

Moorland to Herons Creek EIS

Working Paper No. 7

Flora and Fauna Assessment





**PACIFIC HIGHWAY UPGRADE
MOORLAND TO HERONS CREEK
ENVIRONMENTAL IMPACT STATEMENT-
TERRESTRIAL FLORA AND FAUNA
REPORT**

NOVEMBER 2004

**RHIDIAN HARRINGTON
TOM O'SULLIVAN
TERRI-ANN ENGLISH
EMMA GORROD
MARTIN PREDAVEC
SELGA HARRINGTON**

**REPORT FOR
ARUP**

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PROJECT NO. S3384

**FRONT PICTURE: MIDDLE BROTHER FROM NORTH BROTHER
LOOKOUT SHOWING THE EXISTING HIGHWAY**

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- Matthew Richardson (Biosis Research)
- Martin Henery (Biosis Research)
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ABBREVIATIONS

CAMBA	China-Australia Migratory Bird Agreement
CAVS	Census of Australian Vertebrates
DEC	Department of Environment and Conservation (formerly NPWS)
DEC Estate	National Parks and Nature Reserves owned by DEC
DEH	Commonwealth Department of the Environment and Heritage (formerly Environment Australia)
DIPNR	Department of Infrastructure, Planning and Natural Resources
DLWC	Department of Land and Water Conservation (now DIPNR)
EIS	Environmental Impact Statement
EP&A Act	<i>Environmental Planning and Assessment Act 1979</i>
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i>
EVC	Ecological Vegetation Classes
GIS	Geographic Information System
IUCN	International Union for the Conservation of Nature
JAMBA	Japan-Australia Migratory Bird Agreement
LGA	Local Government Authority
MNES	Matters of National Environmental Significance
NPWS	National Parks and Wildlife Service (now DEC)
RFI Act	<i>Rivers and Foreshores Improvement Act 1948</i>
ROTAP	Rare or Threatened Australian Plant
RTA	NSW Roads and Traffic Authority
SEPP	State Environmental Planning Policy
SIS	Species Impact Statement
sp.	Species (singular)
spp.	Species (plural)
STP	Sewage Treatment Plant
subsp.	subspecies
TSC Act	<i>Threatened Species Conservation Act 1995</i>
var.	variety
WM Act	<i>Water Management Act 2000</i>

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SUMMARY

Biosis Research Pty. Ltd. was commissioned by Arup on behalf of the NSW Roads and Traffic Authority (RTA) to investigate the terrestrial flora and fauna aspects of the proposed upgrade of the Pacific Highway between Moorland and Herons Creek on the NSW North Coast.

The aims in general of this study and report were to identify terrestrial flora and fauna issues associated with the upgrade of the Highway relating to the preferred route. The specific objectives were:

- to conduct a literature review and database search for the local area surrounding the study area;
- undertake field surveys for terrestrial flora and fauna species and their habitats;
- describe the terrestrial habitat values associated with the study area;
- assess the conservation significance of the study area in terms of threatened species, important habitat and the role of the sites in the functioning of the larger landscape;
- evaluate the potential impact of the proposed development by undertaking Eight Part Tests for threatened terrestrial flora and fauna species that may occur in the study area as outlined in the *Threatened Species Conservation Act 1995* (TSC Act) and the *Environmental Planning and Assessment Act 1979* (EP&A Act);
- evaluate further the potential impact of the proposed development by undertaking significance assessments for threatened and migratory species as outlined in the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) guidelines on significance assessment;
- make recommendations to avoid potential impacts of the proposed development on the natural values of the study sites and where avoidance is not possible, recommendations to minimise impacts; and,
- determine any requirements for a Species Impact Statement (SIS) under the provisions of the TSC Act and/or a Referral to the Federal Minister for the Environment under the provisions of the EPBC Act.

The site was assessed between the 5th and 23rd of November 2001, between the 4th and 8th of November 2002 and on 16th, 17th, 30th and 31st March 2004, using a combination of habitat based assessment and targeted sampling techniques.

The study area consists of the area of earthworks for the proposed road, the proposed road reserve and a buffer of approximately 50 m on either side of the road. Standard practices were used to collect data and were based largely on guidelines developed by NPWS (now DEC) for flora and fauna survey methods for Pacific Highway Upgrade Projects. The surveys were conducted in accordance with Section 5A of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and also the NSW NPWS Information Circular on Threatened Species Assessment. Surveys were carried out in advance of the determination of the preferred route so as to coincide with the flowering period of threatened species of plant and the activity period of threatened

species of animal. This meant that all route options were surveyed and hence a wider area was surveyed than simply the preferred route.

Flora

Five native vegetation communities were recorded along the proposed route: Coastal Blackbutt Forest, Dry Tallowood Forest, Flooded Gum Forest, Freshwater Wetland (Sedgeland) and Swamp Sclerophyll Forest. Two of these communities, Freshwater Wetland (Sedgeland) and Swamp Sclerophyll Forest, are listed as Endangered Ecological Communities on the TSC Act. Eight Part Tests determined that these communities would not be significantly impacted by the proposal.

A total of 302 species of plant were recorded from the study area, comprising 255 (84%) native species. No ROTAP (Rare or Threatened Australian Plant) species or threatened flora species listed on the TSC or EPBC Act were recorded during the survey.

Based on the Department of Environment and Conservation (DEC) Atlas of NSW Wildlife and the Department of the Environment and Heritage (DEH) EPBC database, there are 33 threatened species of plant that must be considered under the TSC Act and 18 threatened species to be considered under the EPBC Act. Eighteen of these species must be considered under both Acts. Of the total of 33 species, 15 have potential habitat within the study area. Eight Part Tests and/or the EPBC Act Guidelines on Significance determined the potential impacts of the proposed highway upgrade on these species.

Fauna

Ninety species of vertebrate were recorded from the study area including five amphibians, six reptiles, 61 birds and 18 mammals. All species recorded are native apart from the introduced fox. Six threatened species listed in the schedules of the TSC Act were recorded including two birds (Glossy Black-cockatoo and Black-necked Stork) and four species of bat (three microchiropterans and one megachiropteran). The Grey-headed Flying Fox is listed on both the TSC Act and the EPBC Act. Seven migratory species as listed under the EPBC Act were recorded in the area.

Based on DEC's Atlas of NSW Wildlife and DEH's EPBC database, there are 38 threatened species of animal that must be considered under the TSC Act and 17 threatened and/or migratory species that must be considered under the EPBC Act. Twenty-two species must be considered under both Acts. Five additional migratory species not listed on the EPBC Database were recorded on site. Of the total of 81 species, 38 have actual or potential habitat within the study area. As such, assessment of the proposed upgrading of the highway considered potential impacts on these species as determined by Eight Part Tests and/or the EPBC Act Guidelines on Significance.

Fauna habitat within the study area ranges from cleared vegetation which has low conservation value in terms of fauna habitat characteristics, to relatively intact natural vegetation, including important habitat features such as tree hollows, riparian vegetation, fallen logs and feeding resources.

Wildlife Corridors and Connectivity

To both the east and west of the preferred route there are a number of large areas of vegetation and fauna habitat including both State Forests and National Parks. These areas of vegetation form part of a large network of vegetation patches and connectivity among them should be maintained wherever possible. For example, in the Johns River Bypass Section, Johns River State Forest lies to the east while crown land on South Brother lies to the west. On a small spatial scale, habitat patches can occur on both sides of the highway and where possible connectivity should be maintained in these areas, thereby retaining the amount of available habitat for resident species and preserving ecological functionality in these areas.

A range of different animal species will exist on both sides of the preferred route, utilising the existing corridor network. These species will cover all taxonomic groups including frogs, reptiles, birds and mammals. Threatened species that may use the wider corridor network include the Koala, Spotted-tailed Quoll and Glossy Black-cockatoo.

A number of structures have been included in the road design that can be modified to enhance their functionality as fauna underpasses, including bridges and culverts. From a total of 55 structures it is recommended that 11 be modified to accommodate fauna crossings, hence maintaining or increasing connectivity along the route for a wide range of species.

Impact Assessment

Impacts of the proposed Highway upgrade are likely to come from a number of sources such as:

- Vegetation clearance/habitat loss;
- Edge effects;
- Fragmentation of habitat;
- Mortality of individuals during both the construction and operations phases; and
- Introduction and/or spread of weeds.

The key policy principle of the RTA's Road Development and Impact on Habitat Amelioration Measures is that "in principle, the planning and construction of roads should, in order of consideration endeavour to:

1. avoid impacts on habitat through the planning process;
2. minimise impacts on habitat through the planning process; and
3. mitigate impacts on habitat, through the use of a range of amelioration measures" (RTA 1998).

Where possible, important ecological features have been avoided during the initial route selection stage. For example, SEPP 14 wetlands located north of the Camden Haven River would not be impacted by the Highway upgrade project. Mitigation measures have been suggested to ameliorate impacts on terrestrial flora and fauna, including the:

- inclusion of fauna underpasses and barrier fencing to help animals move under the road and hence reduce mortality and barrier effects;
- implementation of vegetation clearing procedures so that there is minimal disturbance to remaining flora and fauna; and
- design of planting programs for the median strip and road reserve so that fauna are not attracted to the road and weed invasion is limited.

Specific mitigation measures have been recommended for the Green-thighed Frog (*Litoria brevipalmata*) including the provision of artificial breeding ponds.

Eight Part Tests as required under the EP&A and TSC Acts and significance assessments as recommended under the EPBC Act Guidelines on Significance Assessment were carried out for those species with potential habitat in the study area. The proposed upgrade of the Pacific Highway between Moorland and Herons Creek is unlikely¹ to have a significant² impact on any species as determined under the EP&A, TSC and EPBC Acts. As such a Species Impact Statement or a referral to the Federal Minister for the Environment is not recommended.

¹ Taken to be a real chance or possibility (see Glossary)

² Taken to mean important, weighty or more than ordinary (see Glossary).

1.0 INTRODUCTION

Biosis Research Pty. Ltd. was commissioned by Arup on behalf of the NSW Roads and Traffic Authority (RTA) to investigate the terrestrial flora and fauna aspects of the proposed upgrade of the Pacific Highway between Moorland and Herons Creek on the NSW North Coast. This report has been prepared to meet the requirements of the *Environmental Planning and Assessment Act 1979* (EP&A Act), the *Threatened Species Conservation Act 1995* (TSC Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). This assessment also takes into account the requirements of the *Rivers and Foreshores Improvement Act 1948* (RFI Act), State Environmental Planning Policy (SEPP) 14 – Coastal Wetlands and SEPP 44 – Koala Habitat Protection.

1.1 STUDY AREA

The study area is located in the vicinity of the existing Pacific Highway between Moorland and Herons Creek, south of Port Macquarie NSW and within the Greater Taree and Hastings Local Government Areas (LGAs) (Figure 1). The area is situated within the NSW North Coast Bioregion as described by Thackway and Cresswell (1995). The study area contains several habitat types and vegetation communities, including open forest, creek and drainage lines, swamps and SEPP 14 wetlands. The study area lies near to Johns River State Forest and Dooragan and Crowdy Bay National Parks and is adjacent to Yoorigan National Park and Middle Brother State Forest.

The study area consists of the area of earthworks for the proposed Highway upgrade, the proposed road reserve and a zone of likely impact of approximately 50 m on either side of the road. A distance of 50 m was chosen because this is the average distance that edge effects are likely to be seen and recorded from the edge of the road (Bali 2000).

The study area is divided into four sections (Figure 1):

- Johns River Bypass;
- Lake Section;
- Kew Bypass; and
- Herons Creek Section.

Details of the route selection process and a description of the preferred route are presented in other section of the Environmental Impact Statement.

1.2 AIMS

The principal objectives of this study were:

- to conduct a literature review and database search for the local area surrounding the study area;
- undertake field surveys for terrestrial flora and fauna and their habitats;
- describe the terrestrial habitat values associated with the study area;
- assess the conservation significance of the study area in terms of threatened species, important habitat and the role of the site in the functioning of the larger landscape;
- evaluate the potential impact of the proposed development by undertaking Eight Part Tests for threatened terrestrial flora and fauna that may occur in the study area as outlined in the TSC Act;
- evaluate further the potential impact of the proposed development by undertaking Significance Assessments for threatened and migratory species as outlined in the EPBC Act guidelines on significance assessment;
- make recommendations to avoid potential impacts of the proposed development on the natural values of the study sites and where avoidance is not possible, recommendations to minimise impacts; and,
- determine any requirements for further study to the level of a Species Impact Statement (SIS) under the provisions of the TSC Act and/or a Referral to the Federal Minister for the Environment under the provisions of the EPBC Act.

2.0 METHODS

Field flora and fauna investigations of the study area were carried out between the 5th and 23rd of November 2001 (general surveys), between the 4th and 8th of November 2002 (targeted surveys for *Acacia courtii* and *Eucalyptus seeana* and on 16th, 17th, 30th and 31st March 2004 (targeted surveys for Green-thighed Frog). The general condition of the study area was assessed and observations of plant and animal species and vegetation communities were made (as detailed below). During the field investigation the weather was variable and included both rain and high winds during the 2001 surveys, with the temperature generally in the mid to high 20s (degrees celsius). The November 2001 surveys were carried out in advance of the determination of the preferred route so as to coincide with the flowering period of threatened species of plant (e.g. *Caesia parviflora* var. *minor*, *Tetratheca juncea* and *Sarcophilus hartmanii*) and the activity period of threatened species of animal (e.g. bats and frogs). This meant that all route options were surveyed and hence a wider area was surveyed than simply the preferred route.

2.1 PERSONNEL INVOLVED IN FIELD SURVEYS

Personnel involved in the field surveys and the level of their experience is shown below (Table 1). Curricula vitae of survey members are shown in Appendix 1.

Table 1: Personnel involved in field surveys

Name	Field	Qualifications	Experience	Role in project
Dr Martin Predavec	Zoologist Ecologist	BSc(Hons), PhD	12 years	Fauna survey design Fauna surveys Threatened fauna assessment Wildlife corridors Fauna crossing structures
Thomas O'Sullivan	Ecologist	BSc	9 years	Targeted frog surveys
Andrew Hill	Botanist	BSc MEnvSci	6 years	Targeted flora surveys
Matthew Richardson	Botanist	BSc(Hons)	6 years	Flora survey design Flora habitat assessment surveys Targeted flora surveys
Selga Harrington	Botanist	BSc(Hons)	3 years	Flora habitat assessment surveys Targeted flora surveys Threatened flora assessments
Terri-Ann English	Zoologist Ecologist	BEnvSci	3 years	Fauna surveys including targeted frog surveys Targeted flora surveys
Martin Henery	Botanist	BSc(Hons)	4 years	Flora habitat assessment surveys

2.2 TAXONOMY

Plant taxonomy (method of classification) used in this report follows Harden (1990, 1991, 1992, 1993, 2002), Fairley and Moore (2000), Robinson (1994) and additional/supplementary advice from the National Herbarium of NSW.

Names of vertebrates follow the Census of Australian Vertebrates (CAVS) data maintained by DEH

<<http://www.ea.gov.au/biodiversity/abrs/abif/fauna/cavs/index.html>>.

2.3 DATABASE REVIEW

Records were obtained from the NSW Department of Environment and Conservation (DEC) Atlas of NSW Wildlife for the area within a 10 km radius of the study area, using the Camden Haven and Kempsey 1:100 000 map sheets (Accessed October 2001, updated May 2002 and again January 2003). Records for threatened species, populations and communities and migratory species listed in the EPBC Act that could potentially occur in the area were obtained from the DEH's EPBC Online Database (<http://epbcweb.ea.gov.au>, accessed 29/10/01, updated 9/04/02 and again 8/01/03), again within a 10 km radius of the study area.

The Atlas of NSW Wildlife is based on specific records provided by researchers and members of the public. Each point is entered on a 1 km grid and hence location is only accurate to within 1 km. The Atlas of NSW Wildlife is not based on systematic surveys across New South Wales and the number of records tends to be biased towards coastal sites and towards areas where people commonly visit. It is also biased towards particular species, reserves and roads (Ewin 1997, NSW National Parks and Wildlife Service 1999).

The DEH's EPBC Online Database is based on predicted distributions compiled from a number of sources at various resolutions. Generally, where distributions are well known, maps have been derived from recovery plans, State vegetation maps, remote sensing imagery and detailed habitat studies. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data have been used to produce indicative distribution maps. For species whose distributions are less well known, point locations are collated from various sources and bioclimatic distribution models generated and then validated by experts. In some cases, distribution maps are based solely on expert knowledge (Environment Australia 2002).

The following species and ecological communities have not been mapped and do not appear in reports produced from the EPBC database:

- threatened species listed as extinct or considered as vagrants;
- some species and ecological communities that have only recently been listed;

- cetaceans which are not listed as threatened;
- some terrestrial species that overfly the Commonwealth marine area; and
- migratory species that are very widespread, vagrant, or only occur in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites; and
- seals which have only been mapped for breeding sites near the Australian continent (Environment Australia 2002).

Where considered necessary, Wildlife Atlas and EPBC database information is supplemented with records from other sources such as local wildlife groups or personal communications.

2.4 FLORA SURVEY

Species of plant growing in the study area were surveyed by undertaking a general habitat assessment as well as targeted searches for threatened species and their habitat. Incidental observations of other species were recorded.

2.4.1 FLORA SURVEY EFFORT

The survey effort for the flora surveys is shown in Table 2. Time spent in each route section refers to the number of people hours spent surveying the study area which includes the area within proposed acquisition boundary and areas in the immediate vicinity. The time spent in ‘Surrounding Areas’ includes the survey effort along other proposed route options.

Flora habitat assessment surveys were carried out by Selga Harrington and Matthew Richardson in the week starting the 5th of November and Selga Harrington and Martin Henery in the weeks starting the 12th and 19th of November 2001.

Following the flora habitat assessment surveys, Eight Part Tests and EPBC Assessment of Significance concluded that the proposed development was likely to have a significant impact on one threatened plant species (*Acacia courtii*) and one threatened plant population (*Eucalyptus seeana*). Selga Harrington, Matthew Richardson, Andrew Hill and Terri-Ann English carried out targeted surveys for these two species in the week starting the 4th of November 2002.

Table 2: Survey effort (person hours) for the flora surveys.

	Route Section				Surrounding Areas	TOTAL (Hours)
	Johns River Bypass	Lake Section	Kew Bypass	Hérons Creek Section		
Flora Habitat Assessment	48	40	26	32	46	192
Targeted surveys	21	28	21	21	-	91
TOTAL	69	68	47	53	46	283

2.4.2 FLORA HABITAT ASSESSMENT

The condition of the vegetation was assessed according to the degree to which it resembled relatively natural, undisturbed vegetation using the following criteria:

- species composition (species richness, degree of weed invasion); and,
- vegetation structure (representation of each of the original layers of vegetation).

Three categories were used to evaluate general habitat value; Good, Moderate or Poor, as detailed below:

Good: containing a high number of indigenous species; no weeds present or weed invasion restricted to edges and track margins; vegetation community contains original layers of vegetation; vegetation layers (ground, shrub, canopy etc) are intact.

Moderate: containing a moderate number of indigenous species; moderate level of weed invasion; weeds occurring in isolated patches or scattered throughout; one or more of original layers of vegetation are modified; vegetation layers (ground, shrub, canopy etc) are largely intact.

Poor: containing a low number of indigenous species; high level of weed invasion; weeds occurring in dense patches or scattered throughout; one or more of the original layers of vegetation are highly modified; one or more original vegetation layers (ground, shrub, canopy etc) are modified or missing.

2.4.3 VEGETATION MAPPING

Vegetation along the preferred route was mapped using:

- Aerial photographs (flown October, 2000);
- DEC Eastern Bushland Database;
- Hastings Shire Council Vegetation Mapping (1:25 000);
- City of Greater Taree Council Vegetation Mapping (Draft); and,
- Ground truthing.

2.4.4 TARGETED SURVEYS

The plant surveys targeted *Acacia courtii* and *Eucalyptus seeana*. Neither species is cryptic, but the best time for the survey is between November and January when *Acacia courtii* is likely to be flowering. For the purpose of these surveys the study area was the footprint of the Highway, defined as the extent of works plus a width of 100 metres beyond the limit of the works, on both side of the road. A wider corridor was surveyed for the targeted survey than for the initial habitat assessment to ensure that these species were not found within the immediate vicinity of the proposed works in an area which may be subject to indirect impacts (including edge effects). Ninety one person hours were spent undertaking the targeted survey and the entire naturally vegetated route was traversed. As both species may occur in a range of habitat types it was necessary to sample all vegetation types along the route apart from cleared areas. The botanists walked two transects on the eastern side of the route and two on the western side. Transects zigzagged across the footprint to increase coverage of the area. These methods account for the different vegetation types along the route and the need for stratification of the sampling. Since the effort was evenly spread along the route it is proportional to the extent of each vegetation type.

In addition to surveying the two targeted species, notes were made of the location and population of other threatened species encountered during the surveys.

2.5 FAUNA SURVEY

The fauna survey was largely habitat based in accordance with the DEC guidelines for the preparation of Eight Part Tests (NPWS 1996). Although the recording of threatened species within survey results can confirm their presence in a study area, the lack of threatened species records cannot be used to argue for the absence of the species from the site when suitable habitat is present. By the very nature of their rarity, threatened species are often difficult to detect. Therefore suitable habitat is the most important factor to consider when determining the presence of threatened species, although actual fauna surveys can be used to supplement this information, giving a better appreciation of species and habitat types present in the area.

Thus to supplement the habitat surveys, species of animal using the study area were surveyed by undertaking active searching and listening as well as recording incidental observations. Standard survey methods were used to collect data relating to fauna and were based largely on guidelines developed by DEC (NPWS 1999g) as outlined below. The survey effort and associated investigations were considered sufficient to record extant threatened species (and/or their habitats) or the potential for them to occur and undertake Eight Part Test assessments (as required under Section 5A of the EP&A Act).

2.5.1 FAUNA SURVEY EFFORT

The survey effort for the fauna survey is shown in Table 3. In addition to the direct fauna survey shown in this table, the botanists also made incidental observations of fauna while undertaking the flora survey (see Table 2 and Section 3.4.1). Time spent in each route section, unless otherwise stated, refers to the number of people hours spent surveying the specific section and areas in the immediate vicinity. Time spent in ‘Surrounding Areas’ includes survey effort along other proposed route options.

Not all fauna survey techniques were employed in each section of the preferred route. For example frog surveys were not carried out in the Johns River Bypass or the Lake Sections because suitable habitat was not present. Spotlighting and Anabat detection were not carried out in all parts of the Johns River Bypass and the Herons Creek Sections due to the closeness of sections of the preferred route to the existing road causing danger to the researchers and interfering with equipment (see Section 2.8). Martin Predavec and Terri-Ann English carried out fauna surveys (see Table 1). Additional targeted frog surveys were carried out by Thomas O’Sullivan and Terri-Ann English (Table 3).

Table 3: Survey effort for the fauna surveys.

Survey type	Route Section					TOTAL
	Johns River Bypass	Lake Section	Kew Bypass	Herons Creek Section	Surrounding areas	
Habitat Assessment (person hours)	12	24	24	11.5	31	102.5
Bird surveys (person hours)	6	6	6	7.5	7	32.5
Frog surveys (person hours)	- ^a	- ^a	2	2	- ^a	4
Spotlighting (person hours)	4	6	8	- ^b	- ^b	18
Call Playback (hours)	- ^a	1	1	1	- ^a	3
Anabat -Bat detection (hours)	13.5	12	24	- ^c	- ^d	49.5
Additional targeted frogs surveys	-	-	-	30	-	30.0
TOTAL (hours)	35.5	49	65	52	38	239.5

a: Lack of suitable habitat for threatened species.
 b: Route too close to existing highway to carry out spotlighting safely.
 c: Position of route next to existing Highway caused interference.
 d: Equipment failure.

2.5.2 FAUNA HABITAT ASSESSMENT

A general habitat based survey of the study area was carried out as well as an assessment of more specific habitat requirements of threatened species previously recorded or likely to occur in the local area. The habitat assessment was used to predict the likely occurrence of threatened animals in the study area. Habitat characteristics can include structural features such as vegetation layers and fallen timber, feeding resources such as specific feed trees, or nesting resources such as tree hollows. Habitat requirements of threatened animals were determined from the literature as well as previous survey data detailing the habitat in which the species were recorded.

Three categories were used to evaluate general habitat value; Good, Moderate or Poor, as detailed below:

Good: ground flora containing a high number of indigenous species; vegetation community structure, ground, log and litter layer intact and undisturbed; a high level of breeding, nesting, feeding and roosting resources available; a high richness and diversity of native fauna species.

Moderate: ground flora containing a moderate number of indigenous species; vegetation community structure, ground log and litter layer moderately intact and undisturbed; a moderate level of breeding, nesting, feeding and roosting resources available; a moderate richness and diversity of native fauna species.

Poor: ground flora containing a low number of indigenous species, vegetation community structure, ground log and litter layer disturbed and modified; a low level of breeding, nesting, feeding and roosting resources available; a low richness and diversity of native fauna species.

Other habitat features, such the value of the study area as a habitat corridor, or the presence of remnant communities, or unusual ecological vegetation community structure, were also used to assess habitat quality.

As well as the general habitat features detailed above, specific habitat features were noted for individual species. For example, *Allocasuarina* spp. (She-Oaks) is an important foraging resource for Glossy Black-Cockatoos and is an indicator of potential habitat for this species. The presence or absence of potential habitat for each threatened species that has been recorded in the local area was recorded for each section of road.

The habitat based surveys were carried out in November 2001 by M Predavec and T English.

2.5.2.1 Weather Codes

Weather codes used below are standard DEC reporting codes used in fauna survey proformas, as outlined below.

Wind: 0 = calm, 1 = light, leaves rustle, 2 = moderate branches move, 3 = string, tops of trees move.

Rain: 0 = none, 1 = drizzle – light, 2 = drizzle – heavy, 3 = heavy rain.

Moon: 0 = none, 1 = ¼ moon, 2 = ½ moon, 3 = ¾ moon, 4 = full moon.

2.5.3 SUPPLEMENTARY FAUNA SURVEYS

2.5.3.1 Spotlighting

Spotlighting was undertaken to detect nocturnal fauna including mammals, birds, reptiles and frogs. This involved the use of two 100 watt, 12 volt spotlights. Trails and roads within forest/woodland areas were traversed on foot (maximum speed of 500 metres in 30 minutes) or from a slow-moving vehicle during the night (maximum speed 5 km hour). Ground areas and tree canopies were searched for mammal and bird activity. Creeks, drainage lines and ponds were searched for frog species using two head-mounted, 100 watt spotlights. Searches generally commenced between one and two hours after dark and lasted up to 2 hours depending on the size of the forest patch and whether or not the survey was in the car or on foot.

Spotlighting took place on five nights with the following conditions.

Date	Weather	Moon	Researchers
8/11/01	Warm, light wind (1)	New moon (0)	M Predavec and T English
12/11/01	Warm, light wind (1)	No moon (0)	M Predavec and T English
14/11/01	Warm, light wind (1)	No moon (0)	M Predavec and T English
21/11/01	Warm, light wind (1)	½ Moon (2)	M Predavec and T English
06/11/02	Warm, light wind (1)	No moon (0)	T English

2.5.3.2 Nocturnal Call Playback

Nocturnal species with large home-ranges or those that are particularly cryptic are generally difficult to locate during nocturnal spotlighting but may be detected using call-playback. This technique relies on behavioural responses associated with territory and threat, whereby emitted calls may induce a defending response (either call or display) from individuals of the same species. Owls can be surveyed in this manner (Kavanagh & Peak 1993), as well as other nocturnal vocalising species including mammals and frogs. Taped calls of each species were played through a loudspeaker (five minutes) to prompt

a response call, this was followed by a five minute period of quiet listening. Following completion of all species, the direct area surrounding the call playback was searched using a 100-watt spotlight. Species calls used during the survey included Powerful Owl, Sooty Owl, Masked Owl, Barking Owl, Grass Owl, Yellow-bellied Glider, Squirrel Glider and Koala.

Call Playback took place on two nights with the following conditions.

Date	Weather	Moon	Researchers
12/11/01	Warm, light wind (1)	No moon (0)	M Predavec and T English
14/11/01	Warm, light wind (1)	No moon (0)	M Predavec and T English

2.5.3.3 Frog Surveys

Searches for frogs were made along edges of suitable dams, creeks and drainage lines within the study area. The survey combined active searching using two 100-watt spotlights, identification of frogs by their calls and call playback. Calls of threatened species of frog with potential habitat in the site were broadcast using a CD player and megaphone. Calls were played for five minutes followed by 10 minutes of listening and then active searching of the site. Frog calls employed include the Wallum Froglet, Green and Golden Bell Frog, Green-thighed Frog and the Giant Barred Frog.

Frog surveys took place on two nights with the following conditions.

Date	Weather	Moon	Researchers
7/11/01	Warm, light wind (1) and rain (1)	No moon (0)	M Predavec and T English
19/11/01	Warm, heavy wind (3) and rain (2)	No moon (0)	M Predavec and T English

Additional general frog surveys were undertaken as part of the spotlighting.

2.5.3.4 Diurnal Bird Surveys

Diurnal bird species were surveyed by either direct observation using 10 x 50 field binoculars or by their calls. Surveys were carried out at different times of day including dusk and dawn. Two observers were involved in each survey, which included walking along tracks and roads within the study area. Additionally incidental observations of birds were made during the habitat-based assessment.

Diurnal bird surveys were carried out each week morning of the weeks of the 5th, 12th and 19th of November 2001. Martin Predavec and Terri English carried out all surveys. The weather varied during the weeks but was generally fine with little or no rain and medium winds. Birds were also recorded during the habitat based survey.

2.5.3.5 Diurnal Reptile Searches

Diurnal reptile searches were carried out as part of the overall habitat assessment. Reptile species were surveyed by actively searching along tracks and easements in potentially suitable habitat. Rocks, bark and ground debris that provided potential shelter were overturned and replaced during searches. Any captured animals were identified to species and then released at the site of capture.

Diurnal reptile surveys were carried out each day as part of the habitat based surveys in the weeks of the 5th, 12th and 19th of November 2001. Martin Predavec and Terri-Ann English carried out all surveys. The weather varied during the weeks but was generally fine with little or no rain and medium winds.

2.5.3.6 Bat Detection (Anabat)

An Anabat detector (Titley Electronics) with a time delay switch was used to record microchiropteran bat calls (echolocation). Calls can provide information on frequency and call sequence, allowing species identification (De Oliveira 1998). The detector was set before dusk within or near a suspected bat fly-way, leaving it to record for a period of time, of anything up to 90 minutes³. Fly-ways may include overgrown tracks and roads, beneath the canopy of streams and creeks, over larger water bodies (ponds, lakes) or within gaps or along edges of forest/woodland vegetation. A night switch ensured that recording started at dusk. Where possible the Anabat was located away from the existing road to avoid interference from passing vehicles.

Anabat surveys took place on four nights with the following conditions.

Date	Weather	Moon	Researchers
12/11/01	Warm, light wind (1), no rain (0)	No moon (0)	M Predavec and T English
13/11/01	Warm, heavy wind (3), no rain (0)	No moon (0)	M Predavec and T English
06/11/02	Warm, light wind (1), no rain (0)	No moon (0)	T English
07/11/02	Warm, light wind (1), no rain (0)	No moon (0)	T English

Bat calls were analysed by Ray Williams (Ecotone Ecological Consultants) for species identification.

³ The maximum continuous recording time is 90 minutes due to the length of the tape, but with the time delay switch the Anabat may take readings through the entire night, depending on the number of calls recorded.

2.5.3.7 Scat Analysis

Mammal faeces often have features specific to a genus or even species. This may include shape, content (eg. undigested hair and bones of prey associated with predators), location and or arrangement (Triggs 1996). Scats of carnivorous mammals can indicate both predator and prey species within the locality. In addition, owls regurgitate pellets of undigested prey remains (bones, teeth etc.) which are often found below favoured roosting sites. Thus, remains and residual hairs from scats and owl pellets can be analysed under a microscope and identified (Brunner 1974). Scats and pellets were opportunistically collected during the survey period for later identification.

Scat collection was carried out each day as part of the habitat based surveys in the weeks of the 5th, 12th and 19th of November 2001. Martin Predavec and Terri English carried out all surveys. The weather varied during the weeks but was generally fine with little or no rain and medium winds.

2.5.3.8 Incidental Observations

Both indirect and direct evidence of fauna was recorded and used to identify species presence. Direct evidence of fauna species includes actual sightings or identification of the species by calls (eg. birds, frogs and some nocturnal mammals).

Indirect evidence of fauna species includes remains (eg. bones, skin, fur), scats (droppings), diggings or burrows, and hair or body remains identified from predator scats.

Incidental observations were made each day by both the zoologists and botanists as part of the general surveys in the weeks of the 5th, 12th and 19th of November 2001 and again during the November 2002 surveys. Martin Predavec and Terri-Ann English carried out all zoological surveys, while Selga Harrington, Matthew Richardson and Martin Henery carried out incidental observations while undertaking the botanical surveys.

2.5.3.9 Anecdotal information

While accessing properties and moving through the local area, staff had discussions with property owners and locals regarding species that they had observed within the study area. While these anecdotal observations have been included in the species list, where actual observations were made during the field surveys these records take precedence.

2.5.4 TARGETED FROG SURVEYS

Targeted surveys were undertaken at potential breeding sites of the Green-thighed Frog. It was considered necessary to conduct targeted surveys for this species because it has been previously recorded in the study area, there is potential habitat within the study area and, most importantly, it is very difficult to detect. Previously this species has only been located in association with breeding activities, which are highly variable, sporadic and infrequent. The species is one of a few eastern temperate Australian frogs that exhibit explosive breeding (Lemckert & Slatyer 2002). Calling usually occurs immediately following significant rainfall events (>50mm in a 24 hour period) and may only last for one or two nights (Barker et al. 1995, Lemckert et al. 1997, Lemckert & Slatyer 2002). Breeding is thought to be highly variable and may occur just once or twice per year and if rainfall is poor breeding may not occur at all (Lemckert et al. 1997). Searches were restricted to ephemeral ponds and soaks, particularly where better quality native vegetation occurred.

The surveys were conducted over two sessions following a significant rainfall event which occurred during late April 2004 and rather than targeting breeding calls, surveys focused on the collection and identification of tadpoles and/or metamorphlings at potential breeding sites. The first session, conducted on the 16th and 17th March 2004, involved the sampling of potential breeding sites for tadpoles using a dip net. The second on 30th and 31st March, some two weeks later, involved tadpole sampling and searches for metamorphlings (juvenile frogs) from the same sites.

For the purpose of these surveys the study area comprised the proposed Highway footprint between Kew to just north of Herons Creek. Thirty person hours were spent undertaking the targeted surveys and involved active searches within areas of potential habitat previously identified. Collected tadpoles were identified using standard keys (Anstis 2002) either on site or held for a short period in discrete plastic containers, or small aquaria, for later identification and then released at the site of collection.

Conditions during the targeted surveys were as follows.

Date	Weather	Moon	Researchers
16/3/04	Warm, wind (0), no rain (0)	No moon (0)	T O'Sullivan and T English
17/3/04	Warm, no rain (0)	No moon (0)	T O'Sullivan and T English
30/3/04	Warm, light wind (1), rain (2)	No moon (0)	T O'Sullivan and T English
31/3/04	Warm, light wind (1), no rain (0)	No moon (0)	T O'Sullivan and T English

2.6 CONSERVATION SIGNIFICANCE ASSESSMENT

Assessment of overall site conservation significance is based on a combination of the following criteria:

- size;
- connectivity;
- occurrence of significant plant and/or animal species;
- occurrence of significant vegetation communities and/or habitats;
- formal conservation/reserve status;
- ecological integrity; and,
- estimated species richness and diversity.

The significance of plant and animal species, populations and communities are then evaluated on a geographical scale with four levels: National, State, Regional and Local. For the purpose of this study the region is defined as the North Coast Bioregion (Thackway & Cresswell 1995) and the local region is defined as within 10 km of the study area. Due to the depletion and destruction of native vegetation across NSW, all native vegetation is considered to have at least Local significance. The definition and application of the criteria are detailed in Appendix 2.

2.7 IMPACT ASSESSMENT

An assessment of the impact of the proposed development on native flora and fauna was made based on data described above and on the EPBC Act Guidelines on Significance Assessment (Environment Australia 2000) and the NSW NPWS Information Circular No. 2, Threatened Species Assessment under the EP&A Act (NPWS 1996).

The extent of native vegetation clearing was measured based on the extent of new earthworks plus a buffer of 4 m (using the route design issued by Arup on 6 July 2004). The distance of 4 m allows for any construction activities adjacent to the earthworks and the inclusion of structures such as drains. The use of this line is a better estimate of the true extent of vegetation clearing than simply using the extent of earthworks. Although the current line of the extent of earthworks provided by Arup does not contain features such as sediment ponds, the same 4 m margin can be applied to these structures once data is made available to Biosis Research. The extent of vegetation clearing was based on native vegetation within the boundary just described.

The extent of edge effects was measured using the same boundary described above (ie the extent of earthworks plus a buffer of 4 m). Edge effects were calculated based on the area of native vegetation within a distance of 50 m as proposed by Bali (2000). For areas adjacent to already existing carriageways, the edge effects were estimated from the existing boundary of vegetation adjacent to the road.

2.8 LIMITATIONS

This study was by design a habitat based survey and was conducted in accordance with Section 5A of the EP&A Act and also the NSW NPWS Information Circular on Threatened Species Assessment (NPWS 1996). Additional fauna survey techniques (eg. spotlighting, Anabat etc) were employed to target threatened species thought to occur in the area as well as to gather information on groups of species and to assist in the compilation of species lists.

Field surveys were conducted prior to the preliminary listing (and subsequent final determination) of six Endangered Ecological Communities on the TSC Act in September 2004. It was considered that the data collected in the field surveys was sufficient to determine the occurrence of the communities in the study area, thus no additional targeted surveys were conducted.

Further limitations were:

Access to private property

An attempt was made to contact all private land holders prior to and during the field trip to arrange access to their properties. In the majority of cases access was granted but in a small number of cases the owners could not be contacted or would not provide access. In these cases the property was not entered, but where possible was assessed from adjoining public lands or from land to which access had been granted.

Spotlighting

For the Lake and Herons Creek Sections of the preferred route, the construction is generally proposed to be duplication within the existing road reserve. Since bright spotlights were being used (100 w) it was considered unsafe to spotlight along the Pacific Highway, for both the researchers involved and passing vehicles. Hence spotlighting was only carried out in areas that were suitably screened from the existing Highway. During the second and third weeks of the November 2001 field assessment strong winds occurred and it was considered unsafe (and unsuitable) to spotlight in these conditions. This means that the number of species directly observed might have been low, but the general habitat surveys would include threatened species that would normally be detected using spotlighting. Additional spotlighting was carried out during November 2002 in areas that had only limited spotlighting during the initial surveys due to poor weather conditions.

Anabat (Bat detection)

As the Anabat detector picks up ultrasonic frequencies it suffers from interference from the noise of machinery and other sources. This meant that the detector had to be placed in areas away from the existing Highway. Interference in the recordings from a range of sources including vehicles, wind and insects, reduced the number of useable recording nights. The Anabat detector failed at the end of the second week of the November 2001 surveys, further surveys were undertaken in November 2002 in areas that were not sampled in the earlier November 2001 surveys.

3.0 LEGISLATION RELEVANT TO THE SITE AND FLORA AND FAUNA

Federal and State Acts and Policies that apply to the study area with regard to terrestrial flora and fauna are discussed below.

3.1 *ENVIRONMENTAL PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999 (COMMONWEALTH)*

Under the provisions of the EPBC Act any action (activity or development) that requires Commonwealth approval is deemed a controlled action. This is usually the case when an action is likely to have a significant effect on the environment of Commonwealth land or any ‘Matter of National Environmental Significance’ (MNES) listed below:

- World Heritage areas;
- Wetlands protected by international treaty (Ramsar Convention);
- Nationally listed threatened species and ecological communities;
- Internationally listed migratory species- Japan-Australia Migratory Bird Agreement (JAMBA), China-Australia Migratory Bird Agreement (CAMBA) & Bonn Convention;
- All nuclear actions; and,
- The environment of Commonwealth marine areas.

Where an impact is of potential significance then those affected species or habitats must be referred (Referral) to DEH for assessment in accordance with specific criteria outlined in the Guidelines for Significance Assessment. These guidelines provide separate criteria for Extinct, Vulnerable, Endangered and Migratory species against which the significance of the impact can be assessed and whether a referral is required (Appendix 3). The purpose of the referral stage is to determine whether a proposed action requires approval under the EPBC Act. If the Minister determines that an approval is required, the proposed action will proceed through the assessment and approval process.

A referral is a set of information that includes brief descriptions of the proposal, its location and potential impacts on matters of national environmental significance. The EPBC Regulations set out what information must be included in the referral.

If a proposed action has been referred to the Commonwealth Environment Minister and the Minister has decided that the action requires approval, an environmental assessment must be carried out.

The purpose of an environmental assessment is to bring together all the information on the impacts that a proposed action would have on matters protected by the EPBC Act, to ensure that the Minister makes an informed decision on whether or not to approve the action.

If the Commonwealth has signed a bilateral agreement with a State or Territory in which the action is to be carried out, the State or Territory will assess the action under the terms of that agreement. Similarly, the environmental assessment may be carried out by another Commonwealth agency if a ministerial Declaration has been signed with that agency. If no bilateral agreement or Ministerial declaration is in place, the assessment may nonetheless be carried out by a State or Territory under an accredited assessment process. The bilateral agreement between the Commonwealth and New South Wales has not been signed.

If none of these assessment processes is applicable, the Commonwealth will carry out the assessment using one of the following assessment approaches:

- preliminary documentation;
- public environment report (PER);
- environmental impact statement (EIS); or
- public inquiry.

The proponent, or the person proposing to take the action, will be asked to supply preliminary information on the impacts of the proposed action in order to help the Minister select an appropriate assessment approach.

3.2 THREATENED SPECIES CONSERVATION ACT 1995 (NSW) AND ENVIRONMENTAL PLANNING AND ASSESSMENT ACT 1979 (NSW)

One object of the EP&A Act is to encourage the protection of the environment, including the protection and conservation of native animals and plants, including threatened species, populations and ecological communities and their habitats. A second object is to encourage the principles of ecologically sustainable development, including the precautionary principle⁴ as defined under the *Protection of the Environment Administration Act 1991*. The TSC Act protects all threatened plants and animals native to NSW (with the exception of fish and marine plants). It provides for the identification, conservation and recovery of threatened species and their populations and communities. It also aims to reduce the threats faced by those species.

⁴ The precautionary principle states that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

If a planned development or activity will have an impact on a threatened species, this must be taken into account in the development approval process. If the impact is likely to be significant, a Species Impact Statement must be prepared and the Director-General of the DEC must agree to the development approval. In some cases, the Minister for the Environment will also need to be consulted.

Section 5A of the EP&A Act, and Section 94 of the TSC Act lists eight factors (Eight Part Test) which are used to assess the likely impact of a development on a threatened species, population (including their habitats) or Endangered Ecological Community⁵. Eight Part Test criteria are:

1. In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable population of the species is likely to be placed at risk of extinction;
2. 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;
3. In relation to the regional distribution of a habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed;
4. Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community;
5. Whether critical habitat will be affected;
6. Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or similar protected areas) in the region;
7. Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process; and,
8. Whether any threatened species, population or ecological community is at the limit of its known distribution.

⁵ The *Threatened Species Conservation Amendment Bill* 2002 was assented on 2nd October 2002. This Bill amended the TSC Act and other threatened species legislation. Part of the amendment is the modification of the test applied to determine whether or not an activity is likely to significantly affect threatened species, populations and communities as well as provisions the listing of vulnerable ecological communities. Many of the provisions of the Act were proclaimed on 31st January 2003, while the remainder will be implemented over the next two years. Savings provisions will be prescribed by regulation to ensure that the amendments to the TSC Act and EP&A Act do not affect application and assessment processes that have commenced under the previous legislative regime. Details of the Act and its implementation can be found at <<http://www.npws.nsw.gov.au/wildlife/threatened.htm#listing>>.

An assessment of the results of each test indicates the potential significance of impact. If the application of the Eight Part Tests reveals that a significant effect is likely then:

- The proposal may be modified such that a significant effect on threatened species, populations or ecological communities, or their habitats is unlikely; and/or
- A Species Impact Statement (SIS) must be prepared and the concurrence of the Director General of National Parks and Wildlife, or consultation with the Minister for the Environment is required (NPWS 1996).

3.3 WATER MANAGEMENT ACT 2000 AND RIVERS AND FORESHORES IMPROVEMENT ACT 1948 (NSW)

The *Water Management Act 2000* (WM Act) provides for the integrated and sustainable management of the State's waters, including those provisions previously included in the *Rivers and Foreshores Improvement Act 1948* (RFI Act). Whilst proclamation commenced most of the provisions of the WM Act on 1 January 2001 (NSW Government Gazette No. 168, December 2000), matters relating to licences and approvals still continue to be dealt with by the RFI Act and the *Water Act 1912*. The Department of Land and Water Conservation is currently developing the administrative procedures to operate the approvals provisions of the WM Act, however it is not known when these provisions will commence.

While the RFI Act allows the carrying out of works to remove obstructions from and improve rivers and foreshores and to prevent erosion of lands by tidal and non-tidal water, under Part 3A, Section 22B a person must not:

- make an excavation on, in or under protected land (land within 40m from top of bank);
- remove material from protected land;
- do anything which obstructs, or detrimentally affects, the flow of protected waters, or which is likely to do so unless the person is authorised to do so by a permit.

When assessing developments that require a Part 3A permit, the Department of Infrastructure, Planning and Natural Resources (DIPNR) considers whether the proposal is consistent with State Government policy including the NSW State Rivers and Estuaries Policy. Conditions of consent for a Part 3A permit, may as a result, include the establishment of a native vegetation riparian zone along a waterway. Given State Government policy, it is unlikely that a Part 3A permit would be issued for works that degrade watercourses and their environment, as it is DIPNR's aim that:

- an adequate native vegetation riparian zone (minimum 20m) be kept or established on either side of any waterway or wetland,

- on-line or instream water quality structures such as water quality ponds, trash racks and gross pollutant traps are strongly discouraged as they affect the continuity and corridor function of waterways and result in loss of riparian vegetation and habitat, and that
- channelisation, piping and/or relocation of streams and the construction of on-line or instream structures and culverts for waterway road crossing are discouraged.

Under the RFI Act, works in or under protected land that occur within a RTA Road Reserve do not require a Part 3A permit, however, should works occur outside the road reserve, a Part 3A permit may be required. While the RFI Act does not apply to land within the road reserve, it is recommended that the principles of the Act (as described above) and State Government policies are followed in order to ensure that waterways within the study area do not become degraded as a result of the preferred highway upgrade and operation.

3.4 STATE ENVIRONMENTAL PLANNING POLICY 44 – KOALA HABITAT PROTECTION (NSW)

SEPP 44 aims to encourage the proper conservation and management of areas of natural vegetation that provide habitat for Koalas, ensuring a permanent free-living population over their present range and attempting to reverse the current trend of Koala population decline:

- a) by requiring the preparation of plans of management before development consent can be granted in relation to areas of core Koala habitat;
- b) by encouraging the identification of areas of core Koala habitat; and
- c) by encouraging the inclusion of areas of core Koala habitat in environment protection zones.

Under this policy the distinction is made between ‘potential’ and ‘core’ Koala habitat.

“Potential Koala habitat” means areas of native vegetation where the trees of the types listed in Schedule 2 of the Policy constitute at least 15% of the total number of trees in the upper or lower strata of the tree component.

“Core Koala habitat” means an area of land with a resident population of Koalas, evidenced by attributes such as breeding females (that is, females with young) and recent sightings of and historical records of a population.

SEPP 44 applies to land within Local Government Areas (LGAs) listed in SEPP 44, Schedule 1 (including both Hastings and Greater Taree LGA’s) for which a development application has been made (SEPP 44, Section 6) and Council is the determining authority. SEPP 44 does not apply to land dedicated or reserved under the National Parks and Wildlife Act 1974 or to land dedicated under the Forestry Act 1916 as State

Forest or flora reserve (SEPP 44, Section 5). Nor does it apply to land where Council is not the determining authority. Thus, in instances where State agencies such as the RTA undertake Part 5 activities under the EP&A Act (as for the present development), SEPP 44 does not apply even if an EIS is required.

While the RTA is not legally required to consider the provisions of SEPP 44, based on the recommendation of Biosis Research, the RTA and Arup have agreed that a similar approach to assessing Koala habitat as that described under SEPP 44 should be undertaken. This will help ensure the longer-term survival of Koalas, and proper conservation and management of areas of natural vegetation providing habitat for Koalas in the vicinity of the study area. In addition, Koalas were further assessed under the provisions of the TSC Act.

3.5 STATE ENVIRONMENTAL PLANNING POLICY 14 - COASTAL WETLANDS

The aim of SEPP 14 is for coastal wetlands to be preserved and protected in the environmental and economic interests of the State (Department of Planning Circular No. B10). The policy lists clearing, draining or filling and the constructing of a levee on gazetted coastal wetlands as a ‘designated developments’. Such developments proposed on gazetted wetlands require development consent from the relevant Council and the concurrence of the Director-General of Planning NSW. When considering whether to grant concurrent the Director-General takes into account (along with other considerations):

- the environmental effects of the proposed development,
- whether adequate safeguards and rehabilitation measures have been or will be put in place,
- whether consideration has been given to any feasible alternatives, and
- any surrounding wetlands affected by the proposed development and appropriateness of imposing conditions requiring the carrying out of works to preserve or enhance the value of those surrounding wetlands.

4.0 RESULTS

4.1 FLORA

4.1.1 VEGETATION COMMUNITIES

Using data from the DEC Eastern Bushland database, vegetation within the study area can be broadly divided into five distinct categories: moist eucalypt forest, dry open forest, sedgeland, Melaleuca swamp and cleared. For the purpose of this study, these vegetation types have been subdivided into a total of six communities: Coastal Blackbutt Forest (dry open forest), Dry Tallowwood Forest (dry open forest), Swamp Sclerophyll Forest (Melaleuca swamp), Freshwater Wetland (Sedgeland), Flooded Gum Open Forest (Moist Eucalypt) and Cleared/Disturbed communities. These communities are based on those described in Hastings Council and the Greater Taree Council Vegetation Mapping. A comparison of vegetation communities recognised by this and previous studies is given in Table 4.

Table 4: Comparison of vegetation communities recognised in this and previous surveys.

Biosis Vegetation Community	Eastern Bushland Database	Hastings Council Vegetation Mapping *	Greater Taree Council Vegetation Mapping *
Coastal Blackbutt Forest	Dry Open Forest/ Moist Eucalypt Forest	Coastal Blackbutt Forest (35041, 35042)	Blackbutt with Tallowwood and Pink Bloodwood (5); Blackbutt with Smooth-Barked Apple (5a); Blackbutt with Smooth-Barked Apple and Scribbly Gum (5b); Blackbutt Dominant, (5p).
Dry Tallowwood Forest		Dry Tallowwood Forest (35081, 35082); Dry White Mahogany – Tallowwood Forest (35551)	Tallowwood, Bloodwood, Grey Gum, White Mahogany, Rough Barked Apple (type 3m)
Flooded Gum Forest	Moist Eucalypt Forest	Flooded Gum Open Forest (30041, 30042)	Flooded Gum; Flooded Gum with Tallowwood, Flooded Gum Plus Mixed Species, Moist Blackbutt Type (Type 1, 1a, 1b, 5s, respectively)
Freshwater Wetland (Sedgeland)	Sedgeland	<i>Lepironia articulata</i> Sedgeland (64050)	-
Cleared/disturbed	Cleared	Partially Cleared (92020); Completely Cleared (92030)	-
Swamp Sclerophyll Forest	Melaleuca Swamp	Swamp Oak Forest (40051, 40052); <i>Melaleuca linearifolia</i> Swamp (40011); Swamp Mahogany- <i>Melaleuca sieberi</i> Swamp (40121, 40122); Swamp Oak-Broad Leaved Paperbark Forest (40991, 40992)	Swamp Mahogany and Swamp Paperbark (14a); Swamp Mahogany, Swamp Paperbark and Swamp Oak (14b); Swamp Paperbark (15).

Key: * Numbers in brackets refer to vegetation units codes used in the LGA mapping.

Two of the vegetation communities recorded in the study area are consistent with Ecological Communities that are listed as Endangered on the TSC Act, namely Freshwater Wetland (Sedgeland) and Swamp Sclerophyll Forest. Comparison of the listed communities with the vegetation communities in the study area is given both in the vegetation community descriptions and in Table 5.

Coastal Blackbutt Forest

Coastal Blackbutt Forest is a dry open forest community dominated by *Eucalyptus pilularis* (Blackbutt). The associated canopy species vary with topography and other environmental factors throughout the study area. In the northern section of the study area associated canopy species include *Allocasuarina* spp. (Sheoak), *Corymbia* spp. (Bloodwood), *Angophora floribunda* (Rough-barked Apple) and *E. acmenioides* (White Mahogany). In the southern section these canopy species tend to be replaced by *Angophora costata* (Smooth Barked Apple) and *E. microcorys* (Tallowwood). The understorey of this community typically contains an open shrub layer to 5 m including *Ceratopetalum gummiferum* (Christmas Bush), *Xanthorrhoea* spp. (Grass Trees), *Dodonaea triquetra*, *Leptospermum trinervium*, *Acacia longifolia*, *Daviesia ulicifolia* (Gorse Bitter Pea) and *Breynia oblongifolia* (Coffee Bush). Ground cover includes herb and grass species such as *Lomandra filiformis*, *Aristida vagans* (Threeawn Speargrass), *Stipa pubescens*, *Hibbertia aspera*, *H. monogyna*, *Scaevola ramosissima* and *Rubus hillii* (Molucca Bramble).

Coastal Blackbutt Forest is widespread and is found throughout the study area. Coastal Blackbutt Forest does contain some characteristic species of the EEC Subtropical Coastal Floodplain Forest. However, the dominance of *Eucalyptus pilularis* and the absence of a rainforest component in the understorey in Coastal Blackbutt Forest in the study area are inconsistent with Subtropical Coastal Floodplain Forest. Coastal Blackbutt Forest is not consistent with any listed or preliminarily listed Endangered Ecological Communities (EECs).

Dry Tallowwood Forest

Dry Tallowwood forest is a dry open forest that is dominated by *Eucalyptus microcorys* (Tallowwood). Other canopy species include *E. globoidea* (White Stringybark), *Corymbia intermedia* (Pink Bloodwood), *E. fibrosa* (Red Ironbark) and *E. pilularis* (Blackbutt). The understorey consists of a shrub layer to 3 m and includes *Dodonaea triquetra*, *Ozothamnus diosmifolius* (White Dogwood), *Persoonia linearis* (Narrow-leaved Geebung), *P. levis* (Broad-leaved Geebung), *Acacia* spp. (Wattles) and *Leptospermum polygalifolium*. The ground cover typically contains grass and herb species such as *Solanum mauritianum* (Wild Tobacco Bush), *Hardenbergia violacea* (False Sarsparilla), *Aristida vagans* (Threeawn Speargrass), *Hibbertia aspera*, *Polymeria calycina* and *Pratia purpurascens* (Whiteroot). Dry Tallowwood Forest intergrades with Coastal Blackbutt Forest and often contains similar canopy and understorey species which at times makes these two communities difficult to differentiate.

Dry Tallowwood Forest is found throughout the study area. The majority of canopy species in Dry Tallowwood Forest in the study area are not characteristic species of the EEC Subtropical Coastal Floodplain Forest or Riverflat Eucalypt Forest on Coastal Floodplains. Dry Tallowwood Forest is not consistent with any listed or preliminarily listed EECs.

Flooded Gum Forest

Flooded Gum Forest is a tall wet sclerophyll forest that is dominated by *Eucalyptus grandis* (Flooded Gum). Other canopy species include *E. pilularis* (Blackbutt) and *E. saligna* (Sydney Blue Gum). The understorey typically includes a tall, dense, shrub layer to 8 m which includes *Corymbia gummiferum* (Red Bloodwood), *Duboisia myoporoides* (Corkwood), *Cordyline stricta* (Narrow-leaved Palm Lily), *Eupomatia laurina* (Bolwarra) and *Acmena smithii* (Lilly Pilly). The ground cover is typically sparse but includes ferns such as *Adiantum hispidulum* (Rough Maidenhair), *Doodia aspera* (Prickly Raspfern) and *Cheilanthes sieberi*. Vines are common in this community and include *Flagellaria indica* (Whip Vine), *Smilax australis* (Sarsparilla), *S. glycyphylla* (Sweet Sarsparilla) and *Parsonsia straminea* (Common Silkpod).

Flooded Gum Forest is found throughout the study area but is more widespread in the Lakes Section of the study area (Middle Brother State Forest and Yoorigan National Park).

Although *Eucalyptus grandis* and *E. saligna* are characteristic species of the EEC River Flat Eucalypt Forest on Coastal Floodplains, the dominant species of the tall dense shrub layer in Flooded Gum Forest in the study area are not characteristic of River Flat Eucalypt Forest. Flooded Gum Forest is not consistent with any listed or preliminarily listed EECs.

Freshwater Wetland (Sedgeland)

Sedgeland is a wetland community that is dominated by *Lepironia articulata* and *Baumea rubiginosa*. This community is restricted to Sunnyvale Swamp, a SEPP 14 wetland (544a) located to the east of the highway and north of the Camden Haven River. This community is largely separated from the proposed route by a raised embankment that was constructed as part of the formation for the current Pacific Highway alignment at this location.

Freshwater Wetlands on Coastal Floodplains is listed as an EEC on the TSC Act. The final determination describes this community as occurring in areas periodically or semi-permanently inundated by freshwater, with minor saline influence in some wetlands. Typically the community occurs on silts, muds or humic loams in depressions, flats, drainage lines, lagoons and lakes of coastal floodplains.

The final determination states that Freshwater Wetlands or parts of wetlands that lack standing water are usually dominated by dense grassland or sedgeland vegetation, often

forming a turf less than 0.5 metre tall and dominated by amphibious plants. Wetlands or parts of wetlands subject to regular inundation and drying may include large emergent sedges over one metre tall. As standing water becomes deeper or more permanent, amphibious and emergent plants become less abundant, while floating and submerged aquatic herbs become more abundant.

Characteristic plant species described in the final determination for parts of Freshwater Wetlands subject to regular inundation and drying include large emergent sedges over 1 metre tall, such as *Baumea articulata* and *Lepironia articulata*.

The Freshwater Wetland (Sedgeland) that occurs in the study area is consistent with the EEC Freshwater Wetlands on Coastal Floodplains.

Swamp Sclerophyll Forest

Swamp Sclerophyll Forest is a community that is dominated by *Melaleuca* spp. (Paperbarks) and is restricted to moist swampy areas subject to regular inundation. This community includes at least one of the following paperbark species: *Melaleuca linearifolia*, *M. sieberi*, *M. styphelioides*, *M. quinquenervia* (Broad-leaved Paperbark). Other canopy species may include *Casuarina glauca* (Swamp Sheoak) and *Eucalyptus robusta* (Swamp Mahogany). This community typically lacks a shrub layer but includes a dense ground cover to 1 m of sedges and ferns such as *Lepyrodia scariosa*, *Baumea rubiginosa*, *Hypolepis muelleri* (Harsh Ground Fern) and *Blechnum indicum* (Swamp Water Fern).

Nine patches of Swamp Sclerophyll Forest are found scattered throughout the study area in sites that are subject to inundation. The total area occupied by Swamp Sclerophyll Forest in the study area is approximately 37 ha. While this vegetation community is considered relatively uncommon within the study area, it is found in lowland depressions and along creeks such as that found south of Camden Haven River (in the Lakes Section).

The final determination for Swamp Sclerophyll Forest on Coastal Floodplains describes this community as occurring on humic clay loams and sandy loams, on waterlogged or periodically inundated alluvial flats and drainage lines of coastal floodplains. The most widespread and abundant dominant trees include *Eucalyptus robusta* and *Melaleuca quinquenervia* and other trees may include *Casuarina glauca*. A layer of small trees may be present including species such as *Melaleuca linariifolia* and *M. styphelioides*. The groundcover is composed of abundant sedges, ferns, forbs, and grasses.

The Swamp Sclerophyll Forest in the study area is consistent with the EEC Swamp Sclerophyll Forest on Coastal Floodplains.

Cleared/Disturbed Vegetation

Cleared/Disturbed Vegetation corresponds to areas where the vegetation has been completely or partially cleared and no longer represents a natural vegetation community. These areas contain very few native species and have a high proportion of weeds.

Cleared/disturbed vegetation is found throughout the study area and is relatively common particularly in areas adjacent to the existing Pacific Highway.

4.1.1.1 Significant Communities

Endangered Ecological Communities listed on the TSC or EPBC Acts

Seven Endangered Ecological Communities occur in the NSW North Coast bioregion (Table 5). Two of these EECs occur in the study area, Freshwater Wetlands on Coastal Floodplains and Swamp Sclerophyll Forest on Coastal Floodplains.

Eight Part Tests have been prepared to assess the likely impact of the proposed upgrade of the Pacific Highway on the EECs Freshwater Wetlands on Coastal Floodplains and Swamp Sclerophyll Forest on Coastal Floodplains (Section 6.1.1). This assessment determined that it was unlikely⁶ that either of these EECs would be significantly affected by the proposed development.

Table 5. Ecological Communities that are listed) as Endangered on the TSC Act.

Endangered Ecological Community	Habitat	Distinguishing features	Occurrence in study area
Lowland Rainforest on Floodplain	A closed canopy forest characterised by its high species richness and structural complexity.	The major rainforest Suballiance (Floyd, 1990) within the community is Suballiance 3: <i>Cryptocarya obovata</i> - <i>Dendrocnide excelsa</i> - <i>Ficus</i> spp - <i>Araucaria</i> .	Not present in study area.
Freshwater Wetlands on Coastal Floodplains	Periodic or semi-permanent inundation by freshwater, although there may be minor saline influence in some wetlands. Typically occur on silts, muds or humic loams in depressions, flats, drainage lines, lagoons, and lakes of coastal floodplains. Generally occur below 20 m elevation.	Wetland community occurring below 20 m elevation.	Yes, in Sunnyvale Swamp to the north of the Camden Haven River. Approximately 100 ha occurs in one patch in the study area.

⁶ Likely is defined as ‘a real chance or possibility’ (see glossary) and is determined through significance assessments. Unlikely is the opposite of this. These terms have been referred to in a number of Land and Environment Court Cases (eg. Byron Shire Business for the Future Inc v Byron Council and Holiday Villages (Byron Bay) Pty Ltd - 1994 – 84 LGERA 434).

River Flat Eucalypt Forest on Coastal Floodplains	Associated with silts, clay-loams and sandy loams, on periodically inundated alluvial flats, drainage lines and river terraces of coastal floodplains. Generally occurs below 50 m elevation, but may occur on localised river flats up to 250 m above sea level.	Dominance by either a mixed eucalypt canopy or by a single species of eucalypt belonging to either the genus <i>Angophora</i> or the sections <i>Exsertaria</i> or <i>Transversaria</i> of the genus <i>Eucalyptus</i> ; the relatively low abundance or sub-dominance of <i>Casuarina</i> and <i>Melaleuca</i> species; the relatively low abundance of <i>Eucalyptus robusta</i> ; and the prominent groundcover of soft-leaved forbs and grasses.	Not present in study area.
Subtropical Coastal Floodplain Forest	Associated with clay-loams and sandy loams, on periodically inundated alluvial flats, drainage lines and river terraces of coastal floodplains. Generally occurs below 50 m, but may occur on localised river flats up to 250 m elevation.	Dominance by a mixed eucalypt canopy, often with <i>Lophostemon suaveolens</i> ; the presence of rainforest elements as scattered trees or understorey plants; the relatively low abundance or sub-dominance of <i>Casuarina</i> and <i>Melaleuca</i> species; the relatively low abundance of <i>Eucalyptus robusta</i> ; and the prominent groundcover of soft-leaved forbs and grasses.	Not present in study area.
Swamp Oak Floodplain Forest	Grey-black clay-loams and sandy loams, where the groundwater is saline or sub-saline, on waterlogged or periodically inundated flats, drainage lines, lake margins and estuarine fringes of coastal floodplains. Generally occurs below 20 m (rarely above 10 m) elevation.	Dominance by a tree canopy of either <i>Casuarina glauca</i> or, more rarely, <i>Melaleuca ericifolia</i> with or without subordinate tree species; the relatively low abundance of <i>Eucalyptus</i> species; and the prominent groundcover of forbs and graminoids.	Not present in study area.
Swamp Sclerophyll Forest on Coastal Floodplains	Associated with humic clay loams and sandy loams, on waterlogged or periodically inundated alluvial flats and drainage lines of coastal floodplains. Generally occurs below 20 m (though sometimes up to 50 m) elevation, often on small floodplains or where the larger floodplains adjoin lithic substrates or coastal sand plains.	Relatively dense tree canopy dominated by <i>Eucalyptus robusta</i> , <i>Melaleuca quinquenervia</i> or <i>E. botryoides</i> , the relatively infrequent occurrence of other eucalypts, <i>Casuarina glauca</i> or <i>Lophostemon suaveolens</i> ; the occasional presence of rainforest elements as scattered trees or understorey plants; and the prominence of large sedges and ferns in the groundcover.	Present in study area, in lowland depressions and along creeks. Approximately 36.8 ha occurs in nine patches in the study area.

4.1.1.2 Johns River Bypass

This section of the proposed upgrade (Figure 2) would involve duplication of a section of the existing highway as well as the construction of a bypass around Johns River to the west.

North from Camp Obadiah, the proposed route would involve the widening of the existing highway to the west of the existing carriageway. Vegetation in this area consists of a narrow strip of Coastal Blackbutt Forest (up to 70 m wide). This vegetation has a moderate level of weed invasion throughout. The vegetation community is isolated and is considered to be in poor-moderate condition. Widening of the highway in this section would result in the narrowing of the strip of native vegetation, and as a result the entire area is likely to be subject to edge effects and may become invaded by weeds.

Approximately 1.6 km south of Johns River the proposed route would diverge to the west to bypass Johns River. Here the route would bisect a small area of vegetation (32 ha) that extends northwards for approximately 800 m (almost to Stewarts River Road). Vegetation in this area consists of Coastal Blackbutt Forest and a small patch of Swamp Forest in the north. Weed invasion in this area is largely restricted to the area adjacent to the existing highway (ie within 40 m). Vegetation in this area is isolated from the extensive vegetation to the west due to clearing and under-scrubbing (removal of understorey plants) of adjacent vegetation for farming. This small patch of vegetation is considered to be in good-moderate condition.

From Stewarts River Road, the highway would pass through cleared land until a small unnamed creek where a small patch of Coastal Blackbutt Forest extends for 200 m to Bulleys Road. This vegetation is completely isolated from other areas of native vegetation. Due to its small size (9.2 ha), this vegetation patch is almost entirely subject to edge effects and has a moderate-high level of weed invasion. It is considered to be in poor-moderate condition.

North from Bulleys Road to the Stewarts River, no native vegetation communities would be encountered. Vegetation in this area consists largely of roadside weeds and is considered to be in poor condition.

4.1.1.3 Lakes Section

The Lakes Section (Figure 3 and Figure 4) involves an upgrade and duplication of the existing highway largely within the existing road reserve. This route is highly constrained as it runs in a narrow strip bounded by the North Coast Railway to the east and Yoorigan National Park and Middle Brother State Forest to the west.

Vegetation to the east of this route (along the entire length) forms a narrow strip generally less than 50 m wide which is constrained between the existing highway and the North Coast Railway line. This vegetation is highly degraded and weed infested and does not represent a natural vegetation community (mapped as cleared/disturbed vegetation). For this reason the proposed works in this area would be unlikely to have a significant impact on threatened flora or significant vegetation communities.

To the west of the existing highway is an extensive area of vegetation, which includes Yoorigan National Park and Middle Brother State Forest. These areas contain Flooded Gum Forest, Coastal Blackbutt Forest and Dry Tallowwood Forest, which are not distinct communities but rather intergrade with each other. Thus, the vegetation mapping is only a rough guide of the location of these communities in this section of the route. In general, Coastal Blackbutt Forest is the main community in this area with drier, more exposed areas containing Dry Tallowwood Forest and moist protected gullies containing Flooded Gum Forest. Vegetation in this area is in moderate-good condition with weed invasion predominantly restricted to a narrow strip adjacent to the existing highway. It should be noted that although the proposed upgrade would be likely to remove 26 ha of

vegetation, much of which is weed infested, this clearing would result in exposure of vegetation in good condition to increased edge effects.

Immediately south of the bridge over the Camden Haven River is a small area (approximately 3 ha) containing Swamp Forest. *Casuarina glauca*, *Melaleuca linearifolia* and *Eucalyptus robusta* dominate this area. The surrounding areas have been largely cleared and this Swamp Forest is isolated from the extensive vegetation in Middle Brother State Forest by the railway line and Ross Glen Road. Vegetation in this area has a low-moderate level of weed invasion and is considered to be in moderate condition.

4.1.1.4 Kew Bypass

The Kew Bypass (Figure 5) links the Lake Section with the Kew to Herons Creek Section of the proposed Highway upgrade. The proposed route would involve upgrading and duplication of the existing highway south of Sunnyvale Road North and north of Weeroona Place as well as a deviation to the east to bypass the township of Kew.

Between Camden Haven River and Sunnyvale Road North the proposed route would involve duplication of the existing highway. A short section of this route would adjoin Sunnyvale Swamp (SEPP 14 Wetland No. 554a). The sedge swamp is considered to be in good condition with low levels of weed invasion. Although a raised embankment largely separates this swamp from the highway, some swamp species still occur in the area of the embankment. Direct impacts from the proposed upgrade would be unlikely, however, mitigation measures should be implemented to avoid indirect impacts such as increased runoff and sedimentation.

Between Sunnyvale Swamp and Sunnyvale Road, on both sides of the highway there are small patches (between 0.3 and 0.8 ha) of Dry Tallowwood Forest along the highway margin. These patches are very small and isolated, are entirely subject to edge effects and have moderate levels of weed invasion. For these reasons they are considered to be in poor-moderate condition.

North of Sunnyvale Road, the proposed route would diverge to the east to bypass the township of Kew. Between Sunnyvale Road and Ocean Drive, the proposed route would pass along the eastern edge of an area of Coastal Blackbutt Forest (approximately 19 ha) with a high density of *Allocasuarina* spp. Vegetation in this area is considered to be in moderate-good condition. This vegetation is isolated and is surrounded by rural and residential development.

North of Ocean Drive the proposed route would run east of the existing highway, bypassing Kew and rejoining the existing highway at Weeroona Place. This section of the route would cut through a relatively large isolated patch of vegetation (approximately 111 ha), which contains Coastal Blackbutt Forest and Dry Tallowwood Forest. The area also includes a small patch of a moist Coastal Blackbutt Forest that

includes species such as *Cordyline stricta*, *Breynia oblongifolia*, *Parsonsia straminea* and *Cymbidium suave*. Vegetation in this area is considered to be in good condition. This section of the proposed route would result in the fragmentation of a small area of vegetation (1.5 ha). The southbound off ramp would also result in further fragmentation. This fragmentation would increase the edge effects and weed invasion in this vegetation patch particularly in the area between the existing highway and the proposed route. It should be noted, however, that this patch of vegetation has recently been rezoned for a residential subdivision.

North of Herons Creek Road (South) a narrow strip of Dry Tallowwood Forest (approximately 5 ha) on the west would be cleared for the widening of the highway. This vegetation is considered to be in moderate condition as it is subject to edge effects and has a moderate level of weed invasion. This vegetation is already isolated and fragmented by roads, power easements, the North Coast Railway line and rural development.

4.1.1.5 Kew to Herons Creek

This section extends from just north of Kew to just north of Herons Creek (Figure 6) and would involve an upgrade and duplication of the existing highway. Much of the vegetation that would be affected by the proposed upgrade has been previously cleared and is subject to ongoing disturbances. Along the length of the route there are several isolated patches of native vegetation. The proposed works in this area would result in a long strip of vegetation adjacent to the existing highway being cleared. This proposed route would pass through four vegetation communities: Coastal Blackbutt Forest, Dry Tallowwood Forest, Swamp Forest and Cleared/Disturbed Vegetation.

North of Herons Creek Road (South) on the western side of the highway, the proposed works would involve the clearing of a long strip of Dry Tallowwood Forest that is directly adjacent to the existing road (this is a continuation of the clearing described in Section 4.1.1.4). The vegetation to be cleared is generally considered to be in poor-moderate condition due to edge effects and the high level of weed invasion. This vegetation is already isolated and fragmented by the North Coast Railway line, roads, power easements and rural development.

To the east of the highway is the Kew-Kendall Sewage Treatment Plant (STP). This area contains two very small remnants of Dry Tallowwood Forest and much of the area has been revegetated with eucalypts. The proposed works would not affect the remnant patches and the eucalypt plantation is not considered to represent a natural vegetation community.

Between the STP and Cluleys Road is a relatively large area of native vegetation (greater than 130 ha). This area contains three communities: Dry Tallowwood Forest, Swamp Forest and Coastal Blackbutt Forest. This vegetation is generally in moderate to good condition. However, as the vegetation which would be cleared (approximately

6 ha) is subject to edge effects and has a moderate level of weed invasion, this particular section of vegetation is considered to be in poor-moderate condition.

Opposite Cluleys Road, on the western side of the existing highway and north of the Boral Timber Mill is a small isolated area (3.5 ha) of Coastal Blackbutt Forest. This area has a moderate level of weed invasion. The vegetation to be removed is adjacent to the highway is considered to be in poor-moderate condition.

North of Herons Creek, to the east and west of the highway is an area of Coastal Blackbutt Forest. To the west of the existing highway the vegetation is a narrow strip bounded by the existing highway to the east and the North Coast Railway to the west and is separated from the Burrawan State Forest in the north by Bago Road. An area of approximately 2 ha would be removed from vegetation on both the eastern and western sides of the existing highway. The vegetation in this area has a moderate-low level of weed invasion and is in moderate condition.

4.1.2 PLANT SPECIES

A total of 302 species of vascular plant were recorded from the study area, comprising 255 (84%) indigenous species and 47 (16%) introduced species (Appendix 4).

4.1.3 SIGNIFICANT PLANT SPECIES

Thirty-three threatened plant species listed on the TSC Act (Figure 7) and 18 threatened plant species from the EPBC Act, have been recorded or have potential habitat within the local area (DEC Atlas of NSW Wildlife, DEH's EPBC Online Database). Eighteen species are listed under both Acts (Appendix 5). No threatened species listed on the TSC Act or EPBC Act were recorded within the study area during the current surveys. In addition, no ROTAP (Rare or Threatened Australian Plants) species (Briggs & Leigh 1995) were recorded. The ROTAP list is maintained by CSIRO and lists taxa that are presumed extinct, endangered, vulnerable, rare or poorly known at the national level. Inclusion of taxa within the list does not confer any legislative protection.

Of the total of 33 threatened plant species considered in this assessment, 15 (all listed on the TSC Act and 10 on the EPBC Act) have potential habitat within the study area and hence may be present. Due to the presence of potential habitat, potential impacts of the proposed highway upgrade on these threatened species were determined by Eight Part Tests (NPWS 1996) and by the EPBC Act Guidelines on Significance (Environment Australia 2000) (see Section 6.0).

4.1.4 ENDANGERED PLANT POPULATIONS

On 12 July 2002 the Scientific Committee made a Final Determination to list the population of *Eucalyptus seeana* (Narrow-leaved Red Gum) that occurs within the Greater Taree LGA as an Endangered Population. While *Eucalyptus seeana* was not recorded during the November 2001 and 2002 surveys, this species has been recorded previously within the vicinity of the study area (Figure 7).

The preferred habitat for this species is woodland on shallow sandy soils and it is often recorded within swampy areas (Harden 2002). The potential impacts of the proposed upgrade of the highway on this endangered population were considered as determined by an Eight Part Test.

No other endangered plant populations are found in the Greater Taree or Hastings LGAs.

4.2 FAUNA

4.2.1 TERRESTRIAL FAUNA HABITATS

Suitability, size and configuration of vertebrate fauna habitats broadly correlate to the structure, connectivity and quality of local and regional vegetation types. Many of the local habitats are wholly, or in part, contiguous with much larger areas of bushland and therefore form part of a habitat corridor. Generally, these habitats comprise mostly woodland and open forest with smaller components of closed forests and are described in detail above. Finer scale habitat features in and near the study area include foraging resources, tree hollows, hollow logs, riparian habitats including creeks, ephemeral drainage lines, dams and temporary ponds and soaks. These habitats and species associations are discussed below.

4.2.1.1 General Fauna Habitat Descriptions

Open Forest and Woodland

Open forest and woodlands provide a wide range of food and shelter for vertebrate fauna. Myrtaceous trees, mostly eucalypt species, are the dominant upper canopy plants in these areas and supply direct (foliage, nectar, exudates) and indirect (arthropods) food resources for a range of species, particularly birds and arboreal mammals. Tree hollows (formed in stags, mature and/or senescent trees) provide nesting and roosting habitat for hollow-dwelling fauna (eg. cockatoos and parrots, owls, gliders, possums and bats) and are important habitat components of native forests. Some of these microhabitat features are described in more detail below.

Woodland habitat occurs in all sections of the proposed highway route and is the second most dominant habitat type after cleared and modified lands. The most extensive patches of forest and woodland occur in the Lakes Section of the preferred route within Middle

Brother State Forest and Yoorigan National Park. Woodland habitats are generally in good condition in terms of fauna habitat.

Understorey Vegetation

Areas of dense understorey and shrub vegetation, principally within sheltered gullies, provide important habitat for small birds (eg. fairywrens and scrubwrens) ground-dwelling mammals (eg. as Antechinus, Dunnarts and rodents) and reptiles. Dense understorey vegetation occurs in all sections of the preferred highway route, but is more common adjacent to creek lines within the Lakes Section.

Tree Hollows

A number of large trees with hollows were observed within the study site in all sections of the preferred highway route. Tree hollows provide den and nesting habitat for a range of common birds and arboreal mammal species, including the Sulphur-crested Cockatoo, Sugar Glider, Greater Glider and forest dwelling micro-bats (Gibbons & Lindenmayer 2002). Locally recorded threatened species requiring tree-hollows for mating and nesting include the Powerful Owl, Masked Owl, Glossy Black-cockatoo and micro-bat species such as the East Coast Freetail Bat. Whether or not tree hollows will be used by animals, and which species, will depend on a number of factors including hollows characteristics (diameter, height, depth), number of hollows in the tree, tree health, size, location and spacing (Gibbons & Lindenmayer 2002). The NSW Scientific committee has made a preliminary listing of the 'Removal of Dead Wood, Dead Trees and Logs' as a Key Threatening Process under the TSC Act. This would include the removal of dead trees containing tree hollows.

Fallen Timber and Bark

Fallen branches and bark (scattered throughout forested areas) provide refuge and nesting habitat for a range of terrestrial animals. Many invertebrates and amphibians rely on these moisture-retaining micro-habitats to over-winter or as refuge during periods of drought. Similarly, many reptiles rely on ground litter and debris for shelter and foraging. Larger hollow logs provide potential denning and nesting habitat for small to medium sized mammals including the threatened Spotted-tailed Quoll. The NSW Scientific committee has made a preliminary listing of the 'Removal of Dead Wood, Dead Trees and Logs' as a Key Threatening Process under the TSC Act.

Rivers, Creeks, Drainage Lines and Wetlands

Wet depressions (heath/sedgeland), creeks and drainage lines provide optimal habitat for a range of vertebrate (amphibians, reptiles and small ground-dwelling mammals) and invertebrate species. These areas were observed, in various forms, along the entire preferred highway route.

Larger creeks and rivers within the proposed Highway route, such as Herons Creek and the Camden Haven River provide habitat and resources for a range of species. The river environment includes in-stream habitats, riverbanks, riparian vegetation and associated swamps and wetlands. These habitats have a range of characteristics making them attractive to fauna such as the Common Eastern Froglet and Large-footed Myotis.

Major wetlands adjacent to the preferred highway route provide significant habitat for a range of species, such as the threatened Australasian Bittern and Black-necked Stork.

Cleared Areas

Some sections within or near the study site have been cleared for a range of uses including agriculture, residential properties and infrastructure easements. Despite these changes, some native species, such as Latham's Snipe, may occur within disturbed vegetation and microhabitat components of these areas. Generally these areas would however, provide few habitat opportunities for a diverse native fauna. Species more likely to inhabit these areas include introduced and domestic animals and native species tolerant of disturbance or favouring edge/ecotone habitat. Cleared areas within the study site are generally of poor quality in fauna habitat terms.

4.2.1.2 Johns River Bypass

This section of road would start at the southern most part of the upgrade route, diverting to the west of Johns River and joining back with the existing highway at approximately Bulleys Road.

North of the point on the existing highway where the North Coast Railway diverts to the east away from the Highway the preferred route would pass through a patch of vegetation to the west of the existing highway. This habitat is in moderately good condition with extensive fallen logs, leaf litter, mature trees and some tree hollows. There are sections of *Allocasuarina* spp. within the Coastal Blackbutt Forest in this area that may be used as foraging resources by Glossy Black-cockatoos. Anecdotal records suggest that this species does occur in this section of the study area.

Between Stewarts River Road and the Stewarts River the preferred route would pass through one small area of intact vegetation just south of Bulleys Road. The quality of this vegetation is highly variable as a result of weed infestation. It is considered poor quality fauna habitat. Vegetation adjacent to Stewarts River is in poor condition as fauna habitat since it is highly overgrown and weed infested and surrounded by agriculture lands. There does not appear to be any major connectivity along the river.

4.2.1.3 Lakes Section

The highway in this section would be upgraded through construction of a new northbound carriageway that would generally be located on the western side of the existing highway. The existing highway alignment will generally be retained for the southbound carriageway. The median width varies, with a wider median at the Algona Road, Watson Taylor Road and Ross Glen Road intersections and a narrow median in the section just north of Stewarts River and adjacent to the National Park. The existing road reserve is largely bounded in the east by the North Coast Railway easement and in the west by State Forest and National Parks estate.

North of Stewarts River to Algona Road, vegetation that would be removed is considered to be poor fauna habitat since it contains few habitat features of significance or that would be considered of limited supply for fauna in the local area. One exception is Passionfruit Creek, which supports vegetation and habitat suitable for frogs and other semi-aquatic organisms. Mitigation measures would be implemented at this point to avoid any degradation of the creek. However Passionfruit Creek does contain *Gambusia* spp. (Dr P. O'Donnell, The Ecology Lab, *pers. comm.*), which will reduce the suitability of the creek for semi-aquatic fauna such as frogs. Predation by *Gambusia holbrooki* is listed as a Key Threatening Process on Schedule 3 of the TSC Act.

Between Algona Road and Watson Taylor Road, privately-owned properties that have been cleared to varying degrees would bound the preferred highway route to the west followed further north by Yoorigan National Park. The quality of the fauna habitat within the National Park adjacent to the existing Highway is highly variable. Many sites, particularly in gullies are densely overgrown with weeds, whereas other sites are more open and appear to be relatively free of weed infestation. There are some large habitat trees present in this section. There is a narrow strip of vegetation between the existing highway and the North Coast Railway that offers little in the way of fauna habitat.

Between Stony Creek and the Camden Haven River, Middle Brother State Forest would bound the proposed route to the west. The duplication of the existing Highway would remove small amounts of vegetation from the State Forest and much of this is of only moderate quality, due to weed infestation. However, vegetation to be impacted does contain some large habitat trees that may be used by a range of species (including some threatened) for roosting and nesting (Figure 9). This area also contains *Allocasuarina* spp., the preferred feed tree of Glossy Black-cockatoos, two of which were observed foraging in this area during the current surveys. On the eastern side of the existing highway there is a thin strip of vegetation between the road and the North Coast Railway. However vegetation in this strip is in poor condition and does not contain any significant fauna habitat structures. Further to the east is SEPP 14 Wetland No. 544c (Kew Swamp), but this would not be impacted by the upgrade of the highway since it is located away from the preferred Highway route on the eastern side of the North Coast Railway line.

4.2.1.4 Kew Bypass

This section would consist of a deviation to the east of the existing highway and the township of Kew and a duplication and upgrade of sections of the existing highway. At the Camden Haven River there is only minor vegetation on the banks at the point where the preferred highway route would cross. The preferred highway upgrade in this area would be unlikely to have an impact on semi-aquatic and riparian fauna species found in the local area.

North of the Camden Haven River to Sunnyvale Road the proposed highway would include a duplication of the existing highway and would pass between two wetlands, one of which is classified as a SEPP 14 coastal wetland (544a - Sunnyvale Swamp). The SEPP 14 wetland contains a range of important habitat resources for a variety of species, including threatened amphibian and bird species. The endangered Black-necked Stork was observed during the current surveys. Residents report the movement of Eastern Grey Kangaroos in this area.

North of Sunnyvale Road to Ocean Drive the proposed highway would be located to the east of the existing highway and would largely pass through cleared residential land. It would bisect one area of vegetation north of Bethesda Nursery. This vegetation contains a relatively dense area of *Allocasuarina* spp. that may provide foraging resources for Glossy Black-cockatoos. There are some mature trees with hollows in the area but they are not likely to provide significant nesting resources for Glossy Black-cockatoos since they do not have suitable characteristics such as appropriately sized entrances (~ 20 cm: Gibbons & Lindenmayer 2002).

The preferred route would divert to the east to bypass the township of Kew and then pass under Ocean Drive. North of Ocean Drive the preferred highway route would pass through an area of vegetation, which is relatively large (approximately 100 ha) and is considered to be in good condition. The area contains some large mature trees with hollows as well as a range of fauna microhabitats including fallen logs, leaf litter, a small creek and a good diversity of vegetation layers. Although this area of vegetation appears to be relatively isolated in that either roads or cleared agriculture lands separate it from other areas of vegetation, it does contain a diverse fauna including arboreal mammals (Sugar Gliders). The preferred route would fragment this patch leaving a relatively thin strip of vegetation (approximately 100 m wide) between the existing and new Highways. It is likely that the overall condition of the strip would deteriorate over time due to cumulative edge effects (see Section 5.1.1). Development approval has been granted for the area of vegetation directly south of the Sewage Treatment Plant and this is likely to result in a significant loss of vegetation in this area. There has recently (December 2002) been extensive underscrubbing in this patch of vegetation and this is likely to greatly reduce fauna habitat values. North of Weeroona Place to Herons Creek Road (South) there is no significant fauna habitat on the western side of the existing highway where the land is cleared for agriculture.

North of Herons Creek Road (South) the proposed route is a duplication of the existing highway. There is a relatively large (approximately 111 ha) area of native vegetation to the west of the existing highway. This vegetation is in relatively good condition and consists of fairly open habitat. There are some mature trees, a few of which contain hollows. Parts of this vegetation had recently been burnt at the time of 2001 survey. Most of the vegetation to be removed in this section would be at the intersection of the existing highway and Herons Creek Road (South). However, vegetation at this point is relatively close to vegetation on the eastern side of the existing highway and this may maintain a degree of connectivity between habitats on the two sides of the road. However, future housing developments approved for the vegetation in the east would negate the need for future connectivity structures at this point in the proposed road.

4.2.1.5 Kew to Herons Creek

This section of the preferred route would be largely a duplication and widening of the existing highway. North of Herons Creek Road (South) to the Eggbert entrance, the majority of native vegetation occurs to the west of the existing highway. Vegetation on the west is considered to be in good condition and contains both mature trees in the upper canopy and a mid storey of *Allocasuarina* spp. A cleared utilities easement runs parallel to the existing Highway and most of the proposed road reserve would largely be contained within this area. The eastern side of the road contains the Kew-Kendall STP lands, which contains planted *Eucalyptus* spp.

A record of the ‘vulnerable’ Green-thighed Frog, *Litoria brevipalmata*, occurs in this area on the western side of the existing Highway. This record was made in 1997 and is recorded in the Atlas of NSW Wildlife as having standard reliability (5)⁷. However, the record is based on the advertisement call of the species and there are three other common species of frog in the local area with which *L. brevipalmata* can be confused: the Broad-palmed Frog (*L. latopalmata*), Rocket Frog (*L. nasuta*) and Wallum Rocket Frog (*L. freycineti*) (Lemckert et al. 1997). It should also be noted that the accuracy of the location is identified in the Atlas of NSW Wildlife as being 1 km (3)⁸. Potential habitat does occur within this section of the preferred highway route, but even sites that appear to be suitable habitat for this species may never be used (Lemckert et al. 1997).

At Walkers Creek there is potential habitat for a range of semi-aquatic species including frogs, reptiles and turtles. However, the potential presence of *Gambusia* spp. greatly reduces the quality of this habitat for frogs. This introduced species was not recorded by The Ecology Lab as part of their EIS studies, but is likely to occur (Dr P. O’Donnell, The Ecology Lab, *pers. comm.*).

⁷ NPWS use reliability codes on a scale of 1 to 6: (1) Specimen with Public Museum. e.g. National Herbarium / Australian Museum; (2) Specimen with other collection; (3) Voucher specimen used in identification; (4) Specialist reliability; (5) Standard reliability; (6) Suspect sighting.

⁸ NPWS record location with an accuracy code of 1 – 6: (1) within 10 m; (2) within 100 m; (3) within 1 km; (4) within 10 km; (5) within 100 km.

North of the entrance to the Eggbert property to Cluleys Road there is minimal vegetation on the western side that would be impacted by the proposed highway upgrade. Vegetation on the western side is already set back from the existing highway. However, on the eastern side there is an extensive area of vegetation, the westerly edge of which would be impacted by the proposed road reserve to a depth of approximately 50 m (Figure 10). This section of vegetation contains some mature trees, some of which would be removed, although there does not appear to be many significant tree hollows in this section. The mid-storey consists largely of *Allocasuarina* spp., which may provide a foraging resource for Glossy Black-cockatoos.

At Herons Creek Road (North) there is a drainage channel with standing water and emergent vegetation that may provide habitat for frogs. Frog species recorded in this area include *Crinia signifera* and *Litoria fallax*. On either side of the Highway there are ponds with emergent vegetation (Figure 11), which again is potential frog habitat. No *Gambusia* sp. were recorded at this site (Dr P. O'Donnell, The Ecology Lab, *pers. comm.*), but they are likely to occur. Eastern Grey Kangaroos were observed at the eastern pond and it may function as a watering point in the landscape.

Between Herons Creek Road (North) and Herons Creek the land is largely cleared and offers few opportunities for significant fauna habitat. During the surveys some trees in the area were flowering and were attracting large numbers of foraging birds. However, these resources are not considered to be limiting in the area for nectivorous birds.

Herons Creek is comprised of two branches in this section, of which the most northerly was flowing during the 2001 survey period. Both branches contain dense riparian vegetation (mainly rushes), fallen logs and river rocks, and would provide important habitat for a range of species including frogs. Species recorded at Herons Creek during the November 2001, 2002 surveys include *Litoria fallax* and Eastern Whipbird. Riparian vegetation to the east of the highway is relatively narrow, but the creek does provide some connectivity between vegetation to the North and patches further south along the creek. The existing bridge does allow for restricted fauna movements beneath the existing Highway as evidenced by the habitat features beneath and adjoining the bridge and the presence of frogs and birds under the bridge in the current surveys (Figure 12).

North of Herons Creek a small amount of native woodland would be removed on the western side of the existing Highway. This vegetation contains some mature trees, yet large tree hollows appear to be absent. The vegetation is part of a more extensive area that extends to the west of the existing highway north of Bobs Creek Road, but the removal of the vegetation would not result in fragmentation of this habitat. Species recorded in this habitat include common species of bird such as the Superb Wren.

Overall native habitat within the Kew to Herons Creek Section is in good condition, cleared lands are in poor condition and creeks are in moderate condition. The southern end of this route section, west of the Kew Kendall STP, contains potential habitat for the Green-thighed Frog (listed as 'vulnerable' on the TSC Act) and this species has been

recorded in the local area, however, targeted surveys failed to find any evidence of breeding (ie. presence of tadpoles or metamorphlings) during targeted surveys following heavy rainfall.

4.2.2 ANIMAL SPECIES

Ninety species of vertebrate were recorded from the study site (Appendix 6) including five amphibians, six reptiles, 61 birds and 18 mammals. All species recorded are native apart from the introduced Fox. Six threatened species listed on the TSC Act were recorded - two birds (Glossy Black-cockatoo and Black-necked Stork) and four species of bat (three microchiropterans and one megachiropteran). However, the East Coast Freetail Bat is only a probable identification based on Anabat records⁹. The Grey-headed Flying Fox is listed on both the TSC Act and the EPBC Act. Seven migratory species as listed under the EPBC Act were recorded in the area (Appendix 6). An additional three amphibians were recorded during the targeted frog surveys.

4.2.3 SIGNIFICANT SPECIES OF ANIMAL

Based on DEC Atlas of NSW Wildlife and the DEH's EPBC database, there are 38 threatened species of animal that must be considered under the TSC Act (Figure 8) and 17 threatened and/or migratory¹⁰ species that should be considered under the *EPBC Act* (Appendix 7). Twenty-two species must be considered under both Acts. A further five migratory species were recorded during the current surveys. Of the total of 81 species, 38 have actual or potential habitat within the study area. As such, assessment of the proposed upgrading of the highway considered potential impacts on these species as determined by Eight Part Tests and/or the EPBC Act Guidelines on Significance.

One species of particular note is the Green-thighed Frog *Litoria brevipalmata*. This species was not recorded during the current surveys, although it is particularly hard to detect. Two specimens of the Green-thighed Frog were recorded on the western side of the existing Highway near the Eggbert property in 1997 (DEC records, Figure 8) and they are recorded in the Atlas of NSW Wildlife as having standard reliability. Potential breeding sites occur along the Herons Creek Section including ponds, creeks and paddocks. However, it should be noted that the sites that appear to be suitable breeding habitat have not been confirmed as such (Lemckert et al. 1997).

⁹ The analysis of bat calls using the Anabat system is based on the characterization of echolocation calls, which are species specific (de Oliveira, 1998). If the call is short or if there is interference then sometimes the calls cannot be accurately assigned to species. During the characterization of calls, each call is assigned to a "definite", "probable" or "possible" category. In the case of the *Mormopterus norfolkensis* (East Coast Freetail Bat) call in the current study, the call was short and it was assigned to a probable category.

¹⁰ The Environment Australia EPBC database does not list migratory species that are widespread, vagrant or only occur in small numbers. The database records are therefore supplemented with actual records from the site.

The habitat of the Green-thighed Frog is poorly known. It has been found in a range of vegetation types including riparian forest and wet and dry sclerophyll forest and woodlands, including relatively open structures (Ehmann 1997). Within northern NSW records of this species appear to predominantly come from dry sclerophyll forest (Murphy & Turnbull 1999). The majority of records for this species have come from the detection of calls during the breeding season (October to January). Most of the known breeding sites of this species are ephemeral ponds, waterholes in creeks, artificial dams, scrapes and ditches (Ehmann 1997). Calling in this species has also been observed in flooded road verges (F. Lemckert, State Forests, *pers. comm.*). Within NSW all the known breeding sites and their environs are disturbed to various degrees ranging from substantial partial clearing of trees in grazing farmlands to moderate levels of logging (Ehmann 1997). All known sites have nearby stands of relatively undisturbed forest (Ehmann 1997). This species exhibits explosive breeding, with males congregating around temporary pools that form only after very heavy rainfall events (Barker et al. 1995, Lemckert et al. 1997, Lemckert & Slatyer 2002). Breeding is highly variable and may occur just one or twice per year or not at all (Lemckert et al. 1997). The use of the forest environment by this species during the non-breeding season is poorly understood, but it is thought that cover in the form of thick leaf litter or dense low vegetation may be important (Lemckert & Slatyer 2002).

Lemckert *et al.* (1997) suggested that a stochastic event that destroys one breeding site would significantly reduce the total breeding output for the region.

4.2.4 ENDANGERED ANIMAL POPULATIONS

The Emu, *Dromaius novaehollandiae*, is listed as an endangered population in the NSW North Coast Bioregion. The population within the bioregion is isolated from other populations in the Sydney Basin and New England Tableland Bioregions (NSW Scientific Committee 2002a). However, the majority of records are concentrated between Coffs Harbour and Ballina and hence the proposed Highway upgrade is unlikely to impact individuals of this population.

4.3 KOALA HABITAT (SEPP44)

Although SEPP 44 does not apply to the proposed highway upgrade (Section 3.4), an assessment consistent with its provisions was undertaken along the entire preferred route so as to identify potential issues associated with Koalas.

Koala habitat occurs along the length of the proposed Highway upgrade as evidenced by previous records for this species (DEC Atlas of NSW Wildlife, Figure 8) and the presence of Koala feed tree species such as Tallowwood *Eucalyptus microcorys*. Vegetation communities that contain Koala feed trees include Coastal Blackbutt Forest and Dry Tallowwood Forest. However, despite the occurrence of records, the presence of Koala feed trees occurs only in relatively high densities (compared to the remainder

of the preferred route) in the area of vegetation traversed the proposed Kew Bypass north of Ocean Drive. This area of vegetation is part of the Kew corridor proposed by DEC (Scotts *et al.* 2000) and Koalas are noted as a key species for this corridor (see Section 4.5.1). However, under SEPP 44 potential koala habitat is defined as “areas of native vegetation where the trees of the types listed in Schedule 1 (Koala feed trees) constitute at least 15% of the total number of trees in the upper or lower strata of the tree component”. Under this definition, the area north of Ocean Drive cannot be considered potential Koala habitat and as such any modification of this vegetation is unlikely to impact this species. Potential impacts on Koalas are considered further under the formal Eight Part Test assessment (Section 6.1.4).

4.4 SEPP 14 WETLANDS

Two SEPP 14 wetlands occur within the study area, 544a (Sunnyvale Swamp) and 544c (Kew Swamp) (Figure 1). These SEPP 14 wetlands contain a range of important habitat resources for a variety of species, including threatened amphibian and bird species.

The preferred route has been chosen so that it avoids any direct impact on the wetlands ie. works that would require clearing, draining, filling or the constructing of a levee. As such the proposed works associated with the proposed highway upgrade would not be classified as a ‘designated development’. However, there is potential for indirect environmental impacts (erosion, runoff and subsequent changes to water quality) on the SEPP 14 wetlands, especially Sunnyvale Swamp. To ensure against such impacts, the preferred route has been designed such that adequate safeguards would be put in place. Currently there is already a raised embankment between Sunnyvale Swamp and the existing and preferred routes, thus the use of additional mitigation measures (as specified in the road design) would reduce further any potential impacts on the wetlands.

4.5 WILDLIFE CORRIDORS AND CONNECTIVITY

Wildlife corridors can be best defined as “retained and/or restored systems of (linear) habitat which, at a minimum enhances connectivity of wildlife populations and may help them overcome the main consequences of habitat fragmentation” (Wilson & Lindenmayer 1995). Alternatively they can be defined as “linear habitats that differ from a more extensive surrounding matrix. Frequently, they link one or more patches of habitat in the landscape, but they may also occur as isolated lines of habitat” (Bennett 1990).

A corridor serves a number of different functions in terms of wildlife conservation:

- Providing increased foraging area for wide-ranging species;
- Providing cover for movement between habitat patches, and enhancing the movement of animals through sub-optimal habitats;

- Reducing genetic isolation;
- Facilitating access to a mix of habitats and successional stages to those species which require them for different activities (eg. foraging or breeding);
- Providing refuge from disturbances such as fire;
- Providing habitat in itself; and
- Linking wildlife populations and helping to maintain immigration and recolonisation between otherwise isolated patches. This in turn may help reduce the risk of population extinction (Wilson & Lindenmayer 1995).

The functioning of a corridor can be best described in terms of its connectivity, of which there are two components.

1. Structural connectivity

This is the mappable spatial continuity of the corridor. This can include the distance over which the corridor extends, the width, the number of gaps and the presence of habitat nodes.

2. Functional connectivity

This is a measure of the ability of a species to move between two habitats. The functional connectivity of a corridor depends not only on its spatial continuity, but also on factors such as behaviour of the species, the scale of the species' movements, and its response to the width and quality of habitat in the corridor (Bennett 1990).

Some important considerations in corridors include:

Gaps

Gaps in a corridor can disrupt animal movements along a corridor. What constitutes a gap and its effectiveness as a barrier would depend on the species. For example, a 3 m dirt track across a corridor may inhibit the movement of Bush Rats and Brown Antechinus (Barnett et al. 1978) but is unlikely to inhibit the movement of large more mobile species. Similarly, gaps in the tree canopy may inhibit movements of arboreal animals but are unlikely to inhibit the movement of terrestrial species.

The presence of habitat nodes

Incorporation of nodes of habitat along the corridor can increase its effectiveness by providing additional habitat in which animals can pause during lengthy movements, or maintain a larger breeding population. Habitat nodes can include

small forest patches adjacent to corridors.

Quality of habitat in the corridor

If animals are to live in and use a corridor for movements then it is best if there is an availability and reliability of essential resources.

Edge effects

As corridors are linear structures it means that the ratio of perimeter to area is high and as a consequence corridors are particularly vulnerable to edge effects. Edge effects can include:

- Microclimate changes;
- Changes in the composition and structure of plant communities;
- Invasions of edge specialist species into the corridor (eg. Noisy Miners in Australia inhabit the edges of patches and can be aggressive and territorial towards small insectivorous birds: Loyn et al. 1983).

Edge effects appear to be greatest when there is a sharp contrast between the two types of habitats.

Width of corridor

This is probably one of the most important considerations about a corridor. The wider the corridor the greater the number of habitat elements that can be included and hence the range of species that can use the corridor increases. A number of studies have shown that species diversity in a corridor increases with the width of the corridor (Stauffer & Best 1980, Arnold et al. 1987, Recher et al. 1987).

Buffers

The designation of buffer areas may assist to protect sensitive habitats within corridors. They can reduce the distance that edge effects penetrate into the corridor itself. Further, if of the same or similar habitat they can act as habitat nodes and increase the width of the corridor.

4.5.1 CORRIDORS AND CONNECTIVITY IN THE AREA SURROUNDING THE PROPOSED HIGHWAY UPGRADE

Throughout the length of the preferred route there are a number of large areas of significant vegetation in both the east and west, which either the current highway or the proposed upgrade would pass between (Figure 13). Figure 13 shows key habitat and corridors as proposed by DEC (Scotts et al. 2000). These mapped outputs provide an indicative representation and consolidation of areas of potential high conservation value

for priority forest fauna and habitat corridors that link these across the landscape. These maps are based on a regional scale representation of potential habitat and linking habitat for species and species assemblages (Scotts 2001). These areas of vegetation form part of a large network of vegetation patches and connectivity among them should be maintained wherever possible. At the regional scale, four major corridor linkages cross the proposed route option:

- In the Johns River Bypass Section, Johns River State Forest lies to the east, while crown land on South Brother lies to the west (Figure 13). There is a major corridor linkage that runs between these areas, known as the South Brother Link. This is a major east west link between assemblage corridors. The fauna assemblage is the Dry Coastal Foothills Assemblage, which in the Lower North Coast includes Bibron's Toadlet, Green-thighed Frog, Brush Bronzewing, Brush-tailed Phascogale, Common Planigale, Squirrel Glider, Rufous Bettong and Broad-nosed Bat (Scotts et al. 2000).
- The Kew corridor runs in a North-West/South-East direction and links key habitat in the Laurieton/Camden Haven regions with Kew State Forest (Figure 13). This corridor is considered a major linkage for Koalas and Glossy Black-cockatoos.
- The Bulls Ground/Queens corridor (Figure 13) is considered a major link between local State Forests and DEC Estate (National Parks). It is also a link between the two major fauna assemblages, namely the Dry Coastal Foothills Assemblage (see above) and the Moist Escarpment Foothills Assemblage. The Moist Escarpment-Foothills Assemblage includes Glossy Black-cockatoo, Powerful Owl, Masked Owl, Koala, Yellow-bellied Glider, Eastern Little-mastiff Bat, Grey-headed Flying Fox, Little Bent-wing Bat, Common Bent-wing Bat and Little Vespadelus (Scotts et al. 2000). Regional focus species include Yellow-bellied Glider, Brush-tailed Phascogale and Rufous Bettong.
- The Burrawan/Kew corridor links Kew State Forest to the west of the proposed route and Burrawan State Forest to the east. The fauna assemblage on both sides is the Moist Escarpment Foothills Assemblage (see above, Scotts et al. 2000) with a key focus species being the Yellow-bellied Glider.

These corridor linkages are decided at the regional scale. However at the more localised scale, key habitats and corridors are also of importance reflecting more localised species considerations (Scotts et al. 2000). On a small spatial scale, habitat patches can occur on both sides of the highway and where possible connectivity should be maintained in these areas, thereby retaining the amount of available habitat for resident species and preserving ecological functionality.

A range of different animal species will exist on both sides of the preferred route, utilising the existing corridor network. These species will cover all taxonomic groups including frogs (eg. Eastern Dwarf Tree Frog *Litoria fallax* in both Yoorigan National Park and Crowdy Bay National Park), reptiles (eg. Eastern Water Dragon *Physignathus lesueurii* in Kew State Forest and Queens Lake Nature Reserve), birds including a

range of species and mammals (eg. Red-necked Wallaby *Macropus rufogriseus*). Threatened species that may use the wider corridor network include the Spotted-tailed Quoll, Koala and Glossy Black-cockatoo. How species use the corridor network will depend largely on the home and activity ranges of the species, their habitat requirements and the ecological characteristics of the corridor. For example, some large or mobile species may make direct movements through the corridor network, moving from one patch of habitat to another. These direct movements may be on the scale of a foraging expedition or a migration (Bennett 1990). Other species may have movements by single individuals punctuated by pauses in the corridor, which can last anything from a small foraging or resting bout to weeks and even months. If the corridor contains sufficient resources to maintain a population, then continuity through the corridor may be through gene flow through the resident population (Bennett 1990, Wilson & Lindenmayer 1995).

Roads can generally cause a significant barrier to the movement of animals within a wildlife corridor network (Andrews 1990, Bennett 1991, Cuperus *et al.* 1999). Although not necessarily totally stopping all movements of animals, a road without mitigation measures may reduce the number of successful movements through a corridor by acting as a deterrent (Barnett *et al.* 1978, Bennett 1991) or by increasing mortality as they move through the corridor (Van der Zande *et al.* 1980, Andrews 1990, Forman *et al.* 2003). Given that for a large proportion of the highway upgrade the proposed route would consist of a duplication of the already existing highway it is likely that these barriers are to some extent already in place. However, the widening of the highway may increase the effectiveness of the barrier in hindering fauna movements and the design phase may be seen as an opportunity to increase or maintain connectivity through mitigation measures such as fauna underpasses.

A number of areas along the proposed route would benefit from maintained or increased connectivity. There is currently little connectivity between Yoorigan National Park and Watson Taylors Lake due to the presence of the existing highway and the North Coast Railway. Such connectivity would be desirable since it would provide fauna residing in the National Park with access to the lake and also with connectivity with the two coastal National Parks further east. Species that may use such connectivity include a range of relatively common species of mammals such as possums and ground dwelling marsupials as well as amphibians and reptiles. Threatened species that may use increased connectivity include Koalas and Spotted-tailed Quolls. However it should be noted that the land on the eastern side of the existing Highway is bounded in the south by Stewarts River and in the north by Camden Haven River and is in effect an island (Figure 13).

Riparian vegetation along Walkers Creek currently provides a limited level of connectivity between extensive areas of vegetation to the east and more extensive vegetation located approximately 500 m to the west across the North Coast Railway. The North Coast Railway is not considered a major fauna barrier due to the infrequency of rail traffic.

Riparian vegetation along Herons Creek currently forms a significant linkage between more extensive vegetation to the north and southwest (Figure 13). Although the surrounding matrix consists primarily of cleared lands for agriculture and the quality of riparian vegetation along the creek to the east of the existing highway is relatively poor (and narrow), the creek still provides a level of connectivity. Currently the existing Highway and the North Coast Railway form potential barriers in the corridor, although both have bridges over the creek. The span of the existing Herons Creek Bridge is relatively narrow (24.5 m, Figure 12), yet this would be replaced during the upgrade with two new bridges both with a span of 32 m.

Fauna mitigation measures, such as underpasses, as a means of maintaining connectivity are discussed in Section 5.2.

It should also be noted that vegetation within roadside reserves is often an important element within a regional corridor network (Bennett 1991, Forman *et al.* 2003). Animals can use road reserves as habitat in which to live as well as movement corridors facilitating local movements, dispersal and migration (Bennett 1990). Within highly modified landscapes, remnant patches and strips of vegetation within road reserves are often the only remaining vegetation links. A number of studies have indicated the importance of such roadside vegetation (Middleton 1980, Newbey & Newbey 1987).

5.0 IMPACTS AND MITIGATION

This section details the types of impacts that may be experienced as a result of the construction and operation of a road, with specific reference to the Pacific Highway. Many of these impacts can however be mitigated thus greatly reducing or eliminating the impacts.

5.1 TYPES OF IMPACT

5.1.1 VEGETATION CLEARANCE/HABITAT LOSS

Vegetation clearing itself would be limited. In areas where there would be a duplication of the existing highway it would largely involve removal of vegetation that is already highly disturbed and offering few fauna habitat features. In other areas, however, vegetation removal would be more significant, impacting upon relatively intact native vegetation.

A total of 64.3 ha of vegetation will be cleared by the proposed Highway upgrade (Table 6), with a large proportion (38.9%) occurring in the Lakes Section. However, the majority (59.1%) of vegetation to be cleared occurs within the road reserve for the current Pacific Highway. Within the Lakes Section 92% of vegetation to be cleared is within the current road reserve. Only 1.5 ha will be cleared from State Forests, 2.7 ha from Crown Land and no land will be cleared in DEC Estate (National Parks).

Table 6: Area of each vegetation community that would be cleared by the construction of the proposed highway and the area to be cleared from within the current road reserve.

	Road Section	Vegetation Community					TOTAL
		Coastal Blackbutt	Dry Tallowwood Forest	Flooded Gum Forest	Freshwater Wetland (Sedgeland)	Swamp Sclerophyll Forest	
Vegetation clearing (ha)	Johns River	12.1	0.0	0.0	0.0	2.6	14.7
	Lakes	14.5	5.7	3.2	0.0	1.6	25.0
	Kew Bypass	12.7	2.2	0.0	0.0	0.7	15.6
	Herons Creek	3.8	4.9	0.0	0.0	0.3	9.0
	TOTAL	43.1	12.8	3.2	0.0	5.2	64.3
Vegetation to be cleared within current road reserve (ha)	Johns River	4.9	0.0	0.0	0.0	0.4	5.3
	Lakes	12.7	5.6	3.5	0.0	1.2	23.0
	Kew Bypass	4.3	0.8	0.0	0.0	0.0	5.1
	Herons Creek	1.1	3.5	0.0	0.0	0.0	4.6
	TOTAL	23.0	9.9	3.2	0	1.6	38

Johns River Bypass and the Kew Bypass would require the clearing of 14.7 ha and 15.6 ha respectively. In these areas a new road would be built through areas of intact vegetation hence increasing the extent of impact.

The Kew to Herons Creek Section would have the least vegetation clearing (9.0 ha) as this section of the route involves duplication of the existing highway within roadside vegetation much of which has previously been cleared or modified.

Coastal Blackbutt Forest occurs in all sections of the proposed highway route and is considered to be abundant within the study area. A total of approximately 43.1 ha of this community would be removed by the proposed works. The Coastal Blackbutt Forest to be removed generally occurs along the edge of the existing highway, is subject to edge effects and has a moderate level of weed invasion. Given the abundance of this community within the study area and the region in general, it is unlikely that the removal of 43.1 ha would have a significant impact on the Coastal Blackbutt Forest community.

Dry Tallowwood Forest also occurs in sections of the proposed highway north of The Stewarts River but is particularly abundant north of The Camden Haven River. This community is considered to be widespread within the study area and as such the removal of 12.8 ha is unlikely to have a significant impact on Dry Tallowwood Forest.

Flooded Gum Forest occurs in Middle Brother State Forest and Yoorigan National Park within the Lakes Section of the proposed highway. In this section the vegetation to be removed is adjacent to the existing highway and as such is currently subject to edge effects including a moderate level of weed invasion. The removal of 3.2 ha of moderate-poor condition Flooded Gum Forest is unlikely to have a significant impact on the community as a whole.

Swamp Sclerophyll Forest occurs within all sections of the proposed highway. This community is restricted to areas that are subject to inundation and as such Swamp Sclerophyll Forest is located in small areas scattered throughout the study area. This community is listed on the TSC Act as an EEC. The impact of the proposed upgrade of the Pacific Highway, including the removal of 5.2 ha of Swamp Sclerophyll Forest is assessed in an Eight Part Test in Section 6.1.1.

The proposal would not involve any clearing of Freshwater Wetland (Sedgeland) vegetation. However, as this community is listed as an EEC, the likely impact of the proposal is assessed in an Eight Part Test in Section 6.1.1.

Impacts of vegetation clearing can be both direct and indirect. Direct impacts result in the loss of plant species and fauna habitat features that occur in the area. In the current study area this would include nesting habitat and roosting hollows, as well as feeding and shelter resources. Indirect impacts include the increase in edge effects in adjoining vegetation (see Section 5.1.3) and changes in water runoff patterns. Most of the existing vegetation adjacent to the Pacific Highway is already subject to edge effects.

5.1.2 FRAGMENTATION

Habitat fragmentation is the division of a single area of habitat into two or more smaller areas, with a new habitat type occurring in the area between the fragments. This new dividing habitat type is often artificial and inhospitable to the fauna species remaining within the fragments (Bennett 1990, 1993, MacNally 1999). Although the newly created habitat will be used by some species, they are usually generalist species and are often considered aggressive (eg. Noisy Miners (Loyn et al. 1983)), further decreasing population levels of the species remaining in the fragments. In addition to the loss of total habitat area, the process of fragmentation can impact on the species within the newly created fragments in a number of ways (eg. barrier effects, genetic isolation and edge effects). The degree to which these potential impacts affect the flora and fauna within the newly created fragments depends on a number of variables including distance between fragments, local environmental conditions, the species present and mitigation measures (see Section 5.2). Some of the potential impacts are summarised below:

Barrier Effects. Barrier effects occur where particular species are either unable or are unwilling to move between suitable areas of fragmented habitat. This could result in either a complete halt to movement or a reduced level of movement between fragments. Roads through areas of native vegetation can act as barriers, with barrier effects greater for some species than others (Goosem 2002). Species most vulnerable to barrier effects include rare species (even a small reduction in movements can reduce genetic continuity within the population hence reducing the effective population size), smaller ground-dwelling species and species with low mobility. Species least vulnerable to barrier effects tend to be those that are highly mobile (e.g. birds), although even these species can vary in their response to barriers

Genetic Isolation. Genetic isolation occurs where individuals from a population within one fragment are unable to interbreed with individuals from populations in adjoining fragments. Genetic isolation can lead to inbreeding and genetic drift problems for populations isolated within a fragment.

Edge Effects. A zone of changed environmental conditions (ie. altered light levels, wind speed, temperature) occurs along the edges of habitat fragments (see Section 5.1.3).

Increased fragmentation of habitat would occur in those areas where the proposed road diverts away from the existing highway and would run through patches of intact vegetation. These areas would include the Kew Bypass north and south of Ocean Drive and the Johns River Bypass south of Stewarts River Road.

5.1.3 EDGE EFFECTS

Edge effects are zones of changed environmental conditions (ie. altered light levels, wind speed, temperature) occurring along the edges of habitat fragments. These new environmental conditions along the edges can promote the growth of different vegetation types (including weeds) and allow invasion by pest animals specialising in edge habitats. Edge zones can be subject to higher levels of predation by introduced mammalian predators and native avian predators (Berry 2002). This new zone of habitat inside the edge of a fragment can also exacerbate barrier effects. Bali (2000) noted that there are limitations to edge effect studies, with a study by Murcia (1995) noting that it is unrealistic to expect all variables to vary equally with distance from the edge. As edge effects varied between community types and abiotic effects, measuring less than or equal to 50 m in most studies, were the most consistent indicator of edge effects, Bali (2000) concluded that average edge effects generally occur up to 50 m away from the road edge. Similarly, the maximum extent of edge effects for a reliable biological indicator species, the epiphytic lichen, is up to 50 m from the forest edge (Esseen & Rehnhorn 1998). Bali (2000) determined that a 1:1 ratio to compensate for edge effects was not appropriate as edge-affected habitat can be utilised by flora and fauna species, including threatened species. In a review of Australian studies, Bali (2000) determined that the edge zone was 60% less suitable, or provided 60% less habitat for these species. She therefore suggested that a 0.6:1 ratio could be used, which in practical terms equates to a 30-m strip of habitat (0.6 m x 50 m) that should compensate for edge effects along habitat removed for new road corridors. Bali (2000) also recommended that for upgrades, compensatory habitat should only apply to key habitat removed and not to edge effects.

Specifically, edge effects associated with roads can include the degradation of adjacent habitat through:

- Changes in microclimate (e.g. temperature, wind, light humidity);
- Changes in hydrology (i.e. surface and sub-surface water flows);
- Changes in floristics (i.e. species composition and abundance);
- Alteration to the pattern and frequency of fire;
- Invasion by exotic plant and animal species;
- Increase in sedimentation;
- Increase in tree death (e.g. dieback, impact on root zone);
- Increase in rubbish and water pollution; and
- Improved access for predators (Bali 2000).

Edge effects may not affect both sides of the road equally and may be greater if they are downslope, downwind or surrounded by more suitable habitat (Forman & Alexander 1998, Bali 2000).

Using the estimate of edge effects of 50m proposed by Bali (2000), the proposed upgrade of the Pacific Highway, Moorland to Herons Creek, will impact 132.2 ha of native vegetation through edge effects (Table 7). The greatest extent of edge effects (40.7%) will occur in the Lakes Section where there is almost continuous vegetation along one side of the road. However, the current Pacific Highway has edge effects totalling 98.6 ha, making a total net change in edge effects of 33.6 ha. In the Lakes section a total of 24.4 ha will be newly impacted by edge effects.

76.0 ha (42.5%) of the vegetation to be impacted by edge effects will occur within the proposed road reserve and 38.5% occurs within the current road reserve (Table 8). The proposed Highway will impact 2.4 ha of DEC Estate (National Parks) through edge effects (Table 8), an increase of 0.7 ha from the current Pacific Highway. 12.8 ha will be edge effected within State Forest estate with the proposed Highway (increase of 10.9 ha) and 7.5 ha will be impacted by edge effects in crown land (increase of 4.0 ha). This means that a total of 22.7 ha of vegetation to be impacted through edge effects is under some form of conservation tenure. The remaining 80.0 ha (44.8%) are under private ownership (compared to 23.0 % currently).

Table 7: Current and proposed edge effects and net change associated with the Pacific Highway upgrade, Moorland to Herons Creek

	Road Section	Coastal Blackbutt	Dry Tallowood Forest	Flooded Gum Forest	Freshwater Wetland (Sedgeland)	Swamp Sclerophyll Forest	TOTAL
Proposed edge effects (ha)	Johns River	21.7	0.0	0.0	0.0	1.7	23.4
	Lakes Section	35.3	13.6	8.1	0.0	3.3	60.3
	Kew Bypass	17.2	4.9	0.0	1.7	0.5	22.9
	Herons Creek	11.3	13.6	0.0	0.0	0.6	25.6
	TOTAL	85.5	32.1	8.1	1.7	6.1	132.2
Current edge effects (ha)	Johns River	16.6	0.0	0.0	0.0	0.7	17.3
	Lakes Section	29.6	11.0	4.7	0.0	3.1	48.4
	Kew Bypass	9.0	4.0	0.0	0.2	0.0	13.3
	Herons Creek	8.3	10.7	0.0	0.0	0.5	19.6
	TOTAL	63.6	25.7	4.7	0.2	4.4	98.6
Net change (ha) in edge effects	Johns River	5.1	0	0	0	1.0	6.1
	Lakes Section	5.7	2.6	3.4	0	0.2	11.9
	Kew Bypass	8.2	0.9	0	0	0.5	9.6
	Herons Creek	3.0	2.9	0	0	0.1	6.0
	TOTAL	22.0	6.4	3.4	0.0	1.8	33.6

Table 8: Current and proposed edge effects across tenures

	Road section	Tenure					Total
		DEC Estate (NPWS land)	State Forest	Crown Land	Road Reserve	Other	
Proposed (ha)	Johns River	0.0	0.0	4.0	11.2	8.4	23.6
	Lakes Section	0.3	9.1	0.0	40.9	7.3	57.6
	Kew	0.0	0.0	0.0	11.9	16.1	28.0
	Herons Creek	0.0	0.5	1.2	5.0	16.3	23.0
	TOTAL	0.3	9.6	5.2	69.0	48.1	132.2
Current (ha)	Johns River	0.0	0.0	1.8	12.1	3.4	17.3
	Lakes Section	1.7	1.4	0.0	40.0	5.3	48.4
	Kew	0.0	0.0	0.0	9.6	3.7	13.3
	Herons Creek	0.0	0.5	1.7	7.1	10.3	19.6
	TOTAL	1.7	1.9	3.5	68.8	22.7	98.6

5.1.4 MORTALITY

Fauna injury or death can occur as a result of highway construction and operation in two ways:

- *During the break-out phase of construction (when all vegetation is removed to expose a natural earth substrate).* Habitat clearance may result in the injury or death of resident or visiting fauna. Some species can more readily evade injury by flying (birds) or ‘running’ away (eg. the larger mammals). Many species, however, are unlikely to move quickly enough to avoid being caught. For example, many nocturnal species (possums, gliders, bats) shelter during the day and smaller ground-dwelling species, such as lizards and snakes, are unable to move rapidly and over large distances.
- *Roadkills.* Mortality due to roadkill during operation has the potential to affect local fauna species at the sub-population level. In general, rates of roadkill mortality are likely to be directly proportional to the distance of native vegetation/fauna habitat crossed by the Highway (Forman *et al.* 2003). However, other factors such as the design of the road (eg. raised or not, presence of walls and fences, fauna underpasses) also influence roadkill mortality. Generally, the effects of roadkill mortality on sub-populations cannot be accurately predicted without more detailed demographic data than is available for species in the local area.

The RTA has policies and guidelines in place to deal with fauna mortality during construction (see Section 5.2.4).

5.1.5 WEEDS

Weed invasion can be a significant problem along the edges of habitat fragments. Along these boundaries there are changes in the environment (edge effects) including, altered light levels, wind speed, temperature, humidity and runoff. These altered conditions allow the colonisation and growth of weeds which would themselves result in further environmental changes that promote the colonisation and growth of weed species within the area. Due to these environmental changes, weeds may be able to out compete native plant species and (at worst) could result in the loss of the native vegetation community in that area.

5.2 MITIGATION MEASURES

The key policy principle of the RTA’s Road Development and Impact on Habitat Amelioration Measures is that “in principle, the planning and construction of roads should, in order of consideration endeavour to:

1. avoid impacts on habitat through the planning process;
2. minimise impacts on habitat through the planning process; and
3. mitigate impacts on habitat, through the use of a range of amelioration measures” (RTA 2001).

Where possible, important ecological features have been avoided during the initial route selection stage. For example, the SEPP 14 wetlands located north of the Camden Haven River would not be directly impacted by the Highway upgrade project. In addition, the preferred route has been designed, where possible, to minimise impacts on habitat. Mitigation measures are discussed below.

5.2.1 VEGETATION CLEARING

In order to mitigate some of the impacts of vegetation clearing it is recommended that:

- Vegetation clearing is restricted to those areas where it is necessary;
- Where clearing does occur, the area should be fenced with highly visible temporary fencing or flagging tape to ensure that clearing does not extend beyond the area necessary;
- Clearing of vegetation should comply with the RTA Pacific Highway Office guidelines for fauna rescue associated with roadworks. These guidelines have been developed in consultation with DEC and cover the felling of both non-habitat and habitat trees and the rescue and relocation of fauna;

- Where suitable, nest boxes should be used to replace removed hollows. Such a program should be developed in consultation with DEC; and,
- Vegetation within the road reserve and adjacent to areas of vegetation clearing should be managed to reduce invasion of noxious weed species, this may include controlling weeds at their point of source (ie the area of clearing).

5.2.2 EDGE EFFECTS

Mitigation measures related to edge effects relate generally to reducing impacts outside of the direct development zone, controlling possible impacts at their source within the road reserve and reducing the hardness of the edge between the extent of earthworks and native vegetation. Measures that are relevant to the current upgrade of the Pacific Highway include:

- Minimising disturbance to habitat adjacent to construction (e.g. the use of visible temporary fencing);
- Minimising disturbance wherever possible to stream banks and streambeds. This may be more easily achieved with some bridges, but will be impossible in the case of culverts;
- Siting all ancillary building and works in cleared or otherwise disturbed areas away from waterways and other sensitive areas, where possible;
- Avoiding stockpiling materials on adjacent vegetation, where possible;
- Managing general construction activities to appropriately dispose of waste material and/or contaminants away from adjacent habitats;
- Implementing soil erosion and sedimentation control measures;
- Implementing a weed management strategy within the road reserve; and
- Using locally indigenous species for landscape plantings and revegetation.

Compensatory Habitat

Bali (2000) determined, that with respect to edge effects, should not apply to the widening of existing roads and that a 0.6:1 ratio to compensate for new edge effects was appropriate. The additional edge effects created for the preferred route are 33.6 (see Table 7), and based on a 0.6:1 ratio, this results in a value of 20.2 ha to compensate for new edge effects. Bali (2000) also recommended that for upgrades, compensatory habitat should only apply to key habitat removed and not to edge effects. As mentioned above, existing edge effects of the Pacific Highway have been removed from compensatory habitat calculations. Bali (2000) defines key habitat as areas that support

flora and fauna species, populations or ecological communities considered to be of significance because they are listed in relevant legislation. In consultation with DEC it was determined that all native vegetation within the study area should be considered as key habitat. This is due to the extensive distribution of regional key habitat and corridors identified by DEC (Figure 13, Scotts *et al.* 2000) and the large number of EECs, threatened flora (Figure 7) and fauna (Figure 8) species along the preferred route.

5.2.3 FRAGMENTATION

During the design and selection of the preferred route a number of features were included to reduce the effects of habitat fragmentation. For example, where possible disturbances were kept to one side of an area of vegetation rather than be put through the middle.

In order to further mitigate the impacts of fragmentation it is recommended that:

- Only native and locally indigenous plants should be used in the landscaping to reduce weed invasion into the surrounding vegetation;
- Following construction, vegetation adjacent to the highway within the road reserve should be managed to reduce invasion by weed species; and,
- Fauna crossing structures must be included in the design in order to maintain connectivity between habitat on both sides of the road (see Section 5.2.3.1).

5.2.3.1 Fauna crossings

In order to reduce impacts of habitat fragmentation, fauna underpasses should be included in the design. Underpasses can be either constructed solely for the purpose of fauna movements or can be modified from existing structures such as box culverts (AMBS 2002). Suitability of the structures as fauna underpasses would depend on a number of factors including:

- The regional continuity of habitat in the area;
- Habitat directly on either side of the structure;
- The dimensions of the structure (width, height and length); and
- The species in the local area.

Structures such as exclusion fences and refuge poles can also increase the effectiveness of underpasses.

Generally fauna underpasses work well, with a monitoring study of underpasses on the Pacific Highway upgrade from Bulahdelah to Coolongolook indicating that 19 of 27

native mammal species present in the local area used the fauna underpasses (AMBS 2002) (Table 9). Species that were found to use the underpasses include a range of terrestrial mammals including dasyurids, macropods, rodents, bandicoots and bats as well as reptiles and amphibians (AMBS 2002). A smaller range of species used underpasses monitored north of the current study area in the Herons Creek Bypass, although the period of monitoring was significantly less than at Bulahdelah (AMBS 2001b). The previous monitoring of fauna crossing points along the Pacific Highway (AMBS 2001b, c, a, 2002) have covered a range of structures including span bridges and culverts ranging in size from 2.4 x 1.2 m to 3 m². Most structures provided passage for a range of animals, although most tended to be small (e.g. rats) to medium (e.g. bandicoots) sized animals. Larger animals such as wallabies tended to make more passages under the large bridge spans, but were recorded making complete passages in culverts 1.2 m in height (AMBS 2001a).

Table 9: Species of mammal (excluding bats and gliding possums) detected in the area of Bulahdelah to Coolongolook and those detected in fauna underpasses (AMBS 2002).

Common Name and Family (Bold)	Scientific Name	TSC Act ¹	EPBC Act ¹	Recorded using underpass
Native Mammals				
Dasyuridae				
Brown Antechinus	<i>Antechinus stuartii</i>			Yes
Brush-tailed Phascogale	<i>Phascogale tapoatafa</i>	V		No
Common Dunnart	<i>Sminthopsis murina</i>			Yes
Dusky Antechinus	<i>Antechinus swainsonii</i>			No
Spotted-tailed Quoll	<i>Dasyurus maculatus</i>	V	V	Yes
Yellow-footed Antechinus	<i>Antechinus flavipes</i>			Yes
Macropodidae				
Eastern Grey Kangaroo	<i>Macropus giganteus</i>			Yes
Red-necked Pademelon	<i>Thylogale thetis</i>			Yes
Red-necked Wallaby	<i>Macropus rufogriseus</i>			Yes
Swamp Wallaby	<i>Wallabia bicolor</i>			Yes
Muridae				
Bush Rat	<i>Rattus fuscipes</i>			Yes
New Holland Mouse	<i>Pseudomys novaehollandiae</i>			No
Swamp Rat	<i>Rattus lutreolus</i>			Yes
Water-rat	<i>Hydromys chrysogaster</i>			Yes
Peramelidae				
Long-nosed Bandicoot	<i>Perameles nasuta</i>			Yes
Northern Brown Bandicoot	<i>Isodon macrourus</i>			Yes
Petauridae				
Common Ringtail Possum	<i>Pseudocheirus peregrinus</i>			No
Phalangeridae				
Common Brushtail Possum	<i>Trichosurus vulpecula</i>			Yes
Mountain Brushtail Possum	<i>Trichosurus caninus</i>			Yes
Phascolarctidae				
Koala	<i>Phascolarctos cinereus</i>	V		Yes
Potoroidae				
Long-nosed Potoroo	<i>Potorous tridactylus</i>	V	V	Yes
Tachyglossidae				

Common Name and Family (Bold)	Scientific Name	TSC Act ¹	EPBC Act ¹	Recorded using underpass
Short-beaked Echidna	<i>Tachyglossus aculeatus</i>			Yes
Vombatidae				
Common Wombat	<i>Vombatus ursinus</i>			Yes
Introduced Mammals				
Bovidae				
Cattle (feral)	<i>Bos taurus</i>	U		Yes
Canidae				
Dingo and Dog (feral)	<i>Canis familiaris</i>	U		Yes
Fox	<i>Vulpes vulpes</i>	U		Yes
Felidae				
Cat (feral)	<i>Felis catus</i>	U		Yes
Leporidae				
Brown Hare	<i>Lepus capensis</i>	U		Yes
Rabbit	<i>Oryctolagus cuniculus</i>	U		Yes
Muridae				
Black Rat	<i>Rattus rattus</i>	U		Yes
House Mouse	<i>Mus musculus</i>	U		Yes

1: V = Vulnerable, U = Unprotected (feral)

Within the proposed highway upgrade the following points were considered when deciding on the need and suitability of fauna crossing structures:

- The regional connectivity within the local area. This is based on key habitat and corridor mapping produced by DEC (Figure 13). This mapping looks at the broad-scale connectivity within the whole region and assigns priority fauna species to different linkages;
- The size and location of vegetation patches on both sides of the proposed highway and their suitability as fauna habitat. Within the broad-scale corridors, relatively continuous habitat is one factor that contributes to the overall structural connectivity. Outside of the wider corridors, local connectivity between small patches of vegetation can also be important in maintaining local populations;
- Species that are likely to need or use fauna crossing structures at that point;
- Current and, where possible, future land use on either side of the proposed highway and other potential barriers; and
- The feasibility of constructing a fauna crossing structure at that point due to engineering constraints.

A number of drainage structures (55) would be included in the upgraded highway section and some of these may serve as fauna underpasses (Appendix 8). Based on the above features and following discussions with RTA and Arup engineers, 12 drainage and associated structures have been identified as suitable for use as fauna crossing points (Appendix 8), either through modification of the existing structures or through addition of dedicated structures. These structures are detailed below.

It is recommended that fauna fencing is used on most structures. While there is mixed evidence that fauna exclusion fencing guides fauna into structures, it does appear to reduce road kills where it is installed (AMBS 1997, 2002). The crossing should also aim to provide dry passage for fauna either through the inclusion of a raised walkway within existing culverts or through the positioning of new cells. Such features should be determined at the detailed design stage of the project. Details of the recommended fauna fencing requirements are outlined in Table 10.

Table 10: Recommended fauna fencing requirements for highway upgrade

Section	Chainage of Culvert	Chainage of Southern Limit of Fencing	Chainage of Northern Limit of Fencing	Lenth of Highway Requiring Fencing (m)
Johns River	1325	1200	1570	370
Lakes	5660	5600	5700	100
	7180+7750	7000	7900	900
	8770	8600	9100	500
Kew Bypass	12780	no fencing required as raised road with steep embankments		
	13070	no fencing required as raised road with steep embankments		
	15170	15000	15300	300
Heron's Creek	17200	Access road present	17500	300
	19510	19450	19700	250
	21070	21000	21138	58 (frogs only)
	21465	21300	21600	300

5.2.3.1.1 Johns River Bypass Section

Chainage 1325 – Box Culvert 2 x 2.4 m x 1.2 m Reinforced Concrete Box Culvert (RCBC) (Figure 14).

Regional Connectivity

In the wider regional context this section of road runs through the South Brother Link. This is a major east-west link between fauna assemblage corridors, occurring between approximately chainages 900 and 1950. Johns River State Forest lies to the east and private and crown lands of South Brother lie to the west (Figure 13).

Adjacent vegetation

There is only a relatively thin strip of vegetation (approx 50 m) to the west, but this connects to more significant vegetation further north. In the east the current Pacific Highway and the North Coast Railway would present potential barriers and would increase edge effects in the remaining vegetation.

Potential Species Use

The focus species within the South Brother Link include the Brush-tailed Phascogale and Rufous Bettong. The proposed culvert is suitable in size for many native fauna, although larger macropods such as the Eastern Grey Kangaroo may not use it due to the restricted height. A study of fauna movements in an underpass 2.1m x 1.5 m indicated that it was used by a range of species including Koala, Brush-tailed Possum, Ring-tailed Possum, Bandicoots, small mammals, Wallabies and reptiles (Phillips 1999).

Current and Future Land Use

Land to west is currently privately owned and will continue to be so following construction. This has implication for the positioning and type of fauna fencing on the western side. On the eastern side the land is currently road reserve up to approximately chainage 1450 and then is privately owned up to chainage 1574. This section of private land would be acquired as part of the upgrade of the Highway.

Engineering Constraints

This structure would be a combined drainage/fauna structure. Given its relatively low height it is recommended that the height of the culvert be increased to its maximum level within engineering bounds. The provision of dry passage in this structure will reduce the available height and hence this should be maximised where possible. There is no defined gully at this point and hence height is the only limitation for this structure. The width can be increased to provide required hydraulic capacity.

Fauna Enhancement Structures

Floppy-top fauna fencing should be included on both sides of the road. It is recommended that fencing is included north up to approximately chainage 1570 (the boundary of the current property) and south to approximately chainage 1200. Private land to the west should be taken into consideration when designing the position of the fauna fencing. There will be a distance of approximately 20 m between the extent of earth works and the acquisition boundary in the west. It is recommend that a standard 5-wire replacement fence is constructed along the acquisition boundary and that the floppy-top fencing is placed as close to the road as possible. While the 5-wire fencing will act as a partial barrier to some species, particularly larger animals, it will be necessary to have some form of fencing across the entrance to the crossing structure due to the presence of the private land. If the vegetation strip between the acquisition boundary in the west and the extent of earthworks decreases to less than 15 m, it is recommended that the floppy topped fencing should form the property boundary.

It is recommended that a concrete ledge is placed in one culvert to provide dry passage and that fauna refuge structures such as poles are built into the design.

5.2.3.1.2 Lakes Section

Chainage 5660 – Major Box Culvert 3 x 3.0 m x 3.0 m RCBC (Figure 15).*Regional Connectivity*

This crossing does not fall within any of the regional key corridors proposed by DEC. In the wider regional context Middle Brother State Forest and Yoorigan National Park lie to the west of the existing highway. To the east is vegetation surrounding Watson Taylors Lake. However, because of the location of the Stewarts and Camden Haven Rivers, land between the existing Highway and Watson Taylors Lake is largely an island (Figure 13).

Adjacent Vegetation

Vegetation in the west is limited, but Passionfruit Creek does provide limited connectivity leading to Middle Brother State Forest. Vegetation in the east is degraded between the existing highway and the North Coast Railway (Figure 15), but then connects to riparian vegetation along Stewarts River.

Potential Species Use

The proposed culvert is large and hence would be suitable for most native fauna. The monitoring program of fauna underpasses in the Bulahdelah to Coolongolook Pacific Highway Upgrade indicated that this size culvert is used by most sizes of animal including threatened species such as Koalas and Spotted-tailed Quolls (AMBS 2002).

Current and Future Land Use

On the western side of the proposed road and south of the crossing there currently exists a relatively wide road reserve which will in part be extended due to property acquisition. Further west of this line is private property. To the east is again a relatively wide road reserve that will be extended due to acquisitions.

Engineering Constraints

One of the three culverts should be maintained as a fauna crossing with dry passage provided. The other two culverts should be modified to provide the required hydraulic capacity.

Fauna Enhancement Structures

Floppy topped fauna fencing should be included on both sides of the road. The presence of access roads at approximately chainages 5490 and 5720 in the west and 5580 in the east make the positioning on long fauna fencing difficult. It is recommended that fauna fencing is provided south of the crossing point to approximately chainage 5600 and north to approximately chainage 5700. It is recommend that a standard 5-wire

replacement fence is constructed along the acquisition boundary and that the floppy topped fencing is placed as close to the road as possible. While the 5-wire fencing will act as a partial barrier to some species, particularly larger animals, it will be necessary to have some form of fencing across the entrance to the crossing structure due to the presence of adjacent private land.

Chainage 7180 and 7750 – Box culverts 2.4 m x 1.2 m and 3.0 m x 1.2 m RCBC (Figure 16).

These are two proposed crossing structure located within 570 m of each other and are hence considered together.

Regional Connectivity

These crossings do not fall within any of the regional key corridors proposed by DEC. In the wider regional context Middle Brother State Forest and Yoorigan National Park lie to the west of the existing Highway. To the east is vegetation surrounding Watson Taylors Lake as part of Crowdy Bay National Park. However, because of the location of the Stewarts and Camden Haven Rivers, land between the existing Highway and Watson Taylors Lake is largely an island (Figure 13).

Adjacent Vegetation

Vegetation in the west is quite extensive and would come up to the edge of the new highway, while the vegetation in the east is degraded between the existing Highway and the North Coast Railway (Figure 16). Although the railway line is a further barrier to fauna movements this is not considered to be major given the relatively low daily traffic volume.

Potential Species Use

These proposed culverts are large enough to be suitable for many native species, although the height would place a restriction on larger mammals.

Current and Future Land Use

Currently a relatively wide road reserve lies to both the east and west of the proposed road. There will be no property acquisition at this point. To the west lies Yoorigan National Park and to the east lies the North Coast Railway followed by Crowdy Bay National Park. South from chainage 7250 private land lies to the east of the North Coast Railway.

Engineering Constraints

These structures would be combined drainage/fauna structures. Given their relatively low height it is recommended that the height of the culvert be increased to its maximum level within engineering bounds. The provision of dry passage in this structure will reduce the available height and hence this should be maximised where possible.

Fauna Enhancement Structures

Floppy topped fauna fencing should be included on both sides of the road. Given that the two structures are within 570 m of each other and are adjacent to Yoorigan National Park, it is recommended that fauna fencing is used the entire distance between them. The fencing should extend north from the structure at 7750 to Haydons Road and south from the southern structure to approximately chainage 7000.

Dry passage should be provided for in both structures with the provision of a concrete ledge.

Chainage 8770 – Bridge over Stony Creek, 15.2 m span (Figure 17).

This should be considered the major fauna crossing point in the Lakes Section of road.

Regional Connectivity

This crossing lies just south of a DEC key regional corridor that includes Yoorigan National Park and Middle Brother State Forest (Figure 13). In the wider regional context Middle Brother State Forest and Yoorigan National Park lie to the west of the existing Highway. To the east lies vegetation surrounding Watson Taylor Lake. However, because of the location of the Stewarts and Camden Haven Rivers, land between the existing Highway and Watson Taylors Lake is largely an island. Although the North Coast Railway line is a further barrier to fauna movements this is not considered to be major given the relatively low daily traffic volume. The railway bridge to the east has at least a 1 m clearance.

Adjacent Vegetation

Vegetation in the west is quite extensive and there is good connectivity with Yoorigan National Park. Although there is some vegetation along Stony Creek this could be enhanced though revegetation within the road reserve (Figure 17). Vegetation in the east is degraded between the existing highway and the North Coast Railway.

Potential Species Use

The span and height of the proposed bridge is large and hence the crossing should be suitable for many species. The railway to the east has at least a 1 m clearance which should allow smaller animals to pass underneath. Larger animals are likely to be able to cross the railway line.

Current and Future Land Use

A wide road reserve currently exists to both the east and the west of the proposed route. Further west lies private property apart from north of chainage 8900, which forms part of the State Forest estate. Directly east of the road reserve lies the North Coast Railway followed by private holdings.

Engineering Constraints

This is a relatively large bridge and will pose no engineering constraints in terms of fauna crossing.

Fauna Enhancement Structures

Floppy top fencing should be used both north and south of the structure. The location of the proposed road relative to private land and the North Coast Railway make the positioning of fauna fencing difficult. On the western side of the road fauna fencing should be included south of the structure to approximately chainage 8600 where there is an access road to two properties. It is recommended that a standard 5-wire replacement fence is constructed along the property boundary and that the floppy topped fencing is placed as close to the road as possible. While the 5-wire fencing will act as a partial barrier to some species, particularly larger animals, it will be necessary to have some form of fencing across the entrance to the crossing structure due to the presence of the private land. North of the structure on the western side it is recommended that fauna fencing is extended north to approximately chainage 9100, allowing a good section of the fencing to be adjacent to Middle Brother State Forest. A small access road is proposed at approximately chainage 8840 and it is recommended that a gate be placed across this road to allow for continuous fencing north of this point.

Fauna fencing should be used prevent fauna entering the road reserve to the east of the road and south of the crossing structure. Fencing should guide animals under the railway and hence into a larger expanse of vegetation. Ideally, fauna fencing should extend south to approximately chainage 8600 and be placed to the east of the North Coast Railway. For management reasons this may not be possible in which case it should be placed to the west of the railway. Because there is a distance of approximately 40 m from the road boundary to the railway at this point it would be important to include escape points in the fence such as Koala ramps. North of the crossing point, fauna fencing should extend

to approximately chainage 9100 and should be positioned as close to the road as possible within design constraints.

Fauna fencing should be installed between the dual carriageway bridge to prevent fauna accessing the median strip.

5.2.3.1.3 Kew Bypass Section

Chainage 12780 – Bridge over the Camden Haven River – 164 m span (Figure 18).

Regional Connectivity

This crossing point does not form part of a key corridor as recommended by DEC. However, in a wider regional context vegetation in Camden Haven State Forest and Dooragan National Park lies to the east, while vegetation west of Sunnyvale Road lies in the west (Figure 13). Connectivity between these areas is via riparian vegetation along the Camden Haven River.

Adjacent Vegetation

At points along Sunnyvale Road vegetation is relatively thin (Figure 18). This vegetation however, does occur within a road reserve (Sunnyvale Road) and care should be taken that it is maintained.

Potential Species Use

Given that vegetation on both sides is largely devoid of ground cover and a midstorey, it is likely to be used by the larger, more mobile species, such as Wallabies rather than smaller terrestrial species.

Current and Future Land Use

There is currently a wide road reserve on both sides of the road that will be retained. Private holdings occur adjacent to the road reserve. A further road reserve runs in an east-west direction along Sunnyvale Road.

Engineering Constraints

This is a large bridge with good height and a wide span. On the northern bank there is an area of approximately 40m between the fill and the bank providing passage for fauna (part of this distance is taken up with Sunnyvale Road). There are no major engineering constraints that need to be taken into consideration for this crossing.

Fauna Enhancement Structures

The height of the bridge and the extent of fill north of the Camden Haven River will provide partial barriers to fauna and will act as fences guiding fauna under the span. It is not recommended that further fauna fencing is used at this point. Vegetation along Sunnyvale road should be maintained and enhanced to provide protection and cover for fauna.

Chainage 13070 – Stock underpass/bridge– 25 m span bridge up to 2 m in height (Figure 18).

Regional Connectivity

This crossing does not lie within a regional key corridor as defined by DEC and in terms of regional connectivity it offers little chance to increase connectivity since agricultural lands lie to the west and a SEPP 14 wetland lies in the east (Figure 18).

Adjacent Vegetation

There is little suitable fauna habitat on either side. However, there is anecdotal evidence to suggest that mobs of kangaroos may travel down the eastern side of the existing highway and cross at this point.

Potential Species Use

This bridge is designed as a stock crossing point and is likely to be used by larger animals such as macropods. Given the fauna habitat on either side it is unlikely that smaller animals would use this structure.

Current and Future Land Use

Currently a relatively wide (100 m) road reserve exists at this point, which will be slightly extended due to property acquisition. Private land holdings exist on either side. There is a requirement at this point for a cattle/stock underpass to allow connectivity between the two sides of the road.

Engineering Constraints

Dry passage should be provided for in the design.

Fauna Enhancement Structures

The dimensions of the bridge, as proposed, should be suitable for macropods to cross under. Suitable dry passage should be included in the design. The raised embankment that the road currently runs on will act as a form of barrier and will guide animals to the crossing point. It is not recommended that fauna fencing is used at this crossing.

Chainage 15170 – proposed dedicated fauna structure adjacent to culvert with 1.5 m maximum clearance (Figure 19).*Regional Connectivity*

This crossing point does not form part of a regional key corridor as proposed by DEC. A fauna crossing structure at this point would function more at the local scale rather than as part of the wider corridor network.

Adjacent Vegetation

Vegetation to the west is relatively extensive, although the existing Pacific Highway lies to the west. Residential properties lie to the east, although vegetation in parts is still relatively intact.

Potential Species Use

This crossing is likely to be suitable for a range of native terrestrial species including long-nosed bandicoots, which were observed in the vegetation to the west.

Current and Future Land Use

This crossing sits on the Kew Bypass and as such there is no road currently present. Land is currently either private holdings or road reserve (unused). Due to acquisition a relatively large (100 m) road reserve would be established in this area.

Engineering Constraints

This structure would be combined drainage/fauna structure. Given its relatively low height it is recommended that the height of the culvert be increased to its maximum level within engineering bounds. The provision of dry passage in this structure will reduce the available height and hence this should be maximised where possible.

Fauna Enhancement Structures

Dry passage should be provided in the underpass. Floppy-top fauna fencing should be included on both sides of the road. It is recommended that fencing is included north up to approximately chainage 15300 and south to approximately chainage 15000. Private land to the west should be taken into consideration when designing the position of the fauna fencing. There will be a distance of approximately 20 m between the extent of earth works and the acquisition boundary in the west. It is recommended that a standard 5-wire replacement fence is constructed along the acquisition boundary and that the floppy-top fencing is placed as close to the road as possible. While the 5-wire fencing will act as a partial barrier to some species, particularly larger animals, it will be necessary to have some form of fencing across the entrance to the crossing structure due to the presence of the private land. If the vegetation strip between the acquisition boundary in the west and the extent of earthworks decreases to less than 15 m, it is

recommended that the floppy topped fencing should form the property boundary. In the east there is a much larger distance between the extent of earthworks and the acquisition boundary (40 m) and the fauna fence should be placed as close to the road as possible. Fauna friendly replacement fencing should be used along the acquisition boundary.

5.2.3.1.4 Herons Creek Section

Chainage 17200 – Combined fauna/drainage structure up to 2 m in vertical height (Figure 20).

Regional Connectivity

This location forms part of the DEC's Kew Corridor, which links key habitat in the Laurieton/Camden Haven area with significant vegetation further west (Figure 13).

Adjacent Vegetation

Extensive vegetation lies to the west, while the Kew-Kendall STP lies to the east. The STP Lands are currently being revegetated and although at present they offer little in the way of fauna habitat, this is likely to increase in the future as the vegetation matures.

Potential Species Use

Target species of this corridor include Koalas. The land south of the STP is part of an approved subdivision that is likely to reduce the fauna values of this area. The crossing should be designed so that is suitable for a range of fauna, but particularly Koalas.

Current and Future Land Use

A thin strip of private property currently occur to the west and the Kew-Kendall STP lies to the east. Further west of the private property lies land owned by Hastings Council. Land acquisition will create a road reserve of approximately 90 m. To the south-east of the point lies a large residential subdivision. Underscrubbing has already taken place in this subdivision party reducing its value as fauna habitat.

Engineering Constraints

This structure would be combined drainage/fauna structure. It is recommended that the height of the culvert be increased to its maximum level within engineering bounds. The provision of dry passage in this structure will reduce the available height and hence this should be maximised where possible.

Fauna Enhancement Structures

Fauna fencing should be included in the design and it is recommended that it extends north to approximately chainage 17500 on both sides of the road. While it would be highly desirable to have fauna fencing included south of the structure, the location of Herons Creek Road (south) makes the positioning of fauna fencing on the western side difficult. It is not recommended that fauna fencing is placed on only one side of the road.

Chainage 19510 – Walkers Creek - Major Box Culvert – 2 x 4.0 m x 3.5 m RCBC (Figure 21).

Regional Connectivity

The location of this proposed fauna crossing lies within the Bull Ground SF- Queens key corridor of DEC. In terms of regional connectivity Kew State Forest lies in the west and extensive vegetation between the existing Highway and Camden Haven River lies in the east.

Adjacent Vegetation

Surrounding the Highway at this location, most vegetation has been cleared, placing a greater emphasis on vegetation along the creeks. Although in places this vegetation is degraded it still forms a relatively intact corridor in the east-west direction (Figure 21).

Potential Species Use

Given the size of these culverts it is likely that a range of species of all sizes could use them.

Current and Future Land Use

Private land currently lies to both the east and west. Property acquisition will produce a relatively large road reserve (120 m) at the point of the crossing.

Engineering Constraints

At the time of surveying the floor of the current culvert was flooded and it is recommended that a raised concrete shelf connected to the banks/entrances is included in the design as well as fauna refuge structures. This site has been identified as a site for fish passage and the exact structure would need to be approved by NSW Fisheries.

Fauna Enhancement Structures

The locations of property access roads to the west at approximately chainages 19450 and 19700 limit the extent of fauna fencing that can be used. It is recommended that floppy topped fencing is used on both sides of the road between approximately chainages 19450 and 19700. There will be a distance of approximately 30 m between the extent of earth

works and the acquisition boundary in both sides of the road. It is recommend that a standard 5-wire replacement fence is constructed along the acquisition boundary and that the floppy-top fencing is placed as close to the road as possible. While the 5-wire fencing will act as a partial barrier to some species, particularly larger animals, it will be necessary to have some form of fencing across the entrance to the crossing structure due to the presence of the private land.

Chainage 21070 – Box culvert – 2.0 m x 2.0 m RCBC (Figure 22).

This culvert should be designed for frogs. The habitat on either side is not suitable for a wide range of fauna apart from amphibians.

Regional Connectivity

This crossing does not form part of a wider regional corridor. In terms of regional connectivity this structure offers few chances of increasing connectivity due to the highly modified nature of the vegetation on either side (Figure 22).

Adjacent Vegetation

Vegetation on both sides is largely cleared. However, ponds occur on both side of the road that are suitable for frogs and the culvert would provide the opportunity for some connectivity for this group.

Potential Species Use

Frogs recorded at this site were common (eg. *Crinia signifera*), but there is also suitable habitat nearby for the threatened Green-thighed Frog. However this species is not known to use underpasses and is unlikely to do so (F. Lemckert, State Forests, *pers. comm.*).

Current and Future Land Use

Private land currently lies on both sides of the road. Through property acquisition a relatively wide (140 m) road reserve would be created.

Engineering Constraints

Water is currently ponding on both sides and within the culvert. It will be important to provide passage through the culvert, although a ledge of 50 cm should be sufficient.

Fauna Enhancement Structures

Although there is no evidence that Australian frogs will utilise underpasses (Lemckert et al. 1997), some modification such as the use of uneven sized and shaped rocks in the structure or suitable vegetation at the entrances may increase usage (Lemckert et al. 1997). Frog fencing should be included on both sides of the road between chainages 21000 and 21138. This fencing should be at least 40 cm high with an overhang of 10 cm.

There is little opportunity and need for this structure to be modified for other fauna given the degraded nature of fauna habitats on either side outside of the road reserve.

Chainage 21465 – Bridge over Herons Creek – 32 m span (Figure 22).

Regional Connectivity

This site for connectivity lies just south of the Burrawan-Kew key corridor of DEC (Figure 13). In terms of the wider regional connectivity Kew State Forest lies in the west and Burrawan State Forest and Queens Lake Nature Reserve in the east.

Adjacent Vegetation

Surrounding the highway most vegetation has been cleared, placing a greater emphasis on vegetation along the creeks (Figure 22).

Potential Species Use

The nature of the bridge means that it would be a suitable crossing point for a range of different species.

Current and Future Land Use

Private holdings lie to both the east and west of the proposed road. Property acquisition would result in the creation of a 92 m wide road reserve.

Engineering Constraints

This is a good-sized bridge with large span (32 m) and height (4 m), meaning that there will be no engineering modifications necessary in order to accommodate fauna use.

Fauna Enhancement Structures

Floppy Top fencing should be used on both sides of the road to help guide animals through the crossing. Fencing should be used north to chainage 21600 where there is a property entrance to the east. Fencing should be used south to approximately chainage 21300. There will be a distance of approximately 20 m between the extent of earth works and the acquisition boundary in both sides of the road. It is recommend that a standard fauna friendly replacement fence (e.g. 5-wire fence) is constructed along the acquisition boundary and that the floppy-top fencing is placed as close to the road as possible. While the fauna friendly fencing will act as a partial barrier to some species, particularly larger animals, it will be necessary to have some form of fencing across the entrance to the crossing structure due to the presence of the private land.

5.2.3.1.5 Further possible crossings

Other structures were not considered further for possible fauna crossing points for one or more of the following reasons:

- Lack of suitable habitat on at least one side of the structure;
- Functionally, it is likely to be a duplication of one of the structures detailed above;
or
- Does not provide connectivity within a wider regional context.

Details of these structures are provided in Appendix 8. Some of the structures may still allow for some connectivity, such as the bridge over Stewarts River (Chainage 3955), but these are not considered to play an important role in increasing or maintaining connectivity in the area.

5.2.4 MORTALITY

A number of recommendations should be implemented to reduce the risk of mortality.

Prior to and during construction:

- Reduce clearance and disturbance of fauna habitat, particularly hollow-bearing trees and other habitat features where fauna may be sheltering. Although this may be difficult to achieve in areas where earthworks are to proceed, it should be particularly noted within the road reserve where temporary sites such as stockpiles may be placed. However, the placement of such features are subject to separate site selection and assessment procedures; and
- Clearing of vegetation should follow the RTA (Pacific Highway Office) requirements for fauna rescue on Pacific Highway projects as updated from time to time. These guidelines are a dynamic document produced in consultation with DEC. They include procedures for clearing of non-habitat and habitat trees, the relocation of rescued fauna and the inclusion of wildlife specialists in the process.

To reduce the risk of roadkill once the highway is operational:

- Design barriers to prevent access to the highway by animals e.g. possums, Koalas. This should however not reduce connectivity in the area and should be related to fauna crossings;
- Avoid vegetation overhanging barriers that may encourage fauna crossing into the road reserve;

- Carefully consider location and type of plant species for the median strip so that this area does not attract fauna species. For example, *Allocasuarina* spp. should not be planted in the median strip since they might attract Glossy Black-cockatoos. Similarly, Koala feed trees should not be used for plantings in the road reserve generally;
- Where a traffic barrier will be installed in the median strip (e.g. in the Lake Section where the median strip reduces from 11 m to 4 m), structures should be included to allow animals such as Koalas to climb over or move under if they do try and cross the road.

5.2.5 WEEDS

A number of recommendations should be implemented to reduce the impact of weed invasion on native vegetation communities:

- Restrict the area of native vegetation disturbed during construction works;
- Restrict stockpiling to areas already cleared of vegetation;
- Control drainage that may contain weed seeds or high levels of nutrients;
- Use weed-free topsoil in landscaping and revegetate disturbed sites with locally indigenous species. In areas where vegetation to be cleared is in good condition, topsoil may be stockpiled and used for revegetation following the completion of construction works. Generally native vegetation remnants within the study area are in good-moderate condition however, soil (seedbank) stockpiling should be restricted to areas in good-moderate condition, avoiding disturbed areas such as road margins. Revegetation using stockpiled soil should also include planting local native species to stabilise the soil as well as ongoing weed control; and,
- Monitor and control weed populations that establish on disturbed areas, with particular attention to eradication of noxious weeds. Weed invasions should be monitored and controlled by person experienced in weed management.

5.2.6 GREEN-THIGHED FROG

Despite the species not being recorded a precautionary stance is recommended. Since there appears to be suitable habitat at Herons Creek Road (south) loss of even a single breeding site may significantly impact the breeding output of the region (Lemckert *et al.* 1997). Without suitable mitigation measures in place there is likely to be a significant impact on this species as determined by Eight Part Tests (see Section 6.1.4).

Although surveys targeting tadpoles and juveniles failed to find evidence of this species occurrence this should not be taken as proof of the species absence as its breeding

behaviour can be highly variable. But the presence of suitable habitat at Herons Creek Road (south) does provide a potential for this species to occur, despite the survey results. The sampling timing and methods were developed from discussions with Frank Lemckert of NSW State Forests who has carried out a number of studies on this species. During surveys, suitable water bodies were sampled for tadpoles using a dip net. No green-thighed frog tadpoles were recorded.

Following the surveys and prior to road construction it is recommended that suitable mitigation measures be put in place taking into consideration the survey results. If suitable breeding sites (Herons Creek Road south) are likely to be impacted by the upgrade of the Highway then artificial breeding wetlands should be constructed using the following as guidelines. Wetlands should be constructed in consultation with recognised experts on the Green-thighed Frog and DEC

- Wetlands should be located close to the area to be impacted;
- Wetlands should be constructed so as to be ephemeral (ie they are not permanently filled), such that they fill after heavy or sustained rain;
- Wetlands should be at least 20 m long and 5-10 m wide and no more than 1 m deep in the deepest section;
- The sides of the wetlands should be steep ($>30^\circ$) so as to maximise water volume and reduce evaporation;
- The wetlands should be designed so that they remain flooded for over 60 days in sites where the water can warm up and over 100 days in sites where it is shaded. This difference is due to the temperature dependent development rates of frogs;
- Where possible wetlands should be located on natural drainage lines; and
- Dense understorey vegetation should be planted and maintained surrounding the wetland and there should be a vegetated link to nearby retained moist forest areas.

6.0 SIGNIFICANCE ASSESSMENTS

6.1 TSC ACT EIGHT PART TESTS

The Eight Part Test is a statutory mechanism that helps determine whether a proposed development activity could have a significant impact on threatened species, populations or ecological communities or their habitats. The results of this test are used to determine if a Species Impact Statement (SIS) is required. Alternatively the outcomes of the Eight Part Test can be used for guidance to implement impact avoidance/mitigation measures that would avoid significant impacts on threatened species and hence negate the need for a SIS.

When a threatened species known to occur within the vicinity of a study area is not recorded during a survey, the presence of potential habitat can be used to determine the need to undertake an Eight Part Test for that species. Where there is no potential habitat in the study area for threatened species, there is unlikely to be a significant impact on these species and therefore Eight Part Tests are not required.

The significance assessments for flora, fauna and endangered populations are detailed below and the Eight Part Test conclusions are shown in Section 6.1.5.

Except for *Acacia courtii*, all other species of threatened plants with potential habitat in the study area have wide distributions that cover the entire Bioregion. The amount of potential habitat to be removed or impacted by the proposed highway upgrade would be small and cannot be considered significant for these species in a regional context. For this reason other threatened plant species are not been discussed in as much detail as *Acacia courtii*.

With respect to threatened fauna, particular attention was focused on the Green-thighed Frog compared to other threatened fauna species. Additional investigations of the Green-thighed Frog were conducted because it has been previously recorded close to the Highway, is very difficult to detect, its populations are highly sensitive to destruction or modification of breeding sites and potential habitat will be directly impacted by the proposal. In addition, as the Koala is an iconic species as well as a threatened species, it was also important to discuss the implications of the proposal on this species in more detail, so as to allow a comprehensive and objective assessment of any potential impacts.

6.1.1 ENDANGERED ECOLOGICAL COMMUNITIES

Two listed EECs on the TSC Act, Freshwater Wetlands and Swamp Sclerophyll Forest, occur in the study area. Eight Part Tests are conducted for these communities.

Freshwater Wetlands (Sedgeland)

The Freshwater Wetland (Sedgeland) identified in the current study as occurring in the study area is listed as the EEC Freshwater Wetlands on Coastal Floodplains. In the study area Freshwater Wetlands occupy approximately 100 ha in the SEPP 14 Sunnyvale Swamp to the north of the Camden River. The likely impact of the proposed upgrade of the Pacific Highway on the Freshwater Wetland in the study area is assessed in the following Eight Part Test.

1) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable population of the species is likely to be placed at risk of extinction.

Not applicable to Endangered Ecological Communities.

2) 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.

Not applicable to Endangered Ecological Communities.

3) In relation to the regional distribution of a habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

The bioregion in which the study site occurs is the NSW North Coast. Habitat for Freshwater Wetlands is widespread in coastal areas within the region. It is stated in the final determination that Freshwater Wetlands are known to occur in Kempsey LGA to the north of the site and Greater Taree LGA to the south of the site.

None of the Freshwater Wetland vegetation that occurs in the study area would be removed by the proposal, and mitigation measures would be implemented to prevent modification of the Freshwater Wetlands through indirect impacts. Therefore the proposal would not result in the modification or removal of a significant area of known habitat for Freshwater Wetlands.

4) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

The proposal would not involve the removal of any Freshwater Wetland vegetation in the study area as the proposed road upgrade in the vicinity of the Freshwater Wetland is along the existing road alignment. Therefore the proposal would not further isolate any currently interconnecting or proximate areas of habitat for Freshwater Wetlands.

5) Whether critical habitat will be affected.

Critical habitat is declared by the Director General of the NSW National Parks and Wildlife Service and is kept in the Register of Critical Habitat. The proposed highway would affect not affect any critical habitat listed on the TSC Act.

6) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or similar protected areas) in the region.

Small areas of Freshwater Wetlands on Coastal Floodplains are contained within existing conservation reserves in the NSW North Coast bioregion, including Ukerebagh, Tuckean and Tabbimoble Swamp Nature Reserves and Bungawalbin National Park. The full diversity of the community is unlikely to be represented in these reserves.

7) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threatening processes are listed under Schedule 3 of the TSC Act. Key Threatening Processes relevant to this proposal that affect Freshwater Wetlands are: clearing of native vegetation; alteration to the natural flow regimes of rivers, streams, floodplains and wetlands and invasion of native plant communities by exotic perennial grasses. No clearing of Freshwater Wetlands will occur as a result of the proposal, and other processes will not be exacerbated by the proposal provided that the mitigative measures are implemented.

8) Whether any threatened species, population or ecological community is at the limit of its known distribution.

Freshwater Wetlands are known from NSW North Coast, Sydney Basin and South-east Corner bioregions. The study area is not at the limit of the known distribution of this community.

Conclusion

Provided that the mitigation measures are implemented, the proposed upgrade of the Pacific Highway is unlikely to have significant impact on Freshwater Wetlands that occurs in the study area.

Swamp Sclerophyll Forest

The Swamp Sclerophyll Forest identified in the current study as occurring in the study area is listed as the EEC Swamp Sclerophyll Forest on Coastal Floodplains.

Approximately 37 ha of Swamp Sclerophyll Forest has been identified as occurring in nine patches in the study area. The likely impact of the proposed upgrade of the Pacific Highway on Swamp Sclerophyll Forest is considered in the following Eight Part Test.

- 1) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable population of the species is likely to be placed at risk of extinction.**

Not applicable to Endangered Ecological Communities.

- 2) 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.**

Not applicable to Endangered Ecological Communities.

- 3) In relation to the regional distribution of a habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.**

The bioregion in which the study site occurs is the NSW North Coast. Within the region, habitat for Swamp Sclerophyll Forest is widespread on waterlogged or periodically inundated alluvial flats and drainage lines of coastal floodplains. Swamp Sclerophyll Forest occurs in Crowdy Bay National Park to the east of the study area and in Lake Innes Nature Reserve to the north-east of the study area.

In the study area, there are nine patches of Swamp Sclerophyll Forest, ranging in size from about 1 to 15 hectares. Six of these patches would be affected by the proposed upgrade. The largest patch, which occurs in the north of the study area, would not be affected. Of the approximately 37 ha of Swamp Sclerophyll Forest in the study area, 5.2 ha (10%) would be cleared by the proposed upgrade. Approximately one third (1.6 ha) of this clearing would affect degraded Swamp Sclerophyll Forest that is within the existing road reserve. The removal of 5.2 ha of Swamp Sclerophyll Forest in the study area is not a significant area in relation to its local or regional distribution.

Modification of known habitat for Swamp Sclerophyll Forest in the study area through indirect impacts, including edge effects, would be minimised through mitigation measures. Edge effects within 50 m of the proposed upgrade would impact 1.8 ha of Swamp Sclerophyll Forest that is not currently affected by edge effects of the existing Pacific Highway. The modification of known habitat for Swamp Sclerophyll Forest in the study area would not be significant provided mitigative measures, including weed control, are implemented.

- 4) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.**

Swamp Sclerophyll Forest in the study area naturally occurs in fragmented patches, due to the scattered distribution of appropriate habitat. Further, most patches of Swamp Sclerophyll Forest in the study area are fragmented by the existing Pacific Highway,

other roads and developments. The proposed road upgrade will fragment two of the patches of Swamp Sclerophyll Forest in the study area that are not currently fragmented. The largest patch of Swamp Sclerophyll Forest in the study area, which occurs to the north of the Kew-Kendall Sewerage Treatment Plant, will not be further isolated or fragmented as a result of the proposal.

5) Whether critical habitat will be affected.

Critical habitat is declared by the Director General of the NSW National Parks and Wildlife Service and is kept in the Register of Critical Habitat. The proposed highway would affect not affect any critical habitat listed on the TSC Act.

6) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or similar protected areas) in the region.

Small areas of Swamp Sclerophyll Forest on Coastal Floodplains occur in conservation reserves in the NSW North Coast bioregion, including Moonee Beach Nature Reserve, and Hat Head, Crowdy Bay, Wallingat and Myall Lakes National Parks. In the vicinity of the study area, Swamp Sclerophyll Forest occurs in Crowdy Bay National Park and Lake Innes Nature Reserve.

Swamp Sclerophyll Forest is moderately well represented in conservation reserves in the region, although it is unlikely that the full diversity of this community is adequately represented.

7) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Key Threatening Processes listed under Schedule 3 of the TSC Act that are applicable to the current proposal are: clearing of native vegetation; alteration to the natural flow regimes of rivers, streams, floodplains and wetlands; invasion of native plant communities by exotic perennial grasses; and removal of dead wood and dead trees.

The proposal will result in the removal of 5.2 ha of Swamp Sclerophyll Forest from six of the nine patches of Swamp Sclerophyll Forest in the study area. The largest patch, approximately 15 ha, of Swamp Sclerophyll Forest in the study area will not be directly impacted by clearing. Mitigative measures would be implemented to minimise the impact of the clearing works (see Section 5.2.1).

The other threatening processes would not be exacerbated as a result of the proposal, provided mitigative measures are implemented.

8) Whether any threatened species, population or ecological community is at the limit of its known distribution.

Swamp Sclerophyll Forest is known to occur in Local Government Areas from Tweed in the north to Shoalhaven in the south. The study area is not at the limit of the known distribution of Swamp Sclerophyll Forest.

Conclusion

The proposed upgrade to the Pacific Highway is unlikely to have a significant impact on Swamp Sclerophyll Forest. A Species Impact Statement is not recommended.

6.1.2 FLORA

A total of 15 species of threatened plant listed on the TSC Act have potential habitat within the study area. The habitat requirements of these species are shown in Appendix 5. None of these species were recorded within the study area during the November 2001 and 2002 surveys, however, Eight Part Tests need to be undertaken for these species due to the presence of potential habitat. The application of the Eight Part Test is summarised in Table 11.

Table 11: Eight Part Test criteria as applied to flora species with potential habitat in the area.

Latin Name	TSC Act ¹	Eight Part Test Questions ³								Significant Impact
		1	2	3	4	5	6 ²	7	8	
<i>Acacia courtii</i>	V	No	No	No	No	No	Although recorded from Yoorigan NP, Middle Brother SF and Doorigan NP, <i>A. courtii</i> is considered to be inadequately reserved.	Clearing of Native Vegetation	Yes, only recorded from North and Middle Brother mountains.	Unlikely
<i>Asperula asthenes</i>	V	No	No	No	No	No	Wallis Island NR-reserved population size is not accurately known.	Clearing of Native Vegetation	No	Unlikely
<i>Bothriochloa biloba</i>	V	No	No	No	No	No	Not known to occur in any reserves	Clearing of Native Vegetation	No	Unlikely
<i>Caesia parviflora var minor</i>	E	No	No	No	No	No	Not known to occur in any reserves	Clearing of Native Vegetation	No	Unlikely
<i>Diuris pedunculata</i> (Small Snake Orchid)	E	No	No	No	No	No	Not known to occur in any reserves	Clearing of Native Vegetation	No	Unlikely
<i>Eucalyptus glaucina</i> (Slaty Red Gum)	V	No	No	No	No	No	Occurs in Selection Flat FLR, but considered to be inadequately reserved.	Clearing of Native Vegetation	No	Unlikely
<i>Eucalyptus parramattensis</i> ssp. <i>decadens</i>	V	No	No	No	No	No	Not known to occur in any reserves	Clearing of Native Vegetation	Yes, likely to be at northern limit of distribution.	Unlikely

Latin Name	TSC Act ¹	Eight Part Test Questions ³								
		1	2	3	4	5	6 ²	7	8	Significant Impact
<i>Haloragis exalata</i> ssp. <i>velutina</i>	V	No	No	No	No	No	Not known to occur in any reserves in NSW. Occurs in Bunya Mountains NP in QLD.	Clearing of Native Vegetation	No	Unlikely
<i>Hibbertia hexandra</i>	E	No	No	No	No	No	In NSW, recorded in Willi Willi NP, Coorabakh NP and Nightcap NP. Also reserved in QLD.	Clearing of Native Vegetation	Yes, likely to be at the southern limit of distribution	Unlikely
<i>Melaleuca biconvexa</i>	V	No	No	No	No	No	Not known to occur in any reserves	Clearing of Native Vegetation	Yes, close to the northern limit of distribution (Port Macquarie district)	Unlikely
<i>Phaius australis</i>	E	No	No	No	No	No	In NSW occurs in Broadwater NP and Bundjalung NP. Also occurs in reserves in QLD.	Clearing of Native Vegetation	Yes, likely to be at southern limit of distribution	Unlikely
<i>Phaius tankervilleae</i>	E	No	No	No	No	No	Not known to occur in any reserves in NSW. Occurs in Graham Range NP and Iron Range NP in QLD.	Clearing of Native Vegetation	Yes, likely to be at southern limit of distribution	Unlikely
<i>Pomaderris queenslandica</i>	E	No	No	No	No	No	Not known to occur in any reserves	Clearing of Native Vegetation	No	Unlikely
<i>Thesium australe</i>	V	No	No	No	No	No	Recorded from Crowdy Bay NP, Kattang NR, Bullen Range NR, Kosciusko NP, Namadgi NP and Hat Head NP.	Clearing of Native Vegetation	No	Unlikely
<i>Tylophora woollsii</i>	E	No	No	No	No	No	Not known to occur in any reserves.	Clearing of Native Vegetation	No	Unlikely

Key

1: V = Vulnerable, E = Endangered

2: Records of occurrence within the 1:100 000 local Mapsheet - NP = National Park, NR = Nature Reserve, SF = State Forest, FLR= Flora Reserve

3: No indicates a negative response to the specific question

1) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable population of the species is likely to be placed at risk of extinction.

Ten of the species with potential habitat in the area (occurring in sclerophyll forest) would have some potential habitat removed through vegetation clearing (*Bothriochloa biloba*, *Caesia parviflora* var. *minor*, *Diuris pedunculata*, *Eucalyptus glaucina*, *Eucalyptus parramattensis* ssp. *decadens*, *Hibbertia hexandra*, *Melaleuca biconvexa*, *Pomaderris queenslandica*, *Thesium australe* and *Tylophora woollsii*). Although clearing of vegetation as part of the highway upgrade would remove 57 ha of potential habitat (Coastal Blackbutt and Dry Tallowood Forests) for these species, the habitat is not considered to be limiting within the local area. Furthermore, vegetation to be cleared is subject to weed invasion and other disturbances due to its proximity to existing roads and rural/residential developments and is considered to be in poor-

moderate condition. For these reasons much of the proposed route is considered to provide only marginal habitat for these species. As there are large areas of suitable habitat for these species nearby (e.g. Middle Brother, Kew and Johns River State Forests and Yoorigan National Park), clearing of small sections of their habitat would be unlikely to have a significant impact on the viability of populations of these species.

Following the November 2001 habitat assessment survey it was concluded that if *Acacia courtii* is present within the study area that the proposed development was likely to disrupt a viable population of this species. A targeted survey was undertaken in November 2002 to determine whether this species is present within the study site. Despite intensive targeted surveys in November 2002 during its flowering season, *A. courtii* was not recorded within the study area. It is therefore unlikely that the proposed development would disrupt the lifecycle of a viable population of this species.

Asperula asthenes, *Haloragis exalata* ssp. *velutina* and *Melaleuca biconvexa* are generally found in damp places near watercourses. This habitat type is extensive along the vegetated rivers and creeks within the study area and surrounding areas. Only a very small area of this habitat type would be disturbed or modified by the proposed development and these species were not recorded during the November 2001 surveys despite these areas being intensively searched. For these reasons it is considered unlikely that a viable population of *Asperula asthenes*, *Haloragis exalata* ssp. *velutina* or *Melaleuca biconvexa* would be placed at risk of extinction.

Phaius australis and *P. tankervilleae* are terrestrial orchid species that prefer swamps dominated by *Melaleuca quinquenervia*. These evergreen orchids are not considered to be cryptic species since they grow in clumps with leaves up to 125 cm by 12 cm and have a flowering stalk to 2 m tall with up to 20 flowers. These orchids have not previously been recorded as far south as the study area and were not recorded during this survey despite intensive surveys of their habitat. For these reasons it is considered unlikely that either of these species occurs within the study area. It is considered unlikely that viable populations of these orchid species would be placed at risk of extinction by the proposed development.

2) 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.

Endangered populations are listed under Schedule 1 Part 2 of the TSC Act. There is an endangered population of *Eucalyptus seeana* found in the local area but this will be considered in a separate Eight Part Test (see Section 6.1.3).

3) In relation to the regional distribution of a habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

The bioregion in which the study site occurs is the NSW North Coast. *Acacia courtii* has a highly restricted distribution and has only been recorded from North and Middle Brother Mountains, which are located within close proximity to the study area. The area of potential habitat for this species (580 ha) is less than the estimated area required to maintain this species (658 ha). Since the area required to conserve this species is greater than the area of potential habitat it is recommended that all potential habitat be conserved (Environment Australia 1999).

Habitat for *A. courtii* occurs within dry sclerophyll forest. This species has been recorded with a wide range of associated species including *Corymbia gummifera* (Red Bloodwood), *E. pilularis* (Blackbutt), *Allocasuarina torulosa* (Forest Oak) and *Syncarpia glomulifera* (Turpentine) which have been recorded throughout the study area within Coastal Blackbutt Forest and Dry Tallowwood Forest. Other associated canopy species (not recorded during the current survey but potentially occurring within the study area) include, *Eucalyptus umbra* (White Mahogany) and *E. propinqua* (Grey Gum) and *E. siderophloia* (Northern Grey Ironbark) (Australian National Botanic Gardens 2002). *Acacia courtii* has also been recorded along roadsides and in association with *Imperata cylindrica* (Bladey Grass) which is commonly found in disturbed areas. Therefore potential habitat is considered to also include disturbed areas such as roadside verges.

Of the 64.3 ha of vegetation to potentially be removed as a part of the highway upgrade, approximately 57 ha could be considered potential habitat and despite targeted surveys, *Acacia courtii* was not recorded within this area. Furthermore, the vegetation to be cleared is subject to weed invasion and other disturbances due to its proximity to existing roads and rural/residential developments and is considered to be in poor-moderate condition. For these reasons much of the proposed route is considered to provide only marginal habitat for this species. Clearing of 57 ha of marginal potential habitat would be unlikely to have a significant impact on the viability of populations of this species.

Except for *Acacia courtii*, all other species of threatened plants with potential habitat in the study area have wide distributions that cover the entire Bioregion. The amount of potential habitat to be removed or impacted by the proposed highway upgrade would be small and cannot be considered significant for these species in a regional context.

4) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

Much of the proposed highway upgrade would only require the duplication of the existing highway and this would not result in any further fragmentation. However, the

proposed route would also include a bypass to the east of Kew and to the west of Johns River. In these sections the highway would bisect three moderate-sized areas of native vegetation. These vegetated areas are already isolated from other vegetation by roads and other developments, and the fragmentation of these areas would not result in further isolation of flora habitat.

5) Whether critical habitat will be affected.

Critical habitat is declared by the Director General of the NSW National Parks and Wildlife Service and is kept in the Register of Critical Habitat. The proposed highway would affect not affect any critical habitat listed on the TSC Act.

6) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or similar protected areas) in the region.

Conservation reserves near the proposed Highway upgrade include Yoorigan National Park, Crowdy Bay National Park, Dooragan National Park, Coorabakh National Park and Queens Lake Nature Reserve. State Forests in the area include Middle Brother, Johns River, Kendall and Kew. While State Forests are not conservation reserves they may provide extensive areas of habitat for threatened species if suitably managed.

Records of threatened species are generally sparse in reserves in the local area (Table 11), however, this may reflect the paucity of survey effort in these areas. Several species have not been recorded within any conservation reserve (*Bothriochloa biloba*, *Caesia parviflora* var. *minor*, *Diuris pedunculata*, *Eucalyptus parramattensis* ssp. *decadens*, *Melaleuca biconvexa* and *Tylophora woollsii*), while others do not occur within NSW reserves (*Haloragis exalata* ssp. *velutina* and *Phaius tankervilleae*). *Eucalyptus glaucina* and *Asperula asthenes* have only been recorded within one reserve. These species are considered to be inadequately reserved in NSW.

Pomaderris queenslandica and *Phaius australis* have been recorded within two NSW reserves but also occur within Queensland reserves. At least three populations of *Hibbertia hexandra* occur within reserves. The reserved population sizes of these species are not known and it is likely that these species are inadequately represented within conservation reserves.

Acacia courtii has been recorded in Yoorigan National Park, Middle Brother State Forest and Dooragan National Park. The conservation target for the survival of *Acacia courtii* is 658 ha (with a buffer of 350 m) (Environment Australia 1999). This target has not been reached and therefore *Acacia courtii* is considered to be inadequately reserved.

Although not locally represented, *Thesium australe* occurs within six reserves (four within NSW) in the coastal ranges from Cobberas-Tingeray National Park in Victoria to Mount Greville National Park in Queensland. Despite its presence in a number of conservation reserves, it is unlikely that *Thesium australe* is adequately conserved.

7) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threatening processes are listed under Schedule 3 of the TSC Act. There are currently 10 threatening processes listed under the Act. Clearing of native vegetation is listed as a threatening process and is applicable to the current proposed highway upgrade.

8) Whether any threatened species, population or ecological community is at the limit of its known distribution.

Nine of the 15 species considered have a broad range of distribution and the study site does not occur at or near the limit for these species. However, six species with potential habitat in the area are at, or near, to the limit of their distribution as outlined below.

Acacia courtii has only been recorded from North and Middle Brother Mountains (Harden 1991) and therefore both the northern and southern limits of the distribution of this species are located within the limits of the study area.

Eucalyptus parramattensis ssp. *decadens* has previously been recorded from Kurri Kurri and Tomago (Harden 1991, Predavec et al. 2001). The study area is considered to be north of the known distribution of this species.

Hibbertia hexandra has previously been recorded from Mt Warning and near Wauchope (Harden 1990) and therefore the study area is considered to be at or near to the southern limit of the known distribution of this species.

Melaleuca biconvexa occurs in coastal districts with its northern most limit within the Port Macquarie district (Harden 1991). The study area is therefore considered to be at or near the northern most limit of distribution for this species.

Phaius australis and *P. tankervilleae* are generally found north of Evans/Brunswick Head but have also been recorded as far south as Lake Cathie and the Hastings River, respectively (Harden 1993). The study area is considered to be at the southern limit of the distribution of these species.

6.1.3 ENDANGERED PLANT POPULATIONS

An Endangered Population of *Eucalyptus seeana* (Narrow-leaved Red Gum) occurs within the Greater Taree LGA. *Eucalyptus seeana* has previously been recorded within the vicinity of the study area (Figure 7). Targeted surveys were undertaken for this species along the entire route, however, despite these surveys this species was not

recorded within the study area. This species occurs scattered in woodland often in swampy sandy sites (Harden 2002) and is considered to have potential habitat within the study site (in moist sandy areas within Swamp Forest, Dry Tallowood Forest and Coastal Blackbutt Forest). Although not recorded within the study area, an Eight Part Test is required for this endangered population based on the recordings within the vicinity of the study site and the presence of potential habitat.

- 1) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable population of the species is likely to be placed at risk of extinction.**

Not applicable for Endangered Populations.

- 2) 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.**

Within the Greater Taree LGA *Eucalyptus seeana* occurs mostly as scattered trees but some denser stands also occur within the area (NSW Scientific Committee 2002b). *Eucalyptus seeana* was not recorded during the current survey despite intensive targeted surveys. However, based on its habitat requirements it could occur within the study site. Little is known about the ecology of this species, yet due to its scattered distribution within the Greater Taree LGA the disturbance/removal of individual trees may disrupt pollination of this species by increasing distances between individuals. Since no individuals of this species were recorded during the targeted surveys, it is unlikely that the proposed highway would remove any individuals, therefore, a viable population of *Eucalyptus seeana* is unlikely to be significantly compromised.

- 3) In relation to the regional distribution of a habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.**

The bioregion in which the study site occurs is the NSW North Coast. Within the bioregion, *Eucalyptus seeana* occurs in coastal areas north from Taree to the Qld border. The proposed development would require the removal and disturbance of potential habitat, which includes moist sites within dry sclerophyll woodland. This habitat type occurs in small areas scattered within the study area. For this reason, the total area of potential habitat to be removed or impacted by the proposed highway upgrade is likely to be small compared to the area of available habitat within the vicinity and cannot be considered significant for this species in a regional context.

- 4) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.**

Much of the proposed highway upgrade would only require the duplication of the existing highway and this would not result in any further fragmentation. However,

the proposed route would also include a bypass to the east of Kew and to the west of Johns River. In these sections the highway would bisect three moderate-sized areas of native vegetation. These vegetation areas are already isolated from other vegetation areas by roads and other developments, and the fragmentation of these vegetation areas would not result in further isolation of potential habitat.

5) Whether critical habitat will be affected.

Critical habitat is declared by the Director General of the NSW National Parks and Wildlife Service and is kept in the Register of Critical Habitat. The proposed highway would not affect any declared critical habitat.

6) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or similar protected areas) in the region.

Eucalyptus seeana has been recorded within Cowarra State Forest (DEC Atlas of NSW Wildlife) and a small part of the population occurs within a Council Reserve. However, this council reserve is degraded and subject to weed invasion (NSW Scientific Committee 2002b). *Eucalyptus seeana* is not considered to be adequately reserved.

7) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threatening processes are listed under Schedule 3 of TSC Act. Clearing of native vegetation is listed as a threatening process and is applicable to the current proposed highway upgrade.

Threats to the Endangered Population of *E. seeana* include future residential and infrastructure development (NSW Scientific Committee 2002b).

8) Whether any threatened species, population or ecological community is at the limit of its known distribution.

Previously *Eucalyptus seeana* was thought to occur north from Telegraph Point to Caloundra in Qld (Harden 2002) but the known range of this species has now extended further south to Taree (NSW Scientific Committee 2002b). The population in the Greater Taree LGA is disjunct and at or near the southern limit of the distribution of *E. seeana* (NSW Scientific Committee 2002b). The study area is considered to be near the southern limit of the distribution of this species.

6.1.4 FAUNA

A total of 27 species of threatened animal have potential habitat in the study area (Appendix 7). Habitat requirements for these species are shown in Appendix 7 and the application of the Eight Part Test is summarised in Table 12.

Table 12: Eight Part Test criteria as applied to fauna species with potential habitat in the study area.

Latin Name	Common Name	TSC ¹	Eight Part Test Questions ³									
			1	2	3	4	5	6 ²	7	8	Significant Impact	
<i>Litoria brevipalmata</i> ⁴	Green-thighed Frog	V	Limited potential breeding habitat that may be impacted	No	No	No	No	No	Recorded from Coopernook and Lansdowne SF – Level of representation unknown	Clearing of Native vegetation	No	Unlikely with suitable mitigation measures in place.
<i>Botaurus poiciloptilus</i>	Australasian Bittern	V	Wetland species unlikely to be impacted	No	No	No	No	No	Recorded from lake Innes NR– Level of representation unknown	No	No	No
<i>Calyptorhynchus lathami</i>	Glossy Black-Cockatoo	V	Loss of tree hollows combined with feeding resources may impact this species.	No	No	No	No	No	Recorded from eight State Forests, two National Parks and two Nature Reserves – considered to be well represented	Clearing of Native vegetation	No	No
<i>Ephippiorhynchus asiaticus</i>	Black-necked Stork	E	Wetland species unlikely to be impacted	No	No	No	No	No	Not recorded in a reserve in the local area – Level of representation unknown	No	No	No
<i>Lathamus discolor</i>	Swift Parrot	E	Loss of small area of habitat not likely to have a significant impact	No	No	No	No	No	Recorded only from Crowdy Bay NP - Level of representation unknown	Clearing of Native vegetation	No	No
<i>Lophoictinia isura</i>	Square-tailed Kite	V	Loss of small area of habitat not likely to have a significant impact	No	No	No	No	No	Recorded from Coopernook and Lansdowne SF – Level of representation unknown	Clearing of Native vegetation	No	No
<i>Melanodryas cucullata</i>	Hooded Robin	V	Loss of small area of habitat not likely to have a significant impact	No	No	No	No	No	Recorded from Crowdy Bay NP – Level of representation unknown	Clearing of Native vegetation	No	No
<i>Ninox connivens</i>	Barking Owl	V	Loss of small area of habitat not likely to have a significant impact	No	No	No	No	No	Not recorded in a reserve in the local area – Level of representation unknown	Clearing of Native vegetation	No	No
<i>Ninox strenua</i>	Powerful Owl	V	Loss of tree hollows for nesting may impact this species	No	No	No	No	No	Recorded in Broken Bago and Lansdowne SF , Crowdy Bay NP and Khappinghat NR- Level of representation unknown	Clearing of Native vegetation	No	No
<i>Rostratula benghalensis</i>	Painted Snipe	V	Wetland species unlikely to be impacted	No	No	No	No	No	Not recorded in a reserve in the local area – Level of representation unknown	Clearing of Native vegetation	No	No
<i>Tyto capensis</i>	Grass Owl	V	No	No	No	No	No	No	Recorded in Crowdy Bay NP and Johns River SF - Level of representation unknown	Clearing of Native vegetation	No	No

Latin Name	Common Name	TSC ¹	Eight Part Test Questions ³									
			1	2	3	4	5	6 ²	7	8	Significant Impact	
<i>Tyto novaehollandiae</i>	Masked Owl	V	Loss of tree hollows for nesting may impact this species	No	No	No	No	No	Recorded in Coorabakh and Crowdy Bay NPs and Johns River and Middle Brother SFs - Level of representation unknown	Clearing of Native vegetation	No	No
<i>Xanthomyza phrygia</i>	Regent Honeyeater	E	Loss of small area of habitat not likely to have a significant impact	No	No	No	No	No	Not recorded in a reserve in the local area – Level of representation unknown	Clearing of Native vegetation	No	No
<i>Aepyprymnus rufescens</i>	Rufous Bettong	V	Loss of small area of habitat not likely to have a significant impact	No	No	No	No	No	Recorded in Crowdy Bay NP - Level of representation unknown	Clearing of Native vegetation	No	No
<i>Cercartetus nanus</i>	Eastern Pygmy-possum	V	Loss of small area of habitat not likely to have a significant impact	No	No	No	No	No	Recorded in Crowdy Bay NP and Kerewong SF - Level of representation unknown	Clearing of Native vegetation	No	No
<i>Dasyurus maculatus</i>	Spotted-tailed Quoll	V	Loss of small area of habitat not likely to have a significant impact	No	No	No	No	No	Recorded in Broken Bago, Burrawang, Coopernook and Upsalls Creek SFs and Coorabakh and Yoorigan NPs Recorded in Crowdy Bay NP - Level of representation unknown	Clearing of Native vegetation	No	No
<i>Falsistrellus tasmaniensis</i>	Eastern False Pipistrelle	V	Loss of tree hollows for roosting may impact this species	No	No	No	No	No	Recorded from Crowdy Bay NP and Johns River SF - Level of representation unknown	Clearing of Native vegetation	No	No
<i>Miniopterus australis</i>	Little Bent-wing Bat	V	Loss of small area of habitat not likely to have a significant impact	No	No	No	No	No	Recorded from four National Parks, two Nature Reserves and seven State Forests – Likely to be well represented	Clearing of Native vegetation	No	No
<i>Miniopterus schreibersii</i>	Common Bent-wing Bat	V	Loss of small area of habitat not likely to have a significant impact	No	No	No	No	No	Recorded from four National Parks and three State Forests – Likely to be well represented	Clearing of Native vegetation	No	No
<i>Mormopterus norfolkensis</i>	East Coast Freetail Bat	V	Loss of tree hollows for roosting may impact this species	No	No	No	No	No	Not recorded in a reserve in the local area – Level of representation unknown	Clearing of Native vegetation	No	No

Latin Name	Common Name	TSC ¹	Eight Part Test Questions ³									
			1	2	3	4	5	6 ²	7	8	Significant Impact	
<i>Petaurus australis</i>	Yellow-bellied Glider	V	Loss of tree hollows for nesting may impact this species	No	No	No	No	No	Recorded from Bago Bluff and Coorabakh NPs, Queens Lake NR and Cowarra, Lansdowne and Middle Brother SFs– Level of representation unknown	Clearing of Native vegetation	No	No
<i>Petaurus norfolcensis</i>	Squirrel Glider	V	Loss of tree hollows for nesting may impact this species	No	No	No	No	No	Not recorded in a reserve in the local area – Level of representation unknown	Clearing of Native vegetation	No	No
<i>Phascogale tapoatafa</i>	Brush-tailed Phascogale	V	Loss of tree hollows for nesting may impact this species	No	No	No	No	No	Recorded from Dooragan NP and Coopernook, Lansdowne and Middle Brother SFs– Level of representation unknown	Clearing of Native vegetation	No	No
<i>Phascolarctos cinereus</i>	Koala	V	Loss of small area of habitat not likely to have a significant impact	No	No	No	No	No	Recorded from three National Parks, two Nature Reserves and 12 State Forests – considered well represented.	Clearing of Native vegetation	No	No
<i>Planigale maculata</i>	Common Planigale	V	Loss of small area of habitat not likely to have a significant impact	No	No	No	No	No	Not recorded in a reserve in the local area – Level of representation unknown	Clearing of Native vegetation	No	No
<i>Pteropus poliocephalus</i>	Grey-headed Flying-fox	V	Loss of small area of habitat not likely to have a significant impact	No	No	No	No	No	Recorded in Crowdy Bay NP, Queens Lake NR and Queens Lake SF – Considered to be well represented but under sampled	Clearing of Native vegetation	No	No
<i>Scoteanax rueppellii</i>	Greater Broad-nosed Bat	V	Loss of small area of habitat not likely to have a significant impact	No	No	No	No	No	Recorded in Crowdy Bay NP and Johns River SF– Level of representation unknown	Clearing of Native vegetation	No	No

Key

1: V = Vulnerable, E = Endangered under the schedules of the TSC Act

2: Records of occurrence within the 1:100 000 local Mapsheet - NP = National Park, NR = Nature Reserve, SF = State Forest

3: No indicates a negative response to the specific question

4: Additional targeted surveys were conducted for *L. brevipalmata* during the summer of 2004.

1) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable population of the species is likely to be placed at risk of extinction.

The habitat of the Green-thighed Frog (*Litoria brevipalmata*) is poorly known. It has been found in a range of vegetation types including riparian forest and wet and dry sclerophyll forest and woodlands, including relatively open structures (Ehmann 1997). Within northern NSW records of this species appear to predominantly come from dry sclerophyll forest (Murphy & Turnbull 1999), whereas south of Coffs Harbour is also found in moist forest (F. Lemckert, State Forests, *pers. comm.*). The majority of

records for this species have come from during the breeding season (October to January) and so habitat types are associated with breeding ponds and their environs. Most of the known breeding sites of this species are temporary and include ponds, waterholes in creeks, artificial dams, scrapes and ditches (Ehmann 1997). Calling in this species has also been observed in flooded road verges (F. Lemckert, State Forests, *pers. comm.*). Within NSW all the known breeding sites and their environs are disturbed to various degrees ranging from substantial partial clearing of most trees in grazing farmlands to moderate levels of logging (Ehmann 1997). All sites have nearby stands of relatively undisturbed forest (Ehmann 1997). This species exhibits explosive breeding, with males congregating around temporary pools that form only after very heavy rainfall events (Barker et al. 1995, Lemckert et al. 1997, Lemckert & Slatyer 2002). Breeding is highly variable and may occur just one or twice per year or not at all (Lemckert et al. 1997). The use of the forest environment by this species during the non-breeding season is poorly understood, but it is thought that cover in the form of thick leaf litter or dense low vegetation may be important (Lemckert & Slatyer 2002).

Two specimens of the Green-thighed Frog were recorded on the western side of the existing Highway near the Eggbert property in 1997 (DEC records, Figure 8) and they are recorded in the Atlas of NSW Wildlife as having standard reliability. A number of possible breeding sites occur along the Herons Creek Section including ponds, creeks and paddocks. However, it should be noted that sites that appear to be suitable breeding sites to human eyes may not always be used by frogs (Lemckert et al. 1997). The widening of the existing Highway would result in direct loss of some of this potential habitat and also may indirectly impact habitat through possible changes in water quality. Habitat loss and changes in water quality have been suggested as possible threats for this species (Lemckert & Slatyer 2002). It is unclear at this stage the size of the population in the local area as well as the number of potential breeding sites and hence the level of impact that the proposed upgrade of the Highway would have on this species. However, the precautionary principle¹¹ must be used and it must be assumed that the total loss of one or more breeding sites for this species may result in the local extinction of a viable population. In a study approximately 100 km south of the study site at Bulahdelah, Lemckert *et al.* (1997) suggested that a stochastic event that destroys one breeding site would significantly reduce the total breeding output for the region.

However, with further targeted surveys and the implementation of suitable mitigation measures (see Section 5.2.6) it is unlikely that the local population would face extinction.

A large number of species with potential habitat in the area would have some potential habitat destroyed or removed through vegetation clearing. These species include the Swift Parrot (*Lathamus discolor*), Regent Honeyeater (*Xanthomyza phrygia*), Square-

¹¹ The precautionary principle states that “if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation” (*Protection of the Environment Administration Act 1991*).

tailed Kite (*Lophoictinia isura*), Hooded Robin (*Melanodryas cucullata*), Barking Owl (*Ninox connivens*), Rufous Bettong (*Aepyprymnus rufescens*), Eastern Pygmy Possum (*Cercartetus nanus*), Spotted-tailed Quoll (*Dasyurus maculatus*), Little Bent-wing Bat (*Miniopterus australis*), Common Bent-wing Bat (*Miniopterus schreibersii*), Koala (*Phascolarctos cinereus*), Common Planigale (*Planigale maculata*), Grey-headed Flying Fox (*Pteropus poliocephalus*) and Greater Broad-nosed Bat (*Scoteanax ruepellii*). Although removal of vegetation as part of the Highway upgrade would remove potential habitat for these species, the habitat is considered to be general and would not be limiting within the local area. There are large areas of suitable habitat for these species nearby and hence the removal of sections of their habitat as a result of clearing is unlikely to have a significant impact on the viability of populations of these species.

For some species however the removal of vegetation may result in the removal of specific and potentially limiting habitat elements. Some of the species with potential habitat in the study area utilise tree hollows for nesting and breeding. These species include the Glossy Black-cockatoo (*Calyptorhynchus lathami*), Barking Owl (*Ninox connivens*), Powerful Owl (*Ninox strenua*), Masked Owl (*Tyto novaehollandiae*), Eastern False Pipistrelle (*Falsistrellus tasmaniensis*), East Coast Freetail Bat (*Mormopterus norfolkensis*), Yellow-bellied Glider (*Petaurus australis*), Squirrel Glider (*Petaurus norfolcensis*) and Brush-tailed Phascogale (*Phascogale tapoatafa*). The exact nature of the types of tree hollows preferred by these species will vary (Gibbons & Lindenmayer 1997, Gibbons & Lindenmayer 2002). All areas of native vegetation along the proposed route containing mature trees and stags with hollows may be considered a limiting resource in the area. Removal of tree hollows, particularly during the breeding season, may result in a significant impact on the viability of species in the local area. However, the implementation of suitable mitigation measures such as clearing of vegetation out of the breeding seasons of hollow-using species and monitoring hollows prior to and during clearing would be likely to reduce impacts on these species such that they would not be considered significant.

A number of species with potential habitat within the study area are wetland specialists. These include the Australasian Bittern (*Botaurus poiciloptilus*), Black-necked Stork (*Ephippiorhynchus asiaticus*) and Painted Snipe (*Rostratula benghalensis*). Although the proposed highway upgrade would run adjacent to the Sunnyvale SEPP 14 wetland (554a), the proposed works would not directly modify or degrade the water quality of the wetland and hence these species would not be impacted.

2) 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.

Endangered Populations are listed under Schedule 1 Part 2 of the TSC Act. There are no listed endangered populations of animal found in the local area.

3) In relation to the regional distribution of a habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

The bioregion in which the study site occurs is the NSW North Coast (Thackway & Cresswell 1995). All the species with potential habitat in the study area have wide distributions that cover the entire bioregion. The amount of habitat to be removed (64.3 ha) or otherwise impacted (178.7 ha) by the proposed highway upgrade would be small and could not be considered significant in a bioregional context.

4) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

The proposed highway upgrade would result in the fragmentation of three moderate-sized patches of native vegetation that may support threatened fauna habitat. These areas are located in the Kew Bypass north and south of Ocean Drive and in the Johns River Bypass south of Stewarts River Road. However, in all cases the areas of habitat are already isolated in the wider matrix and further fragmentation would not result in further isolation. None of the habitat to be destroyed or modified within these areas is considered to play a significant role in a corridor network that would be used by threatened species. Mitigation measures such as fauna underpasses have been suggested for areas where connectivity in the wider corridor network is considered important.

5) Whether critical habitat will be affected.

Critical habitat is declared by the Director General of the NSW National Parks and Wildlife Service and is kept in the Register of Critical Habitat. To date critical habitat has been declared for only the Mitchell's Rainforest Snail in Stotts Island Nature Reserve and for the endangered little penguin colony in Sydney's North Harbour. Neither of these critical habitats would be affected by the proposal.

6) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or similar protected areas) in the region.

Conservation reserves near to the proposed highway upgrade include Yoorigan National Park, Crowdy Bay National Park, Dooragan National Park, Coorabakh National Park and Queens Lake Nature Reserve. State Forests in the area include Middle Brother, Johns River, Kendall and Kew.

Records of threatened species are generally sparse in reserves in the local area. Exceptions are the Glossy Black-cockatoo (*Calyptorhynchus lathami*), Koala (*Phascolarctos cinereus*), Little Bent-wing Bat (*Miniopterus australis*) and Common Bent-wing Bat (*Miniopterus schreibersii*). These four species are likely to be well represented in reserves within the local area. Although there are few records for the Grey-headed Flying Fox (*Pteropus poliocephalus*) within reserves in the local area, this

is possibly due to lack of records in general for this species and it is likely to be well represented in reserves. The level of representation of all other species is unclear.

7) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Key threatening processes (KTP) are listed under Schedule 3 of the TSC Act. The ‘clearing of native vegetation’ and the ‘removal of dead wood and dead trees’ are listed as KTP and are applicable to the current proposed highway upgrade.

8) Whether any threatened species, population or ecological community is at the limit of its known distribution.

According to DEC Atlas of NSW Wildlife none of the threatened species with potential habitat in the area are at the limit of their distribution.

6.1.5 EIGHT PART TEST CONCLUSION

The Eight Part Tests for threatened plants indicate that there is unlikely to be a significant impact for threatened plants listed under the TSC Act. Similarly the significance assessments for threatened animals suggest that it is unlikely that there will be a significant impact on threatened species providing suitable mitigation measures are implemented during the design, construction and operation phases. A Species Impact Statement is not recommended.

6.2 EPBC ACT SIGNIFICANCE ASSESSMENTS

DEH has published guidelines for determining if an action is likely to have a significant impact on a matter of national significance (see Appendix 3). Under the EPBC Act, an action will require approval from the Environment Minister if the action has, will have, or is likely to have a significant impact on a matter of national environmental significance (as outlined in Section 3.1).

The purpose of the significance assessment guidelines is to assist in determining whether an action should be referred to the Environment Minister for a decision on whether approval is required. In particular, they are intended to provide guidance on whether a proposed action is likely to have a significant impact on any of the matters of national environmental significance.

6.2.1 FLORA

6.2.1.1 Threatened Species

Eleven threatened species must be considered in relation to the guidelines for significance for the EPBC Act (Table 13; Appendix 6).

Table 13: Threatened species of plant listed on the EPBC Act with potential habitat within the study area

Species	EPBC Status	Significance guidelines questions								Significant Impact
		1	2	3	4	5	6	7	8	
<i>Diuris pedunculata</i>	E									No
<i>Phaius australis</i>	E									No
<i>Phaius tankervilleae</i>	E									No
<i>Tylophora woollsii</i>	E									No
<i>Acacia courtii</i>	V									No
<i>Asperula asthenes</i>	V									No
<i>Bothriochloa biloba</i>	V									No
<i>Eucalyptus glaucina</i>	V									No
<i>Haloragis exalata ssp velutina</i>	V									No
<i>Melaleuca biconvexa</i>	V									No
<i>Thesium australe</i>	V									No

E = Endangered, V = Vulnerable, ✓ = a positive response to the questions, ✗ = a negative response to the questions. Yes = significant impact, No = no significant impact.

For the assessment criteria of Vulnerable species, an important population is defined as one that is necessary for a species long-term survival and recovery, including populations that are:

- key source populations either for breeding or dispersal,
- populations that are necessary for maintaining genetic diversity, and/or
- populations that are near the limit of the species range.

None of the species to be considered under the Act were recorded during the current surveys or during the preliminary survey of the proposed route (Richardson & Saunders 2000).

Two of the Vulnerable species (*Acacia courtii* and *Melaleuca biconvexa*) would be considered important populations as defined above as the study area is at the limit of their distribution. However, these species have not been recorded within the study area. The remaining five Vulnerable species are not considered important populations within the study area because:

- they are not near the limit of the species range; and

- vegetation within the study area is in small isolated patches which are unlikely to provide habitat or corridors for key source populations, breeding or dispersal, and would therefore be unlikely to be necessary for maintaining genetic diversity.

Thus, these five Vulnerable species do not require consideration under criteria 1, 2 or 5.

(1) Is the action likely to lead to a long-term decrease in the size of a population (an important population for those listed as Vulnerable)?

The vegetation to be cleared as a result of the proposed road upgrade is subject to moderate weed invasion and other disturbances due to its proximity to existing roads and developments and thus is considered to be in poor-moderate condition. As such, it is considered to provide only marginal habitat for *Acacia courtii*, *Diuris pedunculata*, *Melaleuca biconvexa*, *Phaius australis*, *P. tankervilleae*, *Tylophora woollsii*. Only a small area of marginal habitat would be removed by the proposed development and for three of the species (*Melaleuca biconvexa*, *Phaius australis*, *P. tankervilleae*) this is not considered to be a significant area of their habitat. It is unlikely that a population of *Diuris pedunculata*, *Phaius australis*, *P. tankervilleae*, *Tylophora woollsii* or that an important population of *Melaleuca biconvexa*, would be placed at risk of extinction by the proposed development.

Due to the highly restricted distribution of *Acacia courtii* it was considered likely that if present within the area, the proposed works may lead to a long-term decrease in the size of a population of this species. Targeted surveys were undertaken to determine its presence or absence within the study area. Despite targeted surveys, *Acacia courtii* was not recorded within the study area. The proposed development will therefore not remove any individuals and is unlikely to disrupt the lifecycle of a viable population of this species. It is therefore unlikely that the proposed highway upgrade would result in the long term decrease in the size of an important population.

(2) Is the action likely to reduce the area of occupancy of an important population (the species in the case of an Endangered species)?

None of the six species to be considered (*Diuris pedunculata*, *Phaius australis*, *P. tankervilleae* and *Tylophora woollsii*) were recorded within the study area and despite targeted surveys, *Acacia courtii* was not recorded. Only a small area of potential habitat for these species would be removed by the proposed development and this is unlikely to decrease the area of occupancy for these species.

(3) Is the action likely to fragment an existing habitat critical to the survival of the species?

The proposed highway upgrade would result in the fragmentation of three moderately sized areas of native vegetation that may provide potential habitat for threatened flora. However, in all cases the areas of habitat are already isolated and the fragmentation would not result in any further isolation.

(4) Is the action likely to adversely affect habitat critical to the survival of a species?

The action would remove a small amount of potential habitat for ten species (all excluding *Acacia courtii*). However, the habitat types that would be removed are not considered to be limiting in the local or regional area and hence are not considered to be critical to the survival of the species. The action would however contribute to the gradual loss of general habitat for these species.

Due to the highly restricted distribution of *Acacia courtii* it was considered likely that if present within the area the proposed works may affect habitat critical to the survival of this species. Targeted surveys were undertaken to determine its presence or absence within the study area. Despite targeted surveys, *Acacia courtii* has not been recorded within the study area. The vegetation to be cleared is subject to weed invasion and other disturbances due to its proximity to existing roads and rural/residential developments and is in poor-moderate condition. For these reasons much of the proposed route is provides only marginal habitat for this species. The action is therefore unlikely to affect habitat critical to the survival of *Acacia courtii*.

(5) Is the action likely to disrupt the breeding cycle of a population (or an important population for a vulnerable species)?

The activity would not increase fragmentation as the vegetation within the study site occurs largely as patches that are already isolated and highly fragmented or will require the clearing of vegetation along existing edges. It is therefore unlikely that the activity would disrupt the breeding cycle of a population (or an important population for a vulnerable species).

(6) Is the action likely to modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The removal of vegetation would contribute to the overall reduction in available habitat for the eleven species within Australia. However, only a small area of vegetation would be removed and cannot be considered significant enough to cause the species to decline.

(7) Is the action likely to result in invasive species that are harmful to a vulnerable or endangered species becoming established in the vulnerable or endangered species habitat?

The action would not significantly increase the extent and distribution of invasive species in the region. However, it is likely that weeds would invade areas that are currently in good condition and are being buffered by native vegetation.

(8) Is the action likely to interfere substantially with the recovery of the species?

The action is unlikely to interfere with the recovery of the eleven species.

6.2.2 FAUNA

6.2.2.1 Threatened Species

Four threatened species of animal must be considered in relation to the guidelines for significance for the EPBC Act, two of which are Endangered and two Vulnerable (Table 14, Appendix 7).

Table 14: EPBC guidelines for significance questions for threatened fauna species.

Latin name	Common Name	EPBC Status	Significance guidelines questions								Significant Impact	
			1	2	3	4	5	6	7	8		
<i>Lathamus discolor</i>	Swift Parrot	E										No
<i>Xanthomyza phrygia</i>	Regent Honeyeater	E										No
<i>Dasyurus maculatus</i>	Spotted –tailed Quoll	V										No
<i>Pteropus poliocephalus</i>	Grey-headed Flying Fox	V										No

E = Endangered, V = Vulnerable, = a negative response to the questions, No = no significant impact

For the assessment criteria of Vulnerable species, an important population is defined as one that is necessary for a species long-term survival and recovery, including populations that are:

- key source populations either for breeding or dispersal,
- populations that are necessary for maintaining genetic diversity, and/or
- populations that are near the limit of the species range.

Neither of the Vulnerable species to be considered under the Act are considered to be important populations as defined above. The two species (Grey-headed Flying Fox and Spotted-tailed Quoll) are both found widely in the bioregion and the study area does not represent an area of regional endemism or geographic isolation. Thus these two species do not need to be assessed under criteria 1, 2 and 5.

(1) Is the action likely to lead to a long-term decrease in the size of a population (an important population for those listed as Vulnerable)?

The two Endangered species are migratory and are likely to be only temporary visitors to the area. The upgrade of the highway would thus be unlikely to decrease the size of the populations.

(2) Is the action likely to reduce the area of occupancy of an important population (the species in the case of an Endangered species)?

The action would remove a small amount of feeding resources for the two Endangered species, but this would be unlikely to reduce the areas of occupancy for these species.

(3) Is the action likely to fragment an existing habitat critical to the survival of the species?

The proposed highway upgrade would result in the fragmentation of three moderate-sized patches of native vegetation that may support threatened fauna habitat. These areas are located in the Kew Bypass, north and south of Ocean Drive and in the Johns River Bypass south of Stewarts River Road. However, in all cases the patches of habitat are already isolated in the wider matrix and the fragmentation would not result in further isolation. Mitigation measures have been suggested for areas where connectivity in the wider corridor network is considered important.

(4) Is the action likely to adversely affect habitat critical to the survival of a species?

The action would remove only a small amount of habitat for the four species. Habitat characteristics that would be removed are not considered to be limiting in the local or regional area and hence are not critical to the survival of the species. The action would however contribute to the gradual loss of general habitat for the species.

(5) Is the action likely to disrupt the breeding cycle of a population (or an important population for a vulnerable species)?

The Swift Parrot breeds in Tasmania and hence would not be impacted by the development. Given the relatively small amount of vegetation to be removed it is unlikely that the action would disrupt the breeding cycle of the three remaining species.

(6) Is the action likely to modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The removal of vegetation would contribute to the overall reduction in available habitat for these four species within Australia. However, the extent of vegetation removal cannot be considered significant enough to cause the species to decline.

(7) Is the action likely to result in invasive species that are harmful to a vulnerable or endangered species becoming established in the vulnerable or endangered species habitat?

The action would not increase the extent and distribution of invasive species in the region. Weeds and feral animals are found throughout the study area and the proposed upgrade would be unlikely to significantly increase their numbers.

(8) Is the action likely to interfere substantially with the recovery of the species?

The action is unlikely to interfere with the recovery of the four species.

6.2.2.2 Migratory Species

Based on the EPBC Database eight species should be considered under the migratory provisions of the EPBC Act (Appendix 7). Five additional migratory species were recorded during the current surveys (Appendix 6) and these are also considered below (Table 15).

Table 15: Migratory species to be considered under the provisions of the EPBC Act

Latin Name	Common Name	Significance impact question			Significant Impact
		1	2	3	
<i>Ardea ibis</i>	Cattle Egret				No
<i>Aquila audax</i>	Wedge-tailed Eagle				No
<i>Chenonetta jubata</i>	Australian Wood Duck				No
<i>Falco berigora</i>	Brown Falcon				No
<i>Gallinago hardwickii</i>	Latham's Snipe				No
<i>Haliaeetus leucogaster</i>	White-bellied Sea-Eagle				No
<i>Hieraaetus morphnoides</i>	Little Eagle				No
<i>Lathamus discolor</i>	Swift Parrot				No
<i>Monarcha melanopsis</i>	Black-faced Monarch				No
<i>Monarcha trivirgatus</i>	Spectacled Monarch				No
<i>Myiagra cyanoleuca</i>	Satin Flycatcher				No
<i>Rhipidura rufifrons</i>	Rufous Fantail				No
<i>Xanthomyza phrygia</i>	Regent Honeyeater				No

= a negative response to the questions, No = no significant impact

For the purposes of the Act an area of important habitat for migratory species is:

1. habitat utilised by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species, or
2. habitat utilised by a migratory species which is at the limit of the species range, or
3. habitat within an area where the species is declining.

None of the species to be considered are at the edge of their range, the study area does not constitute an area containing a significant proportion of the population and the species are not considered to be declining in the study area. Thus none of the eight species require consideration under criteria 1 and 2.

- (1) Is the action likely to substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat of the migratory species?

Not applicable.

- (2) Is the action likely to result in invasive species that is harmful to the migratory species becoming established in an area of important habitat of the migratory species?

Not applicable.

- (3) Is the action likely to seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of the species?

The action would remove only a relatively small amount of vegetation that cannot be considered habitat for a significant proportion of the population of the eight species. Thus it is unlikely that an ecologically significant proportion of the population of the eight migratory species would be affected.

6.2.3 EPBC SIGNIFICANCE ASSESSMENT CONCLUSIONS

The proposed upgrade of the Pacific Highway is unlikely to have significant impact on any threatened plants or threatened or migratory animals listed on the EPBC Act. As such a referral under the provision of the Act is not recommended.

7.0 OVERALL IMPACT ASSESSMENT

The implementation of suitable mitigation measures during the design, construction and operational phases of the Highway upgrade will reduce impacts on threatened species such that the action is unlikely to have a significant impact as assessed under the TSC/EP&A and EPBC Acts. Neither a Species Impact Statement or a referral to DEH is recommended.