent landuse was cattle grazing and forestry. The vegetation in the area was pasture grass with dense stands of native trees. The overall disturbance rating for Site W2a according to the Anderson Riverine Habitat Audit Procedure was 'moderate disturbance'. Backpack electro-fishing was used at this site to sample fish populations. In addition, five bait traps and one fyke net were set overnight at this location. Aquatic macrophytes at this site included Water Ribbons *Triglochin procerum* and the filamentous alga *Spirogyra.*

- **Plate 3-1 Butchers Creek upstream**

3.5.1.2. Butchers Creek downstream of the Proposal (Site W2b)

Site W2b, Butchers Creek is located downstream of the Proposal at Easting **489761**, Northing **6594917** (**Plate 3-2**). The site was primarily a dry stream bed, located approximately 700 m upstream of the Pacific Highway crossing with a railway 200 m downstream of the site. The channel pattern was highly irregular ranging from a dry creek bed to approximately six metres depth. Land use in the adjacent area was forestry, with pockets of cattle grazing. The vegetation in the area was dense forest with introduced Lantana growing throughout the region. The overall disturbance rating for site W2b was 'moderate disturbance'. Backpack electro-fishing and macroinvertebrate sampling was used at this site. Five bait traps and one fyke net was set overnight at this location. No instream flora was present at this site, however the Spiny-headed mat-rush *Lomandra Longifolia* grew throughout the channel.

▪ **Plate 3-2 Butchers Creek downstream**

3.5.1.3. Butchers Creek ecology

Fish surveys were conducted at two sites in Butchers Creek on 16 and 17 July 2008. A total of six long finned eels were recorded from the two sites sampled in Butchers Creek with four eels recorded upstream and two recorded downstream. Far fewer species were recorded than were expected at the location; this may be due to the acidic (pH 4.65) and low dissolved oxygen concentrations at the site (34.2) (**Appendix L)**.

Macroinvertebrate sampling revealed that Butchers Creek had the lowest species richness of the five sites with nine taxa reported. The most abundant taxa were the Stick Caddis Caddisfly (*Leptoceridae*) followed by the Leptophleb Mayfly (*Leptophlebiidae*) and Small Water Striders (*Veliidae*) (see **AppendixM**).

The Observed to Expected Ratio (OE50) indicated that Butchers Creek had fewer taxa than expected if the site was within reference condition (OE50<1), receiving an AusRivAS band score of B, suggesting that the site was significantly impaired. Butchers Creek received an OE50 ratio of 0.61, indicating an impact upon water quality and/or habitat quality.

SIGNAL scores were used to assess the distribution of macroinvertebrate families that are considered to be sensitive to environmental disturbances weighted by their relative abundance (Chessman 1995, 2003). The SIGNAL scores are ranked from 1 to 10 based upon the macroinvertebrate family's sensitivity to environmental disturbance, where 1 is the least sensitive and 10 is the most sensitive.

The most sensitive taxa recorded at Butchers Creek were the Leptophleb Mayfly nymphs (*Leptophlebiidae*), with a SIGNAL score of 8. Leptophlebiidae consume detritus in a variety of habitats, including slow flowing waters such as those found at Butchers Creek (Gooderham &

Tsyrlin 2002). The Stick Caddis Caddisfly (*Leptoceridae*) was the next most sensitive taxa (SIGNAL score 6) which were found in similar densities throughout the lower Warrell Creek locations (Butchers Creek and Stony Creek). The SIGNAL score for Butchers creek was 4.22 indicating moderate pollution.

Several water quality results reported were outside the ANZECC/ARMCANZ (2000) trigger values, which may have contributed to the SIGNAL classification of 'moderate pollution' and 'significantly impaired' AusRivAS band score. The water was acidic with a pH of 4.62 and dissolved oxygen percent saturation was 34.6 per cent significantly lower than the minimum recommended guideline of 80 per cent saturation. Dissolved oxygen is essential to most aquatic organisms, and is dependent on a number of variables including temperature, salinity, biological activity and rate of transfer from the atmosphere. All locations including Butchers Creek had slow flow rates and high levels of decaying organic matter at the time of sampling. Slow flow rates limit the diffusion of oxygen from the atmosphere and decaying organic matter is associated with chemical oxidation and break down by bacteria which consume dissolved oxygen.

3.5.2. Rosewood Creek

Rosewood Creek is located in the southern end of the Warrell Creek to Urunga upgrade study area. Rosewood Creek flows into Warrell Creek south-west of Donnellyville. Two sites were sampled at Rosewood Creek. See **Appendix J** for specific site locations.

3.5.2.1. Rosewood Creek upstream of the Proposal (Site W3a)

Rosewood Creek Upstream is located upstream of the Proposal, at Easting 490468, Northing 6595871 (**Plate 3-3**). Site W3a meanders through the bottom of a cattle paddock, and is located approximately 1.5 km upstream of the existing Pacific Highway crossing. Rosewood Creek was at a moderately high flow level at the time of sampling. Adjacent landuse comprised cattle grazing resulting in the erosion of the creek banks due to cattle access. Instream habitat was choked with lilies *Nymphoides* and rushes *Eleocharis* reducing water flow. The vegetation in the area was pasture grass with isolated stands of trees. The overall disturbance rating for Site W3a according to the Anderson Riverine Habitat Audit Procedure was 'very high disturbance'. Due to access constraints Backpack electro-fishing was not used and the five bait traps and one fyke net were only set for three hours at this location.

- **Plate 33 Rosewood Creek upstream**

3.5.2.2. Rosewood Creek downstream of the Proposal (Site W3b)

Rosewood Creek is located upstream of the existing Pacific Highway, and the Proposal at Easting 490458, Northing 6596225 (**Plate 3-4**). The creek runs through the middle of a cleared cattle paddock, with the site located approximately one km upstream of the existing Pacific Highway. Macrophytes present at the site included Cumbungi *Typha sp.,* Frogsmouth *Philydrum lanuginosum* and Water lilies *Nymphoides sp.* No woody snags were observed at this site. Site W3b was at a moderately high flow level during the sampling period and evidence at the site suggested recent flooding. Consistent with the upstream site, land use comprised cattle grazing and no remnant native vegetation was present. The overall disturbance rating for site W3b was 'very high disturbance'. Due to access constraints Backpack electro-fishing was not used and the five bait traps and one fyke net were only set for three hours at this location.

▪ Plate 3-4 Rosewood Creek downstream

3.5.2.3. Rosewood Creek ecology

Fish surveys were conducted in Rosewood Creek on 14 July 2008 as part of the investigations into route options for the Warrell Creek section. Only one species was recorded from site W3b – Gambusia, and a total of 63 individuals were reported. This species has been previously recorded in the study area from historic survey data (**Appendix K**).

3.5.3. Stony Creek

Stony Creek is located south of Donnellyville in the Warrell Creek section. Stony Creek flows into Warrell Creek just after crossing the Pacific Highway and the north coast railway line. Two sites were sampled at Stony Creek to provide baseline data in assessing the ecological response to the proposal. See **Appendix J** for specific sample locations.

3.5.3.1. Stony Creek upstream of the Proposal (Site W4a)

Stony Creek Upstream is located approximately one km upstream of the existing Pacific Highway at Easting 490908, Northing 6596713. Stony Creek traverses a cattle paddock and runs under the existing Pacific Highway. The water at the time of sampling was mid-level and the channel pattern of the creek was irregular. The channel was up to three metres wide with the banks ranging from 0.5m to >10m in height. Fallen trees, branches, macrophytes and leaf litter occur throughout the site, providing macroinvertebrate edge habitat.

The local land use in the adjacent area to site W4a is rural residential. Local disturbances to the site include cattle grazing. The local vegetation comprises pasture grass, with open eucalypt woodland. Rehabilitation work had recently been conducted to remove introduced species

Camphor-Laurel throughout the site. The overall disturbance rating for site W4a was 'moderate disturbance'. Backpack electro-fishing and macroinvertebrate sampling was used at this site. Five bait traps and one fyke net was set overnight at this location.

3.5.3.2. Stony Creek downstream of the Proposal (Site W4b)

Stony Creek Downstream is located approximately 600 m upstream of the existing Pacific Highway, at Easting 490772, Northing 6596913 (**Plate 3-5**). The channel pattern of Stony Creek is irregular with prominent flood channels visible. The adjacent local land use is rural residential. Local disturbances to the creek include cattle grazing. The local vegetation is pasture grass with Camphor-Laurels. Aquatic macrophytes at the site included Water Lillies *Nymphoides sp.,* Water Ribbons *Triglochin preocerum,* Common Spike Rush *Eleocharis actua, Bulboschoenus* and the noxious weed *Elodea Canadensis.*The overall disturbance rating for site W4b was 'moderate disturbance'. Backpack electro-fishing was used at this site. Five bait traps and one fyke net was set overnight at this location.

- **Plate 3-5 Stony Creek downstream**

3.5.3.3. Stony Creek ecology

Fish surveys were conducted at two sites in Stony Creek on 15 and 16 July 2008. A total of 84 fish across four species were recorded from the two sites sampled in Cow Creek. At site W4a, the most abundant species was the Striped Gudgeon, with 32 fish reported. At site W4b the most abundant species was Gambusia, with 20 fish reported.

All of the four species recorded during this current survey have been previously recorded in the study area and none are threatened species under the *Fisheries Management Act 1994* or the

EPBC Act. The presence of exotic species such as Gambusia, may further impact upon native species through competition for resources.

Stony Creek had low species richness with only 18 macroinvertebrate taxa recorded. The most abundant taxa were freshwater shrimp (Atyidae) followed by the Leptophleb Mayfly (Leptoceridae) and the Stick Caddis Caddisfly (Leptoceridae). Both the Leptophleb Mayfly and the Stick Caddis Caddisfly were the most pollution sensitive taxa observed (SIGNAL scores 8 and 6 respectively) and were only recorded in the lower Warrell Creek section during July 2008. Neither the endangered macroinvertebrate, the Sydney hawk dragonfly (*Austrocordulia leonardi*) nor the threatened macroinvertebrate the Adams emerald dragonfly (*Archaeophya adamsi*) were found in Stony Creek.

Stony Creek had a low SIGNAL score (3.76) indicating severe pollution. Fewer macroinvertebrate taxa were observed than were expected if the site was within modelled reference condition, indicated by the Observed to Expected Ratio (OE50<1). Stony Creek had an OE50 ratio of 0.66, resulting in an AusRivAS Band B score, suggesting that the site was significantly impaired.

3.5.4. Williamson Creek

Williamson Creek is located at the southern end of the Warrell Creek to Urunga upgrade study area. Williamson Creek flows into Warrell Creek just west of Donnellyville, between the Pacific Highway and the railway bridge. Two sites were sampled at Williamson Creek. See **Appendix J** for specific site locations.

3.5.4.1. Williamson Creek upstream of the Proposal (Site 1a)

Site 1a is located upstream of the existing Pacific Highway, at Easting 491705, Northing 6598052 (**Plate 3-6**). Williamson Creek meanders through the bottom of a cattle paddock, and is located approximately 50 m upstream of the Pacific Highway crossing. Williamson Creek was at a moderate flow level just below the water mark at the time of sampling. The channel pattern was slightly irregular. The land use in the adjacent areas was cattle grazing. The vegetation in the area was pasture grass with isolated stands of trees. Dense filamentous algae were present thoughout the site. The overall disturbance rating for Site 1a according to the Anderson Riverine Habitat Audit Procedure was ‘high disturbance’. Backpack electro-fishing was used at this site to sample fish populations. In addition, five bait traps and one fyke net were set overnight at this location.

- **Plate 3-6 Williamson Creek upstream**

3.5.4.2. Williamson Creek downstream of the Proposal (Site 1b)

Site 1b is located downstream of the existing Pacific Highway at Easting 491498, Northing 6598010 (**Plate 3-7**). The creek runs through the middle of a cleared cattle paddock, with the site located approximately 50 m downstream of the Pacific Highway crossing with a railway 100 m further downstream of the site.

Williamson Creek was at a moderate flow level just below the water mark during the sampling period. The channel pattern was slightly irregular. The land use in the adjacent area was grazing land, with no remnant native vegetation present. Local disturbances to site 1b include the Pacific Highway, the Pacific Highway creek crossing and cattle grazing activities. The vegetation in the area was pasture grass with isolated stands of trees. Aquatic macrophytes at this site were Common Spike Rush *Eleocharis actua* and the filamentous alga *Spirogyra.* Minimal woody snags were present at the site. The overall disturbance rating for site 1b was 'very high disturbance'. Backpack electro-fishing was used at this site to sample fish populations. Five bait traps and one fyke net was set overnight at this location.

- **Plate 3-7 Williamson Creek Downstream**

3.5.4.3. Williamson Creek ecology

Fish surveys were conducted at two sites in Williamson Creek on 27and 28 November 2007. A total of 122 fish and four species were recorded from the two sites sampled in Williamson Creek. Empire gudgeon (49 fish) and striped gudgeon (41) were both recorded in relatively high abundances at site 1a. At site 1b, the most abundant species was empire gudgeon (13 fish). Two turtles were also captured in fyke nets at each site.

Four species recorded during this current survey have been previously reported in the study area including empire gudgeon, marbled eel (*Anguilla reinhardtii*), gambusia and striped gudgeon (see **Appendix K**).

3.5.5. Boggy Creek

Boggy Creek is located immediately north of Nambucca Heads and flows into Deep Creek just to the east of the existing Pacific Highway. One site (site 4b) was sampled at Boggy Creek to provide baseline data to assist in assessing the ecological response to the Proposal. A second site previously selected was not sampled as the site could not be reached due to dense vegetation. The location of the sampling site in Boggy Creek is illustrated in **Appendix J.**

3.5.5.1. Boggy Creek downstream of the Proposal (Site 4b)

Boggy Creek downstream, site 4b is located downstream of the proposal at Easting 497549, Northing 6612023 (**Plate 3-8**). Boggy Creek runs through softwood scrub with site 4b located about 50 m upstream of the Pacific Highway and just downstream of a private causeway. Boggy Creek was at a moderate flow level just below the water mark. The channel pattern was irregular. The land use in the adjacent area was rural residential/hobby farm. Local disturbances to the site include a private road and a causeway. The overall disturbance rating for site 4b was 'low disturbance'. Backpack electro-fishing and macroinvertebrate sampling was used at this site. Five bait traps and one fyke net were also set overnight at this location.

For the purposes of the macroinvertebrate study, the riparian zone at Boggy Creek was greater than three metres wide with dense vegetation including casuarinas and eucalypts, preventing cattle from contributing to bank erosion and creating a runoff buffer during periods of high rainfall. The channel was up to 12 m wide with a large number of fallen logs, branches and leaf litter providing macroinvertebrate edge habitat.

- **Plate 3-8 Boggy Creek downstream**

3.5.5.2. Boggy Creek aquatic ecology

Fish surveys were conducted in Boggy Creek on 27 and 28 November 2007. Only one species was recorded from site 4b – empire gudgeon, and a total of eight fish were reported. This species has been previously recorded in the study area from historic survey data (**Appendix K**). The low number of fish species and individuals caught in Boggy Creek can be attributed to the low levels of dissolved oxygen (20 per cent saturation) (see **Appendix L**).

Macroinvertebrate sampling revealed that Boggy Creek had the lowest species richness with 20 taxa reported. The most abundant taxa were non-biting midges (Chrinominae), followed by

Copepods (sub orders Cyclopodia and Calenoida) and a variety of water mite families (Acarina) (see **Appendix M**).

The most sensitive taxa recorded were the freshwater mites (Acarina), which received a SIGNAL score of 6. Freshwater mites occur in a variety of habitats, but are especially diverse in slow flowing waters such as those found at all three sites (Gooderham & Tsyrlin 2002). Copepods and Cladocera were the next most sensitive taxa recoded (SIGNAL score 5.5). Neither the endangered macroinvertebrate, the Sydney hawk dragonfly (*Austrocordulia leonardi*), nor the threatened macroinvertebrate the Adams emerald dragonfly (*Archaeophya adamsi*) were found in Boggy Creek.

The observed to expected ratio found that Boggy Creek had fewer taxa than expected at its reference location (OE50<1), with an AusRivAS band score of B, suggesting that the site was significantly impaired. Boggy Creek received an OE50 ratio of 0.76, just below the lower threshold of Band A (OE50=0.8) (reference condition). These findings indicated that any existing impacts have not resulted in a substantial loss of macroinvertebrate diversity.

Boggy Creek had the lowest SIGNAL score (3.23) indicating severe pollution as shown by the high exceedances outside the ANZECC/ARMCANZ (2000) guidelines, with turbidity exceeding the maximum guideline by a factor of 10 (102.03 NTU). Turbidity is caused by suspended particulate and colloidal matter consisting of suspended clay, silt, phytoplankton and detritus which can directly impact on macroinvertebrate abundance and diversity due to the clogging of filter feeder taxa feeding apparatus or gill structures, changes in behavioural responses, and the smothering of benthic macroinvertebrates and their habitat (ANZECC/ARCANZ 2000). Indirect impacts of turbidity include alteration of macroinvertebrate habitat by filling interstitial spaces in the substrate in which many macroinvertebrates inhabit and changes in the availability and decomposition of detritus, the staple diet of many macroinvertebrates (ANZECC/ARMANZ 2000).

With only 32.3 per cent dissolved oxygen saturation, Boggy Creek also had dissolved oxygen content significantly below ANZECC/ARCANZ (2000) recommended guidelines (80 per cent saturation). As previously mentioned, oxygen is essential to most aquatic organisms and the reduced oxygen content may have contributed to the low species richness of both macroinvertebrates and fish populations.

3.5.6. Cow Creek

Cow Creek is located half way between Nambucca Heads and Valla Beach. Cow Creek flows into Deep Creek just east of the Pacific Highway. Two sites were sampled at Cow Creek to provide baseline data in assessing the ecological response to the proposal. See **Appendix J** for specific sample locations.

3.5.6.1. Cow Creek upstream of the Proposal (Site 5a)

Cow Creek Upstream, Site 5a is located upstream of the existing Pacific Highway at Easting 497619, Northing 6613038. Cow Creek traverses a cattle paddock and runs under the existing Pacific Highway. The water level at the time of sampling was normal and the channel pattern of the creek was irregular. The local land use in the adjacent area to site 5a was rural residential. Local disturbances to the site include cattle grazing. The local vegetation was pasture grass, with isolated stands of trees. There were prominent flood channels visible at Cow Creek. The overall disturbance rating for Site 5a was 'high disturbance'. Backpack electro-fishing and macroinvertebrate sampling was used at this site. Five bait traps and one fyke net was set overnight at this location. No aquatic macrophytes were recorded at this site.

3.5.6.2. Cow Creek downstream of the Proposal (Site 5b)

Cow Creek Downstream, site 5b is located downstream of the existing Pacific Highway, at Easting 497728, Northing 6612920. The site is located within the lower reach of Cow Creek, and is influenced by tidal flow. At the time of sampling the water level was within one hour of high tide. The channel pattern of Cow Creek was irregular with prominent flood channels visible. The adjacent local land use includes rural residential. Local disturbances to the creek include vehicular traffic associated with the Pacific Highway and the creek crossing. The local vegetation surrounding Cow Creek was reported as open eucalypt woodland. The overall disturbance rating for site 5b was 'moderate disturbance'. Backpack electro-fishing was not used at this site due to the high electrical conductivity of the water. Five bait traps and one fyke net were set overnight at this location.

At the Cow Creek macroinvertebrate sampling site the banks were approximately two to three metres high, with undercutting and evidence of bank erosion in places. The creek channel width ranged from one metre upstream to approximately six metres at the culvert. The riparian zone was approximately two metres wide, dominated by casuarinas, eucalypts, lomandra, acacias, dense patches of the weed lantana and various pasture grasses. The aquatic macrophyte Ribbon Weed, *Triglochin preocerum* was present, in addition to localised patches of filamentous algae.

- **Plate 3-9 Cow Creek downstream**

3.5.6.3. Cow Creek ecology

Fish surveys were conducted at two sites in Cow Creek on 26 and 27 November 2007. At site 5b, electro-fishing was not possible because of the high electrical conductivity of the water. A total of 87 fish across eight species were recorded from the two sites sampled in Cow Creek. At site 5a, the most abundant species was the empire gudgeon, with 24 fish reported. At site 5b the most abundant species was Pacific blue-eye, with 13 fish reported.

All of the eight species recorded during this current survey have been previously recorded in the study area. The species previously recorded include empire gudgeon, estuary perchlet (*Ambassis marianus*), flathead gudgeon (*Philypnodon grandiceps*), gambusia, Pacific blue-eye (*Pseudomugil signifier*), sea mullet (*Mugil cephalus*), short-finned eel (*Anguilla australis*) and striped gudgeon (see **Appendix K**), none of which are threatened species under the *Fisheries Management Act 1994* or the EPBC Act. The presence of exotic species, such as gambusia, may further impact upon native species through competition for resources. As mentioned previously, gambusia actively competes with small-bodied native fish (McKay, Clunie *et al.* 2001).

Cow Creek had the greatest diversity of macroinvertebrate fauna, with 27 taxa, compared to the other sites. As reported for Boggy Creek, the most abundant taxa across all sites were non-biting midges (Chrinominae) followed by Copepods (sub orders Cyclopodia and Calenoida) and a variety water mite families (Acarina).

A relatively low SIGNAL Score was reported in Cow Creek (3.62). Cow Creek had a lower observed SIGNAL score than was expected, based on reference condition (OE50Signal) (see **Appendix M**). Based upon the SIGNAL results, the water quality of Cow Creek was graded as 'Severe Pollution'.

Neither the endangered macroinvertebrate, the Sydney hawk dragonfly (*Austrocordulia leonardi*) nor the threatened macroinvertebrate the Adams emerald dragonfly (*Archaeophya adamsi*) were found in Cow Creek. The observed to expected ratio found that Cow Creek had fewer taxa than expected, compared to the reference location (OE50<1), receiving an AusRivAS band score of B suggesting that the site was significantly impaired. Cow Creek received an OE50 ratio of 0.76, just below the lower threshold of Band A (OE50=0.8) (reference condition). This finding indicates that any existing impacts have not resulted in a substantial loss of macroinvertebrate diversity.

Turbidity was well above the maximum recommended guideline of 10 NTU, and dissolved oxygen was significantly lower than the minimum recommended guideline of 80 percent saturation. As previously mentioned, these modified water quality conditions in Cow Creek may have contributed to the low SIGNAL scores reported.

3.5.7. Oyster Creek

Oyster Creek is located to the north of Valla Beach. The sites sampled were within the southern tributary to Oyster Creek, which runs under the Pacific Highway then into Oyster Creek. Sites were sampled to provide baseline data to assist in assessing the ecological response to the proposal. See **Appendix J** for specific sample locations.

3.5.7.1. Oyster Creek upstream of the Proposal (Site 7a)

Oyster Creek, Site 7a is located upstream of the existing Pacific Highway at Easting 500188, Northing 6616493. The tributary to Oyster Creek runs through softwood scrub parallel to the Pacific Highway for 50 m (**Plate 3-10**). At the time of sampling the water level in the creek was low. The channel pattern was irregular while floodplain features include oxbows/ billabongs. The adjacent local land use was rural residential with the Pacific Highway the main local disturbance to the creek. Riparian habitat was dominated by Spiny-headed mat-rush. Minimal woody snags were present at the site. The overall disturbance rating for the site was 'low disturbance'. Backpack electro-fishing was used at this site. Five bait traps and one fyke net were set overnight at this location.

- **Plate 3-10 Site 7a at the unnamed tributary to Oyster Creek**

3.5.7.2. Oyster Creek downstream of the Proposal (Site 7b)

Oyster Creek Downstream, site 7b is located downstream of the existing Pacific Highway in an unnamed tributary to Oyster Creek at Easting 500323, Northing 6616504. The water level at the time of the sampling was low. The channel pattern was mildly sinuous. The local land use was rural residential. Local disturbances to the creek include the Pacific Highway, and existing river improvement works. The overall disturbance rating for site 7b was 'low disturbance'.

This site was located immediately downstream of the existing Pacific Highway crossing at the edge of a rural residential lot (**Plate 3-11**). Backpack electro-fishing and macroinvertebrate sampling was used at this site. Five bait traps and one fyke net was also set overnight at this location.

At the Oyster Creek macroinvertebrate sampling site, the banks comprised soft sediment, stabilised by grass and Lomandra growing on the banks. The riparian zone fluctuates up to approximately two metres wide, including casuarinas, eucalyptus and acacias. The water appeared highly turbid with an oily film and choked with exotic macrophytes including the dense water weed (*Egeria densa)* and water hyacinth (*Eichhornia crassipes)*. Other macrophytes present at the site included water lilies *Nymphoides spp.* and water milfoil *Myriophyllum spp.* Submerged woody snags were present throughout the site.

▪ **Plate 3-11 Oyster Creek**

3.5.7.3. Oyster Creek ecology

Fish surveys were conducted at two sites in the unnamed southern tributary to Oyster Creek on 26 and 27 November 2007. A total of 57 fish from five species were recorded from the two sites sampled in Oyster Creek. Striped gudgeon (19 fish) was recorded in high abundance at site 7a, whilst the most abundant species at Site 7b was empire gudgeon (25 fish).

Four species recorded during this current survey have been previously recorded in the study area (see **Appendix K**). The species previously recorded include empire gudgeon, marbled eel, sea mullet, and striped gudgeon.

The investigation revealed a total of 26 invertebrate taxa in Oyster Creek. The most abundant taxa was non-biting midges (Chrinominae), followed by Copepods (sub orders Cyclopodia and Calenoida) and a variety of water mite families (Acarina).

Oyster Creek was rates as severe pollution with a low SIGNAL score (3.6) (see **Appendix M**). Neither the endangered macroinvertebrate, the Sydney hawk dragonfly (*Austrocordulia leonardi*) nor the threatened macroinvertebrate the Adams emerald dragonfly (*Archaeophya adamsi*) were found in Oyster Creek. Turbidity was well above the maximum recommended guideline of 10 NTU at all sites, and dissolved oxygen was significantly lower than the minimum recommended guideline of 80 percent saturation. As previously reported, the low flow rates and high levels of decaying organic matter, may have contributed to the low dissolved oxygen content, and the corresponding low SIGNAL scores indicating severe pollution.

3.6. Freshwater fish distribution

Data from the 13 sites surveyed across the seven waterways has provided preliminary baseline data on species distribution within the Warrell Creek to Urunga project area. A total of twelve species comprising 273 fish were recorded from the 13 sites sampled as summarised in **Table 3-8**). None of the species reported were State or Nationally Threatened, or protected. One exotic species, the Mosquito Fish, *Gambusia holbrooki* was reported. Eleven of these species were reported previously, based on historic studies (see **Appendix K**). The most widely distributed species in the region were the Striped Gudgeon, *Gobimorphus australis* with 138 individuals and the Empire Gudgeon, *Hypseleotris compressa*, with 124 individuals.

- **Table 3-8: Distribution of fish species in the Warrell Creek to Urunga region from surveys conducted between 26 -30 November 2007 and 14-18 July 2008.**

Common name	Butchers Creek W1a	Butchers Creek W1b	Rosewood Creek W2a	Rosewood Creek W2b	Stony Creek W3a	Stony Creek W3b	Williamson Creek 1a	Williamson Creek 1b	Boggy Creek 4b	Cow Creek 5a	Cow Creek 5b	Oyster Creek 7a	Oyster Creek 7b	Total
Native species														
Carp Gudgeon sp.													1	1
Empire Gudgeon							49	13	8	24		5	25	124
Firetail Gudgeon					3									3
Estuary Perchlet											2			2
Flathead Gudgeon										14	4			18
Marbled Eel								2					1	3
Pacific Blue-eye											13			13
Sea Mullet										1			1	2
Short-finned Eel										1				1
Long-finned eel	4	2			10	1								17
Striped Gudgeon					32	17	41	11		13		19	5	138
Exotic species														
Gambusia	4		46	7		20		6		15				98
Total	8	2	46	7	45	38	90	32	8	68	19	24	33	420

3.7. Macroinvertebrate distribution

A total of 60 families from 450 individuals were recorded from the five sites sampled as summarised in **Table 3-9**. None of the families reported were state or nationally threatened or protected. The most widely distributed species in the region were non–biting midges (Chironominae) with 99 individuals and small water striders (Veliidae) with 38 individuals.

- **Table 3-9: Distribution of macroinvertebrate families in the Warrell Creek to Urunga region from surveys conducted between 26 -30 November 2007 and 14-18 July 2008.**

Number of Macroinvertebrate Taxa Found From AusRivAS Edge Samples							
Location		Oyster Creek	Cow Creek	Boggy Creek	Stony Creek	Butcher s Creek	Total
Class/Order	Family						
Hydrozoa	Hydridae	11					11
Turbellaria	IF		1				1
Nematoda	IF	4	2				6
Acarina	Hydracarina		3		9	8	20
Acarina	Limnesiidae	14	18	2			34
Acarina	order Oribatida			1			1
Acarina	Oxidae	5	3				8
Acarina	Pionidae	3					3
Arachnida	Tetragnathidae		1		1		2
Bivalvia	Corbiculidae				1		1
Cladocera	IF	20	5	1			26
Coleoptera	Dytiscidae	7		7			14
Coleoptera	Hydraenidae			1			1
Coleoptera	Hydrochidae	1					1
Coleoptera	Hydrophilidae	2		3	2		7
Coleoptera	Gyrinidae				3		3
Collembola	Isotomidae		1	1	2		4
Copepoda	sub order Calenoida	1	30		1		32
Copepoda	sub order Cyclopoida	19	1	16			36
Crustacea	Atyidae		1		20	1	22
Crustacea	Sphaeromatidae		8				8
Crustacea	sub order Flabellifera		3	3			6
Crustacea	Palemonidae				1		1
Diptera	Ceratopogonidae	2	1				3
Diptera	Culicidae	3	4	1			8
Diptera	Tipulidae		1				1
Diptera	Chironominae	12	40	37	9	1	99
Diptera	Orthocladinae			1			1
Diptera	Tanypodinae	5	2	3			10
Ephemeropt era	Leptophlebididae				22	9	31
Gastropoda	Lymnaeidae	17					17
Gastropoda	Physidae				2		2
Hemiptera	Corixidae			1			1
Hemiptera	Gelastocoridae		1		1	1	3
Hemiptera	Geridae	3	5	1			9
Hemiptera	Notonectidae			1	1	4	6
Hemiptera	Veliidae	6	16	3	4	9	38

Number of Macroinvertebrate Taxa Found From AusRivAS Edge Samples							
Location		Oyster Creek	Cow Creek	Boggy Creek	Stony Creek	Butchers Creek	Total
Hemiptera	Mesoveliidae	6		1	1		8
Hemiptera	Pleidae	1	1				2
Hemiptera	Hydrometridae	1	1		1	3	6
Megaloptera	Corydalidae				2		2
Odonata	Coenagrionidae	7	2				9
Odonata	Hemicordulidae	3					3
Odonata	Libellulidae	1					1
Odonata	Isostictidae				11		11
Oligochaeta	IF	4	3	3			10
Ostracoda	IF	2	4	2			8
Polychaeta	IF		5				5
Tricoptera	Leptoceridae				16	10	26
Hydrozoa	Hydridae	11					11
Turbellaria	IF		1				1
Nematoda	IF	4	2				6
Acarina	Hydracarina		3		9	8	20
Acarina	Limnesiidae	14	18	2			34
Acarina	order Oribatida			1			1
Acarina	Oxidae	5	3				8
Acarina	Pionidae	3					3
Arachnida	Tetragnathidae		1		1		2
Bivalvia	Corbiculidae				1		1
Cladocera	IF	20	5	1			26
Number of taxa		23	21	18	18	9	89
Number of Individuals		182	179	89	108	46	450

**IF = Indeterminate Family. These entries are where specimens were either too immature or too damaged to identify to a lower level.*

3.8. Estuarine fish distribution

The following section summarises the results of the fish sampling program undertaken in estuarine ecosystems associated with the proposal. A description has been provided on each site based on the methods provided in Anderson (1993). The location of each site is depicted in **Appendix J.**

3.8.1. Warrell Creek

Warrell Creek is located at the southern end of the Proposal. The sites sampled were where the Pacific Highway crosses Warrell Creek north of Donnellyville. Two sites were sampled at Warrell Creek, to provide baseline data to assess the ecological response to the proposal.

3.8.1.1. Warrell Creek upstream of the Proposal (Site 2a)

Warrell Creek Upstream, site 2a is located approximately 10-50 metres upstream of the existing Pacific Highway crossing, on the southern bank, at Easting 492152, Northing 6599138 (**Plate 3-2**). The creek is approximately 80 m wide and three metres deep. Woody snags were present along the edges of the river. No aquatic macrophytes were present.

Warrell Creek runs alongside cattle pasture, with regular meanders. At the time of sampling the site was within one hour of high tide at the time of sampling. The land use in the adjacent area was rural, urban residential and rural residential. Local disturbances to the site include vehicular traffic associated with the existing Pacific Highway, the bridge across Warrell Creek and cattle grazing. The vegetation in the area was coastal heathland.

The overall disturbance rating for site 2a was ‘high disturbance’. Five bait traps were deployed at this site for one and a half hours. Gill and seine netting was not undertaken due to depth and access constraints.

- **Plate 3-12 Warrell Creek upstream**

3.8.1.2. Site 2b – Downstream of the proposal

Warrell Creek Downstream, site 2b is located approximately 50 m downstream of the existing Pacific Highway crossing, on the southern bank, at Easting 492358, Northing 6598913 (**Plate 3-13**). Warrell Creek runs alongside woody scrubland and was within one hour of high tide at the time of sampling. The channel pattern had regular meanders. The vegetation in the area was coastal heathland.

Land use in the adjacent area was cattle grazing, as well as urban residential and rural residential/ hobby farms. Local disturbances to site 2b include the existing Pacific Highway, the bridge across Warrell Creek and cattle grazing. The overall disturbance rating for site 2b was ‘high disturbance’. No aquatic macrophytes or seagrasses were observed at the site, however submerged woody snags were present along the edges of the river with small patches of filamentous algae.

Five bait traps were deployed for one and a half hours. Gill nets were not deployed, nor seine netting performed, for the reasons given for site 2a.

- **Plate 3-13 Warrell Creek downstream**

3.8.1.3. Warrell Creek ecology

Fish surveys were conducted at two sites in Warrell Creek on 29 November 2007. During survey work the tide was ebbing, within one hour of high tide. A total of 467 fish from five species were recorded from the two sites sampled in Warrell Creek. Pacific blue-eye (304) was recorded in high abundance at site 2a. Estuary perchlet (74 fish) and Pacific blue-eye (68) were both recorded in relatively high abundances at site 2b.

Four of the five species recorded during the current survey have been previously recorded in the study area (see **Appendix K**). The species previously recorded include Pacific blue-eye (*Pseudomugil signifier*), estuary perch, estuary perchlet, and flathead gudgeon. The species not reported in previous surveys was the grass shrimp, which was found in small numbers (n = 6).

3.8.2. Nambucca River

The Proposal crosses the Nambucca River just to the west of the Council depot on Gumma Road. Two sites were sampled in Nambucca River, to provide baseline data.

3.8.2.1. Nambucca River upstream of the Proposal (Site 3a)

Nambucca River Upstream, site 3a is located approximately one kilometre downstream of the existing Pacific Highway crossing, at Easting 493597, Northing 6602583 (**Plate 3-**). The river is approximately 200 m wide and five metres deep mid channel. Sampling was undertaken on an ebb tide. No aquatic macrophytes were present at the site. The channel pattern had regular meanders. The land use in the adjacent area was urban residential with local disturbances including adjacent public roads and the existing Pacific Highway bridge. The adjacent vegetation type was mangroves. The overall disturbance rating for site 3a was ‘very high disturbance’. Five bait traps were deployed at this site for one and a half hours. Three gill nets were set at the site for one hour, with two on the southern side and one on the northern side of the river (see **Appendix I**). Seine netting was not undertaken as the river was too deep to wade through.

- **Plate 3-14 Nambucca River upstream**

3.8.2.2. Nambucca River downstream of the Proposal (Site 3b)

Nambucca River Downstream, site 3b is located approximately 1.5 km downstream of the existing Pacific Highway crossing, at Easting 493897, Northing 6602516 **(Plate 3-15**). The river is approximately 200 m wide and five metres deep mid channel. Sampling was undertaken on an ebb tide. The channel pattern had regular meanders.

The land use in the adjacent area includes urban residential. Local disturbances to site 3b include adjacent public roads and the existing Pacific Highway bridge. The adjacent vegetation type was mangroves. No aquatic macrophytes were present at the site. The overall disturbance rating for site 3b was 'very high disturbance'.

Five bait traps were deployed at this site for one and a half hours. Three gill nets were set at the site for one hour, including one on the southern side and two on the northern side of the river (see **Appendix J**). Seine netting was not undertaken as the river was too deep to wade through.

Plate 3-15 Nambucca River downstream

3.8.2.3. Nambucca River ecology

Fish surveys were conducted at two sites in the Nambucca River on 28 November 2007. A total of 217 fish across five species were recorded from the two sites. Sea mullet (52 fish) and grass shrimp (29) were both recorded in relatively high abundances at site 3a. Similarly, sea mullet (66 fish) and grass shrimp (38) were both recorded in relatively high abundances at site 3b.

Four of the five species recorded during this current survey have been previously recorded in the study area including Pacific blue-eye, estuary perch, estuary perchlet, and sea mullet (see **Appendix K**). The species not found in previous surveys was the grass shrimp, which was in high abundance, with a total of 67 individuals.

3.8.3. Deep Creek

Deep Creek is located half way between Nambucca Heads and Valla Beach. Downstream from the Pacific Highway crossing, Deep Creek heads north-east towards Valla Beach. Two sites were sampled in Deep Creek, to provide baseline data to assess the ecological response to the proposal.

3.8.3.1. Deep Creek upstream of the Proposal (Site 6a)

Deep Creek Upstream, site 6a is located approximately 50 m upstream of the existing Pacific Highway crossing, at Easting 498381, Northing 6613975 (**Plate 3-16**). The creek is approximately 100 m wide and 2.5 m deep mid-channel. Sampling was undertaken on a flood tide. The channel pattern of Deep Creek has regular meanders. No aquatic macrophytes were present at the site.

The land use in the adjacent area was rural residential/hobby farm. Local disturbances included the Pacific Highway, the bridge across Deep Creek and cattle grazing. The vegetation in the area was eucalypt forest. The overall disturbance rating for site 6a was ‘high disturbance’. Five bait traps were deployed at this site for one and a half hours. Two gill nets were set at the site for one hour, including one net on the southern side and one on the northern side of the creek. Two sets of seine netting were also undertaken.

- **Plate 3-16 Deep Creek upstream**

3.8.3.2. Deep Creek downstream of the Proposal (Site 6b)

Site 6b is located approximately 50 m downstream of the Pacific Highway crossing, at Easting 498474, Northing 6613937 (**Plate 3-17**). The creek is approximately 100 m wide and 2.5 m deep. Sampling was undertaken on a flood tide. The channel pattern had regular meanders. No aquatic macrophytes were present at the site.

The land use in the adjacent area was rural residential/hobby farm. Local disturbances to site 6b included the existing Pacific Highway, the bridge across Deep Creek and cattle grazing. The vegetation in the area was Eucalypt Forest and Coastal Heathland. The local land tenure was freehold/leasehold. The overall disturbance rating for site 6b was ‘high disturbance’. Five bait traps were deployed at this site for one and a half hours. Two gill nets were set at the site for one hour, which included one net on the southern side and one on the northern side of the creek. Two sets of seine netting were also undertaken.

- **Plate 3-27 Deep Creek downstream**

3.8.3.3. Deep Creek ecology

Fish surveys were conducted at two sites in Deep Creek on 27 and 28 November 2007. On the afternoon of 27 November, the five bait traps were set at sites 6a and 6b and one seine netting event was completed at sites 6a and 6b. On the morning of 28 November, two gill nets were set on either side of the river and another seine netting event was completed at both sites 6a and 6b. On 27 November the tide was ebbing, and on 28 November the tide was flooding at the time of sampling.

A total of 445 fish from 14 species were recorded from the two sites sampled in Deep Creek. Estuary perch (57 fish) and grass shrimp (52) were both recorded in high abundances at site 6a. At site 6b the most abundant species was grass shrimp (116 individuals).

Eight of the fourteen species recorded during this current survey have been previously recorded in the study area including the common toadfish (*Tetractenos hamiltoni*), estuary perch, estuary perchlet, flathead gudgeon, Pacific blue-eye, sea mullet, silver batfish (*Monodactylus argenteus*) and transparent goby (*Gobiopterus semivestita*) (see Appendix K). The species not found in previous surveys included the brown ray, devil ray, grass shrimp, sand flathead, summer whiting and weed shrimp.

3.8.4. Kalang River

The Kalang River runs through Urunga to the Pacific Ocean. The site of the proposed highway crossing is on the western outskirts of Urunga. Two sites were sampled at Kalang River to provide baseline data to assess the ecological response to the proposal.

3.8.4.1. Kalang River upstream of the Proposal (Site 9a)

Site 9a is located approximately 50 m upstream of the Proposal, at Easting 497745, Northing 6625199 (**Plate 3-18**). The river is approximately 150 m wide. At the sampling site, the Kalang River transects private properties. Kalang River was at the top of the tide at the time of sampling. The channel pattern has regular meanders. No aquatic macrophytes were present at the site and the only snags present at the site were submerged mangroves.

The surrounding land use is rural residential/hobby farm. Local disturbances to site 9a include forestry activities and channel maintenance. The adjacent vegetation type in the area is mangroves. The overall disturbance rating for site 9a was ‘high disturbance’.

Five bait traps were deployed at this site for one and a half hours. Three gill nets were set at the site for one hour, including two nets on the southern side and one on the northern side of the river. Seine netting was also undertaken in the vicinity of site 9a.

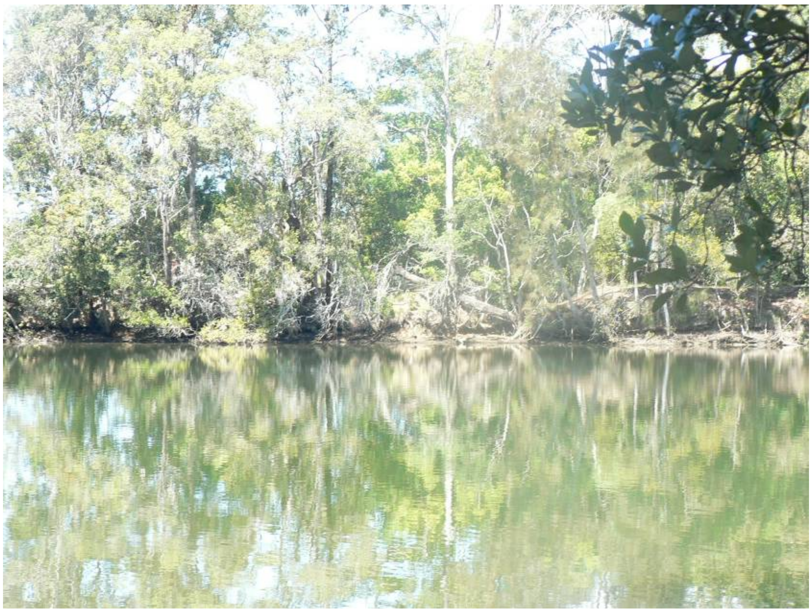
- **Plate 3-38 Kalang River upstream**

3.8.4.2. Kalang River downstream of the Proposal (Site 9b)

Site 9b is located approximately 50 m downstream of the Proposal, at Easting 497640, Northing 6625196 (**Plate 3-19**). The river is approximately 150 m wide. Kalang River was at the top of the tide at the time of sampling. The channel pattern has regular meanders. No aquatic macrophytes were present at the site and the only snags present at the site were submerged mangroves

The surrounding land use was grazing/ sown pasture. Local disturbances to site 9b included an adjacent road and grazing land. The local vegetation type in the area was mangroves. The overall disturbance rating for site 9b was ‘high disturbance’.

Five bait traps were deployed at this site for one and a half hours. Three gill nets were set at the site for one hour, including one net on the southern side and two nets on the northern side of the river.



- **Plate 3-19 Kalang River downstream**

3.8.4.3. Kalang River ecology

Fish surveys were conducted at two sites in the Kalang River on 26 and 27 November 2007. On the afternoon of 26 November, five bait traps were set and one set of seine netting performed at sites 9a and 9b. On the morning of 27 November, three gill nets were set and another seine netting event completed at site 9a and 9b. On 26 November the tide was ebbing, and on 27 November the tide was flooding at the time of sampling.

A total of 3652 fish from 12 species were recorded from the two sites sampled in the Kalang River. Transparent goby (2101 fish), grass shrimp (589) and estuary perchlet (529) were recorded in high abundances at site 9a. Grass shrimp (205) and sea mullet (90) were recorded in high abundances at site 9b.

Nine of the thirteen species recorded during the current survey have been previously recorded in the study area including Australian bass (*Macquaria novemaculeata*), estuary perch, estuary perchlet, flathead gudgeon, Pacific blue-eye, Port Jackson perchlet (*Ambassis jacksoniensis*), sea mullet, and transparent goby (see **Appendix K**). Species not found in previous surveys include the grass shrimp and summer whiting.

3.8.5. Bellinger River

Bellinger River is located at the northern perimeter of the Proposal. The position of the current highway crossing is west of Raleigh and north of Urunga. The Bellinger River runs through Bellingen, to the east of Raleigh, and then heads south-east, where it connects with the Kalang River. Two sites were sampled in the Bellinger River to provide baseline data to assess the ecological response to the Proposal.

3.8.5.1. Bellinger River 50m north of the Proposal, upstream of the existing Pacific Highway (Site 10a)

Site 10a is located on the Bellinger River approximately 50 m upstream of the current Pacific Highway crossing, at easting 500238, northing 6630453 (**Plate 3-20**). The river is approximately 150 m wide and four metres deep mid channel. At the time of sampling the Bellinger River was flooding within one hour of high tide. The channel pattern has regular meanders. No aquatic macrophytes were present at the site.

At the sampling sites, the Bellinger River traverses private properties. The surrounding land use was cattle grazing, with no remnant native vegetation. Local disturbances to site 10a include adjacent roads, the existing Pacific Highway bridge crossing, maintenance dredging and grazing from downstream. The adjacent vegetation type was mangroves. The overall disturbance rating for site 10a was ‘high disturbance’.

Five bait traps were deployed at this site for one and a half hours. Three gill nets were set at the site for one hour, including two nets on the northern side and one on the southern side of the river. Seine netting was also undertaken as the river was shallow enough in sections around to wade.

- **Plate 3-20 Bellinger River Upstream**

3.8.5.2. Bellinger River 50 m north of the Proposal, downstream of the existing Pacific Highway (Site 10b)

Site 10b is located on the Bellinger River approximately 50 m downstream of Pacific Highway crossing, at easting 500238, northing 6630453 (**Plate 3-21**). The river is approximately 150 m wide and four metres deep mid-channel. No aquatic macrophytes were present at the site.

At the sampling site the Bellinger River traverses private properties. At the time of sampling the Bellinger River was ebbing within one hour of high tide. The channel pattern has regular meanders. The surrounding land use was cattle grazing with no remnant native vegetation. Local disturbances to site 10b include roads, the Pacific Highway river crossing, dredge maintenance and grazing. The local vegetation type in the area was mangroves. The overall disturbance rating for site 10b was 'high disturbance'.

Five bait traps were deployed at this site for one and a half hours. Three gill nets were set at the site for one hour, including two nets on the southern side and one on the northern side of the river. Seine netting could not be undertaken as the river was not shallow enough to wade through.

- Plate 3-41 Bellinger River downstream

3.8.5.3. Bellinger River ecology

Fish surveys were conducted at two sites in the Bellinger River on 29 November 2007. At the time of sampling the tide was flooding. A total of 55 fish from eight species were recorded from the two sites sampled in Bellinger River. The most abundant species at site 10a were estuary perchlet (19 fish). Grass shrimp (three) and sea mullet (three) were the most abundant species at site 10b.

Four of the seven species recorded during the current survey have been previously recorded in the project area including the estuary perchlet, flathead gudgeon, sea mullet, and transparent goby (see **Appendix K**). The species not found in previous surveys include brown ray, summer whiting and the invertebrate grass shrimp.

3.9. Summary of estuarine fish distribution

Field data collected from the ten sites surveyed across the five waterways during the present study provides baseline information on species distribution within the area of investigation associated with the proposal. A total of 4836 fish across 17 species has been recorded from the ten sites sampled. The species reported did not include any state or nationally listed species.

The most widely distributed species in the region caught at all sites was the grass shrimp (*Macrobrachium intermedium*) with a total of 1048 individuals. The estuary perchlet (*Ambassis marianus*), also caught at all sites, comprised a total of 697 fish. The estuary perch (*Macquaria colonorum*) was also widely distributed, having been recorded at seven of the ten sites. The flathead gudgeon (*Philypnodon grandiceps*) and sea mullet (*Mugil cephalus*) were also widely distributed across sites.

- **Table 3-10. Distribution of fish species in the Warrell Creek to Urunga region from surveys conducted between 26 November and 30 November 2007**

Species Common Name	Warrell Creek Site 2a	Warrell Creek Site 2b	Nambucca River Site 3a	Nambucca River Site 3b	Deep Creek Site 6a	Deep Creek Site 6b	Kalang River Site 9a	Kalang River Site 9b	Bellinger River Site 10a	Bellinger River Site 10b	Total of Each Species
Australian Bass								1			1
Brown ray					1				1		2
Common toadfish						1					1
Devil Ray					1						1
Estuary Perch	2		2	14	57	18	55	32			180
Estuary Perchlet	9	74	4	11	32	17	529	1	19	1	697
Flathead Gudgeon	4				19	5	2	10	6	1	47
Grass shrimp	1	5	29	38	52	116	589	205	10	3	1048
Pacific Blue-eye	304	68		1	1	10	29				413
Port Jackson Perchlet							2				2
Sand Flathead					1						1
Sea Mullet			52	66	22	8	20	70	6	3	247
Silver batfish						1					1
Summer Whiting						1	1		4		6
Transparent Goby					16	30	2101		1		2148
Weed shrimp					36			5			41
Total number per creek	**320**	**147**	**87**	**130**	**238**	**207**	**3328**	**324**	**47**	**8**	**4836**

4. Conservation significance

4.1. Biodiversity

The results of background research and comprehensive field surveys for the Proposal contribute to the knowledge of the area's biodiversity, and in particular highlight the high diversity of flora and fauna species known and considered to potentially occur in the locality. A major factor which contributes to this diversity is the location within the MacPherson-Macleay Overlap Zone (as previously discussed in section 3.1).

The native flora and fauna of the NSW North Coast Bioregion are among the most diverse in Australia (NPWS 2002a; 2002b) and include a high proportion of threatened species, populations and ecological communities (NPWS 2002a). The high biodiversity of the region highlights the importance of any existing remnant natural habitats in the study area and their subsequent conservation value. As specified in the ecological assessment requirements provided in the DGRs and from DECCW and DII (refer section 1.3) it is a requirement that the Proposal is developed with consideration for these values by minimising vegetation removal and disturbance. This is of particular important for areas identified in this report as having high conservation significance for threatened species, and Endangered Ecological Communities.

The following chapter outlines the findings of the review and survey with regard to the presence of species, populations and communities known or likely to occur in the study area that are listed under the schedules of the TSC Act and EPBC Act.

4.2. Endangered Ecological Communities

No nationally Endangered Ecological Communities, as listed under the Commonwealth EPBC Act have been located in the study area. However several EECs listed in NSW under the TSC Act were identified along the corridor, which is situated in the North Coast Bioregion. A description of their type, distribution and condition in relation to the study area is detailed below in **Table 4-1.** For locations of EECs refer to **Figure 4-1** to **4-4**.

- **Table 4-1: Endangered ecological communities identified in the study area**

Map Unit	Vegetation Community	Endangered Ecological Community	Habitat	Dominant species	Study area section
2	Mixed Floodplain Forest	Subtropical Coastal Floodplain Forest of the NSW North Coast Bioregion	Gully areas along creek lines on metasediments and alluvium	*Corymbia intermedia, Eucalyptus grandis, Eucalyptus resinifera, Eucalyptus siderophloia, Eucalyptus propinqua, Eucalyptus acmenoides*	1, 2, 3, 4

Map Unit	Vegetation Community	Endangered Ecological Community	Habitat	Dominant species	Study area section
5	Lowland Rainforest	Lowland Rainforest of the NSW North Coast and Sydney Basin Bioregion	Riparian corridors and alluvial flats	*Endiandra discolor, Schizomeria ovata, Livistonia australis, Archontophoenix cunninghamiana, Sloanea woollsii, Syzygium* spp.	1, 2, 4
6	Swamp Forest – swamp mahogany/ Paperbark	Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregion	Floodplain areas on waterlogged humic soils	*Eucalyptus robusta, Melaleuca quinquenervia, Eucalyptus resinifera, Lophostemon sauveolens, Callistemon salignus, Melaleuca linariifolia, Glochidion ferdinandi*	1, 2, 3, 4
7	Swamp Forest – Swamp Oak	Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner Bioregions	Floodplain areas on alluvial soils with a saline influence	*Casuarina glauca, Melaleuca quinquenervia, Melaleuca styphelioides, Callistemon salignus*	1, 3, 4
8	Freshwater Wetlands	Freshwater Wetlands on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions	Low elevated depressions on floodplains, alluvial soils.	*Phragmites australis, Juncus usitatus, Typha orientalis, Villarsia exaltata, Myriophyllum* spp., *Villarsia reniformis, Ludwigia peploides* subsp. *montevidensis, Philydrum lanuginosum, Carex appressa, Baumea articulata, Ranunculus inundatus, Cyperus polystachyos, Eleocharis sphacelata, Baumea juncea, Isolepis inundata, Juncus planifolius*	1, 3, 4

4.2.1. Subtropical coastal floodplain forest

Subtropical coastal floodplain forest comprises vegetation associations derived on soils with clay and sandy loams, on periodically inundated alluvial flats, drainage lines and river terraces. They generally occur below 50 m elevation. Structurally, this community varies from the open forests and woodlands of the adjoining elevated lands, with the composition primarily determined by flooding regimes and the texture, nutrient and moisture content of the soil, in addition to latitude and history of disturbance. Features that distinguish this community from other EECs on the coastal floodplains include:

- A dominant mixed eucalypt canopy including *Eucalyptus tereticornis*, *Corymbia intermedia, E. siderophloia, E.resinifera*, *E.propinqua* and/or *E.acmenoides*.
- The presence of rainforest elements as scattered trees or understorey plants.
- The relatively low abundance or sub-dominance of Casuarina and Melaleuca spp.
- The relatively low abundance of E.robusta.
- A prominent groundcover of soft-leaved forbs and grasses (Keith and Scott 2005).

These communities are patchily distributed throughout the central or marginal parts of the floodplains and sandy flats, habitats where flooding is periodic and soils are rich in silt and sand, sometimes humic, and show little influence of saline groundwater (Keith and Scott 2005).

In the study area this EEC occurs in low elevated gullies and creek flats. It was distinguished from other moist open forest communities (Map Units 3 and 4) by its occurrence in low elevated areas and/or a lower abundance of flooded gum (*Eucalyptus grandis*) which dominates Map Unit 4. Some of these areas have been disturbed by logging, frequent fires, edge effects and agricultural activities, and therefore the floristic composition has been highly modified in areas. In the study area this community often occurs adjacent to lower lying swamp forest communities. Examples of the occurrence of this community in the study area include:

- The Warrell Creek and the Kalang River floodplains including thin strips in the riparian zone of these waterways.
- Smaller remnants surrounding creek lines on private property adjacent to the existing highway such as Oyster Creek and Boggy Creek.
- Along some creek lines in Little Newry State Forest.
- Larger stands in Newry State Forest along Dalhousie Creek and some unnamed creek lines connected to the Kalang River floodplain.

4.2.2. Lowland rainforests

In an undisturbed state, lowland rainforest communities exhibit a closed canopy of rainforest tree species characterised by high species richness and structural complexity. In disturbed stands (as are represented in the study area) the canopy continuity may be broken, or the canopy may have introduced tree species, such as camphor laurel (*Cinnamonum camphora*) or thick growth of exotic shrubs in canopy gaps such as *Lantana camara*. Common representative tree species of this EEC (DECC 2006) that are present in the study area include: *Schizomeria ovata, Livistonia australis, Archontophoenix cunninghamiana, Sloanea* spp., *Syzygium* spp., *Lophostemon confertus, Acmena smithii*, *Alphitonia excelsa*, *Glochidion ferdinandi*, *Guioa* *semiglauca, Ficus* spp., *Acacia melanoxylon, Tristaniopsis laurina* and *Endiandra* spp. Emergent *Eucalyptus* species are present in numerous areas of this community in the study area. The combination of features that distinguish this community from other EECs on the coastal floodplains include:

- A closed canopy of mesophyllous trees.
- A relatively low abundance of *Eucalyptus, Melaleuca* and *Casuarina* species.
- An abundance and diversity of vine species (Keith and Scott 2005).

Considering the degree of past disturbances from clearing, frequent fires and logging it is difficult to determine which sub-alliance as described by Floyd (1990) the rainforest vegetation in study area has affinities to. It is likely that more than one sub-alliance may be represented, and separation of sub-alliances may be difficult due to complex integrations of these communities. Sub-alliances (Floyd 1990) with the closest affinities to rainforest vegetation in the study area comprise:

- Sub-alliance 33: Ceratopetalum / Schizomeria / Argyrodendron / Sloanea.
- Sub-alliance 17: Cupaniopsis anacardioides.
- Sub-alliance 33: Syzygium luehmannii – Acmena hemilampra.

In the study area this EEC forms a mosaic with another EEC subtropical coastal floodplain forest along some creek lines of the study area. Areas which have the greatest affinities to this EEC include areas where emergent *Eucalyptus* species are minimal and there is a thick subcanopy of mesophyllous tree species and a diversity of vines. These areas include several patches in the Warrell Creek area, Newry State Forest and private land between Raleigh and the Kalang River.

4.2.3. Freshwater wetlands on coastal floodplains

These communities are associated with periodic or semi-permanent inundation by freshwater, with some minor saline influence in certain wetlands. They were found to occur typically on silts, muds or humic loams in depressions, flats, and drainage lines associated with the Kalang and Nambucca River floodplains, generally below 20 m elevation. Features that distinguish this community from other EECs on the coastal floodplains include:

- The scarcity or complete absence of woody plants species.
- The presence of amphibious, emergent, floating and/or submerged aquatic forbs, grasses and/or sedges (Keith and Scott 2005).

In the study area these communities occur in cleared agricultural areas and therefore have been highly disturbed from grazing, pasture improvement and weed invasion. Most examples of the occurrence of this community in the study area comprise cleared agricultural areas to the south of the Kalang and Nambucca Rivers. One higher quality area of this community is present adjacent to the eastern side of the existing highway near Deep Creek which comprises open areas of water, dense sedges and interspersed paperbarks.

4.2.4. Swamp oak floodplain forest

This community is associated with grey-black clay-loams and sandy loams, where the groundwater is saline or sub-saline, on waterlogged or periodically inundated flats, drainage lines and estuarine fringes of the Nambucca River, Deep Creek and the Kalang River. They generally occur below 20 m elevation. The community may vary structurally from open forests to low woodlands, scrubs or reedlands with scattered trees according to the frequency and duration of waterlogging, the level of salinity in the groundwater, in addition to latitude and history of disturbance. Features which distinguish this EEC from other floodplain communities include:

- Dominance of the tree canopy by swamp oak (*Casuarina glauca*).
- A relatively low abundance of *Eucalyptus* species.
- A prominent groundcover of forbs and graminoids (Keith and Scott 2005).

It generally occupies low-lying parts of floodplains where flooding is periodic and soils usually having some saline influence (Keith and Scott 2005). Examples of the occurrence of this community in proximity to the study area include:

- Thin strips along the estuarine fringe of the Nambucca River.
- Areas surrounding deep creek, including areas running along the edge of existing highway.
- Areas near Raleigh within agricultural lands and along the edges of the power easement at the northern end of the study area.

4.2.5. Swamp sclerophyll forest on coastal floodplains

Swamp sclerophyll forest is associated with humic clay loams and sandy loams, on waterlogged or periodically inundated flats and drainage lines of the Nambucca River, Deep Creek and Kalang River floodplains. They generally occur below 20 m (though sometimes up to 50 m) elevation. The community is characterised by:

- A relatively dense tree canopy dominated by swamp mahogany (*Eucalyptus robusta*) and / or broad-leaved paperbark (*Melaleuca quinquenervia*).
- A relatively infrequent occurrence of other Eucalypts may occur, as well as swamp oak (*Casuarina glauca*) or swamp turpentine (*Lophostemon suaveolens*).
- The occasional presence of rainforest elements as scattered trees or understorey plants.

- The prominence of large sedges and ferns in the groundcover.

Soils are usually waterlogged, stained black or dark grey with humus, and show little influence of saline ground water. Large high quality examples of this EEC are present to the east of the corridor in Bellwood Swamp and an area south of Raleigh. Examples of the occurrence of this community in proximity to the study area include:

- Agricultural land south of the Nambucca River.
- Several smaller remnants adjacent to the existing highway.
- Private property between Newry State Forest and the Kalang River.
- Private property north of the Kalang River and south of Raleigh.

4.2.6. Coastal saltmarsh

This EEC occurs in the intertidal zones surrounding the study area in areas permanently or intermittently open to the sea, and is frequently found on the landward side of mangrove stands. Relatively large areas of this community are present outside of the study area surrounding Deep Creek and Newee Creek. There is potential for the Proposal to result in indirect impacts to these areas of saltmarsh. Strict mitigation measures should be employed in these areas during construction and operation of the proposed highway to limit impacts from additional nutrients, water and sediments impacting areas of saltmarsh.

4.3. EEC condition rating and landscape value

Of the six Endangered Ecological Communities identified in the broader study area, portions of five of these were identified as being potentially affected by the Proposal. The condition of the vegetation present at these locations was assessed in the field by assigning a rating score based on the degree of naturalness versus modification and disturbance, the structural and floristic diversity, weed invasion, the size of the patch and connectivity or proximity to other patches of the same EEC in the landscape. Sites were ranked as either high, medium or low quality, as shown in **Figure 4-1** to **Figure 4-4**.

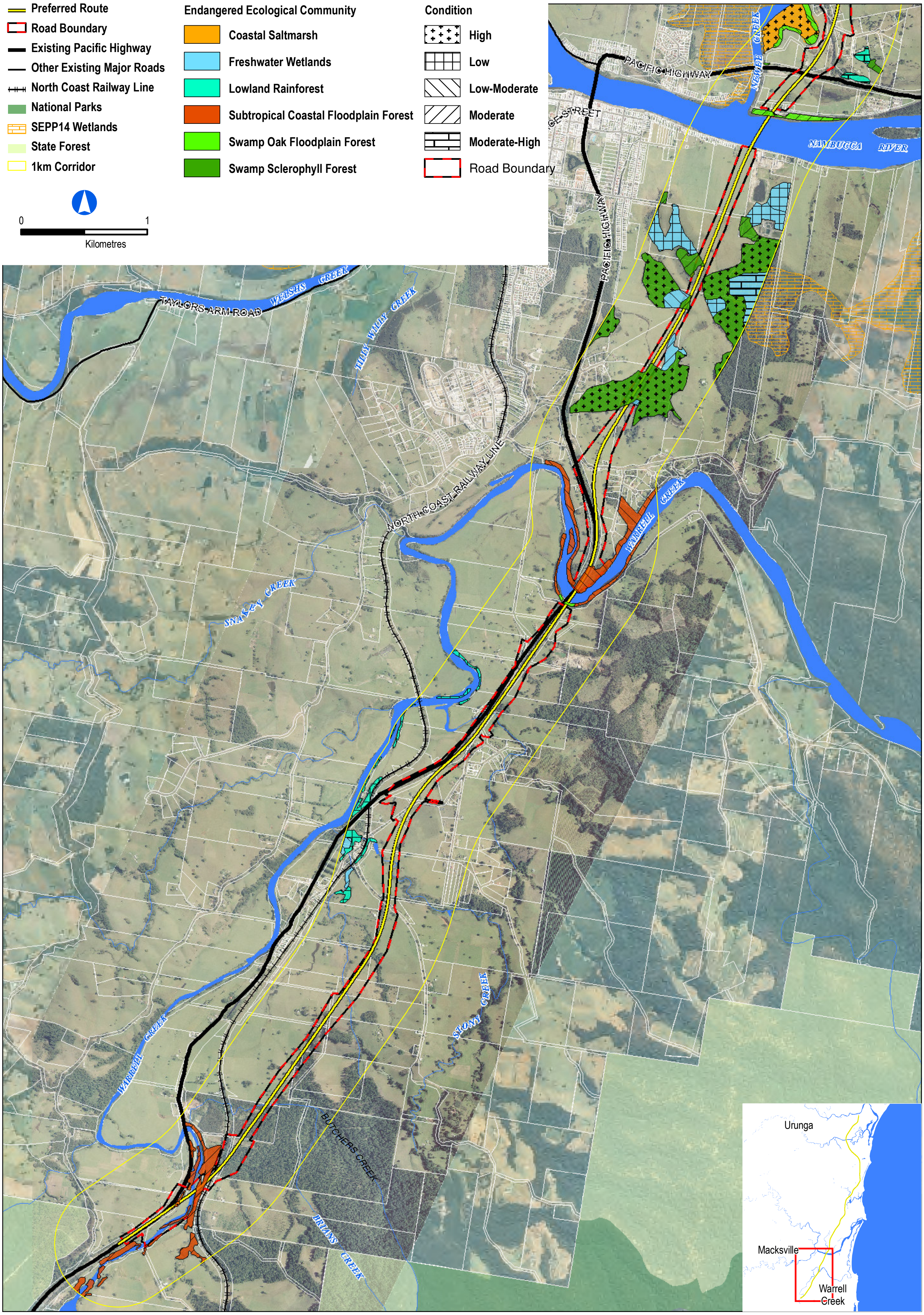


Figure 4-1 : Endangered Ecological Communities and Condition

GDA 94 MGA Zone 56

SKM SINCLAIR KNIGHT MERZ

RTA

Warrell Creek to Urunga - Upgrading the Pacific Highway

June 2, 2009

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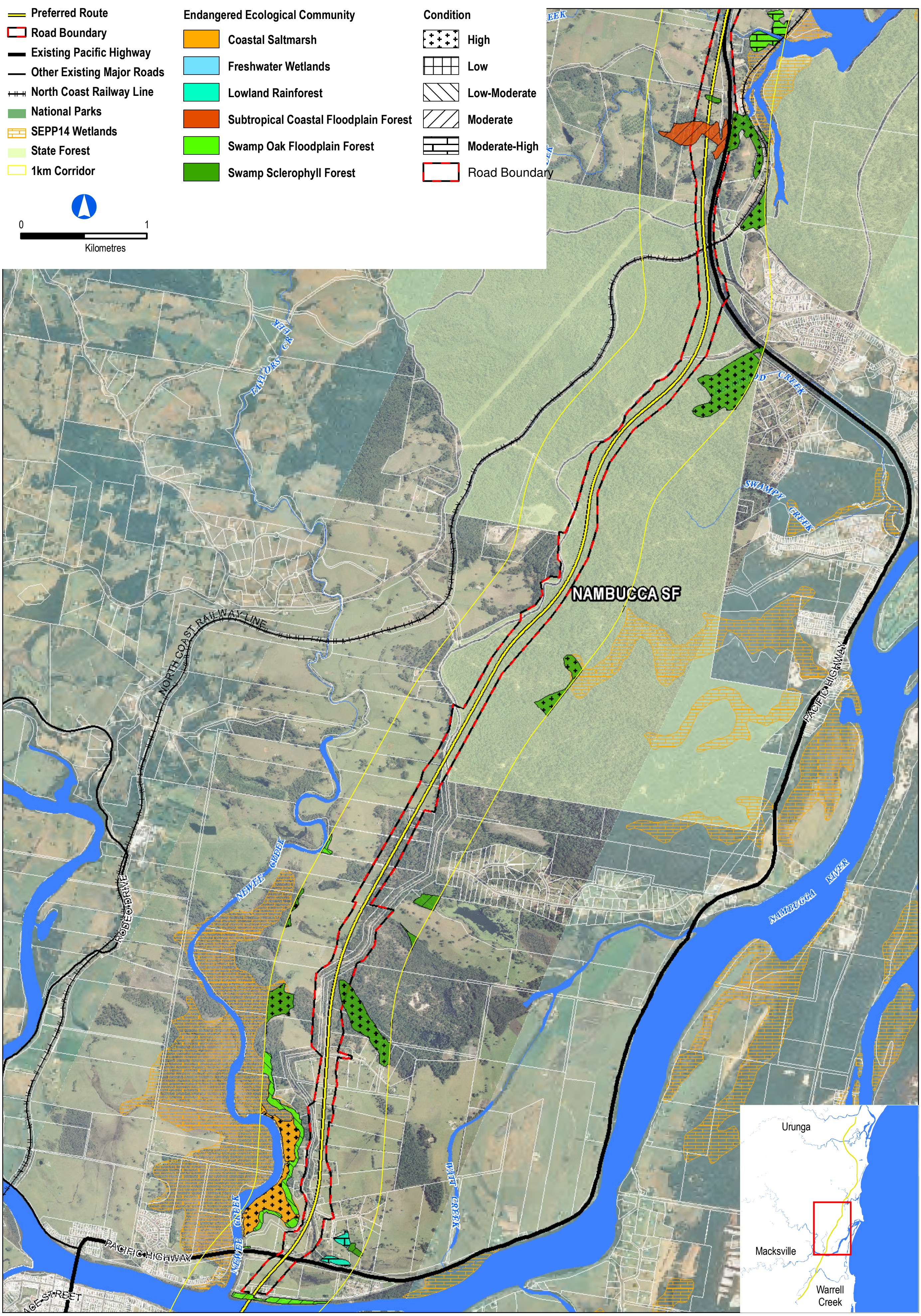

Figure 4-2 : Endangered Ecological Communities and Condition

GDA 94 MGA Zone 56

Warrell Creek to Urunga - Upgrading the Pacific Highway

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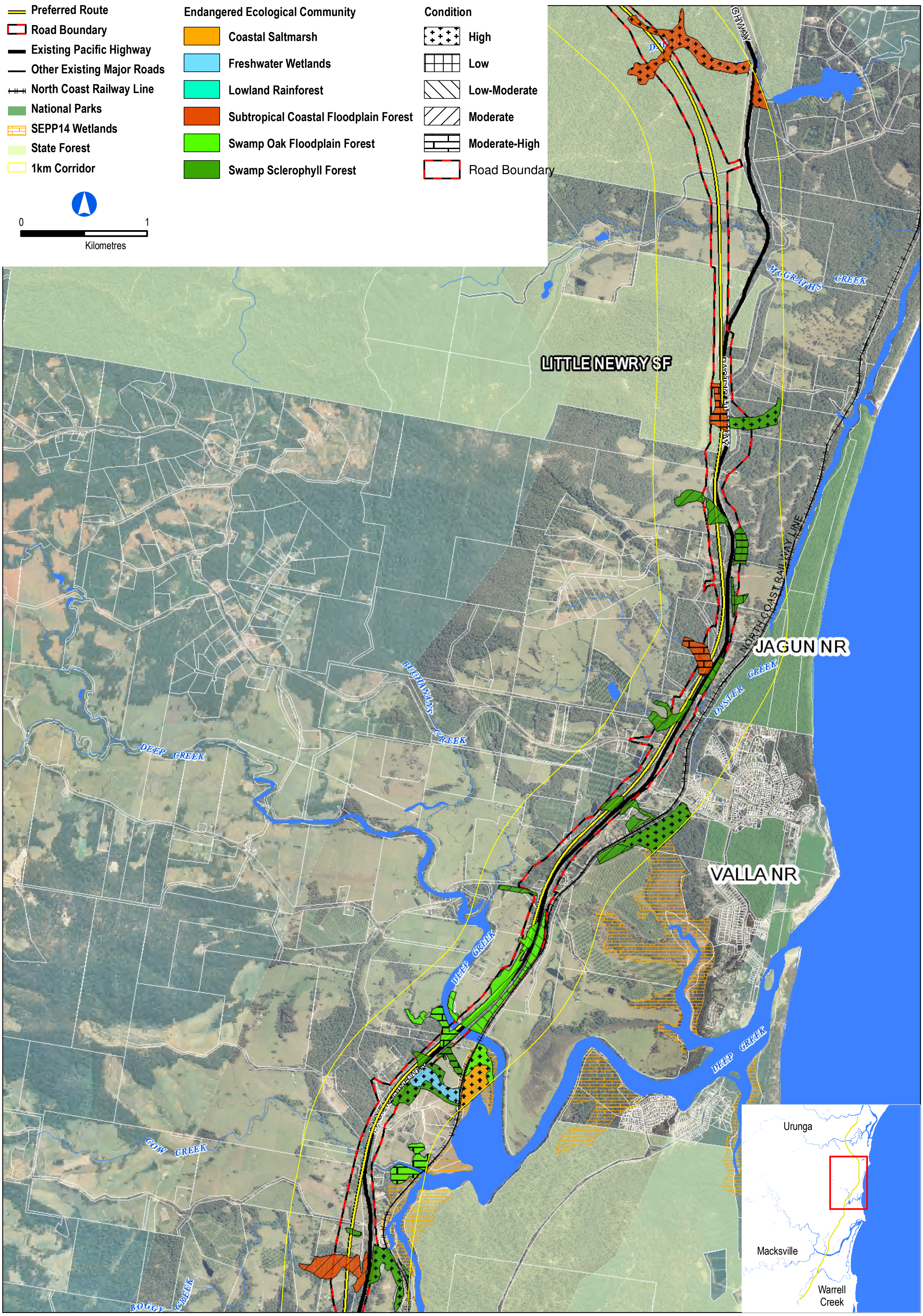

Figure 4-3 : Endangered Ecological Communities and Condition

GDA 94 MGA Zone 56

Warrell Creek to Urunga - Upgrading the Pacific Highway

June 2, 2009

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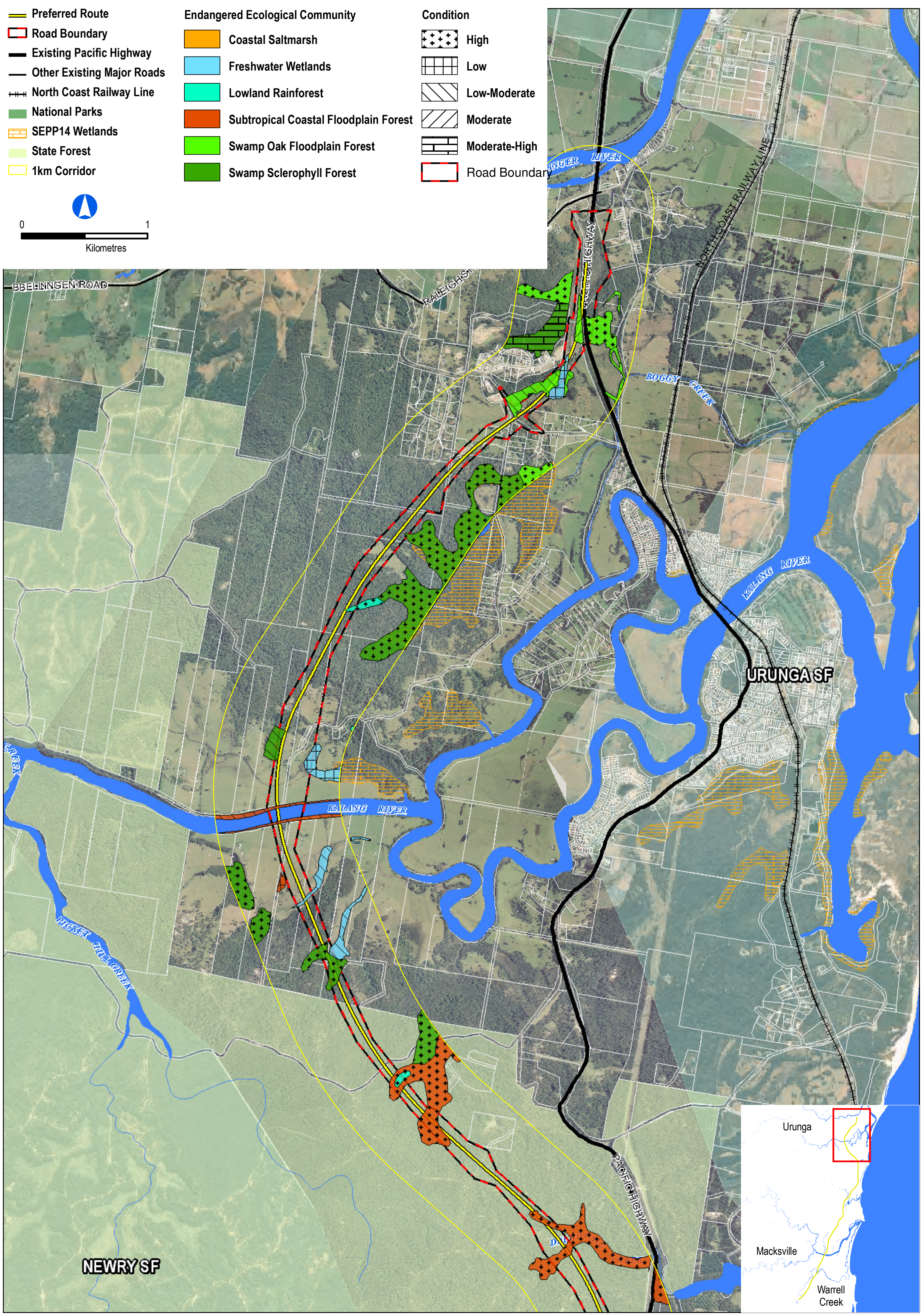

Figure 4-4 : Endangered Ecological Communities and Condition

GDA 94 MGA Zone 56

Warrell Creek to Urunga - Upgrading the Pacific Highway

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4.4. Threatened flora

Threatened flora species identified and potentially occurring in the study area are listed in **Table 4-2**, along with their conservation status, distribution and abundance.

- **Table 4-2: Threatened flora located and potentially occurring in the study area**

Species	Conservation status			Distribution and abundance
	Cwlth	NSW	RoTAP	
Threatened flora Identified in the study area				
Slender milkvine(*Marsdenia longiloba)*	V	E	3RC-	Occurs at six locations along the study area associated with gullies and creek line habitats. Locations include Nambucca, Little Newry and Newry State Forest, as well as a population on private property between the Kalang river and Raleigh. The total number of individuals in these populations was estimated to comprise approximately 156 individuals.
Rusty plum (*Amorphospermum whitei*)	-	V	3RCa	This species was recorded on private property adjacent to the northern side of Boggy Creek. Only one individual was recorded in this area.
Threatened flora potentially occurring in the study area				
Newry golden wattle *Acacia chrysotricha*	-	E	2R	Restricted to an area south of Bellingen on the NSW north coast. An understorey species on rainforest edges and in wet or dry eucalypt forest in steep narrow gullies on quartzite soils. Newry golden wattle is relatively short-lived. The seeds which remain in the soil require heat from fire to induce germination. Too-frequent fire may lead to a decline in the population, as gradual exhaustion of the soil-borne seed bank would result, with no replacement of adult plants over time. Records are present in Newry State Forest, approximately 4.5 km west of the Proposal area and there is a record from 1961 approximately 2 km to the east of the study area in Urunga.
Scented acronychia *Acronychia littoralis*	E	E	3ECi	Scented acronychia is found between Fraser Island in Queensland and Port Macquarie on the north coast of NSW. Scented acronychia grows in littoral rainforest on sand. The nearest record to the Proposal area is 4 km east of Warrell Creek.
Red bopple nut *Hicksbeachia pinnatifolia*	-	V	3RC-	Coastal areas of north-east NSW from the Nambucca Valley north to south-east Queensland. Occurs in subtropical rainforest, moist eucalypt forest and Brush Box (*Lophostemon confertus*) forest.
Maundia triglochinoides	-	V	-	Restricted to coastal NSW north from Wyong extending into southern Queensland. Former sites around Sydney are now extinct. Grows in swamps, creeks or shallow freshwater 30-60 centimetres deep on heavy clay with low nutrients. Flowering occurs during warmer months and is associated with wetland species such as *Triglochin procerum*.

Species	Conservation status			Distribution and abundance
	Cwlth	NSW	RoTAP	
Milky silkpod *Parsonsia dorrigoensis*	E	V	2VCi	Milky silkpod is found only in NSW, with scattered populations in the north coast region between Kendall and Woolgoolga. Found in subtropical and warm-temperature rainforest, on rainforest margins, and in moist eucalypt forest up to 800 m, on brown clay soils. Flowers in summer. Appears to be able to withstand, and maybe even favour, light to moderate physical disturbance.
Brown fairy-chain orchid *Peristeranthus hillii*	-	V	-	Found in north-eastern NSW, north from Port Macquarie, extending to north-eastern Queensland as far as the Bloomfield River. Restricted to coastal and near-coastal environments, particularly Littoral Rainforest and the threatened ecological community Lowland Rainforest on Floodplain. The species is an epiphyte, growing in clumps on tree trunks and thick vines. Flowers appear during September and October.

V= vulnerable E= endangered RoTAP= Rare or Threatened Australian Plant

RoTAP Codes
2 = geographic Range in Australia less than 100km
3 = geographic Range in Australia greater than 100km
V = Vulnerable – at risk over longer period (20-50years)
E= Endangered – at risk within 10-20 years.

R = Rare – uncommon plants with no current threats
C = Reserved
a = 1000 plants or more know from conservation reserves
i = less than 100 plants in conservation reserves
- = reserved population size not accurately known

4.4.1.1. Slender milkvine (Marsdenia longiloba)

a) Identification

The Royal Botanic Gardens has viewed a specimen suspected to be this species and collected from Little Newry State Forest, as part of this investigation and has confirmed that it is probably *Marsdenia longiloba* but flowering material is needed to confirm the identification. No flowering or fruiting material was present during any of the surveys (from November 2007-February 2008), despite the identified flowering time being summer. Therefore a precautionary approach has been taken and the plants found during the surveys are considered to be *Marsdenia longiloba*.

Marsdenia longiloba is a slender vine to five metres in height with hairy twining stems, opposite leaves varying from 3-10 cm long and 1-5 cm wide that are ovate to lanceolate in shape with an acuminate apex drawn to a fine point, and a rounded, truncate or cuneate base (Harden 1992). The leaves are generally thin, hairless, pale green above and lighter on the underside with minute cluster of 5-6 glands at the base of lamina and a long slender petiole 6–20 mm long (Harden 1992). The flowers are arranged in auxiliary umbelliform clusters, 8-12 mm in diameter and creamish green (Williams and Harden 1993). This species is distinguished from other members of the genus by leaf colour and shape and the clear latex that exudes from the leaf stalks. The fruit is a follicle 10-13 cm long and contains numerous seeds and a silky coma (Williams and Harden 1993). Fruits are rarely seen.

Marsdenia longiloba can be identified from other *Marsdenia* species from the clear watery sap instead of being milky or opaque. A very similar looking species in the same family, *Tylophora paniculata* has small hairs on the veins and margins of the leaves, whereas *Marsdenia longiloba* does not, which is an obvious difference when you have both plants side by side. A herbarium specimen of *T.paniculata* was used to compare specimens suspected to be *Marsdenia longiloba* from the study area.

Based on the available keys and identification guides, comparison with herbarium specimens, correspondence from the herbarium and the presence of existing records of *Marsdenia longiloba* nearby to Nambucca State Forest in similar habitat, it is likely that the individuals in the study area are *Marsdenia longiloba.* Reports for flowering times for *Marsdenia longiloba* have been mixed, with vegetation surveys for the Sapphire to Woolgoolga Pacific Highway upgrade finding this species flowering at the end of July 2005 and a single fruit was recorded during December 2005. The flowering period specified in the literature for *Marsdenia longiloba* includes summer (Harden 1992) and November to January (Quinn et al. 1995). Definite confirmation of these plants as *Marsdenia longiloba* would require additional surveys to find the species when in flower from late winter into summer 2008/2009.

b) Distribution and habitat

Marsdenia longiloba is a slender vine species found in various rainforest types and some moist sclerophyll forests, occurring at scattered locations from Barrington Tops north to southeast Queensland (NPWS 2002b). It appears to prefer soils of medium fertility formed on substrates such as metasediment (Ecos Environmental 2007).

c) Ecology

The life cycle attributes for *Marsdenia longiloba* are largely unknown, however assumptions of life history attributes can be drawn from knowledge of other species in the same family (Apocynaceae: Asclepiadoideae). Pollinators are usually insect species including flies and/or beetles (Watson and Dallwitz 2008). Some species in this family have highly specialised pollination mechanisms which involves trapping insects' by their legs or proboscis between the osmotically elastic anther wings, and withdrawal entailing capture of the pollinia by means of ‘sutured corpuscular pollen carriers’ (Watson and Dallwitz 2008). Seeds are adapted for wind dispersal as they are winged and have long silky hairs.

Many plants from the study area appeared to be juveniles and very few larger plants were recorded. Several plants were covered with leaf litter suggesting that the species sprouts from stems beneath the leaf litter or soil. Therefore it is difficult to determine the approximate number of plants in an area.

There is evidence suggesting that translocating *Marsdenia longiloba* is not an effective ameliorative measure to avoid impacts from developments. Transplanting and cutting propagation carried out in an attempt to translocate the species to offset impacts from the Yelgun to Chinderah Highway Upgrade were unsuccessful (Benwell 2003).

d) Local Distribution

Marsdenia longiloba occurs in seven separate sub-populations along the study area in rainforest and wet sclerophyll forest habitats. Most locations are in Newry, Little Newry and Nambucca State Forests, and there are occurrences in private property north of the Kalang River (refer **Figure 4-5** to **4-7**). It is estimated that these occurrences consist of approximately 156 individuals occurring in an area up to 250 m either side of the Proposal centreline. The population in these areas potentially extends further upstream and downstream of some of the surveyed areas, and therefore is likely to consist of a larger population than recorded for this Proposal.

There are numerous records (DECC Atlas 2007) of *Marsdenia longiloba* surrounding the Proposal area at several locations. These records include: areas west of the Proposal area in Nambucca State Forest and surrounding the Nambucca waste management facility; south of the Proposal area in Ngamba Nature Reserve; and north of the Proposal area in the Bellingen region.

4.4.1.2. Rusty plum (*Amorpospermum whitei*)

a) Identification

Medium sized rainforest tree to 20 m in height with a fluted trunk in larger trees. Leaves oblong-elliptic to oblanceolate, 5–15 cm long, 2–5 cm wide, shortly tapering to a pointed apex, lower surface paler, young shoots rusty-hairy, secondary veins curved, 15–20 pairs prominently raised and rusty-hairy below, tertiary veins ± at right angles to and joining secondary veins, fine venation reticulate; petiole 5–10 mm long (Harden 2000). Inflorescences 4–15-flowered and the fruit is 2–5 cm diameter and red turning purple-black, seed globose, 2–3 cm diameter, brown, with a raised elliptic scar, ripening in spring (Harden 2000).

b) Distribution and habitat

Rusty plum occurs in the coast and adjacent ranges of northern NSW from the Macleay River into southern Queensland, with its distributional stronghold on the mid north coast around Coffs Harbour (NPWS 2002b). It has also been recorded in the Port Macquarie district (Harden 2000). It occurs in rainforest and the adjacent understorey of moist eucalypt forest, generally below

600 m altitude on the less fertile soils derived from rhyolite or metasediments (Floyd 1989). The one individual found in the study area is mapped in **Figure 4-8**.

c) Ecology

The ecology of *Amorphospermum whitei* has not been extensively studied and numerous life cycle attributes such as pollination and germination are largely unknown. The large seed is supposedly dispersed by mammal species and is viable for a period of one to three months (Novello and Klohs 1998). Once seedlings are established it can take up to six years for the tree to reproduce (Novello and Klohs 1998).

d) Local distribution

Only one individual of *Amorphospermum whitei* was recorded in the study area on private land adjacent to Boggy Creek, comprising a small tree on the edge of disturbed trail area. Despite targeted searches surrounding this specimen and in other areas of suitable habitat along the route no other individuals were found. Fruit was found beneath this individual indicating that adequate pollination is occurring to produce viable seed, and that other individuals are likely to be present in the vicinity.

There is potential for *Amorphospermum whitei* to occur in other locations of the Boggy Creek catchment on private land to the west of the study area in the same patch of remnant vegetation or in areas of riparian vegetation retained in cleared agricultural landscapes to the west. There are two records of *Amorpospermum whitei* higher in the Boggy Creek catchment in Nambucca State Forest approximately two kilometres to the southwest of the individual recorded in the Proposal area (NSW DPI 2007).

Amorphospermum whitei appears to be relatively widespread in the surrounding locality, as there are numerous records (DECC Atlas 2007; NSW DPI 2007) of *Amorphospermum whitei* surrounding the Proposal area at several locations. These records include areas west of the Proposal area in Nambucca State Forest and Newry State Forest, a historical record in the Warrell Creek area recorded over 100 years ago in disturbed riparian vegetation approximately 200m west of the Proposal, and north of the Proposal area in the Bellingen region.

4.4.2. Regional Threatened Flora Records

There are records of an additional 12 threatened flora species identified in a 10 km radius of the study area (refer to **Appendix A**). While none of these species was identified in the corridor despite intensive surveys, there is potential for additional threatened plant species to occur. Six other threatened flora species are considered to potentially occur in the study area but were not recorded during the investigations, these species are discussed below.

4.4.2.1. Newry golden wattle (*Acacia chrysotricha*)

Newry golden wattle was not recorded in the study area despite targeted searches in areas of suitable habitat. In particular areas of Newry State Forest and Nambucca State Forest had suitable areas of habitat comprising narrow gullies on quartzite soils. There are records of this species to the west of the study area in Newry State Forest.

This species is not particularly difficult to identify in the field, however a similar looking species *Acacia irrorata* was present in moderate abundance in areas of suitable habitat for this species. These species can readily be distinguished from each other by differences in leaf morphology.

4.4.2.2. Scented acronychia (*Acronychia littoralis*)

Scented acronychia was not recorded in the study area despite targeted searches. The preferred habitat for this species is littoral rainforest on sand which does not occur in the study area. There is a low possibility this species is present in rainforest and wet sclerophyll forests of the study area however these habitats are marginal.

This species is not particularly difficult to identify in the field, however a similar looking species *Acronychia oblongifolia* was present in the study area in moderate abundance in rainforest and wet sclerophyll forest habitats. These species can readily be distinguished from each other by differences in leaf and fruit morphology and the scent of the leaves when crushed.

4.4.2.3. Red bopple nut (*Hicksbeachia pinnatifolia*)

Red bopple nut was not recorded in the study area despite targeted searches in areas of suitable habitat. There are no records for this species in the locality, however this species is recorded as occurring from Nambucca Valley to southeast Queensland. red bopple nut may occur in rainforest and wet sclerophyll forests habitats in the study area, however better quality examples of habitat are restricted to a few small areas of rainforest.

This species is not particularly difficult to identify in the field and is easily distinguished from other rainforest species in the study area.

4.4.2.4. Maundia triglochinoides

Maudia triglochinoides was not recorded in the study area despite targeted searches in wetlands, creeks and dams with shallow freshwater 30-60 centimetres deep. The Proposal would result in the removal of only a small area of suitable habitat comprising up to two hectares of dams, creeks and wetland areas. There are several creeks and farms dams which provide suitable habitat for *Maudia triglochinoides*, however many of the wetland habitats in the study area are relatively disturbed and generally provide marginal habitat qualities. There are no records of this species in the locality.

This species is not particularly difficult to identify in the field, however similar looking species including *Triglochin microturberosum* and *T.procera* were present in the study area in areas of shallow water. These species can readily be distinguished from each other by differences in leaf and fruit morphology.

4.4.2.5. Milky silkpod (*Parsonsia dorrigoensis*)

Milky silkpod was not recorded in the study area despite targeted searches in areas of suitable habitat. There are records for this species in the locality. Little is known about the reproductive biology of the species, however it appears to have a well-developed rootstock and may report following fire and may favour light to moderate physical disturbance.

This species is not particularly difficult to identify in the field, however a similar looking species *Parsonsia straminea* is common in the study area in areas of wet sclerophyll and swamp forests. These species can readily be distinguished from each other by differences in leaf morphology and the colour of the exudates (sap).

4.4.2.6. Brown fairy-chain orchid (Peristeranthus hillii)

Brown fairy-chain orchid is an epiphytic orchid that was not recorded in the study area despite targeted searches in areas of suitable habitat. There are no records for this species in the locality. The preferred habitat for this species is littoral rainforest which does not occur in the study area. There is a low possibility this species is present in rainforest and wet sclerophyll forests of the study area however these habitats are marginal. Other epiphytic orchid species were recorded in the study area including *Cymbidium madidum*, *C.sauve*, *Dendrobium kingianum* and *Plectorrhiza tridentata*. However these species can readily be distinguished from each other by differences in leaf and fruit morphology.

4.5. Rare and regionally significant flora

Several rare species listed under the RoTAP database (Briggs and Leigh 1996) and other flora species which are at the limit of their distribution or are generally uncommon in the area and are regarded as being regionally significant were located in the study area (refer **Table 4-3)**.

Table 4-3: Rare and regionally significant flora recorded in the study area

Threatened Flora	Status	Source, Distribution and Abundance
Artanema fimbriatum	Regionally Significant, Southern Limit	Southern limit listed as the Brunswick River (PlantNET 2008). This species was recorded in several locations between Nambucca State Forest and Newry State Forest.
Crinum pedunculatum swamp lily	Regionally significant, sparse species occurring in depleted habitat	Listed as a regionally significant species (Kendall & Kendall 2003). Occurs in areas of swamp forest at several locations, including areas adjacent to Warrell Creek at the southern end of the study area
Cymbidium madidum	Regionally Significant, Southern limit	Southern limit Clarence River (PlantNET 2008), distribution in the study area represent extreme southern limit. Occurs in several locations at the northern end of the study area including private property north of the Kalang River.
Cyperus filipes	Regionally Significant	Listed as a regionally significant species (Kendall & Kendall 2003). Occurs in protected areas in Newry State Forest, and on private property north of the Kalang River.
Eucalyptus ancophila	RoTAP: 2K	Recorded in several gully areas in Nambucca and Newry State Forest.
Lophostemon sauveolens swamp turpentine	Regionally Significant, Southern Limit	The southern limit for this species is Scotts Head (PlantNET 2008), and is listed as a regionally significant species (Kendall & Kendall 2003).
Marsdenia lloydii corky milk vine	Regionally Significant	Listed as a regionally significant species (Kendall & Kendall 2003). Occurs at numerous locations along the entire study area.

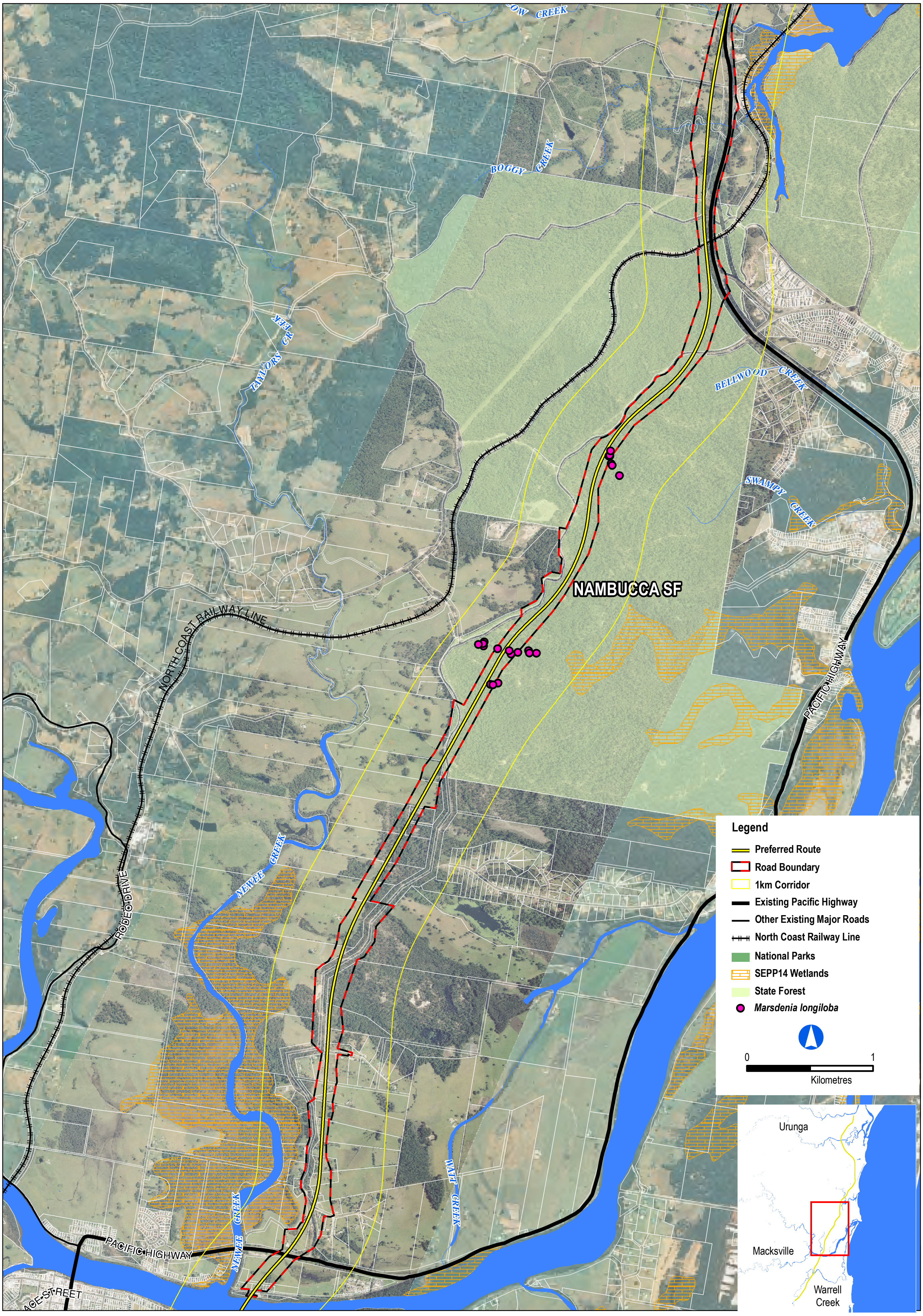

Figure 4-5 : Distribution of *Marsdenia longiloba*

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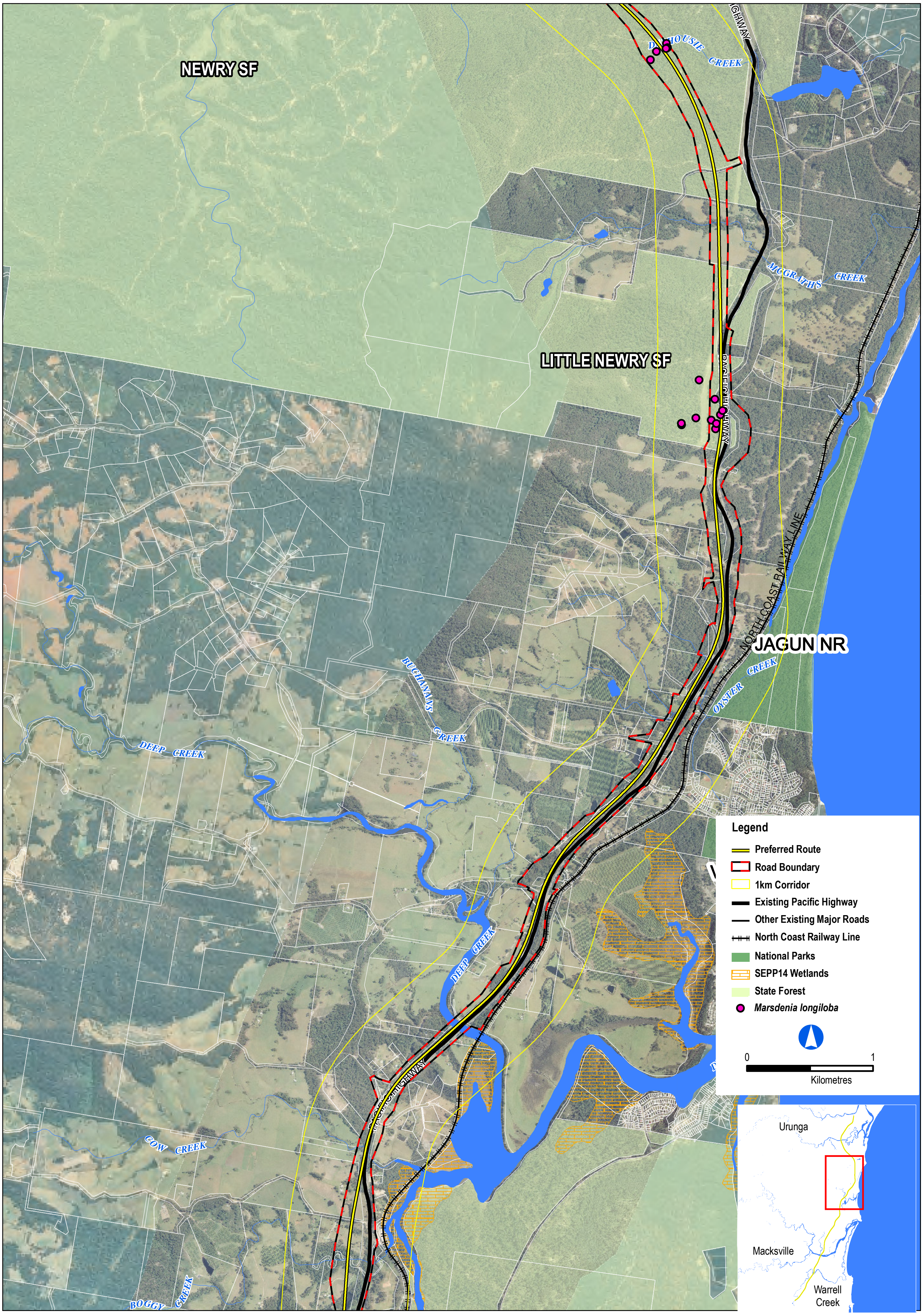

Figure 4-6 : Distribution of *Marsdenia longiloba*

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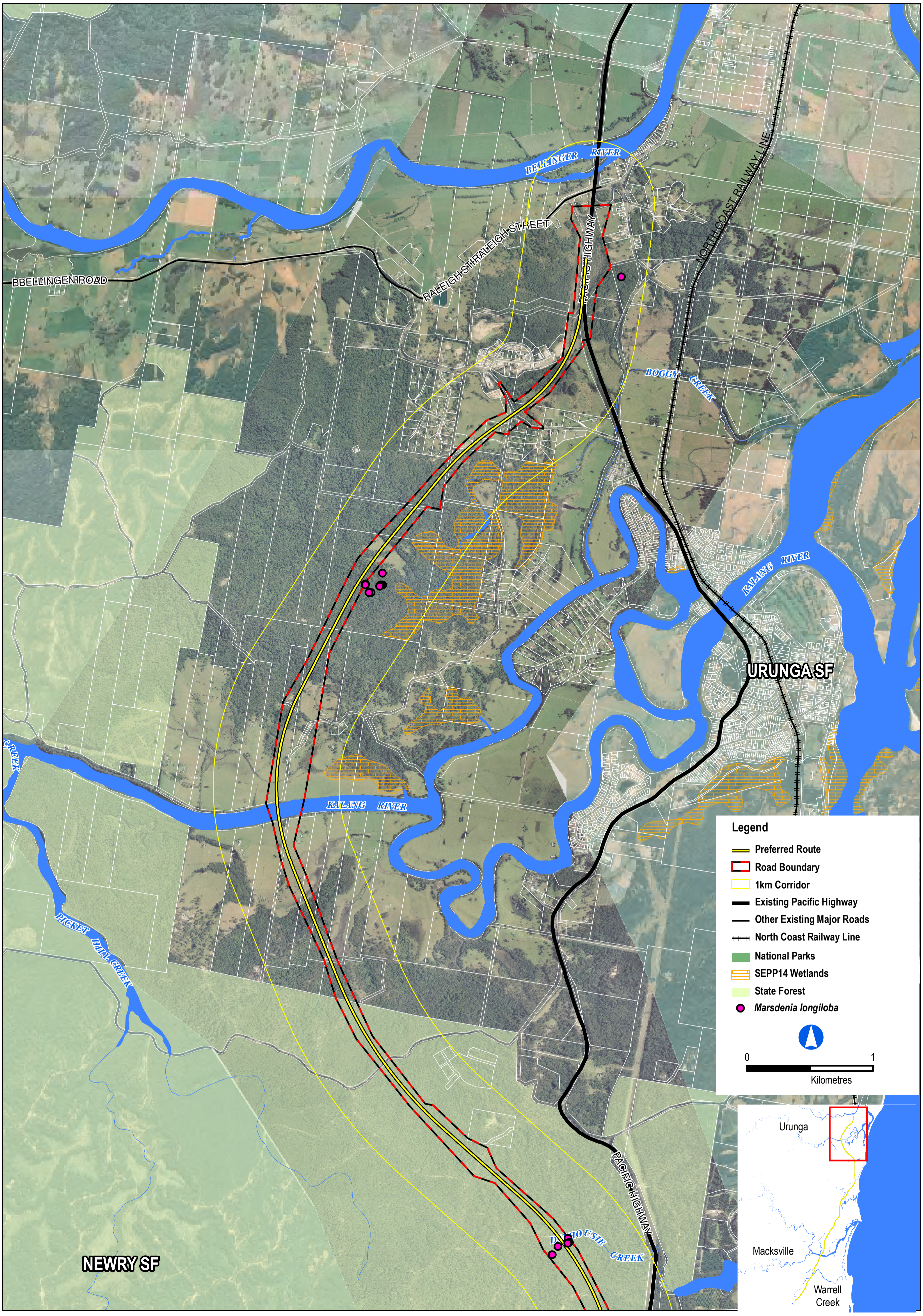

Figure 4-7 : Distribution of *Marsdenia longiloba*

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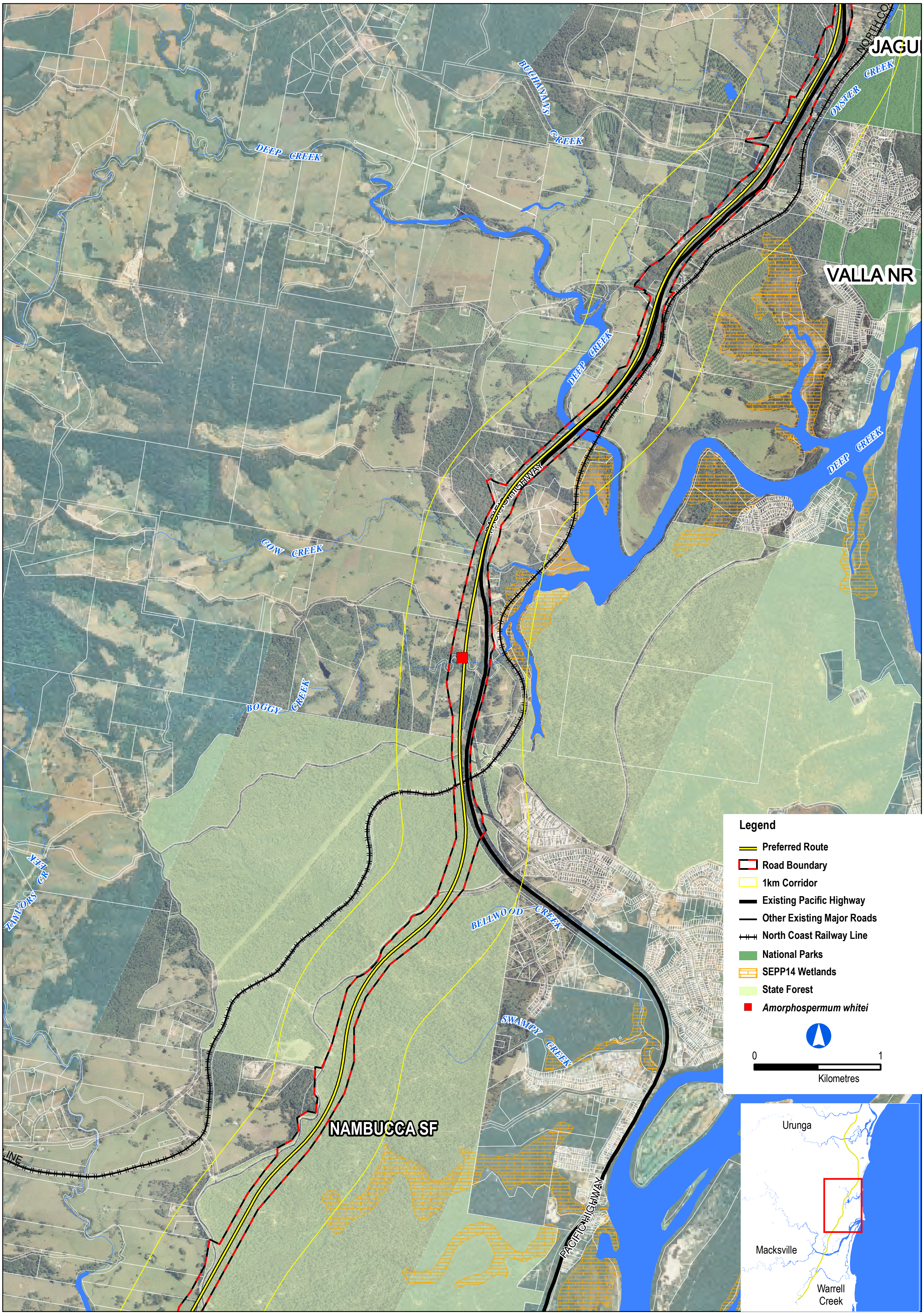

Figure 4-8 : Distribution of *Amorphospermum whitei*

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4.6. Threatened fauna

The results of several comprehensive fauna surveys conducted in the study area between 2005 and 2008 have recorded a total of 14 vertebrate fauna species of conservation significance (refer **Table 4-4**). This list includes one nationally vulnerable species scheduled under the *EPBC Act*, one endangered species and a further 13 species also listed as vulnerable as scheduled in NSW under the *TSC Act*. Locations of threatened fauna recorded in the investigations are illustrated on **Figure 4-9** to **4-12** and detailed below in **Table 4-4**.

Table 4-4: Threatened Fauna recorded in relation to the Proposal

Species	Legislative status		Distribution and abundance
	Cwlth	NSW	
Black-necked stork (*Ephippiorhynchus asiaticus*)		E1	Single adult male identified in freshwater wetland on the Kalang River floodplain located between the northern arm of the river and South Arm Road. Residences on the Kalang River floodplain (north and south) report that storks are occasionally observed in grazed paddocks and swamp vegetation particularly on the northern side of the river suggesting that these modified habitats provide important foraging habitat for local black-necked stork s. Movements are likely to occur between the permanent swamps and ephemeral waterlogged sites in grazed paddocks during high rainfall periods. No nest sites have been identified in the study area.
Grey-headed flying-fox (*Pteropus poliocephalus*)	V	V	Recorded sparsely throughout dry open sclerophyll forest and swamp sclerophyll forest habitats in all sections. A wide-ranging species foraging over a broad range of habitats in response to seasonally available food resources. No roosting colonies have been identified in the study area. A temporary roost site was identified near the village of Urunga in swamp forest adjoining the golf course during the summer of 2004-05. No activity was observed at this site during subsequent visits over 2007-08 suggesting roost sites may change. Roost colonies have been historically reported from Bellingen Island and Bowraville several kilometres to the west of the study area.
Wompoo fruit-dove (*Ptilinopus magnificus*)		V	Single individual recorded in moist sclerophyll habitat in the Boggy Creek catchment south of Boggy Creek Road. Several other records in state forest also in moist forest/rainforest gully habitats in addition to the superb fruit-dove. Potential foraging habitat for both species is patchy and widespread in the coastal portions of the study area particularly along creeks and gullies where fruiting resources are present.
Square-tailed kite (*Lophoictinia isura*)		V	Single observation of adult bird flying over a large expanse of privately owned dry sclerophyll forest habitat located to the north of the Kalang River and adjoining Tarkeeth State Forest. No nest sites recorded in the study area. A wide-ranging species which may occupy a diversity of wet and dry forested habitats.
Yellow-bellied sheathtail-bat (*Saccolaimus*		V	Definite identification via call analyses, single record in Nambucca State Forest in mature dry sclerophyll forest along the edge of cleared track in section 2. Roosts in tree hollows

Species	Legislative status		Distribution and abundance
	Cwlth	NSW	
flaviventris)			and may frequent diversity of dry forest types and age classes provided tree hollows are present.
Greater broad-nosed bat (*Scoteanax rueppellii*)		V	Possible identification via call analysis, single record in private land in section 3. Dry sclerophyll forest habitat adjoining moist creek vegetation, high structural and floristic diversity. Roosts in tree hollows and may frequent diversity of dry forest types and age classes provided tree hollows are present.
Eastern false pipistrelle (*Falsistrellus tasmaniensis*)		V	Possible identification via call analysis recorded in four locations in dry sclerophyll forest habitat adjoining disturbed tracks and cleared edges. Roosts in tree hollows and may frequent diversity of dry forest types and age classes provided tree hollows are present.
Glossy black-cockatoo (*Calyptorhynchus lathami*)		V	Several pairs resident in the northern half of the study area, north from Nambucca State Forest and occupying parts of Nambucca, Newry and Little Newry State Forest as well as dry sclerophyll forest habitats on privately owned lands. Food resources in the study area include *Allocasuarina torulosa* and *Allocasuarina littoralis* which are a common component of the extensive blackbutt open forest community (MU1). No nest sites recorded in the study area, however several potential sites (large tree hollows) identified in proximity to the route.
Koala (*Phascolarctos cinereus*)		V	Recorded from this study in Nambucca State Forest on the western side of the rail line outside of the study area. Numerous other records in Newry State Forest again to the west of the study area and also on the coast around Valla. Likely east west movements across identified key habitats and corridors.
Little bentwing-bat (*Miniopterus australis*)		V	Reported in all habitat types, ranging from swamp forest to dry and moist eucalypt forest and adjacent cleared lands. Recorded from sections 1 and 2. The extent of local population of this species is not known, although probably widespread in terms of foraging habitat. A predominantly cave-roosting species reported to use caves, tunnels and subterranean structures. No roost sites reported or located in the study area.
Eastern bentwing-bat (*Miniopterus schreibersii oceansis*)		V	One individual trapped in Nambucca State Forest at Site D4 (dry sclerophyll forest) along the Ironbark Trail and second individual trapped on private lands in the Warrell Creek area. The extent of local populations unknown for this species, probably widespread in terms of foraging habitat. A cave-roosting species reported to use caves, tunnels and subterranean structures. No roost sites reported or located in the study area.
Osprey (*Pandion haliaetus*)		V	Several breeding pairs expected in the catchment of the Nambucca and Kalang River. Nest sites generally recorded in floodplain areas. One active nest located in the study area during 2008, recorded on private property south of Deep Creek within 50 m of the existing Pacific Highway. Nesting reported to have occurred at this location for several years. Other nests reported north of Martels Road and Champions Lane in 2005 were blown out of tree and collapsed by 2007-08. Also commonly observed in the floodplain and estuarine

Species	Legislative status		Distribution and abundance
	Cwlth	NSW	
			habitats across the study area.
Powerful owl (*Ninox strenua*)		V	One bird (sex unknown) heard calling and seen to the west of Nambucca State Forest in section 2 during spotlighting survey in 2005. Potential habitat widespread through Nambucca, Newry and Little Newry and also large private properties north of the Kalang River in section 4.
Yellow-bellied glider (*Petaurus australis*)		V	Family group of three to four individuals recorded in Nambucca State Forest at sites D2 and D3 between Bellwood Road and Allans Road. Denning expected to be within interconnecting gully habitat. Several clustered records of this species are reported in Nambucca State Forest both east and west of the Proposal route indicating the presence of a localised population extending over a large area. Other records to the east of the existing Pacific Highway around Valla and Valla Nature Reserve.

E1 = Endangered species, V = Vulnerable species

A review of literature and threatened species database records have indentified records of an additional 13 threatened fauna species historically reported in the study area (refer **Table 4-5**). Of these the green and golden bell frog (*Litoria aurea*) has been reported south of Macksville at two locations, although the species has not been reported in the locality since 1975 and is predicted to be locally extinct. Similarly, there is one reported location for the emu (*Dromaius noveahollandiae*) although the record is from 1981 and there have been no recent records of the species in the study area. Coastal emu populations have been listed as endangered in NSW, under the TSC Act. Known populations occur to the north of Coffs Harbour from Red Rock to Bungawalbin. There are no documented populations in the Nambucca Valley.

- **Table 4-5: Threatened fauna previously recorded in the study area, not reported in this study (DECCW Atlas of NSW Wildlife)**

Species	Status	
	Cwlth	NSW
Freen and golden bell frog (*Litoria aurea*)	E	E1
Regent honeyeater (*Xanthomyza phrygia*)	E	E1
Wwift parrot (*Lathamus discolour*)	E	E1
Giant barred frog (*Mixophyes iteratus*)	E	E1
Red-tailed black-cockatoo (*Calyptorhynchus banksii*)	E	V
Spotted-tailed quoll (*Dasyurus maculatus*)	V	V
Emu (*Dromaius noveahollandia*)		E2
Black bittern (*Ixobrychus flavicollis*)		V

Species	Status	
	Cwlth	NSW
Brush-tailed phascogale (*Phascogale tapoatafa*)		V
Eastern freetail-bat (*Mormopterus norfolkensis*)		V
Common blossom bat (*Syconycteris australis*)		V
Masked owl (*Tyto novaehollandiae*)		V
Sooty owl (*Tyto tenebricosa*)		V

E1 = Endangered, E2 = Endangered Population, V = Vulnerable

4.7. Fauna habitat of conservation significance

The results of the fauna survey, habitat assessment and data review identify the general distribution and abundance of fauna across the study area including locations of threatened fauna and associated habitat. The highest diversity of fauna based on the results of replicate surveys for birds and mammals was found to occur in moist and swamp forest habitats, particularly those located on privately owned land where logging has been less intense. Such habitats exhibit a relatively high floristic and structural diversity and moderate abundance of logs and hollow-bearing trees. The best examples of moist and swamp forest habitats occur in the northern section of the corridor between South Arm Road and the Kalang River within riparian and lower elevated lands (refer Figure 3-14). Such areas exhibit a high floristic and structural diversity as a consequence of being protected from frequent fires. Hollow-bearing trees and dead trees were found to be more commonly associated with these gully habitats. Further, the provision of a diversity of food resources and sheltering microhabitats provide optimum habitat for threatened species such as the wompoo and superb fruit-dove, grey-headed flying-fox, powerful owl, yellow-bellied glider, spotted-tailed quoll, brush-tailed phascogale and potentially the giant barred frog.

Lower faunal diversity was found to be associated with the smaller and isolated fragments of dry sclerophyll forest (i.e. <50 ha in area) throughout section 2 and 3 of the corridor, although was also recorded in some larger fragments of dry forest contained within the State Forests and disturbed by the long-term effects of logging, grazing, public access and frequent fire regimes. These factors have simplified the habitat and reduced the number of mature trees and hollow-bearing trees and logs present as well as exacerbating weed invasion and are typical of the Blackbutt Open Forest communities (refer Figure 3-7 to Figure 3-10).

Despite the level of disturbances which have occurred in the habitats of the State Forests, these properties represent the largest fragments of bushland in the study area and as such have been identified as key habitats and important corridors (NSW Department of Conservation and Climate Change 2003) and are of high conservation value (refer Figure 3-5 and Figure 3-6). This is due to their relative size and strategic locations effectively linking the coastal forests to larger forests west of the Project corridor. Nambucca, Newry and Little Newry State Forests are known to be important habitat for a number of threatened species including the koala, yellow-bellied glider, glossy black-cockatoo, square-tailed kite and several microchiropteran bats.

Habitat trees comprise hollow-bearing trees and standing dead trees. Hollows are an important resource utilised by a variety of forest fauna. Several vertebrate species use hollows as diurnal or nocturnal shelter sites, for rearing young, feeding, thermoregulation and to facilitate ranging behaviour and dispersal (Gibbons and Lindenmayer 2002). Habitat trees are sparsely scattered throughout the landscape with no particular habitat type exhibiting higher densities than others. The combination of logging, fire and storm impacts have reduced the abundance of habitat trees such that many are restricted to sheltered gullies. Isolated paddock trees are also present in cleared farmland. Due to the sparse nature of habitat trees in the study area, these were recorded opportunistically during general field survey activity rather than systematic surveys. Quantified data on hollow sizes classes was not recorded nor was the abundance of habitat trees adjacent to the route corridor. The location of significant habitat trees is identified on **Figure 4-13** to **Figure 4-15**, this included a range of medium and large-sized hollows considered to provide potential shelter and nesting sites for hollow dependent fauna, including the threatened species glossy-black cockatoo, powerful owl and yellow-bellied glider. Hollows are also important for non-threatened fauna species recorded in the study area that are resident in these habitats including cockatoos, lorikeets, sugar gliders, greater gliders and feathertail gliders.

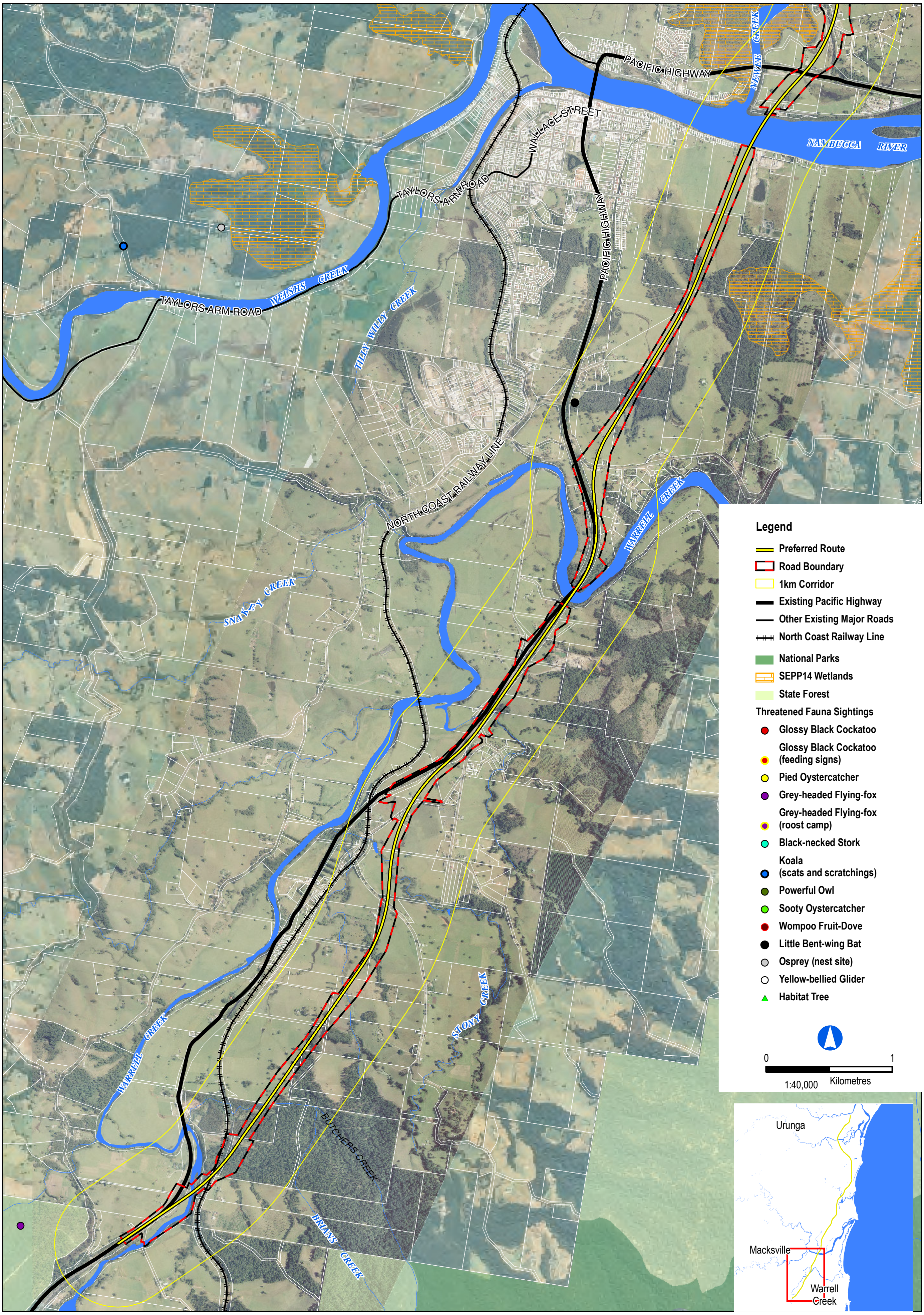

Figure 4-9 : Threatened Fauna Sightings and habitat attributes

GDA 94 MGA Zone 56

Warrell Creek to Urunga - Upgrading the Pacific Highway

June 2, 2009

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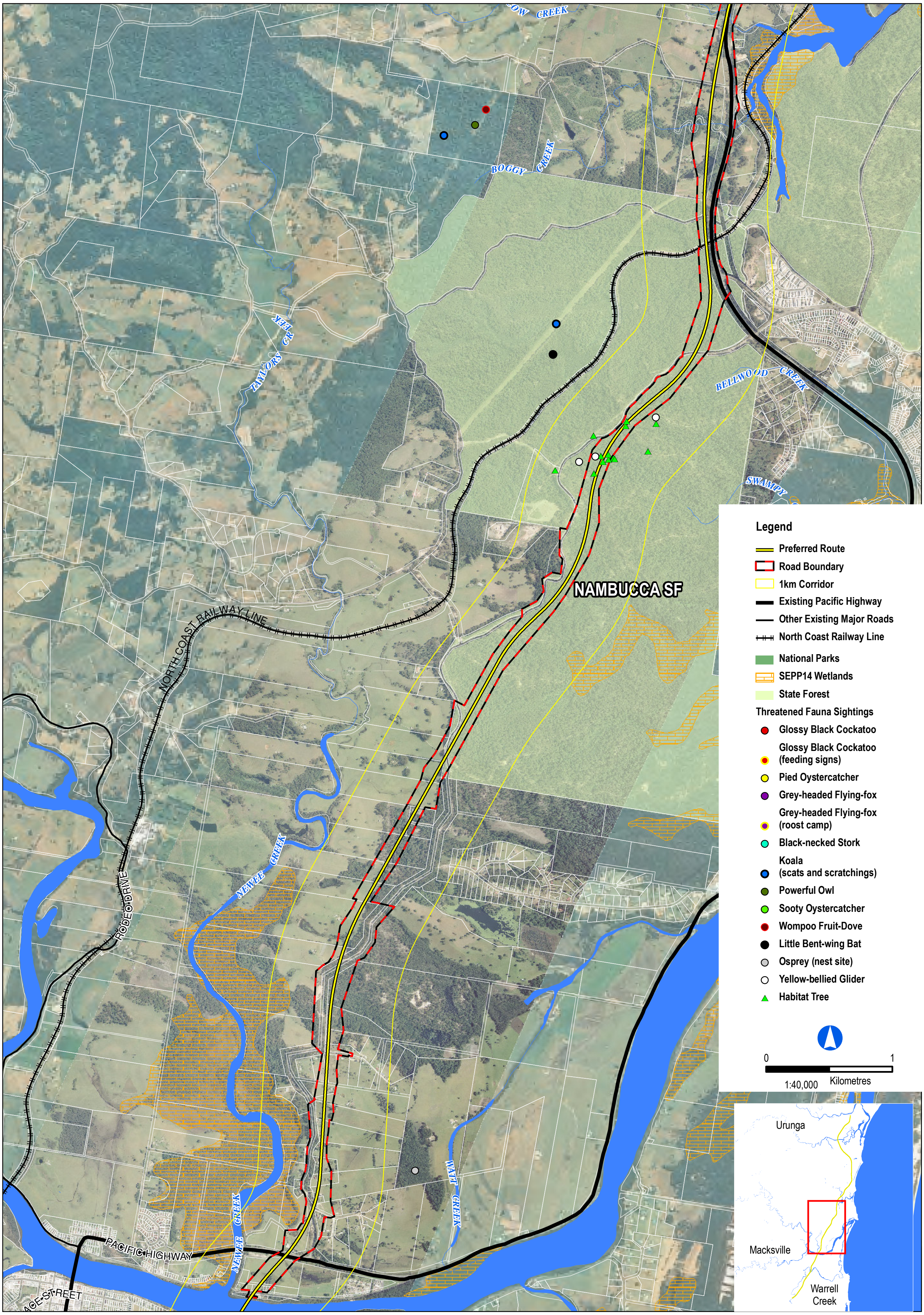

Figure 4-10 : Threatened Fauna Sightings and habitat attributes

GDA 94 MGA Zone 56

Warrell Creek to Urunga - Upgrading the Pacific Highway

June 2, 2009

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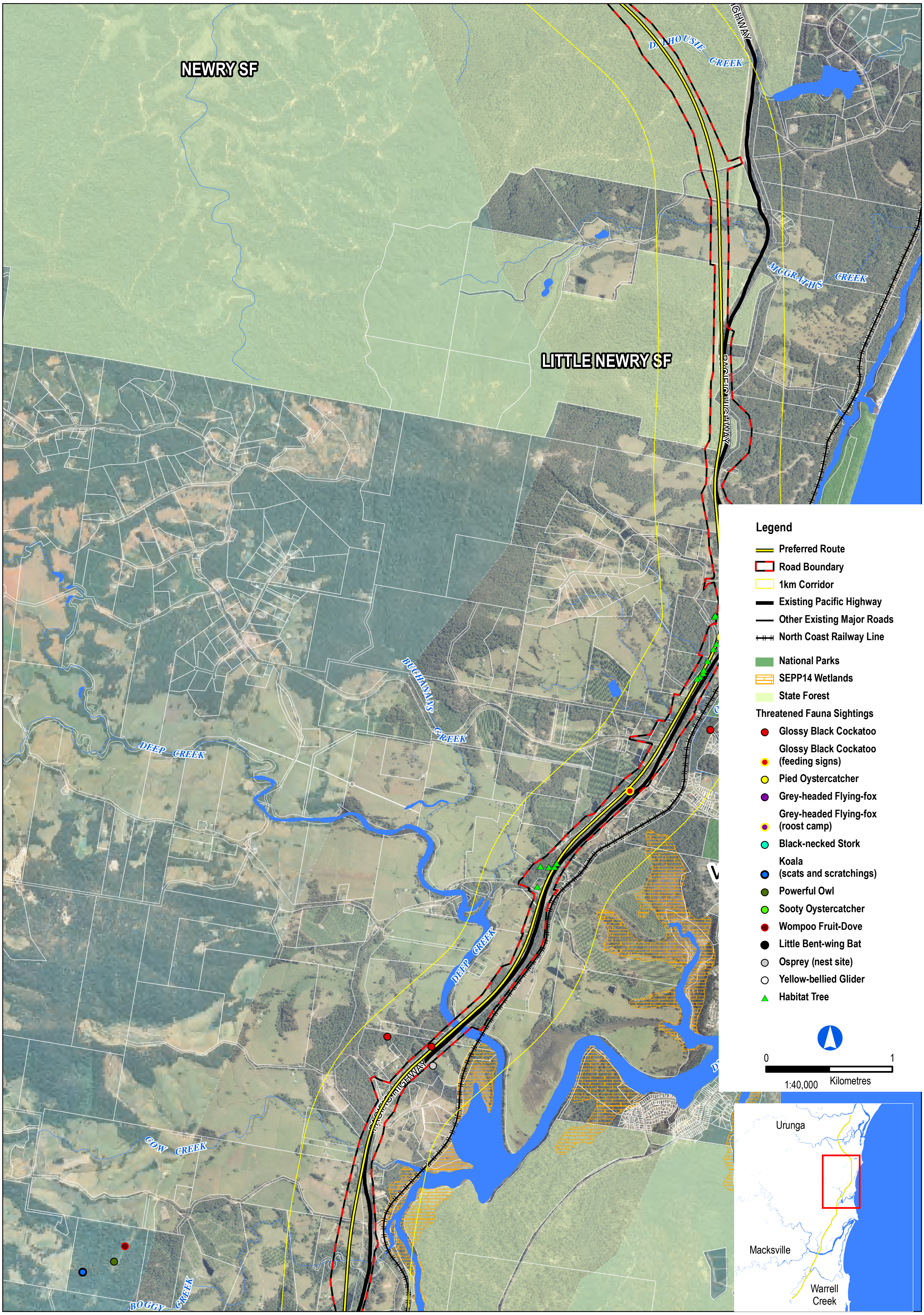

Figure 4-10 : Threatened Fauna Sightings and habitat attributes

GDA 94 MGA Zone 56

Warrell Creek to Urunga - Upgrading the Pacific Highway

June 2, 2009

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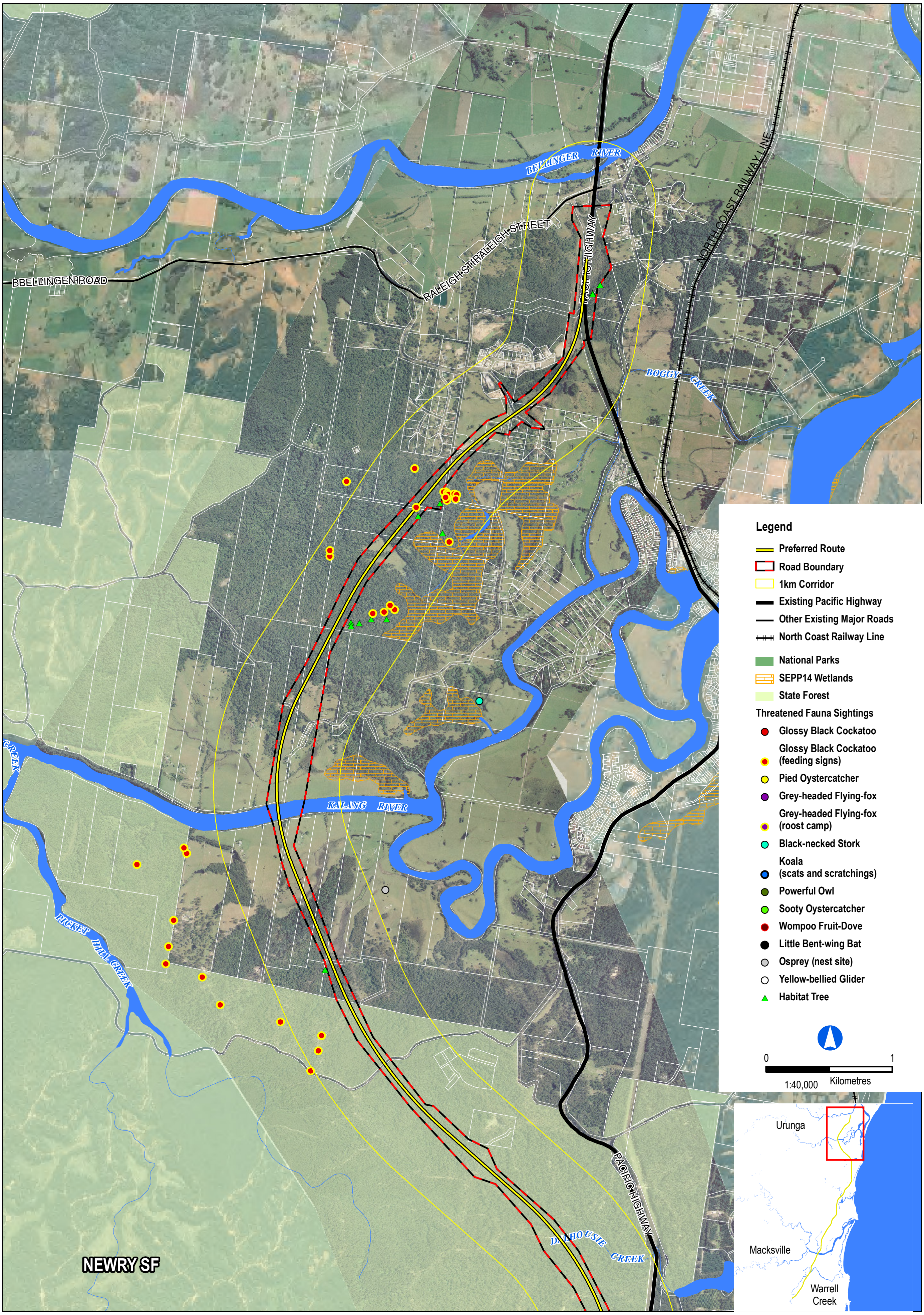

Figure 4-12 : Threatened Fauna Sightings and habitat attributes

GDA 94 MGA Zone 56

Warrell Creek to Urunga - Upgrading the Pacific Highway

June 2, 2009

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4.8. Migratory bird species

Nine listed migratory bird species (EPBC Act) were identified from the field investigation, refer to **Table 4-6** which also includes potential species based on the presence of suitable habitat. The majority of species were considered uncommon and widespread with no specific congregations or habitat represented. The most widespread and abundant species was cattle egret present throughout cleared farmland and rufous fantail and black-faced monarch in moist densely forested gullies. White-throated needletail were observed in the air on several occasions flying over the study area and not specific to any habitat type.

- **Table 4-6: Migratory bird species recorded and predicted in the study area**

Species	Common name	Habitats*						Potential habitat present
		DSF	MSF	SSF	FW	EST	RC	
Bubulcus ibis	Cattle egret						•	
Ardea alba	Great egret			•	•		•	
Haliaeetus leucogaster	White-bellied sea-Eagle						•	
Pandion haliaetus	Osprey			•		•	•	
Gallinago hardwickii	Latham's snipe						•	
Lathamus discolor	Swift parrot							•
Hirundapus caudacutus	White-throated needletail	•	•				•	
Merops ornatus	Rainbow bee-eater							•
Xanthomyza phrygia	Regent honeyeater							•
Rhipidura rufifrons	Rufous fantail	•	•					
Monarcha melanopsis	Black-faced monarch	•	•	•				
Monarcha trivirgatus	Spectacled monarch							•
Acrocephalus australis	Australian reed-warbler						•	

5. Impact assessment

5.1. Avoidance and minimisation

5.1.1. RTA approach to biodiversity impacts

When planning, designing, constructing and maintaining roads, RTA endeavour to:

1) **Avoid** impacts on habitat, through the planning process.
2) **Minimise** impacts on habitat, through the planning process.
3) **Mitigate** for impacts on habitat, through the use of a range of amelioration measures.

This approach has been adopted for the Proposal, firstly via the initial planning phase where a detailed route selection process was designed to avoid and minimise impacts on habitat and secondly via the Environmental Assessment, which incorporates important key design characteristics, and management and monitoring actions designed to mitigate any residual impacts. Further details on these measures as outlined in the following sections.

5.1.2. Route selection process

The route selection process was undertaken during 2003-2006. Relevant input into the process and prediction of impacts on terrestrial flora and fauna was a major component of the process. The work completed was designed to effectively identify, describe and map high conservation value features in the landscape. Four criteria were developed to assess the significance of impacts on biodiversity potentially affected by each option, these included:

- Impacts on high quality habitats.
- Assessment of impacts on threatened species habitats and Endangered Ecological Communities.
- Extent of impacts on SEPP 14 wetlands.
- Severance to wildlife corridors.

The data collection for each criteria provided valuable input into the overall route options assessment, refinement and selection process and was effective in aiding to avoid and minimise significant impacts on regional biodiversity.

5.1.3. Key design characteristics

The results of flora and fauna studies conducted for the early stages of the EA were used as a tool to refine the Proposal and provide assistance with designing measures to further minimise impacts. This relates specifically to the identified locations of threatened species and habitat of conservation significance including wildlife corridors. A summary of the issues identified in the EA and outcomes include:

- Further targeted surveys of the distribution and abundance of the vulnerable species *Marsdenia longiloba* were conducted following the initial identification of several populations within the study area. These data were used to refine the road design in several locations to reduce direct and indirect impacts on the subject populations.
- The identification of habitat trees in the landscape followed by refinement of the design to avoid direct impacts where possible.
- Input into the identified locations of yellow-bellied gliders (*Petaurus australis*) and koalas in the study area and of the location of local and regional wildlife corridors. This was followed by widening of the median at several sites to minimise the impacts of fragmentation on fauna and provide stepping stone opportunities across the dual carriageway.
- Input into the most appropriate location for wildlife underpass structures, particularly where these occur in conjunction with wildlife corridors.

5.2. Residual impacts

Residual impacts on flora and fauna include those unavoidable impacts expected on vegetation and habitat in the study area after the selection of the Proposal and refinement of the design were completed. Direct and indirect impacts from the Proposal on populations of flora and fauna including threatened species would result from:

- The direct removal of vegetation and fauna habitat.
- Impacts to biological and genetic diversity.
- Loss of Endangered Ecological Communities.
- Loss of threatened species and their habitat.
- Loss of habitat for migratory fauna.
- Edge effects and weed invasion.
- Habitat fragmentation.
- Impacts to fauna movement and behaviour.
- Impacts to riparian habitats.
- Impacts to ground-water dependent communities.
- Impacts to designated wetlands (SEPP14).
- Impacts to aquatic habitat.
- Impacts to migratory aquatic species.
- Impacts to water quality.

5.2.1. Loss of native vegetation and fauna habitat

Direct impacts from the proposed design footprint (including batters and cuttings) on vegetation and habitat were calculated using GIS software with the total impact or loss based on the road footprint (the road design with a 10 m construction buffer). The total construction corridor equates to 431 ha of which 255 ha (59 per cent) is occupied by native vegetation. The remaining 176 ha (41 per cent) consists of cleared agricultural land, plantations, modified rural residential zones and river crossings. Impacts on vegetation and habitat are quantified below in **Table 5-1**.

Vegetation and habitat loss would comprise numerous small fragmented patches of remnant vegetation <50 ha in size) as well as several larger patches (>100 ha). The latter includes the removal of vegetation within Nambucca State Forest, Little and Newry State Forest and also on private land north of the Kalang River. Much of this loss relates to the dry sclerophyll forest communities which are widespread and abundant in the region.

- **Table 5-1: Direct impact scenarios for native vegetation and fauna habitat**

Vegetation Association	Corresponding Fauna Habitat Type	Impact 10m buffer (ha) (footprint)	Impact 5m buffer (ha)	Impact 3m buffer (ha)
Dry Open Forest - Blackbutt	Dry sclerophyll forests	144.11	123.84	114.93
Moist Open Forest - white mahogany / grey gum / Ironbark	Moist sclerophyll forest	28.76	24.79	22.99
Moist Open Forest - Flooded Gum		21.91	18.73	17.33
Mixed Floodplain Forest (EEC)		12.49	10.69	9.98
Swamp Forest - Swamp Mahogany / Paperbark (EEC)	Swamp sclerophyll forests	12.47	11.02	10.33
Swamp Forest - Swamp Oak (EEC)		33.07	9.17	8.62
Lowland Rainforest (EEC)	Rainforest	0.58	0.52	0.50
Freshwater Wetlands (EEC)	Freshwater wetlands	1.58	1.22	1.09
Mangroves	Estuarine	0.19	0.15	0.14
Total (ha)		**255.15**	**200.13**	**185.90**

5.2.2. Impacts to biological and genetic diversity

The direct removal of vegetation and fauna habitat described and the associated fragmentation of habitat has the potential to have long-term impacts on genetic diversity in flora and fauna. This impact would be greatest on species with high levels of endemism and in particular species with small restricted home ranges within the study area.

None of the flora and fauna species identified from the field surveys are considered to be restricted in distribution within the study area, with all species recorded known to occur across the entire North Coast Bioregion. The recording of the slender milk vine (*Marsdenia longiloba*) in this location is consistent with the southern limit of the species distribution, a factor of the climatic conditions and not habitat fragmentation. This factor highlights the importance of local populations and the consideration of the individuals in the project design.

In parts the Proposal would effectively increase the degree of isolation of habitat remaining on the eastern (coastal) side of the highway at several locations. This would have a potential effect on the gene pool of less mobile fauna species such as terrestrial and arboreal mammals, reptiles and amphibians conserved on the eastern side of the highway. Conversely, highly mobile species (particularly birds and bats) are likely to be less impacted.

Examples of the potential isolation of flora and fauna populations include:

- The fragmentation of approximately 1000 ha of forest in the vicinity of the Old Coast Road, associated with a portion of Nambucca State Forest and adjoining property to the south which would remain isolated on the eastern side of the highway. The large proportion of habitat retained may lessen the impacts on genetic isolation, however in the absence of opportunities for genetic dispersal there is potential for significant longer term impacts on remaining populations of species such as the yellow-bellied glider.
- The cumulative loss of connectivity is expected to impact on coastal forests such as Valla Nature Reserve and surrounding habitats located to the east of the proposed traverse of Little Newry and Newry State Forest.

Measures to mitigate these impacts have been addressed via the appropriate placement of dedicated and incidental fauna underpasses and the proposed widening of the median at these locations to minimise the barrier effect of the dual carriageway.

5.2.3. Loss of Endangered Ecological Communities

Of a total vegetation loss of 255 ha, approximately 60.21 ha (24 per cent) is classified into five listed EEC (Schedule 1, Part 3 of the TSC Act) (refer **Table 5-2**).

The greatest impact in terms of area (33 ha) would be the removal of 'swamp oak floodplain forest', of which over 70 per cent was identified as a low to moderate condition. Approximately 12 ha each of 'swamp sclerophyll forest' and 'subtropical coastal floodplain forest' would be removed. Only small areas of lowland rainforest and freshwater wetlands would be impacted.

The quantities estimates for EEC removal in **Table 5-2** are based on a 10 m construction buffer beyond the footprint design. There is scope to minimise this impact through strict clearing controls implemented as part of the construction environmental management process. If clearing can be minimised to a three metre construction buffer there would be significantly opportunity to decrease the overall loss of EECs, particularly for 'swamp oak floodplain forest'.

- **Table 5-2: Direct impact of the Proposal on Endangered Ecological Communities**

Endangered Ecological Community	Direct impact (ha) (EEC quality)					Total (ha)
	Low	Low-mod	Mod	Mod-High	High	
Swamp Sclerophyll Forest on Coastal Floodplain	0.38	0.29	5.86	-	5.94	**12.47**
Subtropical Coastal Floodplain Forest	0.24	1.93	2.23	3.25	4.84	**12.49**
Swamp Oak Floodplain Forest	-	9.21	14.88	3.86	5.12	**33.07**
Lowland Rainforest on Floodplain	-	-	-	-	0.6	**0.6**
Freshwater Wetlands on Coastal Floodplains	0.88	0.31	0.18	-	0.21	**1.58**
Total	1.5	11.74	23.15	7.11	16.71	**60.21**

These losses represent a relatively small proportion of the total remaining area of each EEC on the Macleay Coastal Floodplain. It is estimated that approximately 700 ha of ‘swamp sclerophyll forest’, 400 ha of ‘swamp oak floodplain forest’ and 11,000 ha of ‘freshwater wetlands’ are remaining (NSW Scientific Committee 2004). The remaining area of subtropical coastal floodplain forest and lowland rainforest is not known.

5.2.3.1. Assessment of significance (Part 3A EP&A Act)

An assessment of significance was conducted for the EECs known to be impacted by the proposal in accordance with the *Draft Guidelines for Threatened Species Assessment* (Department of Environment and Climate Change and Department of Primary Industries 2005) and in the National context in accordance with the *Significant Impact Guidelines for Matters of National Environmental Significance* (Department of Environment and Heritage 2006) (refer **Appendix B** and **C** for details). A summary of the conclusions of these assessments is discussed in **Table 5-3.**

Table 5-3: Summary of assessment of significance for listed species and communities

Endangered Ecological Communities	Conclusions of assessment
Swamp Sclerophyll Forest on Coastal Floodplains	▪ Removal of approximately 12.47 ha comprising 48 per cent high condition, 47 per cent moderate condition, 2 per cent low-moderate condition and 3% in a low condition. ▪ There is potential for the Proposal to alter hydrological and nutrient regimes in adjacent areas. Mitigation measures are required to limit these impacts. ▪ The Proposal is likely to contribute to further weed invasion in adjacent areas of habitat through edge effects. ▪ Larger high quality areas of this EEC including areas gazetted as SEPP 14 wetlands such as Bellwood Swamp would not be directly impacted. ▪ The Proposal would impact on habitat connectivity for this community, resulting in the dissection of several patches of this EEC.
Swamp Oak Floodplain Forest on Coastal Floodplains	▪ Removal of approximately 33.07 ha comprising 15 per cent high condition, 12 per cent moderate-high condition, 45 per cent moderate condition and 28 per cent low-moderate condition. ▪ There is potential for the Proposal to alter hydrological and nutrient regimes in adjacent areas. Mitigation measures are required to limit these impacts. ▪ The community is currently highly fragmented in the study area and therefore impacts from edge effects and loss of connectivity are unlikely to be significant. ▪ Larger areas of the community would remain in surrounding areas including patches in the Raleigh area and surrounding Deep Creek. ▪ Thin strips of the community along the edges of the Nambucca River and Deep Creek which provide some connectivity along the edge of these waterways would be dissected.
Subtropical Coastal Floodplain Forest on Coastal Floodplains	▪ Removal of approximately 12.49 ha comprising 39 per cent high condition, 26 per cent moderate-high condition, 18 per cent moderate condition, 15 per cent low-moderate condition and 2 per cent low condition. ▪ There is potential for the Proposal to alter hydrological and nutrient regimes in adjacent areas, however mitigation measures would be implemented to limit these impacts. ▪ The Proposal is likely to contribute to further weed invasion in adjacent areas of habitat through creating edge effects in these areas. ▪ Medium sized patches of the community would remain in Newry State Forest, along with areas of this EEC in localities such as Urunga Lagoon. ▪ Thin strips of this community on the edge of the Kalang River and Warrell Creek which provide some level of connectivity along these waterways would be dissected, along with larger patches in Newry State Forest.

Endangered Ecological Communities	Conclusions of assessment
Lowland Rainforest	▪ Removal of approximately 0.6 ha comprising 100 per cent high condition. ▪ The majority of the direct impacts to this community would be on small fragmented patches of this community in agricultural areas at Warrell Creek. ▪ There is potential for the Proposal to alter hydrological and nutrient regimes in adjacent areas, however mitigation measures would be implemented to limit these impacts. ▪ Edge effects are likely to impact understorey floristics where this community occurs in larger intact areas of remnant vegetation. ▪ Habitat connectivity would not be significantly impacted considering the degree of existing fragmentation of the majority of Lowland Rainforest along the Proposal area.
Freshwater Wetlands on Coastal floodplains	▪ Removal of approximately 1.58 ha comprising 13 per cent high condition, 11 per cent moderate condition, 20 per cent low-moderate condition and 56 per cent low condition. ▪ There is potential for the Proposal to alter habitat attributes of surrounding areas of Freshwater Wetlands through indirect impacts such as altering hydrological and nutrient regimes in habitats downstream of the proposed development, potentially resulting in increases in nutrient levels and sedimentation. ▪ Small areas of this community would be further fragmented by the Proposal including wetland areas in agricultural landscapes and in power easements in the Raleigh area.

5.2.4. Loss of Threatened Species and their habitat

The loss of vegetation and fauna habitat would negatively affect several populations of threatened flora and fauna species through the direct loss of known habitat, increasing the fragmentation of habitat and creating barriers to movement and dispersal of individuals. Further details are summarised below.

- A population of the threatened *Marsdenia longiloba* (Endangered TSC Act; Vulnerable EPBC Act) was identified comprising 156 individuals. This species identification was confirmed by the National Herbarium as ‘probably’ *Marsdenia longiloba* although flowering material is needed to positively confirm the identification. No flowering or fruiting material was present during any of the surveys (from November 2007-February 2008). Using the precautionary principal the species identified has been assumed to be *Marsdenia longiloba*. The Proposal would directly impact on an estimated 12 individuals (eight per cent of the local population) assuming that all plants within 10 m of the road design would be impacted. An additional 32 individuals (21%) that would remain between 11 m and 30 m of the constructed road footprint would potentially be indirectly impacted as they may be subject to altered biophysical conditions. Most individuals within 30 m of the road design occur in the Little Newry State Forest population and are upslope of the Proposal and are therefore less likely to be indirectly impacted from altered hydrology, sedimentation and increased nutrient loads. The remaining 112 individuals (72 per cent) would remain in surrounding areas greater than 30 m from the road footprint and are unlikely to be impacted.

- The Proposal would removal an individual rusty plum (*Amorphospermum whitei)* (Vulnerable species TSC Act) located in riparian vegetation along Boggy Creek. This was the only individual found in the study area and the extent of the local population is not known.
- Potential suitable habitat would be directly impacted for an additional six threatened flora species not identified during the field survey although considered to potentially occur based on their known distribution and preferred habitat types.
- The Proposal would directly impact on a portion of the habitat available for known populations of threatened fauna including eight mammal and four bird species. Potential suitable habitat would be directly impacted for an additional five bird species, one frog and one mammal species considered to potentially occur based on their known distribution and preferred habitat types.

Threatened flora species which were targeted during the surveys but not recorded included scented acronychia, milky silkpod, red bopple nut, *Maundia triglochinoides*, brown fairy-chain orchid and Newry golden wattle. As a precautionary approach, the impact on these species has been assessed, however considering the extent and intensity of the targeted seasonal surveys undertaken in the study area, and the fact that these species are not particularly cryptic in appearance or habit, the presence of these species in the Proposal corridor is considered improbable.

5.2.4.1. Assessment of significance (Part 3A EP&A Act)

An assessment of significance was conducted for known and potential subject species (i.e listed threatened species) in accordance with the *Draft Guidelines for Threatened Species Assessment* (Department of Environment and Climate Change and Department of Primary Industries 2005) and in the National context in accordance with the *Significant Impact Guidelines for Matters of National Environmental Significance* (Department of Environment and Heritage 2006) (refer **Appendix B** and **C** for details). A summary of the conclusions of these assessments is discussed in **Table 5-3**.

5.2.5. Loss of habitat for migratory species

Nine listed migratory bird species (EPBC Act) were identified from the field investigation, refer to **Table 4-6** in text which also includes potential species based on the presence of suitable habitat. The majority of species were considered uncommon and widespread vagrants with no specific populations represented. The most widespread and abundant species were cattle egret present throughout cleared farmland, and rufous fantail and black-faced monarch in moist densely forested gullies. White-throated needletail were observed in the air on several occasions flying over the study area and not specific to any habitat type. The Proposal would result in the removal of suitable habitat for migratory species recorded and potentially occurring in the study area (refer **Table 4-6**).

There is no evidence to suggest that an area of important habitat exists or that the study area is occupied by an ecologically significant proportion of a population of a migratory species. Suitable measures would be incorporated into the Proposal to minimise impacts to adjacent habitats suitable for migratory species.

5.2.6. Edge effects and weed infestation

A review of edge effects associated with roads (Bali 2005) summarised data from several sources in identifying the potential impacts on adjacent terrestrial and aquatic habitats. The following effects were documented:

- Increased annual mortality during construction.
- Increased annual mortality from collisions with vehicles.
- Modified animal behaviour.
- Altered physical environment.
- Altered chemical environment.
- Spread in exotic species.
- Increase alteration and use of habitats by humans.

Table 5-3: Summary of assessment of significance for listed species and communities

Species/ Community	Conservation Status		Conclusions of Assessment
	Cwlth	NSW	
Threatened Flora			
Acacia chrysotricha Newry golden wattle	-	E	Newry Golden wattle was not recorded in the study area despite targeted searches in areas of suitable habitat. The Proposal would result in the removal of approximately 34.4 ha of suitable habitat for this species. In particular areas of Newry State Forest and Nambucca State Forest had suitable areas of habitat comprising narrow gullies on quartzite soils. There are records of this species to the west of the study area in Newry State Forest.
Acronychia littoralis scented acronychia	E	E	Scented acronychia was not recorded in the study area despite targeted searches. The preferred habitat for this species is littoral rainforest on sand which does not occur in the study area. There is a low possibility this species is present in rainforest and wet sclerophyll forests. The Proposal would result in the removal of approximately 34.4 ha of marginal habitat for this species.
Amorphospermum whitei rusty plum	-	V	Removal of one individual. The Proposal would potentially lead to changes in potential habitat for colonisation by the species, resulting from increased run-off of untreated surface and edge effects, mostly resulting in increased weed invasion.
Hicksbeachia pinnatifolia red bopple nut	-	V	Red bopple nut was not recorded in the study area despite targeted searches in areas of suitable habitat. There are not records for this species in the locality, however this species is recorded as occurring from Nambucca Valley to southeast Queensland. The Proposal would result in the removal of approximately 34.4 ha of suitable habitat for this species. Better qualities examples of habitat include rainforest areas of which only 0.58 ha would be removed.
Maundia triglochinoides	-	V	Maudia triglochinoides was not recorded in the study area despite targeted searches in wetlands, creeks and dams with shallow freshwater 30-60 centimetres deep. The Proposal would result in the removal of only a small area of suitable habitat comprising up to 2 ha of dams, creeks and wetland areas.
Marsdenia longiloba slender milkvine	V	E	Occurs in seven sub-populations along the study area, of which 5 would be directly impacted to some degree. The total number of individuals in these populations was estimated to comprise approximately 156 individuals, of which 12 would be directly impacted and an additional 32 would potentially be indirectly impacted. The Proposal would potentially lead to changes in potential habitat for colonisation by the species, resulting from increased run-off of untreated surface water and edge effects, resulting in increased potential for weed invasion. Life cycle attributes of remaining plants are unlikely to be significantly impacted from habitat fragmentation.
Parsonsia dorrigoensis milky silkpod	E	V	Milky silkpod was not recorded in the study area despite targeted searches in areas of suitable habitat. There are records for this species in the locality. The Proposal would result in the removal of approximately 34.4 ha of suitable habitat for this species. Better qualities examples of habitat include rainforest areas of which only 0.58 ha would be removed.

Species/ Community	Conservation Status		Conclusions of Assessment
	Cwlth	NSW	
Peristeranthus hillii brown fairy-chain orchid	-	V	Brown fairy-chain orchid was not recorded in the study area despite targeted searches in areas of suitable habitat. There are no records for this species in the locality. The preferred habitat for this species is littoral rainforest which does not occur in the study area. The Proposal would result in the removal of approximately 34.4 ha of marginal habitat for this species, of which only 0.58 ha comprises better quality rainforest habitats.
Threatened Fauna			
swift parrot and regent honeyeater	E	E	Both species are regarded as winter-visitors to this region, and their presence would depend predominantly on the flowering of swamp mahogany (*Eucalyptus robusta*) and forest red gum (*E.tereticornis*) to provide food resources. Both tree species are present in low abundance and the study area is considered only marginal for the swift parrot and regent honeyeater. The largest patches of potential foraging habitat are present as SEPP 14 wetland areas in Nambucca and Newry State Forests. These areas have been avoided as part of the route options study and would not be impacted by the Proposal. The study area would constitute non-breeding habitat for a proportion of the population of both species
black-necked stork		E1	The black-necked stork is considered rare in the immediate study area. Potential habitat for the species in the study area is limited and the scattering of records are mostly associated with a large wetland on the Kalang River floodplain east of South Arm Road in addition to surrounding modified farmland habitats which are used for foraging, such transitional foraging habitats are very common and widespread. Other wetlands in the study area that provide potential habitat include Gumma Swamp on the south side of Warrell Creek and to the east of the alignment. The Proposal would not directly impact on wetland habitat suitable for this species. Indirect impacts would be managed during construction and operation.
grey-headed flying-fox	V	V	The Proposal would clear approximately 253 ha of potential foraging habitat for this species. This represents a relatively minor impact for this species in the local area. In relation to the available habitat in adjacent land surrounding the highway, the Proposal is not considered likely to affect this species at the local or regional level. The proposed action would not result in a decrease in the size of the local population nor impact on a known roost site.
giant barred frog	E	E	Several creeks and drainage lines in the northern half of the study area through Nambucca, Little Newry and Newry State forest were identified as potential habitat for this species. The Proposal would impact on potential habitat via direct traverse of several small streams and gullies. The impact would be linear and restricted to the construction footprint up to 100 m wide. Design measures have been incorporated to provide appropriate fauna passage and protection of waterways during construction and operation to ensure potential habitat is not impacted further. Direct impacts on populations would not be widespread and indirect impacts can be managed appropriately

Species/ Community	Conservation Status		Conclusions of Assessment
	Cwlth	NSW	
spotted-tailed quoll	V	V	The species was not recorded during this study however is expected to occur. The species is an opportunistic predator and would feed on a variety of prey including macropods, birds, reptiles, arboreal mammals and small terrestrial mammals. The Proposal would remove potential habitat for the species and its prey, leading to further fragmentation of habitat, a known threat to the species. Measures to conserve fauna corridors and movement avenues for terrestrial fauna have been incorporated into the Proposal. Breeding, foraging and movement life-cycle opportunities would remain in the region and likely to sustain local populations.
Frugivorous Birds wompoo fruit-dove rose-crowned fruit-dove superb fruit-dove		V	All species are wide-ranging and locally nomadic, capable of moving large distances between remnant vegetation in response to the sporadic availability of food resources. Local populations are expected to be small and nomadic compared to west of the study area in the Dorrigo / Bellingen area where subtropical rainforest habitats are more widespread. The Proposal would involve removal of a small percentage of moist forest habitat (c. 50 ha) which is marginal for the species and up to three hectares of lowland rainforest which is better suited. The current potential for these species to forage in the study area is considered to remain following the works and the impacts on life-cycle activity would be very minimal.
square-tailed kite		V	No nest sites were located along the proposed alignment during the surveys nor have been reported in the vicinity of the route in the local State Forests. Further surveys are recommended prior to construction. The Proposal would not impact on breeding activities of local populations of the square-tailed kite. Potential habitat for foraging and roosting is very common and widespread for this species in the region and the impacts on this life-cycle activity is expected to be minimal.
Tree-roosting Bats Greater Broad-nosed Bat Eastern False Pipistrelle Eastern Freetail-bat Eastern Long-eared Bat		V	Important life-cycle activities include roosting and breeding and are typically associated with tree hollows as well as foraging for insect prey which occurs in a variety of habitat types. The size of local populations is not known, although expected to be moderately large given the expanses of suitable habitat. The Proposal would remove approximately 255 ha of forest habitat and which provides potential foraging habitat. Much of this habitat has been identified as of young age or even age and the abundance of hollows is very low throughout the corridor. Nonetheless the Proposal would involve clearing of habitat trees. Comparable habitats are very well represented throughout the locality and regional area and it is unlikely that the Proposal would have a significant impact on the foraging or roosting life-cycle events for local populations of these bat species and continued presence in the locality could be expected.

Species/ Community	Conservation Status		Conclusions of Assessment
	Cwlth	NSW	
glossy black-cockatoo		V	A population was identified in the northern half of the study area, north from Nambucca State Forest to Raleigh, comprising of several groups occupying parts of Nambucca, Newry and Little Newry state Forest as well as dry sclerophyll forest habitats on privately owned lands north of the Kalang River and east of the existing Pacific Highway near Valla The Proposal would clear up to 144 ha of blackbutt open forest, a portion of which would provide potential habitat for this species. The abundance of food resources and distributional range of the local population together with the high mobility of the species suggests there are several localised family groups in the study area and that these are adapted to moving across modified landscapes to access food resources. The Proposal is unlikely to significantly impact on this situation, despite the loss of food resources. There is potential to remove large hollow-bearing trees which may currently or potentially provide nest sites. These are an uncommon feature in the landscape as a result of the historical land uses. Where feasible these have been identified near the route and refinement of the design carried out to minimise their removal. Further surveys of habitat trees have been recommended as a component of the CEMP (and FFMP) which would be particularly important if construction commences between April and June.
koala		V	Evidence of koala was recorded in this study in Nambucca State Forest on the western side of the rail line several hundred metres west of the proposed route. State Forests (DII) have reported numerous records of koalas in the western parts of Newry State Forest, also to the west of the study area. There are a scattering of records along the coast around Valla. The Proposal would removal potential habitat for the species through the clearing of vegetation communities containing identified food tree species. The impact of this activity on the local population is likely to be minimal as suitable food resources are common and widespread in the region particularly to the northwest of the route and there is little evidence to suggest that koala populations or movements are centred on the proposed route. The potential for east-west movements from the coast at Valla to the west via Newry State Forest have been considered in the design and location of fauna underpass structures combined with widening of the median to provide refuge and minimise the crossing distance and fauna exclusion fencing to facilitate movements and minimise vehicle strike mortalities.
brush-tailed phascogale		V	Evidence of local populations in the study area have not been identified, however suitable habitat is widespread and common. The brush-tailed phascogale is largely arboreal, occupying a variety of habitats, particularly open dry sclerophyll forest with little groundcover (Cuttle 1982). Such habitats are particularly well represented in the region, particularly on ridges and low hills where clearing has been less severe than river flats. Populations are considered to persist following development of the Proposal.

Species/ Community	Conservation Status		Conclusions of Assessment
	Cwlth	NSW	
Cave-roosting Bats little bentwing-bat eastern bentwing-bat large-footed myotis		V	The Proposal would remove approximately 255 ha of forest habitat which provides potential foraging habitat for Miniopterus spp. Comparable habitats are very well represented throughout the locality and regional area and it is unlikely that the Proposal would have a significant impact on the foraging life-cycle events for a local population of these bat species and continued foraging over the site and adjacent lands could be expected. Large-footed myotis hunt over water bodies for small fish and invertebrates and may frequent freshwater wetlands and estuaries as well as creeks and farm dams. Impacts on foraging habitat would result from the Proposal however the overall magnitude of impact is small.
osprey		V	Several breeding pairs of osprey are expected to occur in the catchment of the Nambucca and Kalang Rivers. Nest sites have generally been recorded in floodplain areas, near swamps or estuaries and often in dead trees near the forest edge. One active nest was located in the study area during 2008, recorded on private property south of Deep Creek within 50 m of the existing Pacific Highway. Nesting reported to have occurred at this location for several years. The Proposal would not directly impact on a currently known nest site, however further survey is required prior to construction to determine the location of new sites constructed since the survey. The existing nest on the southern side of Deep Creek and east of the existing highway would not be impacted at given its current location (i.e. 50 m from the highway) it is unlikely that the new carriageway to be constructed to the west of the existing road would significantly impact on the site. The impacts on foraging habitat would be minimal based on the availability in the region and the mobility of the species.
Large Forest Owls powerful owl masked owl sooty owl		V	All three species are known to occupy very large territories particularly in fragmented areas, which is a reflection of their high mobility and diversity of prey species taken. Targeted searches were carried out at all times during the field surveys for the presence of suitable tree-hollows (potential nest sites) for these birds. These are considered very scarce along the route corridor and nesting opportunities are therefore considered limited. Given the paucity of records, long home range size and the low incidence of potential roost / nest hollows in the study area the Proposal is considered unlikely to impose a significant impact on local populations of these species. The removal of 253 ha of forest habitat would impact on the habitat of prey species for these owls and increase fragmentation which may have an impact on juvenile dispersal.
Black Bittern			Suitable habitat for this species in the study area is limited to one large wetland on the floodplain north of the Kalang River and eastern side of South Arm Road. This habitat would not be impacted directly by the proposed alignment and potential indirect impacts are to be monitored and controlled during construction and operation. Other smaller freshwater wetlands identified in the study area typically lack dense fringing vegetation and are considered sub-optimal. Life-cycle activities of any local population are unlikely to be impacted.

Species/ Community	Conservation Status		Conclusions of Assessment
	Cwlth	NSW	
Yellow-bellied glider		V	The Proposal is likely to remove a portion of the home range territory of at least one family group of gliders including possible denning trees. There is no specific data on the home range of this group or known den trees, so the extent of this impact is not known, although data on the species suggest home ranges can extend as large as 60 ha. This group is part of a larger population which extends into the surrounding state forests and possibly private lands to the south and east. Individuals have also been recorded in Newry State Forest in contiguous habitats to the north. Additionally the subject area is part of a larger east west corridor suggesting other populations are likely to occur to the west of the study area. Other populations have been identified in Way Way State Forest and Yarrahappini National Park to the south and east. The long-term persistence of yellow-bellied gliders requires a landscape mosaic of old growth trees which meets both their foraging and sheltering needs. Such habitat is present throughout the remaining portions of Nambucca State Forest to the east and west of the route. The issue of movement and dispersal has been addressed by the proposed widening of the median through the northern end of Nambucca State Forest and also Newry State Forest which was specifically located at strategic glider locations. Where possible the design footprint was refined to avoid identified habitat trees.

V= vulnerable, E= endangered

Introducing edges as a result of the Proposal has the potential to impact the existing vegetation structure through alterations to the chemical and physical environment such as changes to sunlight availability, hydrological regimes and soil nutrients. It is evident from the studies conducted to date that the type and extent of edge effects is highly variable. This is not surprising considering that edge effect intensity may be related to abiotic and biological factors such as age, vegetation structure, aspect, matrix type and management history (Murcia 1995).

There is a clear tendency of edge effects to vary with vegetation structure; they are greatest at new or induced edges and less obvious at old or inherent edges (Bali 2005). The maximum extent of edge effects for reliable indicator species is up to 50 m from the forest edge (Murcia 1995). Edge effects would be expected to be greatest where the Proposal would create ‘new’ edges, such as through large areas of remnant vegetation in Nambucca and Newry State Forest, and private forested lands north of the Kalang River.

The extent of possible edge effect impacts for the Proposal were calculated based on 0.6:1 ratio consistent with the data presented by Bali (2005) (i.e. 0.6 x 50 m wide) along the length of the project footprint only (taking into account only where a new edge is created through vegetation and not adjoining the existing highway or cleared land). This calculation resulted in a total area of impact of approximately **126 ha**. These impacts would be most profound for moist vegetation communities (many of which are EECs) where invasive weed species such as *Lantana camara* are likely to greatly increase in abundance with higher light availability and shade out native understorey species and affect fauna habitats. *Marsdenia longiloba* which would be retained in habitats adjacent to the Proposal are likely to be impacted from edge effects, including competition with weed species and changes to physical attributes such as sunlight, hydrological regimes and soil nutrients.

Edge effects can potentially be reduced through general mitigation and rehabilitation measures associated with the construction and operational stages of road development (Bali 2005). The highest priority is measures that aim to minimise and intersect surface water run-off into adjacent remnant vegetation. Dense roadside plantings using a diversity of local indigenous plant species would reduce the affects of rapid weed invasion into disturbed edge habitats.

5.2.7. Habitat fragmentation

The division of larger patches of remnant habitat into two or more smaller areas has significant impacts to native flora and fauna species, including affecting movement corridors, genetic exchange, decrease the available area of habitat and increasing edge effects. Large of areas of continuous habitat are particularly important for species which have large habitat ranges such as spotted-tail quoll and large forest owls as these areas provide an adequate area of foraging habitat, are more likely to support suitable roosting and nesting habitats, and increase the carrying capacity of the area increasing the chances of finding a mate. Large areas of contiguous vegetation also decrease the likelihood of local extinctions from stochastic events such as wildfire and disease, as individuals can re-populate areas more effectively.

The impact of habitat fragmentation by roads is well known (see review by Andrews 1990). Typically these pressures occur at fine spatial scales such as forest stands, but also impact cumulatively over time (Burris and Canter 1997) on the structure and function of larger forest ecosystems. Potential impacts from habitat fragmentation are detailed in Andrews (1990) and include:

- Alteration of hydrology and siltation of aquatic habitats.
- Impacts on species with localised habits.
- Edge effects.
- Barrier effects.

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

The Proposal would increase the fragmentation of habitat in the landscape by impacting on several contiguous forest areas, particularly the larger fragments associated with Nambucca and Newry State Forest in section 2 of the study area and private forested land to the north of the Kalang River in section 4. The impacts of fragmentation on flora and fauna and threatened species identified in this study area are difficult to determine without more extensive population viability assessments. It is important to note however that all areas of habitat affected by the Proposal have already been fragmented in the past by roads, clearing and power easements. The Proposal would be contributing to this cumulative fragmentation of habitat in the landscape.

Less mobile species such as terrestrial and arboreal mammals, reptiles and amphibians would potentially be most impacted from habitat fragmentation with increases in vehicle collisions, decreases to their habitat range and limited dispersal opportunities for mating, to find seasonal foraging habitats and refuge areas during stochastic events such as fire and storms. Some native flora species may also be impacted by limited genetic dispersal in terms of pollinator movement and seed dispersal. Bird and bat species are less likely to be impacted from habitat fragmentation, although vehicle collisions are still common. Genetic dispersal and exchange are unlikely to be highly impacted for bird and bat species. The impacts of fragmentation may be most evident in Nambucca State Forest in section 2, where an area of up to 1000 ha of forested lands would be separated to the east of the road. This habitat was identified as being occupied by a population of yellow-bellied gliders as well as other threatened species including *Marsdenia longiloba*, glossy black-cockatoo, masked owl, and a number of microchiropteran bats. While the proportion of habitat remaining to the east of the road (c.1000 ha) is considered sufficiently large to support populations of these species, further measures are required to minimise the impacts of fragmentation. Such measures have been considered in the design of the road by incorporating a wider median through the northern end of Nambucca State Forest and placing fauna underpass structures in strategic locations. Highly mobile species such as bats and birds are expected to be less impacted by fragmentation.

The impact of fragmentation in Newry State Forest is difficult to assess as this area is already fragmented from coastal habitats to the east in Valla Nature Reserve as a result of the existing Pacific Highway and existing wide electricity transmission easements. Further widening of the median and fauna underpass structures are also proposed through portions of Newry State Forest to maintain opportunities for fauna crossing.

Vegetated medians provide refuge for all fauna species crossing the road and decrease the width of the crossing with vehicles only coming from one direction. Vegetated medians with taller trees particularly aid the movement of glider species recorded in the study area (i.e. yellow-bellied glider, squirrel glider, sugar glider, greater glider, and feathertail glider) by reducing the barrier effect of two carriageways side by side and providing taller trees in the median to launch from. Natural vegetation and tree cover would be retained in the median in key corridor locations as identified in section 6 of this report.

Up to 360 ha of habitat would be fragmented to the east of the proposed road in Section 4 and associated with forest on private lands. This area provides important habitat for the local population of glossy black-cockatoo and would remove a portion of potential habitat. This species is expected to be able to cross the new roadway with limited constraint.

A strategic approach to mitigating the effects of fragmentation from the Proposal should be developed by focusing on re-establishing links with historically isolated fragments of habitat in proximity to the new road. These opportunities should be investigated along with increasing the size of smaller remnant fragments adjoining the road. The greatest potential for this exists in low-lying agricultural areas adjoining the corridor.

5.2.8. Impacts to fauna movements and behaviour

5.2.8.1. Wildlife corridors

Wildlife corridors play an important role for biodiversity conservation particularly as they allow for migration and dispersal of plants and animals, reduce competition, provide refuge and important movement pathways for maintaining genetic diversity in populations. Corridors are particularly important in fragmented and agricultural areas as they provide pathways for fauna movement for species that are reluctant to move through cleared landscapes.

Taylor (1991) discusses some useful advantages of retaining strips of vegetation between larger patches of forest, using State Forests as an example. These principles are equally applicable to vegetation on private property, crown land and reserves. Some important aspects discussed by this author suggest that retained strips of habitat:

- Allow fauna to re-colonise regenerating habitats as they become available.
- Ensure that populations in larger patches do not become isolated.
- Provide shelter and nesting resources for those species that can utilise regrowth for feeding although require adjoining mature forest for shelter and breeding resources.

The location of wildlife corridors has been investigated as they relate to the Proposal. The study area exhibits a mixture of land use types from agricultural and multiple use forests to the expansion of urban and rural residential areas. Outside of the State Forests strips of vegetation have been retained mostly along road reserves such as the existing Pacific Highway and as riparian habitat along creeks and rivers. There are very few areas of high corridor value in the study area due to the extent of previous clearing and the existing network of roads and rail.

Local and regional wildlife corridors were identified in Chapter 3 of this working paper from data supplied by the DECCW (DECC 2003 and 2007a). The Proposal would impact on a number of identified corridors which currently provide strategic links in the landscape. These relate to large vegetation patches contained in the Nambucca, Newry and Little Newry State Forests and associated with the Ingalba Hills landscape (Mitchell 2003). The Proposal would sever 12.7 km of regional 'moist' and 11.9 km of key corridors as identified by DECCW. Moist corridors have been identified by DECCW, as areas most likely to be used by fauna species which utilise mesic (moist) environments.

These habitats provide a link in the landscape between the coastal lowlands and the larger habitats to the west of the study area including conservation reserves and other state forests, (refer Figure 3-5). Measures to mitigate these impacts are discussed in Chapter 6 and include widening the median at strategic locations and the inclusion of fauna crossing structures to maintain fauna movement opportunities.

Fauna species most likely to utilise the wildlife corridors in the area include all fauna species which have relatively large habitat ranges, migratory species, fauna species in search of unoccupied habitats and species which make small scale migrations seasonally. Fauna species most likely to benefit from adequate wildlife corridor include species with a large habitat range including large forest owls, koalas, spotted-tail quoll, brush-tailed phascogales, gliders and some bird species. These wildlife corridors are particularly important for fauna during large disturbances such as wildfire and habitat clearance. Many fauna species may disperse from an area due to high levels of competition with other fauna species or to seek out seasonal food resources such as flowering trees and shrubs.

5.2.8.2. Fauna mortality

By effectively increasing the road network and traffic volumes in the locality, the Proposal would indirectly increase fauna mortaility and injuries from collisions with vehicles. The significance of this impact on local populations is difficult to determine given the existing network of roads which are currently impacting on populations. Further, the distribution of fauna collisions or 'black spots' is also difficult to identify, and indeed impact locations may in fact be widespread and not isolated to particular locations or patterns may emerge over time in association with wildlife corridors.

Fauna crossing structures, exclusion fencing and signage has been widely used to minimise this impact and consideration of the number and location of these has been incorporated into the Proposal.

5.2.8.3. Animal behaviour

Impacts associated with the barrier effect of new roads as well as increased traffic noise and lighting are well documented. These factors would effectively impact on typical fauna movements in the vicinity of the road, in turn negatively impacting on important life-cycle events such as foraging, breeding and dispersal. Measures to reduce this impact may include the provision of dense landscape planting or physical noise barriers such as mounded earth. Appropriate lighting should consider adequately providing a clear line of sight for motorists to clearly see fauna near the road, whilst also minimising unnecessary light which will attract certain fauna to the road edge, such as owls.

5.2.9. Impacts to riparian habitats

The following section refers to impacts from the Proposal on riparian habitat, which is described as that represented along the banks of the major river ecosystems in the study area (i.e. Nambucca and Kalang) as well as several named creeks including Warrell Creek, Boggy Creek, Deep Creek, Newee Creek and Oyster Creek. Other references to riparian vegetation described in the report refer to gully habitat representing moist forest, swamp forest or rainforest habitat adjoining open forest on slopes. Impacts on these communities have been addressed previously and are not discussed further here.

Riparian habitat varies from narrow linear strips of vegetation (<5 m wide) and restricted to river banks adjoining agricultural lands to broader strips in low-lying fringes of the tidal creek systems. A summary of the riparian vegetation in the study area consists of:

- Mixed floodplain forest (MU2) situated in the riparian zones of Warrell Creek, the Kalang River, Boggy Creek and Oyster Creek, comprises both narrow bands and broader patches.
- Swamp oak forest (MU7) and swamp mahogany / paperbark forest (MU6) which is represented along the edges of Warrell Creek, Deep Creek and the Nambucca River, generally as restricted linear strips and small patches adjoining cleared agricultural lands.
- Estuarine vegetation consisting of narrow bands (<5 m) of mangroves (MU9) surrounding tidal creeks such as Newee and Deep Creek and large portions of the Kalang and Nambucca River foreshores. Mangrove communities are recognised for providing significant habitat for estuarine fish and are protected as important fish habitat under the *Fisheries Management Act 1991*.
- This association occurs along banks of tidal estuaries subject to inundation by salt-laden water. Two species are represented, grey mangrove (*Avicennia marina*) and river mangrove (*Aegiceras corniculatum*).

Impacts on riparian vegetation would occur directly in the road footprint at proposed bridge locations and indirectly through changes to local hydrological regimes and edge effects, including possible shading or proximal vegetation and potential weed invasion. The exact area to be directly lost from the Proposal is difficult to quantify using GIS as many sites are very narrow and small in area. Mangroves and swamp oak are difficult to quantify as they are particularly restricted in distribution and may occur as single rows of trees located along river banks. An example includes the northern bank of the Kalang River adjoining South Arm Road.

Impacts on riparian habitats adjoining the road footprint are to be mitigated through minimising the construction footprint at all proposed bridge crossings, installing run-off storage structures, minimising erosion and rehabilitation post-construction through plantings of locally indigenous riparian species.

5.2.10. Impacts to ground-water dependent communities

Ground-water dependent ecosystems are recognised as falling into one of four types being either: terrestrial vegetation, base flows in streams, aquifers and cave ecosystems, or wetlands. There are no cave ecosystems represented in the study area. However, in the study area those vegetation communities and habitats with the greatest potential to be affected by changing groundwater levels consist of terrestrial vegetation and wetlands located in the low-lying floodplain areas intersected by the route, including:

- Swamp Oak Floodplain Forest.
- Swamp Sclerophyll Forest.
- Subtropical Coastal Floodplain Forest.
- Lowland Rainforest.

- Freshwater Wetlands.

Other communities in riparian areas may have some level of ground-water dependence, including wet sclerophyll forests in proximity to creek flats. The potential adverse impact on groundwater flow from roads is addressed in a review by Forman & Alexander (1998) and is considered to result from:

- The effects from altered runoff and the potential changes in aquifer recharge rates.
- Potential impacts on sub-surface flow from road crossings of wetlands. The road has potential to block drainage passages and groundwater flows effectively raising the upslope water table and killing vegetation by root inundation, while lowering the downslope water table with accompanying impacts.

The latter appears to have a greater impact on areas with naturally high water tables and saturated soils such as freshwater wetlands and swamps. Wetland crossings have been generally avoided in the study area with the exception of a small number of isolated wetlands occurring in cleared agricultural areas. Such sites have been highly disturbed from grazing, pasture improvement and weed invasion. One higher quality area of this community is present adjacent to the eastern side of the existing highway near Deep Creek which comprises open areas of water, dense sedges and interspersed paperbarks. The proposed provision of minimum design standard drainage structures adjacent to wetlands and saturated soils is expected to mitigate the potential impacts from altered ground-water recharge rates.

Potential impacts on groundwater recharge rates from general road construction are expected to be minor in elevated areas on bedrock and more likely in sand aquifers. However as the road would be linear, a detectable change in groundwater levels is not expected. Mitigation measures implemented for the Proposal should ensure that hydrological regimes including ground water levels are not significantly altered in the surrounding areas, particularly in floodplain and riparian areas. Potential impacts can be addressed by ensuring that site practices follow an environmental management plan, which addresses the following issues:

- Areas where significant cuts are required upstream of groundwater dependant ecosystems, the depth of cuttings should be minimised where possible to areas above the natural water table.
- Ensuring appropriate design of water storage areas and temporary drainage systems.
- Minimising disturbance and controlling run-off from construction areas.
- Ensuring good maintenance of vehicles to minimise pollution of water from hydrocarbons.
- Response plans to deal with any spillages or accidents that occur at refuelling sites and machinery compounds.

The most likely impacts to groundwater dependent communities are from altered hydrology regimes which change groundwater levels. For example cuttings required in gully areas may intersect the water table and effect groundwater levels downstream, including SEPP 14 wetlands downstream of areas. There are several areas where cutting in gully areas is required and there would be potentially impacts to the ecology of several drainage lines as result of changes to groundwater flows, including:

- Gully areas in Nambucca, Newry and Little Newry State Forests.
- Creeks and gullies on private property including Boggy Creek, Deep Creek and gully areas in the relatively extensive areas of remnant vegetation north of the Kalang River.
- Major river crossings including the Kalang River and Nambucca River.

There is potential for the EECs listed above being retained adjacent to the Proposal to be impacted from altered hydrology and experience die-back and/or changes to floristics and vegetation structure. Proposed mitigation measures implemented for the Proposal are likely to minimise impacts to ground-water dependant ecosystems through alteration to the water table. The Proposal needs to ensure hydrological regimes are not significantly impacted so adequate drainage of surface and groundwater is provided.

5.2.11. Impacts to SEPP14 wetlands

There are several SEPP14 wetland areas in the in the locality (refer **Figure 1-1**) including Gumma Swamp south of Nambucca River, Newee Creek, Deep Creek complex near Boggy and Cow Creeks, and wetlands west of Urunga and Newry Island. There is potential for altered hydrology regimes as result of the Proposal to impact these wetlands, as well as sedimentation, contamination and nitrification. Mitigation measures would be implemented to ensure these indirect impacts are minimised, as detailed in Working Paper 5 - *Water*.

5.2.12. Impacts on aquatic habitats

Twelve freshwater and estuarine watercourses in the study area contain permanent or near permanent flows. Of these seven are freshwater (Butchers Creek, Rosewood Creek, Stony Creek, Williamson Creek, Boggy Creek, Cow Creek and Oyster Creek) and four are estuarine (Warrell Creek, Nambucca River, Deep Creek and Kalang River). Field investigations identified 12 fish species and 60 families of macroinvertebrates within the freshwater creeks. None are reported as state or nationally threatened or protected. The most widely distributed species in the region were the striped gudgeon and the empire gudgeon. One exotic species, the mosquito fish (*Gambusia holbrooki*) was reported. Of the macroinvertebrates the most common were the non-biting midges and small water striders. In the estuarine systems investigated 17 fish species were recorded, none of which were state or nationally listed.

Removal of in-stream woody debris (snags) is listed as a key threatening process under *the Fisheries Management Act* as it can provide crucial habitat to juvenile fish, macroinvertebrates and other aquatic organisms. Changes to the provision of aquatic habitat, water quality and natural flow regimes can favour exotic species. Predation by exotic species and in particular the mosquito fish (*Gambusia holbrooki*) which is most likely to occur in highly disturbed freshwater streams similar to those observed in the study region.

5.2.13. Migratory aquatic species

Estuary perch (*Macquaria marianus*) was found to be present in a number of the river systems and one Australian bass was captured from the Kalang River. These are migratory species and to ensure their lifecycles are not adversely impacted during construction, activities within the waterway would need to be undertaken outside of the spawning period of June through to August.

The creeks and watercourses crossed by the Proposal do not include any areas of habitat type for the oxleyan pygmy perch, and as such the oxleyan pygmy perch and its habitat would not be affected by the Proposal. The preferred habitat of the eastern cod is clear, flowing streams with rocky beds and deep holes with plenty of boulders or large woody debris (snags). This habitat is also not present within the study area, therefore the eastern cod and its habitat would not be affected by the Proposal.

5.2.14. Water quality

The Proposal would traverse several creeks and watercourse, which provide habitat for fish and other aquatic organisms. Potential impacts on aquatic habitats include overshadowing, pollution of waterways and change to the hydrological regime. Potential water quality issues and mitigation measures are addressed in the Flooding and water quality chapter of the environmental assessment. The greatest potential for impact on local waterways is during construction, therefore, the adoption of best practice water quality controls and protection measures would be implemented to minimise impact on aquatic habitats.

Increased sedimentation and erosion during construction, is considered a threatening process under the FM Act. Increased suspended solids can impact fish and macroinvertebrate abundance through clogging gill structures and benthic smothering. Increased particulates in the water column can also reduce water infiltration which may limit plant growth and influence predator foraging behaviour.

The main operational activity that would impact the associated watercourses is increased traffic flow, which may lead to increased pollutant load in the road run-off. Road run-off can contain a variety of pollutants, which may impact negatively on the aquatic environment and in turn reduce commercial and recreational fishing viability, including aquaculture present in the study area. Pollutants can include cigarette butts, nutrients, heavy metals, pesticides, herbicides and petroleum hydrocarbons. Management and mitigation measures have been proposed to reduce the amount of pollutants entering the waterways.

Increased road runoff and pollutants entering the waterways during construction could have a toxic effect on aquatic habitats and biodiversity. Runoff and associated pollutants should be limited, with sufficient mitigation strategies in place to reduce the risk. In operation, runoff form the Proposal would be directed to detention basis to improve water quality before being discharged to drains and then to local waterways. The operational basins would be located in positions such as alongside wetlands and water courses, to protect sensitive environmental areas from an unexpected spill from an incident.

The concept design for the Proposal has been developed so that the existing hydrological regime would generally be maintained through the use of culverts and bridges where required. Detailed design of culverts would provide fish friendly crossings where applicable and combined culverts and fauna crossings so that barriers to fish passage are not created. Installation of in-stream structures such as pylons is listed as a key threatening process under the FM Act. Culverts and causeways can modify the natural flow of rivers by increasing, decreasing or altering the seasonality, frequency, magnitude and timing of flow which can disrupt natural reproductive cues, and natural sediment movement patterns. Culverts can also act as a physical barrier to native fish and invertebrates. The construction of bridges is not considered a key threatening process as the impact on flow is considered minimal.

5.2.15. Commercial fisheries and oyster farming

Consultation has been undertaken with Maritime NSW who identified the necessary vertical and horizontal clearances required on the bridges to ensure that passage of commercial and recreational fishing vessels is not impeded. Existing launch facilities would be retained and local road access would be provided to ensure continued access to the fisheries and oyster leases along the Nambucca River and for recreational and commercial fishing within the rivers and creeks.

5.3. Key threatening processes

The TSC Act and FM Act lists Key Threatening Processes (KTP) as activities or processes that:

a) adversely affect threatened species, populations or ecological communities, or
b) could cause species, populations or ecological communities that are not threatened to become threatened.

It is evident that the Proposal would instigate some key threatening processes, such as clearing of native vegetation and removal of hollow-bearing trees. Several other processes could be reasonably expected and have been discussed in **Table 5-3** along with proposed measures to mitigate impacts.

Table 5-3 Key Threatening Processes related to the Proposal and proposed mitigation measures

Key Threatening Process (KTP)	Type of threat	Level of threat	Potential impacts	Mitigation measures
Invasion and establishment of exotic vines and scramblers	Weed	High	Exotic Vines and Scramblers were not abundant in the study area, however a potential future problem in gully areas impacted by vegetation loss and edge effects.	Weed management are to be developed as part of the Construction and Operation Environmental Management Plans (see Section 6.2.4)
Invasion of native plant communities by bitou bush & boneseed	Weed	Moderate-High	Bitou bush was recorded in moderate abundance in parts of Newry State Forest. There is potential for this species to increase in distribution and abundance	Weed management are to be developed as part of the Construction and Operation Environmental Management Plans (see Section 6.2.4)
Invasion of native plant communities by exotic perennial grasses	Weed	High	Several exotic perennial grasses were identified in disturbed edges of the existing highway and trails through bushland areas. These species are negatively associated with edge effects .	Weed management are to be developed as part of the Construction and Operation Environmental Management Plans (see Section 6.2.4)
Invasion, establishment and spread of Lantana camara	Weed	Very High	A majority of the moister vegetation communities in the study area have moderate infestations *Lantana camara*, particularly where previous disturbances have occurred. There is a high probability that these areas would become further infested with the creation of edge effects.	Weed management are to be developed as part of the Construction and Operation Environmental Management Plans (see Section 6.2.4)
Competition and grazing by the feral European rabbit	Pest animal	Low-Moderate	Evidence of European rabbit was recorded in the study area. The Proposal may provide additional areas of suitable habitat for European rabbit.	The proposed mitigation measures would limit impacts from this KTP, in particular weed management and habitat restoration (see Section 6).
Competition and habitat degradation by feral goats	Pest animal	Low	The Proposal may provide additional areas of suitable habitat for Feral Goats.	The proposed mitigation measures would limit impacts from this KTP, in particular weed management and habitat restoration (see Section 6).
Competition from feral honeybees	Pest animal	Low	The Proposal may provide additional areas of suitable habitat for feral honeybees.	The proposed mitigation measures would limit impacts from this KTP, in particular weed management and habitat restoration (see Section 6).
Herbivory and environmental degradation caused by feral deer	Pest animal	Low	The Proposal may provide additional areas of suitable habitat for feral deer.	The proposed mitigation measures would limit impacts from this KTP, in particular weed management and habitat restoration (see Section 6).

Key Threatening Process (KTP)	Type of threat	Level of threat	Potential impacts	Mitigation measures
Importation of red imported fire ants into NSW	Pest animal	Low	It is unlikely the Proposal could lead to the importation of red imported fire ants to the study area.	Ensuring construction equipment has been washed down before entering the study area (see Section 6.2.8).
Introduction of the large earth bumblebee (*Bombus terrestris*)	Pest animal	Low	It is unlikely the Proposal could lead to the introduction of large earth bumblebee to the study area	Ensuring construction equipment has been washed down before entering the study area (see Section 6.2.8).
Invasion and establishment of the Cane Toad	Pest animal	Low-Moderate	The Proposal may contribute to the invasion and establishment of cane toad.	The proposed mitigation measures would limit impacts from this KTP, in particular weed management and habitat restoration (see Section 6).
Predation by feral cats	Pest animal	Low-Moderate	The Proposal may contribute to additional predation from feral cats, through habitat fragmentation.	The proposed mitigation measures would limit impacts from this KTP, in particular weed management and habitat restoration (see Section 6).
Predation by the European Red Fox	Pest animal	Low-Moderate	The Proposal may contribute to additional predation from European Red Fox, through habitat fragmentation.	The proposed mitigation measures would limit impacts from this KTP, in particular weed management and habitat restoration (see Section 6).
Predation by the Plague Minnow (*Gambusia holbrooki*)	Pest animal	Low-Moderate	The Proposal may contribute to additional predation from Plague Minnow.	Refer to aquatic ecology report.
Predation, habitat degradation, competition and disease transmission by Feral Pigs (*Sus scrofa*)	Pest animal	Low-Moderate	The Proposal may contribute to additional presence of Feral Pigs in the study area through habitat fragmentation.	The proposed mitigation measures would limit impacts from this KTP, in particular weed management and habitat restoration (see Section 6).
Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands.	Habitat loss/change	Moderate-High	There is a chance the natural flow regimes of creeks, rivers, wetlands and floodplains would be altered from the Proposal.	The Proposal has been designed to limit alterations to natural hydrology regimes (see Section 6.2.6)
Bushrock Removal	Habitat loss/change	Low	Significant areas of bush rock were not noted in the study area.	Where bush rocks are present in the study area these would placed in adjacent habitats (see Section 6.2.1).
Clearing of native vegetation	Habitat loss/change	Very High	The Proposal would result in the clearing of up to 255 ha of native vegetation	Where possible vegetation clearance would be minimised. Mitigation measures are detailed in Section 6.2.1.
Ecological consequences of high frequency fires	Habitat loss/change	Low-Moderate	There is evidence that State Forest areas have been impacted from high frequency fire regimes. The Proposal is unlikely to contribute significantly to this KTP.	N/A

Key Threatening Process (KTP)	Type of threat	Level of threat	Potential impacts	Mitigation measures
Human-caused Climate Change	Habitat loss/change	Moderate	The Proposal would contribute towards human-caused climate change	N/A
Loss and/or degradation of sites used for hill-topping by butterflies	Habitat loss/change	Moderate	Several hill tops would be impacted to some degree in Newry State Forest. It is unknown if these areas are significant for butterflies	Where possible vegetation clearance would be minimised. Mitigation measures are detailed in Section 6.2.1.
Loss of Hollow-bearing Trees – key threatening process	Habitat loss/change	High	The Proposal would result in the clearing of hollow-bearing trees.	Where possible hollow bearing trees would be avoided. Mitigation measures are detailed in Section 6.2.1 and 6.2.3.
Removal of dead wood and dead trees	Habitat loss/change	High	The Proposal would result in the removal of dead wood and dead trees.	Dead wood and dead trees would be relocated to adjacent areas of habitat (see Section 6.2.1 and 6.2.3)
Infection by Psittacine circoviral (beak & feather) disease affecting endangered psittacine species	Disease	Low	It is unlikely the Proposal would exacerbate this KTP.	Ensuring construction equipment has been washed down before entering the study area (see Section 6.2.8).
Infection of frogs by amphibian chytrid fungus causing the disease chytridiomycosis	Disease	Low	It is unlikely the Proposal would significantly exacerbate this KTP.	Ensuring construction equipment has been washed down before entering the study area (see Section 6.2.8).
Infection of native plants by *Phytophthora cinnamomi*	Disease	Moderate	There is potential for this disease to be spread throughout the study area from construction machinery.	Ensuring construction equipment has been washed down before entering the study area (see Section 6.2.8).
Increased sedimentation and erosion during construction	Habitat loss/change	Moderate	There is potential for increased sedimentation to result due to the construction process.	The Proposal has been designed to minimise any bank erosion or increased sedimentation (see Section 6)
Increased pollution	Habitat loss/change	Moderate	The Proposal may result in a slight increase in road runoff and associated pollutants entering waterways during construction and operation.	Runoff and associated pollutants should be limited with sufficient mitigation strategies in place (see Section 6)
Removal of instream woody debris	Habitat loss/change	High	The Proposal would result in the removal of instream woody debris	Instream woody snags would need to be relocated into adjacent areas (See Section 6)
Loss of aquatic and riparian habitats	Habitat loss/change	Moderate	The Proposal would require the removal of aquatic and riparian vegetation to accommodate new crossings.	Where possible aquatic habitat clearance would be minimised (see Section 6)

Key Threatening Process (KTP)	Type of threat	Level of threat	Potential impacts	Mitigation measures
Predation of native fish by exotic species	Pest Animal	Low	Predation by exotic species such as *Gambusi holbrooki* (mosquito fish) is most likely to occur in highly disturbed freshwater streams	Disturbances to water quality and habitat needs to be minimised & monitored where appropriate (see Section 6)
Reduced viability of commercial activities such as oyster leases and fisheries	Habitat loss/change	Moderate	Construction activities have the potential to impact commercial and recreation fisheries through an increase in suspended solids resulting in increase turbidity and reduced water quality.	Runoff and associated pollutants should be limited with sufficient mitigation strategies in place. Instream structures in commercial/recreation fishing areas need to accommodate access (see Section 6)
Impacts associated with Potential Acid Sulphate Soils (PASS)	PASS	Moderate	The study area is characterised by potential acid sulphate soils, which if exposed to air during construction can become oxidised and produce sulphuric acid. These leachates can be toxic to many gilled organisms. Including macroinvertebrates.	(See Section 6)
Installation of instream structures	Habitat loss/change	High	The Proposal would result in the construction of culverts which may modify the natural flow of rivers. This alteration may disrupt natural reproductive cues and natural processes of erosion and sedimentation resulting in a loss of aquatic habitat for fish and macroinvertebrates.	New watercourse crossings associated with the Proposal need to meet NSW Fisheries Guidelines, which aim to ensure passage for aquatic biota is maintained

5.4. Regional scale cumulative impacts

At the landscape scale, the major potential ecological impacts of increasing road networks are likely to be the disruption of landscape processes and loss of biodiversity (Forman & Alexander 1998). An extensive and complex road network is already in existence in the study area region and the proposed new road would be a contributor to this network. However, as the new road would in effect traverse a landscape which is already dominated by human activities, such as farming, logging and urban development, as opposed to a completely forested landscape, the cumulative impacts on biodiversity could reasonably be expected to have a low detectability.

Notwithstanding this fact, the new road would contribute to an increased density of roads versus remaining habitat in the region. Impacts could be offset to a degree by the re-establishment of a few large patches of forest and habitat on currently cleared areas in the region. Any such efforts should be based on the objective of reducing habitat fragmentation by re-establishing connectivity and increasing forest patch sizes.

5.4.1.1. Cumulative impacts of Pacific Highway Upgrade Projects

The ecological impacts of the combined Pacific Highway Upgrade Projects (PHUP) are detailed in **Table 5-5**. The total contribution of the 12 existing PHUP to vegetation loss equates to approximately 1952 ha and the removal of approximately 388 ha of EEC.

The loss vegetation for the Warrell Creek to Urunga project represents approximately 13 per cent (255 ha) of the cumulative vegetation loss and about 16 per cent (60.3 ha) of the cumulative EEC loss.

- **Table 5-5: Approcimate habitat loss associated with the Pacific Highway Upgrade program**

Project name	Project stage	Project length (km)	Vegetation disturbance (ha)	EEC disturbance (ha)
Proposed upgrade Banora Point	Project approval	2.5	7.7	3.82
Tintenbar to Ewingsdale	Environmental assessment completed	17	10	2
Woodburn to Ballina	Concept design selected	36	131	56
Iluka Road to Woodburn*	Preferred route selected	35	Not yet available	Not yet available
Wells Crossing to Iluka Road – Glenugie upgrade	Environmental assessment completed	7.3	85	5.3
Wells Crossing to Iluka Road (remaining)	Concept design selected	63.6	345	55

Project name	Project stage	Project length (km)	Vegetation disturbance (ha)	EEC disturbance (ha)
Woolgoolga to Wells Crossing	Concept design selected	27	230	51 (preliminary estimate)
Sapphire to Woolgoolga upgrade	Project approval	25	83.1	18.2
Coffs Harbour Bypass	Concept design selected	55	21	Not yet available
Warrell Creek to Urunga	Environmental assessment being finalised	42	255	60.3
Kempsey to Eungai	Project approval	40	286	63
Oxley Highway to Kempsey	Environmental assessment being finalised	37	229	66
F3 to Raymond Terrace	Preferred route selected	14	49	Not yet available
Total		**401.4**	**1731.8**	**380.62**

5.5. Impact Summary

Mitigation measures have been considered and recommended for each of the reported impacts imposed by the Proposal, these are addressed in Chapter 6. A summary of the likely impacts and relevant section of the discussion are detailed below (**Table 5-6**)

- **Table 5-6: Impact summary for the Proposal**

Potential Impact	Level of impact/significance	Recommended mitigation measures
Loss of biological and genetic diversity	Moderate	Section 6.2
Loss of native vegetation and fauna habitat	High	Section 6.2.1, 6.2.8
Loss of endangered ecological communities	High	Section 6.2.2, 6.2.8
Loss of threatened species	High	Section 6.2.1, 6.2.3, 6.2.8
Loss of migratory species	Low	Section 6.2.1, 6.2.3, 6.2.8
Edge effects and weed invasion	Moderate	Section 6.2.4
Habitat fragmentation	Moderate-High	Section 6.2.5
Impacts to wildlife corridors	Moderate-High	Section 6.2.5
Impacts to riparian habitats	Moderate-High	Section 6.2.6
Impacts to ground-water dependent communities	Moderate-High	Section 6.2.6

Potential Impact	Level of impact/significance	Recommended mitigation measures
Regional scale cumulative impacts	Moderate-High	Section 6.2.7
Increased sedimentation and erosion during construction	Moderate	Section 6.2.11
Increased pollution	Moderate	Section 6.2.11
Removal of instream woody debris	High	Section 6.2.12
Loss of aquatic and riparian habitats	Moderate	Section 6.2.6
Impacts associated with potential acid sulphate soils (PASS)	Moderate	Section 6.2.11
Installation of instream structures	High	Section 6.2.5

A risk assessment detailing site-specific impacts and proposed mitigation measures for each water way crossing in the study area is provided below (**Table 5-7**). Chapter 6 provides details of each mitigation measure.

Table 5-7 Aquatic ecology site specific risk assessment and mitigation

Route	River/ creek	Estuarine or freshwater	Proposed construction work	Environmental values	Potential constructional impacts	Potential operational impacts	Risk*	Management and Mitigation Measures	Residual Risk
Warrell Creek Village to Nambucca River	Williamson Creek	Freshwater	Existing Pacific Highway crosses Williamson Creek via a multi-span bridge (two sets of piers) approximately 500m upstream of the junction with Warrell Creek. Proposed construction works include duplication of existing bridge.	Diverse fish population. High species diversity and abundance. Riparian vegetation intact, but highly modified due to clearing for grazing pastures.	Pylon construction in adjacent areas and associated runoff into creek. Potential acid sulphate soils (ASS) and the generation of sulphuric acid leachate, which may impact on the surrounding aquatic environment. Changing water quality conditions. Settlement of suspended solids on creek bed. Loss of riparian vegetation Smothering of macroinvertebrate fauna. Oil and diesel fuel spills into the creek.	Increased traffic flow leading to increased runoff of contaminants into waterway.	Medium	Sediment traps to reduce runoff and implementation of sedimentation controls (i.e. hay bales, sediment fences, riffles, in-stream vegetation). Water quality monitoring program. Avoidance of construction activities within creek. Revegetation of riparian zones. Preparation of a site specific EMP to manage environmental conditions. Preparation of an oil spill recovery plan and ASS management plan.	Low - Limited residual risks if mitigation measures are implemented. There is the potential for increased runoff during operation due to increased traffic flow.
	Warrell Creek	Estuarine	Existing pacific highway crossing is a multiple span pylon bridge (three pylons in the water). Duplication of existing bridge of similar design proposed. Bridge is located in the tidal arm of the creek which is approximately 100m wide.	Diverse fish population with major fish habitat. High species diversity and abundance. Habitat present on the banks of the creek included coastal healthland. Reasonably high disturbance has occurred in the area, through vegetation clearing for pastoral land.	Pylon construction in the river. Potential ASS and the generation of sulphuric acid leachate, which may impact on the surrounding aquatic environment. Excavation of sediment resulting in changed water quality conditions. Creation of sediment plumes. Riparian vegetation removal would be required on the southern and northern banks. Construction activities would directly and indirectly impact water quality, fish populations and riparian vegetation.	Increased traffic flow leading to increased runoff of contaminants into waterway.	High	Sediment traps to reduce runoff and implementation of sedimentation controls (i.e. hay bales, sediment fences, riffles, in-stream vegetation). Installation of silt curtains to manage turbidity plumes. Water quality monitoring programs both upstream and downstream to manage the extent of the plume. Riparian vegetation protection, minimising net loss of habitat. Restoration of affected riparian vegetation and replanting of native flora species. Construction activities to be undertaken outside of bass and perch spawning season (June – August).	Low - Limited residual risks if mitigation measures are implemented. There is the potential for increased runoff during operation due to increased traffic flow.
Nambucca River to Nambucca Heads	Nambucca River	Estuarine	Proposed highway crossing is on the eastern outskirts of Macksville, immediately downstream of the existing crossing (approximately 5km west). Bridge is located in the tidal arm of the river which is approximately 200m wide.	Diverse fish population reported. Threatened species may occur in the river and have been previously reported at the river entrance. Northern shoreline features a narrow band of mangrove habitat, whilst the southern shoreline consists of casuarinas and/or eucalypts. Downstream oyster leases.	Pylon construction in the river. Potential ASS and the generation of sulphuric acid leachate, which may impact on the surrounding aquatic environment. Excavation of sediment resulting in changed water quality conditions. Creation of sediment plumes. Construction activities would directly and indirectly impact water quality, fish populations and mangrove	Increased traffic flow leading to increased runoff of contaminants into waterway. Increased downstream impacts on water quality because of bridge relocation and construction.	High	Sediment traps to reduce runoff and implementation of sedimentation controls (i.e. hay bales, sediment fences, riffles, in-stream vegetation). Installation of silt curtains to manage turbidity plumes. Water quality monitoring programs both upstream and downstream. Riparian vegetation protection, minimising net loss of mangrove habitat. Restoration of affected riparian vegetation and replanting of native flora	Low - Limited residual risks if mitigation measures are implemented. There is the potential for increased runoff during operation due to increased traffic flow.

Route	River/ creek	Estuarine or freshwater	Proposed construction work	Environmental values	Potential constructional impacts	Potential operational impacts	Risk*	Management and Mitigation Measures	Residual Risk
				Commercial and recreational fishing area.	habitat. Downstream impacts on oyster leases and fishing (commercial and recreational). Impacts on species listed in the FM Act.			species. Construction activities to be undertaken outside of Bass and Perch spawning season (June – August).	
Nambucca Heads to South Urunga	Boggy Creek	Freshwater	Proposed highway crossing is 150m west of the existing highway crossing. The proposed structure is a single span bridge. The creek is approximately 12 m wide and under tidal influence for approximately 6km.	Boggy Creek is a highly modified freshwater habitat. The creek has low abundance and diversity of fish habitats and modified water quality conditions. The riparian zone is greater than 3m wide, with dense vegetation including casuarinas and eucalypts.	Bridge construction onshore and associated runoff into creek. Potential ASS and the generation of sulphuric acid leachate, which may impact on the surrounding aquatic environment. Changing water quality conditions. Settlement of suspended solids on creek bed. Smothering of macroinvertebrate fauna. Oil and diesel fuel spills.	Increased traffic flow leading to increased runoff of contaminants into waterway.	Medium	Sediment traps to reduce runoff and implementation of sedimentation controls (i.e. hay bales, sediment fences, riffles, in-stream vegetation). Water quality monitoring program. Avoidance of construction activities occurring within creek. Preparation of a site specific EMP to manage environmental conditions. Preparation of an oil spill recovery plan and ASS management plan.	Low - Limited residual risks if mitigation measures are implemented. There is the potential for increased runoff during operation due to increased traffic flow.
	Cow Creek	Freshwater	The creek is crossed at the pacific highway by a 3 x 2 m box culvert. Cow Creek is a tributary of Deep Creek located about 1 km north of Boggy Creek.	Cow Creek is home to a diverse fish population. The surrounding environment consists of a mix of casuarina, eucalyptus and various weed species. The creek is 1-6 m wide with banks 2-3 m high.	Culvert construction in the creek. Potential ASS and the generation of sulphuric acid leachate, which may impact on the surrounding aquatic environment. The proposed culvert duplication requires excavation of material and sediment resulting in changed water quality conditions and the creation of sediment plumes. The construction of culverts involves blocking/diverting the creek for the construction period. Removal of riparian and instream vegetation. Construction activities would directly and indirectly impact water quality and fish populations. Oil and diesel fuel spills.	Increased traffic flow leading to increased runoff of contaminants into waterway.	High	Sediment traps to reduce runoff and implementation of sedimentation controls (i.e. hay bales, sediment fences, riffles, in-stream vegetation). Water quality monitoring program. Avoidance of construction activities occurring within creek. Preparation of a site specific EMP to manage environmental conditions. Preparation of an oil spill recovery plan and ASS management plan.	Low - Limited residual risks if mitigation measures are implemented. There is the potential for increased runoff during operation due to increased traffic flow.
	Deep Creek	Estuarine	Existing pacific highway crosses Deep Creek via a multi-span bridge (two sets of piers). Duplication of existing bridge proposed on the western extent of the current bridge on the northern arm of Deep Creek. Bridge is located in the tidal	Diverse fish population. High abundance and diversity of fish species recorded. Threatened species may occur in the lower estuary. Riparian vegetation comprises a coastal	Pylon construction in the river. Potential ASS and the generation of sulphuric acid leachate, which may impact on the surrounding aquatic environment. Excavation of material and sediment resulting in changed water quality	Increased traffic flow leading to increased runoff of contaminants into waterway.	High	Sediment traps to reduce runoff and implementation of sedimentation controls (i.e. hay bales, sediment fences, riffles, in-stream vegetation). Installation of silt curtains to manage turbidity plumes. Water quality monitoring programs both upstream and	Low - Limited residual risks if mitigation measures are implemented. There is the potential for increased runoff during operation due to increased traffic flow.

Route	River/ creek	Estuarine or freshwater	Proposed construction work	Environmental values	Potential constructional impacts	Potential operational impacts	Risk*	Management and Mitigation Measures	Residual Risk
			arm of the creek which is approximately 50m wide.	heath environment, with mangroves present on the southern bank.	conditions. Creation of sediment plumes. Construction activities would directly and indirectly impact water quality, fish populations and mangrove habitat.			downstream. Riparian vegetation protection, minimising net loss of mangrove habitat. Restoration of affected riparian vegetation and replanting of native flora species. Construction activities to be undertaken outside of Bass and Perch spawning season (June – August).	
	Oyster Creek	Freshwater	The proposed Pacific Highway crossing would be located at the current highway crossing. Box culverts have been recommended for the creek crossing. Existing crossing consist of a 3 x 4 m box culvert.	The creek provides minimal to moderate fish habitat. The riparian zone consists of casuarinas, eucalyptus and acacias. The water is choked with dense water weed (*Egeria densa)* and water hyacinth. Oyster Creek is a permanent or ephemeral creek where semi-permanent pools form in the creek after a rain event. 3-5m wide pools of water. Banks relatively stable.	Culvert construction in the creek. Potential ASS and the generation of sulphuric acid leachate, which may impact on the surrounding aquatic environment. The proposed culvert duplication requires excavation of sediment resulting in changed water quality conditions and the resuspension of sediments. The construction of culverts involves blocking/ diverting the creek for the construction period. Construction activities would directly and indirectly impact water quality and fish populations. Removal of riparian and instream vegetation. Oil and diesel fuel spills.	Increased traffic flow leading to increased runoff of contaminants into waterway.	High	Sediment traps to reduce runoff and implementation of sedimentation controls (i.e. hay bales, sediment fences, riffles, in-stream vegetation). Water quality monitoring program. Reduce construction period and area of impact within creek to a minimum. Preparation of a site specific EMP to manage environmental conditions. Preparation of an oil spill recovery plan and ASS management plan.	Low - Limited residual risks if mitigation measures are implemented. There is the potential for increased runoff during operation due to increased traffic flow.
South Urunga to Existing Raleigh Deviation	Kalang River	Estuarine	Proposed highway crossing would be constructed upstream of existing crossing, approximately 2.5 km west of Urunga (upstream of Newry Island). The proposed bridge is located in the tidal arm of the river, which would be approximately 130m wide.	Diverse fish population. Threatened species may occur in the lower estuary. Riparian vegetation on both sides of the river is a narrow band of mangroves and eucalypts. Beds of seagrass (*Zostrea sp*.) are located in the lower estuary, further downstream of the proposal (SKM, 2004).	Pylon construction in the river. Potential ASS and the generation of sulphuric acid leachate, which may impact on the surrounding aquatic environment. Excavation of sediment resulting in changed water quality conditions. Creation of sediment plumes. Construction activities would directly and indirectly impact water quality, fish populations, mangrove habitat and downstream seagrass habitat.	Increased traffic flow leading to increased runoff of contaminants into waterway. Increased upstream impacts because of bridge relocation and construction.	High	Sediment traps to reduce runoff and implementation of sedimentation controls (i.e. hay bales, sediment fences, riffles, in-stream vegetation). Installation of silt curtains to manage turbidity plumes. Water quality monitoring programs both upstream and downstream. Mapping the extent of seagrass communities in the lower estuary. Riparian vegetation protection, minimising net loss of mangrove habitat. Restoration of affected riparian vegetation and replanting of native flora species. Construction activities to be undertaken outside of bass	Low - Limited residual risks if mitigation measures are implemented. There is the potential for increased runoff during operation due to increased traffic flow.

Route	River/ creek	Estuarine or freshwater	Proposed construction work	Environmental values	Potential constructional impacts	Potential operational impacts	Risk*	Management and Mitigation Measures	Residual Risk
								and perch spawning season (June – August).	
	Bellinger River	Estuarine	Existing Pacific Highway crosses Bellinger River via a multi-span, dual carriageway bridge, with six pylons in the river. Duplication of existing bridge proposed. The Bellinger River is approximately 110m wide and 80 km long, with artificial banks present.	Reasonably diverse fish population present. Threatened species may occur in the lower estuary. Riparian vegetation dominated by mangroves, casuarina and camphor laurel. Highly disturbed riparian habitat, with pasture the dominant land use along the river.	Pylon construction in the river. Potential ASS and the generation of sulphuric acid leachate, which may impact on the surrounding aquatic environment. Excavation of instream sediment resulting in changed water quality conditions. Creation of sediment plumes. Construction activities would directly and indirectly impact water quality, fish populations and mangrove habitat.	Increased traffic flow leading to increased runoff of contaminants into waterway.	High	Sediment traps to reduce runoff and implementation of sedimentation controls (i.e. hay bales, sediment fences, riffles, in-stream vegetation). Installation of silt curtains to manage turbidity plumes. Water quality monitoring programs both upstream and downstream. Riparian vegetation protection, minimising net loss of mangrove habitat. Restoration of affected riparian vegetation and replanting of native flora species. Construction activities to be undertaken outside of bass and perch spawning season (June – August).	Low - Limited residual risks identified. There is the potential for increased runoff during operation due to increased traffic numbers.

* Risk assessment undertaken in accordance with AS/NZS 4360:2004.

6. Recommended mitigation measures

6.1. Management aims

General and specific mitigation measures and long-term management and monitoring strategies would be in accordance with the following management aims.

- Maintain and protect existing biodiversity.
- Maintain and protect species and populations of National and State conservation significance.
- Maintain existing water quality and hydrological flow regimes.
- Minimise the loss of vegetation and habitat.
- Minimise pollution and degradation.
- Enable movements and dispersal of species to be maintained.
- Minimise fauna mortality and injury and damage to individual plant species.
- Enable habitat connectivity for arboreal mammals

These aims would form the basis of a Flora and Fauna Management Plan (FFMP) to be prepared as a supplementary plan to the Construction Environmental Management Plan (CEMP) and the Operation Environmental Management Plan (OEMP) for the Proposal. The RTA would be responsible for initiating management and monitoring programs associated with the proposed upgrade. These would be detailed in the FFMP and would be based on the broader management aims of the Proposal.

In accordance with the RTA's Code of Practice for Water Management: Road Development and Management (RTA 1999), an Environmental Management Plan (EMP) needs to be prepared for all construction and maintenance activities. The EMP's would include a Soil and Water Management Plan (SWMP), which would be created to document methods to limit the movement of sediment and controls to remove sediment from runoff prior to discharge to downstream watercourses.

The SWMP would be prepared during the detailed design stages and would comply with principles and practices in:

- RTA (1998) *RTA Road Design Guide*, Section 7 "Stormwater Management and Drainage Design" and 8 "Erosion and Sedimentation".
- Department of Housing (2004), *Managing Urban Stormwater: Soils and Construction*

The EMPs would aim to prevent and/or limit the potential impacts and risks to aquatic ecology and water quality incorporating (but not limited to) the following control measures outlined below.

- Retention of large woody debris within watercourses where possible.
- Instream structures such as bridges and culverts would be designed and managed to minimise any potential impact to flow regimes and fishways would be constructed at potential barriers to enable the migration of fish and macroinvertebrates during construction and operation where applicable.
- Riparian and aquatic habitat would be protected during construction works and any mangroves or areas of riparian vegetation impacted by construction would be rehabilitated.
- Management of acid sulphate soil to ensure sulphuric acid leachate does not enter watercourses.

6.2. Mitigation Strategies and Design Features

The condition of the vegetation and fauna habitats along the study area and the nature of the Proposal suggest that there is potential for significant impacts on biodiversity. Therefore particular care and consideration is required during each phase of the Proposal (i.e. pre-construction, construction and road operation) to minimise threats and conserve areas of conservation value to flora and fauna. The following sections provide advice and recommendations to achieve this objective.

6.2.1. Native vegetation and fauna habitat loss

Mitigation measures to minimise impacts from the loss of native vegetation and fauna habitat includes a range of general measures including:

- Vegetation would only be cleared where totally required and retained vegetation would be clearly marked and protected from construction activities.
- Installation of protective fencing to mark the limits of clearing (ie“no-go” areas) surrounding the footprint to ensure that vehicles and other direct disturbances associated with the road construction, such as construction compounds and stockpile sites, do not enter adjacent vegetation, particularly Endangered Ecological Communities and widened medians.
- Pre-clearance surveys would be undertaken to flag hollow bearing trees and determine where possible trees occupied by fauna species. During the proposed clearing works an experienced wildlife handler should be present during vegetation removal to retrieve any displaced fauna and release into adjacent habitats safe from construction works.
- Vegetation management measures would be implemented for retained areas of vegetation, including weed removal, native plantings, broadcasting of collected native seed and re-

location of specific habitat resources such as bush rocks, hollow logs, hollow tree trunks and branches.

- Native vegetation cleared from the footprint is to be mulched along with the collection of topsoil to preserve the soil stored seed bank for reuse in rehabilitation works and erosion control and native seed should be sourced from the road footprint and used in landscaping/ revegetation works.
- Revegetation / rehabilitation of the site should be conducted progressively during the construction to ensure use of collected topsoil and seed and to develop different successional stages of rehabilitation.
- Implement mitigation measures to avoid the spread of weeds and plant pathogens.
- Nest boxes would be installed where required in accordance with specialist advice and in consultation with DECCW, prior to construction, to replace hollow resources that are proposed to be removed.
- Implementation of soil erosion and sedimentation control measures.
- These general mitigation measures to minimise impacts to vegetation and fauna habitat would be integrated into the FFMP and CEMP for the Proposal.

6.2.2. Loss of Endangered Ecological Communities

Clearing of EECs would be restricted to the minimum area possible. Protected vegetation outside and adjoining the construction corridor would be clearly flagged to control accidental incursions.

Habitat compensation packages would be negotiated with DECCW to ensure impacts to these communities are offset through protection of larger high quality areas of this community. There is scope for rehabilitated areas and retained areas of vegetation in the road boundary to be included as part of an offset package. The Proposal would result in the removal of up to 60.21 ha of EECs of which approximately 50 per cent is swamp oak floodplain forest, although this is significant scope to retain portions of this EEC within the road reserve through restricting clearing to the minimum area required.

6.2.3. Loss of significant flora and fauna species

6.2.3.1. Threatened Flora

Measures to mitigate the direct impacts on threatened plant species comprise the following:

- Location and tagging of threatened plant species along the construction corridor would be conducted prior to clearing for construction and strict protocols implemented to avoid direct impacts where possible.
- The feasibility of relocating individuals of the rusty plum and slender milkvine directly affected by the Proposal to suitable habitat on nearby land in secure tenure would be investigated and resultant action determined on the basis of expert advice and in consultation with DECCW.
- An adaptive monitoring program would be developed to assess the effectiveness of mitigation and offset measures and allow for refinement and modification of these if monitoring suggests this is required. The program would be implemented prior to construction to establish baseline numbers of threatened flora and would continue for a minimum of two years after construction has been completion.

A monitoring protocol for threatened plant species would be developed according to the following broad guidelines:

- Seasonal monitoring of any translocations or seed or cutting raised plants of rusty plum or slender milkvine should be conducted four times per year for the first year after translocation and then biannually for subsequent years.
- Areas of slender milkvine that are retained adjacent to the construction footprint should be monitored four times per year during the construction period and then biannually for the remainder of the monitoring period.
- Adaptive management measures should be implemented if the health and development of plantings and/or translocations is found to be declining, further follow-up plantings may be required.
- Monitoring of plantings and rehabilitation areas should be conducted twice annually for at least two years post construction and following re-assessment of the monitoring protocols it would be decided if further monitoring is necessary.

6.2.3.2. Threatened and migratory fauna

Mitigation measures for threatened and migratory fauna species includes many of the mitigation measures listed above in section 6.2.1 including pre-clearance surveys and protocols, a fauna rescue framework for clearing works and rehabilitation of disturbed areas and retained areas of remnant vegetation. Monitoring is required for threatened fauna species with the aim of assessing the impacts of the Proposal on select threatened fauna species (i.e. target species) in addition monitoring the efficacy of the proposed fauna mitigation measures. Monitoring would include:

- A strategy for monitoring the yellow-bellied glider population in the affected portion of Nambucca State Forest should be developed as part of the FFMP. This could be done in consultation with the DII. Issues which should be addressed include identifying den locations and sap feeding trees.
- Monitoring of the Osprey nest on the southern side of Deep Creek during construction. This is particularly important during the breeding periods to monitor the impact of construction noise in proximity to the nest and in the event that disturbance to nesting is evident an appropriate strategy can be implemented.
- Routine monitoring of fauna exclusion fencing for damage and repair is to be conducted four times per year for the duration of the monitoring period.

Measures to mitigate potential indirect impacts on threatened flora and fauna at the construction stages of the Proposal are outlined in **Table 6-1**.

Table 6-1: Avoidance and mitigation measures for threatened species

Threatened species	Avoidance and Mitigation measures
Rusty plum *Amorphospermum whitei*	▪ Seed from this one individual should be collected, propagated and planted in areas of suitable habitat adjacent to the Proposal area, such as Boggy Creek and gully areas in State Forests that are protected as riparian exclusion zones. ▪ The feasibility of translocating this single plant should be investigated and if deemed to be feasible a translocation strategy should be developed and implemented in consultation with DECCW and in accordance with relevant guidelines such as *Guidelines for the Translocation of Threatened Plants in Australia* (ANPC 2004). ▪ Various propagation and rehabilitation methods should be implemented, including propagation from cuttings and seed, habitat rehabilitation, and ongoing maintenance and monitoring to ensure the greatest chance of success.
Slender milkvine *Marsdenia longiloba*	▪ Vegetation clearing is to be strictly minimised and controlled where *Marsdenia longiloba* is present adjacent to the footprint. ▪ Protective fencing is to be installed surrounding the identified locations of *Marsdenia longiloba* to avoid incursions from construction machinery and the potential spread of weeds and plant pathogens. ▪ A translocation strategy should be developed and implemented to compensate for the loss of individuals from the construction footprint and promote the establishment of sustainable populations. ▪ The translocation strategy is to be prepared in consultation with DECCW and other relevant interest groups and in accordance with relevant guidelines (ANPC 2004). ▪ To ensure the highest success, the translocation strategy should incorporate a range of methods, including propagation from cuttings and seed, habitat rehabilitation, and ongoing maintenance and monitoring. ▪ Translocated plants and any seedlings and/or cuttings should be established in areas protected from future development such as gullies in adjacent State

Threatened species	Avoidance and Mitigation measures
	Forests that are protected as logging exclusion zones, or other protected areas where suitable habitat occurs.
Forest fauna species *yellow-bellied glider* *glossy black-cockatoo* *grey-headed flying-fox* *koala* *Insectivorous bats* *Frugivorous rainforest birds* *square-tailed kite* *Large Forest Owls* *giant barred frog* *Migratory Species*	▪ Several species identified in dry, moist and swamp sclerophyll forest habitats. The higher conservation values forests comprise moist forest gullies and adjoining slopes. All large mature trees are significant and provide potential hollows and food resources. ▪ Vegetation clearing is to be strictly minimised to the construction corridor only and controlled where known populations of threatened species have been identified. ▪ Identify significant features such as 'habitat trees' (i.e. hollow-bearing trees), sap feeding trees and nest sites from the construction corridor during the pre-construction phase and avoid these features where possible during construction. ▪ A fauna rescue framework for clearing has been developed by the RTA in consultation with DECCW and would be used as a basis for developing a protocol for the handling and translocation of fauna during construction. ▪ Provide dedicated and incidental fauna crossing structures at key locations identified to target the range of large, medium and smaller species present. Monitor fauna crossing during and following construction.
Floodplain fauna *osprey* *black-necked stork* *Migratory Species*	▪ Identified in swamps and open wetlands, estuaries. ▪ Minimise direct and indirect impacts on creeklines and wetland fringes through the pre-construction and construction phase. ▪ Re-survey immediately prior to construction to identify nest locations for osprey, black-necked stork and brolga. Recheck the location of identified osprey nest to confirm if present prior to clearing. Monitor osprey nest during construction to determine if impacted by construction noise, particularly during the breeding period ▪ Manage indirect impacts on hydrology regimes

6.2.4. Management of edge effects and weed invasion

During construction there is potential for noxious and invasive weeds to be spread via earthworks and clearing activities, from seeds and other propagules in the soil and on vegetative material. The rehabilitation and weed control strategies in the CEMP should specify mitigative measures to minimise the spread of weeds. A protocol needs to be developed for weed infested areas to ensure all potential weed propagules from soil and vegetative material is appropriately disposed and weed spread is minimised. Disposal methods may include using this material as fill beneath batters or where feasible from an engineering perspective, or for use off-site. Rehabilitation of adjacent areas of habitat and disturbed areas would also control weed invasion and impacts from edge effects.

Rehabilitation would occur at roadside verges, adjacent to culvert entrances and bridge pylons would contribute to mitigating edge effects and weed invasion. Restoration activities would involve a range of restoration methods including re-use of top soil salvaged from areas of remnant bushland, seed collection, brush matting and tube-stock.

Topsoil should be salvaged from areas of cleared vegetation with low weed abundance and spread in roadside verges that have similar habitat conditions as the area it was collected from. Seed collection should be undertaken before and during vegetation clearing activities from sclerophyll species suitable for tube-stock propagation and hydro-seeding in roadside verges. Where applicable brush matting and collected seed should be utilised for species which are unlikely to be present in the seed-bank of the salvaged soil, such as species from the Myrtaceae, Casuarinaceae and Proteaceae plant families. Brush-matting would also provide protection from direct sunlight and drying of the salvaged soil. Appropriate storage of salvaged topsoil and timing for spreading in road verges needs to be resolved in the rehabilitation and weed control strategies of the CEMP.

Other mitigation measure to further minimise potential impacts from edge effects include implementing adequate soil erosion and sedimentation control measures and stockpiling of materials including waste should not be stored adjacent to areas of native vegetation.

6.2.5. Management of habitat fragmentation and fauna crossings

Impacts of habitat fragmentation would be minimised through a range of mitigation measures including restoration of road verges with locally indigenous flora species and rehabilitation of areas disturbed by the Proposal. Where bridges can be designed to avoid riparian vegetation riparian corridors would be maintained.

The impact of the Proposal on fauna movements and identified wildlife corridors has been considered in the design of the Proposal with regard to providing a specific type and location of fauna crossing structures. Specifically designed fauna crossing measures have proven to be successful for the management of several fauna species of conservation status (e.g. Jackson and Griffith 2000, AMBS 2002) and numerous common fauna species. Although it is not possible to design a single crossing structure that accounts for all species, it is feasible to develop a strategy for making the highway more permeable to wildlife passage for a wide diversity of species. This approach has been used for this Proposal by including two key design considerations: 1) widening of the median at important corridor locations, and 2) the provision of dedicated and incidental fauna underpass structures at important corridor locations and drainage areas.

The installation and operation of structures such as culverts and other instream structures is listed under the FM Act as a key threatening process. Culverts and causeways can modify the natural flow of rivers by increasing, decreasing or altering the seasonality, frequency, magnitude and timing of the flow. Alteration of natural flow regimes can disrupt natural reproductive cues, natural processes of sediment erosion, transport and deposition which can result in a loss of aquatic habitat for fish and macroinvertebrates (NSW DPI 2005). Additionally, culverts can act as a physical barrier to native fish and macroinvertebrate movement and migration by breaking the continuity of water in a stream if its outflow is lifted above the water level downstream of the culvert. Disruption of movement and migration can result in the disruption of genetic stock. The construction of bridges is excluded as a key threatening process as they have minimal impact upon flow.

Bridges, culverts and causeways have been designed to minimise any potential impact to flow regimes and prevent them from becoming a fish/ macroinvertebrate migration barrier. The detailed design would consider Fairfull and Witheridge (2003) *Why do fish need to cross the road? Fish passage requirements for* waterway crossings. Fishways would be constructed at potential barriers to enable the migration of fish and macroinvertebrates during construction and operation, where applicable.

Fishways are also known as fish ladders or fish passes, are structures placed on or around constructed barriers (such as weirs) to give fish the opportunity to migrate. **Table 6-2** below provides details of the seven types of fishways that have been used or considered in NSW.

- **Table 6-2 Types of Fishways for NSW (NSW DPI 2009)**

Type of fishway	Description
Pool-Type	A series of interconnected pools bypassing an obstruction.
Denil	A series of symmetrical close-spaced baffles in a channel to redirect the flow of water, allowing fish to swim around the barrier.
Lock	Fish are attracted to an entrance and accuulate in a holding area at the base of the lock. This is then sealed, filled with water to reach a level equal to the water upstream of the barrier. Fish then swim out of the lock.
Trap and transport	Fish are attracted below a barrier then physically transported over the barrier by road, rail or car. Currently no fishway of this type is operating in NSW.
Rock ramp	Large rocks and timbers are used to create pools and small falls that mimic natural structures.
Bypass	Low-gradient earthen or rocky channels that mimic the structure of natural streams and are often described as ‘nature-like’ fishways. Currently no fishway of this type has been built in Australia, however it may provide a cheaper alternative to more technical fishway designs.
Eel and elver pass	A small-diameter pipe or channel lined with materials such as coarse brushes that provide migrating juvenile eels with a damp, complex surface over which to wriggle

6.2.5.1. Widening of the median

The median is widened at three locations along the alignment by separating the two carriageways at strategic locations designed to provide a ‘stepping-stone’ opportunity for gliders, predominantly *Petaurus* spp as well as temporary refuge for other terrestrial fauna. This included a significant portion of Nambucca State Forest (i.e. 300 m section) in the vicinity of the identified yellow-bellied glider population. The design and location of the proposed widening of the median is detailed below in **Table 6-2** and **Figure 6-1.**

Fauna underpass structures have been placed at the wider median areas to provide passage for ground-dwelling fauna. It is imperative that fauna exclusion fencing is used inside the median area to prevent fauna from exiting the habitat onto the road pavement. Fencing would be used to direct fauna movements through the wider median.

- **Table 6-3: Details of the proposed widening of the median for fauna crossing**

Location	Average median width	Length of widening
Section 2 - Nambucca State Forest	50 m	300 m
Section 3 - Dalhousie Creek, Newry State Forest	50-80 m	800 m
Section 4 - Private property	40 m	900 m
	Total	**2 km**

6.2.5.2. Underpass structures

Thirty-six fauna crossings and associated fauna fencing have been included in the concept design at locations where the highway bisects relatively large areas of native vegetation where fauna are likely to cross and at known wildlife corridors. These are listed in **Table 6-4** and shown in **Figure 6-1** to **Figure 6-4**.

The approach is focused on providing dedicated fauna underpasses for species of high conservation value (i.e. koala, spotted-tailed quoll and brush-tailed phascogale) in addition to a range of structures for a diversity of common fauna. Long-term monitoring of fauna underpass structures has shown success for a range of small to medium sized fauna in eastern Australia (e.g. Goosem 1997; 2001, AMBS 2001, 2002a, 2002b and Taylor and Goldingay 2003). This includes ground-dwelling mammals as large as Red-necked Wallaby and Swamp Wallaby, reptiles and some arboreal mammals such as the koala which have been reported using box culverts (2.4 x 1.2 m and 3 x 3 m) and 10 m spanning bridge and arch structures (AMBS 2001, 2002a, 2002b).

Large mammals (such as Eastern Grey Kangaroo) require much wider and higher areas for daily movements. Typically the provision of 3 x 3 m box culverts (indicatively sized) is considered a sufficient opening for large macropods and 2.4 m considered appropriate for smaller macropods. Factors that are considered to deter larger terrestrial fauna from using underpass structures include flooding, boggy ground, presence of stumps blocking the entrance or long, narrow (and therefore dark) passages. These factors have been considered in the design of underpass structures for the Proposal, which include additional cells raised above the flood level and light in the median at longer passages.

Specific features include:

- One dedicated fauna crossing has been included within a key and regional wildlife corridor (as identified by DECCW) within Newry State Forest (in section 3 of the Proposal) to provide passage for both riparian and non-riparian fauna. This location has been selected as it falls within an east-west corridor identified in the key habitat and corridors dataset (Department of Environment and Conservation 2006), effectively linking the coastal forests north of Valla with forests to the west of the route.
  This location has also been selected to coincide with several koala records and known koala habitat [i.e. vegetation communities comprising a high proportion of Grey Gum (*Eucalyptus punctata*) and Swamp Mahogany (*E.robusta*)]. Other threatened species reported in this area include the brush-tailed phascogale (*Phascogale tapotafa*) and the spotted-tailed Quoll (*Dasyurus maculatus*). The dedicated underpass is designed to provide passage for non-riparian terrestrial fauna as an alternative passage to the combined drainage culverts discussed below.
- An additional 14 drainage culverts with fauna passage capabilities were also included in the design of the Proposal. This included a number of 'Dry Corridors' which were designed to allow dry passage during wet periods via the inclusion of raised outer cells and internal ledges.
- Dry passage access for fauna under six bridge crossings. A minimum bench area of 1.5 m has been designed between the top of the creek bank and the edge of the structure to facilitate fauna movement.

Table 6-4 Details of culverts and dedicated fauna underpasses

Approximate chainage	Details	Indicative size and configuration	Fauna crossing
3760	Box Culvert	3 X 3600 X 3600	Incidental
5760	Box Culvert	3000 X 1200	Incidental
6320	Fauna corridor under bridge over Warrell Creek		
6510	Fauna corridor under bridge over Warrell Creek		
8450	Box Culvert	14 x 3600 x 1800	Incidental
9220	Box Culvert	14 x 3600 x 2100	Incidental
13285	Box Culvert	2400 x 1200	Combined
15885	Box Culvert	2400 x 1200	Combined
16630	Box Culvert	3 x 3600 x 1200	Combined
17205	Box Culvert	2400 X 1500	Combined
17720	Box Culvert	2400 x 2400	Adjacent dedicated crossing
18515	Box Culvert	2400 X 1200	Combined

Approximate chainage	Details	Indicative size and configuration	Fauna crossing
19350	Circular Culvert	750	Incidental
19820	Box Culvert	5 x 2400 x 2100	Combined
20880	Fauna corridor under bridge over Boggy Creek		
21740	Fauna corridor under bridge over Cow Creek		
23040	Fauna corridor under bridge over Deep Creek		
24305	Box Culvert	2700 X 900	Incidental
25255	Box Culvert	2400 x 2400	Combined
26535	Box Culvert	5 x 3600 x 1200	Combined
27845	Circular Culvert	4 x 1200	Incidental
28275	Circular Culvert	3 x 1200	Incidental
28565	Box Culvert	2 X 2400 X 1200	Incidental
29215	Circular Culvert	2 X 1200	Incidental
30855	Box Culvert	2100 X 900	Combined
31510	Box Culvert	4 x 2100 x 1200	Combined
32075	Box Culvert	2400 X 1200	Combined
33395	Circular Culvert	3 x 1200	Incidental
33880	Box Culvert	2400 X 1200	Incidental
34380	Box Culvert	3 X 2700 x 1200	Combined
34615	Box Culvert	3 X 2700 X 1200	Incidental
35095	Box Culvert	23 X 3600 X 3000	Combined
36905	Box Culvert	2 x 2400 x 1200	Combined
37950	Fauna corridor under bridge		
38330	Box Culvert	2 x 3000 x 1500	Combined
39990	Box Culvert	17 X 3300 X 2100	Incidental

[1] The indicative size and configuration would be further refined during the detailed design phase.

6.2.5.3. Underpass features

With all terrestrial fauna, security from predators is important. Therefore, it is necessary to provide a clear line of sight to light and vegetation at both ends of the crossing. For smaller species, provision of protective cover and structures such as ledges or horizontal logs that are designed to restrict access by larger predators would aid their security. Approaches to the structure should allow good visibility and not be obscured by dense vegetation.

6.2.5.4. Fauna exclusion fencing

Large fauna require exclusion fencing for guidance through the crossing structure and to prevent access to the carriageway. Fencing is to be provided at strategic locations including each of the three widened medians (internal and external) and up to 500 m on either side of dedicated fauna underpass structure.

6.2.6. Management of impacts to riparian zones, ground-water dependant ecosystems and SEPP14 wetlands

Impacts to riparian and ground-water dependent communities would be mitigated through the implementation of specific design attributes. The road would be designed to minimise impacts to hydrological regimes. Specific mitigation measures include:

- Changes to existing surface and ground water levels should be minimised through appropriate placement and design of culverts and providing adequate drainage to reflect existing conditions.
- The depth of cuttings in gully areas would be minimised where possible to areas above the natural water table.
- Sedimentation and erosion controls would be implemented.
- Ensuring appropriate design of water storage areas and temporary drainage systems;
- Minimising disturbance and controlling run-off from construction areas.
- Ensuring good maintenance of vehicles to minimise pollution of water from hydrocarbons.
- Response plans to deal with any spillages or accidents that occur at refuelling sites and machinery compounds, which should be part of the CEMP.

6.2.7. Key threatening processes

Key threatening processes are listed in **Table 5-3** along with reference to proposed mitigation measures. The KTPs which have the highest level of threat as a result of the Proposal are those regarding weed invasion, altered hydrology and native vegetation clearing and removal of key fauna habitats such as hollow-bearing trees.

6.2.8. Management of pests and diseases

To minimise the potential for various pests and diseases to be introduced to the study area all construction equipment needs to be washed down prior to arriving on site. Washing procedures need to ensure that insect pest and their eggs/larvae are not present on equipment such as red imported fire ants, large earth bumblebee, feral honeybees, yellow crazy ant and cane toads. Diseases also need to be removed from equipment including Phytophthora cinnamomi, amphibian chytrid fungus, and beak and feather disease. Equipment should be washed of any sediments and debris and disinfected.

6.2.9. Management of regional scale cumulative impacts

The cumulative impacts that the Proposal would contribute to, would be minimised by the mitigation measures and compensatory habitat outlined in this assessment. Other mitigation measures mentioned in this Section would contribute to minimising cumulative impacts for vegetation loss, EEC loss, threatened species, groundwater dependent communities and wildlife corridors.

6.2.10. Compensatory habitat

Compensatory habitat is an area or areas of land containing one or more key habitats which are acquired and/or committed by the RTA for the purposes of nature conservation, to make up for the loss or degradation of one or more key habitat(s) (NSW Roads and Traffic Authority 2001).

Where there is residual loss or degradation of key habitat after route selection, road design and determination of mitigation measures, compensation in the form of compensatory habitat, land rehabilitation and/or contribution to research can be employed.

To mitigate the effects of fragmentation from the Proposal it would be beneficial to re-establish links with historically isolated fragments of habitat in proximity to the new road through increasing the size of smaller remnant fragments adjoining the road. Particular opportunities for this exist in low-lying agricultural areas adjoining the corridor. To offset the residual impacts of the Proposal, a compensatory habitat (or other suitable offset) agreement would be developed.

6.2.11. Management of sedimentation and erosion

A key threatening process under the FM Act is ‘increased sedimentation and erosion during construction of the proposal’. Increased suspended solids in waterways can impact fish and macroinvertebrate abundance and diversity through clogging of gill structures and benthic smothering (ANZECC/ARCANZ 2000). Increased sedimentation in the rivers due to construction and general operation of the highway can impact on aquatic habitats through increased turbidity. Consequently, this can reduce light penetration in the water column, limit plant growth, and influence predator foraging behaviour. Additionally, increased sediments can fill the interstitial spaces in the substrate, the preferred habitat of a number of macroinvertebrates (ANZECC 2000).

Soils in the region are potential acid sulphate soils, and thus if exposed to air during construction may be oxidised and produce sulphuric acid. Sulphuric acid leachate could become mobilised and carried by runoff into rivers and estuaries during periods of high rainfall. This increased acidity can be toxic to many gilled organisms including macroinvertebrate crustaceans and annelid worms (Boulton & Brock 1999). An Acid Sulphate Soils Management

Plan would be prepared which details preventive measures and practices to reduce the risk or erosion and exposure of soils during construction.

Primarily, the area of disturbance would be minimised, reducing the potential for erosion. Areas that are disturbed should be seeded to provide temporary soil stabilisation and prevent windblown dust from entering waterways. Bitumen or straw mulch should be used to protect exposed soil surfaces and to facilitate grass growth. The shaping of land should be designed to improve drainage and minimise the gradient and length of slopes.

Soil stockpiles should be located upon flat areas at the site with the height and slope of soil stockpiles limited, located away from hazardous erosion locations. Sediment fences, sediment traps, sandbags and/or stacked hay bales covered in geotextile materials should be constructed on upstream slopes, catch drains and road drains to slow flow and prevent erosion from entering waterways. Catch drains at the downstream boundaries of construction activities (where appropriate) should be construction to ensure containment of sediment laded run-off and diversion towards treatment.

Instream disturbance should be managed and mitigated where appropriate. Silt curtains should be deployed *in situ*, where dredging and excavation of sediments is occurring, to limit the risk of sediment plumes and increased turbidity. Regular water quality monitoring should be undertaken during construction and operation to ensure water quality values and environmental assets are maintained both upstream and downstream of the construction area.

6.2.12. Management of instream woody debris

Instream woody debris (snags) such as fallen tree trunks, branches and shrubs provide crucial habitat for aquatic organisms including juvenile fish species and macroinvertebrates and provides much of the aquatic habitat at each study site. The potential removal or ’de-snagging’ of large tree trunks and branches during construction at water way crossings can remove substrates and periphyton upon which macroinvertebrates feed, as well as the habitat and cover for many macroinvertebrate and fish species.

The NSW Department of Primary Industries Policy and Guidelines for Aquatic Habitat Management and Fish Conservation (1999) states that large woody debris should be retained to the greatest extent possible, however, if during construction of the proposal the removal of large woody debris is required, lopping/ trimming of the snag should be considered if feasible. If not possible, it is recommended that the woody debris be relocated within the river channel. Permanent removal of large woody debris should be considered as a last resort.

6.2.13. Migratory fish species

During the construction period migratory fish species such as the Australian bass and estuary perch need to be considered, as these species need to migrate from the freshwater reaches of the rivers and creeks into the lower estuaries. Construction works have the potential to create large sediment plumes and noise and vibrations in the water column, which may influence these migration patterns. Construction activities over Warrell Creek, Nambucca River, Deep Creek and the Kalang River should be minimised during the Bass and Perch spawning season between June and August.

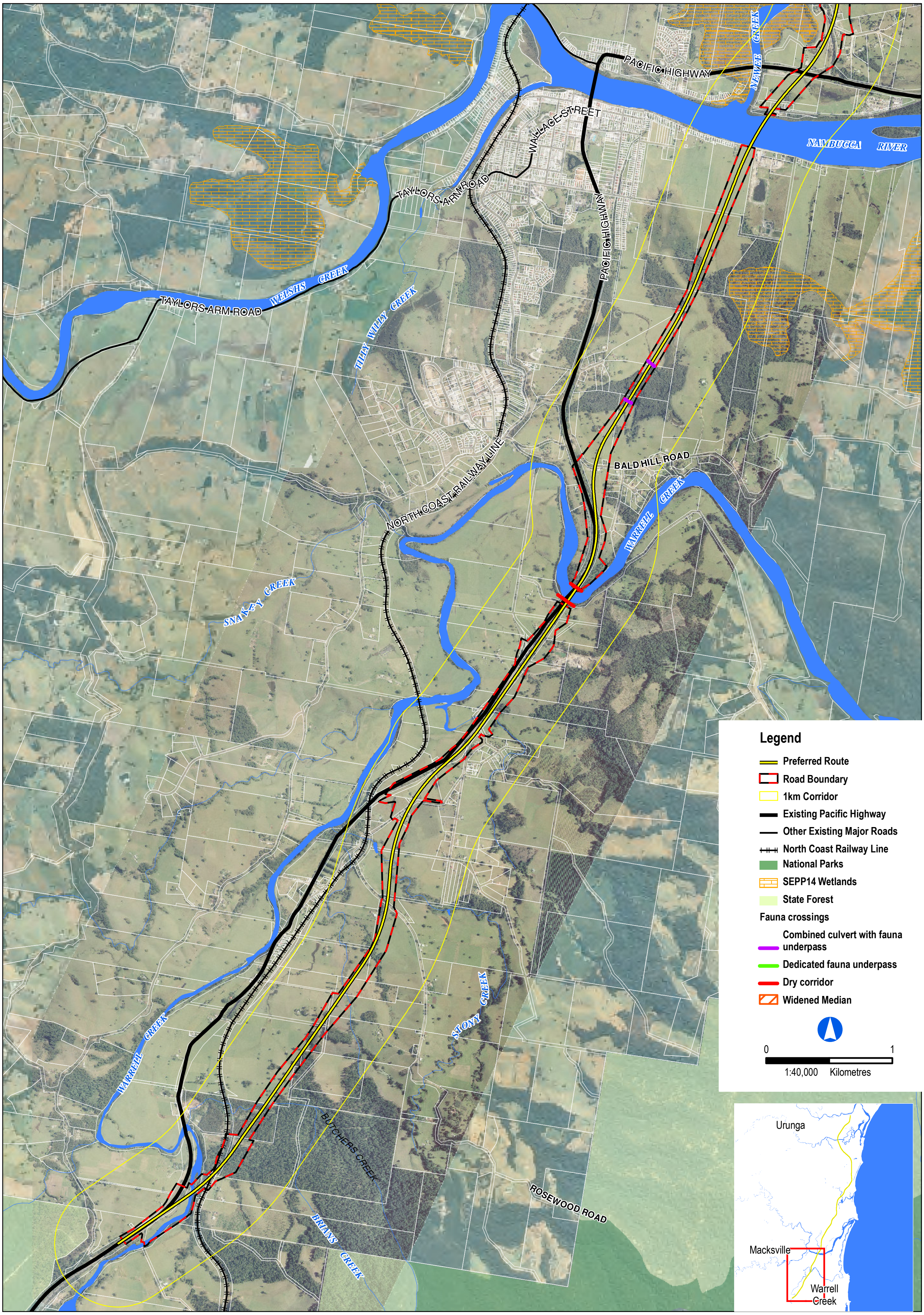

Figure 6-1: Location of median widening measures and fauna crossing structures to mitigate the impacts of habitat fragmentation.

GDA 94 MGA Zone 56

SKM SINCLAIR KNIGHT MERZ

RTA

Warrell Creek to Urunga - Upgrading the Pacific Highway

June 2, 2009
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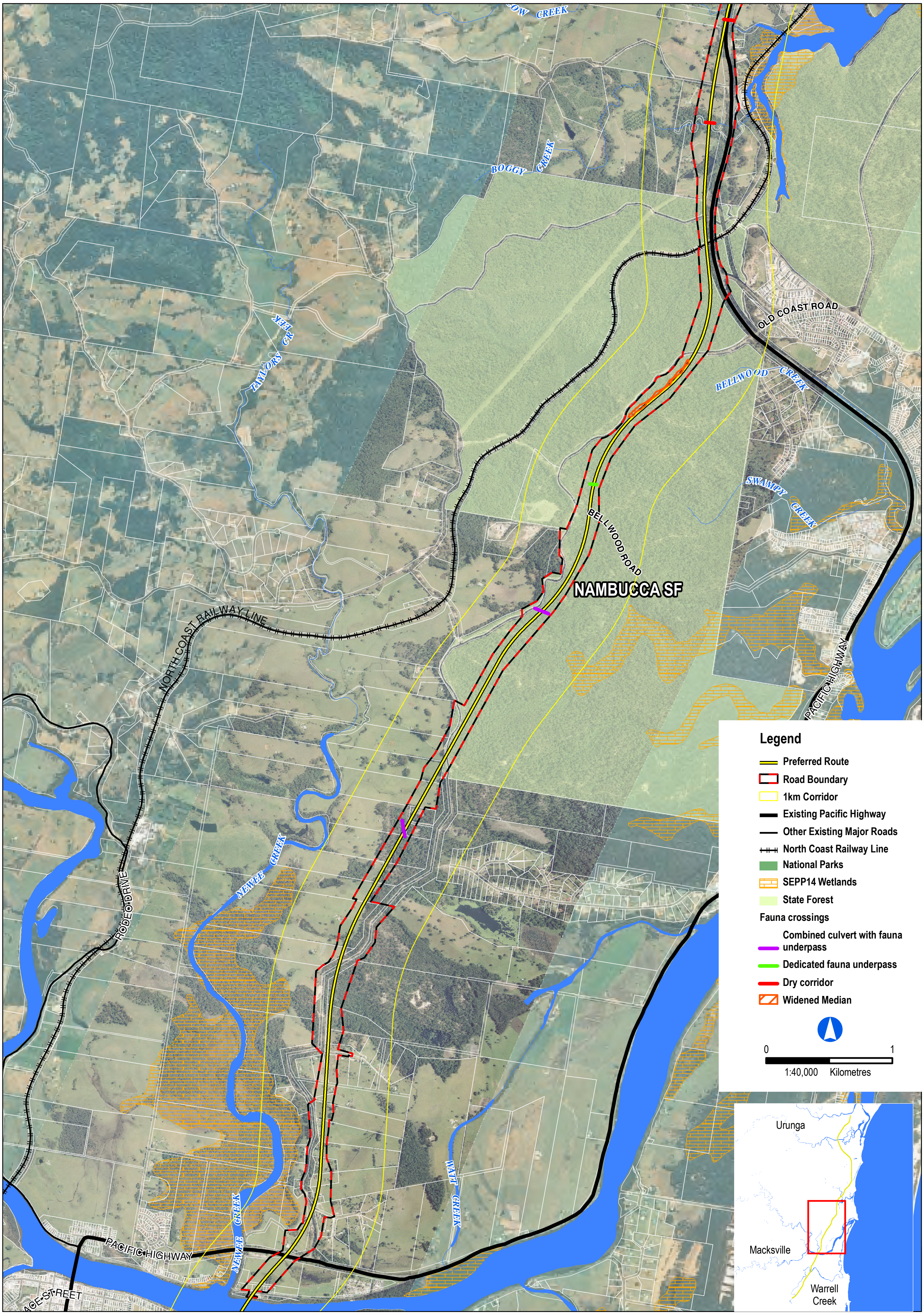

Figure 6-2: Location of median widening measures and fauna crossing structures to mitigate the impacts of habitat fragmentation.

GDA 94 MGA Zone 56

SKM SINCLAIR KNIGHT MERZ

RTA

Warrell Creek to Urunga - Upgrading the Pacific Highway

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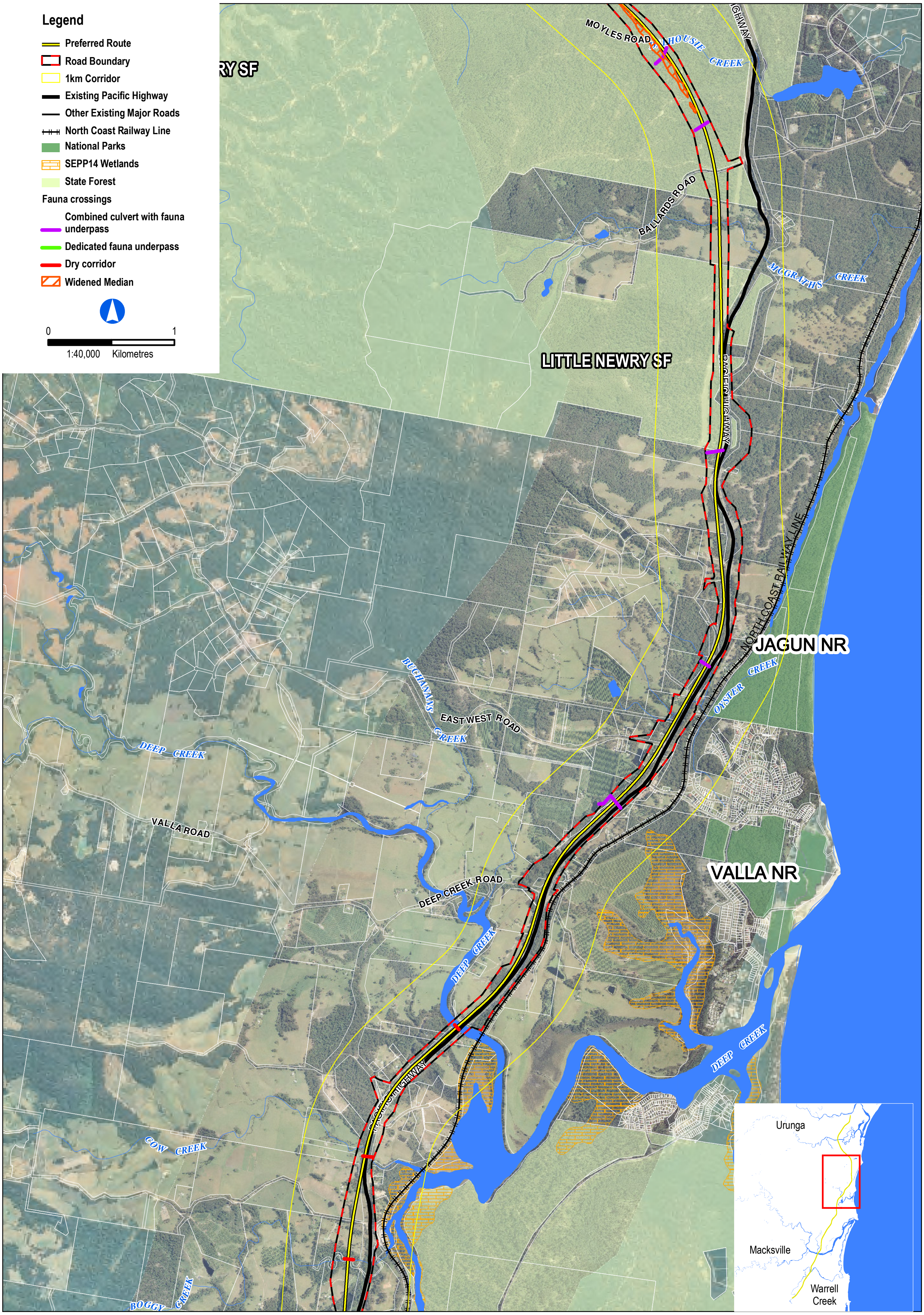

Figure 6-3: Location of median widening measures and fauna crossing structures to mitigate the impacts of habitat fragmentation.

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SINCLAIR KNIGHT MERZ SKM

RTA

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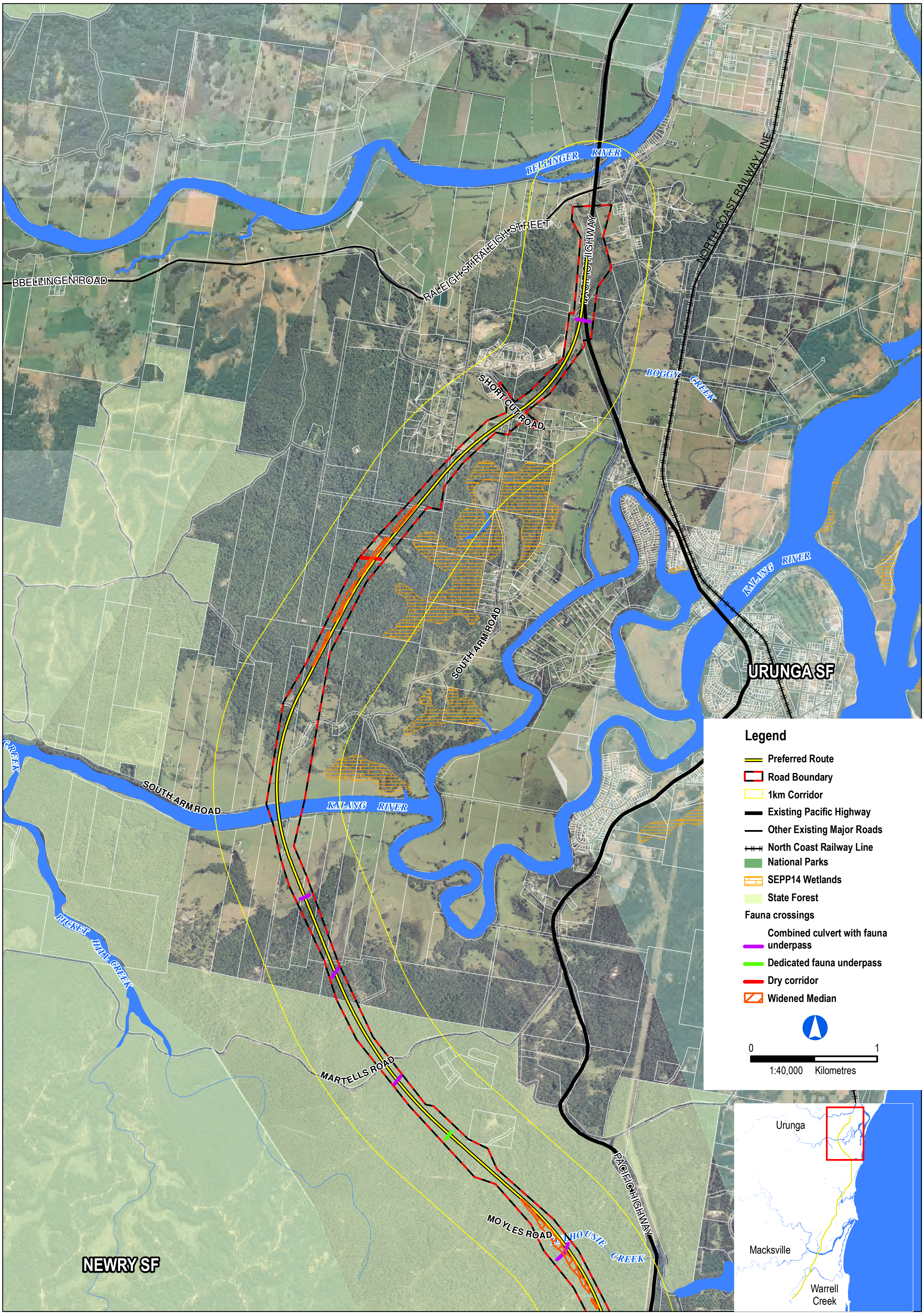

Figure 6-4: Location of median widening measures and fauna crossing structures to mitigate the impacts of habitat fragmentation.

GDA 94 MGA Zone 56

Warrell Creek to Urunga - Upgrading the Pacific Highway

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Appendix A Potential Subject Species

A.1 Threatened flora

Species	Legislative Status		Records in study area	Most recent record	Preferred habitat type	Potential to occur in the study area
	Cwlth	NSW				
Acacia chrysotricha Newry golden wattle	-	E	35	2006	Restricted to an area south of Bellingen on the NSW north coast. An understorey species on rainforest edges and in wet or dry eucalypt forest in steep narrow gullies on quartzite soils. Newry golden wattle is relatively short-lived. The seeds which remain in the soil require heat from fire to induce germination. Too-frequent fire may lead to a decline in the population, as gradual exhaustion of the soil-borne seed bank would result, with no replacement of adult plants over time. Records are present in Newry State Forest, approximately 4.5 km west of the Proposal area and there is a record from 1961 approximately 2 km to the east of the study area in Urunga.	Potential
Acronychia littoralis Scented acronychia	E	E	5	2001	Scented acronychia is found between Fraser Island in Queensland and Port Macquarie on the north coast of NSW. Scented acronychia grows in littoral rainforest on sand. The nearest record to the Proposal area is 4 km east of Warrell Creek.	Unlikely. Small areas of marginal habitat present
Amorphospermum whitei (*Niemeyera whitei*) Rusty plum	-	V	24	2005	Occurs in the coast and adjacent ranges of northern NSW from the Macleay River into southern Queensland. Its distributional stronghold is on the mid north coast around Coffs Harbour. Occurs in rainforest and the adjacent understorey of moist eucalypt forest. Recorded adjacent to Boggy Creek in the study area. There are also records 4.5km west of the Proposal area in Newry State Forest and a record adjacent to the Proposal area from 1900 in the Warrell Creek area.	Recorded

Species	Legislative Status		Records in study area	Most recent record	Preferred habitat type	Potential to occur in the study area
	Cwlth	NSW				
Chamaesyce psammogeton Sand spurry	-	E	1	1987	Occurs sparsely along the NSW coast from south of Jervis Bay to Queensland. Grows on fore-dunes and exposed headlands, often with Spinifex (Spinifex sericeus). There is a record approximately 2.5 km east of the Proposal area north of Nambucca Heads.	Unlikely. No suitable habitat present
Cynanchum elegans White-flowered wax plant	E	E	-	-	Restricted to eastern NSW where it is distributed from Brunswick Heads on the north coast to Gerroa in the Illawarra region. The species has been recorded as far west as Merriwa in the upper Hunter River valley. Occurs on the edge of dry rainforest vegetation. Other associated vegetation types include littoral rainforest; Coastal Tea-tree (Leptospermum laevigatum) – Coastal Banksia (Banksia integrifolia) coastal scrub; forest red gum (Eucalyptus tereticornis) aligned open forest and woodland; Spotted Gum (Corymbia maculata) aligned open forest and woodland; and Bracelet Honeymyrtle (Melaleuca armillaris) scrub to open scrub.	Unlikely. Small areas of marginal habitat present
Glycine clandestina		E2	1	2003	Only known from two locations about 200m apart on narrow shelf of a headland immediately south of Scotts Head. Has been recorded 2km west of Nambucca Heads. Dense, low, coastal grassland (largely Kangaroo Grass and other native species) on black soils. Nambucca Glycine occurs with, and may be confused with, Glycine tabacina and Galactia tenuiflora.	Unlikely. No suitable habitat present
Hicksbeachia pinnatifolia Red bopple nut	-	V	-	-	Coastal areas of north-east NSW from the Nambucca Valley north to south-east Queensland. Occurs in subtropical rainforest, moist eucalypt forest and Brush Box (Lophostemon confertus) forest.	Potential

Species	Legislative Status		Records in study area	Most recent record	Preferred habitat type	Potential to occur in the study area
	Cwlth	NSW				
Maundia triglochinoides	-	V	-	-	Restricted to coastal NSW north from Wyong extending into southern Queensland. Former sites around Sydney are now extinct. Grows in swamps, creeks or shallow freshwater 30-60 centimetres deep on heavy clay with low nutrients. Flowering occurs during warmer months and is associated with wetland species such as Triglochin procerum.	Potential
Melaleuca groveana	-	V	1	1998	Widespread, scattered populations in coastal districts north of Port Stephens to southeast Queensland. Grove's Paperbark grows in heath and shrubland, often in exposed sites, at high elevations, on rocky outcrops and cliffs. It also occurs in dry woodlands.	Unlikely. No suitable habitat present
Marsdenia longiloba Slender marsdenia	V	E	5	2000	Scattered sites on the north coast of NSW north from Barrington Tops. Also occurs in south-east Queensland. Subtropical and warm temperate rainforest, lowland moist eucalypt forest adjoining rainforest and, sometimes, in areas with rock outcrops.	Recorded
Parsonsia dorrigoensis Milky silkpod	E	V	13	2005	Milky silkpod is found only in NSW, with scattered populations in the north coast region between Kendall and Woolgoolga. Found in subtropical and warm-temperature rainforest, on rainforest margins, and in moist eucalypt forest up to 800 m, on brown clay soils. Flowers in summer. Appears to be able to withstand, and may even favour, light to moderate physical disturbance.	Potential
Peristeranthus hillii	-	V	-	-	Found in north-eastern NSW, north from Port Macquarie, extending to north-eastern Queensland as far as the Bloomfield River. Restricted to coastal and near-coastal environments, particularly Littoral Rainforest and the threatened ecological community Lowland Rainforest on Floodplain. The species is an epiphyte, growing in clumps on tree trunks and thick vines. Flowers appear during September and October.	Potential

A.2 Threatened fauna

The results of the assessments confirmed the presence of 14 threatened fauna species. An additional 12 species are considered to potentially occur in the study area on the basis of suitable habitat. The potential impacts on these species have been assessed in line with the factors contained in section 5A of the EP&A Act. Species with similar taxonomy or habitat requirements have been grouped together.

Species	Status TSC Act (NSW)	Presence in the study area
Black-necked stork (*Ehippiorhynchus asiaticus*)	Endangered	Confirmed
Spotted-tailed quoll (*Dasyurus maculatus*)	Vulnerable	Potential
Brush-tailed phascogale (*Phascogale tapotafa*)	Vulnerable	Potential
Yellow-bellied glider (*Petaurus australis*)	Vulnerable	Confirmed
Giant barred frog (*Mixophyes iteratus*)	Endangered	Potential
Koala (*Phascolarctos cinereus*)	Vulnerable	Confirmed
Glossy black-cockatoo (*Calyptorhynchus lathami)*	Vulnerable	Confirmed
Square-tailed kite (*Lophiotinia isura*)	Vulnerable	Confirmed
Osprey (*Pandion haliaettus*)	Vulnerable	Confirmed
Migratory nectivores		
Swift parrot (*Lathamus discolour*)	Endangered	Potential
Regent honeyeater (*Xanthomyza phrygia*)	Endangered	Potential
Cave-roosting microchiropteran bats		
Little bentwing-bat (*Miniopterus australis*)	Vulnerable	Confirmed
Eastern bentwing-bat (*Miniopterus schreibersii*)	Vulnerable	Confirmed
Large-footed myotis (*Myotis macropus*)	Vulnerable	Potential
Hollow-roosting microchiropteran bats		
Eastern long-eared bat (*Nyctophilus bifax*)	Vulnerable	Potential
Greater broad-nosed bat (*Scoteanax rueppellii*)	Vulnerable	Confirmed
Eastern freetail-bat (*Mormopterus norfolkensis*)	Vulnerable	Potential
Eastern false pipistrelle (*Falsistrellus tasmaniensis*)	Vulnerable	Confirmed
Yellow-bellied sheathtail-bat (*Saccolaimus flaviventris*)	Vulnerable	Confirmed
Megachiropteran bats		
Grey-headed flying-fox (*Pteropus poliocephalus*)	Vulnerable	Confirmed
Frugivorous birds		
Wompoo fruit-dove (*Ptilinopus magnificus*)	Vulnerable	Confirmed
Rose-crowned fruit-dove (*Ptilinopus regina*)	Vulnerable	Potential
Superb fruit-dove (*Ptilinopus superbus*)	Vulnerable	Potential

Species	Status TSC Act (NSW)	Presence in the study area
Large forest owls		
Powerful owl (*Ninox strenua*)	Vulnerable	Confirmed
Masked owl (*Tyto noveahollandiae*)	Vulnerable	Potential
Sooty owl (*Tyto tenebricosa*)	Vulnerable	Potential

Appendix B Assessment of significance (EP&A Act)

B.1 Threatened flora recorded

B.1.1 *Marsdenia longiloba* - Endangered Species: TSC Act

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Marsdenia longiloba is a slender vine species found in various rainforest types and some moist sclerophyll forests, occurring at scattered locations from Barrington Tops north to southeast Queensland (NPWS 2002b). The ecology of this species has not been studied extensively and many of its life history attributes are largely unknown. This species has mostly been recorded as occurring in low abundance in small population clusters. The populations recorded in the study area consist of scattered individuals occurring in the understorey with various ferns, herbs and other twiners in moist eucalypt forest usually with a dense rainforest subcanopy.

Marsdenia longiloba occurs within seven separate sub-populations along the study area in rainforest and wet sclerophyll forest habitats. Most locations are in Newry, Little Newry and Nambucca State Forests, and there are occurrences on private property north of the Kalang River. It is estimated that these occurrences consist of approximately 156 individuals occurring within an area up to 250 m either side of the Proposal's centreline. The population in these areas is likely to extend further upstream and downstream of some of the surveyed areas, and therefore is likely to consist of a larger population than recorded for this Proposal.

The life cycle attributes for *Marsdenia longiloba* are largely unknown, however assumptions of life history attributes can be drawn from knowledge of other species in the same family (Apocynaceae: Asclepiadoideae). Pollinators are usually insect species including flies and/or beetles. Some species in this family have highly specialised pollination mechanisms which involves trapping insects' by their legs or proboscis between the osmotically elastic anther wings, and withdrawal entailing capture of the pollinia by means of 'sutured corpuscular pollen carriers' (Watson and Dallwitz 2008).

Pollinators of *Marsdenia longiloba* although not specifically known are unlikely to be significantly impacted from the Proposal assuming pollinators comprise flying insect species which occur in relatively large numbers. Several of the sub-populations would be dissected by the Proposal and would therefore impact pollinator movements between individuals on either side of the Proposal. Therefore the movement of genetic material may be impacted in these sub-populations, and could potentially lead to some inbreeding depressions.

Considering the relatively small sub-populations that *Marsdenia longiloba* occurs in, the removal of individuals may limit the potential for out-crossing and could lead to inbreeding depressions where the majority of the population cluster is removed. Of the 156 individuals estimated to occur within the 500 metre corridor approximately 8 individuals (5 per cent of the population) would be directly impacted and an additional 46 individuals (29.5 per cent of the population) would remain within 30 m of the proposed development and would potentially be indirectly impacted. The remaining 107 individuals (65.5 per cent of the population) would remain at greater than 30 m from the Proposal and would be retained and protected from direct impacts. Only several individuals in each impacted population cluster would be directly removed and therefore a large proportion of the genetic diversity would be retained in each population cluster.

There are numerous records (DECC Atlas 2007) of *Marsdenia longiloba* surrounding the Proposal area at several locations. These records include: areas west of the Proposal area in Nambucca State Forest and surrounding the Nambucca waste management facility; south of the Proposal area in Ngamba Nature Reserve; and north of the Proposal area in the Bellingen region. Habitat for *Marsdenia longiloba* is largely protected in State Forest areas in logging exclusion zones along creeks and gullies.

There would potentially be indirect impacts to individuals downstream of the proposed development where runoff during the construction and operation of the proposed highway would enter the gully habitats where *Marsdenia longiloba* occurs. This would potentially alter the hydrology regime and nutrient loads increasing the potential for changes to habitat attributes which may impact life cycle attributes such as germination due to increased competition from weeds and changed soil conditions. Mitigation measures during construction and the implementation of specific design features into the proposed development would potentially minimise these indirect impacts.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal would remove habitat for this species in several areas and potentially lead to biophysical changes to areas of habitat. There is potential for the Proposal to alter habitat attributes of surrounding areas through indirect impacts which potentially include altering of hydrological and nutrient regimes within habitats downstream of the proposed development and edge effects. This could result in habitat changes, including increases in weed abundance, altered soil conditions and sedimentation. These changes may potentially lead to the area of occupancy of the population to be significantly reduced. However mitigation measures during construction and the implementation of specific design features into the proposed development are likely to minimise these indirect impacts.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

The known distributional limit for *Marsdenia longiloba* is between Barrington Tops north to southeast Queensland (NPWS 2002b). Therefore *Marsdenia longiloba* is in the central portions of its distribution in the Nambucca-Urunga area.

How is the Proposal likely to affect current disturbance regimes?

Current disturbance regimes in habitat of *Marsdenia longiloba* mainly comprises weed invasion by *Lantana camara*. The Proposal is likely to contribute to further invasion of *Lantana camara* particularly along the edges of the Proposal where there would be increased sunlight availability. Other indirect impacts such as increased water and nutrients may also aid the growth of *Lantana camara*.

How is the Proposal likely to affect habitat connectivity?

Marsdenia longiloba generally occurs in gully areas running perpendicular to the Proposal. Therefore suitable areas of habitat would be fragmented from the Proposal, with some sub-population being dissected. Pollinator movements may extend across the proposed highway allowing exchange of genetic material between fragmented areas of habitat, assuming flying insects are the main pollinators, however this is largely unknown.

Of the 6 recorded sub-populations of *Marsdenia longiloba*, two occur on both sides of the proposed route alignment within a 500m corridor, and therefore would be dissected by the proposed development. Individuals would be retained on either side of the proposed highway, with direct impacts limited to the proposed road corridor. Another two populations would be impacted on one edge of the population and the two populations on private property have been avoided by the proposed development.

How is the Proposal likely to affect critical habitat?

No critical habitat has been identified for this species.

B.1.2 *Amorphospermum whitei* (syn. *Niemeyera whitei*) Vulnerable Species: TSC Act

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Rusty plum occurs in the coast and adjacent ranges of northern NSW from the Macleay River into southern Queensland, with its distributional stronghold on the mid north coast around Coffs Harbour (NPWS 2002b). It has also been recorded in the Port Macquarie district (Harden 2000).

It occurs in rainforest and the adjacent understorey of moist eucalypt forest, generally below 600 m altitude on the less fertile soils derived from rhyolite or metasediments (Floyd 1989). The ecology of *Amorphospermum whitei* has not been extensively studied and numerous life cycle attributes such as pollination and germination are largely unknown. The large seed is supposedly dispersed by mammal species and is viable for a period of 1-3 months (Novello and Klohs 1998). Once seedlings are established it can take up to six years for the tree to reproduce (Novello and Klohs 1998).

Only one individual of *Amorphospermum whitei* was recorded in the study area on private land adjacent to Boggy Creek, comprising a small tree on the edge of disturbed trail area. This individual is proposed to be removed to accommodate the Proposal. Fruit was found beneath this individual indicating that adequate pollination is occurring to produce viable seed, and that other individuals are likely to be present in the vicinity. There is potential for *Amorphospermum whitei* to occur in other locations of the Boggy Creek catchment on private land to the west of the study area in the same patch of remnant vegetation or in areas of riparian vegetation retained in cleared agricultural landscapes to the west. There are two records of *Amorpospermum whitei* higher in the Boggy Creek catchment in Nambucca State Forest approximately two km to the southwest of the individual recorded in the Proposal area (NSW DPI 2007). Considering that only one individual is proposed to be removed and other individuals are known from the same catchment it is unlikely that the life cycle attributes for *Amorphospermum whitei* would be significantly impacted.

Amorphospermum whitei appears to be relatively widespread in the surrounding locality, as there are numerous records (DECC Atlas 2007; NSW DPI 2007) of *Amorphospermum whitei* surrounding the Proposal area at several locations. These records include: areas west of the Proposal area in Nambucca State Forest and Newry State Forest; a historical record in the Warrell Creek area recorded over 100 years ago in disturbed riparian vegetation approximately 200 m west of the Proposal; and north of the Proposal area in the Bellingen region. Habitat for *Amorphospermum whitei* is largely protected in State Forest areas in logging exclusion zones along creeks and gullies.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal would remove habitat for this species in several areas and potentially lead to biophysical changes to areas of habitat. There is potential for the Proposal to alter habitat attributes of surrounding areas through indirect impacts which potentially include altering of hydrological and nutrient regimes in habitats downstream of the proposed development and edge effects. This could result in habitat changes, including increases in weed abundance, altered soil conditions and sedimentation. Considering that *Amorphospermum whitei* was recorded in only one location in the study area it is unlikely that the Proposal would lead to the area of occupancy of the population to be significantly reduced from potential changes to areas of suitable habitat. Mitigation measures during construction and the implementation of specific design features into the proposed development are likely to minimise these indirect impacts.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

Rusty plum occurs in the coast and adjacent ranges of northern NSW from the Macleay River into southern Queensland, with its distributional stronghold on the mid north coast around Coffs Harbour (NPWS 2002b). It has also been recorded in the Port Macquarie district (Harden 2000), which would represent the southern limit of the species. Therefore *Amorpospermum whitei* is in the central portions of its distribution in the Nambucca-Urunga area.

How is the Proposal likely to affect current disturbance regimes?

Current disturbance regimes in habitat of *Amorphospermum whitei* mainly comprises weed invasion by *Lantana camara*. In the Boggy Creek area where the only occurrence of *Amorphospermum whitei* in the Proposal area was recorded Broad-leaf Paspalum (*Paspalum wettsteinii*) and other pasture weeds are present along trails in this patch of remnant vegetation. The Proposal is likely to contribute to further invasion of *Lantana camara* particularly along the edges of the Proposal where there would be increased sunlight availability. Other indirect impacts such as increased water and nutrients may also aid the growth of *Lantana camara*.

How is the Proposal likely to affect habitat connectivity?

Amorpospermum whitei generally occurs in gully areas running perpendicular to the Proposal. Therefore suitable areas of habitat would be fragmented from the Proposal. Although no individuals were recorded in the study area in most areas of suitable habitat, individuals are potentially present in areas beyond the study area, and there are records to the west of the Proposal in several areas. Pollinator movements may extend across the proposed highway allowing exchange of genetic material between fragmented areas of habitat, assuming flying insects are the main pollinators, however this is largely unknown. Seed dispersal across the proposed development is likely to be impacted to some degree, as terrestrial fauna movement is likely to be impacted, however seed dispersal by flying mammals and birds is unlikely to be significantly impacted.

How is the Proposal likely to affect critical habitat?

No critical habitat has been identified for this species.

B.2 Threatened flora potentially present

B.2.1 *Acacia chrysotricha* - Endangered Species: TSC Act

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

The distribution of *Acacia chrysotricha* is restricted to an area south of Bellingen on the NSW north coast. It is an understorey species on rainforest edges and in wet or dry eucalypt forest in steep narrow gullies on quartzite soils. It is relatively short-lived and the seeds remain in the soil until disturbed or heated from fire to induce germination. This species is threatened by too-frequent fire which may lead to declines in the population.

Acacia chrysotricha was not recorded in the study area despite targeted searches in areas of suitable habitat. In particular areas of Newry State Forest and Nambucca State Forest had suitable areas of habitat comprising narrow gullies on quartzite soils. Records are present in Newry State Forest, approximately 4.5 km west of the Proposal area and there is a record from 1961 approximately two km to the east of the study area in Urunga.

This species is not particularly difficult to identify in the field, however a similar looking species *Acacia irrorata* was present in moderate abundance in areas of suitable habitat for this species. These species can readily be distinguished from each other in the field by differences in leaf morphology.

Considering the relatively extensive targeted searches undertaken for this species in areas of suitable habitat, it is unlikely it is present in the study area. The Proposal would result in the removal of approximately 34.4 ha of suitable habitat for this species. In particular areas of Newry State Forest and Nambucca State Forest had suitable areas of habitat comprising narrow gullies on quartzite soils.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal would result in the removal of approximately 34.4 ha of suitable habitat for this species. In particular areas of Newry State Forest and Nambucca State Forest had suitable areas of habitat comprising narrow gullies on quartzite soils.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

The distribution of *Acacia chrysotricha* is restricted to an area south of Bellingen on the NSW north coast. Therefore the restricted distribution of this species suggests where it is found in the local area it is near or at the limit of its distribution.

How is the Proposal likely to affect current disturbance regimes?

Current disturbance regimes in habitat of *Acacia chrysotricha* mainly comprises weed invasion by *Lantana camara*. The Proposal is likely to contribute to further invasion of *Lantana camara* particularly along the edges of the Proposal where there would be increased sunlight availability. Other indirect impacts such as increased water and nutrients may also aid the growth of *Lantana camara*.

How is the Proposal likely to affect habitat connectivity?

Acacia chrysotricha potentially occurs in gully areas running perpendicular to the Proposal. Therefore suitable areas of habitat would be fragmented from the Proposal. Although no individuals were recorded in the study area, individuals are potentially present in areas beyond the study area, and there are records to the west of the Proposal in Newry State Forest. Pollinator movements may extend across the proposed highway allowing exchange of genetic material between fragmented areas of habitat, assuming flying insects are the main pollinators, however this is largely unknown. Seed dispersal across the proposed development is likely to be impacted to some degree, as terrestrial fauna movement is likely to be impacted, however seed dispersal by flying mammals and birds is unlikely to be significantly impacted.

How is the Proposal likely to affect critical habitat?

No critical habitat has been identified for this species.

Acronychia littoralis - Endangered Species: TSC Act

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

The distribution of *Acronychia littoralis* is found between Fraser Island in Queensland and Port Macquarie on the north coast of NSW. The preferred habitat for this species is littoral rainforest on sand which does not occur in the study area. There is a low possibility this species is present in rainforest and wet sclerophyll forests of the study area however these habitats are marginal. The nearest record to the Proposal area is 4 km east of Warrell Creek.

This species is not particularly difficult to identify in the field, however a similar looking species *Acronychia oblongifolia* was present in the study area in moderate abundance in rainforest and wet sclerophyll forest habitats. These species can readily be distinguished from each other by differences in leaf and fruit morphology and the scent of the leaves when crushed.

Considering the relatively extensive targeted searches undertaken for this species in areas of suitable habitat, it is unlikely it is present in the study area. The Proposal would result in the removal of approximately 34.4 ha of marginal habitat for this species.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal would result in the removal of approximately 34.4 ha of suitable habitat for this species. However habitats in the study area are marginal and are unlikely to support this species.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

The distribution of *Acronychia littoralis* is found between Fraser Island in Queensland and Port Macquarie on the north coast of NSW. Therefore this species would not be at the limit of its distribution in the locality.

How is the Proposal likely to affect current disturbance regimes?

Current disturbance regimes in habitat of *Acronychia littoralis* mainly comprises weed invasion by *Lantana camara*. The Proposal is likely to contribute to further invasion of *Lantana camara* particularly along the edges of the Proposal where there would be increased sunlight availability. Other indirect impacts such as increased water and nutrients may also aid the growth of *Lantana camara*.

How is the Proposal likely to affect habitat connectivity?

Acronychia littoralis potentially occurs in gully areas running perpendicular to the Proposal. Therefore suitable areas of habitat would be fragmented from the Proposal. Although no individuals were recorded in the study area, individuals are potentially present in areas beyond the study area. Pollinator movements may extend across the proposed highway allowing exchange of genetic material between fragmented areas of habitat, assuming flying insects are the main pollinators, however this is largely unknown. Seed dispersal across the proposed development is likely to be impacted to some degree, as terrestrial fauna movement is likely to be impacted, however seed dispersal by flying mammals and birds is unlikely to be significantly impacted.

How is the Proposal likely to affect critical habitat?

No critical habitat has been identified for this species.

B.2.2 *Hicksbeachia pinnatifolia* - Vulnerable Species: TSC Act

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Hicksbeachia pinnatifolia is found in coastal areas of north-east NSW from the Nambucca Valley north to south-east Queensland. Preferred habitat comprises subtropical rainforest, moist eucalypt forest and Brush Box (*Lophostemon confertus*) forest.

Red bopple nut was not recorded in the study area despite targeted searches in areas of suitable habitat. This species is not particularly difficult to identify in the field and is easily distinguished from other rainforest species in the study area. There are no records for this species in the locality, however this species is recorded as occurring from Nambucca Valley to southeast Queensland. Red bopple nut may occur in rainforest and wet sclerophyll forests habitats in the study area, however better quality examples of habitat are restricted to a few small areas of rainforest. The Proposal would result in the removal of approximately 34.4 ha of suitable habitat for this species. Better qualities examples of habitat include rainforest areas of which only 0.58 ha would be removed.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal would result in the removal of approximately 34.4 ha of suitable habitat for this species. Better qualities examples of habitat include rainforest areas of which only 0.58 ha would be removed.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

Hicksbeachia pinnatifolia is found in coastal areas of north-east NSW from the Nambucca Valley north to south-east Queensland. Therefore this species would be at the limit of its distribution in the locality.

How is the Proposal likely to affect current disturbance regimes?

Current disturbance regimes in habitat of *Hicksbeachia pinnatifolia* mainly comprises weed invasion by *Lantana camara*. The Proposal is likely to contribute to further invasion of *Lantana camara* particularly along the edges of the Proposal where there would be increased sunlight availability. Other indirect impacts such as increased water and nutrients may also aid the growth of *Lantana camara*.

How is the Proposal likely to affect habitat connectivity?

Hicksbeachia pinnatifolia potentially occurs in gully areas running perpendicular to the Proposal. Therefore suitable areas of habitat would be fragmented from the Proposal. Although no individuals were recorded in the study area, individuals are potentially present in areas beyond the study area. Pollinator movements may extend across the proposed highway allowing exchange of genetic material between fragmented areas of habitat, assuming flying insects are the main pollinators, however this is largely unknown. Seed dispersal across the proposed development is likely to be impacted to some degree, as terrestrial fauna movement is likely to be impacted, however seed dispersal by flying mammals and birds is unlikely to be significantly impacted.

How is the Proposal likely to affect critical habitat?

No critical habitat has been identified for this species.

B.2.3 *Maundia triglochinoides* - Vulnerable Species: TSC Act

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Restricted to coastal NSW north from Wyong extending into southern Queensland. Grows in swamps, creeks or shallow freshwater 30-60 centimetres deep on heavy clay with low nutrients. Flowering occurs during warmer months and is associated with wetland species such as *Triglochin procerum*.

Maudia triglochinoides was not recorded in the study area despite targeted searches in wetlands, creeks and dams with shallow freshwater 30-60 centimetres deep. The Proposal would result in the removal of only a small area of suitable habitat comprising up to two hectares of dams, creeks and wetland areas. There are several creeks and farms dams which provide suitable habitat for *Maudia triglochinoides*, however many of the wetland habitats in the study area are relatively disturbed and generally provide marginal habitat qualities. There are no records of this species in the locality.

This species is not particularly difficult to identify in the field, however similar looking species including *Triglochin microturberosum* and *T.procera* were present in the study area in areas of shallow water. These species can readily be distinguished from each other by differences in leaf and fruit morphology.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal would result in the removal of only a small area of suitable habitat comprising up to two hectares of dams, creeks and wetland areas.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

Maudia triglochinoides is restricted to coastal NSW north from Wyong extending into southern Queensland. Therefore this species would not be at the limit of its distribution in the locality.

How is the Proposal likely to affect current disturbance regimes?

Current disturbance regimes in habitat of *Maundia triglochinoides* are relatively high within these areas mainly comprising impacts from grazing and agricultural weeds on the edges of dams and wetlands. Much of the wetland areas in the study area have been highly impacted from grazing. The aquatic weed species *Salvinia molesta* was recorded in some wetland areas south of the Nambucca River.

How is the Proposal likely to affect habitat connectivity?

Habitat for *Maundia triglochinoides* is unlikely to be significantly impacted from fragmentation as much of the habitat in the study is currently highly fragmented. However *Maundia triglochinoides* potentially occurs in gully areas running perpendicular to the Proposal in deeper creek lines. Therefore suitable areas of habitat would be fragmented from the Proposal.

Although no individuals were recorded in the study area, individuals are potentially present in areas beyond the study area. Pollinator movements may extend across the proposed highway allowing exchange of genetic material between fragmented areas of habitat, assuming flying insects are the main pollinators, however this is largely unknown. Seed dispersal across the proposed development is likely to be impacted to some degree, as terrestrial fauna movement is likely to be impacted, however seed dispersal by flying mammals and birds is unlikely to be significantly impacted.

How is the Proposal likely to affect critical habitat?

No critical habitat has been identified for this species.

B.2.4 *Parsonsia dorrigoensis* - Vulnerable Species: TSC Act

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Parsonsia dorrigoensis is found only in NSW, with scattered populations in the north coast region between Kendall and Woolgoolga. It occurs in subtropical and warm-temperature rainforest, on rainforest margins, and in moist eucalypt forest up to 800 m, on brown clay soils. The Proposal would result in the removal of approximately 34.4 ha of suitable habitat for this species. Better qualities examples of habitat include rainforest areas of which only 0.58 ha would be removed.

Parsonsia dorrigoensis was not recorded in the study area despite targeted searches in areas of suitable habitat. There are records for this species in the locality. This species is not particularly difficult to identify in the field, however a similar looking species *Parsonsia straminea* is common in the study area in areas of wet sclerophyll and swamp forests. These species can readily be distinguished from each other by differences in leaf morphology and the colour of the exudates (sap).

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal would result in the removal of approximately 34.4 ha of suitable habitat for this species. Better qualities examples of habitat include rainforest areas of which only 0.58 ha would be removed.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

Parsonsia dorrigoensis is found only in NSW, with scattered populations in the north coast region between Kendall and Woolgoolga. Therefore this species would not be at the limit of its distribution in the locality.

How is the Proposal likely to affect current disturbance regimes?

Current disturbance regimes in habitat of *Parsonsia dorrigoensis* mainly comprises weed invasion by *Lantana camara*. The Proposal is likely to contribute to further invasion of *Lantana camara* particularly along the edges of the Proposal where there would be increased sunlight availability. Other indirect impacts such as increased water and nutrients may also aid the growth of *Lantana camara*.

How is the Proposal likely to affect habitat connectivity?

Parsonsia dorrigoensis potentially occurs in gully areas running perpendicular to the Proposal. Therefore suitable areas of habitat would be fragmented from the Proposal. Although no individuals were recorded in the study area, individuals are potentially present in areas beyond the study area, with records present in the locality. Pollinator movements may extend across the proposed highway allowing exchange of genetic material between fragmented areas of habitat, assuming flying insects are the main pollinators, however this is largely unknown. Seed dispersal across the proposed development is likely to be impacted to some degree, as terrestrial fauna movement is likely to be impacted, however seed dispersal by flying mammals and birds is unlikely to be significantly impacted.

How is the Proposal likely to affect critical habitat?

No critical habitat has been identified for this species.

B.2.5 *Peristeranthus hillii* - Vulnerable Species: TSC Act

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Peristeranthus hillii is found in north-eastern NSW, north from Port Macquarie, extending to north-eastern Queensland and restricted to coastal and near-coastal environments, particularly in Littoral Rainforest and also Lowland Rainforest. The species is an epiphyte, growing in clumps on tree trunks and thick vines.

Peristeranthus hillii was not recorded in the study area despite targeted searches in areas of suitable habitat. There are no records for this species in the locality. The preferred habitat for this species is littoral rainforest and lowland of which the latter does not occur in the study area. The Proposal would result in the removal of approximately 34.4 ha of marginal habitat for this species, of which only 0.58 ha comprises better quality rainforest habitats.

There is a low possibility this species is present in rainforest and wet sclerophyll forests of the study area however these habitats are marginal. Other epiphytic orchid species were recorded in the study area including *Cymbidium madidum, C.sauve, Dendrobium kingianum* and *Plectorrhiza tridentata*. However these species can readily be distinguished from each other by differences in leaf and fruit morphology.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal would result in the removal of approximately 34.4 ha of suitable habitat for this species. Better qualities examples of habitat include rainforest areas of which only 0.58 ha would be removed.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

Peristeranthus hillii is found in north-eastern NSW, north from Port Macquarie, extending to north-eastern Queensland. Therefore this species would not be at the limit of its distribution in the locality.

How is the Proposal likely to affect current disturbance regimes?

Current disturbance regimes in habitat of *Peristeranthus hillii* mainly comprises weed invasion by *Lantana camara*. The Proposal is likely to contribute to further invasion of *Lantana camara* particularly along the edges of the Proposal where there would be increased sunlight availability. Other indirect impacts such as increased water and nutrients may also aid the growth of *Lantana camara*.

How is the Proposal likely to affect habitat connectivity?

Peristeranthus hillii potentially occurs in gully areas running perpendicular to the Proposal. Therefore suitable areas of habitat would be fragmented from the Proposal. Although no individuals were recorded in the study area, individuals are potentially present in areas beyond the study area. Pollinator movements may extend across the proposed highway allowing exchange of genetic material between fragmented areas of habitat, assuming flying insects are the main pollinators, however this is largely unknown. Seed dispersal across the proposed development is likely to be impacted to some degree, as terrestrial fauna movement is likely to be impacted, however seed dispersal by flying mammals and birds is unlikely to be significantly impacted.

How is the Proposal likely to affect critical habitat?

No critical habitat has been identified for this species.

B.3 Endangered ecological communities

B.3.1 Swamp Sclerophyll Forest

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Not applicable

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal would impact approximately 12.47 ha comprising 48 per cent high condition, 47 per cent moderate condition, two per cent low-moderate condition and three per cent in a low condition. There is potential for the Proposal to alter habitat attributes of surrounding areas through indirect impacts such as altering hydrological and nutrient regimes in habitats downstream of the proposed development. There would also be indirect impacts to adjacent areas of vegetation from edge effects increasing light availability which may result in altered understorey floristics. These indirect impacts could result in increases in weed abundance, altered soil conditions and sedimentation. Changes to local hydrological regimes may result in water being contained for longer periods of time or lowering the watertable potentially resulting in changes to understorey floristics and die-back in the canopy. Mitigation measures during construction and the implementation of specific design features into the proposed development are likely to minimise these indirect impacts.

Larger patches of this community including areas gazetted as SEPP 14 Wetlands such as Bellwood Swamp, areas of Newry State Forest and several other large patches of Swamp Sclerophyll Forest would not be impacted.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

Not applicable

How is the Proposal likely to affect current disturbance regimes?

Current disturbance regimes in Swamp sclerophyll Forest mainly comprise weed invasion and cattle grazing. Some drier patches of this community support low-moderate abundances of *Lantana camara* and where under-scrubbing has been implemented for grazing purposes some pasture grasses and other weed species are present. Salvinia (*Salvinia molesta*) was recorded in this community in the area between Warrell Creek and the Nambucca River.

The Proposal is likely to contribute to further invasion of *Lantana camara* particularly along the edges of the Proposal where there would be increased sunlight availability. Other indirect impacts such as altered water and nutrient regimes may also aid the growth of *Lantana camara*. The proposed development may result in some adjacent areas of the community being excluded from grazing activities, however it is envisaged that the majority of this community retained adjacent to the Proposal would retain most of the current disturbance regimes.

How is the Proposal likely to affect habitat connectivity?

Habitat connectivity for Swamp Sclerophyll Forest would be impacted in several locations along the Proposal area. Patches of Swamp Sclerophyll Forest would be dissected in the area between Warrell Creek and the Nambucca River including a 25 ha patch and wetland and swamp forest habitats currently fragmented by farming land would be further fragmented from the Proposal. Some smaller patches between Nambucca State Forest and Little Newry State Forest adjacent to the existing highway would be impacted however habitat connectivity would not be significantly impacted considering the degree of existing fragmentation in these areas.

How is the Proposal likely to affect critical habitat?

No critical habitat has been identified for this community.

B.3.2 Swamp Oak Floodplain Forest

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Not applicable

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal would directly remove approximately 33.07 ha comprising 15 per cent high condition, 12 per cent moderate-high condition, 45 per cent moderate condition and 28 per cent low-moderate condition. The Proposal may also potentially lead to biophysical changes to adjacent areas of habitat which would remain surrounding the Proposal. The better quality areas of this community being impacted are in the Raleigh area, however generally only small fragmented patches of the community would be impacted by the Proposal. Larger areas of the community would remain in surrounding areas including patches in the Raleigh area and surrounding Deep Creek.

There is potential for the Proposal to alter habitat attributes of surrounding areas of Swamp Oak Floodplain Forest through indirect impacts such as altering hydrological and nutrient regimes in habitats downstream of the proposed development and edge effects. This could result in increases in weed abundance, altered soil conditions and sedimentation. Altering hydrological regimes may result in changes to understorey floristics and canopy dieback. Mitigation measures during construction and the implementation of specific design features into the proposed development are likely to minimise these indirect impacts.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

Not applicable

How is the Proposal likely to affect current disturbance regimes?

Current disturbance regimes within Swamp Oak Floodplain Forest mainly comprise weed invasion and cattle grazing. Some drier patches of this community support low-moderate abundances of *Lantana camara* and where under-scrubbing has been implemented for grazing purposes some pasture grasses and other weed species are present including Groundsel Bush (*Baccharis halimifolia*). The Proposal is likely to contribute to further invasion of *Lantana* *camara* particularly along the edges of the Proposal where there would be increased sunlight availability. Other indirect impacts such as altered water and nutrient regimes may also aid the growth of *Lantana camara*.

Several areas of the community where agricultural activities including grazing have been previously implemented such as patches on both sides of the highway in the Raleigh area are now regenerating. Regeneration could be facilitated in some of these areas as part of the Proposal, particularly on RTA owned land where the Raleigh interchange is proposed to be situated.

How is the Proposal likely to affect habitat connectivity?

There would be some minor impacts to habitat connectivity for Swamp Oak Floodplain Forest along the Proposal area. Thin strips of the community along the edges of the Nambucca River and Deep Creek which provide some connectivity along the edge of these waterways would be dissected. Small to medium patches in the Raleigh area would be further fragmented however direct impacts are limited to the edges of these patches, and therefore would not significantly impact connectivity. Habitat connectivity would not be significantly impacted considering the degree of existing fragmentation of Swamp Oak Floodplain Forest along the Proposal area.

How is the Proposal likely to affect critical habitat?

No critical habitat has been identified for this community.

B.3.3 Subtropical Coastal Floodplain Forest

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal would directly remove 12.49 ha of Subtropical Coastal Floodplain Forest comprising 39 per cent high condition, 26 per cent moderate-high condition, 18 per cent moderate condition, 15 per cent low-moderate condition and two per cent low condition. There is potential for the Proposal to alter habitat attributes of surrounding areas through indirect impacts such as altering hydrological and nutrient regimes in habitats downstream of the proposed development and edge effects. This could result in increases in weed abundance, altered soil conditions and sedimentation. Changes to local hydrological regimes may result in water being contained for longer periods of time or lowering the watertable potentially resulting in changes to understorey floristics and die-back in the canopy. Mitigation measures during construction and the implementation of specific design features into the proposed development are likely to minimise these indirect impacts.

Medium sized areas of this community would remain surrounding the Proposal in Newry State Forest. Other occurrences of this community in the locality include Urunga Lagoon and some areas of remnant vegetation on the Kalang River and Nambucca River Floodplain.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

Not applicable

How is the Proposal likely to affect current disturbance regimes?

Current disturbance regimes in Subtropical Coastal Floodplain Forest mainly comprise weed invasion and cattle grazing. Some drier patches of this community support low-moderate abundances of *Lantana camara* and where under-scrubbing has been implemented for grazing purposes some pasture grasses and other weed species are present including Broad-leaf Paspalum (*Paspalum wettsteinii*).

The Proposal is likely to contribute to further invasion of *Lantana camara* particularly along the edges of the Proposal where there would be increased sunlight availability. Other indirect impacts such as altered water and nutrient regimes may also aid the growth of *Lantana camara*.

How is the Proposal likely to affect habitat connectivity?

Habitat connectivity for Subtropical Coastal Floodplain Forest would be impacted in several locations along the Proposal area. Thin strips of this community on the edge of the Kalang River and Warrell Creek which provide some level of connectivity along these waterways would be dissected by the Proposal. Larger patches of Subtropical Coastal Floodplain Forest would be dissected in Newry State Forest comprising two areas approximately 23 ha and 13 ha. Some smaller patches in Little Newry State Forest and surrounding Boggy Creek adjacent to the existing highway would be impacted however habitat connectivity would not be significantly impacted considering the degree of existing fragmentation in these areas.

How is the Proposal likely to affect critical habitat?

No critical habitat has been identified for this community.

B.3.4 Lowland Rainforest

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Not applicable

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal would directly remove approximately 0.6 ha comprising 100 per cent high condition. There is potential for the Proposal to lead to biophysical changes to adjacent areas of habitat which would remain surrounding the Proposal. The majority of the community impacted comprises small fragmented patches in the Warrell Creek area. This community is very rare in the study area, generally only occurring as disturbed patches in cleared agricultural landscapes. Areas of this community would remain in surrounding areas including patches on the northern side of the Nambucca River and in the Warrell Creek areas.

Some gully areas in larger patches of remnant vegetation in Nambucca and Newry State Forest, and in the Raleigh area have affinities to this community, occurring as a subcanopy in moist sclerophyll forest types. Although these areas have not been classified under the definition of this EEC they still have significance, providing habitat for flora species which occur in this community.

There is potential for the Proposal to alter habitat attributes of surrounding areas of Lowland Rainforest through indirect impacts such as altering hydrological and nutrient regimes and creating edge effects in habitats downstream of the proposed development. This could result in increases in weed abundance, altered soil conditions and sedimentation. Mitigation measures during construction and the implementation of specific design features into the proposed development are likely to minimise these indirect impacts.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

Not Applicable

How is the Proposal likely to affect current disturbance regimes?

Current disturbance regimes in Lowland Rainforest mainly comprise weed invasion and cattle grazing. Weed species occur in moderate-high abundance in disturbed patches of the community including Camphor Laurel (*Cinnamonum camphora*) and *Lantana camara*. The Proposal is likely to contribute to further invasion of *Lantana camara* particularly in gully areas along the edges of the Proposal where there would be increased sunlight availability. Other indirect impacts such as altered water and nutrient regimes may also aid the growth of *Lantana camara*. Mitigation measures during construction and the implementation of specific design features into the proposed development are likely to minimise these indirect impacts.

How is the Proposal likely to affect habitat connectivity?

There would be some minor impacts to habitat connectivity for Lowland Rainforest along the Proposal area. Thin strips of the community along the edges of Upper Warrell Creek which provide some connectivity would be impacted. Small isolated patches in largely cleared agricultural areas in the Warrell Creek area would be further fragmented. Habitat connectivity would not be significantly impacted considering the degree of existing fragmentation of Lowland Rainforest along the Proposal area.

How is the Proposal likely to affect critical habitat?

No critical habitat has been identified for this community.

B.3.5 Freshwater Wetlands

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Not Applicable

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal would directly impact approximately 1.58 ha of Freshwater Wetlands comprising 13 per cent high condition, 11 per cent moderate condition, 20 per cent low-moderate condition and 56% low condition in grazed agricultural areas. Generally only small disturbed areas of the community occurring in cleared paddock areas and power easements would be impacted by the Proposal. Several pond areas in agricultural lands would also be impacted. Larger areas of the community with a higher ecological condition would remain in surrounding areas including near Deep Creek and between Warrell Creek and the Nambucca River.

There is potential for the Proposal to alter habitat attributes of surrounding areas of Freshwater Wetlands through indirect impacts such as altering hydrological and nutrient regimes in habitats downstream of the proposed development, potentially resulting in increases in nutrient levels and sedimentation. Mitigation measures during construction and the implementation of specific design features into the proposed development are likely to minimise these indirect impacts.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

Not Applicable

How is the Proposal likely to affect current disturbance regimes?

Current disturbance regimes in Freshwater Wetlands mainly comprise weed invasion, cattle grazing and high nutrient levels. Areas of this community in paddock areas support a mix of native wetland flora and various pasture weeds on the edges of these areas. Salvinia (*Salvinia molesta*) was recorded in one area of this community between Warrell Creek and the Nambucca River. There is potential for indirect impacts such as higher nutrient and sedimentation levels to contribute to a higher abundance of water weeds. Grazing activities would continue following the Proposal in areas of Freshwater Wetlands in paddock areas.

How is the Proposal likely to affect habitat connectivity?

There would be some minor impacts to habitat connectivity for Freshwater Wetlands along the Proposal area. Thin strips of the community in agricultural areas on the southern side of the Nambucca River would be impacted on the edges. Small to medium patches in the power easement in the Raleigh area would also be further fragmented. Habitat connectivity would not be significantly impacted considering the degree of existing fragmentation of Freshwater Wetlands along the Proposal area, and impacts are generally confined to edges of these areas.

How is the Proposal likely to affect critical habitat?

No critical habitat has been identified for this community.

B.4 Threatened fauna

B.4.1 Black-necked stork

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

The evidence gathered from background review and field surveys suggest that black-necked stork is rare and restricted in distribution in the immediate study area. The scattering of records are centred around a large freshwater wetland on the Kalang River floodplain located between the northern arm of the river and South Arm Road (Figure 4-12). Residences on the Kalang River floodplain (north and south) report that storks are occasionally observed in grazed paddocks and swamp vegetation particularly on the northern side of the river near this location suggesting that these modified habitats are also providing important foraging habitat for local black-necked stork s. Movements are likely to occur between the permanent swamp and ephemeral paddock soaks during high rainfall periods.

Important life-cycle components for the species would constitute breeding, feeding, sheltering and refuge and movements. No nest sites have been identified in the study area, nor would be impacted by the Proposal. There is data available on nesting in the study area however it is assumed that at least one nest site may occur in the lower Kalang River floodplain in the vicinity of South Arm Road to Newry Island. There are numerous opportunities for nesting adjacent to the identified wetland which would remain outside of the Proposal footprint. There are no other large freshwater wetland habitats in the study area and therefore potential habitat comprises modified grazing land especially periodically inundated floodplain areas. Such habitats are widespread and well represented. The Proposal would not impact directly on the identified wetland habitat north of the Kalang River currently providing shelter and refuge and feeding habitat. However the road would traverse cleared grazing land on the floodplain where storks have occasionally been observed foraging. Measures to manage potential indirect impacts via nutrient run-off into known black-necked stork habitat have been addressed in the report and form a component of the Flora and Fauna Management Plan (FFMP) as a component of the Construction Environmental Management Plan (CEMP).

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The black-necked stork typically occupies shallow freshwater wetlands on floodplains which may include natural and modified wetlands and adjacent floodplain swamps and forests. Threats to wetland habitats include:

- Changes in natural flow regimes.
- Degradation through pollution and salinisation.
- Loss of habitat through clearing and draining.

The identified habitat for black-necked stork in the study area is as described above, being limited to a single wetland on the Kalang River floodplain in addition to surrounding modified farmland habitats used for foraging. The latter are very common and widespread. Other potential habitats include Gumma Swamp, south of Warrell Creek and to the east of the alignment. The Proposal would not directly impact on wetland habitat suitable for this species.

There is potential for changes in natural flow regimes and increased nutrient inputs into these habitats via the addition of new infrastructure in the catchment. These issues have been addressed adequately through the provision of numerous drainage structures (culverts and sediment ponds) located along the length of the alignment. Potential impacts from runoff during construction are to be managed through the development of a CEMP and FFMP.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

The species is widespread across coastal northern and eastern Australia, becoming increasingly uncommon further south into NSW, and rarely south of Sydney. The study area does not represent the species limit of distribution.

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

The Proposal would increase the fragmentation of habitat in the landscape by impacting on several contiguous forest areas, particularly the larger fragments associated with Nambucca and Newry State Forest in section 2 of the study area and private forested land to the north of the Kalang River in section 4. The impacts of fragmentation on flora and fauna and threatened species identified in this study area are difficult to determine without more extensive population viability assessments. It is important to note however that all areas of habitat affected by the Proposal have already been fragmented in the past by roads, clearing for agriculture and power easements. The Proposal would be contributing to this cumulative fragmentation of habitat in the landscape, however the impact on black-necked stork is not expected to significant. The potential habitat of the species is outside of the road corridor (in terms of wetlands) and widespread (in terms of agricultural land). Further, the species is not dependent on continuous habitat and capable of moving long distances to access habitat resources.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.2 Swift parrot and regent honeyeater

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

The distribution of records for both species in the mid north coast of NSW has been consistently associated with lowland coastal forests dominated by swamp mahogany (*Eucalyptus robusta*) or drier forests and woodlands comprising a high density of Spotted Gum (*Corymbia maculata*) (Menkhorst 1999). The latter species is not present in the study area. The association with this habitat type is a result of the presence of winter flowering eucalypts and the reliance by these nomadic species on the seasonally available winter food resources (nectar).

The study area would constitute non-breeding habitat for a proportion of the population of both species. The Macksville to Urunga study area is not considered a critical area for the regent honeyeater (D.Geering, NPWS, *pers.comm*) or swift parrot (D.Saunders, *pers comm*). The swamp forest communities that are present do contribute to the overall availability of habitat for these species in coastal NSW however, and may be particularly important as refuge sites during drought when trees from other districts such as the inland Box Ironbark woodlands of NSW and Victoria may be experiencing poor flowering conditions. Indeed records from the study area are relatively continuous extending over a 30 year period (1977-2007), indicating that the region from Macksville to Coffs Harbour may constitute seasonally important foraging and refuge habitat for these species. The current potential for these species to occur based on the presence of potential foraging habitat is expected to remain after completion of the Proposal such that foraging and movement life-cycle activities would not be impacted.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

Swamp sclerophyll forest is listed as an endangered ecological community (TSC Act), with some areas also listed under SEPP 14 as protected coastal wetlands, examples of such areas occur in Nambucca State Forest. All areas of EEC and SEPP 14 wetland were identified in the original route options investigation (SKM 2005) and the selection of the preferred route was chosen to minimise impacts on these significant ecological areas. In achieving this, the impacts on fauna species dependent on the swamp forest communities, such as the regent honeyeater and swift parrot, have also been considered.

From the mapping of potential habitat for these species in proximity to the Proposal it is evident that there are three categories of habitat characterised by high, medium and low quality areas (refer SKM 2005b). An overlay of the preferred highway route was used to calculate the loss of potential habitat for these species from the study area. The Proposal would potentially involve removal of up to 5.94 ha of high quality habitat, 5.86 ha of medium and 0.67 ha of low-moderate quality habitat from the study area. This loss is considered low and of little significance to populations of the swift parrot and regent honeyeater. Large areas of high quality habitat are represented outside the road footprint in Nambucca and Newry State Forest to the east of the Proposal, and in private land to the south of Raleigh also to the east of the Proposal. Continued visitation to the region is expected following construction of the Proposal.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

The swift parrot extends from its summer breeding grounds in Tasmania, from where it disperses to over-winter in southeast mainland Australia. Some individuals range north to Queensland, but the majority over-winter in Victoria and central and eastern NSW (Saunders and Heinsohn 2008). The species returns to Tasmania in September. The study area constitutes a small percentage of the known distribution of the species and does not represent its geographical limit.

The regent honeyeater was formerly distributed in about 300 km of the eastern Australian coast from approximately 100 km north of Brisbane to Adelaide (Franklin *et al.* 1989); however, it is no longer found in South Australia (Franklin and Menkhorst 1988) or western Victoria (Franklin *et al.* 1987) and records from Queensland are uncommon. Sightings now centre on a few sites in north-eastern Victoria, along the western slopes of the Great Dividing Range to Tenterfield, the Warrumbungle Ranges and Parkes in the west, and the central coast of NSW. The total population is estimated at close to 1500 individuals (Webster and Menkhorst 1992).

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, examples include the loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient and sediment loads into aquatic habitats, and the presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes via additional vegetation clearing and altering of hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusion of these measures suggests minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

The Proposal would increase the fragmentation of habitat in the landscape by impacting on several contiguous forest areas, particularly the larger fragments associated with Nambucca and Newry State Forest in section 2 of the study area and private forested land to the north of the Kalang River in section 4. It is important to note however that all areas of habitat affected by the Proposal have already been fragmented in the past by roads, clearing for agriculture and power easements. The Proposal would be contributing to this cumulative fragmentation of habitat in the landscape. As stated the impacts of fragmentation may be most evident in Nambucca, Newry and Little Newry State Forest. The dominant habitat types in these locations comprise dry sclerophyll forest of blackbutt and tallowwood and are not suited to the swift parrot or regent honeyeater due to the minimal presence of winter flowering eucalypts. Suitable habitats are represented in swamp sclerophyll communities on floodplains which exist as smaller fragments and less impacted by fragmentation associated with the Proposal.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.3 Grey-headed flying-fox

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

The grey-headed flying-fox was recorded at four locations along the proposed route from widely dispersed locations and no specific habitat type. There were no camps or roost sites identified in the survey area. The grey-headed flying-fox inhabits a wide range of habitats including rainforest, mangroves, paperbark forests, wet and dry sclerophyll forests and cultivated areas. Camps are often located in gullies, typically close to water, in vegetation with a dense canopy. Known roost sites for this species in the regional area are located at Bowraville and Yarrhapinni and an unconfirmed site at Urunga. None of these are located in proximity to the Proposal.

The Grey-headed flying-fox feeds on nectar and pollen of native trees, in particular Eucalyptus Melaleuca, Banksia and Ficus and fruits of rainforest trees and vines. The combined area of Nambucca State Forest (1697 ha), Little Newry (194 ha) and Newry State Forest (3921 ha) through which the Proposal passes is 5812 ha. This represents extensive areas of potential foraging habitat for the species in the State forests. The clearing of approximately 253 ha of potential foraging habitat for this species is required (based on proposed footprint). This represents a relatively minor impact for this species in the local area. In relation to the available habitat in adjacent land surrounding areas, the Proposal is not considered likely to affect this species at the local level. The proposed action would not result in the decrease in size of the population in the local area and would not impact on a known roost site.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

As stated, the clearing of approximately 253 ha of potential foraging habitat for this species represents a relatively minor impact for this species in the local area. In relation to the available habitat in adjacent land surrounding the highway, the Proposal is not considered likely to affect this species at the local level. The proposed action would not result in the decrease in size of the population in the local area and would not impact on a known roost site.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

The grey-headed flying-fox has a large distribution in a range of 200 km from the eastern coast of Australia, from Bundaberg in Queensland to Melbourne in Victoria. The species is not at the limit of its distribution in the study area.

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

The Proposal would increase the fragmentation of habitat in the landscape by impacting on several contiguous forest areas, particularly the larger fragments associated with Nambucca and Newry State Forest in section 2 of the study area and private forested land to the north of the Kalang River in section 4. It is important to note however that all areas of habitat affected by the Proposal have already been fragmented in the past by roads, clearing and power easements. The Proposal would be contributing to this cumulative fragmentation of habitat in the landscape.

Highly mobile species such as bats and birds are expected to be less impacted by fragmentation and the grey-headed flying-fox is particularly well adapted to accessing widely spaced habitat resources given its mobility and preference for seasonal fruits and blossom.

A strategic approach to mitigating the effects of fragmentation from the Proposal should be developed by focusing on re-establishing links with historically isolated fragments of habitat in proximity to the new road. These opportunities should be investigated along with increasing the size of smaller remnant fragments adjoining the road. The greatest potential for this exists in low-lying agricultural areas adjoining the corridor.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.4 Yellow-bellied glider

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

A group of three to four individuals was recorded in Nambucca State Forest at Sites D2 and D3 between Bellwood Road and Allans Road. A number of potential den trees were also identified in this area. The historical presence of this species has been noted throughout Nambucca State Forest and Newry State Forest, with formal records maintained by State Forests dating back to 1999. Based on these records the distribution of the species is widespread across Nambucca State Forest and surrounding localities, occurring both east and west of the proposed highway. These observations suggest the Proposal would impact on the territory of a least one family group of gliders occurring in the vicinity of Old Coast Road and Bellwood Road. This family group would constitute a portion of a larger population extending to the east and west possibly also east of the existing Pacific Highway around Valla and Valla Nature Reserve. Other populations have been recorded in Way Way State Forest.

The species is threatened by the loss of suitable food trees and nesting hollows, as well as intense fires which alter the dynamics of natural forests (Klippel 1992). The clearing of habitat and forest harvesting methods leading to even-aged stands pose a threat as even-aged stands leads to a decrease in hollow bearing trees necessary as dens.

The home range for the species has been estimated at 60 ha (Goldingay and Kavanagh 1991). *P.australis* tends to show a pattern of seasonal use of its home range due to a dependence on certain food types that are only available from particular forest types at particular times of the year (Kavanagh 1984; Goldingay 1992). The home ranges also appear to function as territories, with vocalisations serving to advertise and maintain their integrity (Goldingay 1992).

The foraging behaviour of the species is diverse and responsive to changes in tree phenology such as periods of flowering and bark shedding (Kavanagh 1984). Smooth barked eucalypts are considered to be important to the species due to the diversity of foraging substrates they provide (Forestry Commission of NSW 1993).

The species is mainly nocturnal, sheltering in nests in tree hollows lined with leaves during the day (Gilmore and Parnaby 1994). The species requires relatively large tree hollows because family groups share den sites (Gibbons & Lindenmayer 1997). Dominant males may live with up to five females and their young.

There is a lack of data on the dynamics of the local population (i.e. size, number of family groups and home range territories) to make informed decisions about impacts on life-cycle activities. However based on a precautionary principle it is assumed that the road would further fragment known habitat and remove some habitat trees. The issue of movement and dispersal has been addressed by the proposed widening of the median through the northern end of Nambucca State Forest and also Newry State Forest which was specifically located at strategic glider locations. Where possible the design footprint was refined to avoid identified habitat trees. These issues have addressed movements and denning opportunities for the species. Food resources are widespread and abundant and the extent of clearing required in Nambucca State Forest is not expected to significantly to significantly reduce following the construction of the Proposal.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal is likely to remove a portion of the home range territory of at least one family group of gliders including possible denning trees. There is no specific data on the home range of this group or known den trees, so the extent of this impact is not known, although data on the species suggest home ranges can extend as large as 60 ha (Goldingay and Kavanagh 1991). This group is part of a larger population which extends into the surrounding state forests and possibly private lands to the south and east. Individuals have also been recorded in Newry State Forest in contiguous habitats to the north. Additionally the subject area is part of a larger east west corridor suggesting other populations are likely to occur to the west of the study area. Other populations have been identified in Way Way State Forest and Yarrahappini National Park to the south and east.

The long-term persistence of yellow-bellied gliders requires a landscape mosaic of old growth trees which meets both their foraging and sheltering needs. Such habitat is present throughout the remaining portions of Nambucca State Forest to the east and west of the route.

Yellow-bellied gliders need to occupy large home ranges as there food resources are seasonal and often widely dispersed. Therefore most of the habitats in the study area are likely to provide foraging habitat for yellow-bellied gliders apart from wetland and mangrove communities. Therefore the Proposal would remove up to 253 ha of habitat for this species, however yellow-bellied gliders would be unlikely to occupy isolated fragments which are included in this figure.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

The yellow-bellied glider is found along the eastern seaboard to the western slopes of the Great Divide, from southern Queensland to Victoria (NPWS 2002) and is not at the limit of its distribution in the study area.

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

The Proposal would increase the fragmentation of habitat in the landscape by impacting on several contiguous forest areas, particularly the larger fragments associated with Nambucca and Newry State Forest in section 2 of the study area and private forested land to the north of the Kalang River in section 4. In Nambucca State Forest an area of up to 1000 ha would be separated to the east of the new road. This habitat was identified as being occupied by a population of yellow-bellied gliders. While the proportion of habitat remaining to the east of the road (c.1000 ha) is considered sufficiently large to support populations of this species, further measures are required to minimise the impacts of fragmentation. Such measures have been considered in the design of the road by incorporating a wider median through the northern end of Nambucca State Forest and placing fauna underpass structures in strategic locations. The widened median is predicted to be accessible by yellow-bellied gliders given the narrow carriageway to be traversed on either side (approximately 40 m). The impacts of fragmentation on yellow-bellied glider are difficult to determine without more extensive population viability assessment, however provided the widened vegetated medians are utilised by yellow-bellied gliders impacts to this species from fragmentation would be minimised.

The impact of fragmentation in Newry State Forest is difficult to assess as this area is already fragmented from coastal habitats to the east in Valla Nature Reserve as a result of the existing Pacific Highway and existing wide electricity transmission easements. Further widening of the median and fauna underpass structures are also proposed through portions of Newry State Forest to maintain opportunities for fauna crossing.

The widening of the median is particularly aimed at providing movement opportunities for gliders (i.e. yellow-bellied glider, squirrel glider, sugar glider, greater glider, and feathertail glider) by reducing the barrier effect of two carriageways side by side. Natural vegetation and tree cover would be retained within the median in key corridor locations as identified in section 6 of this report.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.5 Koala

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Evidence of koala was recorded in this study in Nambucca State Forest on the western side of the rail line several hundred metres west of the proposed route. State Forests (DII) have reported numerous records of koalas in the western parts of Newry State Forest, also to the west of the study area. There are a scattering of records along the coast around Valla. These data suggest the presence of a local population of koalas, centred around Newry State Forest with possible sub-populations along the coast north of Nambucca Heads.

Important life-cycle activities for koalas include foraging, shelter and refuge, movements and breeding. The koala feeds predominantly on the foliage of certain species of eucalypts. Likely food trees in the region include primary browse trees such as forest red gum, swamp mahogany, grey gum, tallowwood and Sydney blue gum. Occasional browse trees such as blackbutt, broad-leaved paperbark, and red mahogany are also common in the region. There are marked changes in diet throughout the year and at different sites (Martin & Lee 1984; Reed *et al.* 1990).

Breeding is seasonal with mating taking place during October to February and most births occurring between November and late March. Females become sexually mature at two to three years and males at around three to four years. The species appears to be polygamous with the ranges of dominant males overlapping the range of several females (Lee & Martin 1988; Mitchell 1990).

The Proposal would remove potential habitat for the species through the clearing of vegetation communities containing identified food tree species. The impact of this activity on the local population is likely to be minimal as suitable food resources are common and widespread in the region particularly to the northwest of the route and there is little evidence to suggest that koala populations or movements are centred on the proposed route. The potential for east-west movements from the coast at Valla to the west via Newry State Forest have been considered in the design and location of fauna underpass structures combined with widening of the median and fauna exclusion fencing to facilitate movements and minimise vehicle strike mortalities.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

In coastal northern NSW, populations have been estimated to range from one animal every 45 hectares to one every 4.5 ha (average one every 20-25 ha) (Austeco 1994). Most young disperse at two to three years of age and females remain in their natal area (Martin 1983). There are no data available on the size of local populations or the extent of potential habitat. The Proposal would remove potential habitat for the species through the clearing of vegetation communities containing the identified food tree species. The impact of this activity on the local population is likely to be minimal as suitable food resources are common and widespread in the region particularly to the northwest of the route and there is little evidence to suggest that koala populations or movements are centred on the proposed route.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

The koala occurs throughout eastern Australia through Queensland, NSW and Victoria and the study area is not the limit of distribution for this species.

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

The Proposal would increase the fragmentation of habitat in the landscape by impacting on several contiguous forest areas, particularly the larger fragments associated with Nambucca and Newry State Forest in section 2 of the study area and private forested land to the north of the Kalang River in section 4. These habitats accommodate the majority of potential habitat for koala and recorded observations in the study area. It is important to note however that all areas of habitat affected by the Proposal have already been fragmented in the past by roads, clearing for agriculture and power easements. The Proposal would be contributing to this cumulative fragmentation of habitat in the landscape.

Appropriate measures have been incorporated into the design of the road to minimise the impacts of fragmentation on this species by incorporating a wider median through the northern end of Nambucca State Forest and placing fauna underpass structures in strategic locations. Further widening of the median and fauna underpass structures are also proposed through portions of Newry State Forest to maintain opportunities for fauna crossing.

A strategic approach to mitigating the effects of fragmentation from the Proposal should be developed by focusing on re-establishing links with historically isolated fragments of habitat in proximity to the new road. These opportunities should be investigated along with increasing the size of smaller remnant fragments adjoining the road. The greatest potential for this exists in low-lying agricultural areas adjoining the corridor.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.6 Spotted-tailed quoll

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Preferred habitat includes dry and moist sclerophyll forests where they den in rock caves, hollow logs or trees and would feed in nearby cleared areas (State Forests of NSW 1995a). Suitable habitat is well represented in the larger fragments of forest in the study area, particularly state forests and adjoining private properties. The species was not recorded during this study however is expected to occur. The species is an opportunistic predator and would feed on a variety of prey including macropods, birds, reptiles, arboreal mammals and small terrestrial mammals (Mansergh 1983). The Proposal would remove potential habitat for the species and its prey, leading to further fragmentation of habitat, a known threat to the species. Measures to conserve fauna corridors and movement avenues for terrestrial fauna have been incorporated into the Proposal. Breeding, foraging and movement life-cycle opportunities would remain in the region and likely to sustain local populations.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

Preferred habitat includes dry and moist sclerophyll forests where they den in rock caves, hollow logs or trees and would feed in nearby cleared areas (State Forests of NSW 1995a). Suitable habitat is well represented in the larger fragments of forest in the study area, particularly state forests and adjoining private properties. The Proposal would remove potential habitat for the species and its prey, leading to further fragmentation of habitat, a known threat to the species. The Proposal would result in the removal of up to 255 ha for this species. The overall reduction of habitat is a small proportion of the available potential habitat.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

The spotted-tailed quoll occurs throughout eastern Australia through Queensland, NSW, Victoria and Tasmania and the study area is not the limit of distribution for this species.

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

The Proposal would increase the fragmentation of habitat in the landscape by impacting on several contiguous forest areas, particularly the larger fragments associated with Nambucca and Newry State Forest in section 2 of the study area and private forested land to the north of the Kalang River in section 4. These areas provide potential habitat for spotted-tailed quoll largely because of their size and continuity with forests to the west. It is important to note however that all areas of habitat affected by the Proposal have already been fragmented in the past by roads, clearing and power easements. The Proposal would be contributing to this cumulative fragmentation of habitat in the landscape.

The impacts of fragmentation may be most evident in Nambucca State Forest in section 2, where an area of up to 1000 ha of forested lands would be separated to the east of the road.

Measures have been planned to minimise the impacts of fragmentation and have been considered in the design of the road by incorporating a wider median through the northern end of Nambucca State Forest and placing fauna underpass structures in strategic locations.

The impact of fragmentation in Newry State Forest is difficult to assess as this area is already fragmented from coastal habitats to the east in Valla Nature Reserve as a result of the existing Pacific Highway and existing wide electricity transmission easements. Further widening of the median and fauna underpass structures are also proposed through portions of Newry State Forest to maintain opportunities for fauna crossing.

A strategic approach to mitigating the effects of fragmentation from the Proposal should be developed by focusing on re-establishing links with historically isolated fragments of habitat in proximity to the new road. These opportunities should be investigated along with increasing the size of smaller remnant fragments adjoining the road. The greatest potential for this exists in low-lying agricultural areas adjoining the corridor.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.7 Brush-tailed phascogale

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

The brush-tailed phascogale is largely arboreal, occupying a variety of habitats, particularly open dry sclerophyll forest with little groundcover (Cuttle 1982). The home range of the species is exclusive and densities are correspondingly low. Female brush-tailed phascogales occupy a home range of 37 hectares, and males occupy 86 hectares with their home ranges overlapping the female home range (Traill and Coates 1993; Soderquist and Ealey 1994). Evidence of local populations in the study area has not been identified, however suitable habitat is widespread and common and populations are considered to persist following development of the Proposal.

The diet of this species consists mainly of arthropods, such as spiders and centipedes, as well as small invertebrates including cockroaches, beetles and bull ants (Cuttle 1982). Phascogales would also forage on the ground and eucalypt nectar is extensively utilised when trees are flowering (Traill and Coates 1993). The diet is not particularly specialised to a degree that clearing for the Proposal would significantly affect foraging requirements.

The brush-tailed phascogale has a three week mating season which occurs mid May to early July. Following mating, the pair nests in tree hollows with narrow entrances. After forming the nest, the male would soon die through what is believed to be stress related illness induced by excessive copulative behaviour (Traill and Coates 1993). The Proposal would remove hollow-bearing trees suitable as nesting sites for the species and lead to further fragmentation and reduction of mature forest from the region. Suitable habitat is widespread and common providing continued habitat for local populations.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The brush-tailed phascogale is largely arboreal, occupying a variety of habitats, particularly open dry sclerophyll forest with little groundcover (Cuttle 1982). Such habitats are particularly well represented in the region, particularly on ridges and low hills where clearing has been less severe than river flats. The Proposal would result in the removal of up to 253 ha for this species. The overall reduction of habitat is a small proportion of the available potential habitat. Populations are considered to persist following development of the Proposal.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

The brush-tailed phascogale occurs throughout eastern Australia to the western slopes of the Great Divide from southern Queensland, NSW and Victoria (NPWS 2002) and the study area is not the limit of distribution for this species.

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

The Proposal would increase the fragmentation of habitat in the landscape by impacting on several contiguous forest areas, particularly the larger fragments associated with Nambucca and Newry State Forest in section 2 of the study area and private forested land to the north of the Kalang River in section 4. These areas provide potential habitat for populations of brush-tailed phascogale. It is important to note however that all areas of habitat affected by the Proposal have already been fragmented in the past by roads, clearing for agriculture and power easements. The Proposal would be contributing to this cumulative fragmentation of habitat in the landscape.

The impacts of fragmentation may be most evident in Nambucca State Forest in section 2, where an area of up to 1000 ha of forested lands would be separated to the east of the road. Measures have been planned to minimise the impacts of fragmentation and have been considered in the design of the road by incorporating a wider median through the northern end of Nambucca State Forest and placing fauna underpass structures in strategic locations.

The impact of fragmentation in Newry State Forest is difficult to assess as this area is already fragmented from coastal habitats to the east in Valla Nature Reserve as a result of the existing Pacific Highway and existing wide electricity transmission easements. Further widening of the median and fauna underpass structures are also proposed through portions of Newry State Forest to maintain opportunities for fauna crossing.

A strategic approach to mitigating the effects of fragmentation from the Proposal should be developed by focusing on re-establishing links with historically isolated fragments of habitat in proximity to the new road. These opportunities should be investigated along with increasing the size of smaller remnant fragments adjoining the road. The greatest potential for this exists in low-lying agricultural areas adjoining the corridor.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.8 Glossy black-cockatoo

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

The glossy black-cockatoo inhabits mountain forests, coastal woodlands, open forest, riparian vegetation and partially cleared areas from sea level to 1000 metres. This species distribution is linked to its reliance on their primary food source, the seeds of *Allocasuarina torulosa, A. verticillata* and *A. littoralis*.

Groups of this species (two to twenty individuals) are known to occupy an area permanently, though individuals and sub groups may move around in this area (Blakers *et al* 1984). It is generally unknown what size this area must be, but it is closely linked to the density of *Allocasuarina* species.

A hollow limb or hole, often is a tall dead tree in a forest clearing, is typically used for roosting (Forshaw and Cooper 1978). Blackbutt (*Eucalyptus pilularis*) is known to be used for nesting (Mount King Ecological Surveys 1993) and this species is very common in the study area. This species requires large cavities for nesting and breeding which occurs from March to August (Mount King Ecological Surveys 1993) however, the main breeding season is from April to June (Simpson and Day 1997).

A population was identified in the northern half of the study area, north from Nambucca State Forest to Raleigh, comprising of several groups occupying parts of Nambucca, Newry and Little Newry state Forest as well as dry sclerophyll forest habitats on privately owned lands north of the Kalang River and east of the existing Pacific Highway near Valla. This distribution was determined through observation of birds and feeding signs and collation of database records**.** Food resources in the study area include *Allocasuarina torulosa* and *Allocasuarina littoralis* which are a very common component of the extensive blackbutt open forest community (MU1) throughout the study area. No nest sites were located in the study area, however several potential sites (large tree hollows) were identified in proximity to the route.

The abundance of food resources and distributional range of the local population together with the high mobility of the species suggests there are several localised family groups in the study area and that these are adapted to moving across modified landscapes to access food resources. The Proposal is unlikely to significantly impact on this situation, despite the loss of food resources. There is potential to remove large hollow-bearing trees which may currently or potentially provide nest sites. These are an uncommon feature in the landscape as a result of the historical land uses. Where feasible these have been identified near the route and refinement of the design carried out to minimise their removal. Further surveys of habitat trees have been recommended as a component of the CEMP (and FFMP) which would be particularly important if construction commences between April and June.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

This species distribution in the study area is linked to the distribution of their primary food source, the seeds of *Allocasuarina torulosa* and *A. littoralis* which are a common component of the extensive blackbutt open forest community (MU1) (refer Figure 3-7 to Figure 3-10). MU1 is very common throughout Nambucca, Newry and Little Newry state Forest as well as dry sclerophyll forest habitats on privately owned lands north of the Kalang River and east of the existing Pacific Highway near Valla. The Proposal would clear up to 129 ha of blackbutt open forest a portion of which would provide potential habitat for this species. Nesting resources comprising larger tree hollows are also most abundant in this community.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

The species occurs throughout coastal eastern Australia through Queensland to the Victoria border.

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

The Proposal would increase the fragmentation of habitat in the landscape by impacting on several contiguous forest areas, particularly the larger fragments associated with Nambucca and Newry State Forest in section 2 of the study area and private forested land to the north of the Kalang River in section 4. It is important to note however that all areas of habitat affected by the Proposal have already been fragmented in the past by roads, clearing and power easements. The Proposal would be contributing to this cumulative fragmentation of habitat in the landscape.

Highly mobile species such as bats and birds are expected to be less impacted by fragmentation and the glossy black-cockatoo population in the study area appears to be well adapted to accessing widely spaced habitat resources given its mobility and specific diet.

A strategic approach to mitigating the effects of fragmentation from the Proposal should be developed by focusing on re-establishing links with historically isolated fragments of habitat in proximity to the new road. These opportunities should be investigated along with increasing the size of smaller remnant fragments adjoining the road. The greatest potential for this exists in low-lying agricultural areas adjoining the corridor.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.9 Large Forest Owls (powerful owl, masked owl and sooty owl)

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

All three species are known to occupy very large territories particularly in fragmented areas, which is a reflection of their high mobility and diversity of prey species taken. Whilst the three species are known to occasionally roost by day in dense thickets of vegetation or foliage their nesting requirements are more specialised being totally dependent on suitably large tree-hollows generally found in the trunks of tall and mature trees.

Their dependence on this specific habitat feature restricts the local distribution of the species at least for breeding life-cycle requirements and highlights their vulnerability to increased clearing and fragmentation. Generally foraging territory is more widespread and may occur throughout a variety of habitat types depending on the species, with the powerful owl ranging from swamp forest to wet and dry sclerophyll, preferably in wet gullies for roosting and the barking owl and masked owl favouring the more open forest and woodland types for foraging, particularly on the edge of open lands such as agricultural lands.

Targeted searches were carried out at all times during the field surveys for the presence of suitable tree-hollows (potential nest sites) for these birds. These are considered very scarce along the route corridor and nesting opportunities are considered very limited. As the incidence of potential roost / nest hollows in the study area is minimal it is considered unlikely that the Proposal would constitute a significant impact on local populations of these species. The removal of 253 ha of forest habitat would impact on the habitat of prey species for these owls and increase fragmentation which may have an impact on juvenile dispersal.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

As the incidence of potential roost / nest hollows in the study area is very minimal it is considered unlikely that the Proposal would constitute a significant impact on local populations of these species. There is potential to impact on an unidentified nest tree of one of these species and further survey of habitat trees is required prior to construction. The removal of 253 ha of forest habitat would impact on the habitat of prey species for these owls and increase fragmentation which may have an impact on juvenile dispersal and establishment of new pairs.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

All three species occurs throughout eastern Australia through Queensland, NSW and Victoria and the study area is not the limit of distribution for these species.

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

The Proposal would increase the fragmentation of habitat in the landscape by impacting on several contiguous forest areas, particularly the larger fragments associated with Nambucca and Newry State Forest in section 2 of the study area and private forested land to the north of the Kalang River in section 4. These areas provide potential habitat for large forest owls largely because of their size and continuity with forests to the west. It is important to note however that all areas of habitat affected by the Proposal have already been fragmented in the past by roads, clearing and power easements. The Proposal would be contributing to this cumulative fragmentation of habitat in the landscape.

The impacts of fragmentation may be most evident in Nambucca State Forest in section 2, where an area of up to 1000 ha of forested lands would be separated to the east of the road. Measures have been planned to minimise the impacts of fragmentation and have been considered in the design of the road by incorporating a wider median through the northern end of Nambucca State Forest and placing fauna underpass structures in strategic locations.

The impact of fragmentation in Newry State Forest is difficult to assess as this area is already fragmented from coastal habitats to the east in Valla Nature Reserve as a result of the existing Pacific Highway and existing wide electricity transmission easements.

A strategic approach to mitigating the effects of fragmentation from the Proposal should be developed by focusing on re-establishing links with historically isolated fragments of habitat in proximity to the new road. These opportunities should be investigated along with increasing the size of smaller remnant fragments adjoining the road. The greatest potential for this exists in low-lying agricultural areas adjoining the corridor.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.10 Frugivorous Birds (Wompoo Fruit-Dove, Superb Fruit-Dove and Rose-crowned Fruit-Dove)

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

The wompoo fruit-dove was recorded in the 2005 surveys in the upper reaches of Boggy Creek several hundred metres to the west of the proposed alignment. No other observations were recorded from the detailed surveys of the route however there are additional records in the Atlas of NSW Wildlife database (DECCW) for the study area and the presence of rainforest plant species associated with gullies suggest the presence of suitable habitat. All species are wide-ranging and locally nomadic, capable of moving large distances between remnant vegetation in response to the sporadic availability of food resources. Local populations are expected to be small and nomadic compared to west of the study area in the Dorrigo / Bellingen area where subtropical rainforest habitats are more widespread.

These bird species forage on fruits from native rainforest trees and shrubs as well as the introduced Camphor Laurel. Therefore, these species are threatened primarily by the destruction of habitat by clearing for development and agriculture. The Proposal would involve removal of a small percentage of moist forest habitat which supports rainforest species in the understorey (c. 63 ha) which is marginal for the species and up to 0.58 ha of lowland rainforest which is better suited. The current potential for these species to forage in the study area is considered to remain following the works and the impacts on life-cycle activity would be very minimal. The proposed Proposal is considered unlikely to significantly disrupt the life-cycle of these frugivorous birds such that any viable local population would be placed at risk of extinction.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal would involve removal of a small percentage of moist forest habitat (c. 63 ha) which is marginal for the species and up to 0.58 ha of lowland rainforest which is better suited. Local populations are expected to be small and nomadic compared to those to the west of the study area in the Dorrigo / Bellingen area where subtropical rainforest habitats are more widespread.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

Distributed throughout subtropical and tropical eastern Australia, the study area is not the limit of distribution for these species.

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

The Proposal would increase the fragmentation of habitat in the landscape by impacting on several contiguous forest areas, particularly the larger fragments associated with Nambucca and Newry State Forest in section 2 of the study area and private forested land to the north of the Kalang River in section 4. These areas provide potential habitat for Frugivorous birds largely because of their size and continuity with forests to the west. It is important to note however that all areas of habitat affected by the Proposal have already been fragmented in the past by roads, clearing and power easements. The Proposal would be contributing to this cumulative fragmentation of habitat in the landscape.

These large birds are capable of moving large distances to access seasonally available fruits. Much of their habitat requirements would be met in rainforest gullies and creeklines which are poorly represented in the study area. These species are not totally reliant on continuous habitat connectivity.

A strategic approach to mitigating the effects of fragmentation from the Proposal should be developed by focusing on re-establishing links with historically isolated fragments of habitat in proximity to the new road. These opportunities should be investigated along with increasing the size of smaller remnant fragments adjoining the road. The greatest potential for this exists in low-lying agricultural areas adjoining the corridor.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.11 Osprey

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Several breeding pairs of osprey are expected to occur in the catchment of the Nambucca and Kalang Rivers. Nest sites have generally been recorded in floodplain areas, near swamps or estuaries and often in dead trees near the forest edge. One active nest was located in the study area during 2008, recorded on private property south of Deep Creek in 50 m of the existing

Pacific Highway. Nesting was reported to have occurred at this location for several years. Other nests reported north of Martels Road and Champions Lane in 2005 were blown out of the tree and collapsed by the 2007-08 surveys and incident which is expected to be common for this species given the preference for isolated dead trees. Individuals are commonly observed in the floodplain and estuarine habitats across the study area.

The Proposal would not directly impact on a currently known nest site, however further survey is required prior to construction to determine the location of new sites constructed since the survey. The existing nest on the southern side of Deep Creek and east of the existing highway would not be impacted at given its current location (i.e. 50 m from the highway) it is unlikely that the new carriageway to be constructed to the west of the existing road would significantly impact on the site.

The impacts on foraging habitat would be minimal based on the availability in the region and the mobility of the species.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

As stated, there would be no impact on nesting habitat. Ospreys prey on fish, predominantly saltwater species, and take their prey from beaches, estuaries and tidal stream areas. The Proposal would impact on this habitat through the construction of bridges over the Nambucca and Kalang River, as well as Deep Creek and Oyster Creek. The magnitude of this impact is considered relatively small in the scale of available habitat and unlikely to place significant pressure on the regional populations.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

Cosmopolitan species, the osprey occurs through coastal Australia and is not at the limit of its distribution in the study area.

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

The Proposal would increase the fragmentation of habitat in the landscape by impacting on several contiguous forest areas, particularly the larger fragments associated with Nambucca and Newry State Forest in section 2 of the study area and private forested land to the north of the Kalang River in section 4. These areas do not provide optimum habitat for the osprey which is typically associated with open agricultural landscapes and forest edges on floodplains along with riparian vegetation and tidal estuarine rivers and streams. The reduction in connectivity is not expected to impact significantly on this species.

A strategic approach to mitigating the effects of fragmentation from the Proposal should be developed by focusing on re-establishing links with historically isolated fragments of habitat in proximity to the new road. These opportunities should be investigated along with increasing the size of smaller remnant fragments adjoining the road. The greatest potential for this exists in low-lying agricultural areas adjoining the corridor.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.12 Square-tailed kite

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

The square-tailed kite prefers coastal and sub-coastal open forest and woodlands on fertile soils with abundant prey species being present (Debus *et al*. 1993; Marchant and Higgins 1993). A common feature of the kite's habitat is the presence of profuse eucalypt blossom and attendant nectivorous birds (Debus *et al*. 1993) on which the square-tailed kite preys. On the coast, the kite appears to prefer the drier forest types on the foothills and coastal plains, which is consistent with the observation and records occurring in the study area. Records of the species appear to be associated with the extensive dry sclerophyll forest habitats on low hills.

No nest sites were located along the proposed alignment during the surveys nor have been reported in the vicinity of the route in the local State Forests. Further surveys are recommended prior to construction. The Proposal would not impact on breeding activities of local populations of the square-tailed kite. Potential habitat for foraging and roosting is very common and widespread for this species in the region and the impacts on this life-cycle activity is expected to be minimal.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The square-tailed kite prefers coastal and sub-coastal open forest and woodlands on fertile soils with abundant prey species being present (Debus *et al*. 1993; Marchant and Higgins 1993). Dry sclerophyll forest habitats are very common and widespread throughout the region particularly further west of the study area. The Proposal would remove up to 144 ha of blackbutt open forest considered suitable for this species. This total is a small percentage of the habitat available in the region.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

This species occurs throughout eastern and northern Australia. The study area is not the limit of distribution for this species.

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

The Proposal would increase the fragmentation of habitat in the landscape by impacting on several contiguous forest areas, particularly the larger fragments associated with Nambucca and Newry State Forest in section 2 of the study area and private forested land to the north of the Kalang River in section 4. These areas provide potential habitat for the square-tailed kite largely because of their size and continuity with forests to the west. It is important to note however that all areas of habitat affected by the Proposal have already been fragmented in the past by roads, clearing and power easements. The Proposal would be contributing to this cumulative fragmentation of habitat in the landscape.

The impacts of fragmentation may be most evident in Nambucca State Forest in section 2, where an area of up to 1000 ha of forested lands would be separated to the east of the road. The impact of reduced connectivity is not expected to significantly impact on this species which is wide-ranging and highly mobile, capable of moving across cleared and urbanised landscapes to access suitable habitats.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.13 Black Bittern

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

The black bittern occurs in thick vegetation at margins of watercourses, swamps, billabongs, mudflats and mangroves in tidal creeks and rivers, also streamside vegetation in shrubland or low forest (Marchant and Higgins 1990). The species feeds on small fish and invertebrates. Breeding occurs in densely vegetated wetlands between September and April (Pizzey and Knight 1997). Suitable habitat for this species in the study area is limited to one large wetland on the floodplain north of the Kalang River and eastern side of South Arm Road. This habitat would not be impacted directly by the proposed alignment and potential indirect impacts are to be monitored and controlled during construction and operation. Other smaller freshwater wetlands identified in the study area typically lack dense fringing vegetation and are considered sub-optimal. Life-cycle activities of any local population are unlikely to be impacted.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The black bittern occurs in thick vegetation at margins of watercourses, swamps, billabongs, mudflats and mangroves in tidal creeks and rivers, also streamside vegetation in shrubland or low forest (Marchant and Higgins 1990). Suitable habitat for this species in the study area is limited to one large wetland on the floodplain north of the Kalang River and eastern side of South Arm Road. This habitat would not be impacted directly by the proposed alignment and potential indirect impacts are to be monitored and controlled during construction and operation.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

The species occurs throughout coastal and sub-coastal areas of south-western, northern and eastern Australia. In NSW it occurs in coastal valleys principally at low elevations. The species distribution is not restricted to the study area.

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

The Proposal would increase the fragmentation of habitat in the landscape by impacting on several contiguous forest areas, particularly the larger fragments associated with Nambucca and Newry State Forest in section 2 of the study area and private forested land to the north of the Kalang River in section 4. These areas are not suitable habitat for the species and the impact of fragmentation is not expected to significantly affect this species.

A strategic approach to mitigating the effects of fragmentation from the Proposal should be developed by focusing on re-establishing links with historically isolated fragments of habitat in proximity to the new road. These opportunities should be investigated along with increasing the size of smaller remnant fragments adjoining the road. The greatest potential for this exists in low-lying agricultural areas adjoining the corridor.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.14 Tree-roosting microchiropteran Bats

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Vegetation in the study area provides potential foraging and roosting habitat for the assessed species (Greater Broad-nosed Bat, Eastern False Pipistrelle and Eastern Freetail-bat and Eastern Long-eared Bat). These bat species frequent a variety of habitat types ranging from rainforest to wet and dry sclerophyll forest, woodland and open modified landscapes.

Important life-cycle activities include roosting and breeding and are typically associated with tree hollows as well as foraging for insect prey which occurs in a variety of habitat types. The size of local populations is not known, although expected to be moderately large given the expanses of suitable habitat. The Proposal would remove approximately 253 ha of forest habitat and which provides potential foraging habitat. Much of this habitat has been identified as of young age or even age and the abundance of hollows is very low throughout the corridor. Nonetheless the Proposal would involve clearing of habitat trees. Comparable habitats are very well represented throughout the locality and regional area and it is unlikely that the Proposal would have a significant impact on the foraging or roosting life-cycle events for local populations of these bat species and continued presence in the locality could be expected.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

These bat species frequent a variety of habitat types ranging from rainforest to wet and dry sclerophyll forest, woodland and open modified landscapes.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

None of these tree roosting threatened bat species are at the limit of their distribution in the study area. Dry and moist sclerophyll forest habitats are very common and widespread throughout the region particularly further west of the study area. The Proposal would remove up to 253 ha of forest habitat considered suitable for these species. This total is a small percentage of the habitat available in the region.

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

The Proposal would increase the fragmentation of habitat in the landscape by impacting on several contiguous forest areas, particularly the larger fragments associated with Nambucca and Newry State Forest in section 2 of the study area and private forested land to the north of the Kalang River in section 4. These areas provide potential habitat for tree-roosting forest dwelling bats. It is important to note however that all areas of habitat affected by the Proposal have already been fragmented in the past by roads, clearing and power easements. The Proposal would be contributing to this cumulative fragmentation of habitat in the landscape.

The impacts of fragmentation may be most evident in Nambucca State Forest in Section 2, where an area of up to 1000 ha of forested lands would be separated to the east of the road. The impact of fragmentation in Newry State Forest is difficult to assess as this area is already fragmented from coastal habitats to the east in Valla Nature Reserve as a result of the existing Pacific Highway and existing wide electricity transmission easements. The effects of reduced habitat connectivity are expected to be lower for highly mobile species such as bats.

A strategic approach to mitigating the effects of fragmentation from the Proposal should be developed by focusing on re-establishing links with historically isolated fragments of habitat in proximity to the new road. These opportunities should be investigated along with increasing the size of smaller remnant fragments adjoining the road. The greatest potential for this exists in low-lying agricultural areas adjoining the corridor.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.15 Cave-roosting microchiropteran Bats

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

The site provides potential foraging habitat for the assessed species (Large Bentwing-bat, little bentwing-bat and large-footed myotis). The little bentwing-bat was recorded from at least two locations foraging in clearings near moist and open forest habitats. These species are predominantly cave-roosting bats, although a small colony of little bentwing-bats has been observed roosting in a hollowed tree trunk (Schulz 1997) and large-footed myotis have been recorded roosting under old timber bridges. No timber bridges would need to be removed to accommodate the Proposal. Similarly no caves or abandoned mine shafts have been recorded in the proposed route corridor and the Proposal is not expected to impact on the roosting life-cycle activities of these species.

The Proposal would remove approximately 253 ha of forest habitat and which provides potential foraging habitat for *Miniopterus* spp. Comparable habitats are very well represented throughout the locality and regional area and it is unlikely that the Proposal would have a significant impact on the foraging life-cycle events for a local population of these bat species and continued foraging over the site and adjacent lands could be expected. Large-footed myotis hunt over water bodies for small fish and invertebrates and may frequent freshwater wetlands and estuaries as well as creeks and farm dams. Impacts on foraging habitat would result from the Proposal however the overall magnitude of impact is small.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

Impacts on known or potential roosting habitat are not expected. The Proposal would remove approximately 253 ha of forest habitat and which provides potential foraging habitat for the Bentwing-bats. Comparable habitats are very well represented throughout the locality and regional area and it is unlikely that the Proposal would have a significant impact on the foraging life-cycle events for a local population of these bat species and continued foraging over the site and adjacent lands could be expected. Large-footed myotis hunt over water bodies for small fish and invertebrates and may frequent freshwater wetlands and estuaries as well as creeks and farm dams. Impacts on foraging habitat would result from the Proposal however the overall magnitude of impact is small.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

None of these cave-roosting threatened bat species are at the limit of their distribution in the study area.

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

The Proposal would increase the fragmentation of habitat in the landscape by impacting on several contiguous forest areas, particularly the larger fragments associated with Nambucca and Newry State Forest in section 2 of the study area and private forested land to the north of the Kalang River in section 4. These areas provide potential habitat for forest dwelling bats. It is important to note however that all areas of habitat affected by the Proposal have already been fragmented in the past by roads, clearing and power easements. The Proposal would be contributing to this cumulative fragmentation of habitat in the landscape.

The impacts of fragmentation may be most evident in Nambucca State Forest in section 2, where an area of up to 1000 ha of forested lands would be separated to the east of the road. The impact of fragmentation in Newry State Forest is difficult to assess as this area is already fragmented from coastal habitats to the east in Valla Nature Reserve as a result of the existing Pacific Highway and existing wide electricity transmission easements. The effects of reduced habitat connectivity are expected to be lower for highly mobile species such as bats.

A strategic approach to mitigating the effects of fragmentation from the Proposal should be developed by focusing on re-establishing links with historically isolated fragments of habitat in proximity to the new road. These opportunities should be investigated along with increasing the size of smaller remnant fragments adjoining the road. The greatest potential for this exists in low-lying agricultural areas adjoining the corridor.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.16 Giant barred frog

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Giant barred frogs forage in deep, damp leaf-litter in rainforests, moist eucalypt forest and adjacent dry eucalypt forest slopes (NPWS 2002). They breed around shallow, flowing rocky streams from late spring to summer. Several creeks and drainage lines in the northern half of the study area through Nambucca, Little Newry and Newry State forest were identified as potential habitat for this species. The Proposal would impact on potential habitat via direct traverse of several small streams and gullies. The impact would be linear and restricted to the construction footprint comprising the road design with a 10 m buffer. Design measures have been incorporated to provide appropriate fauna passage and protection of waterways during construction and operation to ensure potential habitat is not impacted further. Direct impacts on populations would not be widespread and indirect impacts can be managed appropriately.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

Several creeks and drainage lines in the northern half of the study area through Nambucca, Little Newry and Newry State forest were identified as potential habitat for this species. However no individuals were recorded despite an extensive survey effort and sampling during optimum high rainfall events in summer (i.e. >200 mm in a week).

It is possible that the species no longer occurs in the study area on the basis of it absence during surveys which may be a factor of the frequency and intensity of fires in the landscape and associated reduction in leaf litter. The stronghold for this species in NSW is the Dorrigo area as determined by the expansive areas of rainforest habitat present in the ranges to the west of the Nambucca valley. The closely related giant barred frog (*Mixophyes fasciolatus*) was commonly recorded during the detailed surveys in moist forest habitat however this species is probably more tolerant of disturbed habitats which dominate the study area. On the basis of suitable habitat it is assumed that the species is present.

This species is threatened by reduction in water quality from sedimentation or pollution, altered hydrological regimes, frequent fire and the reduction of leaf litter, vegetation clearing. The Proposal would impact on potential habitat via direct traverse of several small streams and gullies. The impact would be linear and restricted to the construction footprint. Design measures have been incorporated to provide appropriate fauna passage and protection of waterways during construction and operation to ensure potential habitat is not impacted further.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

Coast and ranges from south-east Queensland to the Hawkesbury River in NSW. North-east NSW, particularly the Coffs Harbour-Dorrigo area is a stronghold for the species. The species is not at the limit of its distribution in the study area (NPWS 2002b).

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

The Proposal would increase the fragmentation of habitat in the landscape by impacting on several contiguous forest areas, particularly the larger fragments associated with Nambucca and Newry State Forest in section 2 of the study area and private forested land to the north of the Kalang River in section 4. Several creeks and riparian habitat in the state forests provide potential habitat for this species and these would be traversed by the highway. All drainage areas would incorporate either bridge or culvert structures which theoretically provide a passage for fauna movements particularly suited to riparian dependent species such as the giant barred frog.

A strategic approach to mitigating the effects of fragmentation from the Proposal should be developed by focusing on re-establishing links with historically isolated fragments of habitat in proximity to the new road. These opportunities should be investigated along with increasing the size of smaller remnant fragments adjoining the road. The greatest potential for this exists in low-lying agricultural areas adjoining the corridor.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

The Proposal would increase the fragmentation of habitat in the landscape by impacting on several contiguous forest areas, particularly the larger fragments associated with Nambucca and Newry State Forest in section 2 of the study area and private forested land to the north of the Kalang River in section 4. It is important to note however that all areas of habitat affected by the Proposal have already been fragmented in the past by roads, clearing for agriculture and power easements. The Proposal would be contributing to this cumulative fragmentation of habitat in the landscape. The impacts of fragmentation may be most evident in Nambucca State Forest in section 2, where an area of up to 1000 ha of forested lands would be separated to the east of the road. Potential habitat for this species occurs in freshwater creeks in dense moist forested gullies. Measures have been planned to minimise the impacts of fragmentation on these habitats and have been considered in the design of the road by incorporating a wider median through the northern end of Nambucca State Forest and placing fauna underpass structures in strategic locations.

The impact of fragmentation in Newry State Forest is difficult to assess as this area is already fragmented from coastal habitats to the east in Valla Nature Reserve as a result of the existing Pacific Highway and existing wide electricity transmission easements. Further widening of the median and fauna underpass structures are also proposed through portions of Newry State Forest to maintain opportunities for fauna crossing.

A strategic approach to mitigating the effects of fragmentation from the Proposal should be developed by focusing on re-establishing links with historically isolated fragments of habitat in proximity to the new road. These opportunities should be investigated along with increasing the size of smaller remnant fragments adjoining the road. The greatest potential for this exists in low-lying agricultural areas adjoining the corridor.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

Appendix C Assessment of Significance (EPBC Act)

C.1 Endangered species

C.1.1 Swift parrot and Regent honeyeater

Lead to a long-term decrease in the size of a population

Both species are regarded as winter-visitors to this region, and their presence would depend predominantly on the flowering of swamp mahogany (*Eucalyptus robusta*) and forest red gum (*E.tereticornis*) to provide food resources. Both tree species are present in low abundance and the study area is considered only marginal for the swift parrot and regent honeyeater. The largest patches of potential foraging habitat are present as SEPP 14 wetland areas in Nambucca and Newry State Forests. These areas have been avoided as part of the route options study and would not be impacted by the Proposal. The study area would constitute non-breeding habitat for a proportion of the population of both species

Reduce the area of occupancy of the species

Both species are wide ranging and highly mobile, semi-nomadic species with patchy and sporadic distribution across coastal NSW. Their presence in the study area is seasonally dependent and influenced by drought and rain periods affecting the flowering of preferred tree species. Therefore there is no defined area of occupancy in the study area.

Evidence gathered on the movements of both species suggest that visits to the coastal swamp mahogany forests are not consistent every year and depend on flowering of the Box-Ironbark woodlands on the south western slopes of NSW and Victoria (Menkhorst et al 1999; swift parrot Recovery Team 2001; Geering 2004). The Proposal would have minor impacts on small areas of potential habitat for these species.

Fragment an existing population into two or more populations

Potential habitat for these species as identified in this report occurs in small and fragmented patches present throughout the study area and already fragmented by existing roads and cleared land. Furthermore, both species are highly mobile and semi-nomadic capable of accessing patchy food resources. There are no defined areas of habitat in the study area that are exclusively occupied by these species and the Proposal would not fragment a population of the swift parrot or regent honeyeater,

Adversely affect habitat critical to the survival of the species

The study area would constitute non-breeding habitat for a proportion of the population of both species. The Macksville to Urunga study area is not considered a critical area for the regent honeyeater (D.Geering, NPWS, *pers.comm*) or swift parrot (D.Saunders, *pers comm*).

Disrupt the breeding cycle of a population

The study area would constitute non-breeding habitat for a proportion of the population of both species

Modify, destroy, remove, isolate or decrease the availability or quality of the habitat to the extent that the species is likely to decline

The area of vegetation potentially removed as a result of the Proposal is not considered significantly large or of a high quality to lead to the decline of these species in NSW. The Proposal would impact on only 5.94 ha of high quality habitat and approximately 5.86 ha of medium quality and 0.66 ha of low quality habitat. This is minimal in relation to the extent of potential habitat in the North Coast Bioregion.

Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the critically endangered or endangered species habitat

Many of the bushland remnants which occur in the study area exhibit high levels of weed invasion and the Proposal avoids the largest patches of potential habitat identified in this study. Any Proposal to remove natural vegetation would be supported by the RTA's standard revegetation and landscaping work methods including follow up weed removal.

Introduce disease that may cause the species to decline

The types of activities involved in the planning and construction of the Proposal, or operation of the highway are not consistent with introducing bird diseases.

Interfere with the recovery of the species

The Proposal and proposed highway construction would not conflict with the recovery of these two species. The Proposal has been selected on the basis of avoiding high quality habitats for these species.

C.1.2 Giant barred frog

Lead to a long-term decrease in the size of a population

Evidence of a local population was not determined from the results of the surveys or background review. However several creeks and drainage lines in the northern half of the study area through Nambucca, Little Newry and Newry State forest were identified as potential habitat for this species. The Proposal would impact on this potential habitat via the direct traverse of several small streams and gullies. The impact would be linear and restricted to the construction footprint. Suitable design measures have been incorporated to provide fauna passage and protect the waterway during construction and operation to ensure such potential habitat is not significantly impacted. Therefore direct impacts on populations would not be widespread and key threats can be managed suggesting that a decrease in the size of population is unlikely.

Reduce the area of occupancy of the species

Due to the absence of records of this species in the study area it is not possible to identify the area of occupancy of a population. The extent of potential habitat and hence possible distribution of a population was determined through identification of suitable habitat. The Proposal would impact on potential habitat via direct traverse of several small streams and gullies. The impact would be linear and restricted to the construction footprint. Design measures have been incorporated to minimise the direct and indirect impact.

Fragment an existing population into two or more populations

The Proposal would increase the fragmentation of habitat in the landscape by impacting on several contiguous forest areas, particularly the larger fragments associated with Nambucca and Newry State Forest in Section 2 of the study area and private forested land to the north of the Kalang River in Section 4. Several creeks and riparian habitat in the state forests provide potential habitat for this species and these would be traversed by the highway. All drainage areas would incorporate either bridge or culvert structures which theoretically provide a passage for fauna movements particularly suited to riparian dependent species such as the giant barred frog.

Adversely affect habitat critical to the survival of the species

There is currently no evidence, based on extensive field survey and review of historical records, to suggest that a population occurs in the study area. Conversely there are numerous records to the west of the corridor, up to several kilometres away and extending to the Dorrigo plateau, that are associated with sub-tropical rainforest. This habitat type is not present in the study area.

While the presence of potential habitat for this species has been identified in the study area and would be impacted to a degree as discussed previously, this habitat is not considered critical to the survival of the species in Australia.

Disrupt the breeding cycle of a population

The species breeds around shallow, flowing rocky streams from late spring to summer. On the basis that the Proposal construction would extent over 2-3 years, there is the potential for the activity to disrupt the breeding cycle of a population. Measures to minimise impacts on waterways during construction are to be implemented as part of the CEMP.

Modify, destroy, remove, isolate or decrease the availability or quality of the habitat to the extent that the species is likely to decline

Giant barred frogs inhabit deep, damp leaf-litter in rainforests, moist eucalypt forest and adjacent dry eucalypt forest slopes (NPWS 2002). Several creeks and drainage lines in the northern half of the study area through Nambucca, Little Newry and Newry State forest were identified as potential habitat for this species. The stronghold for this species in NSW is the Dorrigo area as determined by the expansive areas of sub-tropical rainforest habitat present in the ranges to the west of the Nambucca Valley. Similar habitats are absent from the study area.

The Proposal would impact on potential habitat via direct traverse of several small streams and gullies. The impact would be linear and restricted to the construction. Design measures have been incorporated to provide appropriate fauna passage and protection of waterways during construction and operation to ensure potential habitat is not impacted further.

Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the critically endangered or endangered species habitat

The potential for weed invasion is considered possible with a Proposal of this nature and appropriate controls are required during the construction and operation of the road to reduce this threat as it may have long term implications for the habitat of threatened species. The management of invasive species would be managed under the guidance of the CEMP and OEMP.

Introduce disease that may cause the species to decline

This species is adversely impacted by chytrid fungus. The construction of the Proposal has potential to introduce chytrid fungus through the movements of heavy vehicles and earth moving equipment into the study area. The current status of chytrid fungus in the region is not known and hygiene protocols should be introduced which as a minimum include washdown of vehicles brought in from other projects.

Interfere with the recovery of the species

The Proposal and proposed highway construction would not conflict with the recovery of this species. The route has been selected on the basis of avoiding high quality habitats for threatened fauna.

C.2 Potentially occurring endangered flora species

C.2.1 *Acronychia littoralis*

Lead to a long-term decrease in the size of a population

There is a low possibility this species is present in rainforest and wet sclerophyll forests of the study area however these habitats are marginal. The nearest record to the Proposal area is 4km east of Warrell Creek. Considering the relatively extensive targeted searches undertaken for this species in areas of suitable habitat, it is unlikely it is present in the study area. The Proposal would result in the removal of approximately 34.4 ha of marginal habitat for this species.

Reduce the area of occupancy of the species

The distribution of *Acronychia littoralis* is found between Fraser Island in Queensland and Port Macquarie on the north coast of NSW. The preferred habitat for this species is littoral rainforest on sand which does not occur in the study area. The Proposal is unlikely to impact the area of occupancy for this species considering the lack of suitable habitat.

Fragment an existing population into two or more populations

No known populations would be fragmented by the Proposal.

Adversely affect habitat critical to the survival of the species

The preferred habitat for this species is littoral rainforest on sand which does not occur in the study area. Therefore habitats in the study area are unlikely to be critical for the survival of this species.

Disrupt the breeding cycle of a population

Pollination and seed dispersal mechanisms for *Acronychia littoralis* are unlikely to be impacted by the Proposal.

Modify, destroy, remove, isolate or decrease the availability or quality of the habitat to the extent that the species is likely to decline

The preferred habitat for this species is littoral rainforest on sand which does not occur in the study area. Therefore habitats in the study area are unlikely to be critical for the survival of this species.

Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the critically endangered or endangered species habitat

The potential for weed invasion is considered possible with a Proposal of this nature and appropriate controls are required during the construction and operation of the road to reduce this threat as it may have long term implications for the habitat of threatened species. The management of invasive species would be managed under the guidance of the CEMP and OEMP.

Introduce disease that may cause the species to decline

This species is adversely impacted by *Phytophora* fungus. The construction of the Proposal has potential to introduce *Phytophora* fungus through the movements of heavy vehicles and earth moving equipment into the study area. The current status of *Phytophora* fungus in the region is not known and hygiene protocols should be introduced which as a minimum include washdown of vehicles brought in from other projects.

Interfere with the recovery of the species

The Proposal and proposed highway construction would not conflict with the recovery of this species. The route has been selected on the basis of avoiding high quality habitats for threatened species.

C.2.2 Parsonsia dorrigoensis

Lead to a long-term decrease in the size of a population

The Proposal would result in the removal of approximately 34.4 ha of suitable habitat for this species. Better qualities examples of habitat include rainforest areas of which only 0.58 ha would be removed.

Parsonsia dorrigoensis was not recorded in the study area despite targeted searches in areas of suitable habitat. There are records for this species in the locality. This species is not particularly difficult to identify in the field.

Reduce the area of occupancy of the species

Parsonsia dorrigoensis is found only in NSW, with scattered populations in the north coast region between Kendall and Woolgoolga. *Parsonsia dorrigoensis* is not at the limit of its distribution in the locality. The Proposal would result in the removal of approximately 34.4 ha of suitable habitat for this species. Better qualities examples of habitat include rainforest areas of which only 0.58 ha would be removed.

Fragment an existing population into two or more populations

Parsonsia dorrigoensis was not recorded in the study area despite targeted searches in areas of suitable habitat. Therefore the proposal would not result in the fragmentation of a known population.

Adversely affect habitat critical to the survival of the species

Parsonsia dorrigoensis was not recorded in the study area despite targeted searches in areas of suitable habitat. The Proposal would result in the removal of approximately 34.4 ha of suitable habitat for this species. Better qualities examples of habitat include rainforest areas of which only 0.58 ha would be removed. Considering the small area of optimal habitat being removed and this species was not located in the study area despite targeted searches, the proposal is unlikely to significantly impact this species.

Disrupt the breeding cycle of a population

Pollination and seed dispersal mechanisms for *Parsonsia dorrigoensis* are unlikely to be impacted by the Proposal.

Modify, destroy, remove, isolate or decrease the availability or quality of the habitat to the extent that the species is likely to decline

Parsonsia dorrigoensis was not recorded in the study area despite targeted searches in areas of suitable habitat. The Proposal would result in the removal of approximately 34.4 ha of suitable habitat for this species. Better qualities examples of habitat include rainforest areas of which only 0.58 ha would be removed. Considering the small area of optimal habitat being removed and this species was not located in the study area despite targeted searches, the proposal is unlikely to lead to declines in the species population.

Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the critically endangered or endangered species habitat

The potential for weed invasion is considered possible with a Proposal of this nature and appropriate controls are required during the construction and operation of the road to reduce this threat as it may have long term implications for the habitat of threatened species. The management of invasive species would be managed under the guidance of the CEMP and OEMP.

Introduce disease that may cause the species to decline

This species is adversely impacted by *Phytophora* fungus. The construction of the Proposal has potential to introduce *Phytophora* fungus through the movements of heavy vehicles and earth moving equipment into the study area. The current status of *Phytophora* fungus in the region is not known and hygiene protocols should be introduced which as a minimum include washdown of vehicles brought in from other projects.

Interfere with the recovery of the species

The Proposal and proposed highway construction would not conflict with the recovery of this species. The route has been selected on the basis of avoiding high quality habitats for threatened species habitat.

C.3 Vulnerable species

C.3.1 *Marsdenia longiloba*

Lead to a long-term decrease in the size of an important population

Marsdenia longiloba is a slender vine species found in various rainforest types and some moist sclerophyll forests, occurring at scattered locations from Barrington Tops north to southeast Queensland (NPWS 2002b). The ecology of this species has not been studied extensively and many of its life history attributes are largely unknown. *Marsdenia longiloba* occurs in numerous National Parks in northern NSW and southeast Queensland. This species has mostly been recorded as occurring in low abundance in small population clusters. The populations recorded in the study area are regarded as being “important populations” as described under the EPBC Act due to them being relatively large populations.

Marsdenia longiloba occurs in seven separate sub-populations along the study area in rainforest and wet sclerophyll forest habitats. Most locations are in Newry, Little Newry and Nambucca State Forests, and there is one occurrence in private property north of the Kalang River. It is estimated that these occurrences consist of approximately 156 individuals occurring in an area up to 250 m either side of the Proposal centreline. The population in these areas is likely to extend further upstream and downstream of some of the surveyed areas, and therefore is likely to consist of a larger population than recorded for this Proposal.

Of the 156 individuals estimated to occur in the 500 metre corridor approximately 12 individuals (8 per cent of the population) would be directly impacted and an additional 32 individuals (20 per cent of the population) would remain in 30 m of the proposed development and would potentially be indirectly impacted. The remaining 112 individuals (72 per cent of the population) would remain at greater than 30 m from the Proposal and would be retained and protected from direct impacts. Mitigation measures employed for the Proposal would minimise any potential for indirect impacts, including edge effects and changes in biophysical conditions

There would potentially be indirect impacts to individuals downstream of the proposed development where runoff during the construction and operation of the proposed highway would enter the gully habitats where *Marsdenia longiloba* occurs. This would potentially alter the hydrology regime and nutrient loads increasing the potential for changes to habitat attributes which may impact individuals in these areas. Mitigation measures during construction and the implementation of specific design features into the proposed development would potentially minimise these indirect impacts.

Reduce the area of occupancy of an important population

Of the six recorded populations of *Marsdenia longiloba*, two occur on both sides of the proposed route alignment in a 500m corridor, and therefore would potentially be dissected by the proposed development. Individuals would be retained on either side of the proposed highway, with direct impacts limited to the proposed road corridor. Another two populations would be impacted on one edge of the population and the populations on private property have been avoided by the proposed development. The area of occupancy would be reduced in these four impacted populations, although the linear nature of the Proposal limits the direct impacts to these populations.

There is potential for the Proposal to contribute to indirect impacts through altering hydrological and nutrient regimes in habitats downstream of the proposed development which could potentially result in habitat changes, leading to the area of occupancy of the population to be significantly reduced. However mitigation measures during construction and the implementation of specific design features into the proposed development would potentially minimise these indirect impacts.

Fragment an existing important population into two or more populations

Marsdenia longiloba generally occurs in gully areas running perpendicular to the Proposal. Therefore suitable areas of habitat would be fragmented from the Proposal, with some sub-populations being dissected. Pollinator movements could potentially extend across the proposed highway allowing exchange of genetic material between fragmented areas of habitat, assuming flying insects are the main pollinators, however this is largely unknown.

Of the 6 recorded sub-populations of *Marsdenia longiloba*, two occur on both sides of the proposed route alignment in a 500m corridor, and therefore would potentially be dissected by the proposed development. Individuals would be retained on either side of the proposed highway, with direct impacts limited to the proposed road corridor. Another two populations would be impacted on one edge of the population and the two populations on private property have been avoided by the proposed development. Therefore of the six sub-populations, two would be fragmented into two sub-populations, two would be impacted on one side of the sub-population and two would not be directly impacted.

Adversely affect habitat critical to the survival of the species

Habitat critical to the survival of a species refers to areas that are necessary:

- For activities such as foraging, breeding, roosting, or dispersal.
- For the long-term maintenance of the species including the maintenance of other species essential to the survival of the species, such as pollinators.
- To maintain genetic diversity and long-term evolutionary development.
- For the reintroduction of populations or recovery of the species.

The habitats where *Marsdenia longiloba* was recorded included moderately degraded areas impacted by weed invasion, logging activities, fire and cattle grazing. Although these areas have been degraded, there were better quality pockets of native vegetation cover where the majority of *Marsdenia longiloba* individuals were recorded. Assuming that these habitats would be further impacted over time particularly from weed invasion unless long-term management actions are implemented; these areas are unlikely to be optimal for the long-term survival of the species.

Direct impacts would be limited to the proposed development area comprising a relatively small area of the available habitat for this species in the local area. There is potential for the Proposal to contribute to indirect impacts through altering hydrological and nutrient regimes in habitats downstream of the proposed development, which could potentially result in habitat changes, leading to further weed invasion in areas of habitat downstream. Although mitigation measures would potentially limit the degree of indirect impacts to the surrounding areas of habitat for *Marsdenia longiloba*, the Proposal is likely to contribute to existing threatening processes which would affect these areas of habitat.

Marsdenia longiloba is reserved in numerous National Parks in northern NSW and southeast Queensland. Better quality examples of habitat are likely to be present within these conservation reserves where threatening processes are limited.

Disrupt the breeding cycle of an important population

The life cycle attributes for *Marsdenia longiloba* are largely unknown, however assumptions of life history attributes can be drawn from knowledge of other species in the same family (Apocynaceae: Asclepiadoideae). Pollinators are usually insect species including flies and/or beetles. Some species in this family have highly specialised pollination mechanisms which involves trapping insects' by their legs or proboscis between the osmotically elastic anther wings, and withdrawal entailing capture of the pollinia by means of ‘sutured corpuscular pollen carriers’ (Watson and Dallwitz 2008).

The breeding cycle may be disrupted from the Proposal impacting pollinator populations. Two of the sub-populations are being fragmented into two sub-populations by the Proposal and therefore pollination across the proposed highway may be impacted. This may potentially lead to inbreeding depression where there is not sufficient exchange of genetic material between fragmented sub-populations. Considering the breeding cycle of *Marsdenia longiloba* is largely unknown potential impacts to pollination, seed dispersal and germination from the Proposal are difficult to quantify. Monitoring and adaptive management of populations as part of the mitigation measures for the Proposal may provide valuable information to better manage populations of *Marsdenia longiloba*.

Modify, destroy, remove, or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The Proposal would decrease the area of habitat available for *Marsdenia longiloba*, however these areas of habitat include moderately degraded areas impacted by weed invasion, logging activities, fire and cattle grazing. Indirect impacts from the Proposal would potentially contribute to these existing threatening processes through altering hydrology and nutrient regimes; however these impacts can be limited through the implementation of suitable mitigation measures. Although *Marsdenia longiloba* seems to be resilient to some habitat disturbance, further disturbances may lead to declines in the population. Considering the linear nature of the proposed development which runs perpendicular to most of the gully habitats where *Marsdenia longiloba* occurs, habitat removal would be limited to the direct impact area and relatively extensive areas of habitat would remain surrounding the Proposal.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species habitat

The Proposal could potentially result in the spread and aid the growth of invasive species currently present in the population of *Marsdenia longiloba* such as *Lantana camara*. Changes to hydrological and nutrient regimes in these areas as a result of the Proposal may further encourage weed growth. Although the Proposal is unlikely to result in the establishment of new invasive species in the habitat of *Marsdenia longiloba*, provided adequate mitigation measures are implemented, the Proposal may potentially contribute to aiding the growth of invasive species currently present in these areas of habitat.

Mitigation measures would be implemented to minimise impacts from nutrient loads, sedimentation and altered hydrology regimes. Weed management should be implemented during the construction phase of the Proposal to limit the spread of exotic weed species, including appropriate disposal of exotic vegetative material and propagules.

Introduce disease that may cause the species to decline

Diseases which may impact *Marsdenia longiloba* include the introduction of Root Rot Fungus (*Phytophora cinnamomi*) and other plant pathogens. Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the Proposal, impacts from plant pathogens would be minimised. Monitoring and management actions for the retained populations as part of the mitigation measures of the Proposal should be carried out in a way that minimises the risk of the spread of disease from plant pathogens.

Interferes substantially with the recovery of the species

The Proposal would not conflict with the recovery actions proposed for *Marsdenia longiloba*. Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protecting fencing, ongoing monitoring of populations and weed control within habitat areas.

C.3.2 Grey-headed flying-fox

Lead to a long-term decrease in the size of an important population

As stated, the clearing of approximately 253 ha of potential foraging habitat for this species represents a relatively minor impact for this species in the local area. In relation to the available habitat in adjacent land surrounding the highway, the Proposal is not considered likely to affect this species at the local level. The proposed action would not result in the decrease in size of the population in the local area and would not impact on a known roost site.

Reduce the area of occupancy of an important population

The Proposal would remove approximately 253 ha of vegetation potentially used by this species for foraging. This is a small percentage of the foraging habitat available throughout the distributional range of the Grey-headed Flying fox in Australia. The Proposal is not expected to significantly impact on food resources available for local populations of the grey-headed flying-fox. This species is wide ranging a capable of exploiting seasonally available and wide spread food resources.

Fragment an existing important population into two or more populations

The Proposal would increase the fragmentation of habitat in the landscape by impacting on several contiguous forest areas, particularly the larger fragments associated with Nambucca and Newry State Forest in section 2 of the study area and private forested land to the north of the Kalang River in section 4. It is important to note however that all areas of habitat affected by the Proposal have already been fragmented in the past by roads, clearing and power easements. The Proposal would be contributing to this cumulative fragmentation of habitat in the landscape.

Highly mobile species such as bats and birds are expected to be less impacted by fragmentation and the grey-headed flying-fox is particularly well adapted to accessing widely spaced habitat resources given its mobility and preference for seasonal fruits and blossom. The Proposal would not fragment an important population of the grey-headed flying-fox.

Adversely affect habitat critical to the survival of the species

Habitat critical to the survival of a species refers to areas that are necessary for activities such as:

- Foraging, breeding, roosting, or dispersal.
- For the long-term maintenance of the species including the maintenance of other species essential to the survival of the species, such as pollinators.
- To maintain genetic diversity and long-term evolutionary development.
- For the reintroduction of populations or recovery of the species.

The proposed area of disturbance represents a very small fraction of the potential foraging habitat for the grey-headed flying-fox in the mid north coast region. This species typically exhibits very large home ranges and grey-headed flying-fox are known to travel distances of at least 15km from roost sites to access seasonal foraging resources (Tidemann 1995). No evidence of a roosting colony of the grey-headed flying-fox occurs in proximity to the study area. Habitat in the study area is not considered critical for this species.

Disrupt the breeding cycle of an important population

No evidence of a roosting colony of the grey-headed flying-fox occurs in proximity to the study area and the Proposal would not impact on breeding cycles.

Modify, destroy, remove, or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The Proposal would remove approximately 253 ha of vegetation potentially used by this species for foraging. There would be a decrease in the availability of habitat in the region however this decrease represents a very small fraction of the potential foraging habitat for the grey-headed flying-fox in the mid north coast region and is unlikely to lead to a decline in any local populations.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species habitat

The potential for weed invasion is considered possible with a project of this nature and appropriate controls are required during the construction and operation of the road to reduce this threat as it may have long term implication for the habitat of threatened species. Grey-headed flying-fox forage on a very wide diversity of flora and are unlikely to be dependent on roadside verges. The management of invasive species would be managed under the guidance of the CEMP and OEMP.

Introduce disease that may cause the species to decline

There are no known disease issues affecting this species. The Proposal is unlikely to increase feral animal abundance or the potential for significant disease vectors to affect local populations.

Interferes substantially with the recovery of the species

The Proposal and proposed highway construction would not conflict with the recovery of this species. The route has been selected on the basis of avoiding high quality habitats for threatened fauna.

C.3.3 Spotted-tailed quoll

Lead to a long-term decrease in the size of an important population

Suitable habitat is well represented in the larger fragments of forest in the study area, particularly the state forests and adjoining private properties including the edges of open farmland. The species was not recorded during this study however is expected to occur. The species is an opportunistic predator and would feed on a variety of prey including macropods, birds, reptiles, arboreal mammals and small terrestrial mammals (Mansergh 1983). The Proposal would remove potential habitat for the species and its prey, leading to further fragmentation of habitat, a known threat to the species. Measures to conserve fauna corridors and movement avenues for terrestrial fauna have been incorporated into the Proposal. The generally modified nature of the habitats in the study area suggests that further modification is unlikely to decrease the population. There is no evidence to indicate that there is an important population in the study area.

Reduce the area of occupancy of an important population

The species typically has a large home range and occupies a diversity of habitat types. It is therefore difficult to identify the area of occupancy. Theoretically, quolls could occur in any of the larger forest fragments of the study area. Preferred habitat includes dry and moist sclerophyll forests. Suitable habitat is well represented in the larger fragments of forest in the study area, particularly state forests and adjoining private properties. The Proposal would remove potential habitat for the species however the overall reduction of habitat is a small proportion of the available potential habitat.

Fragment an existing important population into two or more populations

The Proposal would increase the fragmentation of habitat in the landscape by impacting on several contiguous forest areas, particularly the larger fragments associated with Nambucca and Newry State Forest in section 2 of the study area and private forested land to the north of the Kalang River in section 4. These areas provide potential habitat for spotted-tailed quoll largely because of their size and continuity with forests to the west. It is important to note however that all areas of habitat affected by the Proposal have already been fragmented in the past by roads, clearing and power easements. The Proposal would be contributing to this cumulative fragmentation of habitat in the landscape.

Measures have been planned to minimise the impacts of fragmentation and have been considered in the design of the road by incorporating a wider median through the northern end of Nambucca State Forest and placing fauna underpass structures in strategic locations. Further widening of the median and fauna underpass structures are also proposed through portions of Newry State Forest to maintain opportunities for fauna crossing.

Adversely affect habitat critical to the survival of the species

Habitat critical to the survival of a species refers to areas that are necessary for activities such as

- Foraging, breeding, roosting, or dispersal.
- For the long-term maintenance of the species including the maintenance of other species essential to the survival of the species, such as pollinators.
- To maintain genetic diversity and long-term evolutionary development.
- For the reintroduction of populations or recovery of the species.

Some of the larger habitats represented in the study area are suitable for populations of spotted-tailed quoll however, they do not constitute habitat that is critical for the long-term maintenance of the species.

Disrupt the breeding cycle of an important population

Given the large home ranges of this species, potentially only a small number of individuals may be present in the lands surrounding the study area. While there are no cave sites present there may be suitably large hollow logs providing potential den sites for breeding. There is potential therefore to impact on the breeding cycle of a small proportion of the population.

Modify, destroy, remove, or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

Suitable habitat is well represented in the larger fragments of forest in the study area, particularly the state forests and adjoining private properties including the edges of open farmland. Given the large home ranges of this species, potentially only a small number of individuals may be present in the lands surrounding the study area.

The Proposal would remove potential habitat for this small number of individuals, leading to further fragmentation of habitat. The impacts are not likely to cause the species to decline in the region. Measures to conserve fauna corridors and movement avenues for terrestrial fauna have been incorporated into the Proposal.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species habitat

The potential for weed invasion is considered possible with a project of this nature and appropriate controls are required during the construction and operation of the road to reduce this threat as it may have long term implication for the habitat of threatened species. The management of invasive species would be managed under the guidance of the CEMP and OEMP.

Introduce disease that may cause the species to decline

There are no known diseases issues affecting this species. The Proposal is unlikely to increase feral animal abundance or the potential for significant disease vectors to affect local populations.

Interferes substantially with the recovery of the species

The Proposal and proposed highway construction would not conflict with the recovery of this species. The route has been selected on the basis of avoiding high quality habitats for threatened fauna.

C.4 Migratory species

Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species

Nine listed migratory bird species (EPBC Act) were identified from the field investigation, refer to **Table 4-6** in text which also includes potential species based on the presence of suitable habitat. The majority of species were considered uncommon and widespread vagrants with no specific populations represented. The most widespread and abundant species was cattle egret present throughout cleared farmland and rufous fantail and black-faced monarch in moist densely forested gullies. White-throated Needletail were observed in the air on several occasions flying over the study area and not specific to any habitat type.

There is no evidence to suggest that an area of important habitat exists in the study area for any of the identified migratory species.

Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species

There is no evidence to suggest that an area of important habitat exists in the study area for any of the identified migratory species. Suitable measures would be incorporated into the Proposal to control the spread of weeds during the construction and operation of the road.

Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species

There is no evidence to suggest that an area of important habitat exists or that the study area is occupied by an ecologically significant proportion of a population of a migratory species.

Appendix D Flora list

KEY TO SYMBOLS USED IN APPENDIX D

ABBREVIATIONS:

i = introduced (i.e. not indigenous to Australia)

t = listed as a threatened species under State and/or Commonwealth legislation

r = RoTAP species

spp. = several species of the one genus (sometimes occurring as a hybrid swarm)

sp. = unidentified species[4]

sp. aff. = unidentified species with characteristics similar to the indicated species or genus[3]

? = unconfirmed species[4]

var. = variety

subsp. = subspecies

cv. = cultivar (i.e. a anthropogenic form of the species)

agg. = an aggregate of several yet to be defined species

NOTES:

1. Recent 'synonyms' include misapplied names.

2. The inclusion of Boraginaceae in Lamiales is tentative.

3. A sample flora assemblage obtained from a short term survey, such as the present one, cannot be considered to be comprehensive, but rather indicative of the actual flora assemblage. It can take many years of flora surveys to record all of the plant species occurring in any area, especially species that are only apparent in some seasons.

4. Not all species can be accurately identified in a ‘snapshot’ survey due to absence of flowering or fruiting material, etc.

SCIENTIFIC NAMES & AUTHORITIES:

Scientific names & families are those used in the *Flora of NSW* as maintained by the Royal Botanic Gardens (http://.plantnet.rbgsyd.gov.au).

Orders and higher taxa are based on Angiosperm Phylogeny Group (2003).

For sake of simplicity, scientific names in this list do not include authorities. These can be found in the *Flora of NSW*.

Classification/ Scientific name	Common Name	
Ferns		
ADIANTACEAE		
Adiantum hispidulum	Rough Maidenhair	
Cheilanthes sieberi subsp. *sieberi*	Slender Cloak-fern	
ASPLENIACEAE		
Asplenium australasicum	Birds-nest Fern	
AZOLLACEAE		
Azolla pinnata	Rufous Azolla	
BLECHNACEAE		
Blechnum cartilagineum	Gristle Fern	
Blechnum indicum	Swamp Water-fern	
Blechnum wattsii	Hard Water-fern	
Doodia aspera	Prickly Rasp-fern	
Doodia caudata	Small Rasp-fern	
CYATHEACEAE		
Cyathea australis	Rough Tree-fern	
Cyathea cooperi	Scaly Tree-fern	
Cyathea leichhardtiana	Prickly Tree-fern	
DAVALLIACEAE		
Nephrolepis cordifolia	Fishbone Fern	i
DENNSTAEDTIACEAE		
Calochlaena dubia	False Bracken	
Histiopteris incisa	Bats-wing Fern	
Hypolepis muelleri	Harsh Ground-fern	
Pteridium esculentum	Bracken	
DRYOPTERIDACEAE		

Classification/ Scientific name	Common Name	
Lastreopsis spp.	Shield-fern	
GLEICHENIACEAE		
Gleichenia dicarpa	Pouched Coral-fern	
LINDSAEACEAE		
Lindsaea linearis	Screw Fern	
Lindsaea microphylla	Lacy Wedge-fern	
OSMUNDACEAE		
Todea barbara	King Fern	
POLYPODIACEAE		
Platycerium bifurcatum	Elk-horn Fern	
Platycerium superbum	Stag-horn Fern	
SALVINIACEAE		
Salvinia molesta	Salvinia	i
THELYPTERIDACEAE		
Christella dentata	Christella	
Cyclosorus interruptus	Cyclosorus	
Cycads		
ZAMIACEAE		
Lepidozamia peroffskyana	Burrawang	
Macrozamia spp.	Burrawang	
Conifers		
ARAUCARIACEAE		
Araucaria cunninghamii	Hoop Pine	
PINACEAE		

Classification/ Scientific name	Common Name	
Pinus elliotti	Slash Pine	i
PODOCARPACEAE		
Podocarpus elatus	Brown Plum-pine	
Flowering Plants - Dicotyledons		
ACANTHACEAE		
Avicennia marina	Grey Mangrove	
Brunoniella australis	Blue Trumpet	
Pseuderanthemum variable	Pseuderanthemum	
AMARANTHACEAE		
Alternanthera denticulata	Lesser Joyweed	
AMYGDALACEAE		
Prunus spp.		
ANACARDIACEAE		
Euroschinus falcata	Ribbonwood	
APIACEAE		
Centella asiatica	Swamp Pennywort	
Cyclospermum leptophyllum	Slender Celery	i
Hydrocotyle peduncularis	Hairy Pennywort	
Hydrocotyle tripartita	Tre-foil Pennywort	
Trachymene incisa subsp. *incisa*	Native Carrot	
APOCYNACEAE		
Araujia hortorum	Moth Vine	i
Gomphocarpus fruticosus	Narrow-leaved Cotton Bush	i
Marsdenia longiloba	Slender Milk Vine	t
Marsdenia loydii		

Classification/ Scientific name	Common Name	
Marsdenia rostrata	Common Milk Vine	
Marsdenia suaveolens	Scented Marsdenia	
Melodinus australis	Southern Melodinus	
Nerium oleander	Oleander	i
Parsonsia straminea	Common Silkpod	
Tabernaemontana pandacaqui	Banana Bush	
ARALIACEAE		
Astrotricha latifolia	Broad-leaf Star-hair	
Cephalaralia cephalobotrys	Climbing Panax	
Polyscias murrayi	Pencil Cedar	
Polyscias sambucifolia	Elderberry Panax	
Schefflera actinophylla	Umbrella Tree	
ASTERACEAE		
Ageratina adenophora	Crofton Weed	i
Ageratina houstonianum	Blue Bilygoat Weed	i
Ambrosia spp.	Ragweed	i
Aster subulatus	Wild Aster	i
Baccharis halimifolia	Groundsel Bush	i
Bidens pilosa	Cobblers Peg	i
Centipida minima subsp. *minima*	Spreading Sneeze Weed	
Centratherum punctatum subsp. australianum		i
Chrysocephalum apiculatum	Yellow Buttons	
Cirsium vulgare	Spear Thistle	i
Conyza spp.	Fleabane	i
Cotula australis	Lawn Cotula	
Cotula coronopifolia	Water Buttons	

Classification/ Scientific name	Common Name	
Crassocephalum crepidoides	Thickhead	i
Enydra fluctuans	Enydra	
Epaltes australis	Spreading Nut-heads	
Erechtites valerianifolia	Brazilian Fireweed	i
Euchiton sphaericus		
Gamochaeta spicata	Cudweed	i
Hypochoeris radicata	Flatweed	i
Lagenophora stipitata	Bottle-daisy	
Leptinella longipes	Leptinella	
Olearia nernstii	Daisy-bush	
Ozothamnus diosmifolius	Tall Paperdaisy	
Senecio linearifolius	Fireweed Grounsel	
Senecio madagascariensis	Fireweed	i
Sigesbeckia orientalis	Indian Weed	
Sonchus oleraceus	Common Sow-thistle	i
Tagetes minuta	Stinking Roger	i
Vernonia cinerea var. *cinerea*	Vernonia	
BIGNONIACEAE		
Jacaranda mimosifolia	Jacaranda	i
Pandorea jasminoides	Bower Vine	
Pandorea pandorana	Wonga Vine	
BORAGINACEAE		
Ehretia acuminata var. *acuminata*	Koda	
BRASSICACEAE		
Lepidium africanus	Peppercress	i
CAMPANULACEAE		

Classification/ Scientific name	Common Name	
Wahlenbergia spp.	Bluebell	
CAPPARACEAE		
Capparis arborea	Coastal Native Orange	
CAPRIFOLIACEAE		
Lonicera japonica	Honeysuckle	i
CARYOPHYLLACEAE		
Stellaria media	Common Chickweed	i
CASUARINACEAE		
Allocasuarina littoralis	Black She-oak	
Allocasuarina torulosa	Forest Oak	
Casuarina glauca	Swamp Oak	
CELASTRACEAE		
Celastrus subspicata	Large-leaf Staff Vine	
Denhamia pittosporoides subsp. pittosporoides	Veiny Denhamia	
Maytenus silvestris	Forest Maytenus	
CHENOPODIACEAE		
Einadia hastata	Shrubby Berry-saltbush	
Sarcocornia quinqueflora	Samphire	
Suaeda australis	Seablite	
CLUSIACEAE		
Hypericum gramineum	Narrow-leaf St. Johns Wort	
Hypericum japonicum	Matted St. Johns Wort	
CONVOLVULACEAE		
Dichondra repens	Kidney Weed	
Ipomoea cairica	Coastal Morning Glory	i
Ipomoea indica	Blue Morning Glory	i

Classification/ Scientific name	Common Name	
Ipomoea purpurea	Purple Morning Glory	i
Polymeria calycina	Woodland Bindweed	
CUNONIACEAE		
Callicoma serratifolia	Black Wattle	
Schizomeria ovata	Crab-apple	
DILLENIACEAE		
Hibbertia aspera	Rough Guinea-flower	
Hibbertia dentata	Twining Guinea-flower	
Hibbertia linearis	Narrow-leaf Guinea-flower	
Hibbertia scandens	Climbing Guinea-flower	
Hibbertia vestita	Hairy Guinea-flower	
DROSERACEAE		
Drosera sphathulata	Common Sundew	
EBENACEAE		
Diospyros australis	Black Plum	
Diospyros pentamera	Myrtle Ebony	
ERICACEAE		
Leucopogon juniperinus	Juniper Beard-heath	
Leucopogon lanceolatus var. gracilis		
Monotoca scoparia	Prickly Broom-heath	
Trochocarpa elliptica	Tree Heath	
ELAEOCARPACEAE		
Elaeocarpus obovatus	Hard Quandong	
Elaeocarpus reticulatus	Blueberry Ash	
Sloanea australis	Maidens Blush	
Sloanea woollsii	Yellow Carabeen	

Classification/ Scientific name	Common Name	
Tetratheca thymifolia	Thyme-leaf Black-eyed Susan	
EUPHORBIACEAE		
Acalypha nemorum		
Alchornea ilicifolia	Native Holly	
Baloghia inophylla	Brush Bloodwood	
Breynia oblongifolia	Breynia	
Claoxylon australe	Brittlewood	
Croton verreauxii	Green Native Cascarilla	
Glochidion ferdinandi var. ferdinandi	Cheese Tree	
Glochidion ferdinandi var. pubens	Cheese Tree	
Omalanthus populifolius	Bleeding Heart	
Phyllanthus gunnii	Blunt Spurge	
Poranthera microphylla	Small Poranthera	
Ricinus communis	Castor Oil Plant	i
EUPOMATIACEAE		
Eupomatia laurina	Bolwarra	
FABACEAE		
CAESALPINIOIDEAE		
Senna pendula var. *glabrata*	Cassia	i
Senna septemtrionalis	Cassia	i
FABOIDEAE		
Austrosteenisia blackii	Blood Vine	
Crotalaria lanceolata subsp. lanceolata		
Daviesia ulicifolia	Gorse Bitter-pea	
Derris involuta	Derris	
Desmodium nemorosum		

Classification/ Scientific name	Common Name	
Desmodium rhytidophyllum	Rusty Tick-trefoil	
Desmodium varians	Slender Tick-trefoil	
Erythrina x *sykesii*	Coral Tree	i
Glycine clandestina agg.	Twining Glycine	
Glycine tabacina agg.		
Gompholobium pinnatum	Pinnate Wedge-pea	
Hardenbergia violacea	Purple Twining-pea	
Hovea acutifolia		
Indigofera australis	Native Indigo	
Jacksonia scoparia	Dogwood	
Lespedeza striata	Japanese Clover	i
Kennedia rubicunda	Dusky Coral Pea	
Macroptilium atropurpureum	Siratro	i
Pultanaea retusa	Blunt-leaf Bush-pea	
Pultanaea villosa	Wallaby Tails	
Trifolium repens	White Clover	i
Vigna luteola	Dalrymple Vigna	
Zornia dyctiocarpa var. dyctiocarpa	Zornia	
MIMOSOIDEAE		
Acacia baileyana	Cootamundra Wattle	
Acacia binervata	Two-veined Hickory	
Acacia concurrens	Curracabah	
Acacia falcata	Sickle Wattle	
Acacia fimbriata	Fringed Wattle	
Acacia floribunda	Sally Wattle	
Acacia implexa	Hickory	

Classification/ Scientific name	Common Name	
Acacia irrorata subsp. *irrorata*	Rough Green Wattle	
Acacia irrorata subsp. *velutinella*		
Acacia linifolia	Flax-leaf Wattle	
Acacia longifolia	Sydney Golden Wattle	
Acacia longissima	Thin-leaf Wattle	
Acacia maidenii		
Acacia melanoxylon	Blackwood	
Acacia myrtifolia	Myrtle Wattle	
Acacia podalyriifolia	Queensland Silver Wattle	i
Acacia ulicifolia	Prickly Moses	
Archidendron grandiflorum	Pink Lace Flower	
Parachidendron pruinosum	Snow-wood	
FLACOURTIACEAE		
Scolopia braunii	Flintwood	
GENTIANACEAE		
Centaurium spicatum	Spiked Centaury	
GERANIACEAE		
Geranium solanderi var. *solanderi*	Native Cranesbill	
GOODENIACEAE		
Dampiera sylvestris		
Dampieria stricta	Blue Dampieria	
Goodenia hederacea subsp. *hederacea*	Ivy-leaf Goodenia	
Goodenia heterophylla	Variable-leaf Goodenia	
Goodenia ovata	Ovate Goodenia	
Goodenia paniculata	Panicled Goodenia	
Goodenia rotundifolia		

Classification/ Scientific name	Common Name	
HALORAGACEAE		
Gonocarpus humilis		
Gonocarpus chinensis		
Gonocarpus micranthus subsp. *micranthus*	Creeping Raspwort	
Gonocarpus teucroides	Raspwort	
Myriophyllum spp.	Water-milfoil	
LAMIACEAE		
Lycopus australis	Australian Gipsywort	
Mentha satureioides	Creeping Mint	
LAURACEAE		
Beilschmiedia elliptica	Grey Walnut	
Cassytha glabella	Devils Twine	
Cassytha pubescens	Devils Twine	
Cinnamomum camphora	Camphor Laurel	i
Cinnamomum oliveri	Oliver's Sassafras	
Cinnamomum virens	Red-barked Sassafras	
Cryptocarya glaucescens	Native Laurel	
Cryptocarya microneura	Murrogun	
Cryptocarya obovata	Pepperberry	
Cryptocarya rigida	Forest Maple	
Endiandra discolor	Rose Walnut	
Endiandra sieberi	Cork Wood	
Litsea australis	Brown Bolly Gum	
Litsea reticulata	Bolly Gum	
Neolitsea dealbata	White Bolly Gum	
LOBELIACEAE		

Classification/ Scientific name	Common Name	
Isotoma fluviatilis subsp. Borealis	Swamp Isotoma	
Lobelia alata	Angled Lobelia	
Lobelia gibbosa	Lobelia	
Lobelia gracilis	Trailing Lobelia	
Lobelia trigonocaulis	Forest Lobelia	
Pratia concolor	Poison Pratia	
Pratia purpurescens	White Root	
LOGANIACEAE		
Mitrasacme alsinoides		
LORANTHACEAE		
Amyema miquelii	Drooping Mistletoe	
Amylotheca dictyophleba	Rainforest Mistletoe	
LYTHRACEAE		
Lythrum hyssopifolia	Hyssop Loosestrife	
MALACEAE		
Cotoneaster glaucophyllus	Cotoneaster	i
MALVACEAE		
Abutilon oxycarpum	Straggly Lantern-bush	
Hibiscus heterophyllus	Native Rosella	
Hibiscus splendens	Pink Cottonwood	
Modiola caroliniana	Red-flowered Mallow	i
Sida rhombifolia	Paddys Lucerene	i
MENISPERMACEAE		
Sarcopetalum harveyanum	Pearl Vine	
Stephania japonica	Snake Vine	
MONIMIACEAE		

Classification/ Scientific name	Common Name	
Daphnandra micrantha	Socket Wood	
Doryphora sassafras	Sassafras	
Palmeria scandens	Anchor Vine	
Wilkiea huegeliana	Wilkiea	
MELASTOMATACEAE		
Melastoma affine	Native Lassiandra	
MELIACEAE		
Dysoxylum fraserianum	Rosewood	
Dysoxylum rufum	Hairy Rosewood	
Melia azedarach	White Cedar	
Synoum glandulosum	Scentless Rosewood	
Toona ciliata	Red Cedar	
MENYANTHACEAE		
Nymphoides geminata	Marshwort	
Villarsia exaltata	Villarsia	
Villarsia reniformis		
MORACEAE		
Ficus benjamina	Weeping Fig	i
Ficus coronata	Creek Sandpaper Fig	
Ficus frasei	Frasers Sandpaper Fig	
Ficus rubiginosa	Port Jackson Fig	
Ficus watkinsiana	Strangling Fig	
Maclura cochinchinensis	Cockspur Thorn	
Trophis scandens subsp. scandens	Burny Vine	
MYRSINACEAE		
Anagallis arvensis	Pimpernell	i

Classification/ Scientific name	Common Name	
Ardisia crenata	Coral Berry	
Embelia australiana	Embelia	
Myrsine howittiana	Brush Muttonwood	
Myrsine variabilis	Variable Muttonwood	
MYRTACEAE		
EUCALYPTS		
Angophora costata	Smooth-barked Apple	
Corymbia gummifera	Red Bloodwood	
Corymbia intermedia	Pink Bloodwood	
Corymbia maculata	Spotted Gum	
Eucalyptus acmenoides	White Mahogany	
Eucalyptus ancophila		
Eucalyptus grandis	Flooded Gum	
Eucalyptus microcorys	Tallowwood	r
Eucalyptus paniculata subsp. *paniculata*	Grey Ironbark	
Eucalyptus pilularis	Blackbutt	
Eucalyptus propinqua	Small-fruited Grey Gum	
Eucalyptus resinifera subsp. *hemilampra*	Red Mahogany	
Eucalyptus robusta	Swamp Mahogany	
Eucalyptus saligna	Sydney Blue Gum	
Eucalyptus siderophloia	Northern Grey Ironbark	
Eucalyptus signata	Northern Scribbly Gum	
Eucalyptus tereticornis	Forest Red Gum	
OTHER MYRTACEAE		
Acmena smithii	Lilly Pilly	
Archirhodomyrtus beckleri	Rose Myrtle	

Classification/ Scientific name	Common Name	
Sannantha similis		
Backhousia myrtifolia	Grey Myrtle	
Baeckea linifolia	Weeping Baeckea	
Callistemon salignus	Willow Bottlebrush	
Callistemon viminalis	Weeping Bottlebrush	n
Gossia acmenoides	Scrub Ironwood	
Leptospermum juniperinum	Prickly Teatree	
Leptospermum polygalifolium	Yellow Tea-tree	
Lophostemon confertus	Brush Box	
Lophostemon sauveolens	Swamp Turpentine	
Melaleuca linariifolia	Snow-in-Summer	
Melaleuca quinquenervia	Broad-leaved Paperbark	
Melaleuca styphelioides	Prickly Paperbark	
Pilidiostigma glabrum		
Rhodamnia rubescens	Brush Turpentine	
Rhodomyrtus psidioides	Native Guava	
Sannantha similis		
Syncarpia glomulifera	Turpentine	
Syzygium australe	Brush Cherry	
Syzygium luehmannii	Small-leaved Lilly Pilly	
Syzygium oleosum	Blue Lilly Pilly	
Tristaniopsis laurina	Water Gum	
Waterhousea floribunda	Weeping Lilly Pilly	
NYCTAGINACEAE		
Pisonia umbellifera		
NYMPAEACEAE		

Classification/ Scientific name	Common Name	
Nymphaea spp.	Waterlily	
OLEACEAE		
Jasminum suavissimum		
Ligustrum lucidum	Large-leaf Privet	i
Ligustrum sinense	Small-leaf Privet	i
Notelaea longifolia	Large Mock Olive	
Notelaea venosa	Smooth Mock Olive	
Olea paniculata	Native Olive	
ONAGRACEAE		
Ludwigia peploides subsp. *montevidensis*	Water Primrose	
OXALIDACEAE		
Oxalis chnoodes		
Oxalis exilis	Yellow Oxalis	
Oxalis perennans		
PASSIFLORACEAE		
Passiflora edulis	Passion-fruit	i
Passiflora herbertiana	Yellow Passion-flower	
Passiflora subpeltata	White Passion-flower	i
PHYTOLACCACEAE		
Phytolacca octandra	Inkweed	i
PITTOSPORACEAE		
Billardiera scandens	Apple-berry	
Pittosporum multiflorum	Orange Thorn	
Pittosporum revolutum	Yellow Pittosporum	
Pittosporum undulatum	Native Daphne	
PLANTAGINACEAE		

Classification/ Scientific name	Common Name	
Plantago lanceolata	Plantain	i
Plantago major	Large Plantain	i
POLYGONACEAE		
Acetosa sagittata	Rambling Dock	i
Persicaria decipiens	Slender Knotweed	
Persicaria dichotoma		
Persicaria hydropiper	Water Pepper	
Persicaria lapathifolia	Pale Knotweed	
Persicaria strigosa	Spotted Knotweed	
Rumex crispus	Curled Dock	i
PROTEACEAE		
Banksia ericifolia	Heath-leaved Banksia	n
Banksia integrifolia	Coastal Banksia	
Banksia serrata	Saw Banksia	
Banksia spinulosa var. *collina*	Hill Banksia	
Grevillea spp. (hybrid)		
Grevillea robusta	Silky Oak	n
Hakea salicifolia	Willow Hakea	
Helicia glabriflora	Smooth Helicia	
Lomatia silaifolia	Crinkle Bush	
Persoonia stradbronensis		
Stenocarpus sinuatus	Firewheel Tree	
RANUNCULACEAE		
Clematis aristata	Toothed Clematis	
Ranunculus inundatus	River Buttercup	
RHAMNACEAE		

Classification/ Scientific name	Common Name	
Alphitonia excelsa	Red Ash	
Pomaderris ferruginea		
ROSACEAE		
Rubus ellipticus	Yellow Raspberry	i
Rubus fruticosus agg.	Blackberry	i
Rubus hillii	Braod-leaf Bramble	
Rubus nebulosus	Green-leaved Bramble	
Rubus parviflorus	Small-leaf Bramble	
Rubus rosifolius	Rose-leaf Bramble	
ROUSSEACEAE		
Abrophyllum ornans	Native Hydrangea	
RUBIACEAE		
Atractocarpus benthamianus		
Cyclophyllum longipetalum	Coast Canthium	
Hodgkinsonia ovatiflora		
Morinda jasminoides	Morinda	
Opercularia aspera	Common Stinkweed	
Pomax umbellata	Pomax	
Psychotria loniceroides	Hairy Psychotria	
Psydrax lamprophylla	Large-leaved Canthium	
Richardia brasiliensis	Mexican Clover	i
Richardia stellaris		i
RUTACEAE		
Acronychia oblongifolia	Common Acronychia	
Asterolasia correifolia		
Citrus limonia	Lemon	i

Classification/ Scientific name	Common Name	
Melicope hayesii	Small-leaved Doughwood	
Melicope micrococca	White Euodia	
Zieria smithii	Sandfly Zieria	
SALICACEAE		
Salix babylonica	Weeping Willow	i
SANTALACEAE		
Exocarpos cupressiformis	Cherry Ballart	
SAPINDACEAE		
Alectryon subcinereus	Native Quince	
Arytera divaricata	Coogera	
Cupaniopsis anacardioides	Tuckeroo	
Cupaniopsis parviflora	Small-leaved Tuckeroo	
Diploglottis cunninghamii	Native Tamarind	
Dodonaea triquetra	Hop Bush	
Elattostachys nervosa	Green Tamarind	
Guioa semiglauca	Guioa	
Jagera pseudorhus	Foambark Tree	
Mischocarpus australis		
Mischocarpus pyriformis subsp. *pyriformis*	Pear-fruited Tamarind	
SAPOTACEAE		
Niemeyera whitei	Rusty Plum	t
Planchonella australis	Black Apple	
SCROPHULARIACEAE		
Artanema fimbriatum		
Veronica calycina	Common Speedwell	
SOLANACEAE		

Classification/ Scientific name	Common Name	
Duboisia myoporoides	Poison Corkwood	
Solanum aviculare	Kangaroo Apple	
Solanum erianthum	Potato Tree	
Solanum mauritianum	Wild Tobacco	i
Solanum nigrum	Black Nightshade	i
Solanum prinophyllum	Forest Nightshade	
Solanum stelligerum	Star Nightshade	
STACKHOUSIACEAE		
Stackhousia muricata		
STERCULIACEAE		
Commersonia fraseri	Brush Kurrajong	
Heritiera actinophylla	Black Booyong	
Heritiera trifoliolata	White Booyong	
Rulingia dasyphylla	Kerrawang	
Seringea arborescens	Seringia	
STYLIDIACEAE		
Stylidium debile	Frail Trigger Plant	
SYMPLOCACEAE		
Symplocos stawellii	White Hazelwood	
Symplocos thwaitesii	Buff Hazelwood	
THYMELEACEAE		
Pimelea linifolia subsp. *linifolia*	Slender Rice Flower	
Wikstroemia indica	Wikstroemia	
ULMACEAE		
Trema tomentosa	Native Peach	
VERBENACEAE		

Classification/ Scientific name	Common Name	
Clerodendrum tomentosum	Hairy Clerodendrum	
Duranta repens	Pigeonberry	i
Gmelina leichardtii	White Beech	
Lantana camara	Lantana	i
Verbena bonariensis	Purple Top	i
Verbena rigidus	Creeping Verbena	i
VIOLACEAE		
Hybanthus monopetalus	Slender Violet-bush	
Hybanthus stellarioides		
Viola betonicifolia	Showy Violet	
Viola hederacea	Ivy-leaf Violet	
VISCACEAE		
Notothixos incanus		
VITACEAE		
Cayratia clematidea	Slender Grape	
Cissus antarctica	Water Vine	
Cissus hypoglauca	Five-leaf Water Vine	
Cissus opaca	Pepper Vine	
Cissus sterculiifolia		
Tetrastigma nitens	Three-leaf Water Vine	
WINTERACEAE		
Tasmannia insipida	Brush Pepperbush	
AGAVACEAE		
Agave spp.	Century Plant	

Classification/ Scientific name	Common Name	
ALLIACEAE		
Agapanthus spp.	Agapanthus	i
ALSTROEMERIACEAE		
AMARYLLIDACEAE		
Crinum pedunculatum	Stream Lily	
ANTHERICACEAE		
Caesia parviflora var. parviflora	Pale Grass-lily	
Thysanotus tuberosus subsp. *tuberosus*	Common Fringe-lily	
Tricoryne elatior	Yellow Rush-lily	
ARACEAE		
Alocasia brisbaniensis	Cunjevoi	
Arum italicum	Italian Arum Lily	i
Gymnostachys anceps	Caterpiller Flower	
ARECACEAE		
Archontophoenix cunninghamiana	Bangalow Palm	
Calamus muelleri	Southern Lawyer Cane	
Linospadix monostachya	Walking Stick Palm	
Livistona australis	Cabbage Tree Palm	
ASPARAGACEAE		
Protasparagus aethiopicus	Asparagus Fern	i
Protasparagus plumosus	Climbing Asparagus Fern	i
ASTELIACEAE		
Cordyline stricta	Narrow-leaf Palm-lily	
CANNACEAE		
Canna indica	Canna lily	i
COMMELINACEAE		

Classification/ Scientific name	Common Name	
Commelina cyanea	Scurvy Weed	
Tradescantia albiflora	Wandering Jew	i
CYPERACEAE		
Baumea articulata	Jointed Twig-rush	
Baumea juncea	Slender Twig-rush	
Baumea rubiginosa	Soft Twig-rush	
Baumea teretifolia	Wrinkle-nut Twig-rush	
Carex appressa	Tussock Tassel-sedge	
Carex fascicularis	Drooping Tassel-sedge	
Cyperus brevifolius	Mullumbimby Couch	
Cyperus eragrostis	Umbrella Sedge	i
Cyperus exaltatus	a tall leafy-bract sedge	
Cyperus filipes		
Cyperus imbecillis		
Cyperus polystachyos	Bunchy Flat-sedge	
Cyperus sesquiflorus	Mullumbimy Couch	
Cyperus unioloides		
Eleocharis dietrichiana	Spike-rush	
Eleocharis gracilis	Slender Spike-rush	
Eleocharis sphacelata	Tall Spike-rush	
Fimbristylis dichotoma	Common Fringe-rush	
Gahnia aspera	Rough Saw-sedge	
Gahnia clarkei	Tall Saw-sedge	
Gahnia sieberiana	Red-fruited Saw-sedge	
Isolepis cernua	Nodding Club-rush	
Isolepis inundata	Club-rush	

Classification/ Scientific name	Common Name	
Lepidosperma concavum		
Lepidosperma laterale	Variable Sword-sedge	
Lepidosperma viscidum		
Ptilothrix deusta	Ptilanthelium	
Schoenoplectus litoralis	Coast Club-rush	
Schoenoplectus mucronatus	Angled Club-rush	
Schoenoplectus validus	River Club-rush	
Schoenus apogon	Common Bog-rush	
Schoenus melanostachys	Black Bog-rush	
DIOSCOREACEAE		
Dioscorea transversa	Native Yam	
FLAGELLARIACEAE		
Flagellaria indica	Whip Vine	
HYDROCHARITACEAE		
Valisneria gigantea	Eel-weed	
HYPOXIDACEAE		
Curculigo ensifolia		
Hypoxis hygrometrica var. *villosisepela*	Yellow Weather-grass	
IRIDACEAE		
Aristea ecklonii		
Patersonia sericea var. *sericea*	Basal-leaf Purple-flag	
Sisyrinchium sp. A	Scourweed	i
Watsonia meriana cv. 'Bulbillifera'	Wild Watsonia	i
JUNCACEAE		
Juncus continuus	Sand Rush	
Juncus cognatus	Rush	i

Classification/ Scientific name	Common Name	
Juncus kraussii subsp. *australiensis*	Saltmarsh Rush	
Juncus mollis		
Juncus planifolius	Broadleaf Rush	
Juncus polyanthemus	Many-flowered Rush	
Juncus usitatus	Common Rush	
JUNCAGINACEAE		
Triglochin microtuberosum	Small-tubered Water Ribbons	
Triglochin procerum sens. st.	Twisted Water Ribbons	
Triglochin striatum	Streaked Arrowgrass	
LILIACEAE		
Lilium formosum	Formosa Lily	i
LOMANDRACEAE		
Lomandra confertifolia subsp. *rubiginosa*	Slender Mat-rush	
Lomandra filiformis subsp. *coriacea*	Wattle Mat-rush	
Lomandra longifolia subsp. *longifolia*	Spiny Mat-rush	
Lomandra multiflora subsp. *multiflora*	Many-flowered Mat-rush	
LUZURIAGACEAE		
Eustrephus latifolius	Wombat Berry	
Geitonoplesium cymosum	Scrambling Lily	
ORCHIDACEAE		
Calanthe triplicata	Christmas Orchid	
Chiloglottis spp. ?	Ant Orchid	
Chiloglottis trilabra		
Corybas barbarae	Helmet-orchid	
Cryptostylis erecta	Stried Hood	
Cymbidium madidum		

Classification/ Scientific name	Common Name	
Cymbidium suave	Snake Flower	
Dendrobium kingianum	Pink Rock Orchid	
Dipodium variegatum	Hyacinth Orchid	
Microtis unifolia	Onion-orchid	
Plectorrhiza tridentata	Tangle Orchid	
Pterostylis spp.	Greenhood	
Sarcochilus spp.		
Siranthes sinensis var. *australis*	Austral Ladies Tresses	
Thelymitra spp.	Sun-orchid	
PHILYDRACEAE		
Philydrum lanuginosum	Frogsmouth	
PHORMIACEAE		
Dianella caerulea var. *caerulea*	Leafy Blue Flax Lily	
Dianella caerulea var. *producta*	Stemmed Blue Flax Lily	
Dianella tasmanica		
POACEAE		
Andropogon virginicus	Whisky Grass	i
Aristida ramosa	Three-awned Spear Grass	
Aristida vagans	Three-awned Spear Grass	
Arundo donax	Giant Reed	i
Axonopus fissifolius	Carpet Grass	i
Bothriochloa macra	Red-leg Grass	
Briza maxima	Quaking Grass	i
Briza minor	Shivery Grass	i
Bromus catharticus	Prarie Grass	i
Capillipedium spicigerum	Scented-top Grass	

Classification/ Scientific name	Common Name	
Chloris gayana	Rhodes Grass	i
Cymbopogon refractus	Barbed Wire Grass	
Cynodon dactylon	Common Couch	n
Deyeuxia quadriseta	Reed Bent-grass	
Dichelachne micrantha	Short-hair Plume Grass	
Digitaria parviflora	Small-flower Finger Grass	
Echinochloa crus-galli	Barnyard Grass	i
Echinopogon caespitosus	Hedgehog Grass	
Echinopogon ovatus	Hedgehog Grass	
Ehrharta erecta	Panic Veldtgrass	i
Entolasia marginata	Margined Panic	
Entolasia stricta	Wiry Panic	
Eragrostis spp.	Lovegrass	
Eragrostis brownii	Brown's Lovegrass	
Eragrostis curvula	African Lovegrass	i
Eragrostis tenuifolia	Elastic Grass	i
Eriochlora crebra	Cup Grass	
Hemarthria uncinata var. uncinata	Matgrass	
Hyparrhenia hirta	Coolatai Grass	i
Imperata cylindrica	Blady Grass	
Isachne globosa	Swamp Millet	
Ischaemum australe var. australe	Ischaemum	
Joycea pallida	Red-anthered Wallaby Grass	
Lachnagrostis filiformis	Blown Grass	
Lolium spp. (hybrid swarm)	Rye Grass	i
Melinis repens	Red Natal Grass	i

Classification/ Scientific name	Common Name	
Microlaena stipoides var. *stipoides*	Weeping Grass	
Oplismenus aemulus	Broad-leaf Beard-grass	
Oplismenus imbecillis	Narrow-leaf Beard-grass	
Oplismenus undulatifolius var. *mollis*	Basket Grass	
Ottochloa gracillima		
Panicum maximum var. *maximum*	Guinea Grass	i
Paspalidium aversum		
Paspalum dilatatum	Paspalum	i
Paspalum distichum	Water Couch	
Paspalum orbiculare	Ditch Millet	
Paspalum urvillei	Vasey Grass	i
Paspalum vaginatum	Salt-water Couch	
Paspalum wettsteinii	Broad-leaf Paspalum	i
Pennisetum clandestinum	Kikuyu	i
Phragmites australis	Common Reed	
Poa labillardieri	Tussock Grass	
Poa siebriana	Snowgrass	
Setaria gracilis	Slender Pigeon Grass	i
Setaria sphaceulata	South African Pigeon Grass	i
Sporobolus africanus	Parramatta Grass	i
Sporobolus creber	Slender Rats Tail Grass	
Sporobolus virginicus var. *minor*	Saltmarsh Couch	
Stenotaphrum secundatum	Buffalo Grass	i
Themeda australis	Kangaroo Grass	
Zoysia macrantha	Prickly Couch	
RIPOGONACEAE		

Classification/ Scientific name	Common Name
Ripogonum album	White Supplejack
Ripogonum fawcettianum	Small Supplejack
SMILACACEAE	
Smilax australis	Lawyer Vine
Smilax glyciphylla	Sweet Sarsparilla
TYPHACEAE	
Typha orientalis	Broad-leaf Cumbungi
UVULARIACEAE	
Schelhammera undulata	Lilac Lily
Tripladenia cunninghamii	Kresigia
XANTHORRHOEACEAE	
Xanthorrhoea macronema	Narrow-scape Grass-tree
ZINGIBERACEAE	
Alpinia caerulea var. *caerulea*	Native Ginger

Appendix E Vegetation community descriptions

Map Unit 1: Open Forest - Blackbutt
Canopy: *Eucalyptus pilularis, Eucalyptus microcorys, Corymbia intermedia, Eucalyptus propinqua, Syncarpia glomulifera, Angophora costata, Eucalyptus acmenoides, Corymbia gummifera* Subcanopy: *Allocasuarina torulosa, Glochidion ferdinandi, Synoum glandulosum, Alphitonia excelsa, Allocasuarina littoralis*
Structure: Canopy 15-25m; 30-50% foliage cover Subcanopy 8-15m; 10-40% foliage cover
Shrubs: *Dodonaea triquetra, Polyscias sambucifolia, Indigofera australis, Acacia falcata, Daviesia ulicifolia, Leptospermum polygalifolium, Acacia longifolia, Hibbertia vestia, Pultenaea rutusa, Persoonia stradbrokensis, Acacia myrtifolia, Acacia ulicifolia, Monotoca scoparia, Jacksonia scoparia, Pimelea linifolia, Lomatia silaifolia, Lantana camara* Grasses: *Entolasia stricta, Imperata cylindrica, Themeda australis* Herbs: *Pteridium esculentum, Pratia purpurascens, Dampiera stricta, Viola hederacea, Patersonia sericea, Goodenia heterophylla, Thysanotus tuberosus, Pseuderanthemum variable, Dianella caerulea, Tricoryne elatior* Sedges/Rushes: *Lepidosperma laterale, Lomandra filiformis, Gahnia clarkei, Lomandra longifolia* Vines/Twiners: *Hardenbergia violacea, Glycine clandestina, Hibbertia scandens, Billardiera scandens, Cassytha glabella, Desmodium rhytophyllum, Rubus hillii, Eustrephus latifolius, Geitonoplesium cymosum*
Weed Abundance: Weed species are generally restricted to disturbed/regenerating areas of this community such as the edges of the existing highway. Some trails in the State Forest areas are dominated by *Paspalum wettsteinii* and *Lantana camara* is abundant in some sheltered areas with higher soil moisture content.
Equivalent Communities: Ecosystem 34: Dry Grassy Blackbutt-Tallowwood (Kendall & Kendall 2003); Ecosystem 72: Low Relief Coastal Blackbutt (Kendall & Kendall 2003); North Coast dry sclerophyll Forests (Keith 2006).
Rare and Threatened Species: *Marsdenia longiloba* (Endangered, *TSC Act*; Vulnerable EPBC Act) occurs in sheltered locations of this community in ecotonal areas between this community and moist forest communities in gully areas.
Status: Very Common

Map Unit 2: Mixed Floodplain Forest
Canopy: *Eucalyptus grandis, Eucalyptus tereticornis, Melaleuca quinquenervia, Casuarina glauca, Eucalyptus siderophloia, Eucalyptus resinifera, Corymbia intermedia* Subcanopy: *Glochidion ferdinandi, Alphitonia excelsa, Schizomeria ovata, Melaleuca styphelioides, Guioa semiglauca, Ficus coronata, Acmena smithii, Archontophoenix cunninghamiana, Livistonia australis, Endiandra discolor, Sloanea woollsii, Acronychia oblongifolia, Synoum glandulosum, Cryptocarya rigida, Backhousia myrtifolia, Allocasuarina torulosa*
Structure: Canopy 20-30m; 40-60% foliage cover Subcanopy 8-15m; 30-90% foliage cover
Shrubs: *Tabernaemontana pandacaqui, Lantana camara, Breynia oblongifolia, Notelaea venosa, Diospyros australis, Wilkiea huegeliana, Litsea reticulata, Croton verreauxii, Cordyline stricta, Clerodendrum tomentosum, Myrsine variabilis, Pittosporum multiflorum, Polyscias sambucifolia, Psychotria loniceroides, Tasmannia insipida, Archirhodomyrtus beckleri* Grasses: *Entolasia marginata, Oplismenus imbecillis, Oplismenus aemulus, Paspalum wettsteinii* Herbs: *Pseuderanthemum variable, Calanthe triplicata, Dianella caerulea, Blechnum cartilagineum, Doodia aspera, Lobelia gracilis, Viola hederacea, Tripladenia cunninghamii, Hydrocotyle peduncularis, Hypolepis muellerii, Alpinia caerulea* Sedges/Rushes: *Gahnia clarkei, Lomandra longifolia* Vines/Twiners: *Cissus hypoglauca, Pandorea pandorana, Parsonsia straminea, Dioscorea transversa, Cissus steruliifolia, Smilax australis, Ripogonum fawcettianum, Morinda jasminoides, Rubus nebulosus, Stephania japonica, Rubus parviflora, Rubus hillii, Cissus antarctica, Geitonoplesium cymosum*
Weed Abundance: *Lantana camara* is abundant in some areas of this community, and is particularly dense in the ecotonal areas where the subcanopy is not as thick and there is more sunlight reaching the shrub layer. Lantana camara is generally absent or occurs in low abundance where there is a thick subcanopy of rainforest species. Some trails in the State Forest areas which traverse through this community are dominated by *Paspalum wettsteinii*, and this species has spread into this community in some areas.

Map Unit 2: Mixed Floodplain Forest
Equivalent Communities: Ecosystem 154: Wet Flooded Gum-Tallowwood (Kendall & Kendall 2003); Ecosystem 168; Rainforest (Kendall & Kendall 2003); Ecosystem 73: Lowland Red Gum; North Coast Wet Sclerophyll Forests (Keith 2006).
Rare and Threatened Species: *Marsdenia longiloba* (Endangered, *TSC Act*; Vulnerable EPBC Act) occurs in this community where the soil drainage is better, generally comprising slightly elevated areas adjacent to drainage lines and ecotonal areas between this community and Blackbutt Open Forest. *Amorphospermum whitei* was recorded in one location adjacent to Boggy Creek on private property. One RoTAP species *Eucalyptus ancophila* is present in this community in Nambucca and Newry State Forests.
Status: EEC. Subtropical Coastal Floodplain Forest

Map Unit 3: Moist Forest – White Mahogany / Grey Gum / Ironbark
Canopy: *Eucalyptus acmenoides, Eucalyptus propinqua, Eucalyptus siderophloia, Syncarpia glomulifera, Corymbia intermedia, Eucalyptus resinifera, Eucalyptus microcorys, Eucalyptus grandis, Eucalyptus paniculata* Subcanopy: *Allocasuarina torulosa, Allocasuarina littoralis, Synoum glandulosum, Myrsine howittiana, Acacia melanoxylon*
Structure: Canopy 18-25m; 30-60% foliage cover Subcanopy 8-12m; 30-50% foliage cover
Shrubs: *Tabernaemontana pandacaqui, Lantana camara, Cordyline stricta, Notelaea venosa, Wilkiea huegeliana* Grasses: *Entolasia marginata, Entolasia stricta, Oplismenus imbecillis, Imperata cylindrica, Oplismenus aemulus, Poa siebriana* Herbs: *Calochlaena dubia, Pseuderanthemum variable, Dianella caerulea, Blechnum cartilagineum, Lagenophora stipitata, Goodenia heterophylla, Gymnostachys anceps, Schelhammera undulata* Sedges/Rushes: *Lomandra longifolia, Gahnia clarkei* Vines/Twiners: *Morinda jasminoides, Hibbertia dentata, Pandorea pandorana, Parsonsia straminea, Smilax australis, Ripogonum fawcettianum, Smilax glyciphylla, Cissus hypoglauca*
Weed Abundance: Apart from a moderate abundance of Lantana camara, this community is relatively free of invasive weed species. *Lantana camara* has a higher abundance on the edges of this community due to additional light aiding its growth in these areas.
Equivalent Communities: Ecosystem 85: Mixed Moist Hardwood (Kendall & Kendall 2003); North Coast Wet Sclerophyll Forests (Keith 2006).
Rare and Threatened Species: *Marsdenia longiloba* (Endangered, *TSC Act*; Vulnerable EPBC Act) occurs in this community on private property on the northern side of the Kalang River where infestations of *Lantana camara* are low-moderate. It generally occurs in more sheltered locations of this community on lower slopes.
Status: Moderately Common

Map Unit 4: Moist Forest – Flooded Gum
Canopy: *Eucalyptus grandis, Lophostemon confertus, Syncarpia glomulifera, Eucalyptus microcorys, Eucalyptus acmenoides, Eucalyptus resinifera, Eucalyptus pilularis* Subcanopy: *Allocasuarina torulosa, Synoum glandulosum, Callicoma serratifolia, Glochidion ferdinandi, Alphitonia excelsa, Schizomeria ovata, Melaleuca styphelioides, Guioa semiglauca, Ficus coronata, Acmena smithii, Endiandra discolor*
Structure: Canopy 18-35m; 30-50% foliage cover Subcanopy 5-10m; 20-50% foliage cover

Shrubs: *Dodonaea triquetra, Breynia oblongifolia, Lantana camara, Cordyline stricta, Ozothamnus diosmifolius, Acacia floribunda, Wilkiea huegeliana*

Grasses: *Entolasia marginata, Entolasia stricta, Oplismenus imbecillis, Oplismenus aemulus, Paspalum wettsteinii*

Herbs: *Calochlaena dubia, Pseuderanthemum variable, Dianella caerulea, Blechnum cartilagineum, Alpinia caerulea*

Sedges/Rushes: *Lomandra longifolia, Gahnia aspera, Gahnia clarkei*

Vines/Twiners: *Stephania japonica, Geitonoplesium cymosum, Marsdenia lloydii, Morinda jasminoides, Hibbertia dentata, Pandorea pandorana, Cissus hypoglauca*

Weed Abundance: Supports a moderate to high abundance of *Lantana camara*, with higher abundances on the edges of this community due to additional light aiding growth in these areas. Some trails in the State Forest areas which traverse through this community are dominated by *Paspalum wettsteinii*, and this species has spread into the understorey of this community in some areas.

Equivalent Communities: Ecosystem 154: Wet Flooded Gum-Tallowwood (Kendall & Kendall 2003); Ecosystem 85: Mixed Moist Hardwood (Kendall & Kendall 2003)

Rare and Threatened Species: *Marsdenia longiloba* (Endangered, *TSC Act*; Vulnerable EPBC Act) occurs in this community on private property on the northern side of the Kalang River where infestations of *Lantana camara* are low-moderate. It generally occurs in more sheltered locations of this community on lower slopes. One RoTAP species *Eucalyptus ancophila* is present in this community in Nambucca and Newry State Forests.

Status: Moderately Common

Map Unit 5: Lowland Rainforest

Emergents: *Eucalyptus grandis, Lophostemon confertus*

Canopy: *Glochidion ferdinandi, Alphitonia excelsa, Schizomeria ovata, Guioa semiglauca, Ficus coronata, Acmena smithii, Archontophoenix cunninghamiana, Livistonia australis, Endiandra discolor, Sloanea woollsii, Acronychia oblongifolia, Backhousia myrtifolia, Syzygium australe, Litsea australis, Syzygium luehmannii, Tristaniopsis laurina, Jagera pseudorhus, Rhodomyrtus psidioides, Sloanea australis, Acacia melanoxylon, Waterhousea floribunda, Callicoma serratifolia, Syzygium oleosum, Rhodamnia rubescens, Backhousia myrtifolia, Diospyros pentamera, Cryptocarya obovata, Neolitsea dealbata, Cupaniopsis anacardioides, Ficus rubignosa, Cryptocarya glaucescens, Symplocos thwaitesii, Archidendron grandiflorum, Myrsine howittiana, Cryptocarya microneura, Scolopia braunii, Melaleuca styphelioides, Cinnamonum camphora*

Structure:

Canopy 20-30m; 40-60% foliage cover

Subcanopy 8-15m; 30-90% foliage cover

Shrubs: *Linospadix monostachya, Litsea reticulata, Croton verreauxii, Cordyline stricta, Clerodendrum tomentosum, Myrsine variabilis, Pittosporum multiflorum, Polyscias sambucifolia, Psychotria loniceroides, Tasmannia insipida, Archirhodomyrtus beckleri, Synoum glandulosum, Cryptocarya rigida, Tabernaemontana pandacaqui, Lantana camara, Eupomatia laurina, Breynia oblongifolia, Notelaea venosa, Diospyros australis, Wilkiea huegeliana, Cyathea australis*

Grasses: *Entolasia marginata, Oplismenus imbecillis, Oplismenus aemulus*

Herbs: *Pseuderanthemum variable, Blechnum cartilagineum, Doodia aspera, Hypolepis muellerii, Alpinia caerulea, Calochlaena dubia*

Epiphytes: *Cymbidium madidum, Asplenium australasicum, Platycerium bifurcatum, Plectorrhiza tridentata*

Vines/Twiners: *Cissus hypoglauca, Pandorea pandorana, Parsonsia straminea, Dioscorea transversa, Cissus sterullifolia, Calamus muellerii, Smilax australis, Ripogonum fawcettianum, Morinda jasminoides, Rubus nebulosus, Stephania japonica, Rubus parviflora, Rubus hillii, Cissus antarctica, Geitonoplesium cymosum, Celastrus subspicatus*

Weed Abundance: *Lantana camara* is present mainly on the edges of this community, and is particularly dense in the ecotonal areas where the subcanopy is not as thick and there is more sunlight reaching the shrub layer. *Lantana camara* is generally absent or occurs in low abundance where there is a thick subcanopy of rainforest species. Some trails in the State Forest areas which traverse through this community are dominated by *Paspalum wettsteinii*, and this species has spread into this community in some areas.

Equivalent Communities: Ecosystem 154: Wet Flooded Gum-Tallowwood (Kendall & Kendall 2003); Ecosystem 168; Rainforest (Kendall & Kendall 2003); Ecosystem 73: Lowland Red Gum; North Coast Wet Sclerophyll Forests (Keith 2006).

Rare and Threatened Species: *Marsdenia longiloba* (Endangered, *TSC Act*; Vulnerable EPBC Act) occurs in this community where the soil drainage is better, generally comprising slightly elevated areas adjacent to drainage lines and ecotonal areas between this community and Blackbutt Open Forest. *Amorphospermum whitei* was recorded in one location adjacent to Boggy Creek on private property. One RoTAP species *Eucalyptus ancophila* is present in this community in Nambucca and Newry State Forests.

Map Unit 5: Lowland Rainforest
Status: EEC. Subtropical Coastal Floodplain Forest

Map Unit 6: Swamp Forest – Swamp Mahogany / Paperbark
Canopy: *Eucalyptus robusta, Melaleuca quinquenervia, Eucalyptus resinifera* Subcanopy: *Lophostemon sauveolens, Callistemon salignus, Melaleuca linariifolia, Glochidion ferdinandi, Elaeocarpus reticulatus, Melaleuca styphelioides*
Structure: Canopy 15-18m; 30-60% foliage cover Subcanopy 8-10m; 20-40% foliage cover
Shrubs: *Melastoma affine, Lantana camara, Omalanthus populifolius, Acacia irrorata, Cordyline stricta* Grasses: *Phragmites australis, Entolasia marginata, Oplismenus aemulus, Entolasia stricta, Hemarthria uncinata* Herbs: *Hypolepis muellerii, Lycopus australis, Christella dentata, Blechnum indicum, Triglochin procerum, Lobelia alata, Goodenia paniculata, Persicaria dichotoma* Sedges/Rushes: *Carex appressa, Gahnia clarkei, Schoenus apogon, Juncus usitatus, Baumea rubignosa* Vines/Twiners: *Parsonsia straminea, Stephania japonica*
Weed Abundance: Apart from a moderate abundance of *Lantana camara* in areas, this community is relatively free of invasive weed species. No weed species are present in very wet areas where standing water is present.
Equivalent Communities: Ecosystem 142: Swamp Mahogany (Kendall & Kendall 2003).
Rare and Threatened Species: None recorded
Status: EEC. Swamp Sclerophyll Forest

Map Unit 7: Swamp Forest – Swamp Oak
Canopy: *Casuarina glauca, Melaleuca quinquenervia* Subcanopy: *Melaleuca styphelioides, Callistemon salignus, Glochidion ferdinandi, Lophostemon sauveolens*
Structure: Canopy 10-18m; 40-70% foliage cover Subcanopy 8-10m; 20-60% foliage cover
Shrubs: *Lantana camara, Baccharis halimifolia* Grasses: *Phragmites australis, Entolasia marginata, Oplismenus imbecillis, Paspalum wettsteinii, Imperata cylindrica* Herbs: *Hypolepis muellerii, Viola hederacea, Blechnum indicum, Crinum pedunculatum* Sedges/Rushes: *Baumea juncea, Juncus usitatus, Gahnia clarkei* Vines/Twiners: *Parsonsia straminea*
Weed Abundance: Some areas of this community adjacent to the existing highway have thick growth of *Lantana camara* and other weed species including *Baccharis halimifolia* on the edges and in disturbed areas of the community. Some areas of this community in agricultural areas have thick growth of pasture grasses and weeds such as *Setaria sphacelata* and *Axonopus affinis*. Generally no weed species are present in very wet areas where standing water is present.
Equivalent Communities: Ecosystem 143: Swamp Oak (Kendall & Kendall 2003).
Rare and Threatened Species: None recorded
Status: EEC. Swamp Oak Floodplain Forest

Map Unit 8: Freshwater Wetlands
Dominant/Common Species: *Phragmites australis, Juncus usitatus, Typha orientalis, Villarsia exaltata, Myriophyllum spp., Villarsia reniformis, Ludwigia peploides subsp. montevidensis, Nymphaea spp., Nymphoides geminate, Philydrum lanuginosum, Baumea rubignosa, Carex appressa, Baumea articulata, Ranunculus inundatus, Cyperus polystachyos, Eleocharis sphacelata, Baumea juncea, Isolepis inundata, Fimbristylis dichotoma, Schoenoplectus mucronatus, Eleocharis gracilis, Juncus planifolius, Hemarthria uncinata*
Weed Abundance: Areas of this community occurring in paddock areas often have several pasture species present such as *Setaria sphacelata* and *Axonopus affinis*.
Equivalent Communities: Ecosystem 141: Swamp (Kendall & Kendall 2003).
Rare and Threatened Species: None recorded
Status: EEC. Freshwater Wetlands

Map Unit 9: Mangrove Forest

Canopy: *Avicennia marina* Subcanopy: *Aegiceras corniculatum*
Structure: Canopy 5-8m; 20-70% foliage cover Subcanopy 1-4m; 20-60% foliage cover
Weed Abundance: No exotic species were recorded in these communities
Equivalent Communities: Ecosystem 77: Mangrove (Kendall & Kendall 2003).
Rare and Threatened Species: None recorded
Status: Protected as important fish habitat under the Fisheries Management Act 1991.

Appendix F Fauna list

KEY TO SYMBOLS USED IN APPENDIX F

ABBREVIATIONS

Nomenclature follows Stanger *et al* (1997)

Habitat

DSF - Dry Sclerophyll Forest

MSF - Moist Sclerophyll Forest / Riparian Forest

SSF - Swamp Sclerophyll Forest

FW - Freshwater Wetland

EST - Estuarine / River

RC - Rural and Cleared Agricultural Lands

Previous records: includes species recorded during previous fauna surveys in the general locality (refer to references)

a. Smith *et al* (1995) ; b. Gunninah (1998) ; c. Kendall & Kendall (1991), d. Atlas of NSW Wildlife (DECCW); e. State Forests records (DII)

Status

E1 - Schedule 1 endangered species (TSC Act)

V - Schedule 2 vulnerable species (TSC Act)

M - migratory species (EPBC Act)

BIRDS

Family/Scientific Name	Common Name	Status	Habitats						Previous Records
			DSF	MSF	SSF	FW	EST	RC	
Megapodiidae									
Alectura lathami	Australian Brush-turkey								a
Phasianidae									
Coturnix ypsilophora	Brown Quail		•						
Anatidae									

Family/Scientific Name	Common Name	Status	Habitats						Previous Records
			DSF	MSF	SSF	FW	EST	RC	
Chenonetta jubata	Australian Wood Duck					•		•	c
Cygnus atratus	Black Swan					•		•	
Anas superciliosa	Pacific Black Duck					•		•	c
Anas castanea	Chestnut Teal					•			
Oxyura australis	Blue-billed Duck	V							d
Anhingidae									
Anhinga melanogaster	Darter					•			
Phalacrocoracidae									
Phalacrocorax sulcirostris	Little Black Cormorant					•			
Phalacrocorax varius	Pied Cormorant					•			
Pelecanidae									
Pelecanus conspicillatus	Australian Pelican					•			
Ardeidae									
Bubulcus ibis	Cattle Egret	M						•	c
Egretta garzetta	Little Egret								
Ardea intermedia	Intermediate Egret						•		
Ardea alba	Great Egret	M			•	•		•	c
Egretta novaehollandiae	White-faced Heron					•		•	c
Ixobrychus flavicollis	Black Bittern	V							d
Botaurus poiciloptilus	Australasian Bittern	V							d
Threskiornithidae									
Threskiornis molucca	Australian White Ibis					•		•	c
Threskiornis spinicollis	Straw-necked Ibis								c
Platalea regia	Royal Spoonbill					•			
Ciconiidae									

Family/Scientific Name	Common Name	Status	Habitats						Previous Records
			DSF	MSF	SSF	FW	EST	RC	
Ephippiorhynchus asiaticus	Black-necked Stork	E1				•			d
Accipitridae									
Accipiter novaehollandiae	Grey Goshawk				•				
Accipiter fasciatus	Brown Goshawk			•					
Aquila audax	Wedge-tailed Eagle		•						
Haliaeetus leucogaster	White-bellied Sea-Eagle	M						•	c
Haliastur indus	Brahminy Kite						•		c
Haliastur sphenurus	Whistling Kite		•						
Lophoictinia isura	Square-tailed Kite	V	•						d
Elanus axillaris	Black-shouldered Kite			•					c
Pandion haliaetus	Osprey	V, M			•		•	•	c
Falconidae									
Falco longipennis	Australian Hobby		•						
Falco cenchroides	Nankeen Kestrel							•	
Gruidae									
Grus rubicunda	Brolga	V							d
Rallidae									
Gallirallus philippensis	Buff-banded Rail							•	
Porphyrio porphyrio	Purple Swamphen					•		•	c
Fulica atra	Eurasian Coot							•	
Scolopacidae									
Gallinago hardwickii	Latham's Snipe	M						•	
Rostratulidae									
Rostratula benghalensis australis	Painted Snipe (Aust subsp)	E1							d
Jacanidae									

Family/Scientific Name	Common Name	Status	Habitats						Previous Records
			DSF	MSF	SSF	FW	EST	RC	
Irediparra gallinacea	Comb-crested Jacana	V							d
Charadriidae									
Vanellus miles	Masked Lapwing							•	c
Columbidae									
Ptilinopus regina	Rose-crowned Fruit-Dove	V							d
Ptilinopus superbus	Superb Fruit-Dove	V							d
Ptilinopus magnificus	Wompoo Fruit-Dove	V		•					a,d
Columba leucomela	White-headed Pigeon			•					c
Macropygia amboinensis	Brown Cuckoo-Dove		•	•					a, b
Geopelia placida	Peaceful Dove								a
Geopelia humeralis	Bar-shouldered Dove			•					
Chalcophaps indica	Emerald Dove			•					
Phaps chalcoptera	Common Bronzewing		•	•	•				
Ocyphaps lophotes	Crested Pigeon							•	c
Leucosarcia melanoleuca	Wonga Pigeon			•	•				c
Cacatuidae									
Calyptorhynchus banksii	Red-tailed Black-Cockatoo								d
Calyptorhynchus lathami	Glossy Black-Cockatoo	V	•	•					b,d
Calyptorhynchus funereus	Yellow-tailed Black-Cockatoo		•					•	a
Cacatua galerita	Sulphur-crested Cockatoo		•					•	
Eolophus roseicapillus	Galah		•					•	
Psittacidae									
Trichoglossus haematodus	Rainbow Lorikeet		•	•					a, b, c
Trichoglossus chlorolepidotus	Scaly-breasted Lorikeet		•	•	•			•	a, c
Glossopsitta concinna	Musk Lorikeet		•						

Family/Scientific Name	Common Name	Status	Habitats						Previous Records
			DSF	MSF	SSF	FW	EST	RC	
Glossopsitta pusilla	Little Lorikeet		•						
Alisterus scapularis	Australian King-Parrot			•					a, b
Platycercus elegans	Crimson Rosella								a, b
Platycercus adscitus eximius	Eastern Rosella		•	•					a, c
Lathamus discolor	Swift Parrot	E1, M							d
Cuculidae									
Cacomantis flabelliformis	Fan-tailed Cuckoo		•	•					a, b
Cacomantis variolosus	Brush Cuckoo			•					a, b
Chalcites lucidus	Shining Bronze-Cuckoo		•	•					a
Eudynamys orientalis	Pacific Koel		•						
Scythrops novaehollandiae	Channel-billed Cuckoo		•	•	•			•	a
Centropodidae									
Centropus phasianinus	Pheasant Coucal		•	•					c
Strigidae									
Ninox boobook	Southern Boobook		•	•	•				a
Ninox strenua	Powerful Owl	V		•					d
Tytonidae									
Tyto novaehollandiae	Masked Owl	V							d,e
Tyto capensis longimembris	Australian Grass Owl	V							d
Tyto tenebricosa	Sooty Owl	V							d
Podargidae									
Podargus ocellatus	Marbled Frogmouth	V							d
Podargus strigoides	Tawny Frogmouth		•	•	•			•	a, b
Aegothelidae									
Aegotheles cristatus	Australian Owlet-nightjar		•						a

Family/Scientific Name	Common Name	Status	Habitats						Previous Records
			DSF	MSF	SSF	FW	EST	RC	
Apodidae									
Hirundapus caudacutus	White-throated Needletail	M	•	•				•	
Alcedinidae									
Alcedo azurea	Azure Kingfisher					•			
Dacelo novaeguineae	Laughing Kookaburra		•	•	•				a,b,c
Todiramphus sanctus	Sacred Kingfisher		•	•	•	•			a,b,c
Meropidae									
Merops ornatus	Rainbow Bee-eater	M							d
Coraciidae									
Eurystomus orientalis	Dollarbird		•	•					a
PITTIDAE									
Pitta versicolor	Noisy Pitta								a
Climacteridae									
Cormobates leucophaea	White-throated Treecreeper		•	•					a,b
Maluridae									
Malurus cyaneus	Superb Fairy-wren		•	•	•				a,b,c
Malurus lamberti	Variegated Fairy-wren		•						a
Pardalotidae									
Pardalotus punctatus	Spotted Pardalote		•						a
Pardalotus striatus	Striated Pardalote		•						a,b
Acanthizidae									
Gerygone olivacea	White-throated Gerygone			•	•				b
Smicrornis brevirostris	Weebill		•						
Acanthiza lineata	Striated Thornbill		•	•	•				a,b

Family/Scientific Name	Common Name	Status	Habitats DSF	MSF	SSF	FW	EST	RC	Previous Records
Acanthiza pusilla	Brown Thornbill		•	•	•				a,b,c
Sericornis frontalis	White-browed Scrubwren		•	•	•				b,c
Meliphagidae									
Myzomela sanguinolenta	Scarlet Honeyeater			•					a,b
Acanthorhynchus tenuirostris	Eastern Spinebill		•						a,b,c
Xanthomyza phrygia	Regent Honeyeater	E1, M							d
Meliphaga lewinii	Lewin's Honeyeater		•	•	•				
Lichenostomus chrysops	Yellow-faced Honeyeater		•	•	•				a,b
Phylidonyris niger	White-cheeked Honeyeater		•	•					a,c
Manorina manorina	Bell Miner			•					
Manorina melanocephala	Noisy Miner			•					
Anthochaera chrysoptera	Little Wattlebird		•	•					a
Anthochaera carunculata	Red Wattlebird		•	•					
Philemon corniculatus	Noisy Friarbird		•	•					a,b
Philemon citreogularis	Little Friarbird								
Petroicidae									
Eopsaltria australis	Eastern Yellow Robin		•	•	•				a
Eupetidae									
Psophodes olivaceus	Eastern Whipbird		•	•	•				a,b
Neosittidae									
Daphoenositta chrysoptera	Varied Sittella								a
Pachycephalidae									
Pachycephala pectoralis	Golden Whistler		•	•					a,c
Pachycephala rufiventris	Rufous Whistler		•	•					a,b
Colluricincla harmonica	Grey Shrike-thrush		•	•					a,b,c

Family/Scientific Name	Common Name	Status	Habitats						Previous Records
			DSF	MSF	SSF	FW	EST	RC	
Falcunculus frontatus	Eastern Shrike-tit		•	•					a
Dicruridae									
Rhipidura albiscapa	Grey Fantail		•	•	•				a,b,c
Rhipidura rufifrons	Rufous Fantail	M	•	•					a
Rhipidura leucophrys	Willie Wagtail							•	b,c
Myiagra rubecula	Leaden Flycatcher			•					a
Myiagra inquieta	Restless Flycatcher		•						
Monarcha melanopsis	Black-faced Monarch	M	•	•	•				a,b
Monarcha trivirgatus	Spectacled Monarch	M							a
Grallina cyanoleuca	Magpie-lark			•					a,b,c
Dicrurus bracteatus	Spangled Drongo		•		•				a,c
Campephagidae									
Coracina novaehollandiae	Black-faced Cuckoo-shrike		•	•	•				a,b
Coracina papuensis	White-bellied Cuckoo-shrike		•						a,b
Coracina lineata	Barred Cuckoo-shrike	V							d
Coracina tenuirostris	Cicadabird		•	•					a
Oriolidae									
Oriolus sagittatus	Olive-backed Oriole		•	•	•				a
Sphecotheres vieilloti	Australasian Figbird		•						
Artamidae									
Artamus cyanopterus	Dusky Woodswallow								a
Strepera graculina	Pied Currawong		•	•				•	a,b
Cracticus nigrogularis	Pied Butcherbird		•						
Cracticus torquatus	Grey Butcherbird			•					b,c
Gymnorhina tibicen	Australian Magpie		•	•	•			•	a,b,c

Family/Scientific Name	Common Name	Status	Habitats						Previous Records
			DSF	MSF	SSF	FW	EST	RC	
Corvidae									
Corvus orru	Toresian Crow		•					•	c
Corvus coronoides	Australian Raven			•	•				a,b
Ptilonorhynchidae									
Ailuroedus crassirostris	Green Catbird			•				•	a,b
Ptilonorhynchus violaceus	Satin Bowerbird			•					a,b
Sericulus chrysocephalus	Regent Bowerbird			•					
Motacillidae									
Anthus australis	Australian Pipit							•	
Estrildidae									
Neochmia temporalis	Red-browed Finch		•	•	•				a,b
Stagonopleura guttata	Diamond Firetail	V							d
Dicaeidae									
Dicaeum hirundinaceum	Mistletoebird		•						
Hirundinidae									
Hirundo neoxena	Welcome Swallow		•						
Petrochelidon nigricans	Tree Martin		•						
Petrochelidon ariel	Fairy Martin		•					•	
Sylviidae									
Acrocephalus australis	Australian Reed-Warbler	M						•	
Cisticolidae									
Cisticola exilis	Golden-headed Cisticola							•	
Zosteropidae									
Zosterops lateralis	Silvereye		•						a
Introduced Species									

Family/Scientific Name	Common Name	Status	Habitats						Previous Records
			DSF	MSF	SSF	FW	EST	RC	
Columbidae									
Streptopelia chinensis	Spotted Turtle-Dove							•	
Sturnidae									
Acridotheres tristis	Common Myna							•	c
Sturnus vulgaris	Common Starling							•	c
	Total		**70**	**63**	**28**	**16**	**3**	**35**	

MAMMALS

Family/Scientific Name	Common Name	Status	Habitats					Previous records
			DSF	MSF	SSF	FW	RC	
Tachyglossidae								
Tachyglossus aculeatus	Short-beaked Echidna		•					a,b
Dasyuridae								
Antechinus stuartii	Brown Antechinus		•	•				
Dasyurus maculatus	Spotted-tailed Quoll	NV, V						d
Phascogale tapoatafa	Brush-tailed Phascogale	V						d
Peramelidae								
Isoodon macrourus	Northern Brown Bandicoot		•					
Perameles nasuta	Long-nosed Bandicoot		•	•				
Phascolarctidae								
Phascolarctos cinereus	Koala	V	•	•	•			a,d,e
Petauridae								
Petaurus australis	Yellow-bellied Glider	V	•	•				d,e
Petaurus norfolcensis	Squirrel Glider	V						d
Petaurus breviceps	Sugar Glider		•	•				

Family/Scientific Name	Common Name	Status	Habitats					Previous records
			DSF	MSF	SSF	FW	RC	
Pseudocheiridae								
Pseudocheirus peregrinus	Common Ringtail Possum			•	•			
Petauroides volans	Greater Glider							a,b
Acrobatidae								
Acrobates pygmaeus	Feathertail Glider		•					
Phalangeridae								
Trichosurus caninus	Short-eared Possum			•				
Trichosurus vulpecula	Common Brushtail Possum		•	•	•			a,b,c
Macropodidae								
Wallabia bicolor	Swamp Wallaby		•	•	•			a,c
Macropus rufogriseus	Red-necked Wallaby							
Macropus giganteus	Eastern Grey Kangaroo						•	a
Pteropodidae								
Pteropus poliocephalus	Grey-headed Flying-fox	NV, V	•	•	•			a,d
Rhinolophidae								
Rhinolophus megaphyllus	Eastern Horseshoe-bat							b
Emballonuridae								
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	V		•				d
Molossidae								
Tadarida australis	White-striped Freetail-bat		•	•				
Mormopterus sp.2 (planiceps)	Little Mastiff-bat		•	•	•			
Mormopterus norfolkensis	Eastern Freetail-bat	V						b,d
Vespertilionidae								
Vespadelus darlingtoni	Large Forest Bat			•				
Nyctophilus gouldi	Gould's Long-eared Bat			•				

Family/Scientific Name	Common Name	Status	Habitats					Previous records
			DSF	MSF	SSF	FW	RC	
Nyctophilus geoffroyi	Lesser Long-eared Bat		•					b
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	V	•	•				d
Miniopterus australis	Little Bentwing-bat	V	•	•	•			a,b,d
Chalinolobus gouldii	Gould's Wattled Bat		•	•	•			
Chalinolobus morio	Chocolate Wattled Bat			•				b
Falsistrellus tasmaniensis	Eastern False Pipistrelle	V	•	•				
Scoteanax rueppellii	Greater Broad-nosed Bat	V	•					d
Scotorepens orion	Eastern Broad-nosed Bat		•	•				a
Vespadelus pumilus	Eastern Forest Bat		•	•	•			a,b
Vespadelus regulus	Southern Forest Bat		•	•				
Vespadelus vulturnus	Little Forest Bat		•	•				b
Vespadelus darlingtoni	Large Forest Bat			•				
Muridae								
Rattus fuscipes	Bush Rat		•	•	•			a,b
Melomys cervinipes	Fawn-footed Melomys		•	•	•			a
INTRODUCED								
Canidae								
Canis lupus	Dingo, domestic dog							a
Vulpes vulpes	Fox		•					a
Leporidae								
Oryctolagus cuniculus	Rabbit						•	
Muridae								
Rattus rattus	Black Rat		•	•				b
Mus musculus	House Mouse		•					
	Total		**28**	**28**	**11**	**0**	**1**	

REPTILES

Family/Scientific Name	Common Name	Status	Habitats					Previous Records
			DSF	MSF	SSF	FW	RC	
Chelidae								
Chelodina longicollis	Eastern Snake-necked Turtle					•		
Pygopodidae								
Lialis burtonis	Burton's Snake-lizard		•	•				
Agamidae								
Pogona barbata	Bearded Dragon		•					b
Physignathus lesueurii	Eastern Water Dragon					•		
Varanidae								
Varanus varius	Lace Monitor		•					b
Scincidae								
Lygisaurus foliorum	Tree-base Litter-skink		•					
Carlia tetradactyla	Southern Rainbow-skink		•	•	•			
Cryptoblepharus virgatus	Cream-striped Shinning-skink		•	•	•			
Ctenotus robustus	Robust Ctenotus		•	•				
Egernia major	Land Mullet			•				
Egernia striolata	Tree Skink		•					
Lampropholis delicata	Dark-flecked Garden Sunskink			•	•			a,b
Lampropholis guichenoti	Pale-flecked Garden Sunskink		•					a,b
Menetia greyii	Common Dwarf Skink		•					
Morethia boulengeri	South-eastern Morethia Skink		•					
Saiphos equalis	Three-toed Skink			•				
Eulamprus quoyii	Eastern Water-skink					•	•	

Family/Scientific Name	Common Name	Status	Habitats					Previous Records
			DSF	MSF	SSF	FW	RC	
Eulamprus tenuis	Barred-sided Skink			•				
Tiliqua scincoides	Eastern Blue-tongue						•	
Boidae								
Morelia spilota spilota	Diamond Python			•	•			
Elapidae								
Cryptophis nigrescens	Eastern Small-eyed Snake			•				
Hemiaspis signata	Black-bellied Swamp Snake		•	•	•			
Pseudechis porphyriacus	Red-bellied Black Snake				•	•	•	
Pseudonaja textilis	Eastern Brown Snake						•	
Vermicella annulata	Bandy-bandy		•					
	Total		**13**	**11**	**6**	**4**	**4**	

AMPHIBIANS

Family/Scientific Name	Common Name	Status	Habitats					Previous records
			DSF	MSF	SSF	FW	RC	
Myobatrachidae								
Adelotus brevis	Tusked Frog			•	•			
Limnodynastes peronii	Brown-striped Frog			•	•	•	•	a
Limnodynastes tasmaniensis	Spotted Grass Frog				•			
Mixophyes fasciolatus	Great Barred Frog			•	•			
Mixophyes iteratus	Giant Barred Frog	E1						d
Pseudophryne coriacea	Red-backed Toadlet		•	•	•	•		a
Crinia signifera	Common Eastern Froglet			•	•	•	•	a

Crinia tinnula	Wallum Froglet	V						d
Uperoleia laevigata	Smooth Toadlet			•	•			
Hylidae								
Litoria aurea	Green and Golden Bell Frog	E1						d
Litoria caerulea	Green Tree Frog			•			•	
Litoria chloris	Red-eyed Tree Frog			•	•	•		
Litoria dentata	Bleating Tree Frog				•			
Litoria fallax	Eastern Dwarf Tree Frog			•	•	•		a,b
Litoria freycineti	Freycinet's Frog					•		
Litoria latopalmata	Broad-palmed Frog					•		a
Litoria nasuta	Rocket Frog					•		
Litoria peronii	Peron's Tree Frog				•	•	•	a
Litoria tyleri	Tyler's Tree Frog			•	•	•		
Litoria verreauxii	Verreaux's Frog				•		•	
Litoria revelata	Revealed Frog			•	•			
	Total		**1**	**11**	**14**	**10**	**5**	

Appendix G Photographic Plates

Appendix G Photo Plates

Plate 1: Moist Sclerophyll Forest in Nambucca State Forest showing dense *Lantana camara* thickets.

Plate 2: Dense Broad-leaf Paspalum (*Paspalum wettsteinii*) along trail through Moist Sclerophyll Forest in Nambucca State Forest

Plate 3: Close up of *Marsdenia longiloba* in the study area.

Plate 4: trailing habit of *Marsdenia longiloba* in the study area.

Plate 5: Areas of Saltmarsh and Mangroves in the background surrounding Newee Creek.

Plate 6: Small wetland area adjoining Swamp Forest between Warrell Creek and the Nambucca River.

Plate 7: Tyler's Tree Frog (*Litoria tyleri*) in Swamp Forest area shown in Plate 8.

Plate 8: Eastern Sedge-frog (*Litoria fallax*) in wetland area shown in Plate 6.

Plate 9: Flooded area of Swamp Forest between Warrell Creek and the Nambucca River.

Plate 10: Area of Swamp Sclerophyll Forest adjoining the northern end of Newry State Forest

Plate 11: Disturbed Freshwater Wetland in paddock area on northern side of Kalang River.

Plate 12: Disturbed Freshwater Wetland adjoining Swamp Oak Floodplain Forest in power easement in Raleigh area.

Plate 13: Lowland Rainforest within Newry State Forest

Plate 14: Moist Sclerophyll Forest in gullies of Nambucca State Forest which provides habitat for *Marsdenia longiloba*.

Plate 15: Blackbutt Open Forest in Nambucca State Forest.

Plate 16: Blackbutt Open Forest adjoining Blackbutt Road.

Appendix H Swift Parrot and Regent Honeyeater specialist report

SINCLAIR KNIGHT MERZ

SKM

RTA

Macksville to Urunga
Upgrading the Pacific Highway

ASSESSING THE IMPACT OF THE PREFERRED ROUTE ON THE NATIONALLY ENDANGERED SPECIES: SWIFT PARROT AND REGENT HONEYEATER

- September 2005

Pacific Highway Upgrade
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Contents

1. Introduction

1.1 Background

The NSW Roads and Traffic Authority (RTA) propose to upgrade the Pacific Highway between Macksville and Urunga (herein referred to as the study area). A preferred route has been recommended following the investigation of a number of route options. This report assesses the potential impacts and significance on two nationally endangered bird species, the Regent Honeyeater (*Xanthomyza phrygia*) and Swift Parrot (*Lathamus discolour*) in relation to the route recommended by the project value management workshop.

1.2 Aims

The Regent Honeyeater and Swift Parrot are both listed as 'endangered species' under the schedules of the Commonwealth *Environment Protection and Biodiversity Conservation Act,* 1999 and the NSW *Threatened Species Conservation Act*, 1995. Recoveries plans have been prepared for both species (refer to Swift Parrot Recovery Team 2001 and Menkhorst *et al* 1999).

The objectives of this study were to:

- Investigate records of the Regent Honeyeater and Swift Parrot in relation to the study area and broader investigation area through a review of available databases and relevant ecological literature and discussions with experts familiar with these species;
- Identify the type and extent of potential habitat within proximity to the recommended Pacific Highway route;
- Assess the impact of the recommended route on the habitat of the Regent Honeyeater and Swift Parrot in the context of the regional distribution of the species and its habitat;
- Address the national guidelines of significance under the provisions of the EPBC Act to assess the potential impact of the recommended route on these matters on national environmental significance (i.e. the Regent Honeyeater and Swift Parrot); and
- Address the significance of impacts on these state listed species under Section 5a of the EP&A Act and TSC Act (i.e. 8-part test).

2. Description of species

The following section provides an overview of the ecology of the Swift Parrot and Regent Honeyeater to provide a basis for the assessment of the potential significance of the study area and proposed route to each of these species.

2.1 Conservation status

Both the Swift Parrot (*Lathamus discolor*) and Regent Honeyeater (*Xanthomyza phrygia*) are listed as nationally endangered species under the Commonwealth *Environment Protection and Biodiversity Conservation Act*, 1999 (EPBC Act). Both species are also listed as endangered in New South Wales under Schedule 1 of the *Threatened Species Conservation Act*, 1995 (TSC Act).

2.2 Swift Parrot

Distribution and Population Size

The swift parrot breeds only in Tasmania and migrates to mainland Australia in autumn where it remains over the winter season before retuning to Tasmania around September each year (Garnett 1992; Swift Parrot Recovery Team 2001). Surveys conducted in Tasmania during the breeding season estimate a population size of 940 pairs (Swift Parrot Recovery Team 2001).

During the winter season it is semi-nomadic and the population spreads over a wide area predominantly in Victoria and New South Wales, and extending as far north as south-eastern Queensland and west to Adelaide (Garnett 1992). Until recently it was believed that in NSW, swift parrots forage mostly in the western slopes region and also along the inland slopes of the Great Dividing Range, but are patchily distributed along the north and south coasts on NSW. However, recent evidence indicates that the forests on the coastal plains from southern to northern NSW are also extremely important during the winter migration (Swift Parrot Recovery Team 2001)..

Over-wintering foraging Habitat

This species is generally very gregarious and can occur, at times, in populations of several hundred individuals, feeding on flowering Eucalypts. Swift Parrots will also feed on lerps and the secretions of hemipterans, however the nectar of flowering Eucalypts is preferred (Garnett 1992). The principal over-wintering habitat of the species on the mainland is recognised as the box-ironbark forests and woodlands of the inland slopes of the Great Dividing Range in Victoria and New South Wales (Kennedy and Overs 2001).

Within the coastal lowland forests of NSW, the species shows a preference for wet swamp habitat dominated by Swamp Mahogany (*Eucalyptus robusta*). Forests dominated by Spotted Gum (*Corymbia maculata*) and Red Bloodwood (*Corymbia gummifera*) are also visited. In northern NSW, Narrow-leaved Ironbark (*Eucalyptus crebra*), Forest Red Gum (*Eucalyptus tereticornis*) and

Yellow Box (*Eucalyptus melliodora*) may be important and there is evidence that the parrots preferentially select larger trees for foraging (Kennedy 2000).

Current threats

Woodlands and forests within the parrot's over-wintering range continue to be reduced and fragmented as a result of clearing for agriculture, plantation development and urban and coastal subdivision (Swift Parrot Recovery Team 2001). The movements of this species are poorly understood, although it appears that this species congregates in areas where winter-flowering Eucalypts are blossoming profusely. The potential for the species to occur in a particular area of coastal NSW varies greatly from year to year depending on the intensity and extent of winter-flowering eucalypts (i.e. food resources).

2.3 Regent Honeyeater

Distribution and population size

The Regent Honeyeater was formerly distributed within about 300 km of the eastern Australian coast from approximately 100 km north of Brisbane to Adelaide (Franklin *et al.* 1989); however, it is no longer found in South Australia (Franklin and Menkhorst 1988) or western Victoria (Franklin *et al.* 1987) and records from Queensland are uncommon. Sightings now centre on a few sites in north-eastern Victoria, along the western slopes of the Great Dividing Range to Tenterfield, the Warrumbungle Ranges and Parkes in the west, and the central coast of New South Wales. Reports occasionally occur elsewhere (Garnett 1992). The total population is estimated at close to 1500 individuals (Webster and Menkhorst 1992).

Regent Honeyeaters apparently form small flocks, and move according to the flowering times of the preferred tree species (Klippel 1992). Although patterns of seasonal movement are poorly understood, a degree of regularity at some sites where Regent Honeyeaters are well-known to occur has been confirmed (Ley and Williams 1994, Ley *et al.* 1996, Geering and French 1998). There has been no recorded breeding of this species in the study area, the nearest known breeding sites are to the west around Armidale (Oliver *et al* 1998). Coastal areas from Macksville to Coffs Harbour are not considered important breeding areas for Regent Honeyeater (D.Geering, Recovery Plan co-ordinator, NPWS, *pers.comm*)

Habitat

Temperate eucalypt woodland and forests including forest edges, woodlands, farmlands and urban areas which contain mature Eucalypts are utilised by this species. Associations of Red Ironbark (*Eucalyptus sideroxylon*), White Box (*Eucalyptus albens*), Yellow Box (*Eucalyptus melliodora*), Yellow Gum (*Eucalyptus leucoxylon*) and Red Box (*Eucalyptus polyanthemos*) appear to be important. However these accounts are from the slopes and plains of NSW and none of these tree species are present in the Macksville to Urunga study area.

In coastal New South Wales, Regent Honeyeaters are reported to use riparian forests of River Oak (*Casuarina cunninghamiana*) and Swamp Mahogany (*Eucalyptus robusta*). Wet lowland coastal forest dominated by Swamp Mahogany (*Eucalyptus robusta)* are now known to comprise important refuge habitat for Regent Honeyeaters during drought periods when the inland Box-Ironbark forests are stressed and not flowering (Menkhorst *et al* 1999), though visits to the coastal Swamp Mahogany forests are not consistent every year and depend on flowering of the preferred Box-Ironbark woodlands to the west (Geering 2004).

One study, comparing occupied sites to nearby unoccupied sites, found that areas occupied appear to have noticeably larger trees, a greater percentage of trees in flower, and a taller shrub layer than surrounding unoccupied sites (Oliver 2000). Webster & Menkhorst (1992) found that structure appeared to be more important than floristics, and the density of the shrub layer of habitats varied from luxuriant but scattered to almost non-existent, and did not appear to be a critical factor. The birds did appear to seek large, mature, copiously flowering eucalypts, with an abundant nectar flow.

The ecology of the Regent Honeyeater is poorly known. This omnivorous species feeds on insects, taken from the branches and foliage of trees, and nectar, especially of Eucalypt species. Studies suggest that 88% of the time spent foraging was devoted to nectar-feeding, and only 8% of time was spent gleaning insects (Oliver 2000).

Threats

The causal factors involved in the drastic decline of Regent Honeyeater populations are not well understood, but habitat loss, degradation and fragmentation of habitat and drought are considered major contributors. Given the species documented large-scale movements to search for flowering resources, the loss of habitat has reduced stepping stones between dispersed feeding areas, such as coastal New South Wales (Geering 2004).

SKM

3. Methods and results

3.1 Records in the study area

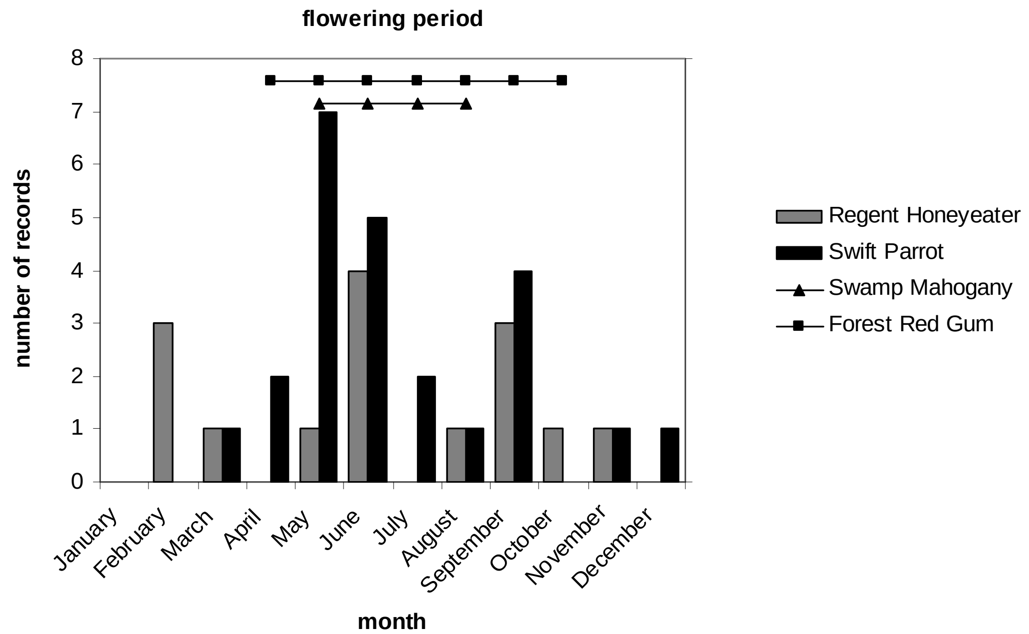
There are relatively few records of the Regent Honeyeater and Swift Parrot between the coastal towns of Macksville and Urunga, particularly in comparison to the number of records around Port Macquarie to the south and Coffs Harbour to the north. The concentration of records at these major towns may however be related to the higher population density and subsequent greater probability of reported sightings. A list of records for both species encompassing the area from Macksville to Moonee Beach, north of Coffs Harbour is presented in Table 1 and illustrated in Figure 1.

Table 1. Records of Regent Honeyeater and Swift Parrot from Macksville to Coffs Harbour
(Source: DEC Atlas of NSW Wildlife).

Date	Species	Number	Easting	Northing	Description of Location
13/06/1977	Regent Honeyeater	5	509610	6642415	South of Boambee Creek, Toormina
1/06/1983	Swift Parrot	-	513500	6657600	Moonee Beach Nature Reserve
1/07/1983	Swift Parrot	-	513500	6657600	Moonee Beach Nature Reserve
25/05/1985	Regent Honeyeater	2	514500	6657100	Moonee Beach Nature Reserve
1/06/1985	Regent Honeyeater	3	514000	6658000	Moonee Beach Nature Reserve
3/06/1985	Regent Honeyeater	1	514000	6658000	Moonee Beach Nature Reserve
28/09/1990	Regent Honeyeater	3	512000	6648100	Coffs Harbour Botanic Gardens
26/09/1990	Swift Parrot	2	512700	6649600	Park Beach, Coffs Harbour
20/11/1990	Swift Parrot	2	512700	6649600	Park Beach, Coffs Harbour
13/04/1991	Swift Parrot	5	513100	6648900	Park Beach, Coffs Harbour
13/08/1991	Swift Parrot	2	512700	6649600	Park Beach, Coffs Harbour
23/09/1991	Regent Honeyeater	3	512000	6648100	Coffs Harbour Botanic Gardens
29/09/1991	Regent Honeyeater	2	512700	6648900	East of Coffs Creek
18/10/1991	Regent Honeyeater	2	509987	6674704	Northwest of Moonee Beach
1/05/1992	Swift Parrot	5	512500	6651000	Jordons Creek, Korora
20/08/1995	**Regent Honeyeater**	**2**	**492022**	**6601784**	**Macksville Golf Course**
30/09/1997	Swift Parrot	20	515100	6657600	Moonee Beach Nature Reserve
31/03/1998	Swift Parrot	4	515100	6657600	Moonee Beach Nature Reserve
1/04/1998	Swift Parrot	4	515100	6657600	Moonee Beach Nature Reserve
1/07/1998	Swift Parrot	6	512950	6652750	Korora
11/09/1998	Swift Parrot	10	512950	6652750	Korora
12/09/1998	Swift Parrot	5	512950	6652750	Korora
12/06/1999	Swift Parrot	30	515100	6657600	Moonee Beach Nature Reserve
20/05/2000	Swift Parrot	10	515100	6657600	Moonee Beach Nature Reserve
26/05/2000	Swift Parrot	20	515100	6657600	Moonee Beach Nature Reserve
15/06/2000	Swift Parrot	6	518650	6670100	Moonee
1/12/2000	Swift Parrot	2	510800	6648000	Coffs Harbour
15/11/2001	Regent Honeyeater	1	500000	6671969	Kangaroo River State Forest
5/02/2002	Regent Honeyeater	2	501200	6678400	Kangaroo River State Forest
10/02/2002	Regent Honeyeater	1	501150	6678300	Kangaroo River State Forest

Date	Species	Number	Easting	Northing	Description of Location
14/02/2002	Regent Honeyeater	2	501152	6678187	Kangaroo River State Forest
6/06/2002	Regent Honeyeater	1	509905	6642753	East of Boambee Creek
28/05/2002	Swift Parrot	150	503055	6582530	Kangaroo River State Forest
29/05/2002	Swift Parrot	100	503055	6582530	Kangaroo River State Forest
30/05/2002	Swift Parrot	10	515100	6657600	Moonee Beach Nature Reserve
31/05/2002	Swift Parrot	2	518810	6666325	Moonee
16/06/2002	Swift Parrot	25	515000	6657700	Moonee Beach Nature Reserve
17/06/2002	Swift Parrot	27	515000	6657700	Moonee Beach Nature Reserve
10/03/2005	Regent Honeyeater	1	509850	6640500	Sawtell

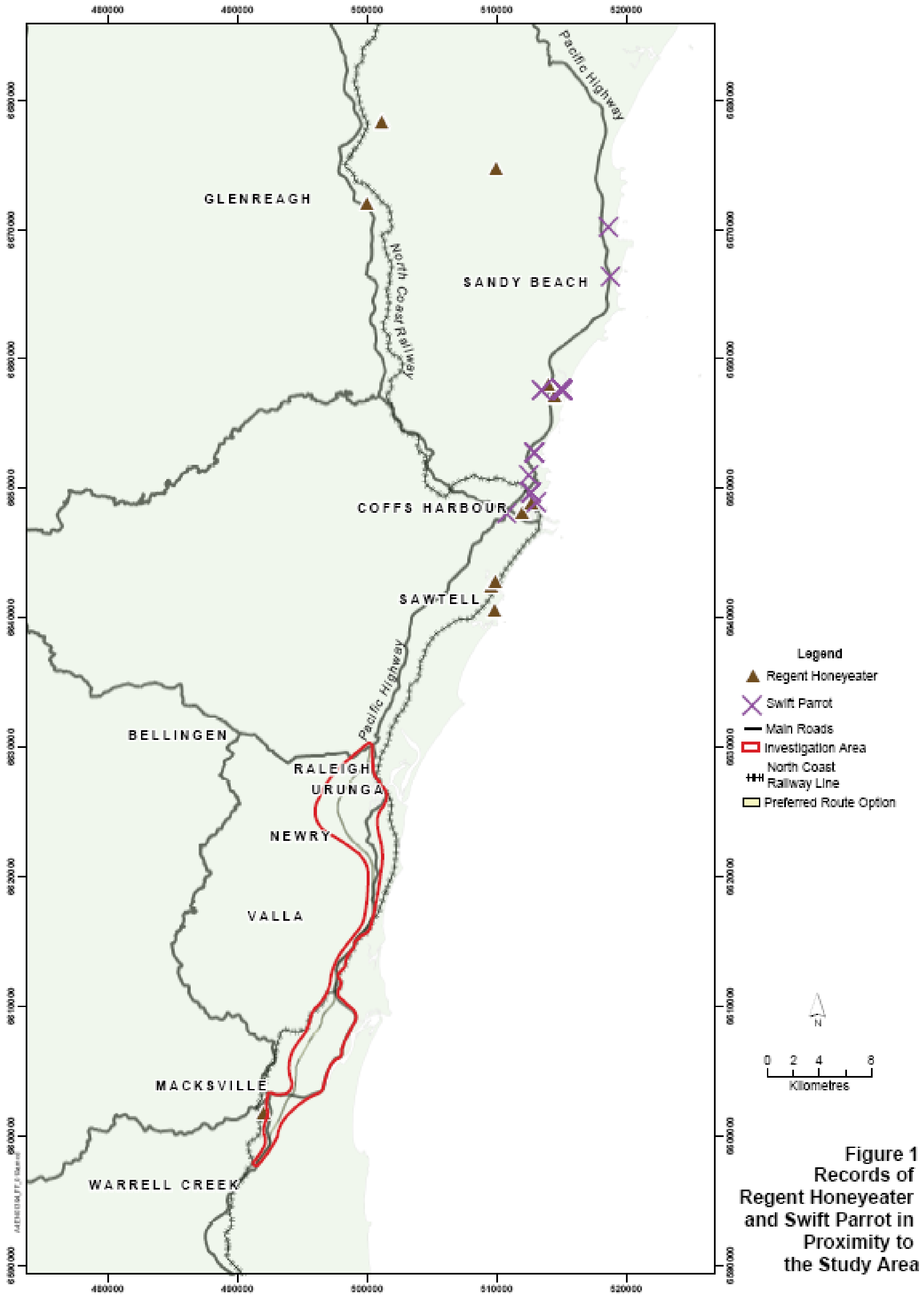
Records from the study area are relatively continuous extending over a 28 year period (1977-2005), indicating that the region from Macksville to Coffs Harbour may constitute seasonally important foraging and refuge habitat for these species. Analysis of the records for both species over this period indicates peaks in detection around the months from May to September. This is to be expected and coincides with the autumn-winter season and the flowering period of Swamp Mahogany (*Eucalyptus robusta*) and Forest Red Gum (*E.tereticornis*).



Wet lowland coastal forests dominated by Swamp Mahogany (*Eucalyptus robusta)* are identified as significant foraging habitat for both Regent Honeyeater and Swift Parrot in coastal New South Wales (Menkhorst *et al* 1999; Swift Parrot Recovery Team 2001) and Forest Red Gum (*E.tereticornis*) is also considered important for the Swift Parrot in coastal areas. The flowering period for these species is consistent with the majority of sightings for both species in the coastal area from Port Macquarie to Coffs Harbour.

SKM

Figure 1. Records of Regent Honeyeater and Swift Parrot within proximity to the study area



3.2 Distribution of potential habitat

Within the study area Swamp Mahogany (*Eucalyptus robusta)* is a component of the Swamp Sclerophyll Forest as described in the preliminary biological working paper (SKM 2004). This community type is typically located along low-lying freshwater creeks and gullies and often associated with SEPP 14 wetland areas. All swamp sclerophyll sites were revisited for this study to assess the presence of *E.robusta.* At all sites the dominant tree species was found to be Broad-leaved Paperbark (*Melaleuca quiquenervia*) and *E.robusta* was only represented as a sub-dominant species along with Forest Red Gum (*E. tereticornis*), Flooded Gum (*E. grandis*) and Smooth-barked Apple (*Angophora costata*). Other indicative species include Prickly-leaved Paperbark (*Melaleuca styphelioides*), Snow-in-summer (*Melaleuca linariifolia*) and Ball Honeymyrtle (*M. nodosa*).

At each of the swamp forest sites, the extent of *E.robusta* present in the tree canopy was quantified by determining the percentage of trees present within a 100x100 m quadrat and from random observations relative to all trees within the quadrat. Habitat where the percentage of *E.robusta* was estimated at less than 5% were considered marginal (low quality), 5-30% medium quality and greater than 30% high quality. The distribution of potential habitat in the study area is presented in **Figure 2.**

Within the study area the best examples of potential habitat are represented in Bellwood Swamp at the southern end of Nambucca State Forest (Section 2), to the south of the Kalang River and near South Arm Road, south of Raleigh (Section 4). These sites comprise a high percentage of *E.robusta* as a component of the community.

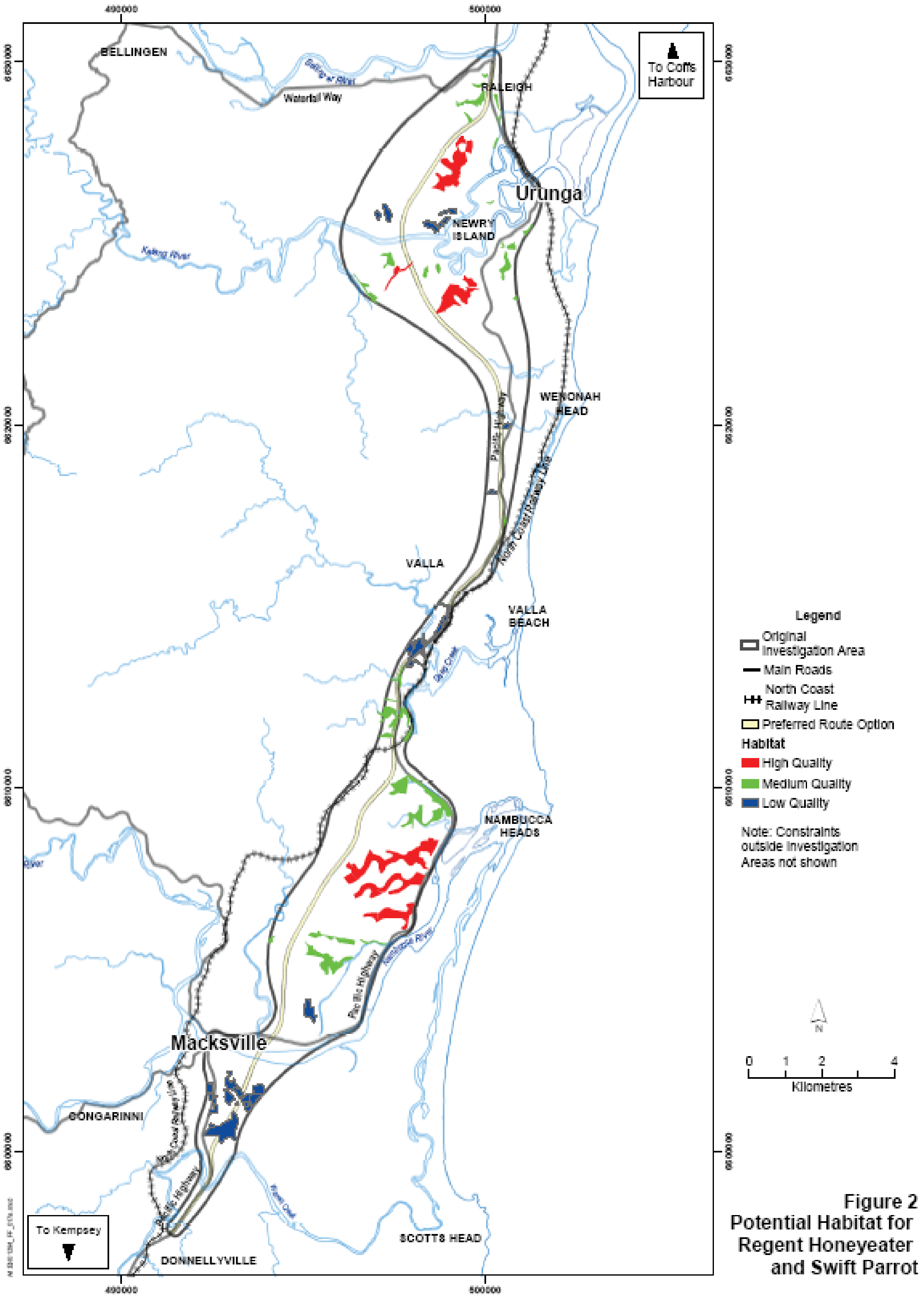
3.3 Targeted surveys

As both the Regent Honeyeater and Swift Parrot are semi-nomadic species that move large distances in search of flowering resources, their presence in a particular area of coastal NSW is unpredictable. This makes targeted surveys difficult without large groups of surveyors and previous knowledge of known sites. The primary focus of this study was to identify the distribution and quality of potential foraging habitat for both species within the study area. As a secondary aim, targeted searches were conducted for both species where flowering trees were noted and visits to known sites were conducted to compare the quality of the habitat to that within the study area.

Potential habitat was identified from aerial photography, topographic maps and vegetation survey data derived from SKM (2005). Potential habitat was identified on the basis of the dominant eucalypt species in the canopy, in particular the presence of wet lowland forests with *E. robusta*) (refer Figure 2 for distribution).

SKM

Figure 2. Distribution of potential habitat within the study area



Vegetation comprising Forest Red Gum (*E.tereticornis*) and Red Bloodwood (*Corymbia maculata*) were also targeted, although these species occurred in very low densities and were scattered throughout the study area and were therefore difficult to map.

A number of private properties within the study area were identified as containing potential habitat and these were visited during the period 15-19 August 2005. An attempt was made to visit all the properties where this community was identified, however due to difficulties contacting all landholders prior to the visit some properties were not accessed, these were assessed based on previous knowledge of the study area (SKM 2005). A total of 16 properties were visited which included several locations within Newry and Nambucca State Forests.

Bird census was conducted at each property during morning periods, which involved a random search listening for calls of the target species and obtaining visual identification of all bird species. Greater survey effort was concentrated around individuals and groups of flowering trees where encountered. Trees with copious flowers were re-visited on consecutive days. Aggregations of other nectarvorous birds, particularly Scaly-breasted Lorikeet (*Trichoglossus chlorolepidotus*) and Rainbow Lorikeet (*T.haematodus*), which could often be heard from a distance, were also used as a guide to locate flowering trees and search for the target species. Swift Parrots are often found in cohort with these other nectaravorous species..

Sites where Regent Honeyeater and Swift Parrot have been recorded previously outside of the study area were visited during the survey period to investigate if birds were present during the study period, as well as to assess resource availability and the condition of these habitats relative to those present in the study area and within proximity to the proposed route. Sites were visited at Moonee Beach Nature Reserve north of Coffs Harbour as both species have been recorded from this location in recent years (NPWS, Coffs Harbour office, *pers.comm*), and Nambucca Heads.

Swift Parrot’s and Regent Honeyeater’s were not identified in the study area during targeted surveys.

4. Assessment of impacts

4.1 Importance of the study area

Coastal forests dominated by Swamp Mahogany (*E.robusta*) are recognised as important habitat for both the Swift Parrot and Regent Honeyeater. This habitat type is considered relatively scarce in the Macksville to Urunga study area, which is dominated by coastal Blackbutt (*E.pilularis*) open forest (SKM 2005). However, swamp forests are represented in lowland areas along drainage lines, where Swamp Mahogany (*E.robusta*) is a component of the plant community.

The distribution of swamp sclerophyll forest is generally restricted to creek lines and gullies in the study area (refer Figure 2). However the actual percentage of *E.robusta* as a component of this community varies across sites and is generally low within most sites being dominated by the Broad-leaved Paperbark (*Melaleuca quinquenervia*). Forests dominated by Paperbark are mapped in Figure 2 as low quality, whereas those with a higher percentage of *E.robusta* are considered medium to high quality potential habitat.

Griffith (1991) considered swamp sclerophyll forest dominated by *E.robusta* to be poorly conserved on the NSW north coast and this community as been recently listed as an endangered ecological community under the schedules of the TSC Act due to its highly fragmented and reduced status. Furthermore *E.robusta* is considered an important keystone species for a variety of nectivorous fauna including threatened bird and mammal species and an important food tree species for the Koala (*Phascolarctos cinereus*). Any areas of swamp forest in coastal NSW that contain *E.robusta* are considered valuable as fauna habitat.

The Macksville to Urunga study area is not considered a critical area for the Regent Honeyeater (D.Geering, NPWS, *pers.comm*) or Swift Parrot. The swamp forest communities that are present do contribute to the overall availability of habitat for these species in coastal NSW however, and may be particularly important as refuge sites during drought when trees from other districts such as the inland Box Ironbark woodlands of NSW and Victoria may be experiencing poor flowering conditions.

Suitable foraging habitat for these species is best represented within the larger fragments of swamp sclerophyll forest located in Nambucca and Newry State Forest.

4.2 Impact of the preferred route on potential habitat

Swamp sclerophyll forest is listed as an endangered ecological community (EEC) under the schedules of the TSC Act. Some swamp sclerophyll areas are also listed under the State Environmental Protection Plan 14 (SEPP 14) as protected coastal wetlands, examples of such areas occur in Nambucca State Forest.

All areas of EEC and SEPP 14 wetland were identified in the original route options investigation (SKM 2005) and the selection of the preferred route was chosen to minimise impacts on these significant ecological areas. In achieving this, the impacts on fauna species dependent on the swamp forest communities, such as the Regent Honeyeater and Swift Parrot, have also been considered.

From the mapping of potential habitat in proximity to the preferred route it is evident that there are three categories of habitat characterised by high, medium and low quality areas (refer Figure 2). An overlay of the preferred highway route was used to calculate the loss of potential habitat for these species from the study area. The extent of removal of potential habitat areas as a result of the preferred route is:

- High 0.3ha
- Medium 5.6ha; and
- Low 19.0ha

The distribution of potential habitat shown in Figure 2 indicates that high quality areas are best represented in Nambucca and Newry State Forest to the east of the preferred route, and within private land to the south of Raleigh also to the east of the preferred route.

4.3 Environmental Planning and Assessment Act, 1979

The *EP&A Act* 1979 was amended by the *TSC Act* 1995. The outcome of any threatened species assessment should be that developments and activities are undertaken in an environmentally sensitive manner, and that appropriate measures are undertaken to minimise adverse effects on threatened species or their habitats.

Section 5A of the EP&A Act outlines eight questions that provide a guide to determining the significance of impacts from the proposed development on threatened species (i.e. the 8-part test). The Swift Parrot and Regent Honeyeater are listed as endangered species under Schedule 1 of the TSC Act, and therefore are subject to the provisions of the 8-part test.

Determining authorities have an obligation under the *EP&A Act* to consider whether a proposal is likely to significantly affect threatened species, populations or ecological communities, or their habitats. In this regard, the determining authority must take into account Section 5A of the *TSC Act* (ie. the eight-part test).

4.3.1 8-part Test

Swift Parrot (*Lathamus discolor*) and Regent Honeyeater (*Xanthomyza phrygia*)

(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

The presence of both species in the study area would depend predominantly on the flowering of Swamp Mahogany (*E. robusta*) and to a lesser extent Forest Red Gum (*E.tereticornis*) and Red Bloodwood (*Corymbia gummifera*) which occurs during the winter season.

The distribution of swamp sclerophyll forest containing *E.robusta* is generally restricted to creek lines and gullies in the study area. However the actual percentage of Swamp Mahogany (*E.robusta*) as a component of this community varies across sites and is generally low within most sites being dominated by the Broad-leaved Paperbark (*Melaleuca quinquenervia*). The distribution of potential habitat was mapped (refer Figure 2) and indicates that high quality areas are best represented in Nambucca and Newry State Forest to the east of the preferred route and also within private land to the south of Raleigh, and also east of the preferred route.

The preferred route will potentially involve removal of up to 0.3ha of high quality habitat, 5.6ha of medium and 19ha of low quality habitat from the study area. This loss is considered low and of little significance to populations of the Swift Parrot and Regent Honeyeater. Continued visitation to the region is expected following construction of the highway upgrade.

(b) In the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised

The Swift Parrot and Regent Honeyeater are scheduled as endangered species in NSW and there are no endangered populations listed of this species.

(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

For the purposes of this assessment and the ‘8-part test’ the ‘region’ referred to in part (c) is the entire North Coast Biogeographic Region. The Swift Parrot is a winter visitor to the north coast of NSW. Both this species and the Regent Honeyeater move considerable distances in search of flowering resources. As the nature of this resource is sporadic, the movements of these species depend on flowering irruptions and are not necessarily tied to specific areas. Both species are documented to exhibit a high degree of site fidelity (i.e. repeated visits to known areas), however accounts of the species between Macksville and Coffs Harbour are not consistent each year indicating that individuals may only visit during favourable flowering seasons and are not critically tied to the presence of winter-flowering species which occur in the study area.

The areas of potential habitat addressed within this assessment (ie. the study area) constitute only a fraction of the area of known habitat for these species within the NSW north coast. Furthermore, whilst the study area is expected to provide important habitat resources and assist in life-cycle events for this species, thus contributing as an area of potential habitat, such resources are not solely restricted to the preferred route area and are better represented outside of this area, for example Moonee Nature Reserve at Coffs Harbour. Therefore the potential habitat to be impacted by the preferred route is not considered to be a significant area in relation to the regional distribution of habitat for the Swift Parrot and Regent Honeyeater.

(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas for a threatened species, population or ecological community.

Most vegetation within the study area has been heavily fragmented by rural and urban development, including the existing Pacific Highway. Based on the movements and records of these species in the north coast region, both species are adapted to finding and accessing fragmented habitats and isolated flowering trees. The preferred highway route will not result in the isolation of potential habitat for these wide-ranging semi-nomadic species. The largest areas of intact forest occur within Nambucca and Newry State Forest and these high quality habitats will be retained to the east of the road footprint.

(e) Whether critical habitat will be affected

No areas of critical habitat have been listed for the Swift Parrot in the study area

(f) whether a threatened species, population or ecological community, or their habitats are adequately represented in conservation reserves (or other similar protected areas) in the region.

For the purposes of this assessment and the ‘8-part test’ the ‘region’ referred to in part (f) is the entire North Coast Biogeographic Region. The Swift Parrot and Regent Honeyeater are semi-nomadic species and movements depend on the availability of seasonally fluctuating flowering resources. Vegetation communities of particular importance in the region for these species include coastal Swamp Mahogany and Forest Red Gum forests. Within the region these forest types have been disproportionately removed for development and agriculture. Indeed the habitat type is poorly conserved (Griffith 1991).

The Swift Parrot has been recorded in Crowdy Bay and Yurygir National Parks as well as Lake Innes, Limeburners Creek and Moonee Beach Nature Reserves. The Regent Honeyeater has been recorded in Hat Head, Yuraygir, Bundjalung, Broadwater and Nightcap National Parks as well as Moonee Beach, Sherwood and Bilinudgel Nature Reserve and Bundjalung Crown Reserve.

It is reasonable to suggest that the habitat of the Swift Parrot and Regent Honeyeater is inadequately represented in conservation reserves in the 'region'. However, this factor is unlikely to reflect a significant concern in relation to the proposal as the habitats which are represented do not constitute a significant area of known habitat and indeed extensive areas of comparable habitat occur throughout the North Coast Bioregion that will not be impacted by the proposal.

(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Clearing of native vegetation is recognised as a major factor contributing to the loss of habitat for these species. The associated impact of this threatening process are well documented and include the destruction of habitat, fragmentation of bushland, riparian zone degradation, increased habitat for invasive species and loss or disruption of ecological function.

Of particular importance relating to the proposed highway route and in assessing the impact on the Swift Parrot and Regent Honeyeater associated with land clearance, is that the proposed route has been specifically selected with an objective of minimising impacts on vegetation among other environmental variables. In achieving this, the route selected avoids the majority of the swamp forest habitat favoured by the Swift Parrot and Regent Honeyeater.

(h) whether any threatened species, population or ecological community is at the limit of its known distribution.

The Swift Parrot extends from its summer breeding grounds in Tasmania, from where it disperses to over-winter in southeast mainland Australia. Some individuals range north to Queensland, but the majority over-winter in Victoria and central and eastern New South Wales. The species returns to Tasmania in September. The study area constitutes a small percentage of the known distribution of the species and does not represent its geographical limit.

4.3.2 Conclusion

The results of the 8-part test for the Regent Honeyeater and Swift Parrot indicate that impacts on these species as a result of the preferred Pacific Highway route are minimal and negligible. While both species are regular visitors to the mid north coast region, the limited extent of habitat present within the Macksville to Urunga study area and lack of records suggests that the study area does not support regionally significant habitat. Furthermore, several large areas of high quality potential habitat for these species have been identified and will not be impacted by the preferred route. The current potential for these species to utilise habitat within the study area is expected to remain following the construction of the preferred route.

4.4 Environmental Protection and Biodiversity Conservation Act, 1999

The EPBC Act regulates any development or activity if it is likely to have a significant impact on any of the following matters of national environmental significance:

- World Heritage properties
- National Heritage List places
- wetlands listed under the Ramsar Convention as wetlands of international importance
- nationally threatened species and ecological communities listed under the EPBC Act
- migratory species listed under the EPBC Act
- the Commonwealth marine environment; and
- nuclear actions.

As the Swift Parrot and Regent Honeyeater are listed as nationally endangered species under the EPBC Act, the proposal is therefore subject to assessment under the provisions of the Act. This assessment provides an appraisal as to whether the project would lead to a significant impact on either species based on the information presented from a desktop review and field studies. The assessment is used to determine if the proposal should be referred to the Department of Environment and Heritage for approval with regard to the Swift Parrot and Regent Honeyeater.

The Australian Government has a bilateral agreement with the NSW Government accrediting the environmental assessment processes of the EP&A Act and TSC Act. The 8-part test undertaking in the previous section indicates that a significant impact would be avoided. Further assessment under the guidelines of the EPBC Act is discussed below, by indicating ***whether the project will*:**

Lead to a long-term decrease in the size of the population.

Both species are regarded as winter-visitors to this region, and would depend predominantly on the flowering of Swamp Mahogany and Forest Red Gum to provide food resources. Both tree species are present in low abundance and the study area is considered only marginal for the Swift Parrot and Regent Honeyeater. The largest patches of potential foraging habitat are present as SEPP 14 wetland areas within Nambucca and Newry State Forests. These areas have been avoided as part of the route options study and will not be impacted by the preferred route.

__Reduce the area of occupancy of the species or important population__

Both species are wide ranging and highly mobile, semi-nomadic species with patchy and sporadic distribution across coastal New South Wales. Their presence in the study area is seasonally dependent and influenced by drought and rain periods affecting the flowering of preferred tree species. Therefore there is no defined area of occupancy within the study area.

Evidence gathered on the movements of both species suggest that visits to the coastal Swamp Mahogany forests are not consistent every year and depend on flowering of the Box-Ironbark woodlands on the south western slopes of NSW and Victoria (Menkhorst et al 1999; Swift Parrot Recovery Team 2001; Geering 2004). The proposal will have minor impacts on small areas of potential habitat for these species.

__Fragment an existing population into two or more populations__

Potential habitat for these species as identified in this report occurs in small and fragmented patches present throughout the study area and already fragmented by existing roads and cleared land. Furthermore, both species are highly mobile and semi-nomadic capable for accessing patchy food resources. There are no defined areas of habitat in the study area that are exclusively occupied by these species and the preferred route would not fragment a population of the Swift Parrot or Regent Honeyeater,

__Adversely affect habitat critical to the survival of these species__

The register of critical habitat under the EPBC Act does not apply to land potentially critical to these species or to land present within the study area.

__Disrupt the breeding cycle of the species__

The Swift Parrot breeds in Tasmania, and no breeding sites of the Regent Honeyeater have been documented for coastal northern NSW.

__Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline__

The area of vegetation potentially removed as a result of the proposed surface construction areas is not considered significantly large or of a high quality to lead to the decline of these species in NSW. The preferred route would impact on only 0.3ha of high quality habitat, and approximately 5.6ha of medium quality and 19ha of low quality habitat. This is minimal in relation to the extent of potential habitat in the North Coast Bioregion.

Result in invasive species that are harmful to a threatened species becoming established in the habitat of the threatened species

Many of the bushland remnants which occur in the study area exhibit high levels of weed invasion and the preferred route avoids the largest patches of potential habitat identified in this study.

Any proposal to remove natural vegetation would be supported by the RTA’s standard revegetation and landscaping work methods including follow up weed removal.

Interfere with the recovery of the species

The preferred route and proposed highway construction would not conflict with the recovery of these two species. The preferred route has been selected on the basis of avoiding high quality habitats for these two species.

5. Conclusion

The results of this assessment for the Regent Honeyeater and Swift Parrot indicate that impacts on these species as a result of the preferred Pacific Highway route are minimal and negligible. While both species are regular visitors to the mid north coast region, the limited extent of habitat present within the study area and the lack of records for these species suggests that the area between Macksville and Urunga does not support regionally significant habitat for these species.

Therefore the assessment concludes that habitat potentially removed as a result of the preferred highway route is not considered significantly large or of a high quality to lead to the decline of these species in NSW. Several large areas of high quality potential habitat for these species have been identified between Macksville and Urunga that will not be impacted by the preferred route. As a result, the current potential for the Swift Parrot and Regent Honeyeater to utilise habitat within the study area is expected to remain following the development of the preferred Pacific Highway route from Macksville to Urunga.

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Appendix I Species listings

Fisheries Management Act 1994 (NSW)

- **Table 7-1 – Endangered Aquatic Fauna Species as listed under the NSW *FM Act* (1994)**

Freshwater	
Austrocordulia leonardi	Sydney Hawk Dragonfly
Craterocephalus fluviatilis	Murray Hardyhead
Maccullochella ikei	Eastern Freshwater Cod
Maccullochella macquariensis	Trout Cod
Nannoperca oxleyana	Oxleyan Pygmy Perch
Notopala sublineata	River Snail
Estuarine	
Pristis zijsron	Green Sawfish
Marine	
Carcharias taurus	Grey Nurse Shark
Thunnus maccoyii	Southern Bluefin Tuna

- **Table 7-2 - Distribution of Endangered Aquatic Fauna Species as listed under the NSW *FM Act* (1994)**

Species	Distribution
Freshwater	
Austrocordulia leonardi	The known distribution of the species includes three locations in a small area south of Sydney, from Audley to Picton. The species is also known from the Hawkesbury-Nepean, Georges River and Port Hacking drainages.
Craterocephalus fluviatilis	They were once widespread and abundant in the Murray and Murrumbidgee river systems in southern NSW.
Maccullochella ikei	Only found naturally in several isolated tributaries of the Clarence River.
Maccullochella macquariensis	Once abundant and widespread in the southern Murray-Darling river system.
Nannoperca oxleyana	Endemic to the coastal region of eastern Australia, from northern NSW to south-eastern Queensland. Populations are most common on the coastal floodplains of NSW where they disperse between water bodies during localised flood events.
Notopala sublineata	Once common and widespread in the Murray-Darling river system.
Estuarine	
Pristis zijsron	From northern NSW to south of Wollongong.
Marine	
Carcharias taurus	Julian Rocks (Byron Bay) Fish Rock (South West Rocks) Green Island (South West Rocks)

	The Pinnacle (Forster) Big and Little Seal Rocks (South of Forster) Little Broughton Island (North of Port Stephens) Magic Point (Maroubra - Sydney) Bass Point (Shellharbour) Tollgate Islands (Batemans Bay) Montague Island (Narooma)
Thunnus maccoyii	Occurs from northern NSW (300 S) to the Victorian border, normally on the seaward side of the continental shelf

- **Table 7-3 – Endangered Fish Populations as listed under the NSW *FM Act* (1994)**

Freshwater	
Ambassis agassizii	Olive Perchlet (western New South Wales population)
Mogurnda adspersa	Purple Spotted Gudgeon (western New South Wales population)

- **Table 7-4 – Distribution of Endangered Fish Populations as listed under the NSW *FM Act* (1994)**

Species	Distribution
Freshwater	
Ambassis agassizii	The western population of the olive perchlet are now found only at a few sites in the Darling River drainage.
Mogurnda adspersa	Purple spotted gudgeons occur in inland drainages of the Murray-Darling basin.

- **Table 7-5 - Marine Vegetation Species Presumed Extinct as listed under the NSW *FM Act* (1994)**

Vanvoorstia bennettiana	Bennetts Seaweed

- **Table 7-6 - Distribution of Marine Vegetation Species Presumed Extinct as listed under the NSW *FM Act* (1994)**

Species	Distribution
Vanvoorstia bennettiana	Last known sites Port Jackson & Sydney Harbour

- **Table 7-7 – Vulnerable Aquatic Fauna Species as listed under the NSW *FM Act* (1994)**

Freshwater	
Archaeophya adamsi	Adams Emerald Dragonfly
Bidyanus bidyanus	Silver Perch

Branchinella buchananensis	Buchanans Fairy Shrimp
Macquaria australasica	Macquarie Perch
Nannoperca australis	Southern Pygmy Perch
Estuarine	
Epinephelus daemelii	Black Cod
Marine	
Carcharodon carcharias	Great White Shark

- **Table 7-8 - Distribution of Vulnerable Aquatic Fauna Species as listed under the NSW *FM Act* (1994)**

Species	Distribution
Freshwater	
Archaeophya adamsi	Only known from a few sites in the greater Sydney region.
Bidyanus bidyanus	Once widespread and abundant throughout most of the Murray-Darling river system.
Branchinella buchananensis	Gidgee and Burkanoko Lakes in the north-west of NSW.
Macquaria australasica	They are found in the Murray-Darling Basin and parts of south-eastern coastal NSW, including the Hawkesbury and Shoalhaven catchments.
Nannoperca australis	Once widely distributed throughout the Murrumbidgee and Murray River systems, also recently been discovered in the upper Lachlan River catchment.
Estuarine	
Epinephelus daemelii	All of NSW coast line.
Marine	
Carcharodon carcharias	All of NSW coast line.

- **Table 7-9 – Vulnerable Marine Vegetation Species as listed under the NSW *FM Act* (1994)**

Nereia lophocladia	Marine Brown Alga

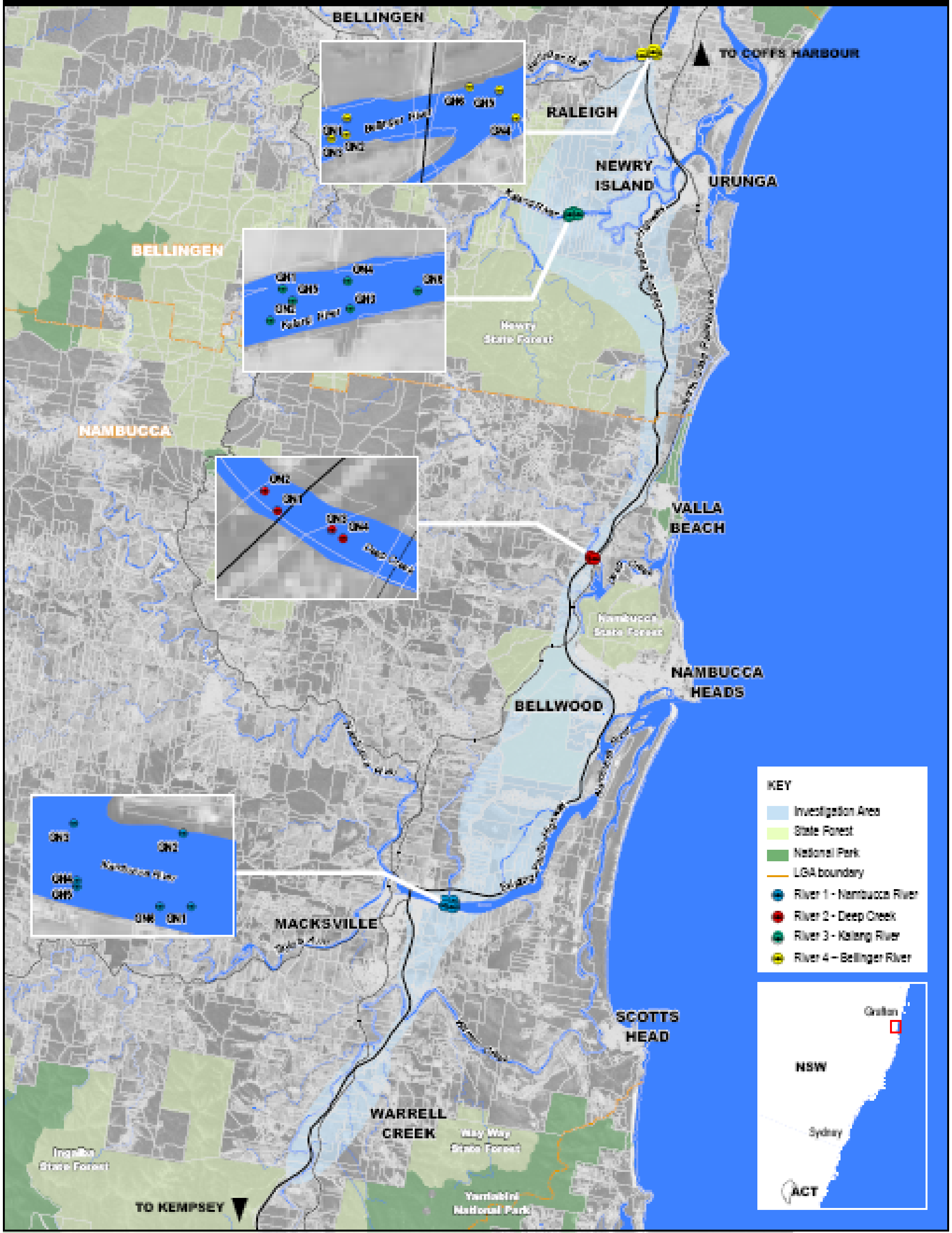
- **Table 7-10 - Distribution of Vulnerable Marine Vegetation Species as listed under the NSW *FM Act* (1994)**

Species	Distribution
Nereia lophocladia	Muttonbird Island at Coffs Harbour

Appendix J Sample location maps


NORTH BANK
BELLINGEN
RALEIGH
Raleigh Industrial Estate
MYLESTOM
MARX HILL
FERNMOUNT
SUNNY CORNER
SEPP351
RALEIGH SOUTH
MOUNT GLADSTONE
TARKEETH
NEWRY ISLAND URUNGA
NEWRY ISLAND
SOUTH URUNGA
BRIERFIELD
KENNAICLE CREEK
NEWRY
Newry State Forest
SPICKETTS CREEK
WENONAH HEAD
PICKETT HILL
Little Newry State Forest
MISSABOTTI
VALLA
VALLA BEACH
NEWEE CREEK
BOWRAVILLE
NAMBUCCA HEADS
TEWINGA
Nambucca State Forest
BELLWOOD
WIRRIMBI
NORTH MACKSVILLE
CONGARINNI NORTH
TALARM
MACKSVILLE
PACIFIC HWY
SEPP386
GUMMA
SEPP388
Macksville Sewage Treatment Plant
CONGARINNI
SCOTTS HEAD
UTUNGUN
DONNELLYVILLE
WARRELL CREEK
GRASSY HEAD
WAY WAY
Legend
Water Quality Sites
SEPP14 Wetlands
Property Boundaries
WC2URoad design
PACIFIC HIGHWAY
A3 1:130,000 Kilometres
URUNGA
MACKSVILLE
WARRELL CREEK
Warrell Creek to Urunga
Water Quality Site Locations
GDA 94 MGA Zone 56
October 30, 2007
SKM

APPENDIX A | GILL NET SURVEY LOCATIONS



Warrell Creek to Urunga - Upgrading the Pacific Highway

ENVIRONMENTAL ASSESSMENT | SINCLAIR KNIGHT MERZ

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Appendix K Historic data

Table 3: Species of fish recorded in the Nambucca and Bellinger River basins. The location of each study is given in relation to the investigation area (i.e. upstream, within, downstream). 1 = The Ecology Lab (1998), 2= Gibbs *et al*. (1999), 3 = Llewellyn (1983), 4 = Bishop (1993). 5 = Storrs

Family name	**Species name**	**Common name**	1 Nambucca (upstream)	2 Warrell (Downst.)	3 Bellinger (upstream)	4 Bellinger (upstream)	5 Bellinger (upstream)
Anguillidae	*Anguilla australis*	Short finned eel	✓				✓
	Anguilla reinhardtii	Long finned eel	✓		✓	✓	✓
	Hyperlophus vittatus	Sandy sprat		✓			
	Potamalosa richmondia	Freshwater herring			✓	✓	✓
Retropinnidae	*Retropinna semoni*	Australian smelt	✓		✓	✓	✓
Galaxiidae	*Galaxias olidus*	Mountain galaxias					✓
	Galaxias maculatus	Common galaxidas					✓
Cyprinidae	*Cyprinus carpio*	European carp				✓	
Plotosidae	*Tandanus tandanus*	Freshwater catfish			✓	✓	✓
Belonidae	*Tylosurus gavialoides*	Stout longtom		✓			
Poeciliidae	*Gambusia holbrooki*	Mosquito fish	✓	✓	✓	✓	
Melanotaenidae	*Melanotaenia duboulayi*	Duboulay's Rainbowfish	✓		✓	✓	✓
Hemiramphidae	*Hyporhamphus regularus*	River garfish		✓			
	Arrhamhus sclerolepis	Snub-nosed gar				✓	
Atherinidae	*Pseudomugil signifer*	Southern blue-eye	✓	✓	✓	✓	✓
Syngnathidae	*Urocampus carnirostrus*	Hairy pipefish		✓			
	Vanacampus margaritifer	Mother of pearl pipefish		✓			
Scorpaenidae	*Centropogon australis*	Fortescue		✓			
	Notesthes robusta	Bullrout	✓		✓	✓	✓
Chandidae	*Ambassis jacksoniensis*	Port Jackson glassfish		✓		✓	

Continued

Table 3: Continued

Family name	Species name	Common name	1 Nambucca (upstream)	2 Warrell (Downst.)	3 Bellinger (upstream)	4 Bellinger (upstream)	5 Bellinger (upstream)
	Ambassis marianus	Ramsey's glassfish		✓			
	Ambassis agassizii	Olive perchlet			✓		
Platycephalidae	*Platycephalus fuscus*	Dusky flathead		✓	✓	✓	✓
Percichthyidae	*Macquaria colonorum*	Estuary perch			✓		
	Macquaria novemaculeata	Australian bass				✓	✓
Apogonidae	*Siphamia spp.*	Siphonfish					
	Siphamia roseigaster	Silver siphonfish		✓			
Sillaginidae	*Sillago ciliata*	Sand whiting		✓			
Pomotomidae	*Pomatomus saltatrix*	Tailor					
Carangidae	*Caranx spp.*	Trevally		✓			
	Pseudocaranx dentex	White trevally					
	Scomberoides lysan	Queenfish		✓			
	Gnathanodon speciosus	Golden trevally					
Sparidae	*Acanthopagrus australis*	Yellow-finned bream		✓		✓	
Terapontidae	*Pelates quadrilineatus*	Four-lined trumpeter		✓			
	Pelates sexlineatus	Eastern striped trumpeter		✓			
	Terapon jarbua	Crescent perch		✓			
Lutjanidae	*Lutjanus russeli*	Moses Perch		✓			
Gerreidae	*Gerres subfasciatus*	Silver biddy		✓		✓	
Sciaenidae	*Argyrosomus japonicus*	Mulloway					
Girellidae	*Girella tricuspidata*	Luderick				✓	
Sparidae	*Chrysophrys auratus*	Snapper		✓			
	Rhabdosargus sarba	Tarwhine		✓			

Continued

Table 3: Continued

Family name	Species name	Common name	1 Nambucca (upstream)	2 Warrell (Downst.)	3 Bellinger (upstream)	4 Bellinger (upstream)	5 Bellinger (upstream)
Monodactylidae	*Monodactylus argenteus*	Silver batfish		✓			
Kyphosidae	*Girella tricuspidata*	Blackfish		✓			
	Microcanthus strigatus	Stripey		✓			
Mugilidae	*Liza argentea*	Flat-tail mullet	✓	✓			
	Mugil cephalus	Sea mullet	✓	✓	✓	✓	
	Myxus elongatus	Sand mullet		✓			
	Myxus petardi	Freshwater mullet	✓		✓	✓	✓
	Valamugil georgii	Fantail mullet					
Scatophagidae	*Scatophagus argus*	Spotted scat		✓			
Labridae	Unknown Labridae	Groper		✓			
	Achoerodus viridis	Eastern blue groper		✓			
Blenniidae	*Petroscirtes lupus*	Brown sabretooth blenny		✓			
Gobiidae	*Redigobius macrostoma*	Largemouth goby		✓			
	Arenigobius bifrenatus	Half bridled goby		✓			
	Favonigobius exquisitus	Exquisite sand goby		✓			
	Favonigobius tamarensis	Tamar goby		✓			
	Gobiopterus semivestitus	Glass goby		✓			
Eleotrididae	*Butis butis*	Bony-snouted gudgeon		✓			
	Gobiomorphus australis	Striped gudgeon	✓	✓	✓	✓	✓
	Gobiomorphus coxii	Cox's gudgeon	✓			✓	✓
	Hypseleotris compressa	Empire gudgeon	✓	✓	✓	✓	
	Hypseleotris galii	Firetail gudgeon	✓	✓			
	Hypseleotris spp.	Unidentified Gudgeon	✓	✓			
	Philypnodon grandiceps	Flathead gudgeon	✓	✓		✓	✓

Continued

Table 3: Continued

Family name	Species name	Common name	1 Nambucca (upstream)	2 Warrell (Downst.)	3 Bellinger (upstream)	4 Bellinger (upstream)	5 Bellinger (upstream)
	Philypnodon spp.	Dwarf flathead gudgeon	✓	✓			
Gobiidae	*Pandaculus lidwilla*	Dwarf goby		✓			
	Parkraemeria ornata	Goby		✓			
	Pseudogobius olorum	Blue-spot goby		✓			
	Mugilogobius paludis	Mangrove goby		✓			
Nomeidae	*Psenes arafurensis*	Banded driftfish		✓			
Monacanthidae	*Juvenile Monacanthidae*	Leatherjacket		✓			
	Meuschnia freycineti	Six spine leatherjacket		✓			
	Meuschnia trachylepis	Yellow-finned leatherjacket		✓			
	Paramonacanthus otisensis	Dusky leatherjacket		✓			
Tetraodontidae	*Marilyna pleurosticta*	Toadfish		✓			
	Tetractenos hamiltoni	Common toadfish		✓			

Appendix L Water quality results

Water quality parameters reported between 26th November and 30th November 2007

Site name	Coordinates*	Electrical conductivity (µS/cm)	DO (ppm)	DO (% sat)	pH	Turbidity (NTU)	Temperature (°C)
Williamson Creek Site 1a	491 705 / 6598 052	254	-	*	6.38	42	20.5
Williamson Creek Site 1a	491 498 / 6598 010	315	-	65	6.45	24	22.3
Boggy Creek Site 4b	497 549 / 6612 023	625	-	20.7	6.26	12.4	21.3
Cow Creek Site 5a	497 619 / 6613 038	258	5.75	-	6.28	0	25.4
Cow Creek Site 5b	497 728 / 6612 920	14700	4.5	-	6.5	5.9	25.8
Unnamed Tributary to Oyster Creek 7a	500 188 / 6616 493	203	2.5	-	6.18	7.5	24.3
Unnamed Tributary to Oyster Creek 7b	500 323 / 6616 504	270	4.2	-	6.34	11	23.3

* Due to equipment malfunction

- Not recorded

Water quality parameters reported between 14th July and 17th July 2008

Site name	Coordinates	Electrical conductivity (µS/cm)	DO (ppm)	DO (% sat)	pH	Turbidity (NTU)	Temperature (°C)
Butchers Creek Site W2a	489895/6594912	147.67	5	49.4	4.8	3.6	14.62
Butchers Creek Site W2b	489761/6594917	148	3.43	34.2	4.65	2.07	14.49
Rosewood Creek Site W3a	490468/6595871	250	7.27	72.17	6.44	6.5	15.12
Rosewood Creek Site W3b	490458/6596225	239.33	3.4	64.53	5.1	8.4	15.53
Stony Creek Site W4a	490908/6596713	425.33	6.47	62.4	6.12	24	14.21
Stony Creek Site W4b	490772/6596913	438	8.13	79.1	5.64	17.73	14.67

Appendix M Macroinvertebrate results

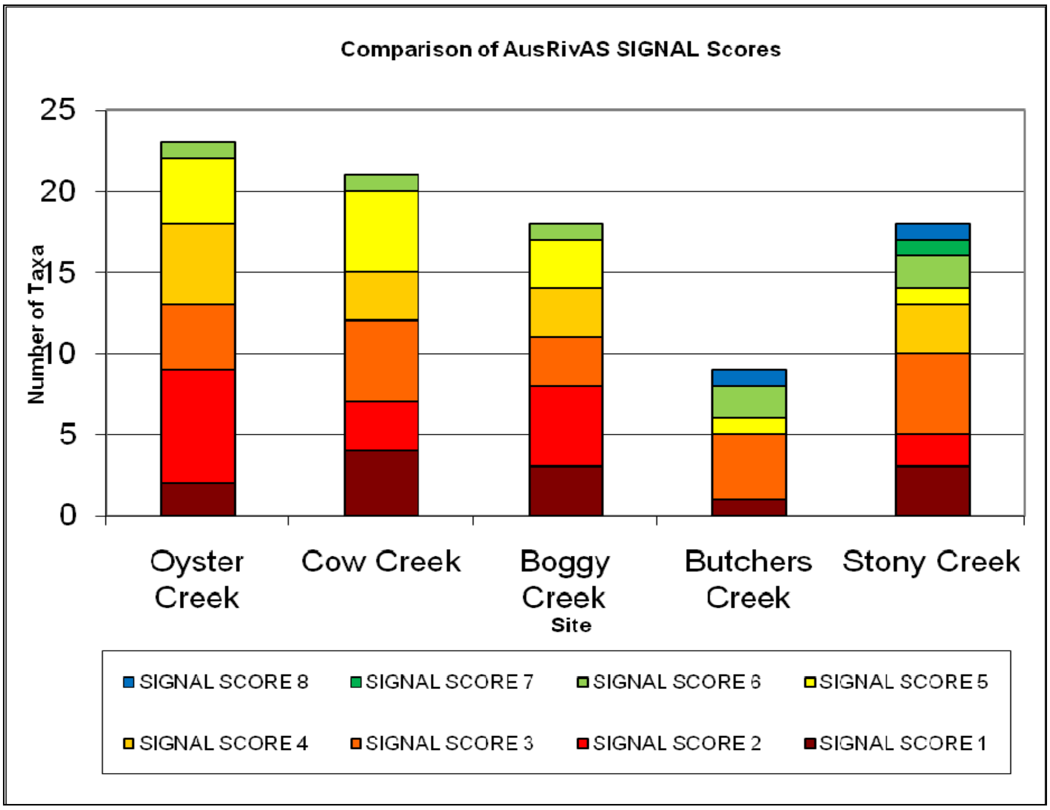
AusRivAS modelling output

Site	Butchers Creek	Stony Creek	Cow Creek	Boggy Creek	Oyster Creek
NTE50	9.92	13.67	10.49	10.49	10.46
NTP50	13	18	13	13	13
NTC50	6	9	8	8	8
OE50	0.61	0.66	0.76	0.76	0.76
E50Signal	4.24	4.43	3.92	3.91	3.93
O50Signal	4.83	4	3.38	3.13	2.75
OE50Signal	1.14	0.9	0.86	0.8	0.7
E0Signal	4.3	4.74	3.92	3.92	3.93
O0Signal	4.22	3.76	3.62	3.23	3.6
OE0Signal	0.98	0.79	0.92	0.82	0.91
Band	B	B	B	B	B

Summary water quality statistics

Parameter	No. Replicates	Boggy Creek	Cow Creek	Oyster Creek	Butchers Creek	Stony Creek	ANZECC/ ARMCANZ (2000) trigger values
pH	3	7.11	7.22	**6.99**	**4.65**	**6.12**	7.0 - 8.5
Conductivity	3	485.67	245	258.33	148	425.33	
Salinity	3	0.24	0.1	0.1133	0.08	0.24	
Turbidity (NTU)	3	**102.03**	**17.93**	**71.8**	2.07	**24**	0.5 - 10
Dissolved Oxygen (%	3	**3.37**	**51.43**	**32.3**	**34.2**	62.4	80 - 110
Temperature (°C)	3	17.45	22.55	21.31	14.49	14.21	
Alkalinity (mg/L	1	40	35	35	11	16	

- **Comparison of AusRivAS SIGNAL scores**



- **AusRivAS band scores (observed to expected ratios)**