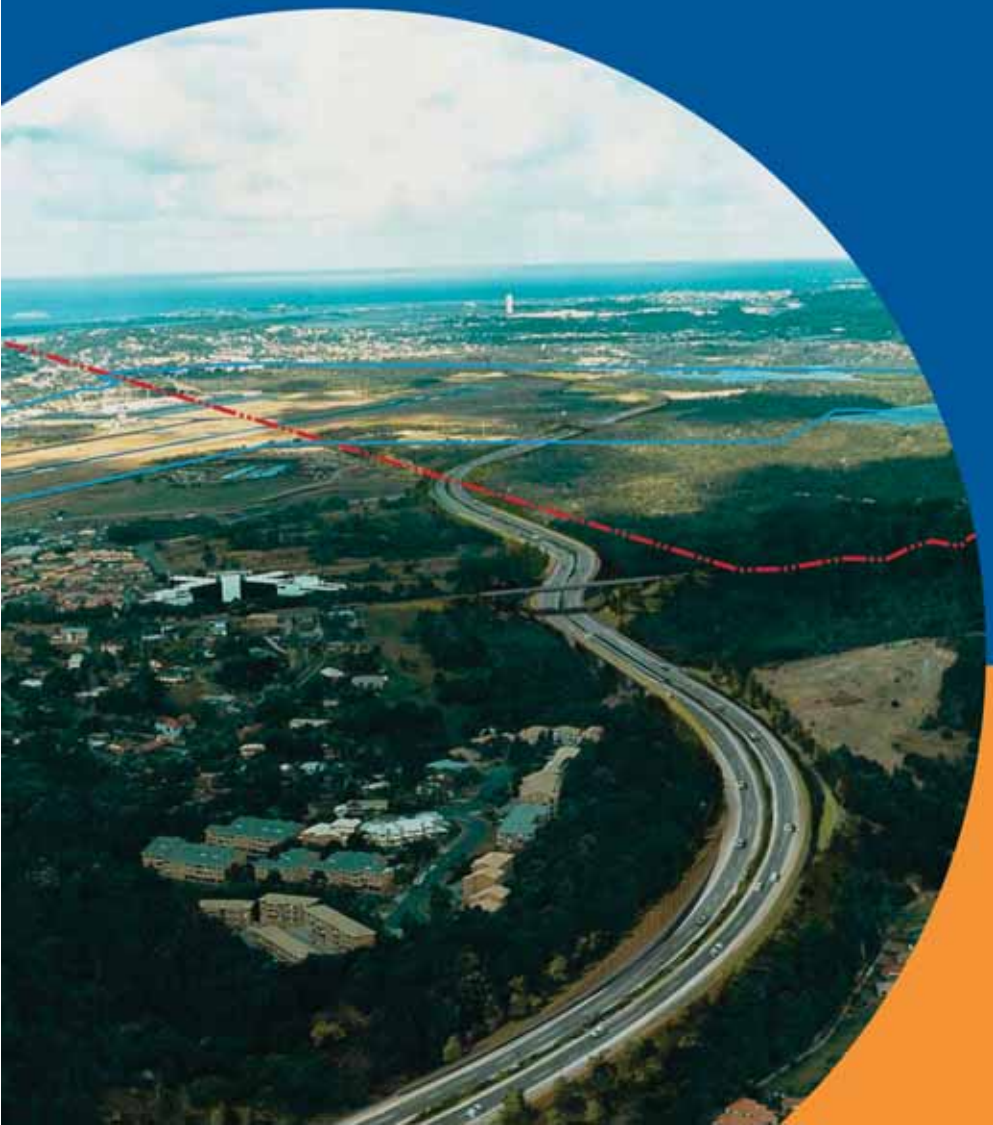
Australian Government
Department of Transport and Regional Services

RTA

Queensland Government
Department of Main Roads

TUGUN BYPASS

stewart road to kennedy drive



Technical Papers

December 2004

Tugun Bypass Environmental Impact Statement

Technical Paper Number 12
Flora and Fauna Assessment

Tugun Bypass Alliance

Parsons Brinckerhoff

348 Edward Street
Brisbane Qld 4000
GPO Box 2907
Brisbane Qld 4001
Australia

Telephone: + 61 7 3218 2222
Facsimile: + 61 7 3831 4223
E-mail: brisbane@pb.com.au

ABN 84 797 323 433

NCSI Certified Quality System to ISO9001

Parsons Brinckerhoff Australia Pty Limited ACN 078 004 798 and
Parsons Brinckerhoff International (Australia) Pty Limited ACN 006 475 056 trading as Parsons Brinckerhoff
ABN 84 797 323 433

Queensland Department of Main Roads – South Coast Hinterland District

36-38 Cotton Street
Nerang Qld 4211
PO Box 442
Nerang Qld 4211
Australia

Telephone: + 61 7 5583 8111
Facsimile: + 61 7 5583 8100
E-mail: www.SouthCoast@mainroads.qld.gov.au

November 2004
2134070A-PR054Car

Contents

Contents (continued)

Page Number

Contents (continued)

List of Tables

List of Figures

List of Appendices

1. Introduction

1.1 Summary of the Technical Paper

This technical paper describes the terrestrial and aquatic flora and fauna found along the proposed Tugun Bypass extending from Stewart Road, Currumbin, to Kennedy Drive, Tweed Heads. It also addresses the potential impacts of the proposed bypass on flora and fauna and describes mitigation measures that would be implemented in order to minimise these. The study area is approximately 7 kilometres long and lies 1 kilometre either side of the proposed bypass.

Terrestrial flora and vertebrate fauna surveys were undertaken between August 2000 and June 2004. The initial surveys were conducted over several seasons, including periods of intense rainfall in early 2001. Terrestrial invertebrates were surveyed during November-December 2000 and January-February 2001. Fish and wetland surveys were conducted from September 2000 to January 2001. Supplementary survey work was also undertaken for the Long-nosed Potoroo (*Potorous tridactylus*) during April – May 2003 and for the Common Planigale (*Planigale maculata*) during June 2004.

The proposal crosses three state and federal boundaries and is subject to different environmental legislation in each. Legislatively significant species in Queensland are those listed on the Nature Conservation (Wildlife) Regulation 1994. Legislatively significant species in NSW are those listed under the *Threatened Species Conservation Act 1995,* while legislatively significant species on Commonwealth land are those listed on the *Environment Protection and Biodiversity Conservation Act 1999*. Other species of conservation significance are determined through relevant literature and expert opinion.

Overall, at least 37 vegetation communities and 12 terrestrial habitat types occur in the study area. A total of 479 native plant species and 244 native terrestrial fauna species (16 amphibians, 20 reptiles, 25 mammals, 175 birds and 8 invertebrates) were recorded in the study area. A further 107 weed species and 11 terrestrial introduced vertebrates were also noted. Three wetland vegetation communities were described in the study area. Thirteen native species of aquatic fauna and one introduced fish species were recorded during the survey. Fifty-five flora and fauna species of legislative significance (including bird species listed on the Japan-Australia and China-Australia Migratory Birds Agreements) and 20 species of conservation significance at the local and regional level were recorded in the study area. A further 13 species of legislative significance have been recorded in the locality and could occur in the study area.

Twenty-eight terrestrial vegetation communities would be transected by the proposed bypass. Vegetation communities of state conservation significance that would be affected by the proposed bypass are Swamp Oak Forest and Swamp Oak Woodland communities in NSW and Slashed Heathland communities in Queensland. Eighteen vegetation communities of regional conservation significance would also be directly or indirectly affected by the proposed bypass. A total of six plant species of legislative significance and four species of regional conservation significance would be affected by the proposed bypass through the removal of some individuals and/or their habitat.

Eleven fauna habitat types would be transected by the proposed bypass. Four terrestrial habitats of at least regional conservation significance were also recorded in the study

area. A total of 10 fauna species of legislative significance and one of regional conservation significance would potentially be affected by the proposed bypass through the removal of individuals and/or habitat. Amongst invertebrate species, the Swordgrass Brown Butterfly and the Queensland Giant Dragonfly were recorded. Although not listed in state or national legislation, both of these species are considered to be of conservation significance at the regional level.

One aquatic habitat of legislative significance in NSW, *State Environmental Planning Policy Number 14* Wetland Number 5a, is located in the study area. The Cobaki Broadwater also constitutes major fish habitat and supports a commercial fishery. Other drainage lines and creeks in the study area are of local significance providing minimal to moderate fish habitat. No fish species of higher than local conservation significance was noted. Three fish species of commercial/recreational significance were captured.

Overall, the study area is considered to be of national significance for nature conservation. It supports a high diversity of flora and fauna species of conservation significance, especially frog and bat species. It also provides important habitat for a number of small regionally/state significant populations of Swamp Orchid, Wallum Sedge Frog, Wallum Froglet, Long-nosed Potoroo and Common Planigale.

Ten sites of conservation significance were identified along the proposed bypass. The potential impacts of the proposed bypass and the effectiveness of mitigation measures on these sites were assessed. Given the implementation of appropriate mitigation measures, the potential impacts are expected to be local or high local for most sites and species. The proposed bypass may have a regional impact on populations of the Wallum Sedge Frog and Common Planigale. This is primarily due to potential fragmentation of these populations associated with barrier effects of the proposed bypass and the experimental nature of the underpasses provided. Furthermore, impacts to these two species may be further exacerbated if the proposed rail line extension proceeds, widening the corridor further. Cumulative impacts associated with the Cobaki Lakes development are likely to be significant for Long-nosed Potoroos.

The impacts of the proposed bypass on regional and local fauna movement corridors were also assessed. The southern end of the proposed alignment forms a partial barrier across a sub-regional fauna corridor. In this area, the road tunnel in the south would be excavated and then recovered and revegetated, although part of the tunnel may be utilised by the proposed runway extension. The revegetation portion would still provide an approximately 100 metre-wide vegetated overpass for fauna.

Overall, a total of 26.5 hectares of key habitat would be removed or edge-affected in NSW, 23.8 hectares in Queensland and 20.8 hectares on Commonwealth land. Habitat loss cannot be mitigated except through negotiation of a compensatory habitat package. A preferred compensatory habitat package has been prepared and agreed to in principle by NSW Department of Environment and Conservation, although this needs to be updated. Compensatory measures aimed at minimising the effects of cumulative impacts on Long-nosed Potoroos form part of the package.

1.2 Purpose and Approach

This report has been prepared as part of the Environmental Impact Statement under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, the

NSW *Environmental Planning and Assessment Act 1979* and the Queensland *Environmental Protection Act 1994*.

In accordance with the requirements of the NSW *Threatened Species Conservation Act 1995,* a Species Impact Statement (SIS) must be prepared when it is determined under Section 5a of the NSW *Environmental Planning and Assessment Act 1979* that a significant impact on threatened species, populations or ecological communities is likely to occur. Section 5a assessments (eight-part tests of significance) conducted as part of this study concluded that a significant impact on threatened species was likely to occur. As such, requirements of the Director-General of the NSW Department of Environment and Conservation were sought and a SIS prepared. A SIS is not required under Queensland or Commonwealth legislation. However, in line with the terms of reference issued by Commonwealth Department of Environment and Heritage, equivalent ecological assessments were undertaken for species of legislative significance occurring in Queensland or on Commonwealth land. The SIS and equivalent ecological assessments for Queensland and Commonwealth are contained in parts B, C and D respectively of the report entitled *Species Impact Statement under the NSW Threatened Species Conservation Act 1995* (Main Roads 2004). The requirements of the Director-General of the NSW Department of Environment and Conservation and eight-part tests of significance are contained in Appendices A and H respectively of that document.

In accordance with the requirements of the *Environmental Protection and Biodiversity Conservation Act 1999*, a referral must be made to the Commonwealth Department of Environment and Heritage if it is considered that the proposal may have a significant impact on nationally listed threatened or migratory species. An assessment pursuant to this legislation has been undertaken and is summarised in this report. The Tugun Bypass has been deemed to be a controlled action by the Department of Environment and Heritage and the EIS has been prepared to meet both the requirements of the NSW *Environmental Planning and Assessment Act 1979* and the Commonwealth Environment Protection and Biodiversity Conservation Act.

The aim of this technical paper is to describe the terrestrial and aquatic flora and fauna assemblages along the proposed alignment for the Tugun Bypass and to determine the impacts of road construction and operation on them. Mitigation measures that would be implemented in order to minimise these impacts are also described.

1.3 Reporting of Study Findings in the EIS

The studies for the Tugun Bypass environmental impact assessment commenced in 2000. In the subsequent four years the results of the various studies have been used to refine the concept design of the proposal. Further studies were also commissioned to ensure that all aspects of the various environmental issues were fully understood.

The long time period of the assessment has meant that the content of some of the earlier reports has been superseded by newer work. Changes to the design of the bypass have also been introduced to take account of these studies.

In the event that there is a contradiction between the technical papers and the text of the EIS, the EIS takes precedence as it reports the current understanding of issues, impacts and the concept design.

2. Survey Methods

2.1 Overview

Vegetation mapping and plant community descriptions were undertaken by Khaalyd Brown (PB) with data provided by Mike Olsen (Land Assessment Management and Rehabilitation Pty Ltd) and Andrew Benwell (Flora Consultant). Targeted searches for flora species of conservation significance were conducted by Mike Olsen and by Andrew Benwell.

A number of detailed fauna reports were commissioned as part of the study. These were:

- *Assessment of the Impact of the Proposed Tugun Bypass: Terrestrial and Estuarine Birds* (Sandpiper Ecological Surveys 2001a);
- *Tugun Bypass Assessment of Impacts on Birds: Boyd Street Interchange to Stewart Road* (Sandpiper Ecological Surveys 2001b);
- *Survey for Reptiles, Amphibians and Mammals Inhabiting Coastal Lowland Areas Associated with the Proposed Tugun Bypass* (Hero *et al*. 2000);
- *Survey for Reptiles, Amphibians and Mammals Inhabiting the Northern Section of the Proposed Tugun Bypass* (Hero *et al*. 2001a);
- *Supplementary Surveys of Common Planigales, Eastern Long-eared Bat and Wallum Sedge Frogs within the Proposed Tugun Bypass* (Hero *et al*. 2001b);
- *Amelioration and Monitoring Measures for the Conservation of Herpetofauna along the Proposed Tugun Bypass* (Hero *et al*. 2001c);
- *Survey for the Land Snail* Thersites mitchellae*: Proposed Tugun Bypass Route* (Stanisic 2001);
- *Survey for the Giant Dragonflies,* Petalura gigantea *and* Petalura litorea *and the Swordgrass Brown Butterfly,* Tisiphone abeona morrisi (Reeves 2001);
- *Tugun Bypass Proposal – Aquatic Flora and Fauna* (FRC Environmental 2001);
- *The Status and Distribution of the Cobaki Long-nosed Potoroo Population* (Bali *et al* 2003*); and*
- *Systematic Surveys for the Coastal Planigale* (Planigale maculata*) on Crown Lands and a Detailed Habitat Appraisal of the Tugun/Cobaki Locality* (Lewis 2004a).

The methods used and results obtained are set out in these reports. The original reports are contained in Appendices A through K. These reports were mostly produced during 2000 and 2001, and while a number of changes have been made to the proposed alignment since that time, the overall findings of these reports still remain valid. These reports are reviewed and summarised below.

The specialist consultants surveyed a wide corridor associated with the original C4 alignment (Main Roads 1999). The survey area was roughly bounded by Gold Coast Airport to the east, Cobaki Broadwater to the west, Tweed Heads Bypass to the south and Stewart Road to the north. Subsequent minor adjustments to the road alignment were based on environmental constraints identified by the consultants. The alignment for the proposed Tugun Bypass is wholly contained within the study corridor surveyed by the specialist consultants.

2.1.1 Study Area

For the purposes of this technical paper, the study area has been defined as that area between Stewart Road to the north, Tweed Heads Bypass to the south, and within a 1 kilometre band either side of the proposed alignment.

2.1.2 Taxonomy

Species names for plants and animals are taken from specific publications referenced throughout this chapter. Common names are used throughout the text wherever possible. Where these are not available, as for some plants and invertebrates, scientific names are used. Complete lists of common and scientific names for all flora and fauna species found in the study area are contained in Appendices L and M respectively.

2.1.3 Defining Conservation Significance

Legislatively significant species include all those listed as:

- 'endangered', 'vulnerable' or 'rare' under the Queensland Nature Conservation (Wildlife) Regulation 1994;
- 'endangered' or 'vulnerable' under the NSW *Threatened Species Conservation Act 1995*;
- 'endangered' or 'vulnerable' under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* or listed as migratory including being listed on international agreements such as the Japan-Australia Migratory Birds Agreement (JAMBA) or the China-Australia Migratory Birds Agreement (CAMBA); and/or
- Rare or Threatened Australian Plants (ROTAPs) in Briggs and Leigh (1996).

These lists are regularly updated and are current as of September 2004. Species of conservation significance include legislatively significant species as well as regionally significant species.

In addition populations and ecological communities can be listed as "endangered" under the NSW *Threatened Species Conservation Act 1995* and/or Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

2.2 Terrestrial Flora

2.2.1 Vegetation Communities

Vegetation communities in the study area were identified using aerial photographic interpretation (API), previous surveys of the area by Main Roads (1999), Peter Parker (1999) and James Warren (1994), targeted surveys along the proposed route by Mike Olsen and Andrew Benwell and ground-truthing by PB staff. Additional plot-based surveys for Saltmarsh were undertaken by Andrew Benwell in October 2004.

Thirty-seven vegetation communities were identified and described within the study area. Structural vegetation attributes were described according to Walker and Hopkins (1984).

2.2.2 Plant Species

Targeted flora surveys were undertaken in spring and summer between August 2000 and January 2001. Field survey dates in 2000 included 23 and 31 August, 1, 8, 9, 10, 12, 15, 19, 22, 29 and 30 September, 1, 3, 4, 15 and 18 October. Survey dates in 2001 included 17, 22 and 23 January. While these surveys were conducted in 2000 and 2001, hence prior to some recent species of conservation significance being listed on relevant legislation, they were very detailed in nature. These surveys detected a number of species previously undetected in the area and included species which were thought to be extinct in the locality or outside of their distribution in the study area prior to the surveys. It is considered that if any recently listed plant species were present in the area they would have been detected during the intensive survey effort employed.

The flora assessment comprised a literature review, database searches and vehicle and foot transects along the proposed corridor. Targeted surveys focussed on the proposal footprint with short meanders to either side (Figure 2.1). All plant species encountered were identified and recorded. Intensive searches for plants of conservation significance were undertaken in potential habitat areas. Locations of plants of conservation significance were recorded with a backpack differential global positioning system.

Plant taxonomy or species naming follows: Queensland Herbarium (1997), Harden (1990-3), Sharpe (1986), Simon (1993) and Stanley and Ross (1983).

2.2.3 Limitations

The detailed flora field survey corresponded to the original C4 alignment. Targeted surveys were consequently undertaken to account for any deviations of the proposed alignment from the original alignment.

No quadrat data were collected during the present study. However three experienced botanists searched the site extensively, targeting species of conservation significance. Site coverage was considered to be good to excellent. Using the random meander method, survey effort was roughly 1 day per 5 hectares. Survey times were appropriate for the detection of threatened species known or likely to occur in the study area.

A possible limitation is that the majority of surveys were conducted in 2000 and 2001. Since this time a number of sites in the study area have been subject to further disturbance, although this has been discussed within the text and any relevant maps updated. The intensity of the surveys conducted in the area is considered sufficient to offset the time delay in publication of this document. The surveys are considered likely to have detected all significant species that occur along the route and population estimates are still likely to be valid. However, as a precaution a pre-clearing survey of the route alignment has been proposed to be undertaken prior to the commencement of works to ensure any additional individuals that have grown on the alignment are detected and appropriately dealt with prior to clearing.

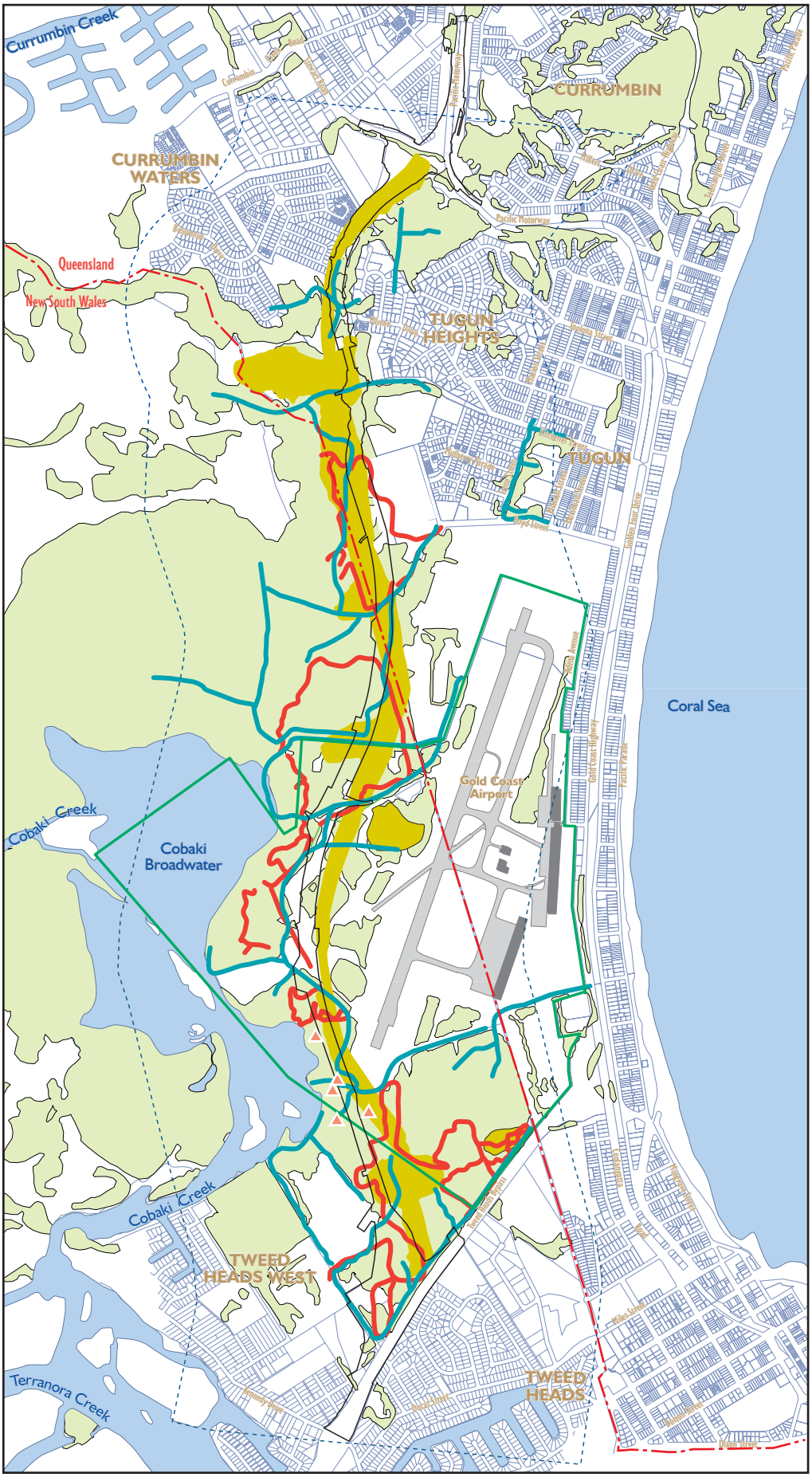


Figure 2.1 **Flora Survey Sites**

2.2.4 Conservation Significance

Vegetation Communities

In Queensland, a regional ecosystem is defined as a vegetation community, within a bioregion that is consistently associated with a particular combination of geology, landform and soil (Sattler and Williams 1999). The proposed Tugun Bypass is mainly located in the South-east Hill and Ranges province of the South-east Queensland Bioregion. However, small sections of the proposed corridor at Burleigh and Tugun, traverse the South-east Coastal Lowlands province.

The conservation status for each regional ecosystem is assigned as one of three categories: 'endangered', 'of concern' and 'no concern at present' according to its current distribution relative to its pre-European distribution. The conservation status for each regional ecosystem in Queensland is listed in the Vegetation Management Regulation 2000. Ecosystems considered to be 'endangered' are protected by the Queensland *Vegetation Management Act 1999*.

In NSW the *Threatened Species Conservation Act 1995* lists a number of vegetation communities as '*endangered ecological communities*'. These are protected under the legislation and approval from the Department of Environment and Conservation is required to remove or otherwise significantly impact upon these communities. The *Environment Protection and Biodiversity Conservation Act 1999* also list a variety of vegetation communities as '*threatened ecological communities*' under its legislation.

Regional conservation significance is determined on the basis of expert opinion.

Plant Species

Plant species considered to be 'endangered', 'vulnerable' or 'rare' in Queensland are listed in Schedules 2, 3 and 4 respectively of the Nature Conservation (Wildlife) Regulation 1994. Plant species considered to be 'endangered' or 'vulnerable' in NSW are listed in Schedules 1 and 2 of the NSW *Threatened Species Conservation Act 1995*. At the national level, significant plant species are listed as 'endangered' or 'vulnerable' under the *Environment Protection and Biodiversity Conservation Act 1999*. Briggs and Leigh (1996) also list Rare or Threatened Australian Plants (ROTAPs). These are classified as 'presumed extinct', 'endangered', 'vulnerable', 'rare' or 'poorly known'.

Information on plant species of conservation significance at the regional level comes from: Sheringham and Westaway (1995), NSW Department of Environment and Conservation (1998a) and Harden (1990-3).

2.3 Terrestrial Vertebrate Fauna

Separate surveys were undertaken for terrestrial vertebrate fauna: amphibians, reptiles and mammals; estuarine birds; and terrestrial birds. Due to differences in survey methods and timing, these are discussed separately below.

2.3.1 Terrestrial Vertebrate Fauna Habitat

Habitat types for terrestrial vertebrate fauna are described primarily with respect to vegetative structure and condition. Although habitat types may correspond to vegetation communities, they are more likely to be related to type and presence of

understorey and mid-stratum layer, size and presence of trees and occurrence of weeds. Important habitat resources for fauna were identified for each habitat type.

2.3.2 Estuarine Bird Habitat

Roosting and foraging habitat of estuarine birds was assessed in the lower Tweed River as part of the current study. A wider area was surveyed in order to take into account the regional movement patterns of shorebirds. Surveys were conducted at the 10 most important intertidal sites at low-tide. A range of attributes including general features, area, substratum type, presence of seagrass and invertebrate species were sampled. The major characteristics of high-tide roosts in the lower Tweed River estuary were summarised.

2.3.3 Terrestrial Bird Habitat

The major habitat types were identified in the field during 11 to 14 January 2000 (Sandpiper Ecological Surveys 2001a) with reference to vegetation mapping provided by Main Roads (1999).

2.3.4 Amphibians, Reptiles and Mammal Species

Fauna surveys were conducted between January 2000 and March 2001 (Hero *et al*. 2000, 2001a and b). Peak sampling activities were timed to coincide with ideal conditions for mammals (new moon), amphibians (rain events) and other fauna groups. Supplementary survey work was also undertaken for Long-nosed Potoroos (*Potorous tridactylus*) during April - May 2003 by Lewis Ecological Surveys (Bali *et al* 2003). A supplementary survey was also conducted for the Common Planigale (*Planigale maculata*) during June 2004 by Lewis Ecological Surveys (Lewis 2004a).

Initial Surveys

The initial fauna assessment comprised a literature review, database searches and field survey to determine the presence and distribution of amphibians, reptiles and mammals in the general vicinity of the transport corridor. The following databases were searched for an area of approximately 100 kilometre^2 around the study area: Queensland Environmental Protection Agency 'Wildnet', NSW Department of Environment and Conservation Wildlife Atlas and Queensland Museum.

Ten primary survey precincts were selected as being representative of vegetation communities along the proposal corridor. Survey methods involved the use of standardised techniques for fauna, including Elliot traps, cage traps, dry pitfalls, hair tubes, spotlighting, harp traps, mist nets, bat detectors and visual and acoustic surveys (Figures 2.2 and 2.3). Supplementary sampling included Koala *(Phascolarctos cinereus)* spot assessments (Phillips and Callaghan 1995) and predator scat collection. Additional surveys were undertaken for the Common Planigale *(Planigale maculata)*, Wallum Sedge Frog *(Litoria olongburensis)*, Eastern Long-eared Bat *(Nyctophilus bifax)* and Long-nosed Potoroo (*Potorous tridactylus*). Details of survey effort are included in Table 2.1.

Fauna taxonomy or species naming follows Strahan (1998) and Cogger (1992).

Table 2.1: Overall Survey Effort for Amphibians, Reptiles and Mammals along the Proposed Alignment

Survey Method	Sites (Number*)	Traps (Number)	Survey Effort
Trapping			
Elliot traps	14	25 traps x 12 transects, 10 traps x 1 transect, 5 traps x 1 transect	1,285 trap-nights
Cage traps	1	10	40 trap-nights
Pitfall lines	19	5	600 trap-nights
Hair tubes	10	5 tubes x 1 transect, 6 tubes x 6 transects, 10 tubes x 2 transects, 15 tubes x 1 transect	994 trap-nights
Bat Surveys			
Anabat detector	13	N/A	24.75 hours
Harp traps	21	1	30 trap-nights
Mist nets	5	1 site sampled twice 4 sites sampled once	194 metre-hours
Spotlighting	14	N/A	21 person-hours
Herpetelogical Searches			
Nocturnal	N/A	N/A	37.5 person-hours
Diurnal	N/A	N/A	41.5 person-hours
Koala SPOT Assessments	11	N/A	N/A
Predator Scats	58	N/A	12 person-hours
Targeted Searches			
Common Planigale	6	5 pitfall traps	325 trap-nights
	3	40 pitfall traps	845 trap-nights
	3	8 Elliott traps	192 trap-nights
Wallum Sedge Frog	N/A	5 non-consecutive days/nights	Approximately 30 to 40 person-hours
Eastern Long-eared Bat	14	1	12 harp-trap nights, 80 metre-hours mist nets, 3 hours Anabat
Long-nosed Potoroo	16	268 cage traps	1,250 trap-nights,
	3	250 hair tubes	2,000 trap-nights,
	N/A	radio-tracking	330 location fixes

* Some sites used multiple times

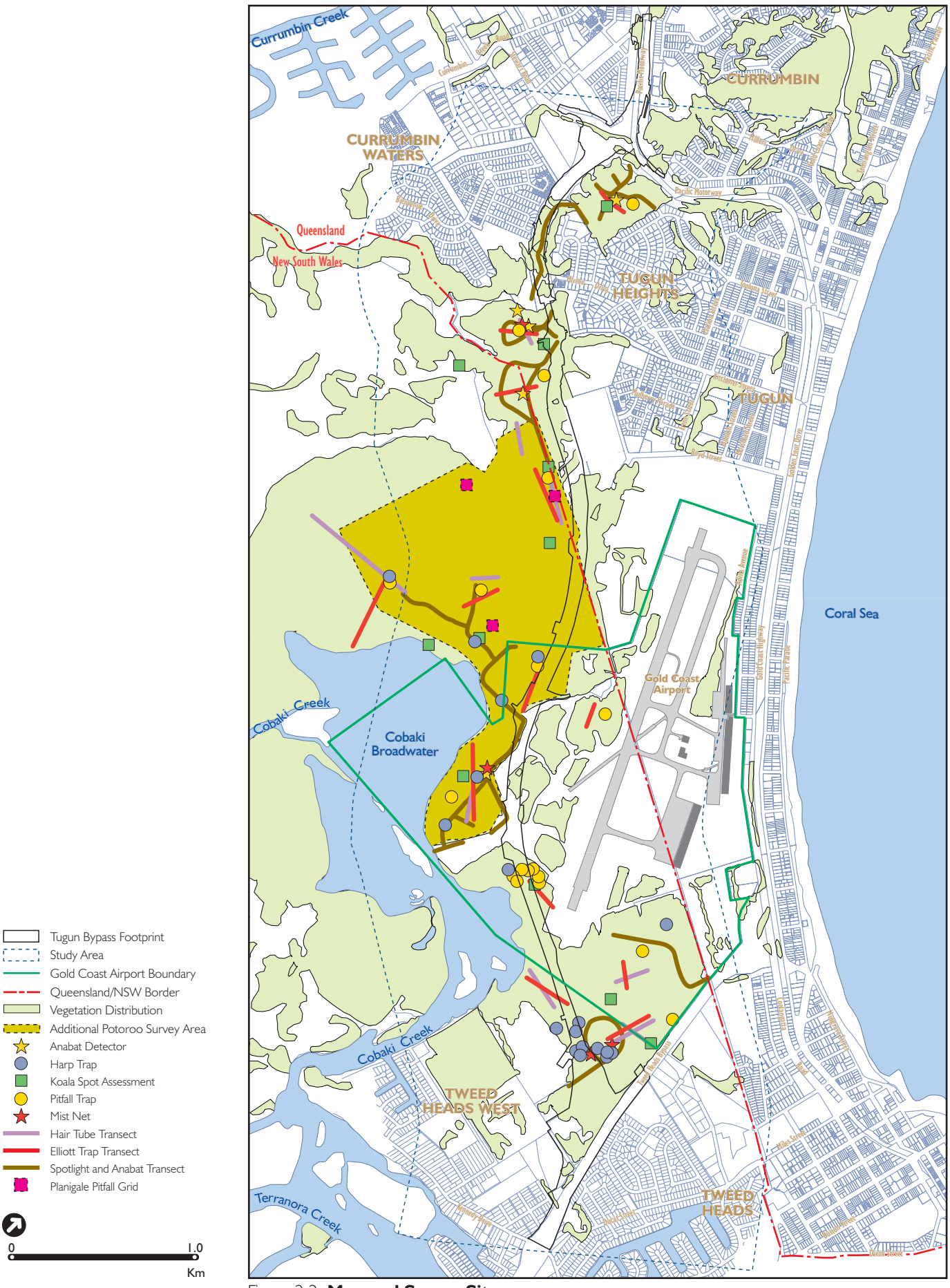


Figure 2.2 **Mammal Survey Sites**

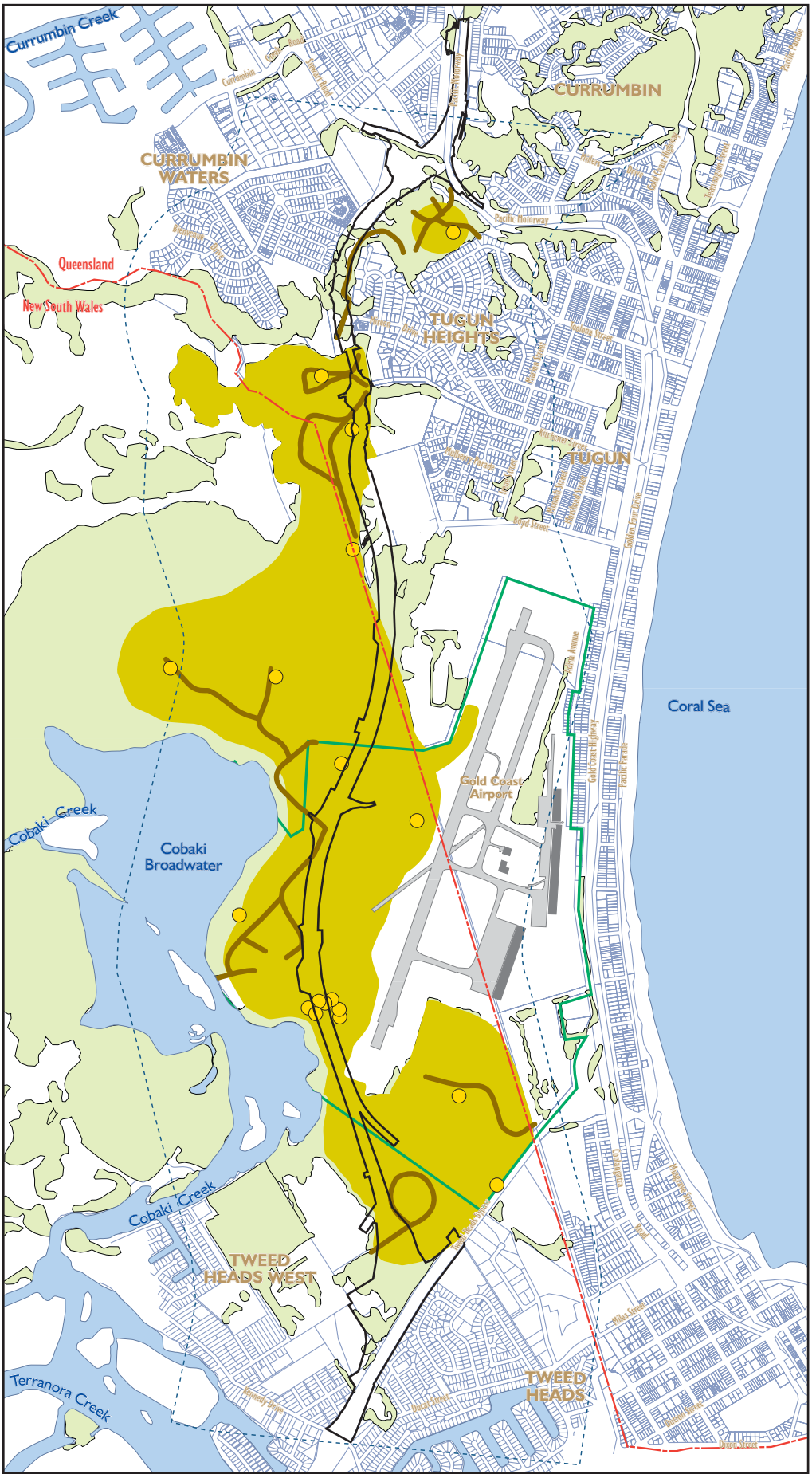


Figure 2.3 **Amphibian and Reptile Survey Sites**

Long-nosed Potoroo Supplementary Survey

Prior to the 2000 – 2001 fauna surveys undertaken for the proposed Tugun Bypass, the population of Long-nosed Potoroos at Cobaki was only known from historical records (Warren 1992 and Mason 1993). The presence of the population was confirmed in the study area through observation of one individual between the access road to the Cobaki Lakes development and the southern flank of the ridge behind the John Flynn Hospital and Medical Centre and the collection of three hair samples (Hero *et al*. 2001a). In order to assess the impacts of the bypass on the population and to recommend appropriate mitigation and compensation measures, it was considered necessary to undertake a detailed trapping and radio-tracking study. Trapping was conducted from 7 April to 30 May 2003 and radio-tracking from 18 April to 30 May 2003. The area intensively surveyed for Long-nosed Potoroos is shown on Figure 2.2.

Overall, a total of 27 potoroos were captured 65 times. Approximately half of these were females (n = 11), of which about half (n = 6) had pouch young. Twelve individuals (5 females and 7 males) were radio-tracked for up to two weeks, providing information about habitat utilisation, movement patterns and home range size.

Common Planigale Supplementary Survey

Lewis Ecological Surveys (2004a) undertook supplementary trapping of the Common Planigale in NSW Crown land to the north of Cobaki Broadwater during 15-24 June 2004. This comprised three 1 hectare grid configurations containing 40 pitfall and eight Elliott traps. A detailed habitat assessment was also undertaken as part of this survey. The three grid locations are shown in Figure 2.2.

2.3.5 Estuarine Bird Species

Sandpiper Ecological Surveys (2001a) surveyed estuarine birds over the periods 21 to 30 January 2000 (summer) and 16 to 21 May 2000 (autumn). The timing of surveys was consistent with a recognised period of stability in the migratory shorebird populations (Watkins 1993). The summer surveys coincided with both a spring and neap tidal cycle and a full moon phase; the autumn surveys coincided with a full moon phase.

Although estuarine birds in the lower Tweed River have been regularly monitored since the 1980s, a short-term survey was conducted near the proposed Tugun Bypass (Figure 2.4). In a local context, habitat use, movement patterns and foraging behaviour of estuarine birds using Cobaki Broadwater were monitored. Details of survey effort are given in Table 2.2.

Estuarine bird taxonomy follows Christidis and Boles (1994).

Table 2.2: Overall Survey Effort for Estuarine Birds along the Proposed Alignment

Survey Method	Locations	Samples (Number)	Survey Effort
High Tide Surveys	22	126	38 hours
Low Tide Surveys	10	20	20 hours
Habitat Use	1 (Cobaki)	2	about 16 hours
Bird movements	1 (Cobaki)	48	about 16 hours

Survey Method	Locations	Samples (Number)	Survey Effort
Foraging	1 (Cobaki)	47	16 hours
Foraging habitat Assessment	10	9 parameters	2.5 hours
Roost Assessment	11	9 parameters	8 hours

2.3.6 Terrestrial Bird Species

Sandpiper Ecological Surveys (2001a and b) surveyed terrestrial birds over the periods 21 to 30 January 2000 (summer) and 16 to 21 May 2000 (autumn), 23 to 27 October (spring) and 4, 6, 15 and 17 February 2001 (summer). Summer surveys coincided with the fruiting period for a number of important feed tree species. The autumn survey was conducted during the peak flowering period for Paperbark Forest.

Stratified sampling was undertaken in which replicate survey sites were selected in each of the major habitat types prior to the survey. Terrestrial birds were surveyed using point counts, area searches, general traverses and canoe traverses, call playback, dusk listening, opportunistic sightings and habitat assessment (NSW Department of Environment and Conservation 1999b). Survey sites are shown in Figure 2.4.

Targeted searches were undertaken for raptor nests, Square-tailed Kite *(Lophoictinia isura)*, Red Goshawk *(Erythrotriorchis radiatus)*, Ground Parrot *(Pezoporus wallicus)*, Rose-crowned Fruit-Dove *(Ptilinopus regina)*, and Black Bittern *(Ixobrychus flavicollis)* (Figure 2.5). Details of survey effort are given in Table 2.3.

Table 2.3: Overall Survey Effort for Terrestrial Birds along the Proposed Alignment

Survey Method	Locations	Samples (Number)	Survey Effort
Point Counts	30	171	14.3 hours
Area Search	89	118	68 hours
General Traverse	17	12 sites sampled once 5 sites sampled twice	21 hours
Canoe Traverse	2	2	6.8 kilometres
Call Playback			
Nocturnal	11	31	about 8.75 hours
Dusk	11	22	about 14.3 hours
Dawn	3	10	about 6.5 hours
Dusk Listening	12	Unknown	7 hours
Bird Movements	1	3	6 hours
Targeted Searches			
Bird of Prey Nest Searches	-	-	20 hours
Ground Parrot	3	2	2.4 hours
Rose-crowned Fruit-Dove	3	2	3 hours
Black Bittern	2	2	2 hours

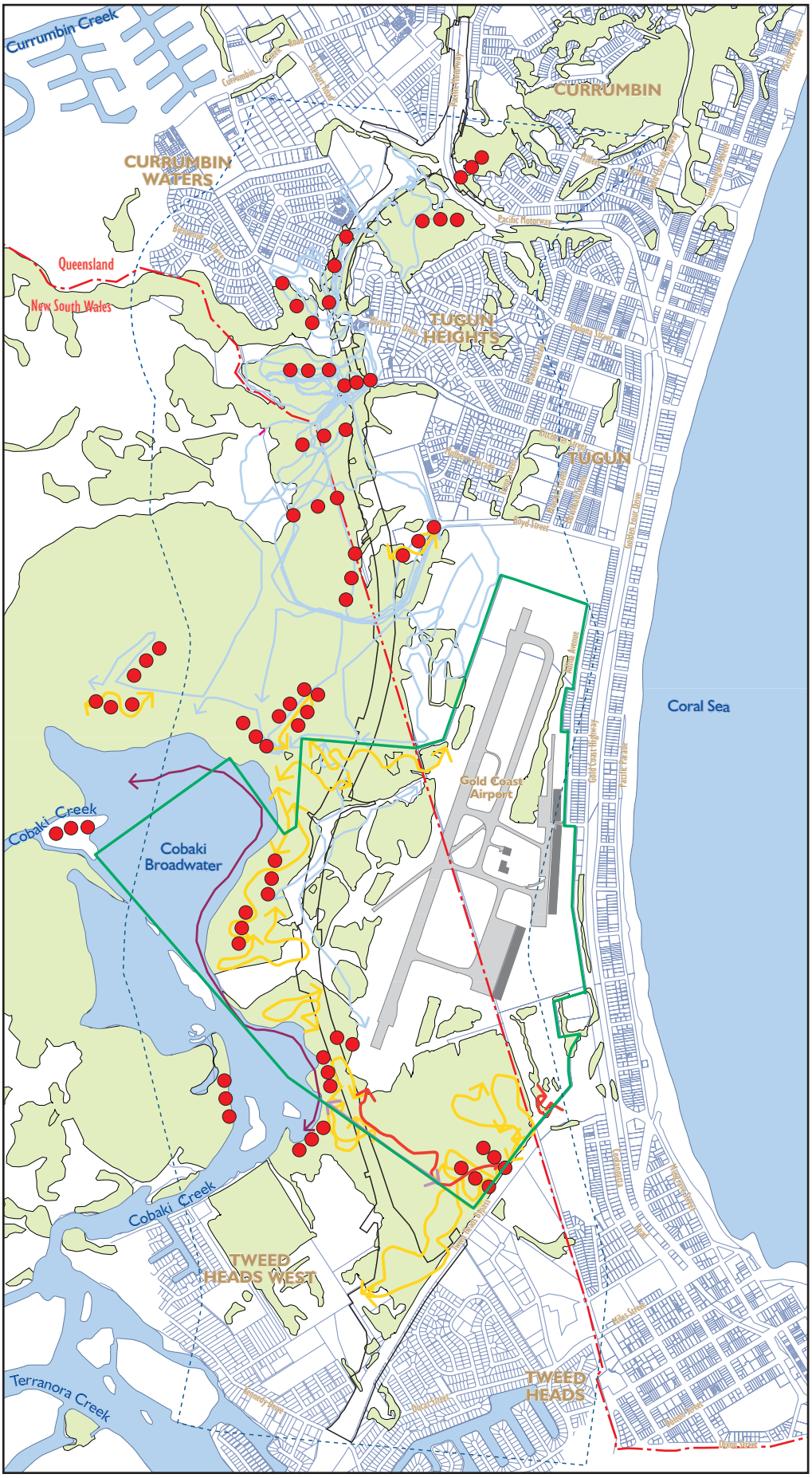


Figure 2.4 **Bird Survey Sites (standard)**

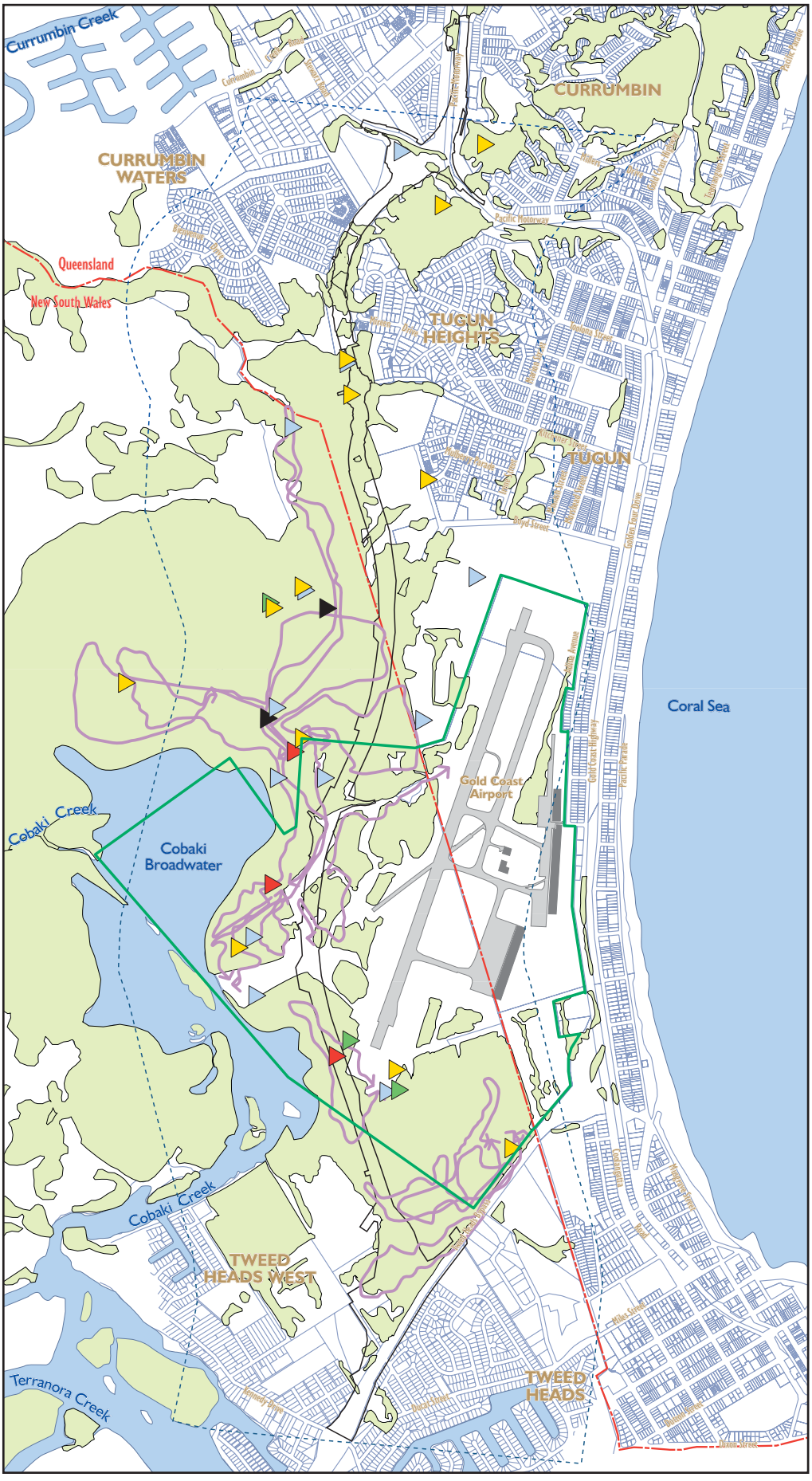


Figure 2.5 **Bird Survey Sites (targeted)**

Terrestrial bird taxonomy follows Christidis and Boles (1994).

Limitations

Mammal, amphibian and reptile surveys are considered to be adequate given the large number of surveys conducted in the area in the past. Extensive survey periods covered several seasons and included wet conditions appropriate for frog sampling. Site coverage was good.

In summer, bird surveys were generally conducted under favourable weather conditions although some nocturnal surveys were subject to periods of heavy cloud and light rain. During autumn surveys, weather conditions were fairly stable. Nocturnal surveys were not conducted on 19 May 2000 due to strong wind and rain. Persistent rain during late January and early February 2001 delayed the start of field work.

A possible limitation is that the majority of surveys were conducted in 2000 and 2001. Since this time a number of sites in the study area have been subject to further disturbance, although this has been discussed within the text and any relevant maps updated. The surveys were undertaken over a range of years, seasons and climatic conditions and therefore have been very intensive in nature and a high biodiversity of species were detected. The intensity of the surveys conducted in the area is considered sufficient to offset the time delay in publication of this document. In addition information has been obtained from monitoring activities regularly conducted on the Airport Land that has been used to supplement information where necessary.

2.3.7 Conservation Significance

Vertebrate Fauna Habitats

In Queensland, fauna habitats are considered of conservation significance at the state level if they are listed as 'endangered' regional ecosystems and therefore protected under the *Vegetation Management Act 1999*. Regional ecosystems afforded 'of concern' status are also considered to be of state significance. Those habitats listed as regional ecosystems 'no concern at present' may be considered as regionally significant.

In NSW, fauna habitats are considered of conservation significance at the state level if they are listed as 'endangered ecological communities' on Part 3 of Schedule 1 of the *Threatened Species Conservation Act 1995*. Habitats comprising vegetation communities considered to be of conservation significance by recognised experts are considered to be of regional significance.

Vertebrate Fauna Species

Fauna species considered to be of conservation significance in Queensland are listed in Schedules 2, 3 and 4 of the Nature Conservation (Wildlife) Regulation 1994. Fauna species considered to be of conservation significance in NSW are listed in Schedules 1 and 2 of the NSW *Threatened Species Conservation Act 1995*. At the national level, fauna species of conservation significance are listed as 'endangered' or 'vulnerable' under the *Environment Protection and Biodiversity Conservation Act 1999*. Two international agreements, the Japan-Australia Migratory Birds Agreement (JAMBA) and the China-Australia Migratory Birds Agreement (CAMBA) have also been considered

for estuarine bird species and their habitat. These agreements are aimed at protecting habitats used by migratory birds.

Fauna species of conservation significance at the regional level are listed in Gilmore and Parnaby (1994).

2.4 Terrestrial Invertebrate Fauna

Targeted searches were undertaken for four invertebrate species – Mitchell's Rainforest Snail (*Thersites mitchellae)*, the Giant Dragonfly *(Petalura gigantea)*, the Queensland Giant Dragonfly *(Petalura litorea)* and the Swordgrass Brown Butterfly *(Tisiphone abeona morrisi)* (Figure 2.6). Completed reports are included in Appendices I and J.

2.4.1 Mitchell's Rainforest Snail *(Thersites mitchellae)*

A field survey was undertaken for land snails targeting Mitchell's Rainforest Snail (*Thersites mitchellae*) on 29 November 2000. The entire route was transected and suitable habitat searched on foot. Potential habitat in Hidden Valley was sampled intensively for two hours while other areas were sampled for varying periods. Sampling included searching for preferred snail microhabitat under fallen logs, rocks and the bark of standing and fallen trees. All land snail species were collected for identification. Visual sighting of shell fragments was undertaken in all parts of the proposed bypass route. A total of some seven hours was spent searching for this species along the alignment.

In order to assess the likely presence of land snails in the proposal area, a search was made of the Queensland Museum's land snail database containing 170,000 specimen records for eastern Australia. Analysis of the taxonomic complexity in an area can provide an indication into the likelihood of particular species being present.

Limitations

Weather and moisture conditions were suitable for snail collecting. The survey followed several days of moderate storm rain in the area and habitat searched was relatively moist. Therefore, it is considered that there are no limitations to the survey.

Conservation Significance

Mitchell's Rainforest Snail (*Thersites mitchellae)* is listed as 'endangered' under Schedule 1 of the NSW *Threatened Species Conservation Act 1995*. It is also listed as 'critically endangered' under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

2.4.2 Giant Dragonflies

A field survey was undertaken for the Giant Dragonfly (*Petalura gigantea*) and Queensland Giant Dragonfly (*Petalura litorea*) on 20 December 2000, 4 and 10 January 2001 and on 22 February 2001 (Reeves 2001).

Figure 2.6 **Invertebrate and Aquatic Survey Sites**

Potential search sites were located on a map showing the proposed bypass. Searches were undertaken for adults, burrows in the substrate, larval exuviae (shed skins) and substrate type. Important habitat characteristics included peaty and moist substrates. Search transects were undertaken 3 to 5 metres apart in suitable habitat with meanders either side to investigate particular habitat features. A total of approximately 25 hours was spent searching for these species.

Limitations

Survey work was restricted by rough terrain and dense Lantana thickets. However, the survey was considered to be adequate as all potential habitats were investigated.

Conservation Significance

The Giant Dragonfly *(Petalura gigantea)* is considered to be 'vulnerable' under International Union for Conservation of Nature (IUCN) guidelines. It is also listed as 'endangered' in NSW under Schedule 1 of the *Threatened Species Conservation Act 1995*.

Until recently, the Queensland Giant Dragonfly was included with the Giant Dragonfly under the single taxon, *Petalura gigantea*. Theischinger (1999) described it as a distinct species, *Petalura litorea*. Although not listed on any legislation, it is considered that the Queensland Giant Dragonfly is of at least regional conservation significance.

2.4.3 Swordgrass Brown Butterfly

Targeted searches for the Swordgrass Brown Butterfly (*Tisiphone abeona morrisi)* were undertaken on 20 December 2000 and on 4 and 10 January 2001 (Reeves 2001). An additional search was undertaken on 22 February 2001 to coincide with the flying of the summer-autumn generation.

Potential search sites were located on a map showing the proposed bypass. Searches were undertaken for adults and larvae sheltering in clumps of Swordgrass (*Gahnia* sp.). Important habitat characteristics include Swordgrass (*Gahnia clarkei* and *G. sieberiana*), the host plant for this species. Search transects were undertaken 3 to 5 metres apart in suitable habitat with meanders either side to investigate particular habitat features. A total of approximately 25 hours was spent searching for this species.

Limitations

The timing of the initial surveys for this species was not appropriate (in relation to life-cycle stage). However, this was overcome by additional sampling during late February 2001.

Conservation Significance

The NSW Department of Environment and Conservation, Director-General Requirements (see Section 1.2) listed the subspecies *Tisiphone abeona rawnsleyi* as a subject species for the purposes of the SIS. However, the distribution of this species extends from the lower valley of the Brisbane River to Fraser Island, Queensland. The subspecies *Tisiphone aboena morrisi* is found in the Tugun study area. Although it is not listed on state or national legislation, it is considered to be of at least regional significance in Queensland.

2.5 Aquatic Biota

The aquatic assessment focussed on the following:

- coastal wetlands fringing Cobaki Creek and adjacent to the airport;
- the aquatic flora, fauna and fisheries of the Cobaki Creek and Broadwater; and
- the freshwater fish fauna of drainage lines and water bodies in the immediate vicinity of the proposed bypass.

The assessment comprised a literature review, examination of historic aerial photos, consultation with relevant agencies and individuals and field surveys.

2.5.1 Wetland Habitats

The wetland habitat survey sites are shown on Figure 2.6 and included:

- reaches below Cobaki Broadwater (Sites RC);
- Cobaki Broadwater (Site CB);
- a small lake formed as a remnant of the dredge pond used during sandmining (Site 1);
- semi-permanently flooded *Melaleuca* dominated wetland (Site 2);
- an extensive wetland subject to occasional tidal inundation located to the immediate west of the southernmost portion of the main airport runway (Site 3);
- a number of drainage lines which flow across the proposed route to the west of the airport – to the north-west, these drains are undisturbed while near the airport they have been channelled and trained (Sites 4a and 4b);
- a small creek meandering through relatively undisturbed bushland to Cobaki Broadwater from the Tugun Landfill (Site 6) to an area downstream of Tandy's Lane (Site 5);
- a substantial channel running east-west through saltmarsh, bordered by a narrow discontinuous band of Grey Mangrove *(Avicennia marina*) and River Mangrove *(Aegiceras corniculatum*) saplings (Site 7); and
- a shallow drainage line that was dry at the time of sampling (Site 8).

2.5.2 Fish Species

Field surveys were undertaken from September 2000 to January 2001 (FRC Environmental 2001). Details of survey effort are provided in Table 2.4. A beam trawl survey was undertaken to survey juvenile finfish, crustaceans (shrimps, crabs etc) and molluscs (shellfish). Replicate trawls measuring approximately 150 metres in length were undertaken at four locations in reaches below the Cobaki Broadwater, adjacent to the NSW *State Environmental Planning Policy Number 14* Wetland Number 5a and in the Broadwater. Trawls were conducted over a single day. Sample sites are shown in Figure 2.6.

Table 2.4: Overall Survey Effort for Fish and Macroinvertebrates along the Proposed Alignment

Survey Method	Locations	Replicates (Number)	Survey Effort
Freshwater Fish Surveys			
Beam trawl	4	3	1.5 kilometres
Gill nets	2	3	540 metre-hours
Baited traps	3	3 sites samples once 4 sites sampled twice	132 trap-hours
Macroinvertebrate Surveys			
Dip net samples	4	3	120 metres

Drainage lines and water bodies in the immediate vicinity of the proposed bypass were surveyed using set nets, dip nets and baited traps. Small, fine-mesh baited traps were set in each surveyed water body to sample yabbies, prawns and freshwater crabs. Surveys were undertaken over a three-day period. Nets and traps were set from early afternoon to approximately 1 hour past light each day.

Dip net samples were taken from relatively natural streams over four sites. Three 10 metre long scoops were taken with a dip net. These scoops collected macro-invertebrate fauna associated with leaf litter of the streambed, vegetation from the banks and small snags. Each sample was returned to the laboratory, frozen and sorted under a microscope.

Basic water quality parameters were recorded in January 2001 from each surveyed water body using an Horiba U10 multi-probe water quality analyser. Parameters included pH, dissolved oxygen, salinity/conductivity, turbidity and temperature.

Fish taxonomy follows: Grant (1991), Hutchins and Swainston (1986) and Merrick and Schmida (1984).

Limitations

On the whole, the aquatic field work was undertaken under suitable conditions although some drainage channels and water bodies were dry or almost dry at the time of sampling.

Conservation Significance

Wetland Habitat

Wetlands listed under NSW *State Environmental Planning Policy Number 14* are regarded as being of state significance in that state (NSW Environment Protection Authority 1997).

Fish Species

Fish of commercial/recreational value are listed in Grant (1991), Quinn (1992) and Williams (1997). At the national and state levels, 'endangered' or 'vulnerable' fish species are listed in *Conservation Status of Australian Fishes* (Australian Society for Fish Biology Conservation 1999), ANZECC (2000) and in Schedules 4 to 6a the NSW *Fisheries Management Act 1994*.

2.6 Regional Mapping for the Study Area

It should be noted that the following regional studies were undertaken in NSW. Therefore, the results only apply to those parts of the proposal in this state. However, this does not mean that important habitats and fauna corridors do not also occur in Queensland.

2.6.1 Key Habitats and Fauna Corridors

The Key Habitats and Corridors Project (Scotts and Drielsma 2003) consolidates areas of potential high conservation value for priority forest fauna and habitat corridors linking these areas across landscapes in north-eastern NSW. Key habitat and corridor maps are indicative only and have been prepared for the purposes of planning and assessing conservation values at a regional scale. The following should be taken into consideration when interpreting key habitat and corridors mapping:

- the mapping is based on fauna models based specifically on the Regional Forest Agreement process in upper and lower north east NSW
- despite some preliminary site assessment, mapped areas have not been ground-truthed
- regional and sub-regional corridors follow least costly pathways, favouring areas that form part of the National Parks and Wildlife Service estate or NSW Crown lands
- numerous qualitative decisions were required to finalise outcomes of the project.

Key habitats were identified by concentrated occurrences of priority species, overlap areas of high quality habitat for priority species, and areas where endemic species are most likely to occur. Landscape connectivity is based on linking core habitats via other predicted habitats following least costly pathways (these favour vegetated areas that form part of the NSW Department of Environment and Conservation estate or NSW Crown lands). Regional fauna corridors are between 1 and 5 kilometres wide whereas sub-regional corridors are 1 to 2 kilometres wide. Mapping provides a landscape context for conservation planning and assessment. It should be noted that fauna corridors do not necessarily take into account land ownership.

2.6.2 Regionally Significant and Core Ecological Areas

The *Tweed Vegetation Management Plan* (Kingston *et al*. 1999) describes Regionally Significant Natural Areas and Core Ecological Areas and Corridors for the Tweed Shire, NSW. These identify areas that are poorly conserved and/or have a major functional role in the landscape.

In general, the larger and more significant areas are classified as Regionally Significant Natural Areas while minor corridor connections are Core Ecological Areas. Other Significant Remnants identify those areas with fewer special characteristics.

Type 2 sub-categories identify areas considered Regionally Significant or Core Ecological Areas because of their incremental contribution to the functional attributes of remnant size and connectivity. The *Tweed Vegetation Management Plan* classifies all remnants in the Shire as follows:

- Regionally Significant Natural Areas – Type 1;
- Regionally Significant Natural Areas – Type 2;

- Core Ecological Areas and Corridors – Type 1;
- Core Ecological Areas and Corridors – Type 2;
- Other Significant Remnants;
- Isolated Small Remnants, Camphor Dominated Areas and Native Plantations; and
- Not Assessed.

Criteria for determining ecological status are given in Appendix N.

2.6.3 Koala Habitat Atlas

The Australian Koala Foundation have undertaken Koala habitat mapping in the Tweed Shire, NSW (Phillips and Callaghan 1996). This comprised searching for signs of Koalas by stratified random plot selection, replicating plots within each vegetation community, delineation of four 20 by 20 metre plots and intensive searches for scats beneath all suitable trees. Analysis of strike rates is based on the number of trees with Koala scats divided by total number of trees recorded in each plot giving an indication of activity levels, tree preference and habitat usage.

Koala habitat use within the Tweed Shire is based primarily on the presence of three eucalypt species, Swamp Mahogany *(Eucalyptus robusta)*, Tallowwood *(E. microcorys)* and Forest Red Gum *(E. tereticornis)*. Four types of Koala habitat were defined:

- Primary Koala habitat comprises communities containing tree species as a dominant or co-dominant component of the canopy that are preferred by Koalas and whose strike rate is independent of density;
- Secondary (Class A) habitat comprises communities containing tree species preferred by Koalas that make up less that 35 percent of the canopy;
- Secondary (Class B) habitat comprises communities where tree species preferred by Koalas are absent or found at low densities (< 10 percent); and
- Unknown habitat comprises vegetation communities where the species composition is unknown but there is a possibility of one or more preferred species being present.

2.7 Assessing Conservation Significance

For the purposes of the present study, conservation significance has been assessed at local, regional, state and national levels according to the following criteria:

- a site is considered to be of local significance for nature conservation if it provides ecological resources and habitat for species, populations and communities in the local area. An accepted definition of local area is within a 10 kilometre radius;
- a site is considered to be of regional significance for nature conservation if it provides ecological resources and habitat for species, populations and communities in the region. In the case of the proposal, the relevant regions are the South-east Queensland Bioregion and the North Coast Region in NSW. Regional significance is generally determined through studies undertaken in the area or through expert opinion;
- a site is considered to be of state significance for nature conservation if it provides ecological resources and habitat for species, populations and communities in the state. Generally, the latter are listed on relevant state legislation; and

- a site is considered to be of national significance for nature conservation if it provides ecological resources and habitat for species, populations and communities in Australia. Generally the latter are referred to in relevant Commonwealth legislation or in international agreements.

3. Existing Habitat

3.1 Overview and Regional Context

The regional and land use context of the study area is shown in Figure 3.1. The proposed route is located in coastal lowlands, spanning the Queensland and NSW border. The Gold Coast Airport is located to the east of the proposed alignment together with a densely populated residential strip. The area to the west is dominated by a mosaic comprising native vegetation remnants, cleared land and the Cobaki Broadwater. Some of the native vegetation in this area is subject to disturbance associated with airport maintenance such as slashing. Although there are a number of locally and regionally significant vegetation remnants in the area, their viability and integrity are threatened by ongoing clearing, weed invasion and other disturbance.

The following information is summarised from Young and Dilleward (1999). The coastal strip and adjacent hills and ranges of northern NSW and southern Queensland (which are part of the South-east Queensland Bioregion) comprise one of the most species-rich areas for flora and fauna in Australia. This area is characterised by moderate to high rainfall with a substantial winter component (up to 30 percent), warm to hot summers and cool winters.

The proposed bypass is located primarily in Southern Coastal Lowlands which are characterised by the presence of heathlands and banksia woodlands, Broad-leaved Paperbark *(Melaleuca quinquenervia)* forests and woodlands, mangrove forests, sedgelands and Scribbly Gum (*Eucalyptus racemosa)* and Blackbutt (*E. pilularis)* open forests. The patterns of species' distribution vary throughout the bioregion with species richness of forests and heathlands tending to decrease from south to north. Many rainforest species are located in the south-eastern part of the bioregion. The drier western part shares species in common with the Brigalow Belt Bioregion located to the west and north.

The high floristic diversity in this bioregion is related to the unique combination of landform, soil and climate. The wide range of habitat types available is directly related to a high diversity of fauna, particularly frogs, turtles, snakes and raptors. It also provides suitable habitat for a number of migratory bird species. More than one-third of terrestrial and freshwater fauna species are at the limit of the distributional ranges here. Similarly, more than one-third of the fauna species listed on Queensland legislation as threatened occur in south-east Queensland.

The greatest threat to biodiversity in the region is population growth and associated infrastructure. This area is one of the most densely populated in Queensland and the rate of population growth is currently high. Much of the remnant vegetation is being cleared and fragmented. Other threats include weed invasion and proliferation of feral animals.

Figure 3.1 **Existing Land Usage**

3.2 Local Context

3.2.1 The proposed bypass alignment in Queensland

The assessment area is located to the west of the main centre of Tugun. The eastern boundary lies within existing residential areas to the east of the proposed alignment, while the western boundary also abuts dense residential areas in the northern section, and a proposed and approved urban settlement to the south. The northern end of the alignment ends at Stewart Road, while the southern end roughly corresponds to Boyd Street just north of the Queensland–NSW border. The Tugun Landfill and a decommissioned sewage treatment plant are located immediately to the east of the proposed alignment in the vicinity of Boyd Street.

The topography varies, with steeper slopes located in the northern part of the route and lowland areas in the vicinity of Boyd Street. The drainage flows north into the lower catchment of Currumbin Creek and south into Cobaki Creek. Run-off from the assessment area drains directly into these creeks, then into estuarine areas or tidal reaches of streams close to the ocean entry points.

3.2.2 The proposed bypass alignment in NSW

The proposed Tugun Bypass crosses NSW land in two locations:

- from the Queensland–NSW border south to the northern boundary of the Gold Coast Airport
- from the southern Gold Coast Airport boundary south to Kennedy Drive, Tweed Heads.

Between the Queensland–NSW border and the northern boundary of Gold Coast Airport, the proposed bypass crosses an area of vacant NSW Crown land that is mostly vegetated. Tugun Landfill drains into this area, and some weed infestation and disturbance is associated with this land use. Run-off from this area drains into Cobaki Broadwater.

The section of the proposed bypass between the southern Gold Coast Airport boundary and Kennedy Drive crosses privately owned and NSW Crown land. The area immediately to the south-east of the airport runway is fragmented and disturbed by access tracks. Land is used for grazing (horses), recreation and light industry. Run-off from this area also drains into Cobaki Broadwater.

3.2.3 The proposed bypass alignment on Commonwealth land

The dominant land use in the study area is the Gold Coast Airport. Approximately 2 kilometres of the proposed Tugun Bypass crosses Commonwealth land associated with the airport. The proposed alignment is located to the west of the main airport runway. The airport lands are subject to ongoing environmental disturbance from management activities including slashing, controlled bird-scaring and licensed bird shooting.

The coastal plain east of the Gold Coast Airport is densely settled. The topography along the proposed route is typical of seasonally and periodically inundated coastal lowlands. Drainage flows west into the Cobaki Broadwater and then into the Tweed River. Artificial drains have allowed tidal waters to encroach further into freshwater

wetlands than would be expected under natural conditions. Run-off from the proposed alignment would be directly into the Cobaki Broadwater via constructed drains.

Land to the west of the proposed bypass includes a National Estate area and a former dredge spoil dump, both of which are inside the boundary of the Gold Coast Airport. The area listed on the Register of the National Estate has aboriginal values and contains one of the few remaining examples of lowland rainforest in north-eastern NSW. With the exception of the area previously subject to sandmining, much of the habitat on the western edge of the proposal is relatively undisturbed.

3.3 Legislative Context

The proposed bypass passes through Queensland, NSW and Commonwealth land. It is therefore subject to state as well as Commonwealth environmental legislation. Legislation relevant to the proposed Tugun Bypass is described briefly below.

3.3.1 Relevant Queensland Legislation

Nature Conservation Act 1992

The *Nature Conservation Act 1992* deals with the legal status and management of 'endangered', 'vulnerable', 'rare' or 'culturally significant' flora and fauna species in Queensland. Species considered to be 'endangered', 'vulnerable' or 'rare' are listed in Schedules 2, 3 and 4 respectively, of the Nature Conservation (Wildlife) Regulation 1994.

Environmental Protection Act 1994

The *Environmental Protection Act 1994* was introduced to protect Queensland's environment while allowing for economic development that is consistent with the principles of ecologically sustainable development.

A key provision of the Act is the general environmental duty of care, which means that a person must not carry out any activity that causes, or is likely to cause harm to the environment, unless the person takes all reasonable and practical measures to prevent or minimise the harm. This environmental duty can be met by the implementation of effective due diligence.

Vegetation Management Act 1999

The Queensland *Vegetation Management Act 1999* was proclaimed on 15 September 2000. The Act makes clearing of native vegetation on freehold land assessable development under the *Integrated Planning Act 1997*. Consequently, a development approval is required for clearing of native vegetation on freehold land. The conservation status for each regional ecosystem is assigned as one of three categories: 'endangered', 'of concern' and 'no concern at present' according to its current distribution relative to its pre-european distribution. The conservation status for each regional ecosystem in Queensland is listed in the Vegetation Management Regulation 2000.

3.3.2 Relevant NSW Legislation

Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979* concerns development planning and control in NSW. It allows local and state governments to prepare land use planning documents that seek to balance environmental, social and economic factors. Local Environmental Plans (LEPs), Regional Environmental Plans (REPs) and State Environmental Planning Policies (SEPPs) determine the development status of a site. The following Environmental Planning Instruments have particular relevance to the proposal:

- *State Environmental Planning Policy Number 14 - Coastal Wetlands* came into force in 1985 to identify wetlands of high conservation value and protect them from development (NSW Environment Protection Authority 1997). It includes maps identifying wetlands of state significance. Provisions under State Environmental Planning Policy set out development guidelines and assessment criteria requirements for any proposed developments.
- *State Environmental Planning Policy Number 71 – Coastal Protection* was gazetted on 1 November 2002. The policy aims to protect and manage the natural, cultural recreational and economic attributes of the NSW coastal zone for the benefit of the NSW community and future generations. It aims to ensure that development within the coastal zone occurs in a strategic manner, and that development is appropriate and suitably located in context to the adjacent and surrounding coastal attributes. The policy aims to ensure that coastal development does not place life and property in conflict or at risk.
- *State Environmental Planning Policy Number 44 - Koala Habitat Protection* commenced in 1995 and aims to encourage conservation and management of Koala habitat to ensure the persistence of permanent populations over their present range and to reverse the current trend of population decline.
- *North Coast Regional Environmental Plan* 1988 is directly relevant to the management of native vegetation within the Tweed Shire. It requires that local councils include significant areas of natural vegetation, including rainforest and littoral rainforest, wildlife habitat, scenic areas and potential wildlife corridors into Local Environmental Plans.

The Environmental Planning and Assessment Act also requires that the potential environmental impacts of a development are assessed. As state significant development, that part of the Tugun proposal that lies in NSW requires development consent and will be assessed under Part 5 of the Act.

Threatened Species Conservation Act 1995

The *Threatened Species Conservation Act 1995* provides for the protection, conservation and recovery of threatened flora and fauna species (excluding fish), populations and ecological communities or their habitats in NSW. These are listed in Schedules 1 and 2 of the Act. The introduction of the Threatened Species Conservation Act in 1996 substantially amended the Environmental Planning and Assessment Act by integrating consideration of threatened species conservation into the planning and assessment process. The effect of a development or activity must be considered by the

consent or determining authority. Where there is likely to be a significant impact on threatened species, populations or ecological communities, a SIS is required.

Fisheries Management Act 1994

This *Fisheries Management Act 1994* provides for the protection, conservation and recovery of threatened fish species and makes provisions for the management of threats to threatened species, populations and communities in NSW waters. These are listed in Schedules 4 to 6A of the Act. The introduction of the Act in 1994 substantially amended the Environmental Planning and Assessment Act by integrating consideration of threatened fish and marine flora conservation into the planning and assessment process. The effect of a development or activity must be considered by the consent or determining authority. Where there is likely to be a significant impact on fish species, populations or ecological communities, a SIS is required.

Native Vegetation Conservation Act 1998

The *Native Vegetation Conservation Act 1998* relates to native vegetation conservation and management in NSW. The Act provides for the preparation of Regional Vegetation Management Plans for all or part of a local government area. Schedules 1 and 2 within the Act identify those local government areas that are totally or partially excluded from the Act. For local government areas subject to the Native Vegetation Conservation Act, all clearing of native vegetation must be undertaken in accordance with the relevant Regional Vegetation Management Plans or with an exemption or a development consent granted by the Minister for Land and Water Conservation. The *Tweed Vegetation Management Plan* (1999) is of relevance to the current project.

Following approval, the NSW Roads and Traffic Authority would take the necessary action to dedicate the proposed route as a public road. In accordance with Section 12(m) of the *Native Vegetation Conservation Act 1998*, the proposal would be excluded from the provisions in that Act in regard to clearing native vegetation by virtue of Section 88 of the *Roads Act 1993*.

3.3.3 Relevant Commonwealth Legislation

Environment Protection and Biodiversity Conservation Act 1999

Under the *Environment Protection and Biodiversity Conservation Act 1999*, any actions that are likely to have a significant impact on a matter of national environmental significance are subject to a rigorous assessment and approvals process. The matters of national environmental significance are:

- World Heritage properties;
- RAMSAR wetlands of international importance;
- listed threatened species and communities;
- migratory species protected under international agreements;
- nuclear actions; and
- the Commonwealth marine environment.

Department of Environment and Heritage has issued administrative guidelines to assist project proponents to determine whether an action, will have, or is likely to have a significant impact on a matter of national environmental significance under the Act.

Relevant schedules list threatened species, ecological communities, migratory species and marine species. The Environment Protection and Biodiversity Conservation Act replaces five Acts, including the *Endangered Species Protection Act 1992*.

Australian Heritage Commission Act 1975

This *Australian Heritage Commission Act 1975* provides for the protection of the National Estate at the Commonwealth level through the identification and listing of places on the Register of the National Estate. Both natural and cultural heritage values are taken into consideration in the listing process. The Act also imposes obligations on the Commonwealth ministers, departments and authorities to protect places listed on the National Estate Register.

Airports (Environment Protection) Regulations 1997

Division 2 of the Commonwealth Airports (Environment Protection) Regulations 1997 sets out a general duty to preserve habitat on airport sites. This includes the necessity for the operator to undertake all reasonable and practical measures to ensure that there are no adverse consequences for local biota and ecosystems, endangered flora and fauna and ecological communities known to be endangered.

Japan-Australia Migratory Birds Agreement (JAMBA)

The Japan-Australia Migratory Birds Agreement was signed in 1988 and provides for the conservation of habitat for migratory shorebird species migrating between Australia and Japan.

China-Australia Migratory Birds Agreement (CAMBA)

The China-Australia Migratory Birds Agreement was signed in 1988 and provides for the conservation of habitat for migratory shorebird species migrating between Australia and China.

3.3.4 Regional and Local Plans and Strategies

The following regional and local plans and strategies have also been considered for NSW and Queensland:

- *Gold Coast City Council Planning Scheme – Our Living City* (Gold Coast City Council 2003);
- *Draft Gold Coast City Council Nature Conservation Strategy* (Ecograph and Mary Maher & Associates 1997);
- *Draft Regional Conservation Strategy for South-east Queensland 2001-6* (Queensland Environmental Protection Agency 2001b);
- *Southern Gold Coast – Tweed Corridor Study* Working Paper Number 1 - *Biological Constraints Analysis* (Queensland Transport 1997); and
- *Tweed Local Environmental Plan* 2000 (Tweed Shire Council 2000).

4. Survey Results

4.1 Terrestrial Flora

4.1.1 Vegetation Communities

Thirty-seven vegetation communities have been identified from within the study area. These communities are briefly described below, while their distribution is shown on Figure 4.1. The proposed bypass would directly affect 28 of these vegetation communities.

Littoral Rainforest

Structure: Tall (18 to 20 m) closed forest; sparse small tree layer (15 m); mid-stratum sparse; lower stratum dense.

Floristics: The canopy is dominated by Moreton Bay Fig *(Ficus macrophylla)*, while the Bangalow Palm *(Archontophoenix cunninghamiana)* and young figs form the small tree layer. Other common species in the small tree layer include Broad-leaved Paperbark, Cheesetrees *(Glochidion ferdinandi* and *G. sumatranum)* and Blueberry Ash *(Elaeocarpus reticulatus)*. The understorey is composed of ferns and sedges. This community would meet the classification of the Endangered Ecological Community Littoral Rainforest in the North Coast Bioregion

Distribution: This community occurs in a small patch of forest on Commonwealth land adjacent to the Cobaki Broadwater. It occupies 3.5 hectares of land in the study area. None of this vegetation type would be removed as a result of the Tugun Bypass proposal.

Regenerating Vine Forest

Structure: Mid-tall open canopy (12 to 18 m); dense mid-stratum; dense lower stratum.

Floristics: The canopy is dominated by Sandpaper Fig (*Ficus coronata*) and Bangalow Palm (*Archontophoenix cunninghamiana*). The understorey is dominated by Lantana (*Lantana camara*), although other common species include Cheesetree (*Glochidion ferdinandi*), wattles (*Acacia aulacocarpa* and *A. melanoxylon*), Ochra (*Ochra serrulata*) and *Commersonia bartramia*. The ground cover is dominated by ferns and soft forbs (herbaceous plants with broad leaves). This community would meet the classification of the Endangered Ecological Community Littoral Rainforest in the North Coast Bioregion

Distribution: This community occurs in a steep valley just to the north of the Queensland border (known locally as Hidden Valley). It totals 10.6 hectares in the study area. This community would be affected by the construction of a bridge over the valley, with a total of 0.6 hectares being removed.

Moist Blackbutt Forest

Structure: Tall (25 to 30 m) closed forest; mid-dense to dense mid-stratum; dense lower stratum.

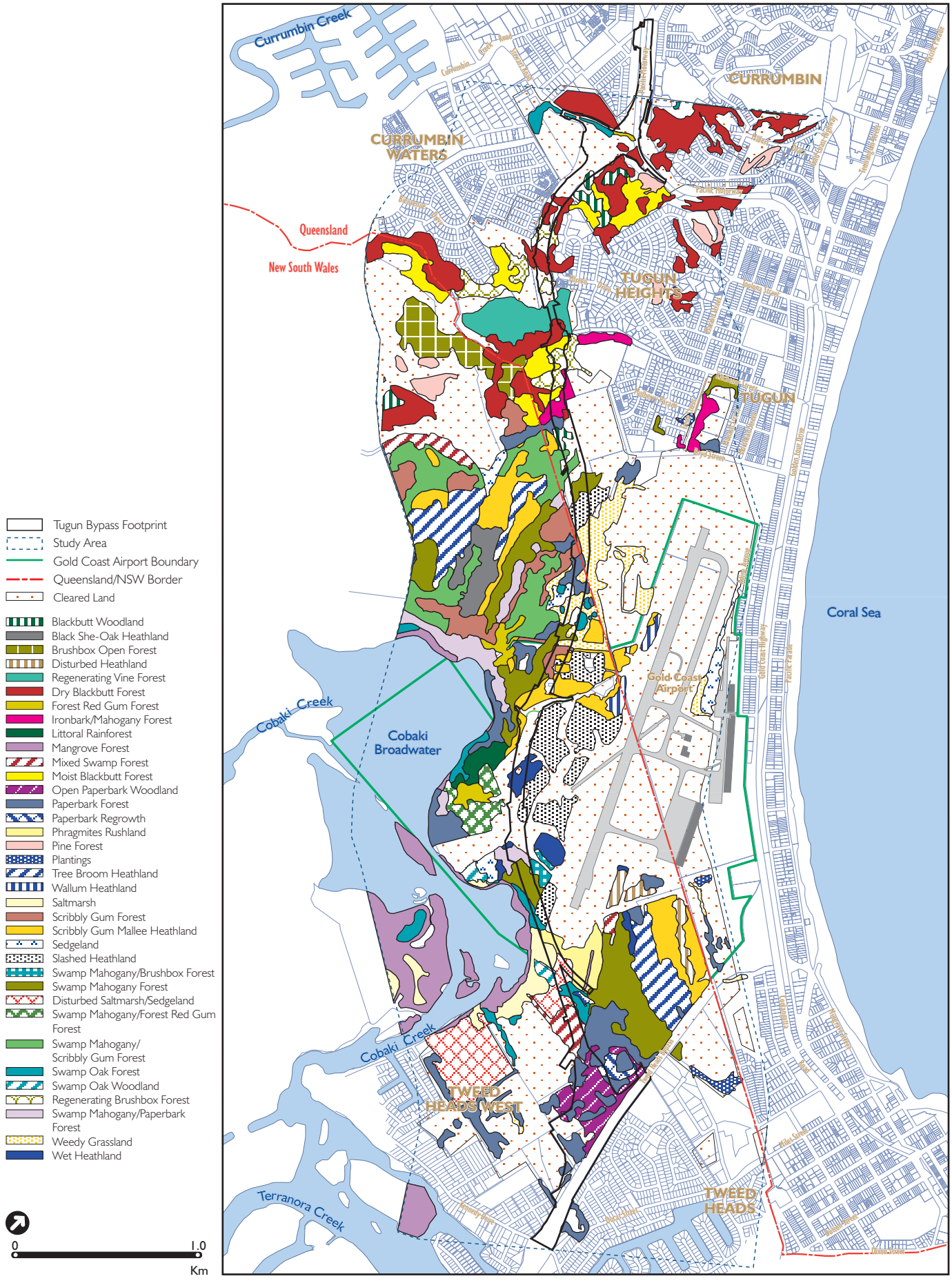


Figure 4.1 **Vegetation Communities**

Floristics: The dominant canopy species in this community is Blackbutt (*Eucalyptus piluaris*) with Brushbox (*Lephostemon confertus*), Tallowwood (*E. microcorys*), Flooded Gum (*E. grandis*) and Grey Gum (*E. propinqua*) less commonly occurring. The understorey is composed of a variety of rainforest trees and weeds including Cheesetree, Lantana and Camphor Laurel (*Cinnamomum camphora*). The ground cover is dominated by grasses and ferns.

Distribution: This community is found in a number of sheltered gullies in the northern portion of the study area, primarily north of the Queensland-NSW border. This vegetation type covers an area of 17.1 hectares in the study area, with the proposed bypass resulting in the removal of 0.9 hectares of this community from Queensland.

Dry Blackbutt Forest

Structure: Tall (25 to 30 m) closed forest; sparse mid-stratum; sparse to dense lower stratum.

Floristics: The dominant canopy species in this community is Blackbutt, with an occasional Red Ironbark (*E. siderophloia*) and Grey Gum. The understorey is sparse and includes Bush Pea (*Daviesia arborea*), Scrub Ironbark Wattle (*Acacia aulacocarpa*) and Lantana. The ground cover is dominated by a variety of grasses.

Distribution: This community is found in the north of the study area on more elevated land. It occupies 50.9 hectares of land in the study area, with the proposed bypass resulting in the removal of 3.5 hectares of this community from Queensland.

Blackbutt Woodland

Structure: Tall (25 to 30 m) woodland to open woodland; sparse mid-stratum; dense lower stratum.

Floristics: The dominant canopy species in this community is Blackbutt. The understorey is sparse and non-existent in many areas. The ground cover is dominated by a variety of grasses.

Distribution: This community occurs in the northern section of the study area and has been subject to disturbance. It occupies 4.5 hectares of land in the study area with the proposed bypass resulting in the removal of 0.7 hectares of this community type from Queensland.

Ironbark–Mahogany Forest

Structure: Tall (20 to 25 m) closed forest; sparse to mid-sparse mid-stratum; sparse to dense lower stratum.

Floristics: The dominant trees in this community are Red Ironbark and White Mahogany (*E. acmenoides*). Other occasional species include Spotted Gum (*Corymbia maculata*), Tallowwood and Grey Gum. The mid-stratum consists of isolated shrubs typical of dry sclerophyll forests, while the herb layer is dominated by a variety of grasses.

Distribution: This community occurs in the northern part of the study area. This vegetation type occupies 5.7 hectares of land in the study area, with the proposed bypass resulting in the removal of approximately 1.1 hectares from Queensland.

Scribbly Gum Forest

Structure: Mid-tall (15 to 20 m) closed forest; mid-dense small tree layer (8 to 12 m); mid-stratum sparse to dense; lower stratum sparse to mid-dense.

Floristics: The dominant tree in this community is Scribbly Gum (*E. racemosa*). Other species include Red Bloodwood (*Corymiba gummifera*) (common) and Pink Bloodwood (*C. intermedia)* (less common). The small tree layer is dominated by banksias (*Banksia aemu*lea and *B. oblongifolia*). The shrub layer is often dominated by tea-tree (*Leptospermum polygalifolium* and *L. whitei*), while the herb layer is dominated by a variety of grasses, sedges and herbs.

Distribution: This community is found primarily in a large patch of intact forest to the north of the Cobaki Broadwater. This forest type occupies 17.8 hectares of land in the study area, with the proposed bypass resulting in the removal of 1.1 hectares of this community type (0.3 hectares in NSW, 0.75 hectares on Commonwealth land and 0.03 hectares in Queensland).

Forest Red Gum Forest

Structure: Tall (20 to 30 m) closed forest; mid-stratum dense to mid-dense; lower stratum dense.

Floristics: The dominant tree species in this community is Forest Red Gum (*E. tereticornis*), with less commonly occurring species including Red Bloodwood, Brushbox and occasionally Swamp Mahogany (*E. robusta*). The shrub layer is composed of a variety of swamp and rainforest species, while the herb layer is dominated by ferns, sedges and grasses.

Distribution: This community occurs in a few small patches on the north-eastern edge of the Cobaki Broadwater and further to the north. It occupies about 4.6 hectares of land in the study area with the proposed bypass resulting in the removal of about 0.2 hectares of this community in Queensland.

Brushbox Open Forest

Structure: Tall (20 to 25 m) open forest; mid-stratum dense to mid-dense; lower stratum dense.

Floristics: The canopy in this community is dominated by Brushbox, although an occasional Tallowwood, Grey Gum or Blackbutt may occur. Rainforest shrubs, young eucalypts and weeds, especially Lantana, dominate the mid-stratum. The herb layer is composed of grasses and ferns.

Distribution: This community occupies 12.3 hectares mainly in sheltered gullies in the northern part of the study area, none of which would be removed as a result of the proposed bypass.

Regenerating Brushbox Forest

Structure: Mid-tall (12 to 16 m) open to closed canopy; mid-stratum dense; lower stratum mid-dense to dense.

Floristics: Similar floristic composition to the Brushbox Open Forest community, although more weed species are present.

Distribution: This community occupies 9.2 hectares of the study area, with the proposed bypass resulting in the removal of 2.5 hectares of this vegetation type in Queensland.

Swamp Mahogany Forest

Structure: Mid-tall (12 to 18 m) open forest and woodland; mid-stratum dense to mid-dense; lower stratum dense.

Floristics: The canopy is dominated by Swamp Mahogany with an occasional Broad-leaved Paperbark. The shrub layer is dominated by Swamp Banksia (*Banksia robur*) and Grass Tree (*Xanthorrhoea latifolia),* with occasional Broad-leaved Paperbark, Sally Wattle (*Acacia melanoxylon)*, Umbrella Cheesetree (*Glochidion sumatranum),* Common Tea-tree (*Leptospermum polygalifolium*) and Beard Heath (*Leucopogon lanceolatus* var. *gracilis*). The herb layer is composed of ferns and sedges.

Distribution: This community occurs in a number of patches in the low-lying areas around the Cobaki Broadwater, as shown on Figure 4.1. It covers 38.1 hectares of the study area, with the proposed bypass resulting in the removal of about 3.25 hectares of this vegetation type (0.6 hectares in NSW, 1.75 hectares from Commonwealth land and 0.9 hectares from Queensland).

Swamp Mahogany–Brushbox Forest

Structure: Tall (18 to 20 m) open to closed forest; mid-stratum mid-dense to sparse; lower stratum dense.

Floristics: The canopy is dominated by Swamp Mahogany with an occasional Swamp Brushbox (*Lephostemon suaveolans*). The shrub layer is similar to that of Swamp Mahogany Forest, although more sparsely distributed. The herb layer is composed of ferns and sedges.

Distribution: This community occurs in two small patches in Commonwealth land. The community covers 1.4 hectares of the study area, with the proposed bypass removing approximately 0.1 hectares of this vegetation type from Commonwealth land.

Swamp Mahogany – Scribbly Gum Forest

Structure: Mid-tall (12 to 18 m) open forest; mid-stratum dense to mid-dense; lower stratum dense.

Floristics: The canopy is dominated by Swamp Mahogany and Scribbly Gum. An occasional Broad-leaved Paperbark and Banksia also occur. The shrub and herb layer is similar to that of Swamp Mahogany Forest.

Distribution: This community occurs in the large patch of forest to the north of Cobaki Broadwater. It occupies 28.2 hectares of the study area, with the proposed bypass resulting in the removal of 0.5 hectares in Queensland.

Swamp Mahogany – Forest Red Gum Forest

Structure: Mid-tall to tall (15 to 25 m) closed forest; mid-stratum sparse; lower stratum dense.

Floristics: The canopy is dominated by Swamp Mahogany and Forest Red Gum, with an occasional Bangalow Palm or Broad-leaved Paperbark. The shrub layer is

dominated by rainforest and swamp shrubs, while the herb layer is composed of ferns and sedges.

Distribution: This community occurs in a small patch of forest on the eastern side of the Cobaki Broadwater on Commonwealth land. It occupies 5.9 hectares of the study area. The proposed bypass would not result in the removal of any of this vegetation type.

Swamp Mahogany–Paperbark Forest

Structure: Mid-tall (12 to 18 m) closed forest; mid-stratum mid-dense; lower stratum dense.

Floristics: The canopy is dominated by Swamp Mahogany and Broad-leaved Paperbark. The shrub layer is dominated by Swamp Banksia and Grass Tree and other swamp shrub species. The herb layer is composed of ferns and sedges.

Distribution: This community is found in the lower lying parts of the study area around the Cobaki Broadwater, often as an ecotone between Swamp Mahogany Forest and Paperbark Forest. This community occupies 12.3 hectares in the study area, with the proposed bypass resulting in the removal of about 1.25 hectares of this vegetation type, including 0.4 hectares from NSW and 0.85 hectares from Commonwealth land.

Paperbark Forest

Structure: Mid-tall (14 to 20 m) closed to open forest; mid-stratum sparse to mid-dense; lower stratum dense.

Floristics: The canopy is dominated by Broad-leaved Paperbark, although an occasional Swamp Mahogany or Camphor Laurel also occurs. The shrub layer is dominated by swamp shrub species and weeds, while the herb layer is composed of ferns, grasses and sedges.

Distribution: This community is found on all sides of the Cobaki Broadwater in low-lying areas. It occupies 39.8 hectares of the study area with the proposed bypass resulting in the removal of 6.6 hectares of this vegetation type (6.3 hectares in NSW and 0.3 hectares in Queensland).

Open Paperbark Woodland

Structure: Mid-tall (12 to 18 m) woodland to open woodland and scattered trees; mid-stratum sparse to dense; lower stratum dense.

Floristics: Broad-leaved Paperbark dominates the canopy, with Swamp Brushbox and Coast Banksia (*Banksia integrifolia*) also occurring. The shrub layer when present is primarily composed of weed species and regenerating paperbarks. The herb layer is composed of grasses and sedges.

Distribution: This community is found at the southern end of the study area, which has been subject to previous disturbance. It occupies 8.8 hectares of the study area, with the proposed bypass resulting in the removal of 6.45 hectares of this vegetation type in NSW.

Paperbark Regrowth

Structure: Low (6 to 12 m) closed to open forest; no mid-stratum sparse; lower stratum sparse to dense.

Floristics: The dominant species in this community is Broad-leaved Paperbark, although an occasional swamp, heath species and weed species also occur. The herb layer is composed of ferns, grasses and sedges.

Distribution: This community is found in the southern portion of the study area, to the south of the airport. It occupies 1.9 hectares of land in the study area, with the proposed bypass resulting in the removal of 0.25 hectares of this community in NSW.

Swamp Oak Forest

Structure: Mid-tall (10 to 12 m) closed forest; mid-stratum sparse; lower stratum sparse to dense.

Floristics: The canopy is dominated by Swamp Oak (*Casuarina glauca*). The shrub layer is composed of young Swamp Oak, while the herb layer is composed of grasses and sedges.

Distribution: This community is found primarily around the edges of the Cobaki Broadwater, although a few patches occur in other low-lying areas. In Queensland a small patch of this community is found adjacent to the proposed Stewart Road Interchange. This vegetation type occupies 10.5 hectares of land in the study area, with the proposed bypass resulting in the removal of 1. 5 hectares, including 0. 6 hectares from NSW, 0.3 hectares from Commonwealth land and 0.6 hectares from Queensland.

Swamp Oak Woodland

Structure: Mid-tall (10 to 12 m) open forest to woodland; mid-stratum sparse; lower stratum sparse to dense.

Floristics: The floristic composition is similar to that of Swamp Oak Forest.

Distribution: This community is found in two small patches around the south-eastern edge of the Broadwater. This community has been subject to disturbance and occupies 2.0 hectares of land in the study area, 0.02 hectares of which would be removed as a result of the proposed bypass in NSW.

Mixed Swamp Forest

Structure: Mid-tall (12 to 18 m) closed forest; mid-stratum mid-dense to sparse; lower stratum dense.

Floristics: The canopy is dominated by Swamp Oak and Broad-leaved Paperbark, with an occasional Swamp Mahogany. The shrub layer is dominated by swamp shrub species, while the herb layer is composed of ferns, sedges and grasses.

Distribution: This community occurs at the southern end of the proposal area in land currently used by the Tweed Heads Pony and Hack Club. It occupies 8.5 hectares of land in the study area, with the proposed bypass resulting in the removal of 1.7 hectares in NSW.

Scribbly Gum Mallee Heathland

Structure: Tall (12 to 18 m) open to closed shrubland; lower stratum mid dense to dense.

Floristics: The dominant species in this community are Scribbly Gum, Wallum Banksia and Weeping Baekea. A variety of other shrub species also occurs in this area. The herb layer is dominated by grasses.

Distribution: This community occurs throughout much of the gently undulating parts of the study area. This vegetation type occupies 32.5 hectares of the study area with the proposed bypass resulting in the removal of about 2.1 hectares from Commonwealth land.

Tree Broom Heathland

Structure: Tall (3 to 7 metres) open to closed shrubland; lower stratum mid-dense to dense.

Floristics: The tall shrub layer is dominated by Tall Broom Heath (*Monotoca elliptica*), Beard Heath (*Leucopogon leptospermoids),* Weeping Baeckea*,* Common Tea-tree*,* White's Tea-tree (*Leptospermum whitei*) and Dwarf Banksia (*Banksia oblongifolia*). The herb layer is dominated by sedges and other soft forbs.

Distribution: This community is found scattered throughout the study area, on slightly elevated land often adjacent to Swamp Mahogany Forests. It occupies 25.6 hectares of land in the study area. The proposed bypass would not result in the removal of any of this vegetation type.

Wet Heathland

Structure: Tall (2 to 6 m) closed heathland, lower stratum sparse to dense.

Floristics: This community is dominated by Swamp Banksia, tea-trees (*Leptospermum polygalifolium*, *L. semibaccatum*, *L. trinervium* and *L. whitei*) and Broad-leaved Paperbark, with young Swamp Mahogany sometimes occurring. The herb layer is dominated by sedges and grasses.

Distribution: This community is found only in low-lying areas of the Commonwealth land and occupies 5.9 hectares of the study area. The proposed bypass would result in the removal of 1.3 hectares of this vegetation type from Commonwealth land.

Wallum Heathland

Structure: Mid-tall (1 to 2 m) closed heathland; lower stratum sparse.

Floristics: This community is dominated by Wallum Banksia, Weeping Baeckea and Saw Sedges (*Gahnia clarkei* and *G. sieberana*). Occasionally other species occur throughout the area, including wattles and grass trees. The herb layer is dominated by sedges and grasses.

Distribution: This community is found on the Commonwealth land and in NSW, occupying 2.5 hectares of the study area. The proposed bypass would not result in the removal of any of this vegetation type.

Disturbed Heathland

Structure: Low to tall (1 to 6 m) open to closed heathland; lower stratum sparse to dense.

Floristics: This community has similar floristics to Wallum Heathland, although it may include species also found in Tree Broom Heathland. This vegetation community has been subject to disturbance and is in the process of regenerating.

Distribution: This community occupies 4.6 hectares of land at the south-eastern end of the airport runway on Commonwealth land. The proposed bypass would not result in the removal of any of this vegetation type.

Black She-oak Heathland

Structure: Tall (3 to 6 m) closed heathland; lower stratum sparse.

Floristics: This community is dominated by Black She-oak (*Allocasuarina littoralis*), with other heathland and scrub species being less common. An occasional Red Bloodwood occurs in this area. The sparse herb layer is composed primarily of Bracken Fern (*Pteridium esculentum*) and grasses.

Distribution: This community is found in the large area of NSW Crown land to the north of Cobaki Broadwater. It occupies 7.9 hectares of land in the study area. The proposed bypass would not result in the removal of any of this vegetation type.

Slashed Heathland

Structure: Low (0.2 to 0.5 m) closed shrubland.

Floristics: This community has a varied species composition, depending on location; however, it is primarily composed of species also found in Scribbly Gum Mallee Heathland and Wet Heathland.

Distribution: This community occurs on the Commonwealth land, where heathland has been subject to continual slashing near the Gold Coast Airport. It also occurs to the south of the Pacific Beach Estate in Queensland. It occupies 24.1 hectares of land in the study area, with the proposed bypass resulting in the removal of 3.2 hectares of this vegetation type (1.8 hectares from Commonwealth land and 1.4 hectares from Queensland).

Saltmarsh

Structure: Low (0 to 0.1 m) sedgeland.

Floristics: The dominant species in this community are Salt Couch (*Sporobolus virginicus*), *Triglochin striatum*, Sea Rush (*Juncus krausii*), *Suadea australis,* Samphire (*Sarcocornia quinqueflora*) and Common Reed (*Phragmites communis*). This community would meet the classification of the Endangered Ecological Community Coastal Saltmarsh in the NSW North Cost Bioregion.

Distribution: This community is found adjacent to the Mangrove Forest fringing the Cobaki Broadwater. It occupies 8.8 hectares in the study area. The proposed bypass would result in the removal of about 0.57 hectares of this vegetation type in Commonwealth Land

Disturbed Saltmarsh–Sedgeland

Structure: Low (0 to 0.1 m) sedgeland.

Floristics: The species composition in this area is occasionally similar to that of the Saltmarsh community, although there are more weeds and the area is often dominated by Common Reed (*Phragmites communis*). In some areas regeneration of Swamp Oaks and Tea-trees is also occurring.

Distribution: This community is in low-lying areas to the south of Cobaki Broadwater, which have been subject to disturbance in the past. It occupies 18.3 hectares of land in the study area, with 1.4 hectares of this vegetation removed as a result of the proposed bypass in NSW.

Mangrove Forest

Structure: Low (6 to 8 m) closed to open forest, mid-stratum sparse, lower stratum sparse.

Floristics: The dominant species in this community is Grey Mangrove (Avicennia marina), Red Mangrove (*Rhizophora stylosa*), River Mangrove (*Aegiceras corniculatum*), Large Leafed Orange Mangrove (*Burguiera gymnorrhiza*), Blind Your Eye Mangrove (*Excoecaria agallocha*) and Mangrove Fern (*Acrostichum speciosum*). The lower stratum is dominated by similar species to those found in the Saltmarsh community.

Distribution: This community occurs along the tidal fringes of the Cobaki Broadwater in the study area. It occupies 33.7 hectares in the study area, with the proposed bypass resulting in the removal of 0.05 hectares of this vegetation type from Commonwealth land.

Phragmites Rushland

Structure: Previously very tall (1 to 1.5 m) dense rushland, dense. Recent slashing has reduced the height of this community to less than 0.3 metres in height.

Floristics: The dominant species in this community are Common Reed (*Phragmites communis*) and Saltmarsh Twig Rush (*Baumea juncea*). A number of other sedges and ferns also occur in the area, and Prickly Tea-tree (*Leptospermum juniperinum*) occasionally occurs in the area.

Distribution: This community occurs in a wide band around the southern end of the main airport runway. It occupies 5.7 hectares of land with the proposed bypass resulting in the removal of 1.05 hectares from Commonwealth land.

Sedgeland

Structure: Tall (0.6 to 1 m) closed sedgeland.

Floristics: This community is dominated by Saltmarsh Twig Rush, although other sedges and reeds also occur.

Distribution: This community occurs around the edges of wet areas, occupying 7.1 hectares in the study area. The proposed bypass would result in the removal of 0.02 hectares of this vegetation type from NSW.

Weedy Grassland

Structure: Very tall (1 to 1.5 m) closed grassland.

Floristics: This community is dominated by weeds and introduced grasses as a result of high nutrient levels.

Distribution: This community occurs around the Tugun Landfill and in a few other small areas where nutrient-rich run-off occurs. It occupies 18.3 hectares of land in the study area, with the proposed bypass resulting in the removal of 3.3 hectares of this vegetation type (1.75 hectares in NSW, 0.05 hectares from Commonwealth land and 1.5 hectares in Queensland).

Cleared Land

Structure: Tall to low (0.2 to 1 m) dense to sparse grassland.

Floristics: This community has been cleared in the past, with very little regrowth occurring due to a variety of reasons. Any vegetation in these areas usually consists of introduced grasses and weeds. This community is dominated by a variety of native and introduced grasses, with some weed species occurring.

Distribution: This community is extensive throughout the study area, totalling 349.4 hectares. The proposed bypass would result in the removal of 23.0 hectares, including 13.3 hectares in Queensland, 5.8 hectares from Commonwealth land and 3.9 hectares from NSW.

Pine Forest

Structure: Tall (20 to 25 m) closed forest; mid-stratum sparse; lower stratum sparse to mid-dense.

Floristics: This community is dominated by Hoop Pine (*Araucaria cunninghamii*). A number of other species may intrude from surrounding vegetation communities, although the diversity of species is very low.

Distribution: This community is found in scattered patches throughout the study area. It occupies 7.7 hectares, of which none would be removed by the proposed bypass.

Plantings

Structure: The structure of this community is highly variable, depending upon the age and type of the plantings.

Floristics: The floristic composition of this community is also highly variable, but usually consists of native eucalypts and introduced species.

Distribution: This community is found primarily adjacent to urban areas. It occupies 2.3 hectares in the study area, none of which would be removed as a result of the proposed bypass.

4.1.2 Conservation Significance

Vegetation communities of conservation significance recorded along the proposed alignment are shown in Figure 4.2 and described below.

Queensland

Remnant vegetation in Queensland is managed at state and regional levels through the Regional Ecosystem (RE) framework. Vegetation communities described for the study area have been correlated against regional ecosystems as outlined in Table 4.1.

Table 4.1: Correlation of Vegetation Communities in the Queensland Portion of the Study Area to Regional Ecosystems (RE)

Vegetation Community	Corresponding Regional Ecosystem	Description
Regenerating Vine Forest	12.11.1	This community appears to be regenerating RE 12.11.1 (notophyll rainforest and/or *Lophostemon confertus* forest in gullies) on metamorphics 'no concern at present'. *Lantana camara* dominated areas containing vine forest taxa including scheduled species Stinking Cryptocarya (*Cryptocarya foedida*).
Ironbark-Mahogany Forest	12.11.5	This community resembles RE 12.11.5 tall open forest in which Spotted Gum is a relatively common species on Mesozoic to Proterozoic moderately to strongly deformed and metamorphosed sediments and interbedded with volcanics 'no concern at present'.
Moist Blackbutt Forest/Dry Blackbutt Forest/Blackbutt Woodland	12.11.5f	Partially degraded Blackbutt communities have elements consistent with RE 12.11.5f tall open forest of *Eucalyptus pilularis, E. microcorys, Angophora woodsiana* ± *E. racemosa, E. tindaliae, Corymbia trachypholia, C. intermedia, C. gummifera, E. resinifera* (Nerang area). Despite having a conservation status of 'not of concern' advice from Queensland Herbarium is that this regional ecosystem is considered to be regionally significant.
Scribbly Gum Forest	12.2.6/12.2.9	This community resembles RE 12.2.6/12.2.9 *Eucalyptus racemosa* woodland on dunes and sand plains ('no concern at present'); *Banksia aemula* woodland on dunes and sand plains 'no concern at present'.
Forest Red Gum Forest	-	The incidence of this vegetation type in Queensland near Stewart Road is highly disturbed and degraded consisting of a few isolated specimens and is unrecognisable as a forest. This stand of trees is not considered representative of an regional ecosystem.
Regenerating Brushbox Forest	12.11.5	This community resembles RE 12.11.5 tall open forest in which Spotted Gum is a relatively common species on Mesozoic to Proterozoic moderately to strongly deformed and metamorphosed sediments and interbedded with volcanics 'no concern at present'.
Swamp Oak Forest	-	This community is represented by a thin stand along Stewart Road. This stand may have been planted as part of a past revegetation scheme. It is not considered representative of a regional ecosystem, as it is highly disturbed with ground cover consisting almost entirely of Molasses Grass and an infestation of Morning Glory.

Vegetation Community	Corresponding Regional Ecosystem	Description
Swamp Mahogany Forest	12.3.4 12.3.14	This community is considered to most closely resemble RE 12.3.4 open forest to woodland of *Melaleuca quinquenervia* and *Eucalyptus robusta* in drainage lines in coastal areas 'no concern at present' but also has elements of RE 12.3.14 woodland of *Banksia aemula* ± mallee eucalypt low woodland to shrubland and/or *E. racemosa* woodland to open forest 'of concern'. This community is reasonably intact in places with minimal disturbance evident particularly adjacent to the Queensland-NSW border.
Swamp Mahogany – Scribbly Gum Forest	12.3.4 12.3.14	This community is considered to most closely resemble RE 12.3.4 open forest to woodland of *Melaleuca quinquenervia* and *Eucalyptus robusta* in drainage lines in coastal areas 'no concern at present' but also has elements of RE 12.3.14 woodland of *Banksia aemula* ± mallee eucalypt low woodland to shrubland and/or *E. racemosa* woodland to open forest 'of concern'. This community is reasonably intact in places with minimal disturbance evident particularly adjacent to the Queensland-NSW border.
Slashed Heathland	12.3.13 12.2.12	This community contains landform and floristic elements of RE 12.3.13 closed or wet heathland on seasonally waterlogged Cainozoic alluvial plains along coastal lowlands 'of concern' and floristic elements of RE12.2.12 closed or wet heath ± stunted emergent shrubs/low trees on Quaternary coastal dunes and beaches and poorly drained sand plains 'no concern at present'. Athough this vegetation community is regularly slashed it is considered reasonably intact and is a good example of RE12.3.13. Landform does not correlate to RE12.2.12.
Paperbark Forest	12.3.5	This community strongly correlates to RE 12.3.5 *Melaleuca quinquenervia* tall open forest near coastal alluvial plains 'of concern'.

Regional ecosystems are part of a Queensland-wide hierarchical classification system that is recognised by federal and state governments through the national heritage trust partnership agreement. Regional ecosystems are also used by the state and federal governments in selecting reserves that are representative of each bioregion in Queensland.

The site does not have vegetation that has been mapped as a regional ecosystem polygon remnant under current 1:100,000 mapping (Environmental Protection Agency 2001a). Although the Environmental Protection Agency regional ecosystem mapping for the area does not identify any regional ecosystems in the project area, field investigations of the alignment identified vegetation communities that resemble three regional ecosystem, including subdominant communities, as described by Sattler and Williams (1999).

The following is a brief description of the regional ecosystems that have been identified on the site, and an outline of each of the regional ecosystems, as listed under the Schedules of the Vegetation Management Regulation 2000:

- RE 12.11.1 – notophyll vine forest often with abundant *Archontophoenix cunninghamii* on metamorphics, 'no concern at present';

Figure 4.2 **Terrestrial Vegetation Communities of Conservation Significance**

- RE 12.11.5 – tall open forest in which Spotted Gum is a relatively common species on Mesozoic to Proterozoic moderately to strongly deformed and metamorphosed sediments and interbedded with volcanics 'no concern at present';
- RE 12.11.5f – tall open forest of *Eucalyptus pilularis, E. microcorys, Angophora woodsiana* ± *E. racemosa, E. tindaliae, Corymbia trachypholia, C. intermedia, C. gummifera, E. resinifera* (Nerang area). Despite having a conservation status of 'not of concern' advice from Queensland Herbarium is that this regional ecosystem is considered to be regionally significant;
- RE 12.2.6/12.2.9 – *Eucalyptus racemosa* woodland on dunes and sand plain, 'no concern at present'; *Banksia aemula* woodland on dunes and sand plains, 'no concern at present';
- RE 12.2.12 – closed or wet heath ± stunted emergent shrubs/low trees on Quaternary coastal dunes and beaches and poorly drained sand plains, 'no concern at present';
- RE 12.3.4 – open forest to woodland of *Melaleuca quinquenervia* and *E. robusta* in drainage lines in coastal areas, 'no concern at present';
- RE 12.3.5 – *Melaleuca quinquenervia* tall open forest near coastal alluvial plains 'of concern';
- RE12.3.13 – closed or wet heathland on seasonally waterlogged Cainozoic alluvial plains along coastal lowlands 'of concern'; and
- RE 12. 3.14 – woodland of *Banksia aemula* ± malle eucalypt low woodland to shrubland and/or *E.racemosa* woodland to open forest, 'of concern'.

The representativeness of the vegetated areas that were identified during field investigations in the study area to the regional ecosystems is shown in Table 4.1. This table also identifies the current status of the regional ecosystems.

Vegetation communities are considered to be of conservation significance if they correspond to a regional ecosystem. Regional ecosystems are classified as either 'endangered', 'of concern' or 'no concern at present' according to an ecosystem's current distribution relative to its pre-European distribution. 'Endangered' and 'of concern' regional ecosystems are considered to be of state significance in Queensland.

State Significance

Paperbark Forest communities correlate strongly to regional ecosystem 12.3.5 'of concern' and Slashed Heathland communities contain landform and floristic elements of regional ecosystem 12.3.13 'of concern'. Both of these communities are therefore considered to be of state significance in Queensland.

Regional Significance

Swamp Mahogany Forest and Swamp Mahogany – Scribbly Gum Forest communities contain elements of regional ecosystem 12.3.14 'of concern' and as such are considered to be of regional conservation significance.

The Regenerating Vine Forest found in Hidden Valley is representative of regional ecosystem 12.11.1 (Sattler and Williams 1999). While this regional ecosystem is considered to be of 'no concern at present', the vegetation community contains elements of regional ecosystem 12.11.4 that is considered to be 'of concern' in Queensland. Moist Blackbutt Forest, Dry Blackbutt Forest and Blackbutt Woodland communities are considered to be representative of regional ecosystem 12.11.5f. Despite having a conservation status of 'no concern at present' advice from

Queensland Herbarium is that this regional ecosystem is considered to be regionally significant. As such, these vegetation communities have been assigned regional conservation status in Queensland.

Local Significance

Swamp Oak Forest communities from the study area in Queensland are represented by a thin stand along Stewart Road. This stand may have been planted as part of a past revegetation scheme. It is not considered representative of a regional ecosystem as it is highly disturbed with groundcover consisting almost entirely of Molasses Grass and an infestation of Morning Glory. As such this vegetation community in Queensland has been assigned local conservation status.

A further five vegetation communities of local significance would be transected by the proposal in Queensland. Ironbark-Mahogany Forest, Regenerating Brushbox Forest, Forest Red Gum Forest, Weedy Grassland and Cleared Land are considered to be of conservation significance at the local level.

NSW

State Significance

In NSW the forest ecosystem classified as Littoral Rainforest in the North Coast Biogeographic Region is listed as an Endangered Ecological Community under the *Threatened Species Conservation Act, 1995*. The Littoral Rainforest and Regenerating Vine Forest in the study area would be classified as part of this endangered ecological community.

In NSW, forest ecosystems dominated by Swamp Oak are considered to be 'vulnerable' at the state level (Benson 1989) and at the regional level using the Regional Forest Assessment criteria (NSW Department of Environment and Conservation 1999a). More than 70 percent of this ecosystem has been cleared since pre-European times. In the study area this ecosystem includes Swamp Oak Forest and Swamp Oak Woodland.

Three additional ecological communities relevant to the Tugun Bypass have been preliminarily listed as endangered pursuant to the Threatened Species Conservation Act on the 10th September 2004. These communities are Freshwater Wetlands on Coastal Floodplains, Swamp Oak Floodplain Forest and Swamp Sclerophyll Forest on Coastal Floodplains. Within the study area the vegetation communities of Phragmites Rushland and Sedgelands would be classified as the Freshwater Wetlands Endangered Ecological Community, while Swamp Oak Forest and Swamp Oak Woodland would meet the classification of the Swamp Oak Floodplain Forest Endangered Ecological Community. A number of vegetation communities within the Tugun Bypass study area would be classified as the Swamp Sclerophyll Forest Endangered Ecological Community including Swamp Mahogany Forest, Swamp Mahogany/Brushbox Forest, Swamp Mahogany/Paperbark Forest, Paperbark Forest, Open Paperbark Woodland, Paperbark Regrowth and Mixed Swamp Forest.

While preliminary determinations have no statutory obligation until they are finalised (due to the possibility they may be rejected) it is prudent to give some consideration to them. The proposed Tugun Bypass would impact on all three communities, with 1.1 hectares of Freshwater Wetlands being directly impacted, 1.5 hectares of Swamp Oak Floodplain Forest impacted and 19.6 hectares of Swamp Sclerophyll Forest.

Further consideration would be given to the endangered ecological communities if they become finalised.

Regional Significance

References used to determine conservation significance at the regional level are compared below in Table 4.2. Generally, Griffith (1993) has conducted detailed studies of coastal north-eastern NSW. Kingston *et al*. (1999) have derived overall significance ratings based on their analysis of previous studies.

Table 4.2: Regional Conservation Status in North-eastern NSW for Vegetation Communities Found Along the Proposed Alignment

Vegetation Community[1]	Status	
	Griffith (1993)	**Kingston *et al.* (1999)**
Swamp Mahogany/ Forest Red Gum Forest, Swamp Mahogany Forest, Swamp Mahogany–Brushbox Forest	Well reserved over parts of its range	Inadequately reserved over all its range
Swamp Mahogany–Scribbly Gum Forest, Scribbly Gum Forest/Open Forest	Well represented in parts of its range but not in Far North	Inadequately reserved in major part of its range
Paperbark Forest/Open Paperbark Woodland	Generally poorly reserved	Inadequately reserved in major part of its range
Swamp Mahogany/ Paperbark Forest, Mixed Swamp Forest	Poorly reserved in general	Inadequately reserved in major part of its range
Tree Broom Heath, Scribbly Gum Mallee Heathland	Only reserved in limited areas	Inadequately reserved over all its range
Saltmarsh, Disturbed Saltmarsh	Limited areas are reserved	Inadequately reserved over all its range
Mangrove Forest	Only reserved in limited areas	Inadequately reserved over all its range
Sedgeland, Phragmites Rushland	-	Inadequately reserved over major parts of its range

Notes 1: Vegetation community naming is from the present study.

Griffith (1993) recommends that the Cobaki area be considered as an opportunity to reserve further stands of Swamp Mahogany associations and Mangrove Forest.

Local Significance

Five vegetation communities of conservation significance at the local level would be transected by the proposed bypass in NSW. These are Paperbark Regrowth, Wet Heathland, Slashed Heathland, Weedy Grassland and Cleared Land.

4.1.3 Plant Species

A total of 596 plant species was recorded from the study area. This comprised 489 indigenous and 107 introduced species. A complete plant species list is found in Appendix L.

Plant Species of Legislative Significance

Fifteen species of legislative significance (Table 4.3) were recorded along the proposed bypass during the field survey. These are shown in Figure 4.3. Swamp Orchid *(Phaius australis)* colony sites and *Geodorum densiflorum* individuals are confidential for security reasons (to discourage pilfering) and therefore are not mapped in this report. A further 41 flora species of legislative significance may occur in this area (refer to the SIS).

Table 4.3: Plant Species of Legislative Significance Recorded from the Study Area

Species Name	Status			Location
	Queensland	NSW	Commonwealth	
Little Wattle (*Acacia baueri* subsp. *baueri*)	NCR (V)			Qld, NSW, Cwlth
White Lace Flower *(Archidendron hendersonii)*		TSC (V)		Cwlth
Viney Lace Flower *(Archidendron muellerianum)*	NCR (R)		ROTAP	Qld
Christmas Bells *(Blandfordia grandiflora)*	NCR (R)			Cwlth
Stinking Cryptocarya *(Cryptocarya foetida)*	NCR (V)	TSC (V)	ROTAP; EPBC (V)	Qld, Cwlth
Long-leaved Tuckeroo *(Cupaniopsis newmanii)*	NCR (R)		ROTAP	Qld
Black Walnut *(Endiandra globosa)*	NCR (R)		ROTAP	Qld
Endiandra muelleri subsp. *bracteata*		TSC (E)		Qld
Geodorum densiflorum		TSC (E)		Cwlth
White Silky Oak (*Grevillia hilliana)*		TSC (E)		Qld
Fine-leaved Tuckeroo *(Lepiderema pulchella)*	NCR (R)	TSC (V)	ROTAP	Qld
Rough-leaved Queensland Nut *(Macadamia tetraphylla)*	NCR (V)	TSC (V)	ROTAP; EPBC (V)	Qld
Swamp Orchid *(Phaius australis)*	NCR (E)	TSC (E)	ROTAP, EPBC (E)	NSW, Cwlth
Smooth-scrub Turpentine (Rhodamnia maideniana)	NCR (R)		ROTAP	Qld
Durobby*(Syzygium moorei)*	NCR (V)	TSC (V)	ROTAP; EPBC (V)	Qld

Notes: TSC = NSW *Threatened Species Conservation Act 1995*;
NCR = Queensland Nature Conservation (Wildlife) Regulation 1994;
EPBC = Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*;
ROTAP = Rare or Threatened Australian Plants (Briggs and Leigh 1996);
E = Endangered;
V = Vulnerable;
R = Rare.

An additional eight species of conservation significance at the regional level were recorded from the study area (Figure 4.3). They are:

- Blunt-leaved Wattle (*Acacia obtusifolia)* – unusual lowland population on sands;
- Star Hair Plant *(Asterotricha longifolia* – Tweed Heads Form) – only population in NSW;
- Match Sticks *(Comesperma ericinum)* – prior to this study was thought to be extinct in Queensland, northern distribution limit in NSW;

Figure 4.3 **Locations of Significant Flora Species**

* Location of *Phaius australis* and *Geodorum densiflorum* individuals is confidential

- Coast Palm Lily (*Cordyline congesta*) – until recently this species was listed as 'rare' under the Queensland Nature Conservation (Wildlife) Regulation 1994. It is also listed on Rare and Threatened Australian Plants (ROTAPs) (Briggs and Leigh 1996). Three individuals of this species were detected in and along the edge of the Regenerating Vine Forest;
- *Mucuna gigantea* – regionally significant, threatened north-eastern NSW;
- Lemon-scented Baekea *(Ochrasperma citriodora)* – northern limit of distribution;
- *Strangea linearis* – regionally significant, only found north of Byron Bay; and
- Chinese Burr *(Triumfetta rhomboidea)* – critically threatened north-eastern NSW.

A Swamp Orchid (*Phaius australis)* colony located in the study area is one of only 14 colonies known to occur in NSW. As such, it is of conservation significance at the state level and, because of its large size it is likely to be of national significance.

The highest concentration of threatened plant species in the study area was recorded in the Regenerating Vine Forest located at Hidden Valley. This valley is representative of regional ecosystem 12.11.1. While this regional ecosystem is considered to be of 'no concern at present' the vegetation community contains elements of regional ecosystem 12.11.14 that is considered to be 'of concern' in Queensland. As such this community has been assigned regional conservation status in Queensland.

4.2 Terrestrial Vertebrate Fauna

4.2.1 Terrestrial Vertebrate Fauna Habitat

Twelve habitat types were described for the study area. Their distribution in the study area is shown in Figure 4.4. Relevant vegetation communities are included in brackets.

Ridge Woodland/Forest (Ironbark–Mahogany Forest, Dry Blackbutt Forest, Moist Blackbutt Forest, Blackbutt Woodland, Brushbox Open Forest, Regenerating Brushbox Forest) is the predominant community found north of Boyd Street, covering an area of 99.7 hectares in the study area. This community is dominated by Blackbutt, with a wide range of co-dominant species including Tallowwood, White Mahogany and Grey Gum. The mid-stratum is generally sparse or composed of Lantana in regenerating forest. The understorey is grassy. Other important habitat characteristics include: medium density of small hollows, some large hollows and ground debris.

Dune Woodland/Forest (Scribbly Gum Forest, Swamp Mahogany–Scribbly Gum Forest) occurs in the northern part of the study area, covering 46 hectares. It is dominated by Scribbly Gum and Red Bloodwood or Swamp Mahogany and contains a dense heathy understorey and a mid-stratum composed of banksias and wattles. A small area of old-growth Scribbly Gum Forest located north of Cobaki Broadwater provides large hollows. Other important habitat characteristics include some small tree hollows, shrubby understorey and a high diversity of flowering and fruiting plants.

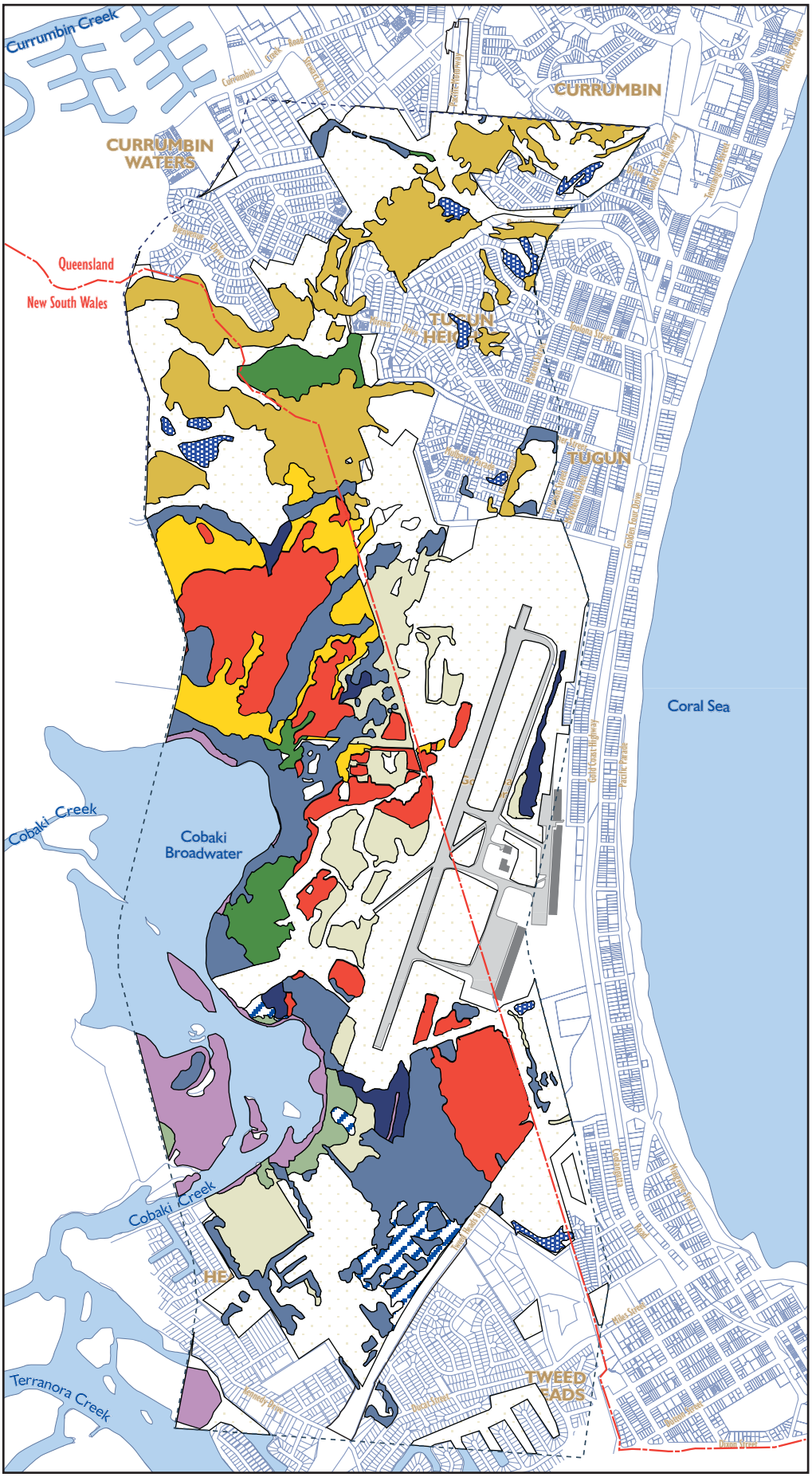


Figure 4.4 **Fauna Habitats**

Rainforest/Rainforest Elements (Littoral Rainforest, Regenerating Vine Forest, Forest Red Gum Forest, Swamp Mahogany/Forest Red Gum Forest) is restricted to Hidden Valley and a narrow strip of land adjacent to Cobaki Broadwater. This community covers an area of 24.6 hectares in the study area. The overstorey forms a dense or open canopy layer dominated by Bangalow Palm and figs or occasionally by eucalypts. There are a number of dense layers in the mid-stratum comprising mainly rainforest fruiting trees. The ground cover consists of a dense layer of ferns. Areas of this habitat are highly disturbed by weed infestation from Umbrella Trees, Camphor Laurel and Lantana. Important habitat characteristics include a wide diversity of fruiting trees, a low density of small and large hollows and a dense ground cover.

Swamp Forest (Paperbark Forest, Swamp Oak Forest, Swamp Mahogany Forest, Swamp Mahogany–Paperbark Forest, Mixed Swamp Forest, Swamp Mahogany–Brushbox Forest) occurs throughout the southern section of the study area and in small patches in Queensland, occupying 110.4 hectares in the study area. It is dominated by Broad-leaved Paperbark and Swamp Mahogany. The mid-stratum comprises banksias and Cheesetree while ferns occur in the understorey. This habitat type contains small freshwater lagoons and a small permanent creek and is likely to become inundated after prolonged rainfall. Other important habitat features include a high density of flowering trees and shrubs, winter-flowering species, low densities of small and large tree hollows and an abundance of decorticating (i.e. peeling) bark suitable for bat roosting and bird foraging.

Regenerating Swamp Forest (Swamp Oak Woodland, Open Paperbark Woodland) is located in the south-eastern corner in the vicinity of the Tweed Heads Pony and Hack Club, on the western edge of sedgeland and to the south of the Tugun Landfill, occupying 12.7 hectares of the study area. It is dominated by Broad-leaved Paperbark with occasional Swamp Oak, Swamp Box, Cheesetree and Camphor Laurel. This habitat type is characterised by clumps of trees up to 15 metres surrounded by grassy areas dominated by exotic species. Important habitat features include nectar and fruit producing plant species, winter-flowering species, shallow wet depressions, decorticating bark for roosting bats and foraging birds, and a dense understorey. However, this habitat does not provide hollows.

Heathland (Paperbark Regrowth, Scribbly Gum Mallee Heathland, Tree Broom Heathland, Wet Heathland, Disturbed Heathland, Black She-oak Heathland, Wallum Heathland) includes both wet and dry types and is located throughout the survey area, covering 74.4 hectares. Many of the areas of this habitat adjoin cleared land and are fragmented by tracks. Some heath is characterised by the presence of occasional emergent mallee eucalypts. It is comprised mainly of Broad-leaved Paperbark, Wallum Banksia, Tree Broom Heath and Black She-oak. Heath species dominate the mid-stratum and ferns and sedges are found in the understorey. Important habitat features include dense cover, flowering shrubs and some ephemeral ponding. No hollows are present in this habitat type.

Sedgeland/Rushland (Disturbed Sedgeland, Phragmites Rushland) includes both wet and dry types and is located throughout the survey area covering 12.8 hectares. Many of these adjoin cleared land and are fragmented by tracks. Some heath is characterised by the presence of occasional emergent eucalypts or mallee eucalypts. It is comprised mainly of Broad-leafed Paperbark, Wallum Banksia, Tree Broom Heath and Black She-oak. Heath species dominate the mid-stratum and ferns and sedges are found in the

understorey. Important habitat features include dense ground covering and seeds. No hollows are present in this habitat type.

Mangroves (Mangrove Forest) are widespread within the survey area, occurring as a narrow fringe along the northern edge of Cobaki Broadwater and totals 33.7 hectares. It also occurs on four islands within Cobaki Broadwater and along the southern edge of Cobaki Creek. Dominant species include Grey Mangrove, Red Mangrove, River Mangrove, Large Leafed Orange Mangrove, Blind Your Eye Mangrove and Mangrove Fern. Important habitat features include an abundance of insects, regularly flowering plants and nurseries for estuarine species.

Saltmarsh (Saltmarsh) grows on the landward side of mangroves, covering an area of 8.8 hectares. The main species are Saltcouch, Samphire and Sea Rush. Important habitat features in this community include foraging and roosting resources for estuarine birds.

Disturbed Open habitats (Weedy Grassland, Slashed Heathland, Disturbed Saltmarsh–Sedgeland) occur along access tracks and within the airport, covering an area of 65.3 hectares. It is dominated by exotic grass species or is composed of native species, but is subject to ongoing disturbance from airport maintenance activities (e.g. slashing) or Tweed Heads Pony and Hack Club operations. It provides limited habitat values for all but open-country species. A dam and a large tidal drain are located on disturbed land. Slashed Heathland provides flowering plants for native birds.

Plantings (Exotic garden species including pines) occur throughout the survey area, covering 10 hectares. These are most likely to be associated with development, public parks, ovals and old plantations. These areas have few habitat values for native species, although they may provide nectar, pine cones or other foraging resources for birds and other opportunistic fauna.

Cleared Land (Cleared Land) covers 349.4 hectares and occurs throughout the study area. It represents a highly modified community and is dominated by exotic grass species (that are continually kept to a low height) or is devoid of vegetation. It provides limited habitat values for all but open-country species. A number of drainage structures in this habitat are suitable for frogs.

Conservation Significance

Terrestrial fauna habitats of conservation significance recorded from the study area are shown on Figure 4.5 and described below.

Wallum Froglet (Crinia tinnula)

Habitat for the Wallum Froglet is considered to be of conservation significance at the regional level. Known and potential habitat for this species comprises approximately 429 hectares of the study area. It broadly encompasses the following vegetation communities: Slashed Heathland, Wet Heathland, Swamp Mahogany Forest, Swamp Mahogany–Brushbox Forest, Littoral Rainforest, Swamp Paperbark Forest and other moist forest types. Breeding is confined to slow-moving water less than 1.5 metres deep within the pH range of 3.0 to 5.2.

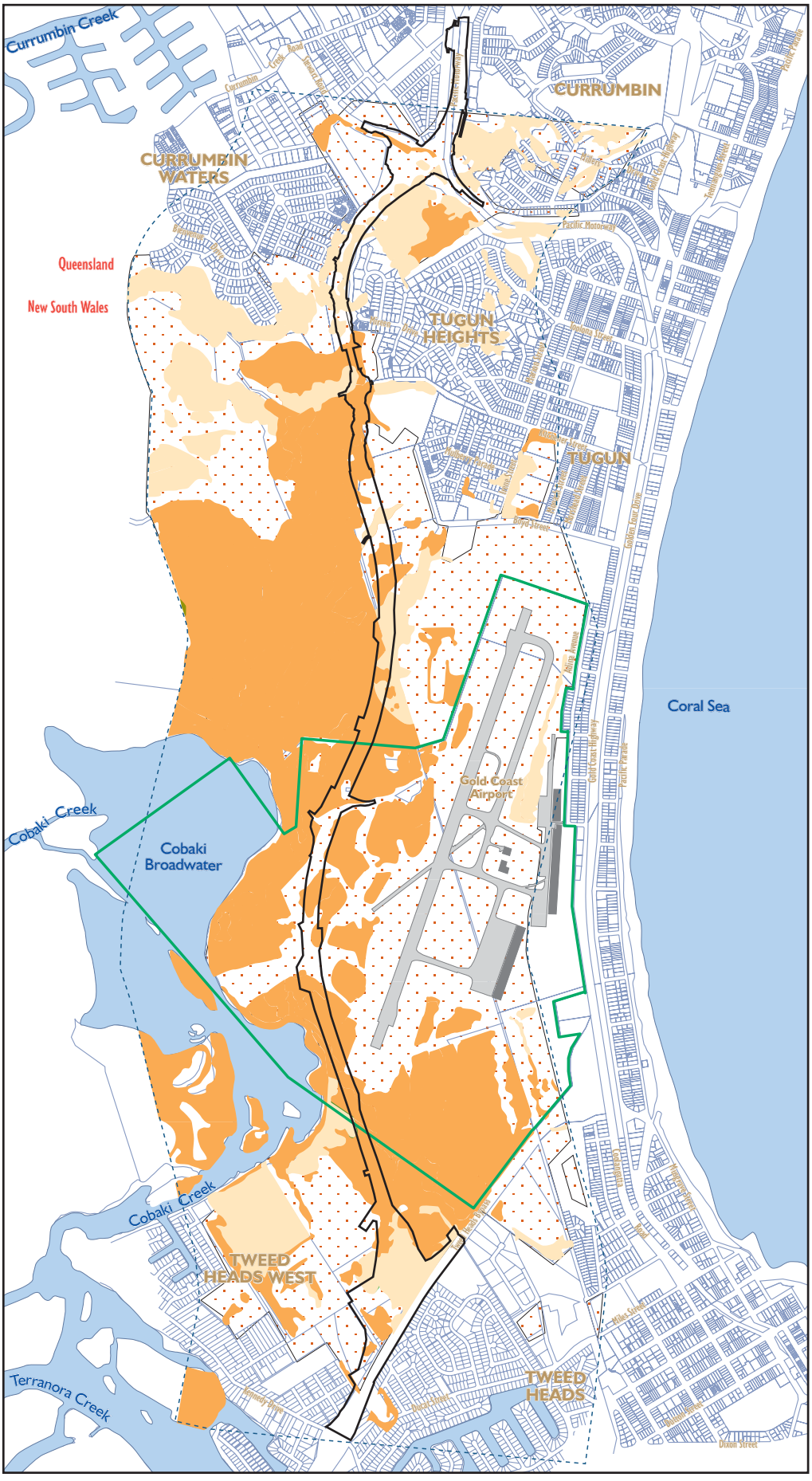


Figure 4.5 **Terrestrial Fauna Habitats of Conservation Significance**

Wallum Sedge Frog (Litoria olongburensis)

Habitat for the Wallum Sedge Frog is considered to be of conservation significance at the regional level. Known and potential habitat for this species is comprises approximately 56 hectares of the study area. Breeding habitat is characterised by low pH and relatively deep water with some capacity to retain water for longer periods. The condition of the six potential breeding ponds are described in Table 4.4 (numbering as per Hero et al 2000c). Tadpoles were present at Sites 1 and 3.

Table 4.4: Summary of Suitable Breeding Conditions for the Wallum Sedge Frog

Site No.	pH	Depth (mm)	Individuals (Number)
1	3.8-4.2	500	>6
2	4.4-5.2	370	Large numbers
3	3.5-5.3	730	9
4	4.0-4.4	Not recorded	2
5	Not recorded	Not recorded	2-5
6	Not recorded	Not recorded	2-5

Two ponds (Sites 2 and 5) located along the proposed alignment support an exceptionally high diversity of frogs (14 species), including the Wallum Sedge Frog (Hero *et al*. 2001b and c).

Long-nosed Potoroo (Potorous tridactylus)

Habitat for the Long-nosed Potoroo is considered to be of state conservation significance as the population has recently been listed as a preliminary Endangered Population. The Long-nosed Potoroo was recorded in the study area near the Queensland–NSW border. Known habitat for the Long-nosed Potoroo in the study area is estimated to be about 88 hectares with Swamp Mahogany/Scribbly Gum Forest, Scribbly Gum Mallee Heathland and Tree Broom Heathland supporting the highest densities of potoroos. Lower densities were recorded in Black She-Oak Heathland, Scribbly Gum Forest and Swamp Mahogany Forest. Although Mason (1993) estimated that the population comprised 10 - 20 individuals, preliminary analysis of the results of the supplementary study indicate that the population may consist of at least 55–65 individuals, but may go as high as 85 individuals. It is still considered to be a small isolated population subject to extinction through stochastic (i.e. random) events.

Common Planigale (Planigale maculata)

Habitat for a small localised population of Common Planigales is considered to be of conservation significance at the regional level. Primary and secondary habitat where Common Planigales have been captured between Boyd Street and Kennedy Drive comprises Swamp Mahogany and Swamp Mahogany–Brushbox Forest and measures approximately 1 hectare. It is at a slightly higher elevation than surrounding lands and appears to be critical to the survival of the population during wet periods. The closest known Common Planigale populations are found along Coolangatta Creek on Commonwealth land and in Dry Blackbutt Forest at the northern end of the proposal in Queensland.

Terrestrial Bird Habitat

Rainforest, Mangrove Forest, Swamp Forest and Ridge Woodland/Forest are considered to be important for terrestrial birds in the study area. Due to its restricted distribution and its habitat values for fauna species of conservation significance, Rainforest and Mangrove Forest are considered to be of regional conservation significance (D. Rohweder *pers. comm.*). A breeding pair of Bush Hens *(Amaurornis olivaceus)* was recorded at Hidden Valley, while Collared Kingfishers and Mangrove Honeyeater were recorded in Mangrove Forest. Swamp Forest was the most locally important habitat type with more than 80 species recorded there, including 10 threatened or significant species. It is considered to be of conservation significance at the high local level (D. Rohweder *pers. comm.*). Sedgeland was also considered to be an important habitat type for threatened bird species and therefore of high local significance, while Ridge Woodland/Forest is of local conservation significance (D. Rohweder *pers. comm.*).

4.2.2 Estuarine Bird Habitat

There are a variety of roost types available in the lower Tweed River including, ocean beaches, sand islands, sand bars, saltmarsh and mangroves. All roosts are disturbed due to human activity or are declining through vegetation encroachment or erosion. Historical studies indicate that there has been a decline in the use of high-tide roosting sites in the local area over the past 10 years. In particular, a considerable decline has been noted in the use of the roost in the vicinity of the Tweed Heads Pony and Hack Club. Historically, this was the most important roost in the estuary and it is still the most important in the Cobaki Broadwater.

In the context of the Tweed Estuary, the following points were noted about roost sites within the local Cobaki Broadwater area:

- small numbers of waterbirds were recorded at roost sites at the Tweed Heads Pony and Hack Club, Cobaki north and Cobaki south;
- four species of birds of prey were recorded roosting or foraging along the northern fringe of Cobaki Broadwater; and
- roosts at Cobaki Creek, the Tweed Heads Pony and Hack Club and Cobaki Broadwater are used by shorebirds, in particular Whimbrel *(Numenius phaeopus)*, Eastern Curlew, Pacific Golden Plover *(Pluvialis fulva)*, Common Greenshank *(Tringa nebularis)* and Grey-tailed Tattler *(Heteroscelis brevipes)*.

Intertidal foraging habitat generally includes extensive mudflats in sheltered bays and exposed sandflats in areas of greater flow. There are four main foraging areas in Cobaki Broadwater. These are Cobaki Creek, Tweed Heads Pony and Hack Club, Cobaki south and Cobaki north. The Tweed Heads Pony and Hack Club foraging area is the least significant and is used mainly by small numbers of Whimbrel and Eastern Curlew. Historical records suggest that there has been a decline in the use of intertidal areas in the Cobaki Broadwater over the past 10 years or so. No definite trends in the use of foraging areas could be determined during the present study.

In the context of the Tweed Estuary, the following points were noted about foraging sites within the Cobaki Broadwater area:

- low species diversity and small numbers of waterbirds were noted with Cobaki north having the highest foraging values and Tweed Heads Pony and Hack Club having the lowest;
- low numbers of foraging birds of prey were recorded;

- a high diversity of shorebirds was recorded at Cobaki north; lower numbers but high species richness was noted at the Tweed Heads Pony and Hack Club and Cobaki south; and
- some gulls and terns were recorded foraging at Cobaki north; none were observed at the Tweed Heads Pony and Hack Club and Cobaki south.

Conservation Significance

Four major high-tide roosts have been identified at: Cobaki Broadwater, the Tweed Heads Pony and Hack Club, mangroves at Cobaki Creek and the southern fringe of Cobaki Broadwater. These have been used regularly for the past three years. Although there appears to have been an overall decline in the quality of roosts as indicated by bird usage, these are still important in a local context, especially for Whimbrel, Eastern Curlew, Pacific Golden Plover and Common Greenshank. As there is a critical shortage of spring tide roosts in the area, the Tweed Heads Pony and Hack Club roost is considered to be of conservation significance at the high local level (D Rohweder *pers. comm.)*.

The expansive intertidal mudflats at Cobaki south and Cobaki north are considered to be the most important foraging areas for shorebirds; these are of high local significance (D. Rohweder *pers. comm*.).

Cobaki Broadwater is significant as a foraging area in an estuary-wide context. Three foraging areas: Tweed Heads Pony and Hack Club, Cobaki Creek and Cobaki Broadwater have been identified close to the proposal. An estimated 20 percent of migratory shorebirds were recorded foraging at these three sites. Cobaki Broadwater is considered to be of conservation significance at the high local level.

4.2.3 Terrestrial Vertebrate Fauna Species

Amphibian, Reptile and Mammal Species

Overall, 68 species of amphibians, reptiles and mammals (61 indigenous, seven introduced) are known to occur in the study area. This includes 17 amphibian species, 20 reptile species and 31 mammal species. A complete list is included as Appendix M. Potentially, another six amphibian species, 17 reptile species and 22 mammal species occur there. In all, at least 113 species are known or likely to occur in the study area.

Major findings of the fauna survey for the study area are noted below:

- no threatened reptile species were recorded;
- a population of Common Planigales was recorded in weed-infested habitat at the northernmost part of the proposal, along Coolangatta Creek and within a 1 hectares area on Commonwealth land;
- a high amphibian diversity possibly related to breeding sites available;
- a high density of the Wallum Froglet, suggesting that the survey area contains a significant population of this species;
- a high capture rate for the Grassland Melomys (*Melomys burtoni*), suggesting that the survey area contains a significant population of this species;
- a low density and depauperate community of arboreal mammals;
- a lack of a resident Koala population;
- a rich and diverse community of microchiropteran (insect-eating) bats was noted;

- a high incidence of the Eastern Long-eared Bat, suggesting that the area supports a significant population of this species; and
- a reasonably large population of Long-nosed Potoroos has been confirmed (and has been preliminarily listed as endangered on the Threatened Species Conservation Act).

Amphibian Reptile and Mammal Species of Legislative Significance

Eleven legislatively significant species of mammals, reptiles and amphibians were recorded in the study area during field surveys (Table 4.5 and Figures 4.6 and 4.7). A further four species (Hero *et al*. 2000) may occur there (Appendix O).

Table 4.5: Amphibian, Reptile and Mammal Species of Legislative Significance Recorded from the Study Area

Species Name	Status			Recorded
	Queensland	NSW	Commonwealth	
Black Flying-fox *(Pteropus alecto)*	-	TSC (V)	-	NSW, Cwlth
Common Blossom Bat *(Syconcteris australis)*	-	TSC (V)	-	Cwlth
Common Planigale *(Planigale maculata)*	-	TSC (V)		Qld, Cwlth
Eastern Long-eared Bat *(Nyctophilus bifax)*	-	TSC (V)	-	NSW, Cwlth
Grey-headed Flying Fox *(Pteropus polioccphalus)*	-	TSC (V)	EPBC (V)	NSW, Qld, Cwlth
Large-footed Myotis *(Myotis adversus)*	-	TSC (V)	-	Cwlth
Little Bent-wing Bat *(Miniopterus australis)*	-	TSC (V)	-	Cwlth, Qld
Long-nosed Potoroo *(Potorous tridactylus)*	NCR (V)	TSC (V)	EPBC (V)	Qld, NSW
Squirrel Glider *(Petaurus norfolcensis)*	-	TSC (V)	-	NSW
Wallum Froglet *(Crinia tinnula)*	NCR (V)	TSC (V)	-	NSW, Qld, Cwlth
Wallum Sedge Frog *(Litoria olongburensis)*	NCR (V)	TSC (V)	EPBC (V)	Cwlth

Notes: TSC = NSW *Threatened Species Conservation Act 1995;*
NCR = Queensland Nature Conservation (Wildlife) Regulation 1994;
EPBC = Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*;
V = Vulnerable.

One species of regional conservation significance, the Grassland Melomys has also been recorded from the study area.

The Regenerating Vine Forest represents an extreme eastern outlier of bio-geographic importance (Hero *et al*. 2001b). The presence of the Gully Skink (*Saproscincus challengeri)*, the Blue-speckled Forest Skink (*Eulamprus murrayi)* and a resident population of Bush Rats are of scientific interest.

Bird Species

A total of 179 bird species was recorded from the study area during the field surveys, of which 175 are native and four are introduced. A complete list of species is found in Appendix M.

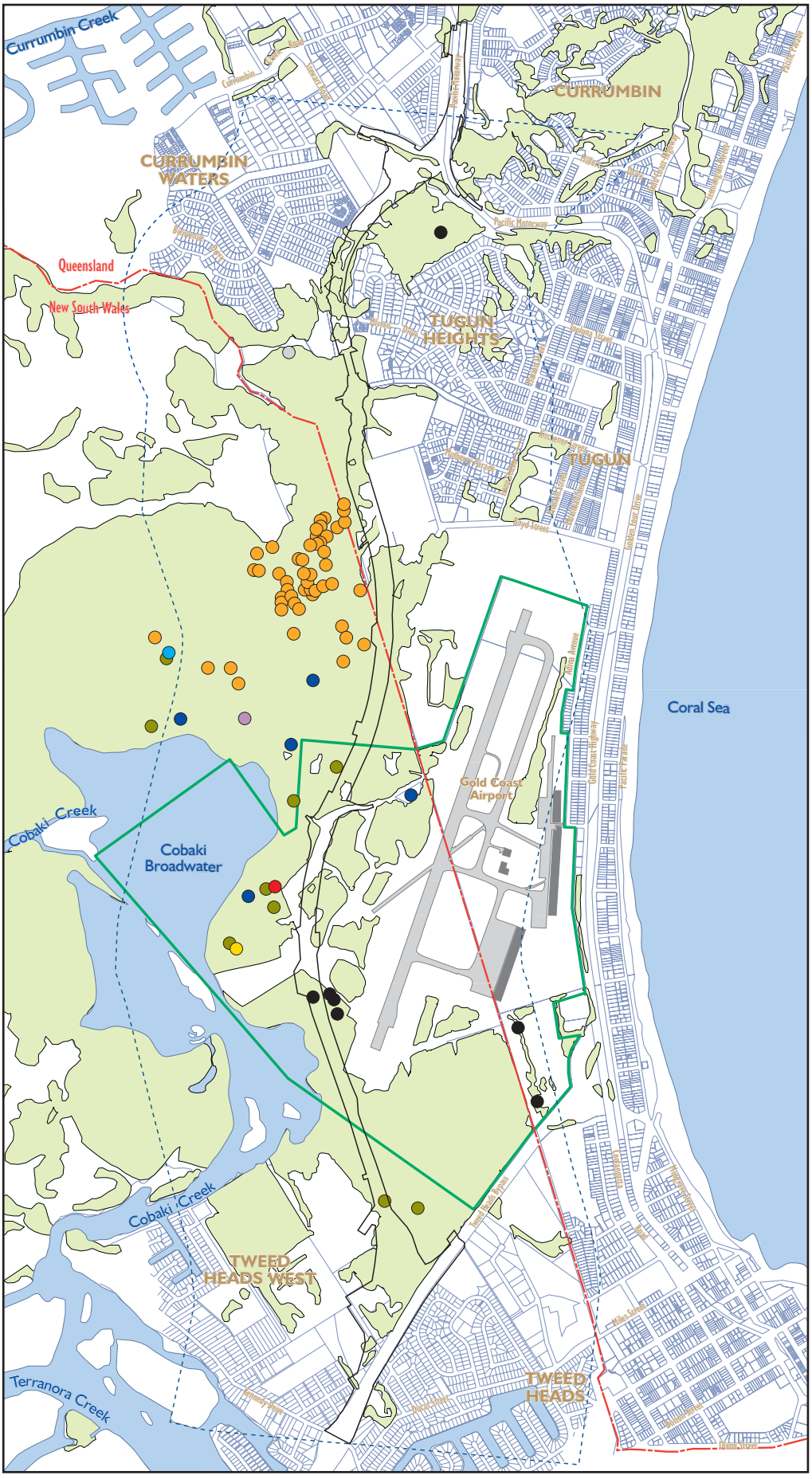


Figure 4.6 **Locations of Legislatively Significant Mammal Species**

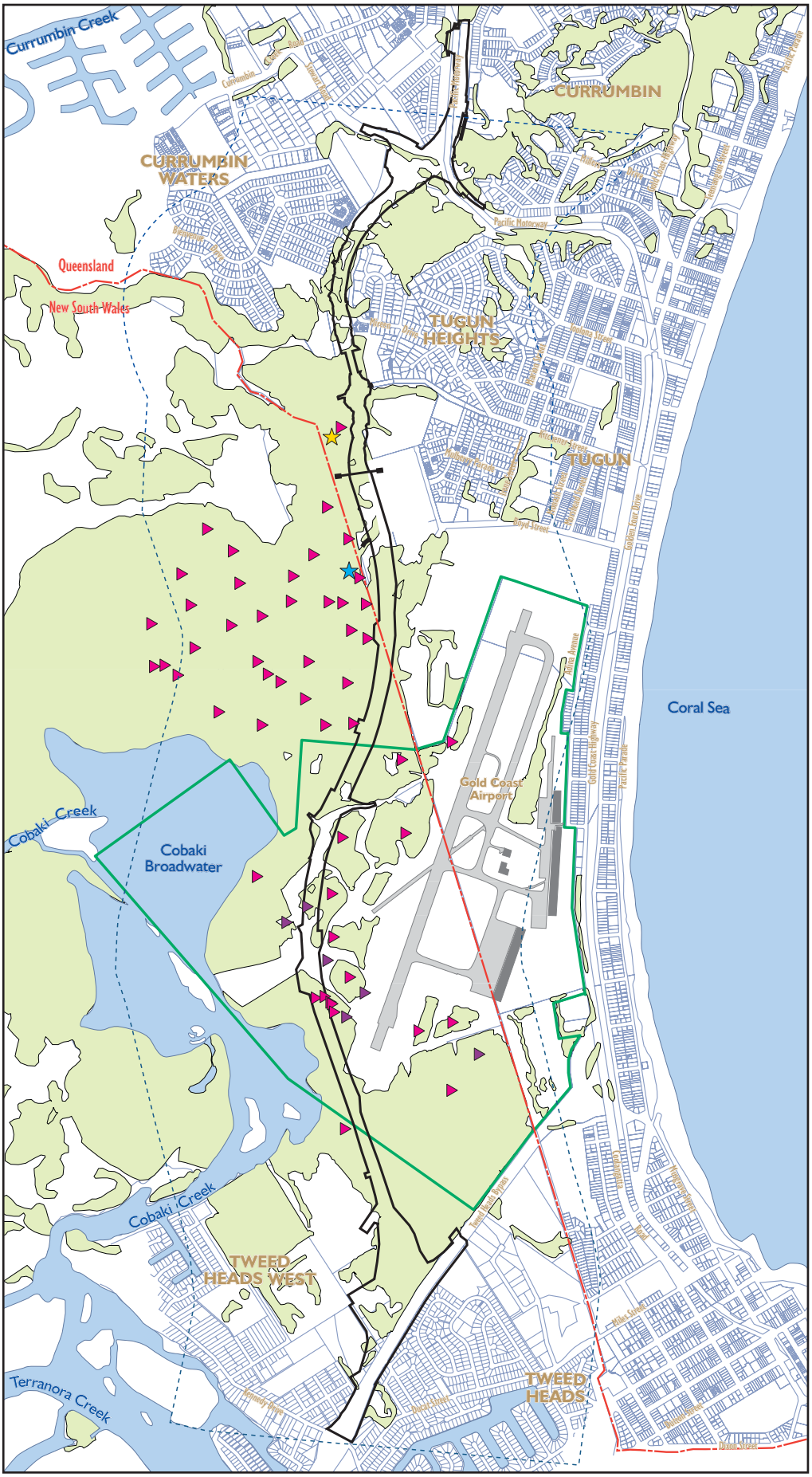


Figure 4.7 **Locations of Legislatively Significant Amphibian and Invertebrate Species**

Figure 4.8 **Locations of Threatened Bird Species (Excluding JAMBA/CAMBA Species)**

Bird Species of Conservation Significance

A total of 29 bird species of legislative significance was recorded from the study area during the field survey (Table 4.6 and Figure 4.8). A further four species of legislative significance (Appendix O) have suitable habitat present and may occur in the study area (Sandpiper Ecological Surveys 2001a).

Table 4.6: Legislatively Significant Terrestrial Bird Species Recorded from the Study Area

Species Name	Status			Recorded
	Queensland	NSW	Commonwealth	
Black Bittern *(Ixobrychus flavicollis)*		TSC (V)		?NSW
Brolga *(Grus rubicunda)*		TSC (V)		NSW, Cwlth
Bush Hen *(Amaurornis olivaccus)*		TSC (V)		Qld, NSW
Collared Kingfisher *(Todiramphus chloris)*		TSC (V)		NSW, Cwlth
Eastern Curlew *(Numenius madagascariensis)*	NCR (R)	-	J/C	NSW
Eastern Grass Owl *(Tyto capensis)*		TSC (V)		Cwlth
Glossy Black-Cockatoo *(Calyptorhynchus lathami)*	NCR (V)	TSC (V)		Cwlth, NSW
Lewins Rail *(Rallus pectoralis)*	NCR (R)			Qld, NSW, Cwlth
Masked Owl *(Tyto novaehollandiae)*		TSC (V)		?NSW
Mangrove Honeyeater *(Lichenostomus fasclogularis)*		TSC (V)		NSW, Cwlth
Osprey *(Pandion haliaetus)*		TSC (V)		NSW, Cwlth
Rose-crowned Fruit-Dove *(Ptilinopus regina)*		TSC (V)		Qld, NSW, Cwlth
Superb Fruit-Dove *(Ptilinopus superbus)*		TSC (V)		?Qld, ?Cwlth
White-eared Monarch *(Monarcha leucotis)*		TSC (V)		Qld
Wompoo Fruit-Dove *(Ptilinopus magnificus)*		TSC (V)		Qld
Common Sandpiper *Actitus hypoleucos*			J/C	NSW
Fork-tailed Swift *Apus pacificus*			J/C	Qld
Great Egret *Ardea alba*			J/C	NSW
Cattle Egret *Ardea ibis*			J/C	NSW, Cwlth, Qld
Latham's Snipe *Galliago hardwickii*			J/C	NSW
White-bellied Sea-eagle *Haliaectus leucogaster*			C	NSW
Grey-tailed Tattler *Heteroscelis brevipes*			J/C	NSW, Cwlth
White-throated Needletail *Hirundapus caudacutus*			J/C	Cwlth, Qld
Bar-tailed Godwit *Limosa lapponica*			J/C	NSW

Species Name	Status			Recorded
	Queensland	NSW	Commonwealth	
Rainbow Bee-eater *Merops ornatus*			J/C	NSW, Cwlth, Qld
Whimbrel *Numenius phaeopus*			J/C	NSW
Pacific Golden Plover *Pluvialis fulva*			J/C	NSW, Cwlth
Crested Tern *Sterna bergii*			J	NSW
Common Greenshank *Tringa nebularia*			J/C	NSW

Notes TSC = NSW *Threatened Species Conservation Act 1995*;
NCR = Queensland Nature Conservation (Wildlife) Regulation 1994;
V = Vulnerable;
R = Rare
? = unconfirmed record
J/C = JAMBA/CAMBA

Nine other species of conservation significance at the regional level were recorded from the study area. These were the Brahminy Kite *(Haliastur indus)*, Forest Kingfisher *(Halcyon macleayii)*, Little Bronze-Cuckoo *(Chrysococcyx minutillus)*, Little Shrike Thrush *(Colluricincla megarhyncha)*, Dusky Honeyeater *(Mysomela obscura)*, Mangrove Gerigone *(Gerigone levigaster)*, Pacific Baza *(Aviceda subcristata),* Peregrine Falcon *(Falco peregrinus)* and Wandering Whistling Duck *(Dendrocygna arcuta)*.

Significant populations of two legislatively significant endemic mangrove specialist species, the Collared Kingfisher and the Mangrove Honeyeater, were recorded along the eastern fringe of the Cobaki Broadwater closest to the proposal. Despite lower overall bird densities, one of these sites had the highest density of Collared Kingfishers (3.5 birds/hectares) and Mangrove Honeyeaters (4.7 birds/hectares) recorded for the study area (Sandpiper Ecological Surveys 2001a).

The proposed bypass forms part of a much wider area that has been extensively monitored for shorebirds over the past 10 years. The results of these surveys suggest a steady decline in population size over time, particularly for migratory waders. Reasons for this are not known although a decline in roost and/or foraging habitat quality, dredging and noise from surrounding land uses may have had some effect.

4.2.4 Terrestrial Invertebrate Fauna

Mitchell's Rainforest Snail

Habitat for Mitchell's Rainforest Snail (*Thersites mitchellae*) is characterised by subtropical lowland rainforest, usually adjacent to wetlands between the Richmond and Tweed Rivers. The northernmost limit is at Bandore Point, just south of Tweed Heads. At the microhabitat level, this species prefers rainforest dominated by *Archontophoenix*, *Ficus* and *Erythtrina* species.

In general, the results of land snail collecting in the study area were poor. Even within Hidden Valley, snail diversity was considerably less than would be predicted for this habitat type. The taxonomic diversity of the other land snails collected during the survey and in the general area strongly suggests that the study area is outside the general habitat range preferred by this species.

Giant Dragonfly

The Queensland Giant Dragonfly *(Petalura litorea)* was recorded from the northern section of the study area. It was found approximately 80 metres from the proposal near Hidden Valley (Figure 4.9). Although this species is not listed on any state legislation, it was only recently considered to be a separate species from the Giant Dragonfly (*Petalura gigantea)*, a species that is 'endangered' in NSW. For the purposes of this study, *P. litorea* is considered to be of at least regional conservation significance and subject to similar threats as *P. gigantea*.

Suitable and potential habitat for this species along the proposed alignment is shown in Figure 2.6 and includes:

- a temporarily dry swamp south of the John Flynn Hospital and Medical Centre at Tugun, Queensland (Site A);
- a large patch of temporarily dry swamp habitat north-west of the proposed Tweed Heads Bypass interchange (Site B);
- swamps on the western side of the Tugun Landfill (Site C); and
- a shallow, boggy soak in a drainage line near the southern end of runway 14/32 on Gold Coast Airport (Site D).

Swordgrass Brown Butterfly

Second instar (second stage of insect moulting process) larvae of the Swordgrass Brown Butterfly (*Tisiphone aberona morrisi*) were found within the study area, in both NSW and Queensland north of Boyd Street (Site A in Figure 2.6). Breeding habitat for this species may be found wherever the host plant Swordgrass occurs. Potential breeding habitat also occurs at Sites B and C. The favoured host plant of this species occurs in scattered patches throughout this habitat.

4.2.5 Aquatic Biota

Wetland Habitat – Cobaki Broadwater

Estuarine wetlands are coastal communities that are at least occasionally inundated by saline to brackish waters. Three wetland habitat types have been described for the survey area and two of these are shown in Figure 4.1. The area of each community within the entire Tweed River (West *et al* 1985; Pressey and Griffith 1987) is given in brackets.

Mangrove Forest (309 hectares) fringes the entire Cobaki Broadwater and densely covers several dredge spoil islands in the Broadwater. Dominant species include Grey Mangrove, Red Mangrove, River Mangrove, Large Leafed Orange Mangrove, Blind Your Eye Mangrove and Mangrove Fern.

Mangroves are important habitats because they input significant amounts of vegetable matter into the food chain, trap, accumulate and release nutrients and particulate matter from surrounding land, provide habitat and shelter for a range of flora and fauna and protect the shoreline from erosion.

Saltmarsh (44 hectares) vegetation is located on the landward side of the mangroves and comprises shrublands, sedge and rush swamps and grasslands. There are three main saltmarsh communities in the survey area: Saltcouch (*Sporobolus*

virginicus)/Samphire (*Sarcorcornia quinqueflora*), Sea Rush (*Juncus kraussii*) associations and Bare Twig Rush (*Baumea juncea*).

Saltmarsh habitats are important because they stabilise bare mud flats, remineralise terrestrial and marine debris and provide a direct food source and habitat for terrestrial fauna, birds and marine fauna.

Seagrass (3 hectares) is limited to a number of subtidal patches in the entrance and is composed mainly of Eel Grass (*Zostera capricornii*). Sampling undertaken during the current study demonstrated that juvenile fish catches taken in the vicinity of seagrass beds were significantly higher in both diversity and abundance than those taken above bare substrate. The seagrass underwent a significant decline in the 1960s, probably associated with extensive dredging and catchment development.

Seagrasses are significant primary producers and play a critical role in coastal marine ecosystems by providing shelter and refuge for resident and transient fish of recreational and commercial importance, trapping, stabilising and holding bottom sediments, slowing and retarding water movement and promoting sedimentation of particulate matter. They also supply and fix biogenic calcium carbonate, produce and trap detritus and secrete dissolved organic matter, provide large amounts of substrate for encrusting animals and plants and provide a food source for some species of fish and crustacea.

Wetland Habitat – Drainage Lines

Habitats found along other wetlands in the vicinity of the proposal are described below. Their locations are shown in Figure 2.6.

- The dredge pond (Site 1) was less than 2 metres deep and was covered in water lilies at the time of survey. It may also support eels.
- The *Melaleuca* site to the south-east of the airport (Site 2) was dry at the time of survey.
- The wetlands to the immediate west of the southern end of the main runway drain surface run-off and are occasionally subject to tidal inundation. These were nearly dry during the survey, although some shallow turbid pools persisted (Site 3). These were dominated by sedges, rushes and water lilies but had critically low dissolved oxygen concentrations and evidence of acidic inflow.
- The large watercourse flowing from the airport to the Cobaki Broadwater has been channelled and trained to enhance drainage. The drain (Site 4a) is tidally influenced with the penetration of saline water extending approximately 75 m. Above this point, Site 4b is highly influenced by rainwater. It is likely that pH has a significant influence on the fauna community occurring in this wetland. The bed of both the channel and pools was characterised by a deep detrital layer. Although its steep banks supported little riparian vegetation, rushes and water lilies dominated the wetland flora.
- Small pools separated by stretches of damp creek bed occurred downstream of Tandy's Lane (Site 5). Although there was no flow in this creek during the survey, low velocity flow was apparent in January 2001. While this creek and its wetlands are relatively undisturbed, the lack of permanent flow, low dissolved oxygen concentrations and likelihood of run-off associated with either the Tugun Landfill or airport reaching the creek suggest that it is unlikely to support a significant fish fauna.

- Immediately west of the Tugun Landfill, an access track associated with the Cobaki Lakes development has been constructed through the creek's upper reaches at Site 6. A culvert provides continuation of flow in this area. On either side of the access track, wetland vegetation has been cleared and the creek forms shallow silty pools dominated by rushes, ferns and sedges. This vegetation community continues for about 100 metres before the creek forms a distinct channel in rainforest-dominated vegetation. The lack of permanent flow, low dissolved oxygen concentrations and likelihood of run-off associated with either the landfill or airport reaching the creek suggest that it is unlikely to support a significant fish fauna.
- A large mangrove-lined drainage channel runs along the northern boundary of the Tweed Heads Pony and Hack Club in NSW (Site 7). Some Swamp Oak and Cotton Tree (*Hibiscus tileaceus*) also occur. Its banks are generally steep and soft below the high-tide mark. Numerous snags in the form of fallen trees, debris and dumped rubbish provide some cover for Mullet, Garfish, Toadfish, Bream and Tarwhine. Although most or all of the fish of commercial/recreational importance found in the Broadwater may use this channel, it does not provide good quality habitat and would quickly turn fresh after heavy rains. This channel was not sampled.
- Site 8 runs along the NSW/Commonwealth border and was dry at the time of survey.

Conservation Significance

The Cobaki Broadwater was identified as an area of high scenic and ecological value in the *Lower Tweed Estuary River Management Plan* (NSW Department of Public Works 1991).

State Environmental Planning Policy Number 14 Wetland Number 5a fringes the north-eastern shore of Cobaki Creek and lies immediately adjacent to the airport. The proposal encroaches into the defined landward boundary of the estuarine wetland community by 27 m. The wetland comprises Saltmarsh and Mangrove communities. The Saltmarsh is subject to past and ongoing degradation due to off-road vehicle traffic, weed invasion, channel construction and encroachment by terrestrial plant communities. However, it provides an important roosting habitat for migratory shorebirds and for waterbirds. The distribution of mangroves appears to have altered since 1959 due to siltation, clearing, fragmentation, landward encroachment, dredging, airport development and dilution of salinity. However, the existing Mangrove community appears to be healthy.

The Tweed estuary supports important recreational and commercial fisheries and is recognised as being one of the highest producing rivers for both finfish and crustacea within the northern estuaries of NSW. The Cobaki Broadwater forms a substantial part of the Tweed system. The Cobaki Broadwater, especially its fringing mangroves and seagrass beds, is also considered to be an important breeding area for fish. Estuarine wetlands provide important habitats and food resources for a variety of terrestrial and bird fauna, including migratory birds. It therefore comprises Class 1 or major fish habitat.

None of the drainage channels and water bodies in close proximity to the proposal are considered to have more than local conservation significance. Sites 1, 4a, 4b, 5, 6 and 7 are all Class 2 or moderate fish habitat. Site 3 is Class 3 or minimal fish habitat. Sites

2 and 8 were dry at the time of survey and would be Class 3 or 4 (unlikely fish habitat) when inundated.

Fish Species

Overall, 11 native fish species were recorded in the Cobaki Broadwater during the current study. A further 22 species have been recorded in the Broadwater (Pease and Grinberg 1995). Fish species commonly caught by fishers within the Cobaki Broadwater include Whiting, Flathead, Bream, Mangrove Jack, Garfish, Trevally, Herring and Mullet. Some or all of these species are likely to occur in the drainage channel at Site 7 at times.

Furthermore, two native fish species, the Empire Gudgeon (*Hypseleotris compressa*) and Striped Gudgeon (*Gobiomorphus australis*), were found in drainage channels and water bodies located at Sites 1, 3, 4, 5 and 6. An introduced fish species, the Mosquito Fish (*Gambusia affinis*) was observed in all drainage channels and a crustacean, the Yabbie (*Cherax* sp.), was also recorded at Sites 3, 5 and 6. Eels may also occur at Site 1. All of these species are considered to be common.

Significant Fish Species

A total of 24 fish species of recreational or commercial significance was recorded or may occur within the Cobaki Broadwater and Site 7. These are listed in Table 4.7 with those species recorded shown in bold.

Table 4.7: Fishes of Recreational/Commercial Significance Recorded or Likely to Occur Within the Cobaki Broadwater

Common Name	Scientific Name	Recorded
Queenfish	*Scomberoides lysan*	No
Southern Herring	*Herklotsichthys castelnais*	No
Sandy's Sprat	*Hyperlophus vittatus*	No
Common Silver Belly	*Gerres subfasciatus*	No
Luderick	*Girella tricuspidata*	Yes
Snub-nosed Garfish	*Arrhamphus sclerolepis*	No
Sea Garfish	*Hemirhamphus australis*	No
Yellow-finned Leatherjacket	*Meuschenia trachylepis*	Yes
Tiger Mullet	*Liza argentea*	No
Flat-tailed Mullet	*Liza dussumieri*	No
Sea Mullet	*Mugil cephalus*	No
Fantail Mullet	*Mugil georgii*	No
Sand Mullet	*Myxus elongatus*	No
Large Tooth Flounder	*Pseudorhombus arsius*	No
Flag-tail Flathead	*Platycephalus arenarius*	No
Dusky Flathead	*Platycephalus fuscus*	No
Fringe-eyed Flathead	*Papilloculiceps nematophthalmus*	No
Tailor	*Pomatomus saltatrix*	No
Golden-line Whiting	*Lillago analis*	No
Sand Whiting	*Sillago ciliata*	No

Common Name	Scientific Name	Recorded
Trumpeter Whiting	*Sillago maculata*	No
Bream	*Acanthopagrus australis*	No
Tarwhine	*Rhabdosargus sarba*	Yes
Eastern Striped Trumpeter	*Pelates sexlineatus*	No

No fish species of legislative significance were recorded in wetlands in the survey area. In particular, the survey did not detect the Oxleyan Pygmy Perch *(Nannoperea oxleyana)*, a species listed as 'endangered' in NSW. This species is found in water bodies associated with wallum vegetation. It is considered unlikely to occur near the proposal because:

- it is intolerant of contaminants that may be associated with run-off from the airport and Tugun Landfill;
- water bodies surveyed are small and isolated;
- small shrimps that make up a significant proportion of its diet are absent from the drainage channels sampled; and
- species such as the Honey Blue-eye *(Pseudomugil mellis)* and Ornate Sunfish *(Rhadinocentrus ornatus)* that normally co-occur with the Oxleyan Pygmy Perch were not recorded.

Macro-invertebrates

A diverse and abundant macro-invertebrate fauna was recorded at Sites 5 and 6 (see Table 4.8). While midge larvae are most abundant in the stagnant waters of Site 6, the larval stages of insects, aquatic beetles and bugs and water snails are most abundant at Site 5. None of the species recorded are of conservation significance.

Table 4.8: Macro-invertebrates recorded from the natural creek to the west of Tugun Landfill and the airport.

Family Name	Common Name	Site 5*	Site 6*
Belostomatidae	Giant Water Beetles	0	1
Ceratopogonidae	Biting Midges	0	2
Chironomidae	Midges	158	397
Coenagrionidae	Terrestrial insect	15	1
Corduliidae	Dragonfly Larae	2	0
Corixidae	Water Boatment	0	1
Dytiscidae	Aquatic Beetles	2	0
Ephemerellidae	Mayfly Larvae	0	1
Heliminthidae	Aquatic Beetles	3	0
Helodidae	Aquatic Beetles	12	1
Hydrometridae	Water Bugs	1	0
Hydrophilidae	Water-scavenger Beetles	3	1
Mesoveliidae	Surface Dwelling Bugs	15	1
Parastacidae	*Cherax* sp. Yabbies	4	6
Planorbinae	Water Snail	19	0

Family Name	Common Name	Site 5*	Site 6*
Order Ostracoda	Shell Shrimps	0	1
Order Trichoptera	Caddis Fly Larvae	1	0
Order Plecoptera	Stone Fly Larvae	37	0

* Number of indivdials is the sum of 3 replicate 10 metres 'scoops' at each site

4.3 Regional Mapping for the Study Area

A number of reports have documented regionally significant habitats and fauna corridors in the area including Scotts and Drielsma (2003), Kingston *et al*. (1999) and Phillips and Callaghan (1996). These are generally broad planning tools and their boundaries do not correspond to the vegetation communities and habitats defined as part of this study. These are considered further in Chapter 5.

Key Habitats and Fauna Corridors

Two sub-regional fauna corridors and one regional corridor have been identified near the proposed bypass in NSW by Scotts and Drielsma 2003 (Figure 4.9). These could be used by all fauna groups particularly medium and large ground-dwelling mammals, seasonal and altitudinal migrants and mobile species such as birds and bats. One sub-regional fauna corridor is located at the southern end of the proposal area, connecting habitat south-west of the proposed bypass to land used by the Tweed Heads Pony and Hack Club and airport land south of the main runway. The other sub-regional fauna corridor follows the eastern shore of Cobaki Broadwater northwards, to NSW Crown land and branches off towards Currumbin Sanctuary in Queensland. The regional fauna corridor extends from Boyd Street westwards through NSW Crown land.

In Queensland the area known locally as 'Hidden Valley' forms part of an important link between the coastal lowland communities to the south and the elevated areas of the McPherson Ranges to the north-west. The *Gold Coast City Council Planning Scheme – Our Living City* recommends that part of Hidden Valley be rezoned as Environmental Protection for its fauna corridor properties.

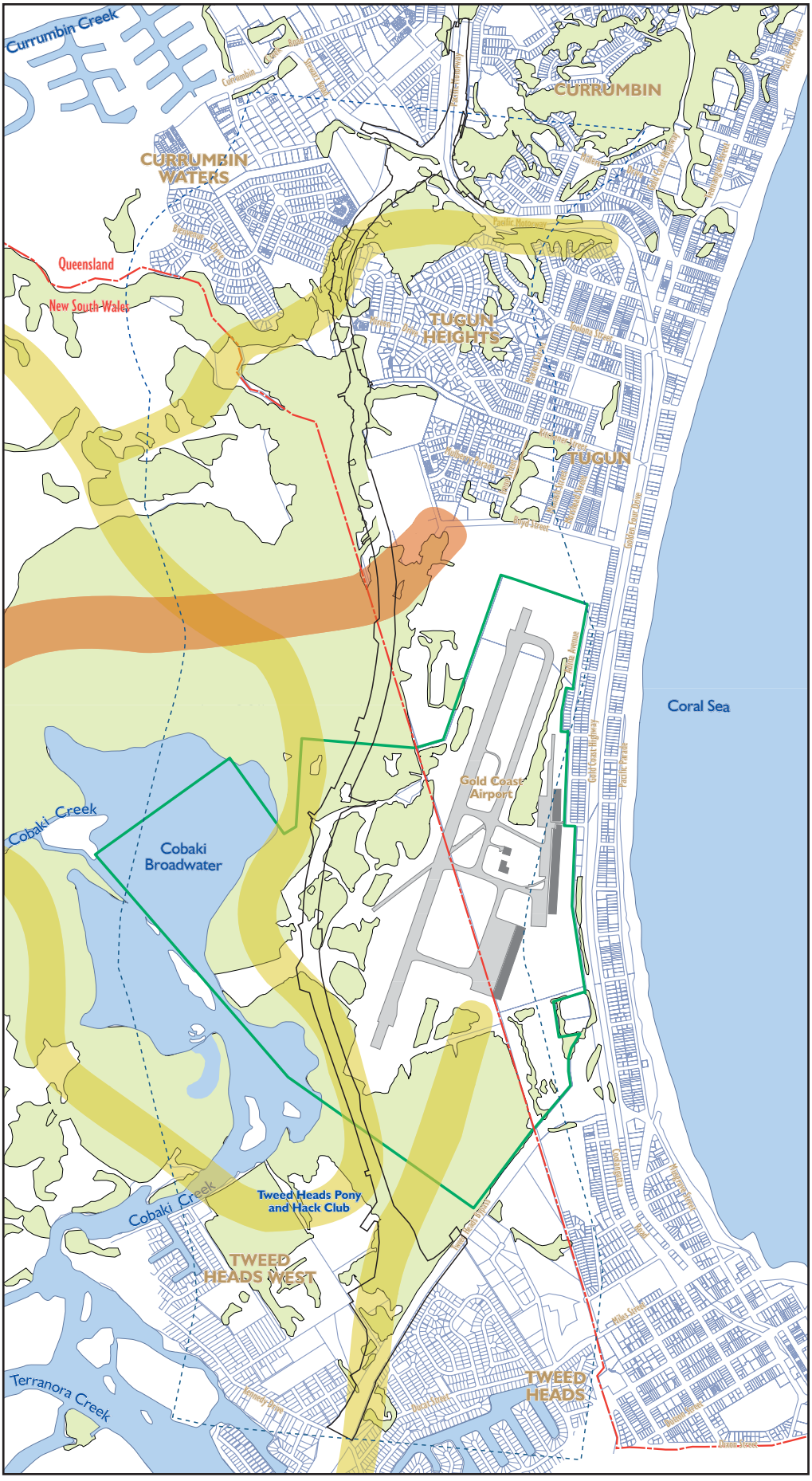
Another corridor also is likely to exist in Queensland at the far northern end of the proposed alignment. In this area a patch of vegetation to the west of the proposed corridor, although mostly degraded, forms part of an avifauna corridor linking to Currumbin Bird Sanctuary.

Regionally Significant and Core Ecological Areas (Kingston *et al.* 1999)

Type 1 and 2 Regionally Significant Natural Areas are found in the vicinity of the proposal. A large Natural Area (Types 1 and 2) is located at the southern end of the proposal encompassing land used by the Tweed Heads Pony and Hack Club and airport lands south of the existing runway. A smaller Type 2 Natural Area is located north of where the proposal intersects the airport boundary.

Koala Habitat Mapping (Phillips and Callaghan 1996)

The Tweed Shire comprises 2.5 percent Primary Koala habitat, 10.7 percent Secondary (Class A) Koala habitat, 10.3 percent Secondary (Class B) Koala habitat and 0.7 percent Unknown habitat.



Note:
The potential corridors on this figure are taken from the NSW DEC's " Key Habitats and Corridors - a Landscape framework for Regional Conservation Programs in North-east New South Wales". There have been no field surveys to determine if they exist.

References: Scotts D, Key Habitats and Corridors for Fauna as a Framework for Regional Biodiversity, Conservation Planning in Northern NSW. - Kingston et al, 1999, Tweed Vegetation Management Plan.

Figure 4.9 **Regionally Significant Fauna Habitats and Corridors**

However, Phillips and Callaghan (1996) note that approximately 80 percent of the Primary and Secondary habitat in the Tweed Shire no longer supports stable Koala populations due to extensive fragmentation. The population of Koalas in the Shire is estimated at 200 to 300.

In the vicinity of the proposal, vegetation communities dominated by Swamp Mahogany and/or Forest Red Gum are considered to provide Primary habitat for Koalas (and would meet the definition of SEPP 44 Potential Koala Habitat). Phillips and Callaghan (1996) note that the Primary habitat located to the south of the Queensland-NSW border adjacent to the Gold Coast Airport and bisected by the Tweed Heads Bypass has been extensively fragmented and may no longer support Koala populations. Some Secondary (Class B) Koala habitat is located where the proposal intersects the northern boundary of the Gold Coast Airport.

4.4 Summary of the Ecological Significance of the Study Area

4.4.1 Terrestrial Vegetation Communities

Of the 37 vegetation communities described for the study area, 28 would be affected by the proposed Tugun Bypass (refer to Table 6.1). Of these six are of conservation significance at the state level, 16 at the regional level and seven at the local level.

The six terrestrial vegetation communities of conservation significance at the state level affected by the proposed bypass are Littoral Rainforest, Regenerating Vine Forest, Saltmarsh, Swamp Oak Forest, Swamp Oak Woodland and Slashed Heathland. Littoral Rainforest and Regenerating Vine Forest would meet the classifiecation of Littoral Rainforest Endangered Ecologicla Community, while saltmarsh is also listed as an Endnagered Ecological Community under the *Threatened Species Conservation Act 1995*. Swamp Oak communities are of conservation significance at the state level in NSW (Benson 1989) and have recently been preliminarily listed as an Endangered Ecological Community under the *Threatened Species Conservation Act 1995*. Slashed Heathland is of conservation significance at the state level in Queensland as listed on the *Vegetation Management Regulation 2000*.

Terrestrial vegetation communities of regional conservation significance affected by the proposed bypass are: Moist Blackbutt Forest, Dry Blackbutt Forest, Blackbutt Woodland, Swamp Mahogany Forest, Swamp Mahogany–Paperbark Forest, Swamp Mahogany-Scribbly Gum Forest, Scribbly Gum Forest, Open Paperbark Woodland, Mixed Swamp Forest, Swamp Mahogany–Brushbox Forest, Scribbly Gum Mallee Heathland, Disturbed Saltmarsh–Sedgeland, Phragmites Rushland, Sedgeland, Mangrove Forest and Paperbark Forest.

The seven vegetation communities of local conservation significance affected by the proposed bypass are: Ironbark-Mahogany Forest, Forest Red Gum Forest, Regenerating Brushbox Forest, Paperbark Regrowth, Wet Heathland, Weedy Grassland and Cleared Land.

Some of these communities would meet the classification of recently preliminarily listinged Endangered Ecological Communities pursuant to the *Threatened Species Conservation Act 1995*. These communities would include Phragmites Rushland, Sedgelands, Swamp Mahogany Forest, Swamp Mahogany/Brushbox Forest, Swamp Mahogany/Paperbark Forest, Paperbark Forest, Open Paperbark Woodland, Paperbark Regrowth and Mixed Swamp Forest.

4.4.2 Terrestrial Plant Species

Overall, 489 native plant species were recorded in the study area of which 15 are of national or state significance, eight are of conservation significance at the regional level and 466 are of local significance. The following nine species of national, state and/or regional conservation significance are noteworthy because they may be affected by the proposed bypass:

- The **Swamp Orchid *(Phaius australis)*** is considered to be 'endangered' in NSW, Queensland and nationally. The NSW Department of Environment and Conservation is currently preparing a Recovery Plan for this species. Two colonies were recorded along the proposed bypass. This orchid grows in paperbark swamps and in sclerophyll forests on the coast at or near sea level from Port Macquarie, NSW to Cairns in far north Queensland.

  Phaius orchids are the largest terrestrial orchids in Australia. Although this species was once widespread along the eastern coast of Australia, only about 5 percent of the original population persists today. The total number of wild plants in Queensland is estimated at 5,000 to 10,000 while the total in NSW is about 1,500 (Benwell 1994, in Kelly 1998). However, these figures may overestimate actual population sizes by up to 50 percent. Threats to the species include habitat clearing for agriculture and urban development, grazing by cattle, horses and pigs, sandmining, collecting, tourism and recreational activities. Because of their rarity, large size and spectacular flowers, Swamp Orchids are highly sought after by native orchid enthusiasts. For this reason, exact locations have been made available to NSW Department of Environment and Conservation but are not included in this report.

- The **Little Wattle (*Acacia baueri* subsp. *baueri*)** is not protected under NSW or Commonwealth legislation but is listed as 'vulnerable' in Queensland. It grows in low, wet sandy heaths from southern NSW to Queensland. Nine individuals of this species were recorded from the study area including in NSW, on Commonwealth land as well as near Boyd Street in Queensland. It is found in regularly Slashed Heathland within the airport boundaries and has become 'miniaturised' as a result. However, this habitat is relatively weed-free and has a similar floristic composition to contiguous Scribbly Gum Mallee Heathland and Scribbly Gum Forest.
- **Stinking Cryptocarya (*Cryptocarya foetida*)** is listed as 'vulnerable' in NSW, Queensland and Commonwealth legislation. It is found scattered in Littoral Rainforest north from Iluka Nature Reserve to Fraser Island in Queensland. It was recorded from Regenerating Vine Forest in Queensland and approximately 310 metresfrom the alignment on Commonwealth land.
- The **Fine-leaved Tuckeroo (*Lepiderema pulchella*)** is not protected in Commonwealth land but is considered to be 'vulnerable' in NSW and 'rare' in Queensland. It grows in riverine and Littoral Rainforest north from the Brunswick River in NSW. Twelve plants were recorded from Hidden Valley in Queensland.
- **Black Walnut (*Endiandra globosa*)** is not protected in NSW or in Commonwealth land but is considered to be 'rare' in Queensland. This species is restricted to riverine rainforest on rich alluvial soils and on moist slopes in subtropical rainforest in the Brunswick and Tweed Valleys in NSW. Nine individuals were recorded from the study area.

- **Long-leaved Tuckeroo (*Cupaniopsis newmanii)*** is not protected in NSW or in Commonwealth land but is considered to be 'rare' in Queensland. It grows along the margins and within warmer subtropical rainforest on basalt or alluvium north from Mullumbimby in NSW. Four individuals were recorded in the study area.
- The **Coast Palm Lily (*Cordyline congesta*)** is not protected in NSW or in Commonwealth land but until recently was considered to be 'rare' in Queensland. The Coast Palm Lily grows in and on the margins of warmer rainforest on coastal lowlands, chiefly north of the Clarence River in NSW. The Coast Palm Lily was recorded on the proposed alignment in Queensland and 130 metresto the west of the proposed alignment on Commonwealth land.
- **Chinese Burr *(Thriumfetta rhomboidea)*** is regionally significant and is listed as being critically threatened in the NSW Comprehensive Regional Assessment due to the threat of coastal development. This species thrives on disturbed sandy or clayey soils. It was recorded from NSW and Commonwealth land and is considered to be reasonably common in the southern part of the study area. At least 150 plants were observed between the southern end of the airport and the Tweed Heads Bypass.
- The **Match Sticks *(Comesperma ericinum)*** record from Queensland is considered to be significant because it represents the only record of this shrub from this state since 1930. Historically, it has been recorded from only two locations in Queensland – Burleigh Heads in 1921 and Tugun in 1930. In addition the two plants located in Weedy Grassland along the northern boundary of the airport near the Queensland-NSW border in NSW represent the northernmost distributional limit for this species in NSW.

4.4.3 Aquatic Vegetation Communities

All marine plants (including mangroves, Saltcouch, Seagrass and Samphire vegetation species) are protected in Queensland under the *Fisheries Act 1994* and Regulations 1995 and in NSW under Part 7 of the *Fisheries Management Act 1994*. A permit is required from the Department of Primary Industries – Queensland Fisheries Service to disturb, damage or remove marine plants in Queensland. Saltmarsh and Mangrove Forest are considered to be of conservation significance at the regional level in NSW. A permit is required from NSW Fisheries to trim or remove mangroves in NSW.

4.4.4 Terrestrial Vertebrate Fauna Habitats

Terrestrial fauna habitats of conservation significance in the study area are shown on Figure 4.5.

All fauna habitats containing native or exotic vegetation used by native fauna species are considered to be of at least local conservation significance.

The Tweed Heads Pony and Hack Club roosting site and Cobaki Broadwater foraging area are of conservation significance at the high local level for migratory bird species.

Regenerating Vine Forest in Queensland and Lowland Rainforest and Mangrove Forest in NSW are considered to be of conservation significance at the regional level because they support a high diversity of legislatively significant bird species and have a restricted distribution in the region.

Habitat supporting a small-localised population of Common Planigales in Commonwealth land is considered to be of conservation significance at the regional

level. It appears to be critical to the survival of the population during wet periods. The closest known population was recorded near Stewart Road in Queensland and along Coolangatta Creek on Commonwealth land.

Habitat for the Wallum Froglet in NSW, Queensland and Commonwealth land is considered to be of conservation significance at the regional level because it supports one of the largest mainland populations of this species. Wallum Sedge Frog habitat is considered to be of conservation significance at the regional level because it supports a metapopulation (comprising several local interbreeding populations) of frogs.

4.4.5 Terrestrial Vertebrate Fauna Species

Overall, a total of 247 native terrestrial vertebrate fauna species was recorded in the study area of which 40 species are of state and national significance (including 14 species listed on international agreements such as JAMBA/CAMBA), 12 are of conservation significance at the regional level and 195 are of local significance.

The following species are noteworthy as they would be affected by the proposed bypass:

- The **Wallum Froglet** is currently listed as 'vulnerable' in NSW and Queensland. It has been nominated for listing as 'vulnerable' in the International Union for the Conservation of Nature (IUCN) Red Data Book (Jean-Marc Hero, *pers. comm.*). It is widely distributed throughout the vicinity of the Tugun proposal on NSW, Queensland and Commonwealth land. The population of froglets is estimated to be in excess of 10,000 individuals and is considered to be the largest recorded from the region according to Hero *et al*. 2001a. However very large populations of the Wallum Froglet occur at the Broadwater, Bundjalung, Yurragir and Myall Lakes National Parks, Tyagarah Nature Reserve and Crown land north of Lennox Heads. These populations are considered to be at least equivalent in size to the Tugun population, if not larger (Lewis *pers.comm.*). This species is restricted to low nutrient soils associated with acidic waters (pH less than 5) found on coastal lowlands and sand islands between Wyong, NSW and Fraser Island in Queensland. The nearest populations are located approximately 15 kilometres to the south and 25 kilometres to the north. Little is known about the ecology of this species but some evidence suggests that fidelity to breeding sites is maintained. Major threats include habitat loss through clearing for agriculture, pine plantations, housing and infrastructure. Mosquito Fish prey on the tadpoles of this species and may be implicated in their decline. The maintenance of water quality and hydrological regimes is critical for this species.
- The **Wallum Sedge Frog** is currently listed as 'vulnerable' in NSW, Queensland and nationally. It has been nominated for listing as 'vulnerable' in the International Union for the Conservation of Nature (IUCN) Red Data Book (Jean-Marc Hero, *pers. comm.*). Six subpopulations (local populations making up a larger interbreeding metapopulation) were recorded in ponds located on Commonwealth land. However, there were not enough data to determine population size. Generally, this species is restricted to coastal habitats characterised by low nutrient soils and acidic waters, extending between Coffs Harbour, NSW and Fraser Island, Queensland. It is one of several frog species that breeds in water of low pH (3.4 to 4.5). The nearest known mainland populations of this species are located 30 to 40 kilometres to the south and over 100 kilometres to the north. Very little is known about the ecological requirements of the Wallum Sedge Frog, but data

suggest that deeper semi-permanent ponds are required for breeding success. It is threatened directly by habitat destruction and indirectly by changes to hydrological regimes. Mosquito Fish prey on the tadpoles of this species and may be implicated in their decline.

- The **Bush Hen** is listed as 'vulnerable' in NSW. Unconfirmed records were obtained from near Stewart Road in Queensland and near Boyd Street in NSW. A pair of Bush Hens exhibiting nesting behaviour was recorded from a small dam in Hidden Valley. In NSW, habitat for this species is likely to be restricted to Swamp Mahogany Forest habitat along a small drainage line near Boyd Street.
- **Lewins Rail** is listed as 'rare' in Queensland and is considered to be of regional conservation significance in NSW. It is also considered to be 'near threatened' in the most recent *Action Plan for Australian Birds* (Garnett and Crowley 2000). It was recorded calling from several sites in NSW including Saltmarsh adjacent to Mangrove Forest, small wetlands in woodland, Swamp Forest and Sedgeland. It was also recorded from disturbed grassland near Stewart Road in Queensland. Some of this marginal habitat may be removed as a result of the proposal. The latter habitat is considered to be marginal as it provides dense vegetation but does not contain areas of permanent water.
- The **Eastern Grass Owl** is listed as 'vulnerable' in NSW. One individual was recorded in Sedgeland at the southern end of the main airport runway in NSW. The nearest historical records for this species are at Vintage Lakes approximately 4 kilometres south of the Gold Coast Airport and at Chinderah, south of the Tweed River in NSW. These owls are most likely restricted to low wet heath and tall grass habitat, in particular Phragmites Rushland. It is not clear whether the recorded individual was a resident but the area appeared to be large enough to support a breeding pair (Sandpiper Ecological Surveys 2001a). Unfortunately recent slashing activities conducted by Airport Maintenance has virtually rendered this habitat unsuitable for Eastern Grass Owls.
- The **Brahminy Kite** is of regional conservation significant and is widespread throughout the Tweed estuary, often observed foraging and roosting in NSW and on Commonwealth land. Kites were observed at Cobaki Creek, Cobaki south, Cobaki north and at the Tweed Heads Pony and Hack Club. Three nests were observed in Swamp Mahogany Forest near the existing Tweed Heads Bypass and a pair of kites was recorded nesting in one of these in June 2000. A further two possible nest sites were located in tall paperbarks located adjacent to Littoral Rainforest.
- The **Masked Owl** is listed as 'vulnerable' in NSW. Unconfirmed recordings of this species were made during the current surveys from vacant NSW Crown land to the north of the Cobaki Broadwater. The available data indicates that although Masked Owls may use the study area, they are unlikely to do so on a regular basis.
- The **Long-nosed Potoroo** is listed as 'vulnerable' in NSW and in Queensland. It is also considered to be 'vulnerable' at the national level. Although this species has been detected only sporadically since 1992, the supplementary study undertaken in 2003 confirmed the presence of a small isolated potoroo population at Cobaki. Mason (1993) estimated the population at Cobaki to consist of between 10 and 20 individuals; however recent trapping indicates that it may comprise at least 55–65 individuals, but may go as high as 85 individuals. The study area contains approximately 88 hectares of potoroo habitat with Scribbly Gum Mallee

Heathland, Tree Broom Heathland and Swamp Mahogany-Scribbly Gum Forest supporting the highest densities of potoroos. This species is known to occur at Cudgen Nature Reserve to the south and in Tyagarah Nature Reserve in the Byron Shire, NSW. Major threats include habitat loss, fragmentation and modification mainly through inappropriate fire regimes. As a Critical Weight Range (CWR) species (weighing between 18 and 550 grams) (Burbidge and McKenzie 1989), it is highly vulnerable to predation by introduced predators such as dogs, foxes and cats.

- The **Common Planigale** is listed as 'vulnerable' in NSW. Very little is known about the ecology of this species. Populations were recorded at the northernmost part of the proposal adjacent to Stewart Road in Queensland and within a 1 hectares area located where the proposal comes closest to the Cobaki Broadwater in Commonwealth land. As the latter population was surveyed during a range of environmental and seasonal conditions, it became apparent that individual Common Planigales were restricted to an area of higher elevation Swamp Mahogany and Swamp Mahogany–Brushbox Forest during high rainfall events. Although this population appeared to be small and localised, there was insufficient data from which to estimate population size. A total of six Common Planigales were captured in this area, five of these being captured within 20 metresof each other. Additonal surveys have detected two individual Common Planigales along Coolangatta Creek on Commonwealth land (Ecosure 2003). Supplementary surveys were conducted in 2004 in NSW Crown land to the north-west of the airport, however, no individuals were detected (Lewis 2004a).
- The **Eastern Long-eared Bat** is listed as 'vulnerable' in NSW. It has a near-coastal distribution from Cape York in far north Queensland to Coffs Harbour in NSW. This species was relatively abundant in the vicinity of the proposal suggesting that it represented a significant population in the area. An additional survey was undertaken for this species in January 2001 to determine the importance of a stand of mature Paperbark Forest as roosting habitat. Despite considerable effort, only one individual was captured and fitted with a radio transmitter. The individual dispersed from the area on the following day and no location data could be collected. At the time of the additional survey, bat activity appeared to be minimal suggesting that the area is used seasonally. This species is associated with a range of habitats in Queensland but generally prefers rainforest in NSW.
- The **Grey-headed Flying Fox ha**s is listed as 'vulnerable' in NSW and at the national level. The Grey-headed Flying Fox is relatively common within the study area at times. This species has been recorded in a foraging in a number of locations in the study area from NSW, Commonwealth land and Queensland. A day-roost site for a small group (15 to 20 individuals) of this species was found in Hidden Valley.

4.4.6 Terrestrial Invertebrate Fauna Species

At least two invertebrate species of regional conservation significance, the Swordgrass Brown Butterfly and the Queensland Giant Dragonfly were recorded along the proposed alignment.

4.4.7 Wetland Habitats

Fish habitat in drainage channels and streams located along the alignment was considered to be of local conservation significance. However, the Cobaki Broadwater constitutes major fish habitat.

Within NSW, Mangrove Forest and Saltmarsh are protected under Section 7 of the *Fisheries Management Act 1994*. One wetland of conservation significance at the state level, *State Environmental Planning Policy Number 14* Wetland Number 5a, is located adjacent to the proposed bypass.

4.4.8 Aquatic Fauna Species

No fish species of conservation significance at the regional or state level were recorded within the proposal area. Three fish species of recreational/commercial significance were recorded in the Cobaki Broadwater namely Luderick, Yellow-finned Leatherjacket and Tarwhine.

4.4.9 Introduced Species of Flora and Fauna

The presence and density of introduced species of flora and fauna gives an indication of the existing condition of native habitats and threats to their survival. A total of 11 terrestrial and one aquatic introduced fauna species were recorded. Foxes are abundant throughout the study area. One-hundred and seven (107) weed species were recorded in the study area, with weeds present in most of the communities in the study area.

4.4.10 Overall Ecological Significance

Overall, the proposal study area (defined as a 2 kilometres wide corridor along the proposed alignment from Stewart Road to Kennedy Drive) is considered to be of national significance as it supports:

- habitat for four flora and three fauna species listed at the national level and 14 species listed on international agreements;
- habitat for 11 flora and 26 fauna species of state significance;
- habitat for two invertebrate species of at least regional significance, the Swordgrass Brown Butterfly and the Queensland Giant Dragonfly;
- habitat for two NSW Endangered Ecological Communities and three preliminarily listed NSW Endangered Ecological Communities;
- two Swamp Orchid populations of state and possibly national significance;
- habitat for a large mainland populations of Wallum Froglets, a species that has recently been nominated for listing in the IUCN Red Data Book;
- a small disjunct population of Long-nosed Potoroos, a species of national and state significance, with the population preliminarily listed in NSW as Endangered ;
- a small isolated metapopulation of Wallum Sedge Frogs, a species listed as 'vulnerable' on the *Environment Protection and Biodiversity Conservation Act 1999* and recently been nominated for listing in the IUCN Red Data Book;
- significant populations of legislatively significant endemic mangrove specialist species, the Mangrove Honeyeater and the Collared Kingfisher;

- important habitat for a number of species listed on international migratory bird agreements;
- habitat for Match Sticks, a species which prior to this study was thought to be extinct in Queensland;
- a small disjunct population of Common Planigale, a species of state significance in NSW; and
- at least two wetlands with an exceptionally high diversity of frog species (14 species).

Sites of significance are outlined in the following chapter.

5. Sites of Significance

The process of refinement of the C4 option (Main Roads 1999) aimed to avoid areas of particular ecological significance along the proposed alignment. Where these could not be protected or avoided, mitigation measures would apply. These ecologically significant (ES) areas are described below and shown in Figure 5.1.

5.1 Common Planigale Population (ES1)

A population of the Common Planigale was recorded within Regenerating Blackbutt Forest at ES1. This species is listed as 'vulnerable' in NSW but has no conservation status in Queensland. However, it is only one of three populations recorded in the vicinity of the proposed bypass. This species is not readily detected using conventional survey methods and little is known about its ecology and behaviour. Ecologically significant area 1 (ES1), although mostly degraded, may form part of an avifauna corridor linking to Currumbin Bird Sanctuary.

The proposed alignment passes to the west of ES1. The Common Planigale population would therefore not be directly or indirectly affected by the proposed bypass.

5.2 Hidden Valley (ES2)

Hidden Valley contains a rainforest community of regional conservation significance comprising a high diversity (at least 9 species) and density of legislatively significant plant species. It also provides habitat for a high diversity of birds including up to three species of fruit-doves and a breeding pair of Bush Hens. These species are of conservation significance at the state level in NSW. Hidden Valley was identified as an important roosting and foraging habitat for bats. It is used as a day camp for a small group of Grey-headed Flying Foxes, a species that has been recently listed as 'vulnerable' in NSW and nationally. Hero *et al*. (2001a) consider Hidden Valley to be of bio-geographic importance because it contains two reptile and one mammal population of scientific interest.

This area also forms part of an important fauna link between the coastal lowland communities to the south and the elevated areas of the McPherson Ranges to the north-west. The *Gold Coast City Council Planning Scheme – Our Living City* (Gold Coast City Council 2003) recommends that part of Hidden Valley is rezoned Environmental Protection for its fauna corridor properties.

The refined C4 alignment transects the eastern side of ES2 where vegetation is already disturbed. However, this area still contains individuals from legislatively significant plant species. Potential impacts in this area would be associated with bridge construction and the creation of a large cutting to the south of Hidden Valley.

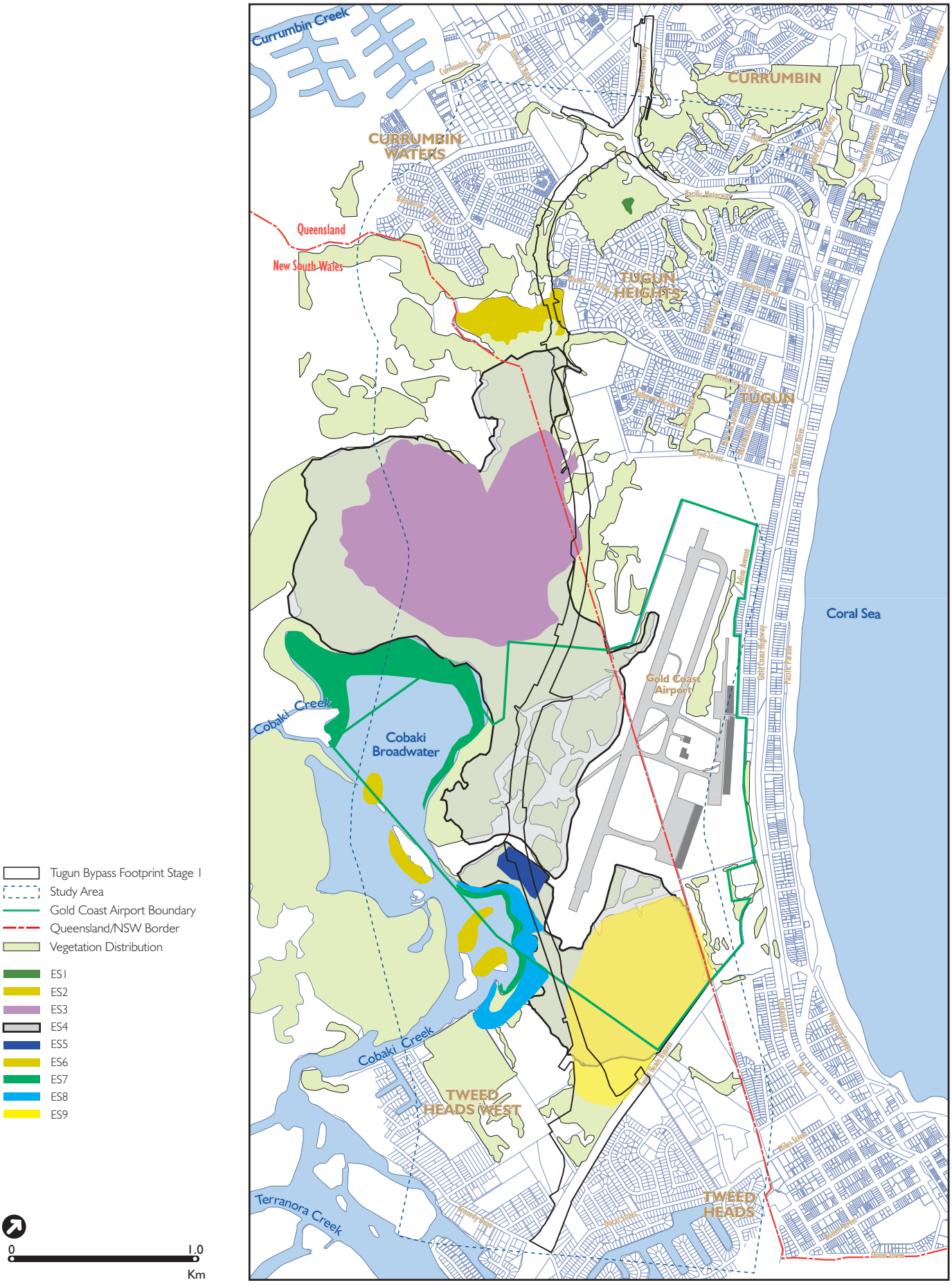


Figure 5.1 **Sites of Ecological Significance Along the Proposed Alignment**

5.3 Long-nosed Potoroo Habitat (ES3)

Ecologically significant area 3 (ES3) is an extensive vegetated area in NSW extending from the proposed bypass in the north through to heathlands in the west and bordering on the Cobaki Broadwater to the south. It contains dense heathland habitat suitable for Long-nosed Potoroos, old-growth Scribbly Gum Forest and a small area of Littoral Rainforest. While the rainforest community is considered to be of regional conservation significance, the old-growth forest provides some of the only large tree hollows near the proposed bypass. This area contains key habitat and forms part of regional and sub-regional wildlife corridors as defined by Scotts and Drielsma (2003).

A small disjunct population of the Long-nosed Potoroo occurs throughout ES3. This species is considered to be of legislative significance in NSW, Queensland and nationally. Although potoroos have been detected only sporadically in this area since 1992, recent trapping indicates the population may comprise at least 55–65 individuals, but may go as high as 85 individuals. The highest densities of potoroos were recorded to the north and south of the access track to the Cobaki Lakes development. Of the 27 individuals captured, 15 were located in a 18 hectares patch of habitat to the north of the access track. No individuals were observed crossing the track, indicating that it has effectively divided the population into two sub-populations. Furthermore, construction of the access track has resulted in extensive seasonal flooding to the north, and the subsequent loss of potoroo habitat.

To minimise impacts from the proposed bypass on this population, the proposed alignment has been located as far as possible to the east of the known habitat for this species. Constraints associated with the Tugun Landfill have prevented the alignment from being moved further eastward.

The area of NSW Crown land also provides habitat for the Swordgrass Brown Butterfly, the Wallum Froglet and potentially for bird species of legislative significance including Black Bittern, Bush Hen, Masked Owl and Glossy Black-Cockatoo.

Suitable habitat for threatened species of flora also occurs in this area including known habitat for the Little Wattle and Match Sticks. Little Wattle is considered to be 'vulnerable' in Queensland and the population identified in Queensland may represent the southernmost population of this species in that state. Although not listed in Queensland, NSW or Commonwealth legislation, Match Sticks are considered to be of state significance in Queensland as prior to this study, it was thought to be extinct there. The proposed bypass would result in the removal of two individual Little Wattles from the Queensland population. It is also likely that the proposed bypass would result in the removal of some individual Match Sticks in Queensland. The exact location and numbers of the Queensland population is not known due to continued slashing activities in the area making individuals difficult or impossible to locate.

5.4 Known Wallum Froglet and Wallum Sedge Frog Habitat (ES4)

Ecologically significant area 4 (ES4) encompasses almost the entire study area including parts of ES3 and ES10 and all of ES5 (Figure 5.1). It therefore contains all those areas of key habitat and fauna corridors identified by Scotts and Drielsma (2003) and Kingston *et al*. (1999). The outer boundary of ES4 is defined by known habitat for the Wallum Froglet (Figure 4.6), a species of legislative significance at the state level in both NSW

and Queensland. The Wallum Froglet occurs throughout this area as determined by calling individuals. Approximately 9 percent of 429 hectares of known and potential habitat for this species would be removed as a result of the proposed bypass. As there are limited opportunities to mitigate barrier impacts, the proposed bypass may fragment the population.

A metapopulation of the Wallum Sedge Frog, a species considered to be of state significance in NSW and listed nationally, was also recorded in a localised area within ES4 (see Figure 4.11). The alignment would result in the removal of approximately 8 percent of 56 hectares of known and potential habitat for this species. The closest subpopulation would become extinct as a result of the proposal, while it is possible that the next closest subpopulation may also be significantly affected by the proposed bypass. The proposed bypass avoids most of the breeding ponds for this species but the final alignment was constrained by the need to minimise any impacts on the National Estate area, Saltmarsh (in Commonwealth land), *State Environmental Planning Policy Number 14* Wetland Number 5a (ES9) and threatened flora species. The proposed bypass would fragment the metapopulation by isolating the remaining subpopulations to the east from a small amount of known and potential habitat to the west. Two of the breeding ponds for the Wallum Sedge Frog provide habitat for at least 14 species of frogs, an exceptionally high frog biodiversity.

In addition Wallum Froglet and Wallum Sedge Frog populations located in ES4 may be indirectly affected by alterations to the local hydrology, edge effects and water contamination (Section 6.5.3).

5.5 Common Planigale Population (ES5)

Ecologically significant area 5 (ES5) is located on Commonwealth land and provides known primary and secondary habitat for a small disjunct population of Common Planigales. This species is considered to be of conservation significance at the state level in NSW. The population appears to be mostly be confined to a 1 hectares area of habitat that may be critical to their survival during wet periods. Common Planigale habitat at ES5 is included within key habitat as defined by Scotts and Drielsma (2003) and as a Type 1 Regionally Significant Natural Area (Kingston *et al*. 1999).

The original C4 alignment (Main Roads 1999) transected important habitat for the Common Planigale and a Wallum Sedge Frog breeding pond adjacent to it. The route was consequently moved further to the west to avoid the majority of ES5. The final alignment was further constrained by the need to minimise any impacts on the National Estate area, Saltmarsh (in Commonwealth land), *State Environmental Planning Policy Number 14* Wetland Number 5a (ES9) and threatened flora species. The proposed bypass would remove approximately 5 percent of known primary habitat for the Common Planigale and 67 percent of secondary habitat. It would also isolate known habitat from potential habitat located to the west. There are no opportunities to establish underpasses in this area due to the construction of tunnel ramps. Retained habitat for this species may still be potentially affected by indirect impacts associated with hydrological regimes.

5.6 High Tide Roosts for Estuarine Birds (ES6)

Two major high-tide roosts were identified near the proposed bypass – Tweed Heads Pony and Hack Club and the Cobaki Creek mangroves. Although there appears to have

been an overall decline in roost site usage in the lower Tweed, these roosts are important in a local context especially for Eastern Curlew, Whimbrel, Pacific Golden Plover and Common Greenshank. It is unknown what the effect surrounding land uses have had on these roost sites. There is a critical shortage of spring tide roosts in the lower Tweed River. The Tweed Heads Pony and Hack Club roost is one of only four available in the area.

The high-tide roosts are unlikely to be directly affected by the proposed bypass but may be indirectly affected through noise and other construction disturbances (Section 6.5.5).

5.7 Intertidal Foraging Areas for Estuarine Birds (ES7)

Despite the apparent decline in migratory shorebirds in the area, Cobaki Broadwater continues to be significant as a foraging area in an estuary-wide context. Three foraging areas have been identified close to the proposed bypass – Tweed Heads Pony and Hack Club, Cobaki Creek and Cobaki Broadwater. Approximately 20 percent of the total migratory shorebird population was recorded feeding there.

Intertidal foraging areas are unlikely to be directly affected by the proposed bypass but may be indirectly affected through noise and other construction disturbances (Section 6.5.6).

5.8 State Environmental Planning Policy Number 14 Wetland Number 5a and adjacent Wetland Habitat (ES8)

State Environmental Planning Policy Number 14 Wetland Number 5a fringes the north-eastern shore of Cobaki Creek. This wetland spans both NSW and Commonwealth land and is part of a sub-regional wildlife corridor described by Scotts and Drielsma (2003). Within NSW, this wetland is regarded as being of conservation significance at the state level but this status is not recognised on Commonwealth land. Although the Saltmarsh and Mangrove Forest are subject to past and ongoing degradation, the mangrove community appears to be healthy. Furthermore, the Saltmarsh in *State Environmental Planning Policy Number 14* Wetland Number 5a provides an important roosting habitat for migratory shorebirds and waterbirds (NSW Department of Public Works 1990).

The proposed bypass would transect the defined landward boundary of the estuarine wetland community where it crosses into NSW from Commonwealth land. Some wetland habitat would be removed as a result of the proposed bypass. However, this area is located at the tunnelled section of the proposed bypass and rehabilitation of the wetland would be undertaken once the tunnel is constructed. There may also be indirect effects associated with hydrological changes and edge effects in this area (Section 6.5.7).

5.9 Area of High Amphibian and Bat Biodiversity (ES10)

Ecologically significant area 10 (ES10) supports a high diversity of frog and bat species, at least five plant species of conservation significance and several recently used Brahminy Kite nests. Fourteen species of frogs were recorded from this single wetland habitat located in Commonwealth land. This high species diversity may have been due

to extensive flooding in the area at various times throughout the study. Species recorded included the threatened Wallum Froglet and the Wallum Sedge Frog. It has also been described as key habitat and a sub-regional wildlife corridor by Scotts and Drielsma (2003). It comprises Types 1 and 2 Regionally Significant Natural Areas (Kingston *et al*. 1999).

Furthermore, this area was considered to provide foraging habitat for several bat species of legislative significance, including the Black Flying Fox, Common Blossom Bat, Large-footed Myotis, Eastern Long-eared Bat and Little Bent-wing Bat. In particular, the Eastern Long-eared Bat, a species of state significance in NSW, was found in high numbers in summer and may use mature paperbark trees in this area for roosting.

Although the preferred alignment follows the western edge of vegetation, it still results in some fragmentation of the Paperbark Forest. However, the area of mature paperbarks located further to the east, would not be affected by the proposed bypass. It is likely that at least one Brahminy Kite nest tree would need to be removed. There is also the potential for indirect impacts associated with hydrological changes, edge effects and disturbance (Section 6.5.9).

6. Potential Impacts of the Proposed Tugun Bypass

6.1 The Proposed Tugun Bypass

Potential impacts and recommended mitigation measures apply to the proposal footprint. The proposed bypass was located to avoid as many identified environmental constraints as practical and to minimise habitat fragmentation by keeping the route as close as possible to the edge of disturbed land. However, the proposed bypass would still result in the removal of some individuals from species of conservation significance and their habitat.

The final road footprint also includes sedimentation ponds, surface drains, collecting drains, access tracks and ancillary construction facilities such as asphalt batch plants and site compounds (Figure 6.1). The width of the footprint is typically 60 m, although it extends further in some areas. It should be noted that the width of the road footprint is an estimated maximum and the potential exists to reduce this width by up to 10 metres.

6.2 General Impacts

There are two main types of impacts associated with linear corridor developments. These are construction and operation impacts:

- Construction impacts are those associated with constructing a highway, railway or utility corridor. Construction activities potentially affecting flora and fauna include clearing, excavation, sudden and unpredictable noise, truck movements, drilling, blasting and other mostly noisy and unpredictable activities. Construction impacts could be expected to occur in the short- to medium-term (approval to end of construction = 3 years).
- Operation impacts are those associated with long-term operation of the highway. These are ongoing and long-term (>3 years from start of construction) and are related to the continued use and management of the highway. Although some impacts are common to both construction and operational phases, these tend to differ in their magnitude and timing in the two different phases.

Compared to large-scale developments such as airports and residential subdivisions, linear developments have a relatively small 'footprint' at any one point in the landscape. At the local level, their effects may therefore be relatively small or easily mitigated. However, because of their extensive nature in the broader landscape, they have a range of less localised potential environment impacts that need to be assessed and mitigated through incorporation of appropriate design and amelioration measures.

Tugun Bypass Footprint
Study Area
Gold Coast Airport Boundary
Queensland/NSW Border

0 1.0
Km

Figure 6.1 **Proposal Footprint**

6.2.1 Habitat Loss and Fragmentation

Loss and fragmentation of vegetation/habitats would occur predominantly during construction. Additional fragmentation may also occur through ongoing habitat degradation when the bypass is in operation.

Some native vegetation would be removed as a result of the proposed bypass. This would result in the direct loss of vegetation communities as well as habitat available for flora and fauna species in the area including roosting, foraging and nesting resources (fruiting and flowering trees, hollows, logs and shrubs). In aquatic habitats, these include riparian vegetation, gravel beds, pools, snags, mangroves and seagrass. Loss of habitat may have the effect of increasing the risk of local or regional extinction for some species (especially sedentary or threatened ones), reducing recolonisation opportunities and/or increasing edge effects.

Habitat fragmentation may isolate remnant vegetation and create barriers to the movement of small and/or sedentary fauna species such as ground-dwelling mammals, reptiles and amphibians. This is of particular concern where wildlife corridors are fragmented.

6.2.2 Loss of Individuals from Species of Conservation Significance

Loss of some individuals from species or populations of conservation significance is more likely to occur during the construction phase but may also occur during highway operation due to ongoing habitat degradation and consequent edge effects.

Some individual plants and animals belonging to species of conservation significance would be removed as a result of the proposed bypass. Although most known locations of such plants and animals have been avoided through careful refinement of the proposed final alignment, it is still possible that additional individuals may be found within the footprint. Whereas in most cases the removal of some individuals from species of conservation significance is unlikely to have a significant effect, there is a risk of local or regional extinction in the case of small disjunct populations. In these cases, mitigation measures would aim to minimise habitat loss and fragmentation and to rehabilitate or revegetate suitable habitat. These populations would be carefully monitored and measures taken to protect them further if required. Strategies for locating individuals and providing for their protection through translocation or rehabilitation need to be considered.

6.2.3 Altered Hydrological Regimes

Alterations to hydrological regimes are primarily associated with the construction phase although structures such as major tunnels may have more permanent effects.

Road construction requires extensive earth moving and excavation that may have significant impacts on the aquatic environment. Possible primary impacts of the proposed bypass include alterations to water flow into existing wetlands, some ponding of water and lowering of the groundwater table. However, the probability of these occurring would be low given that mitigation measures would be implemented. Surface water would be transferred to the other side of the bypass via piping, diverting or draining to maintain existing flows and prevent ponding.

Construction of the proposed tunnel may result in draw-down of the groundwater table. Any lowering of the table may affect the wetland vegetation communities in the

southern portion of the bypass. If this impact occurs over only a short period (one to two months) no lasting effects would be expected (FRC Environmental 2001). However, longer periods or permanent lowering would result in a change of species composition, replacing existing species with those that prefer drier habitats. This would be observed initially in the herb layer, but would also affect Swamp Mahogany and paperbark communities in the long-term. Such impacts would be minimised through the establishment of recharge wells to pump water out of the tunnelled section and back into the water table.

Any lowering of the groundwater table may allow the oxidation of potential acid sulphate soils. This would result in acid water flows downstream of the proposed tunnel, resulting in short-term and long-term impacts on the vegetation communities and aquatic habitats. It may alter species composition and depending upon the amount of acid run-off, may eventually result in the disappearance of sensitive vegetation communities such as Littoral Rainforest. Oxidation of potential acid sulphate soils would be minimised through the management of surface and groundwater at all times during excavation and construction. Protocols for the monitoring and management of acid sulphate soils have also been developed (see Technical Paper 5).

6.2.4 Wetland Contamination

Wetland contamination is associated with both construction and operation phases.

During construction, there is the potential to affect water quality through contamination of surface waters by uncontrolled erosion and sedimentation, fuel or chemical spills and possibly generation of acid sulphate run-off. During operation, contamination may occur through normal road run-off or fuel or chemical spills.

Water quality may be degraded by elevating turbidity, allowing nutrient enrichment and by introducing petroleum hydrocarbons and heavy metals. Any increase in concentrations of suspended solids is likely to affect the ability of seagrass to photosynthesis, thereby affecting its depth distribution and vigour. Suspended sediments may also smother fish eggs and food resources and have been implicated in the reduction of fish diversity and numbers. The introduction of contaminants into the Cobaki Broadwater has the potential to affect fish and fisheries. This would in turn have negative impacts on fauna dependent on the Broadwater for foraging.

There is a risk of oxidation of potential acid sulphate soils disturbed by engineering works. Short-term effects of acid water may include fish kills, fish disease, mass mortality of benthic (bottom-dwelling) organisms and increased light penetration. Acidification has the potential to alter the natural community structure for many years. Long-term effects include:

- alteration and loss of habitat;
- reduced spawning success;
- reduced food resources;
- dominance of acid-tolerant plankton species;
- increased predation;
- changes in the food chain;
- damaged and undeveloped eggs, reduced recruitment; and

- increased availability of toxic elements and reduced availability of nutrients.

Low pH often has the indirect effect of altering dissolved oxygen concentrations and biotoxifying elements.

6.2.5 Edge Effects

The proposed bypass would create new habitat-road edges along the alignment during the construction phase. Edge effects would be maintained and possibly exacerbated throughout the operational phase.

Edge effects relate to disturbance associated with the creation of an edge or a boundary between vegetated habitat and cleared areas such as pastures and roads. Edge effects may include any or all of the following:

- loss of soil moisture;
- increase in wind exposure;
- changes to species composition and abundance;
- weed proliferation;
- increase in predation and brood parasitism; and
- increased competition.

A review of international and Australian literature on edge effects, particularly those associated with roads, found that edge-affected zones extend at least 50 metres from the edge, but some effects, such as noise and disturbance, may extend much further (Bali 2000). Although edge habitats may attract some species (edge-preferring species), these are generally common and adaptable. On the other hand, threatened species tend to be sensitive to disturbance and prefer interior habitats. The proposed road corridor is already subject to edge effects associated with tracks, roads and past and ongoing disturbance associated with land management. Generally edge effects increase in proportion to the edge to area ratio of the vegetation remnant.

6.2.6 Barrier Effects

The construction of linear transport corridors such as the proposed Tugun Bypass creates barriers that remain when the corridor is in operation.

Both physical and biological barriers, would be created and maintained as a result of the proposed bypass. Roads are known to represent major barriers for ground-dwelling and sedentary species (Andrews 1990; Bennett 1991, 1999) by increasing road mortality or road avoidance. Physical barrier effects may be most significant for small mammals or species requiring cover such as amphibians, reptiles, small ground-dwelling mammals and passerine birds. Similarly, barriers to fish passage may prevent fish from accessing food, shelter or breeding grounds. Barriers act to isolate subpopulations and may, in populations that are already small and isolated, result in local extinction through inbreeding and loss of genetic variation. Barrier effects are of particular concern where they transect wildlife corridors. Fauna-exclusion fencing may also act as a partial barrier by restricting road crossings to a limited number of overpasses and/or underpasses.

6.2.7 Road Mortality

Road mortality would occur predominantly during the operational phase.

Road kills could occur along the proposed bypass when animals attempt to cross a road or use roadside verges for foraging. Those species most susceptible to road kills are ground-dwelling mammals, reptiles, frogs and some bird species such as owls, passerines, cockatoos, ravens or magpies. Apart from road kills increasing the overall mortality rate, small populations in particular can be affected by selective mortality of certain age/sex classes. In the long-term, a skewed sex ratio or increased adult mortality may drive these populations to extinction. Fauna-exclusion fencing would minimise or prevent road kills.

Road mortality could occur along the entire length of the proposed bypass except in the southern section, where the tunnel and associated ramps would exclude animals from crossing the road or would enable safe movement over the road (i.e. over the tunnel or above the ramps for aerial species). Road mortality is likely to be higher where suitable habitat is present on both sides of the road and during the initial phase before animals become accustomed to the road.

6.2.8 Disturbance

The area covered by the proposed bypass project is already subject to disturbance associated with surrounding land uses. However, additional disturbance, in particular due to noise, lighting, movement and vibration, would be associated with both the construction and operation phases of the Tugun Bypass. Disturbance during construction is likely to be variable in type and intensity. During operation, disturbance would be more continuous and therefore predictable.

Although there is some evidence to suggest that the effects of traffic noise on fauna may be far-reaching and result in behavioural avoidance (Van der Zande *et al*. 1980), it has not been clearly demonstrated that the reproductive success of species is directly affected by noise alone. In fact, numerous studies investigating the effects of noise on some bird species have shown that they habituate readily to continuous noise (United States Department of Agriculture 1992). Similarly, there is no conclusive data demonstrating that fauna species are adversely affected by light and there is some anecdotal evidence to show that bats and frogs may be attracted to insects attracted to lights. However, near roads, this may result in additional road kills of these species.

Initially it is proposed to restrict lighting along the proposed bypass to interchanges, tunnel approach ramps and within the tunnel itself.

6.2.9 Cumulative Impacts

Cumulative impacts are expected to result from construction and operation of the proposed bypass, and interactions between other existing and proposed developments.

Cumulative impacts are not well understood because the sum total of impacts to which any species or populations would be exposed is not known nor is the weighting to assign to each. However, it is important to assess all the impacts associated with the proposed bypass in the context of other existing and future threatening processes in the vicinity. For instance, the Cobaki Lakes development and the proposed extension of the rail link to Gold Coast Airport need to be assessed with respect to the regional distribution and significance of flora and fauna. The long-term result of cumulative impacts is a gradual reduction of biodiversity and the replacement of highly specialised species with generalist and highly adaptive species.

Cumulative impacts are discussed further in Chapter 8.

6.3 Level of Impact

Most of the environmental impacts described below are associated with the construction phase. However, barrier impacts and fragmentation are ongoing and would occur throughout operation of the bypass. Although some impacts like disturbance are associated with both construction and operation phases, these would vary in both intensity and predictability during each phase (heavy machinery movements versus traffic).

For the purposes of the current study, impact assessment criteria are as follows:

- a local impact would affect flora and fauna occurrences and/or behaviour in the immediate vicinity of the proposed bypass;
- a high local impact would affect flora and fauna abundance and/or distribution within a 10 kilometres radius of the proposed bypass;
- a regional impact would affect flora and fauna abundance and/or distribution in the region (north-east NSW or south-east Queensland); and
- a state impact would affect flora and fauna abundance and/or distribution in NSW or Queensland.

6.4 Impacts Along the Alignment

This section examines the potential impacts associated with the entire bypass from Stewart Road to Kennedy Drive. It assumes that appropriate and effective mitigation measures would be implemented as part of the proposed bypass. Impacts related to specific sites of significance are described in Section 6.5.

6.4.1 Loss of Vegetation Communities

Overall, 45.2 hectares or 9.1 percent of native vegetation in the study area would be removed as a result of the proposed bypass (Table 6.1). Two regionally significant communities, Open Paperbark Woodland and Mixed Swamp Forest, would have about 6.5 hectares (73.3 percent) and 1.7 hectares (20.0 percent) respectively, of their areas removed by the proposed bypass. Five other regionally significant vegetation communities, Blackbutt Woodland, Swamp Mahogany/Paperbark Forest, Paperbark Forest, Phragmites Rushland and Sedgeland would also have 0.7 hectares (15.6 percent), 1.25 hectares (10.2 percent), 6.6 hectares (16.6 percent),1.1 hectares (18.6 percent) and 1.3 hectares (13.4 percent) respectively, of their areas removed by the proposed bypass. The proposed bypass would result in the loss of approximately 3.2 hectares (13.3 percent) of Slashed Heathland, a community of conservation significance at state level in Queensland and local conservation significance in NSW. It would also result in the loss of approximately 14.5 percent of Swamp Oak Forest, a community of conservation significance at the state level in NSW.

Table 6.1: Area to be Removed From Each Vegetation Community Within the Study Area

Vegetation Community	Total in Study Area (ha)	Area Removed per Jurisdiction			Total Area Removed	
		NSW (ha)	Comm (ha)	Qld (ha)	ha	%
Littoral Rainforest (S)	3.5	0	0	0	0	0
Regenerating Vine Forest (S)	10.6	0	0	0.6	0.6	5.7
Moist Blackbutt Forest (R)	17.1	0	0	0.9	0.9	5.3
Dry Blackbutt Forest (R)	50.9	0	0	3.5	3.5	6.9
Blackbutt Woodland (R)	4.5	0	0	0.7	0.7	15.6
Ironbark–Mahogany Forest (L)	5.7	0	0	1.1	1.1	19.3
Scribbly Gum Forest (R in NSW)	17.8	0.3	0.75	0.03	1.1	6.2
Forest Red Gum Forest (L)	4.6	0	0	0.2	0.2	4.3
Brushbox Open Forest	12.3	0	0	0	0	0
Regenerating Brushbox Forest (L)	9.2	0	0	2.5	2.5	27.2
Swamp Mahogany Forest (R)	37.9	0.6	1.75	0.9	3.25	8.6
Swamp Mahogany–Brushbox Forest (R)	1.4	0	0.1	0	0.1	7.1
Swamp Mahogany–Scribbly Gum Forest (R)	28.2	0	0	0.5	0.5	1.8
Swamp Mahogany–Forest Red Gum Forest	5.9	0	0	0	0	0
Swamp Mahogany–Paperbark Forest (R)	12.3	0.4	0.85	0	1.25	10.2
Paperbark Forest (R in NSW; S in Qld)	39.8	6.3	0	0.3	6.6	16.6
Open Paperbark Woodland (R)	8.8	6.45	0	0	6.45	73.3
Paperbark Regrowth (L)	1.9	0.25	0	0	0.25	13.2
Swamp Oak Forest (S in NSW, L in Queensland)	10.5	0.6	0.3	0.6	1.5	14.3
Swamp Oak Woodland (S in NSW)	2.0	0.02	0	0	0.02	1.0
Mixed Swamp Forest (R)	8.5	1.7	0	0	1.7	20.0
Scribbly Gum Mallee Heathland (R in NSW)	32.5	0	2.1	0	2.1	6.5
Tree Broom Heathland (R)	25.6	0	0	0	0	0
Wet Heathland (L)	5.9	0	1.3	0	1.3	22.0
Wallum Heathland	2.5	0	0	0	0	0
Disturbed Heathland	4.6	0	0	0	0	0
Black She-oak Heathland	7.9	0	0	0	0	0
Slashed Heathland (L in NSW, S in Queensland)	24.1	0	1.8	1.4	3.2	13.3
Saltmarsh (S)	8.8	0	0	0	0	0
Disturbed Saltmarsh–Sedgeland (R)	18.3	0.65	0.8	0	1.4	7.7

Vegetation Community	Total in Study Area (ha)	Area Removed per Jurisdiction			Total Area Removed	
		NSW (ha)	Comm (ha)	Qld (ha)	ha	%
Mangrove Forest (R)	33.7	0	0.05	0	0.05	0.15
Phragmites Rushland (R)	5.7	0	1.05	0	1.05	18.4
Sedgeland (R)	7.1	0.02	0	0	0.02	0.3
Weedy Grassland (L)	18.3	1.75	0.05	1.5	3.3	18.0
Cleared Land (L)	349.4	3.9	5.8	13.3	23.0	6.7
Pine Forest (L)	7.7	0	0	0	0	0
Plantings (L)	2.3	0	0	0	0	0
Urban	367.2	7.8	0	0.02	7.82	2.1
TOTAL	1,215.0	30.7	17.3	28.05	76.0	6.3
TOTAL (excluding Cleared Land)	498.4	19.0	11.5	14.7	45.2	9.1

Notes: **S = State significance,**
R = Regional significance,
L = Local significance.

Littoral Rainforest in the North Coast Biogeographic Region is listed in NSW as an Endangered Ecological Community (EEC) on Schedule 1 Part 3 of the *Threatened Species Conservation Act*. The Littoral Rainforest and Regenerative Vine Forest communities in the study area would meet the classification of this community. A total of 0.6 hectares in Queensland of the Endangered Community or 4.2 percent of the community found in the study area would be impacted due to the proposed Bypass.

Coastal Saltmarsh in the North Coast Biogeographic Region is listed in NSW as an Endangered Ecological Community (EEC) on Schedule 1 Part 3 of the Threatened *Species Conservation Act*. The Saltmarsh communities in the study area would meet the classification of this community. A total of 0.57 hectares or 4.2 percent of this community found in the study area would be impacted due to the proposed Bypass. This impact would occur on Commonwealth land.

Three additional ecological communities relevant to the Tugun Bypass have been preliminarily listed as endangered pursuant to the Threatened Species Conservation Act on the 10 September 2004. These communities are Freshwater Wetlands on Coastal Floodplains, Swamp Oak Floodplain Forest and Swamp Sclerophyll Forest on Coastal Floodplains. Within the study area the vegetation communities of Phragmites Rushland and Sedgelands would be classified as the Freshwater Wetlands EEC, while Swamp Oak Forest and Swamp Oak Woodland would meet the classification of the Swamp Oak Floodplain Forest EEC. A number of vegetation communities within the Tugun Bypass study area would be classified as the Swamp Sclerophyll Forest EEC including Swamp Mahogany Forest, Swamp Mahogany/Brushbox Forest, Swamp Mahogany/Paperbark Forest, Paperbark Forest, Open Paperbark Woodland, Paperbark Regrowth and Mixed Swamp Forest.

While preliminary determinations have no statutory obligation until they are finalised (due to the possibility they may be rejected) it is prudent to give some consideration to then. The proposed Tugun Bypass would impact on all three communities, with 0.02 hectares of Freshwater Wetlands being directly impacted, 1.5 hectares of Swamp Oak Floodplain Forest impacted and 19.6 hectares of Swamp Sclerophyll Forest. Further

consideration would be given to the endangered ecological communities if they become finalised.

Indirect impacts caused by alterations to surface and groundwater flows, changes in groundwater levels, oxidation of acid sulphate soils and/or water contamination have the potential to cause short and long-term changes to vegetation communities. In the case of relatively minor hydrological impacts, this may result in the replacement of existing communities with more or less water-tolerant species. In the case of major hydrological impacts, it could result in the loss of sensitive communities such as rainforest. Overall, habitat loss of significant communities is considered to be of high local significance. Habitat loss constitutes a residual impact and cannot be mitigated. A compensatory habitat package based on the amount of key habitat removed is discussed in Section 7.1.1. Mitigation measures aimed at minimising hydrological impacts are discussed in Section 7.1.5 and Chapter 8 of the EIS.

6.4.2 Potential Impacts on Terrestrial Flora Species of Conservation Significance

One or more known individuals of species of legislative significance may be removed by the proposed bypass (Table 6.2). Individuals from three regionally significant species, the Blunt-leaved Wattle, Match Sticks (*Comesperma ericinum)* and Coast Palm Lily (*Cordyline congesta*), would also be removed as a result of the proposed bypass. Most of the population of regionally significant Chinese Burr located at the southern end of the proposed bypass would be removed during the construction of the proposed Tweed Heads Bypass interchange.

Table 6.2: Summary of Potential Impacts on Terrestrial Flora Species of Conservation Significance

Species	Individuals Removed (#)	Habitat Removed[1] (ha)	Location	Overall Impacts[2]
National Significance				
Swamp Orchid	0	0.38 (7.7%)	NSW, Cwlth	High local
State Significance				
Little Wattle	2	6.6 (27%)	Qld, NSW, Cwlth	Regional
Stinking Cryptocarya	2	1.3 (11.1%)	Qld	Local
Fine-leaved Tuckeroo	1	0.6 (5.5%)	Qld	Local
Black Walnut	1	2.0 (14.2%)	Qld	Local
Long-leaved Tuckeroo	1	0.6 (5.5%)	Qld	Local
Regional Significance				
Chinese Burr	Most of population (n = 150)	14.3 (34%)	NSW	High local
Match Sticks	1	1.5 (45%) known habitat 6.4 (9.1%) potential habitat	Qld, NSW, Cwlth	State
Blunt-leaved Wattle	1	8.8 (7.3%)	Qld, NSW, Cwlth	Local
Coast Palm Lily	1	1.2 (11.1%)	Qld	Local

Note: 1 = Includes known and potential habitat.
2 = Includes direct and indirect impacts.

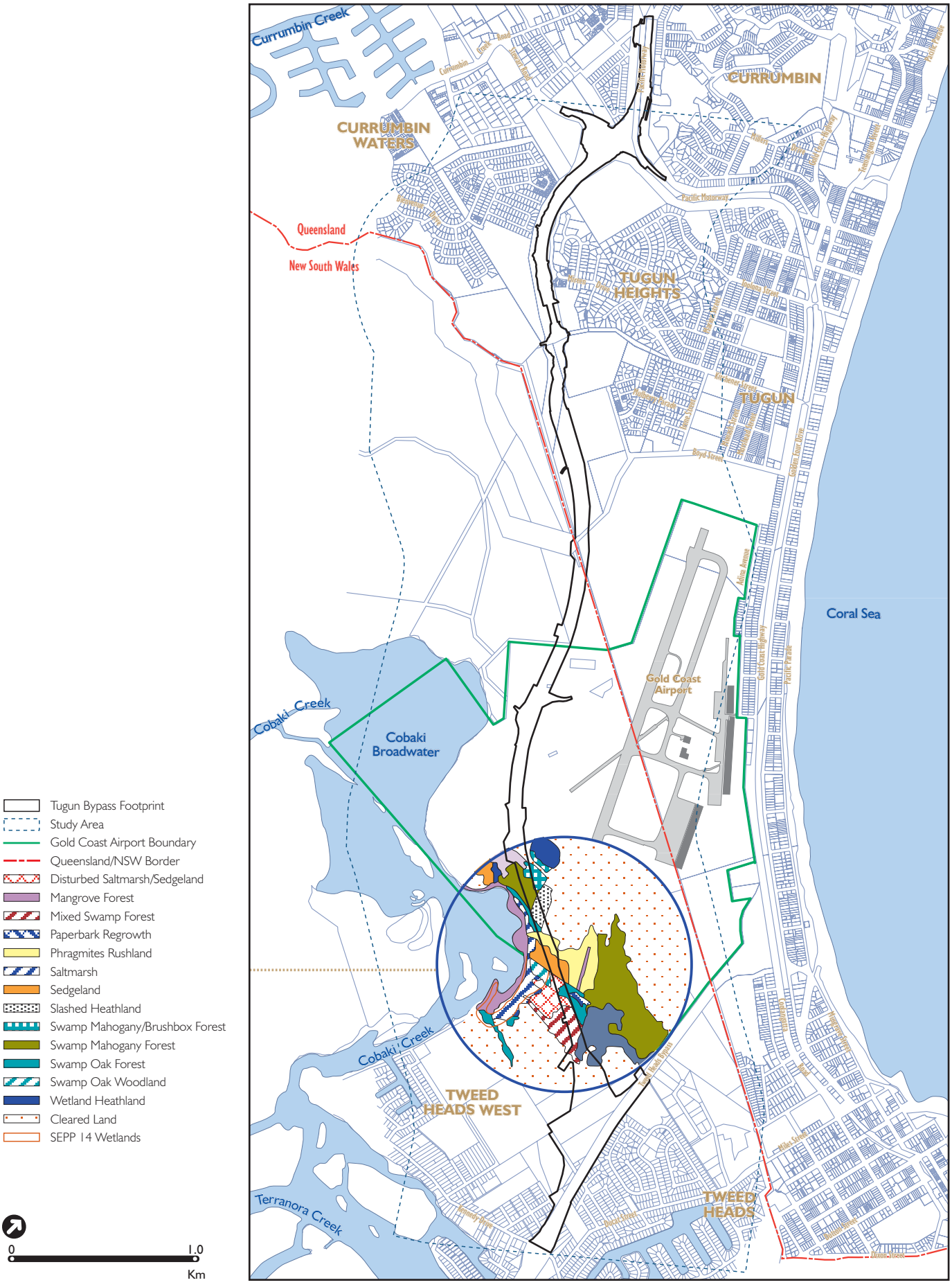


Figure 6.2 **Vegetation communities within and adjacent to Environmental Planning Policy Number 14 Wetlands**

For most of these species, removal of individuals would have a local impact and would not affect the distribution and abundance of populations or species. However, removal of individual Match Sticks from the Queensland population may have a state impact and efforts would be made to translocate these. Similarly, removal of most of the Chinese Burr population is considered to have a high local impact. As this species is a colonising one preferring disturbed ground, it would probably respond favourably to translocation efforts. Translocation is discussed further in Section 7.1.2.

Other individuals may be affected indirectly through edge effects, or hydrological impacts associated with the proposed bypass. These are difficult to predict but would be minimised through the implementation of appropriate mitigation measures.

6.4.3 Potential Impacts on Terrestrial Fauna Species of Conservation Significance

The proposed bypass would result in the direct loss of individual Wallum Froglets, Wallum Sedge Frogs and Common Planigales (Table 6.3). The loss of one and possibly two out of six known subpopulations of Wallum Sedge Frogs is likely to have a regional impact on the metapopulation. Similarly, the loss of some Common Planigales from a very small disjunct population may be of regional significance. However, the loss of individuals from the Wallum Froglet population estimated at 10,000 individuals is likely to be locally significant. Translocation of fauna species is considered in Section 7.1.3.

Table 6.3: Summary of Potential Impacts on Terrestrial Fauna Species of Conservation Significance

Species	Habitat Removed[1] (hectares)	Location	Overall Impacts[2]
Regional Significance			
Brahminy Kite	11.1 (9.3%)	NSW, Cwlth	High local
State Significance			
Long-nosed Potoroo	0.5 (0.6%)	NSW	Local
Wallum Froglet	44.3 (10%)	Qld, NSW, Cwlth	Regional
Bush Hen	3.5 (5.8%)	Qld, Cwlth, NSW	High local
Lewins Rail	40.6 (10.6%)	Qld, NSW, Cwlth	Local
Eastern Grass Owl	2.4 (28.6%)	NSW	High local
Wallum Sedge Frog	4.7 (8.4%)	Cwlth	Regional
Common Planigale	0.05 (5%) known primary habitat 2.0 (67%) secondary habitat	Cwlth	Regional
Eastern Long-eared Bat	21.2 (12.6%) foraging habitat 1.5 (65%) roosting habitat	Qld, NSW, Cwlth	Local
Masked Owl	13.7 (8.7%)	Qld, NSW, Cwlth	High local
Grey-headed Flying Fox	0.6 (5.7%) known roosting habitat; 32.2 (9.8%) foraging habitat	NSW, Qld, Cwlth	Local

Note: 1 = Includes known and potential habitat.
2 = Includes direct and indirect impacts.

At least one Brahminy Kite nest tree may be removed. However, this is not expected to have a significant impact on this regionally significant species as other nest sites have been recorded in the area, including within the National Estate area. The Grey-headed Flying Fox roost site located in Hidden Valley is unlikely to be affected directly or indirectly as a result of the proposed bypass.

The Eastern Grass Owl and the Masked Owl may be at greater risk of road strike if foraging along the side of the proposed bypass or crossing it to access foraging habitat. Habitats directly affected by the proposed bypass are likely to represent only part of single home ranges for both of these species (assuming that the Eastern Grass Owl is still present in the area).

Other individuals may be affected indirectly through fragmentation, edge effects, disturbance or hydrological effects associated with the proposed bypass. These are difficult to predict but would be minimised through the implementation of appropriate mitigation measures.

6.4.4 Loss of Wetland Habitat

Within wetlands, Mangrove Forest and Saltmarsh are protected in NSW under Section 7 of the *Fisheries Management Act 1994*. The removal of mangroves below mean high-tide mark in NSW, would require a permit from NSW Fisheries. Although no Mangrove Forest would be removed as a result of the proposed bypass in NSW, 0.05 hectares would be removed from Commonwealth land. A small amount of Saltmarsh (0.57 hectares) and degraded Saltmarsh/Sedgeland (1.4 hectares) would be removed as a result of the proposed bypass (Figure 6.2). Loss of a small proportion of *State Environmental Planning Policy Number 14* wetland is discussed in Section 6.5.7.

Indirect impacts caused by alterations to surface and groundwater flows, changes in groundwater levels, oxidation of acid sulphate soils and/or water contamination have the potential to cause short and long-term changes to wetland vegetation communities.

Overall, habitat loss of wetland communities is considered to be of local significance. Wetland habitat loss constitutes a residual impact and cannot be mitigated. Compensatory wetland habitat is discussed in Section 7.1.4. Mitigation measures aimed at minimising hydrological impacts are discussed in Section 7.1.5.

6.4.5 Potential Impacts on Aquatic Biota

The proposed bypass would not directly affect wetland habitats, fringing the Cobaki Broadwater or its aquatic flora and fauna. However, the Cobaki Broadwater would continue to receive most of the run-off from the proposed bypass in the vicinity of the Gold Coast Airport. Surface waters west of the airport drain to the Broadwater through a number of waterways that would be transected by the proposed bypass. Construction and operational activities would have the potential too indirectly affect downstream flora and fauna communities through sedimentation, turbidity, nutrification, water pollution or the introduction of oil and heavy metals. If additional leachate from the Tugun Landfill enters the Cobaki Broadwater, then this may result in increased nutrients and weed proliferation or in heavy metal contamination of the downstream environment.

The proposed bypass would have direct and indirect impacts on estuarine and freshwater drainage channels found throughout the study site. Changes to surface water flows may occur as a result of the overflow channel of the Coolangatta Creek

into the Broadwater (east of Site 3) being moved to the south during tunnel construction.

Sites 1 and 2 (Figure 2.6) are unlikely to be directly or indirectly affected by the proposed bypass. Site 3 provides minimal fish habitat and would be diverted slightly (ca. 20 m) and reinstated as an open drain near the tunnel approach ramp. Direct impacts would include loss of a small amount of aquatic habitat while indirect impacts would be associated with potential erosion and sedimentation during construction. Operational impacts may include contamination by oil and/or heavy metal pollution. Site 4 is tidally influenced and comprises moderate fish habitat. It would be subject to some habitat loss and possibly to indirect impacts.

Site 5 also provides moderate fish habitat, especially near the Cobaki Broadwater. The proposed bypass would result in the loss of some degraded wetland habitat near Boyd Street associated with the construction of longitudinal side drains. Site 6 provides moderate fish habitat and has already been culverted under the access track associated with the Cobaki Lakes development. It may be subject to indirect impacts associated with potential erosion and sedimentation (construction) and to water pollution (operation). If additional leachate from the Tugun Landfill enters the drainage channels at Sites 5 or 6, then this may result in increased nutrients and weed proliferation or in heavy metal contamination of the downstream environment.

Site 7 provides moderate fish habitat for a number of commercially or recreationally important species. Some loss of habitat, in particular mangroves, would be associated with construction of a culvert under the bypass. Indirect impacts would be associated with potential sedimentation and erosion and with contamination. Site 8 would be reinstated as an open drain and would not be diverted. It would be subject to some habitat loss, temporary barrier effects and indirect impacts.

Mitigation measures aimed specifically at minimising impacts on aquatic flora and fauna are outlined in Section 7.1.5. A detailed hydrological impact assessment has been undertaken and is described in Technical Papers 7, 8 and 9. Potential impacts of contamination deriving from Tugun Landfill adjacent to Boyd Street are discussed in Technical Paper 6. Environmental impacts associated with acid sulphate soils would also be minimised through strict adherence to the protocols and monitoring outlined in Technical Paper 5.

6.4.6 Fauna Corridor Impacts

The proposed bypass bisects at least two sub-regional wildlife corridors (as defined by Scotts and Drielsma 2003) near the Pony Club land. Generally, the proposed Tweed Heads Bypass interchange and tunnel ramps restrict east-west movement in the southern part of the proposed bypass. It is expected that, although the barrier effect in this area may be up to 1,060 metres long, a fauna corridor measuring approximately 100 metres would be maintained via the revegetation of part of the top of the road tunnel. Therefore the barrier impact is expected to only be of high local significance.

The identified wildlife corridors in the area are also already highly fragmented and traverse urban areas. Therefore, the proposed bypass is not considered to affect the viability of any regional or subregional wildlife corridor. The bypass has been positioned on the eastern edge of most of the habitat in the area to minimise the impact on fauna movements.

6.4.7 Fish Passage

The proposed bypass would result in some physical barriers to fish movement in freshwater drainage channels in the study area. Two native fish species recorded at Sites 1, 3, 4, 5 and 6, the Empire Gudgeon and the Striped Gudgeon, require unobstructed fish passage to move between fresh and salt water and to reach spawning areas.

Site 3 (Figure 2.6) provides minimal fish habitat and would be temporarily blocked (for up to 12 months) while it is reinstated over the tunnel. As only Mosquito Fish were recorded here, native fish species are not likely to be affected by barrier impacts. No temporary or permanent barriers would be erected at Site 4 as a wet/dry culvert would be constructed under the bypass. Sites 5, 6 and 7 would not be subject to permanent or temporary barrier impacts. Site 6 already has a culvert in place under the existing access track to the Cobaki Lakes development. A box culvert would be constructed at Site 7 where it transects the proposed bypass. Site 8 would be reinstated as an open drain and would be temporarily blocked. As it was dry at the time of survey, there is no information on the native fish species that may occur during wet periods.

Creek diversions would have a local effect on fish species or yabbies inhabiting them. Impacts associated with fish barriers are also likely to be local. Mitigation measures to maintain fish passage are discussed in Section 7.1.7

6.5 Potential Impacts Associated with Sites of Significance

In this section, potential impacts associated with the proposal are assessed for ecologically significant sites. These sites are shown in Figure 5.1.

6.5.1 Hidden Valley (ES2)

Habitat loss in Hidden Valley would result directly from clearing associated with constructing bridge piers, an access track and a cutting immediately to the south of the valley. The proposed construction technique for the bridge involves launching 35 metre pre-cast beams, thereby avoiding the use of heavy machinery and cranes on the valley floor. In addition, the entire bridge sub-structure (footings and piers) would be pre-constructed to avoid disturbing the valley when the bridge is eventually upgraded to six lanes.

During construction, a 5 metres by 15 metres area would be disturbed around the base of each of the piers. A 5 metre-wide access track would be built from the quarry side of the valley, thus minimising the amount of vegetation to be cleared. Indirect impacts would be associated with shading under the bridge and hydrological impacts. These may alter some vegetation communities over the longer term. Habitat loss is expected to have a local impact in Hidden Valley.

Habitat fragmentation at the eastern end of Hidden Valley would be minimised because the bridge would allow fauna movement beneath it. The proposed bypass is also located close to the eastern edge of existing habitat. The bridge may initially create a new barrier for birds and Giant Dragonflies (if they occur). However, barrier effects for birds and other mobile species are expected to be minor with the Grey Goshawk, White-eared Monarch and Rose-crowned Fruit-Dove most at risk of road mortality. It is expected that birds would eventually habituate to the presence of the bridge. The bridge is unlikely to pose a barrier for any other flora or fauna species.

Edge effects already exist in the area transected by the proposed bypass. Hidden Valley also has a moderate infestation of Lantana and dogs/foxes have been recorded in this location. The proposed bypass is not expected to increase edge effects significantly.

Hidden Valley is relatively undisturbed. It is expected that construction of the road and bridge would cause disturbance effects for fauna species, especially sensitive ones. In particular, the Bush Hen, Grey Goshawk and Rose-crowned and Wompoo Fruit-Doves and roosting bat species may be affected by disturbance associated with construction. Disturbance to breeding Bush Hens would be of high local significance. It is considered unlikely that the proposed bypass would impact upon the day roost of the Grey-headed Flying Fox.

Hydrological impacts may be associated with altered water flow or increased erosion or sedimentation during construction or with run-off of pollutants from road surfaces during operation. Alterations to existing hydrological regimes may reduce habitat quality for aquatic flora and fauna, including the Bush Hen. Given that the bridge would be located at the lower end of the valley, any hydrological impacts are likely to be minor. Water pollution would reduce habitat quality for aquatic species such as aquatic insects, frogs and Bush Hens.

Given that mitigation measures would be implemented, hydrological impacts are expected to be local. Mitigation measures aimed at minimising habitat loss, disturbance and hydrological impacts are discussed in Section 7.2.1.

6.5.2 Long-nosed Potoroo Habitat (ES3)

As the proposed bypass is located along the eastern edge of identified potoroo habitat, there would only be a loss of approximately 0.5 hectares of habitat as a result of construction. Mason (1993) cautions that any reduction or fragmentation in habitat may have a deleterious effect on the population. However, the removal of such a small area of habitat is considered to be of local significance.

In Queensland, the proposed bypass would result in the removal of two individuals of Little Wattle from the Queensland population. This species is considered to be 'vulnerable' in Queensland and the individuals that would be removed may represent the southernmost population of this species in that state. It is also likely that the proposed bypass would result in the removal of some individuals of Match Sticks in Queensland. The exact location and numbers of the Queensland population is not known due to continued slashing activities in the area, making individuals difficult or impossible to locate. Although not listed in Queensland, NSW or Commonwealth legislation, this species is considered to be of state significance in Queensland as, prior to this study, it was thought to be extinct there. Habitat loss for this species is therefore considered to be of state significance.

For the Long-nosed Potoroo, there would be no habitat fragmentation in an east-west direction as the proposal passes along the eastern edge of Long-nosed Potoroo habitat. Results from the recent radio-tracking study (Bali *et al* 2003) suggest that the habitat to the west of the proposal is already fragmented by the existing access track to the Cobaki Lakes development. Results from this study have shown that the access track has split the population in two with no evidence of individuals crossing the track. Furthermore, construction of the access track has resulted in seasonal flooding to the north and the subsequent loss of potoroo habitat. The bypass would act to further isolate the small area of high quality potoroo habitat to the north of the Cobaki Lakes

development access track, making this sub-population more susceptible to extinction. It is therefore likely to result in a cumulative impact on the population at the regional level. For the Little Wattle and Match Sticks, however, the proposed bypass would isolate remaining habitat to the east of the proposed alignment from potential habitat to the west**.** Habitat fragmentation for both these species is considered to be of high local and regional significance respectively.

The erection of fauna-exclusion fencing along the proposed bypass would act as an impassable barrier, preventing Long-nosed Potoroos and other ground-dwelling fauna species from crossing the bypass, however, this is likely to provide a positive benefit in preventing domestic predators from entering the Crown Land. Evidence from recent studies suggests that the access track associated with the Cobaki Lakes development presently forms an impenetrable north-south barrier to potoroo movement. Species such as the Glossy Black-Cockatoo and Masked Owl may forage along roadsides and may be at risk of road strike from both the proposal and any future extension of Boyd Street associated with the Cobaki Lakes development. The Common Blossom Bat, Queensland Giant Dragonfly and Swordgrass Brown Butterfly may also be susceptible to road strike.

Edge effects already exist near the Cobaki Lakes development access track. Foxes are commonly encountered throughout the study area (S. Phillips, B. Lewis *pers. comm*.). The densities of dogs, cats and weeds are likely to increase once the Cobaki Lakes development is established (Section 6.2.9). The proposal would be expected to result in edge effects of high local significance in ES3.

Disturbance effects would increase in this area due to the increasing volumes of traffic travelling along the bypass. This may affect the behaviour and activities of Long-nosed Potoroo, Glossy Black-Cockatoo and potentially the Masked Owl. These are likely to be localised effects. Both the Little Wattle and Match Sticks occur in habitats that are already subject to disturbance as a result of continued slashing activities, and as such the proposed bypass is unlikely to have any secondary impacts on the retained population. Disturbance effects associated with construction are expected to be of high local significance.

The proposed bypass is located within the catchment of a drainage line near the Cobaki Lakes development access track. Alterations to water flow and/or sedimentation or pollution of the creeks in this area have the potential to affect habitat for the Wallum Froglet, Bush Hen, Black Bittern, Large-footed Myotis, Swordgrass Brown Butterfly and the fish and macroinvertebrate fauna found in the creek. Significant vegetation communities and threatened flora species may also be susceptible to changes in hydrological regimes. Maintaining hydrological flows is particularly important for *Gahnia* or *Melaleuca* swamp habitats as these provide habitat for the Swordgrass Brown Butterfly.

Oxidation of acid sulphate soils, erosion and sedimentation and potential contamination of local waterways from the Tugun Landfill site may result in the loss of aquatic flora and fauna and sensitive vegetation communities in the short-term. If leachate enters the water table, adjacent wetlands or the Cobaki Broadwater, then this may result in increased nutrients and weed proliferation or in heavy metal contamination of the downstream environment. Alterations to surface water flow may alter vegetation composition through replacement by more or less water-tolerant

species in the longer term. Given the implementation of mitigation measures, it is expected that hydrological impacts would be local.

Mitigation and compensatory measures aimed at minimising habitat loss, fragmentation, barrier impacts, road strike, edge effects, disturbance and hydrological impacts are discussed in Section 7.2.2.

6.5.3 Known Wallum Froglet and Wallum Sedge Frog Habitat (ES4)

Wallum Froglets were recorded throughout the proposal area, in particular south of Boyd Street but also near the ridge behind the John Flynn Hospital and Medical Centre in Queensland. Approximately 44.3 hectares (10 percent) of known and potential habitat for this species would be removed as a result of the proposed bypass. The Wallum Sedge Frog has a more restricted distribution in the southern part of ES4. Approximately 4.7 hectares or 8.4 percent of known and potential habitat would be removed for this species.

Participants at the IUCN Threatened Frog Workshop held in February 2001 recommended an objective method for assessing impacts on vulnerable frog species under the *Environment Protection and Biodiversity Conservation Act 1999* (Hero *et al.* 2001b). It was therefore decided to draft the sixth criterion in the administrative guidelines as:

Any action has, will have or is likely to have a significant impact on a vulnerable species if it does, will or is likely to modify, destroy, remove, isolate or decrease the known occupied habitat of a vulnerable frog species by 0.5 percent or more.

The Wallum Froglet population found in the study area is thought to represent more than 0.5 percent of the mainland Australian population. That is, removal of the entire population of Wallum Froglets (total available habitat) would be considered to be significant. However since approximately 10 percent of known and potential Wallum Froglet habitat would be removed as a result of the proposed bypass, the impact on this species would be high local.

Similar data describing the size and importance of the Wallum Sedge Frog metapopulation in relation to other populations Australia-wide is lacking (Jean-Marc Hero, *pers. comm.*). The proposal would remove about 4.7 hectares or 8.4 percent of the known and potential habitat for this species from the study area. This is likely to represent much less than 0.5 percent of the known habitat for this species in Australia and is therefore not considered to be significant. However, as two subpopulations of the Wallum Sedge Frog would be significantly affected, the proposed bypass would have a high local impact on the Wallum Sedge Frog.

The proposed bypass would fragment habitat for both frog species into eastern and western parts, but generally maintain connectivity in a north-south direction. Unless gene flow is maintained across the proposed bypass, the existing populations would be expected to diverge genetically in the very long-term (thousands of years). The proposed bypass forms an impassable barrier in places (where the road is associated with tunnel ramps (near ES5 and ES10) and may facilitate frog movement in others (south of Boyd Street to ES4). Frog-exclusion fencing erected in the latter areas may prevent road mortality by acting as a barrier while directing frogs into underpasses. As the effectiveness of mitigation measures for these frog species is unknown, a precautionary approach has been taken in predicting that impacts may be regional for both species.

Edge effects are already prevalent in the area south of the Cobaki Lakes development access track. These are likely to be augmented where the proposed bypass is directly adjacent to Wallum Froglet and Wallum Sedge Frog habitat and would be associated with disturbance and changes in moisture levels. The effect of noise and vibration on frogs is unknown. However these are considered likely to have at least a localised impact on individuals occurring adjacent to road construction.

There is the potential for alterations to surface and groundwater flows, lowering of the water table, oxidation of acid sulphate soils and/or water contamination to affect the Wallum Froglet and Wallum Sedge Frog populations in the short- and long-term. Impacts may be direct through acid water flows or contaminated water entering wetland habitats. Both species are dependent on a very narrow range of water conditions for their survival and reproduction. Any alterations to pH, water depth and/or water retention properties may make these habitats unsuitable. The NSW Department of Environment and Conservation usually requires that sediment basin releases are in the order of pH 6.5 to 8. If basins overflow into frog ponds, then this could make these habitats unsuitable for breeding. Indirectly, any changes to surface water flow throughout froglet habitat would alter soil moisture and result in changes to vegetation communities in the longer term. Therefore, liaison with other relevant agency personnel and specialist consultants to determine the most appropriate discharge criteria for those sedimentation basins discharging to frog ponds would be undertaken, prior to the commencement of construction activities.

Given that mitigation measures would be implemented, hydrological impacts are expected to be local. Mitigation measures aimed at minimising fragmentation, barrier impacts and hydrological impacts are discussed in Section 7.2.3. For ethical reasons, it may be necessary to trap and translocate individuals immediately before construction commences (Section 7.1.3).

6.5.4 Common Planigale Population (ES5)

Habitat loss in this area would be associated with the construction of road, tunnel ramps, drains, a sedimentation basin and an access road. Approximately 5 percent of known primary and 67 percent of known secondary habitat for the Common Planigale would be removed as part of the proposal. Potential habitat in the area may include Swamp Mahogany and Swamp Mahogany–Brushbox Forest to the west and Wet Heathland to the east. The effect of habitat loss of this species is likely to be of high local significance.

The Common Planigale population would become isolated from potential habitat to the west. A precautionary approach has been taken in predicting that this may have regional impacts on the population.

The barrier formed by the tunnel ramps in this area would preclude the construction of underpasses. In order to prevent flood waters from entering the tunnel, the ramps would be constructed as impermeable walls between 0.5 to 1.5 metres high, preventing the implementation of mitigation measures for fauna. The road and associated ramps would act as physical and behavioural barriers for Common Planigales found on either side of the bypass. Barrier impacts are therefore likely to be regional. Road strike would not occur as there would be no movement by fauna across this part of the proposed bypass.

Edge effects already exist in this area and are associated with access tracks and airport maintenance activities. However, as the proposed bypass would be located adjacent to known and potential Common Planigale habitat, additional edge effects associated with disturbance and hydrological changes would be expected. These are likely to be of high local significance.

Construction disturbance associated with noise and vibration may be of high local significance for Common Planigales as they are small, ground dwelling mammals that are likely to be particularly sensitive to excavation works.

Indirectly, any changes to surface water flow throughout frog and Common Planigale habitats would alter soil moisture and result in changes to vegetation communities in the longer-term. Given that mitigation measures would be implemented, it is expected that hydrological impacts would be local.

Mitigation measures aimed at minimising habitat loss, fragmentation, barrier effects, edge effects and hydrological effects are discussed in Section 7.2.4.

6.5.5 High Tide Roosts for Estuarine Birds (ES6)

The proposed bypass is located at least 100 metres from the Tweed Heads Pony and Hack Club roost and is not expected to affect high-tide roosts directly. These are used by migratory shorebirds protected under international agreements. Noise and disturbance associated with construction and operation may have an indirect impact on roosting birds. Although sudden and unpredictable noises associated with construction may disturb roosting birds initially, it is evident that most bird species habituate to continuous traffic noise. For example, the Eastern Grass Owl and Masked Owl are often found foraging near highways while the Collared Kingfisher, Mangrove Honeyeater, Osprey, Black Bittern and numerous migratory shorebirds appear tolerant of traffic in some locations (Sandpiper Ecological Surveys 2001a). Once the bypass is operational, tunnel ramps in this area would minimise traffic noise. Birds in the area appear to have habituated to noise generated at Gold Coast Airport. The impact of disturbance is of local significance.

6.5.6 Intertidal Foraging Areas for Estuarine Birds (ES7)

The proposed bypass is located at least 80 metres from the nearest foraging area and is not expected to directly affect intertidal foraging areas used by migratory shorebirds protected under international agreements. Noise and disturbance associated with construction and operation may have an indirect effect on roosting birds. Although sudden and unpredictable noises associated with construction may disturb roosting birds initially, it is evident that most bird species habituate to continuous traffic noise. Furthermore, once the bypass is operational, tunnel ramps in this area would reduce the traffic noise. Birds in the area appear to have habituated to noise generated by the Gold Coast Airport. It is not known however, what role if any surrounding land uses have had to play in the decline in birds using roosts in the Cobaki Broadwater. The impact of disturbance is of local significance.

6.5.7 State Environmental Planning Policy Number 14 Wetland Number 5a and adjacent Wetlands (ES8)

Habitat loss in this area would be associated with construction of the road tunnel and an access track for the Gold Coast Airport. A small amount of habitat (about 0.02 hectares) would be lost at the edge of the SEPP 14 wetland (Refer to Figure 6.2). However, the margins of Wetland Number 5a consist of highly degraded Swamp Oak Woodland. More sensitive communities within the SEPP 14 Wetland including

mangroves and saltmarsh would not be directly affected by the proposed bypass. The proposed bypass would have a local impact on this wetland loss.

Wetland habitat loss in Commonwealth land would be associated with construction of the road tunnel and an access track for Gold Coast Airport. A small amount (0.57 hectares) of Saltmarsh and Swamp Oak Forest (0.3 hectares) would be lost at the edge of this wetland. Although these communities are considered to be of legislative significance at the state level in both NSW and Queensland, they are not listed nationally. Sensitive Mangroves Forest would not be directly affected by the proposed bypass. Loss of these wetland areas is considered to be of high local significance.

No fragmentation or barrier impacts would be caused by the proposal in this area as the road would be in tunnel. Edge effects are already present as weed infestation and past grazing activities. The proposal is not expected to increase edge effects significantly.

Disturbance associated with construction may affect birds and other fauna at least initially. However, disturbance impacts associated with operation are unlikely to be significant as the road would be tunnelled adjacent to the wetland.

Alterations to existing hydrological regimes would be primarily associated with the construction of the tunnelled section of the proposal, although some permanent minor changes to surface run-off would occur. Surface water would be transferred to the other side of the bypass via piping, diverting or draining to maintain existing flows and prevent ponding.

Construction of the proposed tunnel may require or result in draw-down of the groundwater table. This impact would be minimised through the establishment of recharge wells to pump water out of the tunnelled section and back into the water table. Any lowering of the groundwater table may allow the oxidation of potential acid sulphate soils. Oxidation of potential acid sulphate soils would be minimised through the management of surface and groundwater at all times during excavation and construction. Protocols for the monitoring and management of acid sulphate soils have also been developed (see Technical Paper 5).

Wetland contamination could occur as a result of acid water flows and/or sedimentation associated with construction. Given the implementation of mitigation measures, hydrological impacts are expected to be of local significance. Mitigation measures that aim to minimise hydrological impacts are discussed in Section 7.1.5 and 7.2.5. Compensatory wetland habitat is discussed in Section 7.1.4.

6.5.8 Area of High Amphibian and Bat Biodiversity (ES10)

Loss of habitat in this area would be associated with construction of the road, interchange, tunnel ramps and tunnel, drains and access track. Approximately 8.7 hectares of habitat would be removed as a result of the proposed bypass in this area. This area comprises mainly Open Paperbark Woodland and Paperbark Forest and also includes an area of old-growth paperbarks thought to be important for roosting Eastern Long-eared Bats. Removal of Coast Banksia (*Banksia integrifolia)*, a lengthy flowering species, may affect the Common Blossom Bat. At least one Brahminy Kite nest tree may be removed. However, this is not expected to have a significant impact on this regionally significant species as other nest sites have been recorded in the area, including within the National Estate area. The pond containing a high diversity of frog species is unlikely to be directly or indirectly affected by the proposed bypass. Overall, habitat loss in this area is expected to be of local significance.

The proposed bypass would cause some fragmentation of ES10 in an east-west direction, fragmenting a sub-regional fauna corridor (as defined by Scotts and Drielsma

2003) and isolating a small habitat remnant to the east. Fragmentation is not likely to affect highly mobile species such as bats and birds but may impact the Wallum Froglet and Wallum Sedge Frog populations found in this area. The impact is likely to be high local because the revegetated tunnelled section of the proposed bypass is located along the northern part of ES10.

The Tweed Heads Bypass interchange and tunnel ramps would form an impassable barrier through the southern part of ES10 although the revegetated tunnel overpass would allow fauna movement through the northern part of ES10. It is expected that although the barrier in this area may be up to 1 kilometre long, connectivity would be retained over approximately 100 metresvia the revegetated tunnel overpass. Road mortality would be an issue particularly for the Eastern Grass Owl and the Common Blossom Bat. Barrier effects are likely to be high local in this area.

Edge effects associated with tracks, weeds and horse riding activities already occur in this area. There is also the potential for edge effects through disturbance or hydrological changes, however, it is not expected that the proposed bypass would increase edge effects significantly.

Disturbance associated with construction would be expected to affect birds and other fauna at least initially. Disturbance associated with operation is unlikely to have more than a local impact on fauna.

Alterations to existing hydrological regimes are primarily associated with the construction of the tunnelled section of the proposed bypass, although some permanent minor changes to surface run-off would occur. Surface water would be transferred to the other side of the bypass via piping, diverting or draining to maintain existing flows and prevent ponding.

Changes to surface water flows may occur as a result of the overflow channel of Coolangatta Creek into the Broadwater being moved to the south during tunnel construction or of drains draining the western portion of the airport being re-routed to achieve proposed road levels. Creek diversions would have a local affect on fish species or yabbies inhabiting them. Any alterations to surface flows between Coolangatta Creek and the Cobaki Broadwater are likely to be minor and temporary and would not result in significant changes to the existing vegetation communities. Similarly, flora communities would be expected to be more water tolerant in any new floodway created. There is the potential for habitat loss through indirect hydrological effects. This would be of particular relevance to those species which are susceptible to changes in hydrological regimes where any changes to surface and sub-surface flows in the area may remove suitable habitat.

Given the implementation of mitigation measures, it is expected that hydrological impacts would be local. Mitigation measures that aim to minimise habitat loss, fragmentation, barriers, edge effects and hydrological impacts are discussed in Section 7.2.7.

6.6 Summary of Potential Impacts

Table 6.4 summarises the potential impacts of the proposed bypass on sites of conservation significance.

Table 6.4: Summary of Potential Impacts on Significant Sites Potentially Affected by the Proposed Bypass

Location	Loss of habitat	Fragmentation and Barrier Effects	Edge Effects and Disturbance	Water Flow and Quality[1]	Cumulative Impacts	Overall Impacts
ES2	Local	Local	High local	Local	N/A	High
ES3	Local (NSW) State (Qld)	Regional (NSW) High Local (Qld)	High local (NSW) Local (Qld)	Local (NSW) Local (Qld)	State	Regional (NSW) State (Qld)
ES4						
Wallum Froglet	High local	Regional	Local	Local	High local	Regional
Wallum Sedge Frog	High local	Regional	Local	Local	Regional	Regional
ES5	High local	Regional	Local	Local	High local	Regional
ES6	N/A	N/A	Local	Local	N/A	Local
ES7	N/A	N/A	Local	Local	N/A	Local
ES8	Local	N/A	N/A	Local	N/A	Local
ES9	High local	N/A	High local	Local	N/A	High local
ES10	High local	High local	Local	Local	High local	High local

Notes 1: Impact assessment assumes implementation of appropriate mitigation measures.
2: ES = Ecologically significant sites (see Figure 5.1)
3: N/A = Not applicable

6.7 Impact Assessment

6.7.1 Environmental Protection and Biodiversity Conservation Act

The Environment Protection and Biodiversity Conservation Act 1999 commenced on 16 July 2000. The Act requires that approval be obtained from the Minister for the Environment and Heritage for certain activities (including any development, project or undertaking) which have, may have or are likely to have a significant impact on a matter of national environmental significance. Matters of national environmental significance are considered to include:

- World Heritage-listed properties;
- Ramsar wetlands of international importance.
- nationally listed threatened species and ecological communities;
- nationally listed migratory species;
- Commonwealth marine areas;
- Nuclear actions (including uranium mining); and
- Areas of National Heritage.

The Tugun Bypass has been deemed to be a controlled action by the Department of Environment and Heritage and the EIS has been prepared to meet both the requirements of the NSW *Environmental Planning and Assessment Act 1979* and the Commonwealth Environment Protection and Biodiversity Conservation Act.

Each of the above seven matters of environmental significance is discussed below in context of the current proposal.

World Heritage Properties

No World Heritage areas are located in close proximity to the study area.

Ramsar Wetlands

The Convention on Wetlands, signed in Ramsar, Iran in 1971 (commonly known as the Ramsar Convention) is an intergovernmental treaty dedicated to the conservation and 'wise use' of wetlands. The Convention encourages the designation of sites containing representative, rare or unique wetland types, or that are important for conserving biological diversity to the List of Wetlands of International Importance (Ramsar sites). The study area is located approximately 10 kilometres from the Ramsar Wetland Moreton Bay. The proposed Upgrade would not be expected to have a significant impact on Moreton Bay, with no waterways flowing from the study site into the wetland.

Threatened Species and Ecological Communities

Seven nationally threatened species are listed on the *Environment Protection and Biodiversity Conservation Act 1999* have been recorded in the study area. These species are the Long-nosed Potoroo (*Potorous tridactylus*), Grey-headed Flying Fox (*Pteropus poliocephalus*), Wallum Sedge Frog (*Litoria olongburensis*), Stinking Cryptocarya (*Cryptocarya foetida*), Rough-leaved Queensland Nut (*Macadamia tetraphylla*), Swamp Orchid (*Phaius australis*) and Durobby (*Syzygium moorei*). An additional species, the Little Tern (*Sterna albifrons*), has previously been recorded in the study area.

The *Environment Protection and Biodiversity Conservation Act 1999* states that a proposal will have, or is likely to have a significant impact on a threatened species if it does, will, or is likely to:

a) Decrease the size of a population.

b) Reduce the area of occupancy of the species.

c) Fragment an existing population into two or more populations.

d) Adversely affect critical habitat.

e) Disrupt the breeding cycle of a population.

f) Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

g) Directly or indirectly result in invasive species that are harmful to an endangered species becoming established in the endangered species' habitat.

h) Interfere with the recovery of the species.

Table 6.5 outlines an assessment of the impact of the proposal pursuant to the criteria outlined above for the 8 nationally threatened species that have been recorded in the study area.

Table 6.5: Assessment of Nationally threatened species pursuant to the Environmental Protection and Biodiversity Conservation Act Criteria

Species Name	EPBC Act Criteria							
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**
Long-nosed Potoroo *Potorous tridactylus*	? Yes	Yes	No	No	No	Yes	No	No
Grey-headed Flying-fox *Pteropus poliocephalus*	No	No	No	No	No	No	No	No
Wallum Sedge Frog *Litoria olongburensis*	Yes	Yes	Yes	No	Yes	Yes	No	Yes
Stinking Cryptocarya *Cryptocarya foetida*	Yes	Yes	No	No	No	No	No	No
Rough-leaved Queensland Nut *Macadamia tetraphylla*	No	No	No	No	No	No	No	No
Swamp Orchid *Phaius australis*	No	Yes	Yes	No	No	No	No	No
Durobby *Syzygium moorei*	No	No	No	No	No	No	No	No
Little Tern *Sterna albifrons*	No	No	No	No	No	No	No	No

Table 6.5 shows that the proposal would not have a significant impact on most nationally threatened species. However, the proposed bypass would have a significant impact on the Wallum Sedge Frog and possibly the Long-nosed Potoroo. Individual profiles detailing specific impacts and mitigation measures for these two threatened species are provided in the Species Impact Statement.

No nationally listed endangered ecological communities occur in the study area.

Migratory Species

Fifteen species of listed migratory birds have been recorded within the study area. These species have previously been listed in Table 4.6. An additional 10 species have previously been recored in the study area. These species are the Sharp-tailed Sandpiper (*Calidris acuminata*), Curlew Sandpiper (*Calidris ferruginea*), Great Knot (*Calidris tenuirostris*), Lesser Sand Plover (*Charadrius mongolus*), Black-tailed Godwit *(Limosa limosa),* Little Tern (*Sterna albifrons*), Caspian Tern (*Sterna caspia*), Common Tern (*Sterna hirundo*), Marsh Sandpiper (*Tringa stagnatilis*) and Terek Sandpiper (*Xenus cinereus*).

According to the *Environment Protection and Biodiversity Conservation Act 1999*,

"an action has, will have, or is likely to have a significant impact on a migratory species if it does, will, or is likely to:

a) 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, or

b) result in invasive species that is harmful to the migratory species becoming established in an area of important habitat of the migratory species, or

c) seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of the species."

An area of important habitat is defined by the Act as:

- *"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*
- *habitat utilised by a migratory species which is at the limit of the species range, or*
- *habitat within an area where the species is declining. "*

The Cobaki Broadwater is considered likely to provide important habitat for most of the migratory bird species recorded, as it provides important roosting and foraging habitat. The study area is not at the limit of any migratory species' range, however at least five species recorded in the area are declining within the region. Therefore, for the purposes of this assessment the study area is considered to support "important habitat" for the majority of migratory species outlined previously.

Therefore, an assessment of the action pursuant to an important population is undertaken below. Is the proposed bypass likely to:

a) 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, or

The refined C4 alignment runs near to a high tide roost site and foraging area used by a variety of migratory birds at the 'Pony Club'. This area may be affected by noise and disturbance in the short-term during construction activities. However, once, operational, the road would be in the tunnelled section of the bypass near this area and therefore, the roost and foraging site would be shielded from noise and disturbance until the entry/exit of the tunnel, about 300 metres distant from these areas. This area is also currently subjected to aircraft noise as it is located directly beneath the flyway. The proposed airport runway extension would impact upon this area more significantly than the bypass.

There is also a small possibility that the bypass may result in changes to the hydrological characteristics of the area, especially near the road tunnel. However, this impact is expected to be negligible and mitigation and monitoring measures have been detailed to ensure that hydrological impacts are small. This is further discussed in Chapter 8 of the EIS and Technical Paper 6.

Pollution of the Broadwater by acid sulphate runoff, sedimentation, hydrocarbons and oil/chemical spills could also occur as a result of the bypass. However, the existing road network passes close to the Broadwater and the Pony Club site and therefore, the potential for oil/chemical spills is already present. Acid sulphate soils would be managed to ensure that no acid water runoff occurs as detailed in Chapter 8 of the EIS and Technical Paper 4. Appropriately designed sedimentation structures would ensure that erosion and sedimentation of the Broadwater does not occur and that road pollution is captured and treated prior to road runoff being released into the environment. Therefore, it is considered only a low likelihood that pollution of the Cobaki Broadwater would occur as a result of the proposed bypass.

Overall, it is therefore, considered that the proposal would not substantially modify, destroy or isolate an area of important habitat for migratory birds.

b) result in invasive species that is harmful to the migratory species becoming established in an area of important habitat of the migratory species,

The proposed bypass would not result in any invasive species becoming established in the area.

c) seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of the species."

The proposal is considered unlikely to seriously disrupt the lifecycle of migratory species in the study area. While some short-term impacts associated with construction may occur, it is unlikely that the operational phase of the project would disrupt any roost or foraging area for migratory species.

Commonwealth Marine Areas

The proposal would not impact upon the Commonwealth marine environment.

Nuclear Actions

The proposal does not involve any nuclear activity.

Areas of National Heritage

One site, on the edge of the Cobaki Broadwater within Commonwealth land to the west of the proposed C4 alignment is listed on the Australian Heritage Database. This site is labelled 'Coolangatta Airport Aboriginal Site, Tweed Heads West, NSW'. The proposal would traverse a very small portion of this site, in an existing disturbed area.

6.7.2 Threatened Species Conservation Act

In accordance with the requirements of the NSW *Threatened Species Conservation Act 1995,* a Species Impact Statement (SIS) must be prepared when it is determined under Section 5a of the NSW *Environmental Planning and Assessment Act 1979* that a significant impact on threatened species, populations or ecological communities is likely to occur. Section 5a assessments (eight-part tests of significance) conducted as part of this study concluded that a significant impact on threatened species was likely to occur.

Flora

A total of 89 flora species of legislative or regional significance were assessed for their habitat requirements, distribution and likelihood of occurring in the study area. Details of this assessment are contained in Appendix F of the SIS. This assessment determined that 49 of these flora species have been recorded or have potential habitat within the study area.

A total of 15 flora species of legislative significance and 8 species of regional or other significance were recorded from the study area during current surveys. An eight-part test of significance (see Appendix G of the SIS) was undertaken for these 23 species. This assessment determined that 9 of these species would be affected by the proposal and a detailed profile for each of these species is provided in the SIS. These species are the Little Wattle *(Accicia baueri* subsp. *baueri*), Chinese Burr (*Triumfetta rhomboidea*), Swamp Orchid (*Phaius australis*), Coast Palm Lily (*Cordyline congesta*), Stinking Cryptocarya (*Crytocarya foetida*), Long-leaved Tuckeroo (*Cupanipsis newmanii*), Black Walnut (*Endiandra globosa*) and Fine-leaved Tuckeroo (*Lepiderma pulchella*).

An eight-part test of significance was also undertaken for an additional 26 flora species not recorded in the study area but considered likely to occur (see Appendix G of the SIS). It was concluded that while potential habitat exists in the area for these species, they would not be affected by the proposal.

Vertebrate Fauna

A total of 133 vertebrate fauna species of legislative or regional significance were assessed for their habitat requirements, distribution and likelihood of occurring in the study area. Details of this assessment are contained in Appendix F of the SIS. This assessment determined that 91 of these fauna species have been recorded or have potential habitat within the study area.

A total of 40 vertebrate fauna species of legislative significance and 10 species of regional or other significance were recorded from the study area during current surveys. A further 12 species of legislative significance were recorded from the study area during previous surveys. It was determined that five bird species of regional significance and the Grassland Melomyes would not require further impact assessment, as they were widespread in the study area, the proposed bypass would remove only a

small portion of their habitat, and the birds were highly mobile. Therefore, the proposal was unlikely to have an affect on these species. An eight-part test of significance was subsequently undertaken for the remaining 56 significant fauna species recorded in the study area (as detailed in Appendix G of the SIS). This assessment determined that 12 vertebrate fauna species recorded in the study area would be affected by the proposal and a detailed profile for each of these species is provided in the SIS. There species are the Bush Hen, Masked Owl, Eastern Grass Owl, Brahminy Kite, Eastern Long-eared Bat, Long-nosed Potoroo, Wallum Froglet, Lewins Rail, Grey-headed Flying Fox, Common Planigale, Wallum Sedge Frog and Eastern Grass Owl.

An eight-part test of significance was also undertaken for an additional 29 vetebrate fauna species not recorded in the study area but considered likely to occur (see Appendix G of the SIS). It was concluded that while potential habitat exists in the area for these species, they would not be affected by the proposal.

Invertebrate Fauna

A total of six significant invertebrate fauna species were assessed as part of the SIS. While the four invertebrate species listed as subject species were not recorded from the study area, two species of regional significance were detected. An eight-part test of significance was undertaken for all six species and it was determined that the two species of regional significance, the Queensland Giant Dragonfly (*Petalura litorea*) and Swordgrass Brown Butterfly (*Tisiphone abeona morrisi*) would be affected by the proposal and detailed profiles for these species are provided in the SIS.

Endangered Populations

No endangered populations have been listed on or near the study site. However, a preliminary listing of the Long-nosed Potoroo population, Cobaki Lakes and Tweed Heads West was made on 10 of September 2004. While preliminary listings have no statutory obligations (as they may be rejected) the Long-nosed Potoroo population in the area has been considered in detail in the SIS.

Endangered Ecological Communities

Littoral Rainforest and Coastal Saltmarsh in the North Coast Biogeographic Region are listed in NSW as an Endangered Ecological Community (EEC) on Schedule 1 Part 3 of the Threatened Species Conservation Act. Both of these communities occur in the study area and a detailed profile for each has been provided in the SIS.

Three additional ecological communities relevant to the Tugun Bypass have been preliminarily listed as endangered pursuant to the Threatened Species Conservation Act on 10 September 2004. These communities are Freshwater Wetlands on Coastal Floodplains, Swamp Oak Floodplain Forest and Swamp Sclerophyll Forest on Coastal Floodplains. The proposed Tugun Bypass would impact on all three communities, with about 1.1 hectares of Freshwater Wetlands being directly impacted, 1.5 hectares of Swamp Oak Floodplain Forest impacted and 19.6 hectares of Swamp Sclerophyll Forest. However, preliminary determinations have no statutory obligation until they are finalised (due to the possibility they may be rejected) and further consideration would be given to these communities if they become final.

7. Mitigation Measures

Mitigation measures for the entire alignment and for those sites of significance that would be affected are broadly described below and shown in Figure 7.1. Detailed mitigation measures would be described as part of the environmental management plan for the project.

While the recommendations of the expert subconsultants have been considered when compiling the mitigation measures these have been modified according to new information and issues that have arisen regarding practicality, timing and land ownership.

7.1 Mitigation Measures Along the Alignment

7.1.1 Compensating for Terrestrial Habitat Loss

Compensatory habitat policies for Queensland, NSW and Commonwealth land are described in Appendix P. In summary, current NSW Roads and Traffic Authority policy has been adopted for the alignment because it has been subjected to considerable review by the Roads and Traffic Authority in consultation with NSW Department of Environment and Conservation, applied to a number of Pacific Highway upgrades and developed specifically to compensate for impacts associated with linear corridors. As an additional measure, edge effects would be taken into consideration in the calculation of compensatory habitat along the proposed bypass. This would provide an additional 30 metre strip of compensatory habitat wherever the proposed bypass creates a new cleared corridor through native vegetation (Bali 2000). It should be noted that compensatory habitat is only required in NSW. However, recommendations are also made for Queensland and Commonwealth land.

Compensating for Key Habitat Loss

Key habitat areas are those that support significant species, populations or ecological communities (Appendix P). Table 7.1 outlines the amount of key habitat lost as a result of the proposed bypass.

Approximately 26.5 hectares of habitat would need to be compensated in NSW as a result of the proposed bypass. This comprises 19 hectares to be removed and 7.5 hectares that would be edge-affected. Key habitat includes known habitats for threatened species, land zoned Environmental Protection, National Estate land and habitats containing significant plant communities. It does not include the small area to be removed from the *State Environmental Planning Policy Number 14* wetland. This would be compensated separately according to the Department of Infrastructure, Planning and Natural Resource policy (see below).

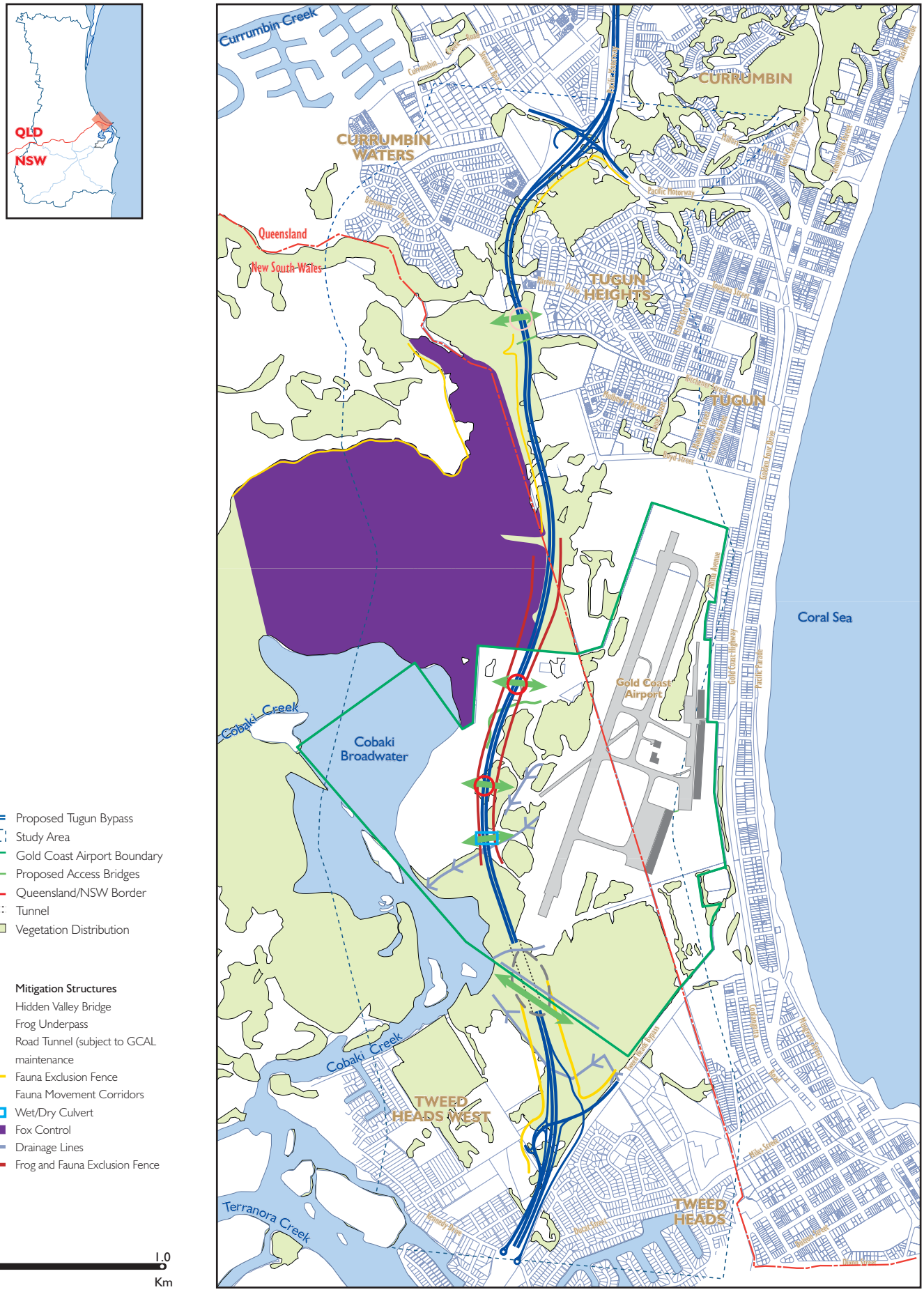


Figure 7.1 **Location of Proposed Major Mitigation Structures and Compensatory Measures**

Table 7.1: Area to be Removed From Each Key Habitat Type Within the Study Area

Key Habitat Type	Total in Study Area (hectares)	Area Removed per Jurisdiction			Total Area Removed	
		NSW (hectares)	Comm (hectares)	Qld (hectares)	hectares	%
Dune Woodland/Forest	46.0	0.3	0.75	0.53	1.6	3.5
Ridge Woodland/Forest	99.7	0	0	8.7	8.7	8.7
Rainforest/Rainforest Elements	24.6	0	0	0.8	0.8	3.3
Swamp Forest	110.1	9.55	3.0	1.8	14.35	13.0
Regenerating Swamp Forest	13.1	6.72	0	0	6.72	51.3
Mangrove Forest	33.7	0	0.05	0	0.05	0.15
Heathland	74.4	0	3.4	0	3.4	4.6
Sedgeland/Rushland	15.6	0.03	2.4	0	2.4	15.4
Saltmarsh	6.4	0	0	0	0	0
Disturbed Open habitat	62.5	2.4	1.85	2.9	7.15	11.4
Pine Plantings	10.0	0	0	0	0	0
Cleared/Urban	718.8	11.7	5.8	13.32	30.82	4.3
TOTAL	**1,215.0**	**30.7**	**19.9**	**28.0**	**76.0**	**6.3**
TOTAL (key habitat lost)	**496.2**	**19.0**	**11.5**	**14.7**	**45.2**	**9.1**
Edge Effects		**7.5**	**9.3**	**9.1**	**25.9**	
Total Area to be Compensated		**26.5**	**20.8**	**23.8**	**71.1**	

Although not a requirement in Queensland, approximately 23.8 hectares of habitat would be compensated in Queensland as a result of the proposed bypass. This comprises 14.7 hectares to be removed and 9.1 hectares that would be edge-affected. Key habitat includes known habitats for threatened species and habitats containing significant plant communities.

Approximately 20.8 hectares of habitat would be impacted in Commonwealth land as a result of the proposed bypass. This comprises 11.5 hectares to be removed and 9.3 hectares that would be edge-affected. Key habitat includes known habitats for threatened species. This 20.8 hectares has been included in the compensatory habitat package.

In NSW, compensatory habitat arrangements may include land purchase and/or a range of other measures including Voluntary Conservation Agreements and rehabilitation. It is important that, where possible, any site proposed for compensatory habitat be of a similar size and comprise similar ecological values to key habitat removed. This is, however, not always easy to achieve. A preferred compensatory habitat package has been described and submitted to NSW Department of Environment and Conservation and the Department of Infrastructure, Planning and Natural Resources for comment, although this package probably needs to be updated. Compensatory measures for Long-nosed Potoroos form part of the compensatory package (see Section 8.2).

7.1.2 Minimising Terrestrial Habitat Loss

Habitat loss would be minimised during construction. Removal of vegetation would be restricted to the development footprint where possible. Construction compounds,

storage areas or asphalt batch plants would either be located within the footprint to avoid any further loss of habitat or located in previously cleared sites in the locality. These sites would include the Landfill, sand-mined area near Stewart Road and the old Quarry site near Hidden Valley. . Any additional clearing for compounds and other ancillary uses would be subject to future approval processes.

The footprint would be fenced first and then cleared to minimise disturbance to adjacent areas. Where this is not possible, then sensitive areas would be identified as "no-go" areas in consultation with regulatory authorities and clearly marked/protected by temporary fencing during clearing. Fauna-exclusion fencing would be erected along the route (with the exception of the tunnel overpass and bridge at Hidden Valley) as soon as practical after clearing. Some areas in the additional 10 metres from the edge of batters or cuts that has been included in the footprint may be identified as "no-go" areas to provide protection for important habitat features or populations.

Where an area of native vegetation is required to be cleared and then revegetated post-construction (over the top of the tunnel and around bridge pylons at Hidden Valley), then sensitive areas outside the construction footprint would be protected using temporary fencing. The following mitigation measures would also be taken:

- seeds and other propagative material used for rehabilitation and/or revegetation would be collected from native species present within 1–5 kilometres of the site;
- soil erosion and sedimentation control measures would be progressively implemented to minimise the area of unstable or unprotected soil surface; and
- utilising the seed collected from near the site to revegetate roadside verges and other disturbed areas within the footprint, especially adjacent to underpasses, progressively.

Construction activities would avoid the loss or disturbance of estuarine and freshwater wetland vegetation by being confined to the fenced footprint or unprotected areas.

Approximately 33 hollow-bearing trees would be removed as part of road construction. Portions of trees containing hollows would be removed and reinstated in adjacent areas. If any hollows are damaged or destroyed during clearing, then appropriately designed nest boxes would be affixed to standing trees in the vicinity. The design and placement of boxes should take account of the following:

- all hollow-bearing trees to be felled should be clearly marked and their species and approximate dimensions catalogued so that hollows and nest boxes can be affixed to similar standing trees allowing for size and safety restrictions;
- small hollows should be replaced with nest boxes designed for bats (see Hoye 1994), incorporating an overhanging roof and internal baffles and having both external and internal walls lined with flyscreen to improve grip
- medium-sized hollows should be replaced with those designed for Squirrel Gliders and Brush-tailed Phascogales (Land for Wildlife 1991)
- nails used to attach nest boxes should not be galvanised or coated and should not contain zinc to avoid poisoning the trees
- metal strapping that allows for tree expansion should be used to attach nest boxes
- boxes should be placed between four and eight metres above the ground and oriented to minimise penetration by rainfall and sunlight

- boxes should be placed away from main access tracks to minimise the chances of them falling and injuring anyone.

In general, reinstated hollows and nest boxes should be placed in intact forest near the preferred alignment. The actual placement should take into account the density and dispersion of existing hollows and will be examined in detail in the Construction Environmental Management Plan and discussed with relevant landowners and NSW Department of Environment and Conservation. Reinstated hollows removed near the Crown land, should be placed within the Crown land, while hollows near the proposed Tweed Heads Bypass interchange could be placed in adjacent paperbark forest to the east of the alignment. Approval of landowners would need to be obtained prior to placement of hollows. If hollows cannot be re-instated in these areas, then an opportunity exists to re-instate hollows on land in the locality purchased for compensatory habitat purposes.

Habitat Rehabilitation and Revegetation

Road edges and any other areas disturbed during construction would be revegetated with local native plant species where practical in order to minimise edge effects, increase habitat connectivity and to provide additional flora and fauna habitat. There are a number of opportunities to improve habitat connectivity and to revegetate disturbed areas post-construction:

- any areas disturbed outside the footprint and the fauna-exclusion fencing as a result of road construction would be revegetated as soon as possible;
- roadside verges within the footprint (within fauna-exclusion fence) would be landscaped with seed collected locally;
- disturbed areas around bridge pylons at Hidden Valley would be revegetated (see Section 7.2.1);
- sedimentation ponds and mitigation ponds would be selectively planted/seeded and allowed to revegetate naturally (see Section 7.1.3) to create habitat for wetland species;
- the eastern side of the ridge behind the John Flynn Hospital and Medical Centre would be revegetated with endemic species post-construction;
- the vegetation over the top of the road tunnel would be re-established to its original pre-construction state where possible; and
- disturbed areas located between remnant vegetation and mitigation culvert openings would be revegetated with appropriate vegetation, especially near the wet/dry culvert.

While weeds are already prolific in the area, weed management would be undertaken in any rehabilitation or revegetation areas to ensure native species dominate the floristic composition.

7.1.3 Loss of Individuals from Terrestrial Flora Species of Conservation Significance

All plant species of conservation significance directly or indirectly affected by the proposed bypass have been considered in the SIS (Main Roads 2004). Although the loss of individuals from plant populations of conservation significance is not

considered to be significant for most species, it is recommended that the population of Chinese Burr and affected individuals of Little Wattle *(Acacia baueri* subsp. *baueri)* and Match Sticks (*Comesperma ericinum)* are translocated. Any translocation would incorporate the Australian Network for Plant Conservation translocation guidelines (2004). Translocation is not considered by NSW Department of Environment and Conservation to be a mitigation measure but an emergency measure undertaken only where habitat destruction is imminent.

A strategy for the translocation of plants would be detailed in the Construction Environmental Management Plan in consultation with NSW Department of Environment and Conservation, Commonwealth Department of Environment and Heritage and/or Queensland Environmental Protection Agency, depending on jurisdiction. In the case of Chinese Burr, it is recommended that all plants removed during pre-clearing surveys are transplanted into appropriate habitats nearby and/or that topsoil containing the seed bank is spread in adjacent areas. For Match Sticks and Little Wattle, the removal of affected individuals to suitable habitat nearby is recommended.

It is unknown whether more plants of conservation significance occur in the area of the proposed Tugun Bypass. Prior to clearing the footprint, the following protocol would be followed for species of conservation significance:

- pre-clearing surveys targeting plant species of conservation significance would be undertaken by a qualified botanist;
- seed from all threatened plants required to be removed will be collected once approval is obtained to enable potential propagation and re-establishment of threatened species in the area;
- marking all threatened species, parawebbing and/or fencing of plants of significance or the footprint near populations will be undertaken prior to construction to ensure that vehicles and other direct disturbances associated with road construction do not encroach into adjacent habitat containing significant species;
- a protocol for the removal and possible translocation of plants of conservation significance would be developed in consultation with the NSW Department of Environment and Conservation, Department of Environment and Heritage and/or Queensland Environmental Protection Agency, depending on jurisdiction; and
- revegetation works would commence as early as possible within the construction phase of the project to minimise the time lag between clearing and rehabilitation.

Wherever possible, plant species of conservation significance would be incorporated into rehabilitation plans. In particular the Little Wattle and Match Sticks would be considered for incorporation into revegetation of land between the Tugun Bypass and NSW Crown land north of the Tugun Landfill. Seeds of the Chinese Burr would be spread in Paperbark Regrowth and Woodland communities near the Tweed Interchange.

7.1.4 Loss of Individuals from Terrestrial Fauna Species of Conservation Significance

All conservation significant fauna species directly or indirectly affected by the proposed bypass have been considered in the SIS (Main Roads 2004). Although the loss of individuals from fauna species of conservation significance is not considered to

have more than a local effect on most species, Hero *et al*. (2001b) recommend the capture and translocation of individual Wallum Sedge Frogs and Common Planigales from habitat to be cleared during construction. However, in both instances problems arise as to where to put displaced individuals.

In the case of Wallum Sedge Frogs, Hero *et al*. (2001c) recommend translocating individuals to new ponds created on Commonwealth land. However, the test pond constructed did not provide suitable habitat for this species. Main Roads also, has no jurisdiction over this land and cannot ensure that ponds would be constructed and maintained, or landholder permission would be obtained to translocate individuals. It may be possible to obtain some more land as part of the project footprint for constructing the ponds, although the success of these ponds cannot be guaranteed and therefore, translocation of individuals may not be possible.

In the case of the Common Planigale, Hero *et al*. (2001b) have recommended that individuals captured pre-construction are maintained in captivity and then released into the same area post-construction and revegetation. Common Planigales are readily reared in captivity and it may be possible to keep individuals in captivity until the construction of the road is completed (David Read, *pers. comm*.). Alternatively individuals could be translocated into nearby suitable habitat, such as vegetation to the south-east of the existing population, however, landholder permission may be difficult to obtain. If these options are unsuitable then immediate translocation into habitat beside the footprint would be undertaken although disturbance during construction may result in mortality of these individuals and landholder permission may also be difficult to obtain.

Any translocation in NSW must be undertaken in accordance with the NSW Department of Environment and Conservation translocation policy (NSW National Parks and Wildlife Service 2001). Translocations (if undertaken) on Airport Lands would be undertaken in accordance with the requirements of the Airport Environment Officer.

It is likely that individuals from fauna species of conservation significance occur in the footprint and prior to clearing, the following protocol would be followed:

- a hygiene protocol for contractors to minimise the spread of the amphibian chytrid fungus would be developed in consultation with NSW Department of Environment and Conservation;
- surveys and removal of fauna species of conservation significance along the footprint would be undertaken by a qualified ecologist ;
- where major excavations such as that associated with tunnel construction are to be left open for extended periods, then temporary impermeable fencing would be used to prevent fauna from becoming trapped and ramps would be provided to enable fauna to exit the hole if they do enter;
- during pre-clearing surveys, bark would be removed from old growth paperbarks after bats have left roost sites to begin foraging at dusk to prevent individuals from being injured or killed during clearing;
- a fauna rescue framework for clearing has been developed by the NSW Roads and Traffic Authority in consultation with NSW Department of Environment and Conservation and would be used as basis for developing a protocol for the removal of injured animals during this project; and

- a two-stage clearing process would be implemented that involves removing non-hollow-bearing vegetation first

Mitigation measures for specific species are described below.

Wallum Sedge Frogs and Wallum Froglets

Translocation is not an mitigation measure, but is an animal ethics issue to avoid the unnecessary death of individuals where possible. However, it may prove to be impossible to implement given potential problems with translocation sites and landholder permission. It is recommended that a translocation policy be developed in consultation with relevant government agencies and landholder to determine if translocation is feasible.

If translocation is undertaken then pre-construction surveys and translocation would focus on minimising the scale of translocation such that movement of individuals does not impact on other populations through the transmission of disease (Dodd and Seigel 1991) or the mixing of potentially divergent gene pools (Reinert 1991) and to maximise the probability that habitats and conditions at introduction sites closely reflect those from removal sites. Broad guidelines for translocating the Wallum Froglet and Wallum Sedge Frog are listed below:

- testing would initially be undertaken to ensure that the Chytrid fungus is not present within the footprint or at the proposed translocation sites
- a hygiene protocol for the translocation of the frogs would be developed in consultation with the NSW Department of Environment and Conservation to minimise the spread of the Chytrid fungus
- pre-clearing, an impermeable fence would be erected to delineate the footprint and to prevent subsequent dispersal of individual frogs into the area post-capture;
- a combination of trapping methods including pit falling, dip-netting and active daytime and night-time searches would be undertaken
- if practical, pre-construction surveys would commence in September after high rainfall events and in warm temperatures and continue until repeated searches yield few or no new individuals
- Wallum Sedge Frogs and Wallum Froglets captured during pre-clearing surveys would be marked and immediately transferred to the nearest available habitat.

In some instances, it may be necessary to rescue and maintain amphibian populations through the provision of alternative breeding habitat where historical breeding sites have been damaged or destroyed (Denton *et al*. 1997). Pond creation is a potential mitigation measure where populations are small (less than 100) as in the case of the Wallum Sedge Frog. In addition, the proposed bypass would result in the loss of at least one, possibly two (Figure 4.7) out of six ponds where this species has been recorded in the study area. However, the construction of artificial ponds for the Wallum Sedge Frog has not been successfully done to date and therefore, this measure is considered to be experimental. During preparation of the representations report consultation with Department of Environment and Conservation would be undertaken to determine the suitability of constructing artificial ponds for Wallum Sedge Frogs. The number and location of these ponds would be decided at this stage.

The most appropriate site would be chosen based upon a number of factors that may require testing including:

a. proximity to known sites;

b. suitability to have permanent (>80% time) surface water;

c. appropriate soil conditions (including pH of 3-5 preferably 4 and low salinity levels);

d. vegetation should be of similar composition to the removal site; and

e. status of Chytrid fungus should be determined at both the removal and introduction sites.

Given that Main Roads has no jurisdiction over Commonwealth land, potential locations for these ponds are restricted to suitable habitat areas within the proposal footprint or to areas of land acquired as part of the proposal. The use of temporary sediment ponds could be considered if constructed and revegetated appropriately. The construction of more than one pond would be preferable to provide enough breeding sites for a metapopulation, to safeguard against the introduction of predatory Mosquito Fish and to reduce the risk of failure in establishing suitable habitat. Ponds should:

- be a minimum of 1.5 metres deep with a gradient sloping to 0.3 metres at the pond edges;
- be between 15 to 20 metres long and 5 to10 metres wide;
- be constructed away from permanent waterbodies and drainage lines to prevent the import of saline water and predatory fish;
- be constructed so that banks have a gradual slope, being deepest in the middle;
- have the same physio-chemical properties as existing used water bodies;
- have a slow release liner, similar to those used in dam construction and sedimentation traps, to increase the permanency of surface water (>80% time);
- be revegetated with species consistent with the local habitat requirements for the Wallum Sedge Frog, such as *Restio* spp.;
- utilise dense *Restio* stands that are to be removed from the footprint by use of machinery such as a Bobcat or small backhoe by a process known as "slabbing'. Slabbing depth should be at least 30 cm to ensure organic layers are collected;
- be constructed during a dry period (spring) leading up to a pronounced rainfall event (normally summer) to enable machinery to access the site with minimal damage and enhance the likelihood that the transplanted vegetation will survive (reduce chance of drying out);
- be interspersed with existing breeding ponds, thereby increasing the connectivity of aquatic habitats; and
- where practical, connected by terrestrial vegetated corridors.

Common Planigale

Minimal mitigation measures are available for the Common Planigale due to surrounding constraints. As such it is recommended that during construction all practical measures are taken to minimise the loss of known and potential planigale habitat.

General mitigation measures aimed at minimising habitat loss and maintaining existing regimes would minimise the impact to this species. Species-specific mitigation measures include:

- preventing or minimising indirect impacts on known Common Planigale habitat directly adjacent to the footprint;
- avoiding known habitat for the Common Planigale when constructing any access tracks associated with the proposed bypass;
- installation of a wet/dry culvert at the northern end of the road tunnel ramp to potentially enable an east – west fauna movement; and
- revegetation of a 10–30 metre habitat link along the road edges between Common Planigale habitat in the south to the wet/dry culvert to provide continuous habitat for fauna to the underpass.

Pre-construction surveys and translocation of individual planigales is recommended, however, this is not a mitigation measure, but is an animal ethics issues to avoid possible unnecessary death of individuals where possible. However, it may prove to be impossible to implement given potential problems with translocation sites and landholder permission. It is recommended that a translocation policy be developed in consultation with relevant government agencies and landholder to determine if translocation is feasible

If translocation is conducted pre-construction surveys and translocation would focus on minimising the scale of translocation such that movement of individuals does not impact on other populations through the transmission of disease (Dodd and Seigel 1991) or the mixing of potentially divergent gene pools (Reinert 1991) and to maximise the probability that habitats and conditions at introduction sites closely reflect those from removal sites. Broad guidelines would include:

- pre-clearing, an impermeable fence would be erected to delineate the footprint and to prevent subsequent dispersal of individual Common Planigales into the area post-capture;
- pit falling to capture individuals within the proposal footprint would be undertaken;
- if practical, pre-construction surveys would be undertaken in autumn and winter to avoid the breeding season; and
- captured animals would be immediately transferred to the nearest available habitat.

If Common Planigales are captured within the footprint then a number of scenarios could occur. Hero *et al*. (2001b) recommended that individuals captured pre-construction be maintained in captivity and then released into the same area post-construction and revegetation. Common Planigales are readily reared in captivity and it may be possible to keep individuals in captivity until the construction of the road is completed (David Read, pers. comm.). However, ethical issues are problematic when discussing keeping animals in captivity.

Alternatively individuals could be translocated into nearby suitable habitat, such as vegetation to the south-east of the existing population, however, landholder permission may be difficult to obtain. While this vegetation has been identified as potentially providing seasonal or transient habitat for the Common Planigale, no individuals have been recorded in this area and conflicts with translocation and future development opportunities occur.

The only other alternative is the immediate translocation of individuals into habitat retained beside the road. However, disturbance associated with construction may

result in mortality of individuals residing in adjacent habitats and therefore, the translocation may not benefit the species or individual animal.

Given the limited mitigation measures available for this species and the high probability that this species may go extinct in the area as a result of the proposed Bypass compensatory measures need to be re-examined. This may include the investigation of purchasing known Common Planigale habitat elsewhere close to the site (perhaps near Cudgen Creek).

7.1.5 Compensating for Wetland Habitat Loss

Approximately 0.02 hectares of *State Environmental Planning Policy Number 14* habitat would be removed as a result of the proposed bypass. Good quality *State Environmental Planning Policy Number 14* wetland is generally compensated at a ratio of 10:1 according to the Department of Infrastructure, Planning and Natural Resources draft policy. From discussions with the Department of Infrastructure, Planning and Natural Resources staff, it appears that rehabilitation of the existing wetland would be acceptable as a compensatory measure. This could occur as part of revegetation works over the tunnel in this area.

In NSW, approximately 0.65 hectares of Disturbed Saltmarsh/Sedgeland would be removed as a result of the proposed bypass. If these are located below the mean high-tide mark, then NSW Fisheries may require compensation for these significant wetland types at a ratio of 2:1.

7.1.6 Mitigation Measures for Aquatic Biota

The maintenance of water quality and of surface and sub-surface flows is integral to the conservation of aquatic ecosystems. Hydrological mitigation measures are outlined below and described in detail in Technical Papers 6, 7 and 8. The protocol for management and monitoring of acid sulphate soils outlined in Technical Paper 4 is also relevant.

Construction activities would attempt to minimise the loss of or disturbance to estuarine and freshwater wetland vegetation. Operation impacts would also be minimised to ensure that minimal disturbance to estuarine and freshwater wetland vegetation occurs. This is discussed if further detail in Chapter 8 of the EIS.

Any mitigation measures aimed at minimising chemical contamination of habitats in the vicinity of the proposal through diversion of run-off from the bypass and detention ponds would limit the impact on frog and fish species. Of particular importance for frogs are the NSW Department of Environment and Conservation usual requirements that pH of sedimentation basin releases be between 6.5 to 8. This is inappropriate for those basins that would overflow into existing or constructed frog ponds. Therefore, liaison with relevant agency personnel and specialist consultants to determine the most appropriate discharge criteria for those sedimentation basins discharging to frog ponds would be undertaken, prior to the commencement of construction activities.

Mitigation measures listed below would minimise impacts on aquatic flora and flora:

- if practical, construction activities in the vicinity of waterways would be scheduled to avoid periods of heavy rainfall;

- where the groundwater is to be lowered for periods exceeding one week, groundwater levels would be monitored and the surface rewatered at intervals as required (see Technical paper 6)
- appropriate drainage structures, sediment traps and other mitigation structures would be constructed and maintained to minimise the likelihood of run-off from the road surface entering the environment without filtering of contaminated substances such as oil and heavy metals;
- stormwater treatment devices would be designed to maintain existing flow paths and regimes where practical;
- 'best practice' surface water quality management would be implemented during construction and operation to trap a high proportion of suspended sediments, adsorbed metals, nutrients and hydrocarbons;
- spill scenarios would be taken into consideration during design of water treatment facilities (see Technical Paper 2);
- all practical measures would be taken to prevent pH from changing significantly as a result of exposure of acid sulphate soils by tunnel construction;
- site management during construction would provide for the appropriate management of potential acid sulphate soils that are oxidised and would be detailed in an Acid Sulphate Management Plan written as part of the Construction Environmental Management Plan;
- existing channels would be maintained as close as possible to their existing locations to avoid concentrating flows (see Section 7.1.7);
- balancing channels (for example flat grades, shallow drains) would be constructed to maintain existing sheet flow and ponding areas;
- salt intrusion would be minimised at the southern end of bypass; and
- road run-off would be kept separate from undisturbed run-off, prior to treatment and discharge.

7.1.7 Key Terrestrial Habitat and Fauna Corridor Mitigation Measures

Most mitigation structures incorporated as part of the proposed bypass are aimed at maintaining fauna movement during the operation of the proposed bypass. These are outlined below and shown on Figure 7.1.

Road Bridge at Hidden Valley

The launched construction of the bridge at Hidden Valley would minimise vegetation clearing in this sensitive rainforest gully. The dual carriageway bridge would span the valley allowing light penetration and the maintenance of a natural substrate. It would also allow fauna to pass beneath it.

Frog Culverts

Frog-exclusion fencing used in conjunction with culverts have been trialled in Denmark (Graff 1996), England (Cooke 1988), Luxembourg (Engel and Bressanutti 1993), Netherlands (Chardon *et al*. 1996), Spain (Yanes *et al*. 1995) and in the United States (Piersan 1987). They have also been trialled at Bulahdelah in NSW (although

this targeted non-climbing frog species). Little is known about the relationship between culvert length, height and width although use of culverts by amphibians is expected to decrease with length and to increase with height, width and openness (Yanes *et al*. 1995). Although one study of underpasses in the Netherlands did not find any correlation between relative diameter of the underpass (i.e. the width of the underpass multiplied by the height multiplied by the length of passageway) and the use of the structure by frogs (Brandjes and Veenbaas, 1999). A frog culvert aimed at facilitating movement by the Green-thighed Frog was constructed at Bulahdelah (Australian Museum Business Services 2001). However, few species were recorded using this culvert as it was prone to flooding. Usage by frogs may also have been prevented by the fact that vegetation was severely trampled near the entrances during construction (Frank Lemckert *pers. comm*.).

Frog culverts are proposed at two locations along the bypass (Figure 7.1). These were selected in order to maintain connectivity for a site of high frog diversity to the west and to reinforce habitat connectivity to the east. There is no information available on the use of frog culverts by the Wallum Sedge Frog and Wallum Froglet. Guidelines for the design of culverts and frog-exclusion fencing have been provided by Jean-Marc Hero (Hero *et al*. 2001c) and Ben Lewis (Lewis 2004b). Frog-exclusion fencing would help direct frogs towards culverts. Detailed design of these structures would be undertaken at a later stage although they and would attempt to ensure that they:

- connect known habitats to the east and west of the proposed bypass
- be a minimum of 1 metre-high and 3 metres wide
- have a channel through the centre of the culverts to hold water even in dry times to better encourage frogs to use the structures
- be otherwise lined with a natural substrate comprising earth or humus
- have a fence (either made from fine mesh or 50 cm vertical metal) constructed at the entrance of the culverts to prevent adult Cane Toads from entering to limit their predation on the smaller frogs within the culverts.

Wet/Dry Culvert North of the Common Planigale Habitat

An underpass would be provided for ground-dwelling mammals, frogs and fish at the northern end of the road tunnel ramps (see Site 4, Figure 2.6 and Figure 7.1). This would consist of four multicell box culverts, 0.6 metres high by 2.4 metres wide and approximately 90 metres long. The middle two culverts would be lower than the outside culverts and would provide drainage. The two outside culverts would be higher to maintain dry conditions and to enable terrestrial fauna to cross. Underpasses would have a natural substrate and may allow the movement of a range of large and small fauna possibly including the Common Planigale, although the small height and length may limit its use. In addition, low, dense vegetation similar to that found in the vicinity would be planted right up to the entry/exit openings and shelter would be provided in the form of logs and large rocks within the tunnel (unless recent monitoring suggests otherwise). Scour protection measures would be designed to enable fauna movement.

Frog-exclusion Fencing

Frog-exclusion fencing erected at Bulahdelah comprised fauna-exclusion fencing with some silt fence or geofabric attached to the bottom. It is also not considered to be

effective in preventing movement by tree frogs such as the Wallum Sedge Frog (Frank Lemckert, *pers. comm.*) and is therefore unsuited to the Tugun study area.

Frog-exclusion fencing would be erected from about chainage 3,200 south through to the tunnel ramps near ES5 along both sides of the proposed bypass. The exact form of the frog-exclusion fencing would be finalised during detailed design and would be trialled prior to being finalised. At this stage it is envisaged that fencing would consist of a solid sheet of durable material (for example hard plastic or metal) measuring approximately 400 millimetres high, with a small, possibly curved overhang at the top to discourage individuals from climbing over it. It would be attempted to be designed to allow surface water flow across the proposed bypass and to be relatively maintenance free. It may also be possible to combine the frog fencing with the fauna exclusion fencing. Given the ability of the frogs to climb it is important that vegetation be kept away from both sides of the frog fence to ensure that individual frogs do not climb the vegetation to navigate the fence.

Fauna-exclusion Fencing

Fauna-exclusion fencing, consisting of a chain-link fence, would be erected along both sides of the bypass and along crossroads to the south of the proposed tunnelled section of the bypass. North of the tunnel the walls of the entry/exit ramps would act as fauna fencing. Fencing would also be constructed on both sides of the road from the end of the ramp walls to the Tugun landfill, however, north of the landfill the majority of vegetation occurs on the western side of the bypass and hence fauna fencing is only proposed on the western side. The aim of the fencing is to prevent ground-dwelling fauna from crossing the bypass and to thereby minimise injuries and death caused by motor vehicles.

Access Over the Tunnel

Once the tunnel is excavated and constructed, it would be covered and partly revegetated to its pre-construction state. If approved part of the tunnel would be covered by the airport runway extension (as discussed in Section 8.3). A 100 metre length of tunnel at the southern end would be revegetated providing a connection between areas of core habitat to the east and west of the proposed bypass. However, this area would require on-going maintenance by the airport to conform to height restrictions.

7.1.8 Fish Passage Mitigation Measures

Guidelines for the maintenance of fish passage for different classes of waterways are provided by NSW Agriculture and Fisheries (1999). In general, watercourse crossings should be designed so that:

- the velocity of water flowing through the structure remains unchanged;
- the invert levels of the crossings mimic the natural invert level of the stream bed to maintain natural flow rates;
- the base of a crossing is set into the stream bed; and
- crossings ensure adequate light penetration.

Four out of the eight drainage channels (Sites 3, 4, 7 and 8) transected by the proposed bypass would require minor deviation, reinstatement over the tunnel or construction of culverts to maintain the fish passage across the bypass.

As Site 3 provides only minimal fish habitat, a culvert is required by NSW Agriculture and Fisheries (NSW Fisheries 1999). However, this channel would be diverted slightly (20 m) and reinstated as an open waterway. It would therefore be necessary to block water flow temporarily. As only Mosquito Fish (an introduced species) were recorded here, this is unlikely to result in a significant impact on native fish species. Site 8 also provides minimal fish habitat and would be reinstated as an open waterway over the tunnel. As it was dry during the survey period, there is no information regarding fish species utilising this drainage line.

Sites 4 and 7 provide moderate fish habitat and therefore require large box culverts or bridge crossings. The box culvert constructed at Site 4 would comprise four box culverts and would measure 90 metres in length. A 100-m box culvert would be constructed at Site 7. There would be no temporary or permanent barriers to fish movement along these drainage lines during construction or operation of the bypass. The removal of mangroves along the drainage channel at Site 7 would be minimised.

Where existing drainage channels are to be realigned, measures would be undertaken to minimise degradation of water quality of adjoining sections. This may require measures to prevent elevated turbidities, reduced pH and reduced dissolved oxygen concentrations. The following mitigation guidelines apply to creek diversion, reinstatement or culvert construction:

- if practical, construction activities in the vicinity of waterways would be scheduled to avoid periods of heavy rainfall;
- existing channels would be maintained as close as possible to their existing locations to avoid concentrating flows; and
- open waterways would be reinstated as soon as possible to allow revegetation of macrophytes to occur.

7.2 Mitigation Measures Associated with Sites of Significance

This section discusses mitigation measures to be applied to sites of ecological significance that would be affected by the proposed bypass.

7.2.1 Hidden Valley (ES2)

As a bridge would be constructed here, there would be no opportunities to fence off the footprint. Mitigation measures would therefore aim to protect important habitats and resources for threatened species. The following mitigation measures would be implemented:

- potential food trees for fruit-doves, particularly Bangalow Palms, located near the proposed bypass would be flagged and/or temporarily fenced to avoid accidental damage or removal during construction;
- the dam used by breeding Bush Hens would be clearly identified and protected from disturbance and/or hydrological effects during construction;
- a protocol for activities conducted near Bush Hen breeding sites would be developed in consultation with the relevant regulatory authorities and form part of the Construction Environmental Management Plan;
- areas of disturbance around each bridge pylon would be replanted with endemic shade tolerant species to minimise the risk of plant dieback and weed invasion;

- the southern side of the proposed bypass on the eastern slope of the ridge behind the John Flynn Hospital and Medical Centre would be revegetated to its original state post-construction; and
- if clearing is to be undertaken between October and April, then pre-clearing surveys would be undertaken to detect breeding Bush Hens within 100 metres of the footprint.

7.2.2 Long-nosed Potoroo Habitat (ES3)

The following mitigation measures would be implemented to minimise impacts to known and potential Long-nosed Potoroo habitat, threatened bird species, threatened flora species, Swordgrass Brown Butterfly, the Queensland Giant Dragonfly (if it occurs) and aquatic organisms:

- every practical precaution would be taken to prevent any leachate from entering the ecosystem during landfill excavation (see Chapter 8 of the EIS); and
- *Gahnia* and *Melaleuca* swamps would be protected from disturbance or accidental damage during construction.

The small disjunct population of Long-nosed Potoroos that occurs in the NSW Crown land is currently under threat from habitat loss, fragmentation and predation. Habitat in the area is already highly fragmented by the Cobaki Lakes development and associated access track to this site. The proposed bypass is not in itself considered to be a major threat to the Long-nosed Potoroo population. Siting of the alignment along the eastern edge of known habitat for this species would result in only 0.5 hectares of habitat for this species being removed as a result of the proposal. It would also minimise any habitat fragmentation for this species with all remaining habitat retained to the west of the proposed bypass. Fauna-exclusion fencing to be constructed along the proposed bypass would also minimise road kills for this species and deter domestic dogs and cats from residential areas to the east from accessing potoroo habitat. Although the proposed bypass may not in itself be a major threat to the Long-nosed Potoroo population, it may result in a regional impact on this species in combination with impacts associated with the approved developments in the vicinity (Section 8.2). Compensatory measures aimed at improving Long-nosed Potoroo habitat would be implemented in NSW Crown land (see Figure 7.1). These include the implementation of a fox control program and fire-management plan.

7.2.3 Known Wallum Froglet and Wallum Sedge Frog Habitat (ES4)

As the Wallum Froglet is distributed over most of the site, mitigation measures are not site-specific. Although the footprint would be fenced, it is critical to prevent or minimise any indirect impacts in adjacent habitat. Mitigation measures aimed at maintaining hydrological flows and water quality are of particular importance to frogs and other aquatic species (Section 7.1.5 and Chapter 8 of the EIS). In addition, the following mitigation measures are aimed at minimising impacts for Wallum Froglets and Wallum Sedge Frogs:

- pre-construction surveys and possible translocation of individuals as discussed in Section 7.1.3;
- pH monitoring and correction (if required) would be undertaken during tunnel excavation and groundwater extraction and infiltration to maintain suitable habitat conditions for the Wallum Froglet and Wallum Sedge Frog;

- frog-exclusion fencing would be erected and maintained along both sides of the proposal from about chainage 3,200 south to the tunnel ramps;
- existing hydrological flow regimes and water quality would be maintained post-construction;
- consideration would be given to the possible construction of several mitigation ponds for Wallum Sedge Frogs; and
- access tracks associated with the proposal would avoid known breeding ponds for the Wallum Sedge Frog.

7.2.4 Common Planigale Population (ES5)

The following mitigation measures would be implemented in order to minimise habitat loss, fragmentation, disturbance and edge effects for the Common Planigale:

- pre-construction surveys and possible translocation of individual Common Planigales as discussed in Section 7.1.3;
- every practical precaution would be taken to prevent or minimise direct and indirect impacts on known Common Planigale habitat adjacent to the footprint; and
- any access tracks associated with the proposal would avoid known habitat for the Common Planigale.

7.2.5 State Environmental Planning Policy Number 14 Wetland Number 5a (ES8)

The *State Environmental Planning Policy Number 14* designation of wetland significance only applies in NSW. Any *State Environmental Planning Policy Number 14* wetland loss associated with the proposed bypass would require compensation at a ratio of 10:1 unless it can be shown that habitat to be removed is highly degraded or incorrectly mapped. As the tunnel overpass would be constructed and revegetated in this area, it would be appropriate to rehabilitate an area of degraded Swamp Oak Woodland as compensatory habitat.

Hydrological mitigation measures outlined in Section 7.1.5 and Chapter 8 of the EIS would be implemented to minimise impacts in the wetland and adjoining Cobaki Broadwater.

7.2.6 Area of High Amphibian and Bat Biodiversity (ES10)

Mitigation measures proposed for this area are aimed at minimising habitat loss and fragmentation of a wildlife corridor and an area of core habitat and maintaining existing hydrological flows:

- every practical precaution would be taken to minimise indirect impacts on threatened flora species, Brahminy Kite nesting trees, *Banksia integrifolia* trees and old growth paperbarks;
- if clearing is to be undertaken between August and October, then pre-clearing surveys would be undertaken to detect breeding Brahminy Kites within 100 metres of the footprint;

- a protocol for activities conducted near Brahminy Kite nest sites would be developed in consultation with the relevant regulatory authorities and form part of the Construction Environmental Management Plan;
- extraction and infiltration wells would be established to pump water out of the tunnelled section and back into the water table to minimise draw-down of the water table during construction;
- a cross-connecting pipe would be constructed under the roof of the tunnel to maintain groundwater levels and flows post-construction;
- existing run-off that occurs as sheet flow across the proposed tunnel locations would be redistributed as sheet flow on the western side of the ramps; and
- the proposed tracks to be located on each side of the tunnel to provide access to the well heads (groundwater) would be allowed to revegetate post-construction.

7.2.7 Summary of Mitigation Measures

The following mitigation measures have been compiled from the technical paper. They are classified as general and species-specific and listed separately under pre-construction and construction and operation phases of the project.

7.2.8 Pre-construction Mitigation Measures

General

General mitigation measures aimed at minimising the impacts of the proposed bypass pre-construction include:

- "no-go" areas near the proposed bypass would be identified and mapped in consultation with appropriate regulatory authorities prior to commencement of construction activities;
- the boundary of the footprint would be permanently fenced and the area cleared in such a way that the boundary would not be extended during clearing works;
- seeds and other propagative material to be used for rehabilitation and/or revegetation would be collected from native species present within 5 kilometres of the site and collected from the footprint prior to clearing;
- pre-clearing surveys targeting plant species of conservation significance would be undertaken by a qualified botanist to mark all plants requiring translocation;
- seed from all threatened plants required to be removed will be collected immediately following approval for the project being obtained to enable potential propagation and re-establishment of threatened species in the area;
- marking of all threatened flora species, parawebbing and/or fencing of plants of significance or the footprint near populations will be undertaken prior to construction to ensure that vehicles and other direct disturbances associated with road construction do not encroach into adjacent habitat containing significant species;
- a protocol for the removal and possible translocation of plants of conservation significance would be developed in consultation with the appropriate regulatory authority immediately following approval for the project being obtained;

- the viability of removal and translocation of fauna species of conservation significance would be assessed in consultation with relevant government agencies and landholders;
- during pre-clearing surveys, bark would be removed from old growth paperbarks after bats have left roost sites (i.e. under the bark) to begin foraging at dusk to prevent individuals from being injured or killed during clearing;
- a fauna rescue framework for clearing has been developed by the NSW Roads and Traffic Authority in consultation with NSW Department of Environment and Conservation and would be used as basis for developing a protocol for the removal of injured animals during this project; and
- a hygiene protocol for contractors to minimise the spread of the amphibian chytrid fungus will be developed in consultation with NSW Department of Environment and Conservation and other relevant authorities.

Species-specific

Mitigation measures aimed at minimising impacts on particular species pre-construction include:

- the Little Wattle and Match Sticks would be considered for incorporation into revegetation plans (outside of the road verges) in Queensland;
- the Chinese Burr would be considered for incorporation into revegetation plans in New South Wales, including revegetation of the tunnelled section of the proposal;
- trials of frog-exclusion fencing would be established (see Section 31.5 for more details) and the results used to determine the final design of the fencing to be used;
- pre-clearing, the frog-exclusion fencing would be erected to delineate the footprint and to prevent subsequent dispersal of individual Wallum Sedge Frogs, Wallum Froglets and Common Planigales into the footprint area;
- if translocation is undertaken then during pre-clearing surveys, Wallum Sedge Frogs and Wallum Froglets would be trapped using pit falling, dip-netting and active daytime and night-time searches with individuals marked and translocated outside of the footprint;
- if practical, pre-construction surveys for Wallum Sedge Frogs and Wallum Froglets would start after rainy periods in warmer weather during September and would continue until repeated searches yield few or no new individuals;
- testing of sites for the chytrid fungus would be undertaken both within the footprint and at possible translocation sites;
- the pond in Hidden Valley used by breeding Bush Hens would be clearly identified and protected from disturbance and/or hydrological effects during construction;
- a protocol for activities conducted near Brahminy Kite nest sites, Bush Hen breeding sites and Eastern Grass Owl breeding habitat would be developed in consultation with the relevant regulatory authorities and form part of the Construction Environmental Management Plan. This would include:
  - pre-clearing surveys to detect breeding of significant fauna species would be undertaken within 100 metres of the clearing operations for:

    Bush Hens between October and April;

    Brahminy Kites between August and October; and

Eastern Grass Owl between March and June.

- investigating the removal and possible re-location of the Brahminy Kite nest site near the bypass prior to the breeding season; and
- minimise construction activities near recorded breeding sites for the Bush Hen and Eastern Grass Owl.

- a fox control program on NSW Crown lands to the west of the Tugun Bypass would be implemented as soon as practical after approval for the project has been obtained to assist the Long-nosed Potoroo population;
- a fire management plan for the Crown land taking into account the habitat requirements of the potoroo by prescribing a mosaic of 'patch' burning and the prevention of catastrophic wildfires would be prepared and implemented as soon as practical after approval for the project has been obtained; and
- weed management and rehabilitation of the Saltmarsh on the Pony Club land would be undertaken.

7.2.9 Construction and Operation Mitigation Measures

General Terrestrial

Mitigation measures would generally be implemented during construction but would be maintained over the operational phase of the bypass. General terrestrial mitigation measures aimed at minimising the impacts of construction include:

- a two-stage clearing process will be implemented that involves removing non-hollow-bearing vegetation first to encourage hollow-dependant fauna to leave the area;
- portions of trees containing suitable roosting/nesting hollows would be removed from felled trees and reattached to suitable standing trees located nearby allowing for size and safety restrictions;
- if tree hollows are destroyed during felling then nest boxes will be placed in adjacent habitat (with approval from relevant land owners) according to the following protocol:
  - small hollows will be replaced with nest boxes designed for bats (see Hoye 1994), incorporating an overhanging roof and internal baffles and having both external and internal walls lined with flyscreen to improve grip;
  - medium-sized hollows will be replaced with those designed for Squirrel Gliders and Brush-tailed Phascogales (Land for Wildlife 1991);
  - a single large hollow would be removed and replaced with nest boxes designed for owls
  - nails used to attach nest boxes will not be galvanised or coated and will not contain zinc to avoid poisoning tree;
  - metal strapping that allows for tree expansion will be used to attach nest boxes
  - boxes will be placed between four and 8 metres above the ground and oriented to minimise penetration by rainfall and sunlight; and
  - boxes will be placed away from main access tracks to minimise the chances of them falling and injuring anyone.
- fauna-exclusion fencing would be erected along vegetated portions of the bypass;

- revegetation works would undertaken progressively during the construction phase of the project to minimise the time-lag between clearing and rehabilitation;
- any areas disturbed as a result of road construction outside the footprint and 2-3 metres distant from the fauna-exclusion fencing as a result of road construction would be revegetated;
- roadside verges within the footprint (excluding 2-3 metres from the fauna-exclusion fence) would be landscaped;
- disturbed areas around bridge pylons at Hidden Valley would be revegetated;
- revegetation of Common Planigale habitat along the road edges to the north of the existing known habitat leading to the wet/dry culvert would be undertaken as soon as possible;
- soil erosion and sedimentation control measures would be progressively constructed to minimise the area of unstable or unprotected soil surface;
- sedimentation ponds and mitigation ponds would be selectively seeded and allowed to revegetate naturally with endemic plants to create habitat for wetland species;
- post-construction the eastern side of the ridge behind the John Flynn Hospital and Medical Centre would be revegetated to its natural state;
- seed collected from near the site will be used to revegetate roadside verges and other disturbed areas within the footprint especially adjacent to underpasses as soon as possible during construction;
- revegetation over the top of the tunnel overpass would be undertaken as soon as possible with low-growing species so as not to interfere with airport operations
- disturbed areas located between remnant vegetation and frog mitigation culvert openings would be revegetated with appropriate vegetation;
- where major excavations such as that associated with tunnel construction are to be left open for extended periods, then temporary impermeable fencing would be used to prevent fauna from entering the site and ramps provided to enable fauna access out of excavations in the event they do enter the area; and
- every practical precaution would be taken to prevent any contaminated leachate from entering the ecosystem during landfill excavation (see Technical Paper 5).

General Aquatic

General aquatic mitigation measures aimed at minimising the impacts of the proposed bypass during construction include:

- if practical, construction activities in the vicinity of waterways would be scheduled to avoid periods of heavy rainfall;
- where the groundwater is to be lowered for periods exceeding one month, vegetation in the vicinity would be monitored and the surface rewatered at intervals as required;
- appropriate drainage structures, sediment traps and other mitigation structures would be constructed and maintained to minimise the likelihood of run-off from the road surface entering the environment without filtering of contaminated substances such as oil and heavy metals;

- stormwater treatment devices would be designed to maintain existing flow paths and regimes;
- 'best practice' surface water quality management would be implemented during construction and operation to trap a high proportion of suspended sediments, adsorbed metals, nutrients and hydrocarbons;
- spill scenarios would be taken into consideration during design of water treatment facilities (see Technical Paper 2);
- all practical measures would be taken to prevent pH from changing significantly as a result of exposure of acid sulphate soils from tunnel construction and the mitigation of these soils (i.e. natural acidic conditions would be maintained);
- site management during construction would provide for the appropriate management of potential acid sulphate soils that are oxidised;
- existing channels would be maintained as close as possible to their existing locations to avoid concentrating flows (see Section 7.1.7);
- balancing channels (for example flat grades, shallow drains) would be constructed to maintain existing sheet flow/ponding areas;
- salt intrusion would be minimised at the southern end of bypass;
- road run-off would be kept separate to undisturbed run-off, prior to treatment and discharge;
- extraction and infiltration wells would be established to pump water out of the tunnelled section and back into the water table to minimise draw-down of the water table during construction;
- a cross-connecting pipe would be constructed under the roof of the tunnel to maintain groundwater levels and flows post-construction;
- existing run-off that occurs as sheet flow (running east to west) across the proposed entry/exit ramps to the tunnel locations would be redistributed as sheet flow on the western side of the ramps
- the proposed tracks to be located on each side of the tunnel to provide access to the well heads (groundwater) would be allowed to revegetate post-construction; and
- open waterways would be reinstated as soon as possible to allow revegetation of macrophytes to occur.

Species-specific

Mitigation measures aimed at minimising impacts on particular species during construction include:

- indirect impacts to known Common Planigale habitat directly adjacent to the footprint would be minimised;
- fencing/parawebbing would be erected to protect *Gahnia* and *Melaleuca* swamps from disturbance or accidental damage during construction would be implemented;
- physico-chemical monitoring (including pH) and correction (if required) would be undertaken during tunnel excavation and groundwater extraction and infiltration to

maintain suitable acidic habitat conditions for the Wallum Froglet and Wallum Sedge Frog;

- two frog underpass would be constructed between the tunnel ramps and Boyd Street about chainage 3,200 to facilitate movement under the bypass;
- any access tracks associated with the proposed bypass would avoid known breeding ponds for the Wallum Sedge Frog and known habitat of the Common Planigale;
- frog-exclusion fencing would be erected and maintained along both sides of the proposed bypass south from about chainage 3,200 to the tunnel ramps;
- fauna-exclusion fencing would be erected along the western side of the bypass in Long-nosed Potoroo habitat to prevent road mortality; and
- every practical precaution would be taken to minimise indirect impacts on the threatened flora species, Brahminy Kite nesting trees, *Banksia integrifolia* trees and old growth paperbarks.

7.3 Summary of Mitigation Measures for Sites of Significance

Table 7.2 summarises the mitigation measures associated with the proposal on sites of conservation significance.

Table 7.2: Summary of Mitigation Measures to be Implemented at Significant Sites Potentially Affected by the Proposed Bypass

Location	Translocation of Flora/Fauna	Loss of Habitat	Fragmentation and Barrier Effects	Edge Effects and Disturbance	Water flow and quality[1]
ES2	✗	✓	✓	✗	✓
ES3	✗	✓	N/A	✓	✓
ES4	✓2	✓	✓1	✗	✓
ES5	✓2	✓	✓	✗	✓
ES6	✗	N/A	N/A	✗	✓
ES7	✗	N/A	N/A	✗	✓
ES8	✗	✓	N/A	N/A	✓
ES9	✓	✓	✓	✗	✓

Notes * Assumes that appropriate and effective mitigation measures are implemented.
1: Underpasses are experimental.
2: Translocate fauna species only if suitable habitat available in vicinity.
ES = Ecologically significant sites.
NA = Not applicable.
✓ = Mitigation measure implemented.
✗ = No mitigation measures implemented.

8. Cumulative Impacts

When considered individually, many development activities may have relatively minor impacts on the environment. However when considered collectively the impacts to the environment can be devastating. The consequences arising from the additive effects of incremental development can be termed 'cumulative impacts'.

The potential cumulative impacts considered in this assessment arise from the interaction of the construction and operation of the proposed Tugun Bypass with other significant proposals and activities planned for the Tugun area and the Gold Coast-Tweed region.

Cumulative impact assessment was undertaken for the proposal within the context of five other developments proposed for or already approved in the local area (Figure 8.1). The Cobaki Lakes development and Pacific Beach Estate have been approved. The Robina to Tugun Rail Link, Gold Coast Airport Runway Extension and the Final Master Plan for Gold Coast Airport (Gold Coast Airport Limited 2001) have been proposed and are subject to future approvals processes. In the longer term, Tweed Shire Council is considering the area around land leased by the Tweed Heads Pony and Hack Club at the southern end of the proposal for industrial uses.

8.1 Robina to Tugun Rail Link

The Queensland government is committed to achieving better transport outcomes in the region through the implementation of the *Integrated Regional Transport Plan for South East Queensland* and its companion document *Transport 2007*. In the longer-term the Integrated Regional Transport Plan identified the extension of rail from Robina to Coolangatta. In the short-term *Transport 2007* identified the investigation of the rail extension to meet the travel demands of the southern Gold Coast region.

The rail extension from Robina to Coolangatta has three stages, the northern stage which runs from Robina to Stewart Road and covers the majority of the route, a short stage from Stewart Road to a proposed station at Tugun and the southern stage which runs from the proposed Tugun Station to the airport terminal area of Gold Coast Airport.

Queensland Transport has completed Part A of the Robina to Tugun draft impact assessment study. This covered the proposed northern stage of the rail link from Robina to Stewart Road and was released for public comment in March 2003. Part B, which will cover the rail extension from Stewart Road to the proposed Tugun Station, will be released during 2005. Approval for the final extension through to the Gold Coast Airport will sought at a later date.

The extension of the Gold Coast rail line would accommodate Queensland gauge urban passenger trains and would consist of a single track with provision for twin track in the future.

The rail corridor would be 20-30 metre-wide depending on the earthworks required. The corridor would pass under Stewart Road following an alignment to the west of the bypass. It would continue in tunnel under Hidden Valley and emerge on the eastern side of the road alignment near the John Flynn Hospital and Medical Centre. The proposed rail station is located immediately north of Boyd Street. South of the station the rail alignment is immediately east of the bypass alignment until the approach to the

road tunnel. Here the rail alignment also enters a tunnel and curves around under the runway and arrives at the terminal of Gold Coast Airport.

Habitat loss associated with the rail extension would be about an additional 15.7 hectares. It would transect a number of vegetation communities as shown in Table 8.1.

Table 8.1: Additional Loss of Vegetation Due to the proposed Rail Link

Vegetation Community	Cumulative Area Removed (Hectares)
Dry Blackbutt Forest	0.13
Ironbark/Mahogany Forest	0.25
Scribbly Gum Forest	0.02
Swamp Mahogany Forest	1.7
Swamp Mahogany - Brushbox Forest	0.07
Swamp Mahogany - Paperbark Forest	0.01
Paperbark Forest	0.9
Swamp Oak Forest	0.5
Scribbly Gum Mallee Heathland	0.6
Tree Broom Heathland	0.7
Wet Heathland	0.3
Slashed Heathland	1.7
Weedy Grassland	2.8
Cleared Land	6.0
TOTAL	**15.68**

Individuals from three regionally significant plant species, Blunt-leaved Wattle, Lemon-scented Baeckea and *Strangea linearis*, would be removed as a result of the proposed rail line construction. The proposed rail corridor, when constructed, would further fragment the vegetation to the south of the airport, as it diverges from the road corridor and increase edge effects in the locality.

With construction of the proposed rail line, additional structures will be required to align with the wet/dry culverts and the frog underpasses of the bypass. Until monitoring of the effectiveness of the wet/dry culverts is complete it is uncertain what effect this will have. However, the rail corridor will be some distance to the east of the road and there will be open space between the two footprints. However, it would further fragment and divide populations of significant species.

The additional width associated with the rail footprint would remove more habitat of the Wallum Sedge Frog and Wallum Froglet at ES4 and Common Planigale habitat at ES5. As the implementation of mitigation measures for the Common Planigale is not possible due to surrounding constraints (i.e. tunnel and ramps) the risk to the population becoming extinct is likely to increase with the removal of a higher proportion of critical habitat. Similarly, the further disturbance to the Wallum Sedge Frog population may also contribute to the decline and possible extinction of this species in the study area.

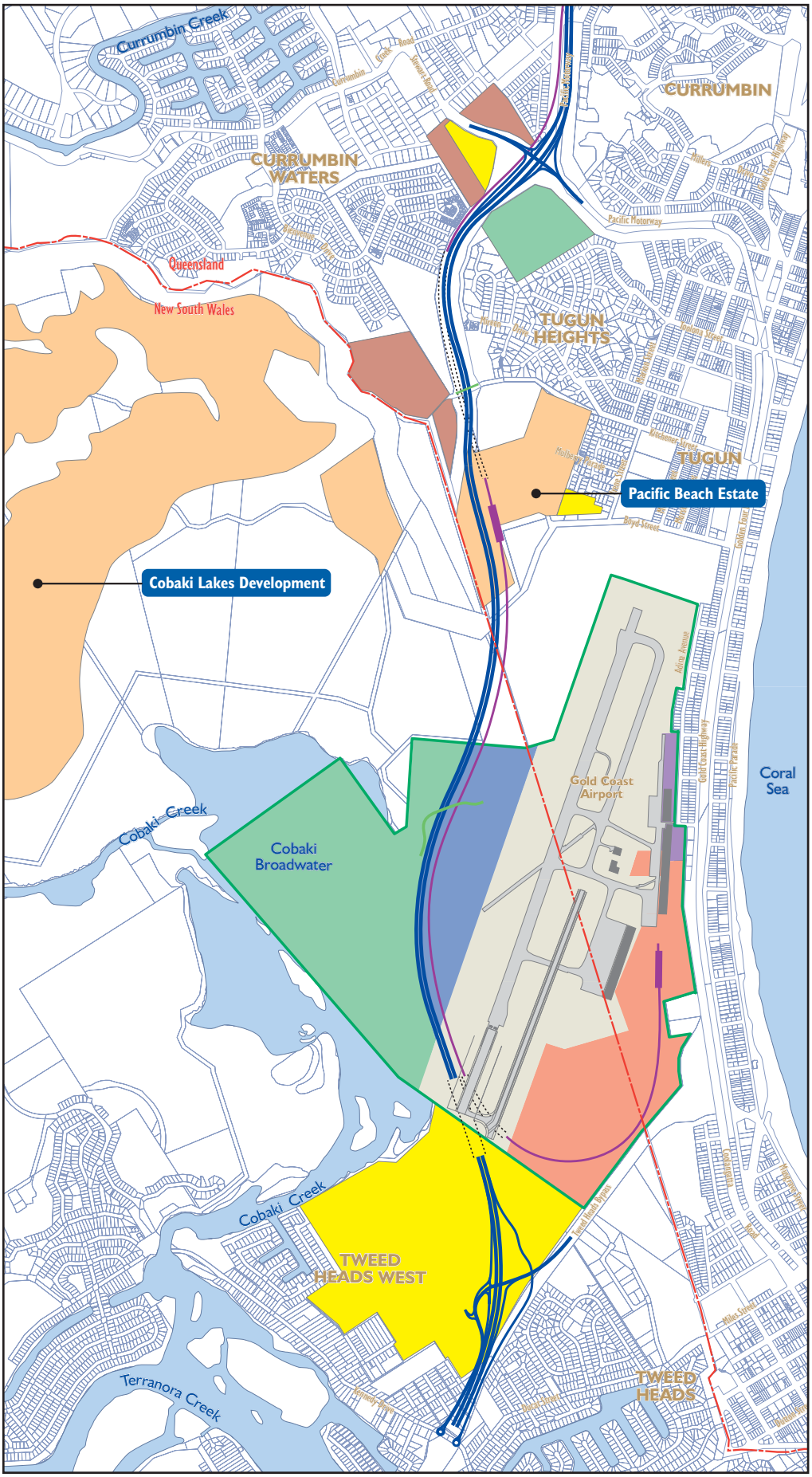


Figure 8.1 **Location of Cobaki Lakes and Other Potential Developments**

8.2 Cobaki Lakes Development

Cobaki Lakes is a very large approved development located entirely in NSW adjacent to the Queensland border. The master plan prepared in 1999 proposed a gross developable area of 284.5 hectares with 1,162 residential lots, 531 'greenstreet' lots, and 202 duplex lots providing a total of 2,260 units with a capacity to accommodate 14,000 residents.

The development would be serviced by two possible routes, Piggabeen Road in NSW and the Cobaki Parkway (western extension of Boyd Street) in Queensland. No provision has been made for a transport node within the development.

No provision for an overpass at Boyd Street has been included as part of this proposal. If it is decided that access to the development is required from Boyd Street separate approvals would need to be obtained by the developers.

The development is surrounded to the south, east and north by vegetated NSW Crown land zoned Environmental Protection. It lies in the centre of a major regional fauna corridor extending from Cobaki Broadwater through to the NSW Crown Land Border Reserve and to the Mount Cougal-Boyds Butte area. The project will result in the loss of more than 150 hectares of cleared and vegetated land and create a major barrier to fauna movement through loss and fragmentation of habitat. Species of significance likely to be affected by this development are the Long-nosed Potoroo, Squirrel Glider, Masked Owl, Glossy Black-Cockatoo, other threatened birds species and potentially the Swordgrass Brown Butterfly.

The proposed Tugun Bypass generally passes to the east of NSW Crown land through disturbed land. The provision of fauna-exclusion fencing in this area would act as a barrier to east-west movement although there is little native vegetation to the east. Fencing and the lack of underpasses in this area would deter domestic dogs from the proposed Pacific Beach Estate and surrounding residential areas accessing Long-nosed Potoroo habitat.

The species most at risk of cumulative impacts in this area is the Long-nosed Potoroo. Even though the recent supplementary study has shown that the actual population size may comprise of at least 55–65 individuals, but may go as high as 85 individuals, this should still be considered as a small population subject to extinction by stochastic events. Of particular concern is the 18 hectares area of habitat located north of the Cobaki Lakes development access track where 15 out of 27 individuals were captured during recent studies. Results from this study have shown that the access track has split the population into two with no evidence of individuals crossing the track. Furthermore, failure to mitigate drainage impacts associated with the access track has caused seasonal flooding to the north resulting in a loss of some potoroo habitat. Continued development in this area would further isolate this habitat, making the sub-population more susceptible to extinction through habitat loss and disturbance, predation and fire.

This species is currently under threat from habitat loss and fragmentation and predation by introduced species. Predation would be expected to increase with completion of the Cobaki Lakes development. The incidence of dogs and cats in adjacent NSW Crown land would also increase as the area becomes populated. As a Critical Weight Range species, Long-nosed Potoroos are particularly susceptible to predation by these introduced species. The provision of fauna-exclusion fencing along the proposed

bypass would deter domestic dogs and cats from residential areas to the east from accessing Long-nosed Potoroo habitat.

While the proposed bypass is unlikely to have a significant impact on this population, the addition of fragmentation and edge-effects associated with the Cobaki Lakes development may result in the extinction of this regionally significant population. It is therefore critical that compensatory measures are implemented in order to improve habitat quality and reduce threats to this species. These measures are shown in Figure 7.1 and would include:

- implementation of a fox control program on NSW Crown lands.
- erection of fencing around part of the Cobaki Lakes development area once construction on this site commences in order to reduce predation by cats and dogs on adjacent NSW Crown land; and
- preparation and implementation of a fire management plan for the NSW Crown land taking into account the habitat requirements of the potoroo by prescribing a mosaic of 'patch' burning and the prevention of catastrophic wildfires.

Some of these measures would require negotiation with the developer of the Cobaki Lakes development. However, without compensatory measures there is a risk that the Long-nosed Potoroo population would be affected by cumulative impacts such that it is placed at risk of extinction.

Consent is required by the developers to construct the Boyd Street overpass. Detailed examination of the Long-nosed Potoroo population, as part of the Tugun Bypass, has recommended that if the overpass is approved then mitigation should be required for the Long-nosed Potoroo. It is suggested that this include the provision of underpasses and predator control fencing.

8.3 Pacific Beach Estate

Pacific Beach Estate is located to the north of the Queensland-NSW border adjacent to the John Flynn Hospital and Medical Centre. Initial stages have been completed. Future stages are subject to the outcome of the approval process for the Tugun Bypass.

The development would mainly consist of medium density residential development located around the proposed Tugun rail station immediately north of Boyd Street. A commercial component is also included, located in the north-east corner of the site which may contain a service station, tavern and motel. Community services including a nursing home and child-care centre have also been proposed.

The proposed Tugun Bypass would result in the removal of two individuals of Little Wattle from the Queensland population. This species is considered to be 'vulnerable' in Queensland and the individuals that would be removed may represent the southernmost population of this species in that state. It is also likely that the proposed bypass would result in the removal of some individuals of Match Sticks in Queensland. The exact location and numbers of the Queensland population is not known due to continued slashing activities in the area, making individuals difficult or impossible to locate. Although not listed in Queensland, NSW or Commonwealth legislation, this species is considered to be of state significance in Queensland as, prior to this study, it was thought to be extinct here.

Potential habitat in the vicinity for both these species may be found on the proposed Pacific Beach Estate. As these species are already growing in disturbed communities, the proposed bypass is unlikely to have secondary impacts on the retained population. Cumulative impacts from the Pacific Beach Estate may however place both populations at risk of extinction unless these species can be incorporated into rehabilitation plans for either the Pacific Beach Estate or the proposed bypass. As such, the cumulative impacts from the proposed bypass have been assessed to be regional for the Little Wattle and state for Match Sticks.

8.4 Gold Coast Airport Runway Extension

Approval is currently being sought for an extension to the main runway at Gold Coast Airport. This runway is called the 14/32 runway. The extension will require an additional 458 metres of pavement to be constructed at the southern end of the airport. The runway extension is 45 metres wide with 7.5 metre-wide sealed shoulders on each side, located within a 300 metre-wide graded runway strip.

The runway extension will require the construction of a new taxiway to connect the runway to the terminal areas. The taxiway extension is 23 metres wide with 10.5 metre-wide sealed shoulders on each side, located within a 47.5 metre-wide taxiway strip. The route of the perimeter access road will be altered to ensure that safe access is maintained around the airport site for operational and emergency situations.

The runway extension if approved would result in the removal of the majority of Phragmites Rushland vegetation from the study area. This area prior to recent slashing was identified as Eastern Grass Owl habitat and was considered likely to be used for roosting. The recent slashing has decreased the habitat values of this community for the Grass Owl, while the runway extension would permanently modify this species habitat. An additional area of Saltmarsh community would also be modified by this proposed development.

Known and potential habitat for the Wallum Froglet and Wallum Sedge Frog would also be modified by the proposed runway extension. A report detailing the impact of the proposal on these species has been undertaken by Biodiversity Assessment and Management Pty Ltd (Ingram 2004). This report determined that the proposal would not have a significant impact upon either of these species due to the species occupying man-made habitat and supplementary habitat being provided by the proposal. However, the success of providing artificial habitat for these species in the short-term is unknown and the loss of additional habitat for the Wallum Sedge Frog in addition to that impacted by the proposed Tugun Bypass would place extra pressure on this threatened species population.

The runway extension would also impact upon a number of birds in the area, potentially including estuarine bird roosts in the Cobaki Broadwater. This impact was assessed by Lewis Ecological Service (2003) and determined that the extension could potentially have a significant impact upon one wader roost site. The Tugun Bypass would not increase pressure on this roost site in the long-term above that of the runway extension, as the bypass is in the underground tunnel near this roost site.

8.5 Final Master Plan for Gold Coast Airport

The approved master plan for the airport (Gold Coast Airport Limited 2001) includes a land use plan, which divides the site into a number of precincts. The proposed bypass

would directly affect land in two of these and, indirectly affect one other, by creating a potential barrier to access. The proposed rail corridor would result in direct effects on the same two precincts, plus the precinct including the terminal facilities, which would also include the proposed transport interchange.

A corridor to accommodate both the road and rail components of the Tugun Bypass proposal is included on the land use plan.

The master plan sets out the overall planning intention for the area, land use strategies and related objectives and development control principles associated with the various precincts. The overall intention is to continue to satisfy the primary air transport needs of the locality.

As no airport development proposal has yet to be described in detail and none has any development status, the significance of the nominated proposals remain conjectural. In addition, any airport development proposal is required to be subjected in due course to formal environmental assessment, and because effective mitigation measures may become involved, the following related statements must be considered only to serve present purposes and be subject to change. However, if development proceeds in some or all of the areas, much of the vegetation currently occurring in the Airport Lands to the east of the proposed bypass may be removed or highly modified. This would impact upon a number of threatened species including the Common Planigale, Wallum Sedge Frog, Wallum Froglet, Eastern Long-eared Bat and Little Wattle and may lead to extinction of local populations.

Edge effects and increased noise may also impact outside of Airport land decreasing the quality of adjacent habitat areas. This would occur in particular to remnant vegetation retained between the Airport boundary and the Tweed Interchange. This would impact upon the Eastern Long-eared Bat, Brahminy Kite and a number of plants in the locality

8.6 Long-term Industrial Uses

In the longer-term, Tweed Shire Council is considering that land around the Tweed Heads Pony and Hack Club at the southern end of the proposed bypass be zoned for industrial uses (Spiller Gibbens Swan Pty Ltd 2001). This area is currently zoned for open space and special use. Council is continuing its assessment of the feasibility of commercial/industrial development in this area. In addition to development at the airport, other areas with potential for commercial or industrial uses include 16 hectares of vacant land known as the Tringa Street Industrial Estate in Tweed Heads West and an industrial subdivision on a site adjacent to the Tweed Heads West Sewage Treatment Plant. Development of these areas would result in habitat loss in an area of regional conservation significance at the southern end of the proposed Tugun Bypass. It would also form a barrier along two recognised sub-regional corridors and reduce connectivity to vegetated areas around the Cobaki Broadwater. Ecological impacts would need to be addressed when appropriate approvals are sought to rezone this land.

9. Construction and Operation Management and Monitoring

There is the potential for the proposed Tugun Bypass to have regional/state impacts on habitats and populations of a number of species of conservation significance (namely the Little Wattle, Match Sticks, Wallum Sedge Frog, Wallum Froglet, Common Planigale and Long-nosed Potoroo). Long-term management would be aimed at conserving the majority of these populations within the study area. Compensatory measures aimed at improving the viability of the Long-nosed Potoroo population have been proposed and are discussed in Section 8.2.

Unless otherwise specified, monitoring would be undertaken over a five-year period, including three years during pre-construction/construction and two years during operation. Baseline data would be collected between project approval and the start of construction. Monitoring guidelines are described below and detailed monitoring programs would form part of the Construction Environmental Management Plan. As part of this plan a Flora and Fauna Management Plan would be prepared for construction and operation which would further detail all of the issues discussed below. Monitoring and management measures would be refined at this stage in consultation with regulatory authorities. A practical and integrated approach to the management and monitoring would be sought.

This section outlines long-term management and short- and medium-term monitoring that would be required in order to minimise local and regional impacts on terrestrial and aquatic ecosystems.

While the recommendations of the expert subconsultants have been considered when compiling long-term management and monitoring measures, these have been modified according to issues of practicality, timing and land ownership. They have also been brought into line with standard NSW Roads and Traffic Authority monitoring measures.

9.1 Operational Management

It should be stressed that the Main Roads and NSW Roads and Traffic Authority are not a land management agency and therefore are not responsible for implementing long-term management strategies. However, Main Roads would be responsible for initiating management and monitoring programs in Queensland and NSW. This would include Commonwealth land on either side of the border within the proposal footprint.

Hero *et al*. (2001b) recommend that management and recovery programs be established in order to monitor the effects of further development in the area and to ensure the continued long-term survival of the Wallum Froglet, Wallum Sedge Frog and Long-nosed Potoroo. They suggest that state and national conservation agencies, Gold Coast Airport Limited and other relevant landholders and experts from the scientific community be involved in these programs.

A preferred compensatory habitat package has been described. It provides an opportunity to acquire and manage land with the aim of conserving local and regional biodiversity in the long-term. The land package would form a strategically located link that provides an opportunity for the establishment of a continuous area of habitat having environmental protection around the Cobaki Broadwater. The loss of *State*

Environmental Planning Policy Number 14 wetlands and other significant wetlands habitats would also be compensated.

9.1.1 Broad Management Aims

General and specific mitigation measures and long-term management and monitoring strategies would be in accordance with the following broad management aims, which would form the basis of the detailed Construction and Operation Environmental Management Plan.

- maintain and protect existing biodiversity;
- maintain and protect species and populations of conservation significance;
- maintain existing water quality and hydrological flow regimes;
- minimise habitat loss, pollution and degradation;
- enable gene flow to be maintained across the proposed bypass and throughout the study site;
- minimise mortality and injuries to individual animals and damage to individual plant species;
- maintain and protect regionally/state significant populations of Little Wattle, Match Sticks, Swamp Orchid, Wallum Froglet, Wallum Sedge Frog, Common Planigale and Long-nosed Potoroo; and
- enable maintenance of habitat connectivity through revegetation and rehabilitation programs.

9.2 Fox Control

Fox control has been recommended as a compensatory measure to improve habitat quality for Long-nosed Potoroos in NSW Crown land in the vicinity of the Cobaki Lakes development. Any fox control measures would be implemented in consultation with NSW Department of Environment and Conservation and other relevant bodies. Baiting would need to be targeted and undertaken according to advice provided by the NSW Rural Lands Protection Board.

9.3 Monitoring Terrestrial Flora

Monitoring programs for terrestrial ecosystems would be developed in consultation with the NSW Department of Environment and Conservation, the Queensland Environmental Protection Agency and the Commonwealth Department of Environment and Heritage.

9.3.1 Habitat Rehabilitation and Revegetation

Habitat rehabilitation and revegetation would be undertaken along roadsides, partly over the tunnel, near culvert entrances and exits, around bridge pylons and around mitigation and sedimentation ponds. While at most of these sites such rehabilitation and revegetation would involve limited planting augmented by natural revegetation, extensive areas revegetated over the tunnel and near the wet/dry culvert would require monitoring. This will be undertaken to ensure the plantings are successful and/or to undertake follow-up plantings if required. A monitoring protocol would be undertaken according to the following broad guidelines:

- vegetation checked to estimate rate of growth, species composition, levels of weed infestation, general vigour and health, and to identify any areas that have not re-established:
- monitoring should be undertaken twice a year during the first two years after revegetation including at least once during spring;
- annual monitoring should then be undertaken during spring/summer for an additional three years or until vegetation is established;
- if weeds are becoming prolific then hand-weeding or spraying may need to be undertaken to minimise their spread (although care needs to be taken to ensure no spray drift occurs) ; and
- areas where native revegetation has not re-established would require follow-up plantings or seeding to be undertaken.

9.3.2 Translocated Species

Translocation and seed collection/propagation has been recommended for Chinese Burr, Match Sticks and Little Wattle. Transplanted individuals would be monitored four times over the first year and at least biannually during the following four years. Monitoring should include fruiting/flowering periods and may involve collection of the following data:

- substrate condition;
- growth rate;
- general health; and
- reproductive condition.

Enough seed should also be collected prior to translocation, so that additional individuals can be propagated and transplanted into the area to maintain the population and genetic diversity.

9.4 Monitoring Terrestrial Fauna

Monitoring guidelines for the Wallum Sedge Frog, Wallum Froglet and Common Planigale are described below. It should be noted that without a stringent scientific approach with appropriate analytical methods the outcome of the monitoring may well be masked by a series of other threat processes operating in the area.

9.4.1 Frog Species of Conservation Significance

In general, the Wallum Froglet is likely to be a useful indicator species for assessing changes in habitat suitability during and after construction, as it is widespread in the area and is readily detected by acoustic surveys (although this is male-biased). However, frog monitoring should be designed to ensure adequate sampling of both the Wallum Froglet and Wallum Sedge Frog. The monitoring should be designed to both monitor populations of these frog species near the road footprint and also enable the detection and monitoring of individual frogs captured from within the footprint and translocated into nearby habitats. The exact methodology of monitoring would be worked out during the detailed flora and fauna management plan but should follow the general guidelines outlined below:

- If translocation is undertaken then all frogs captured within the footprint prior to construction would be permanently marked with toe clipping (this is the only

method available to effectively monitor these small frog species) prior to release into nearby habitats (an animal ethics license would need to be obtained)

- survey methods used would incorporate a variety of methods including:
  - counts by acoustic survey would be undertaken while walking along 50 metre transects along and within the general vicinity of the footprint;
  - active searches should also be conducted in appropriate habitat areas near the footprint to catch individual frogs; and
  - pit falling using 20 L buckets should also be used and checked regularly throughout the night to minimise individual frogs escaping (especially the Wallum Sedge Frog which is an agile climber).
- during construction, surveys would be undertaken monthly during the first year and then bimonthly through the next year and then seasonally during the remaining construction period; and
- during the first two years of operation, surveys would be conducted on a seasonal basis (four times per year) and be undertaken at least once following heavy rains between April and August for the Wallum Froglet and once following heavy rains between September and April for the Wallum Sedge Frog.

9.4.2 Common Planigale Population

A monitoring program aimed at estimating potential impacts would be undertaken in known Common Planigale habitat adjacent to the proposed bypass in accordance with the following broad guidelines that would be refined during the Construction Environmental Management Plan:

- pre-construction, dry pitfall-drift fence traps laid in a grid configuration would be distributed throughout the remaining known Common Planigale habitat on either side of the footprint (see Figure 4.9);
- surveys would be undertaken before, during and after construction twice yearly (winter-spring and summer-autumn); and
- surveys would be conducted for a minimum of two years after the start of operation.

9.5 Monitoring Aquatic Ecosystems

Monitoring protocols aimed at measuring impacts of the proposed bypass on aquatic ecosystems would be developed in consultation with NSW Fisheries, the Queensland Department of Primary Industries and Commonwealth Department of Environment and Heritage, and detailed in a Construction Environmental Management Plan. Detailed hydrological monitoring is outlined in Technical Papers 5, 7, 8 and 9. It is already proposed in these papers that monitoring for water quality and drawdown impacts be undertaken rigorously. Changes in groundwater levels or water quality usually have time-lag between visible signs of stress showing in flora and fauna. Therefore, it is currently recommended that no specific aquatic flora and fauna monitoring would be undertaken unless discussion with appropriate regulatory authorities suggest otherwise.

9.6 Monitoring Barrier Mitigation Measures

Although mitigation measures are proposed to minimise barrier impacts along the proposed bypass, the effectiveness of 60 metre long underpasses, 90 to 100 metres

long fish culverts and frog-exclusion fencing is unknown for species occurring in the study area. It is therefore important that these species are monitored during the short- and medium-term.

9.6.1 Terrestrial Monitoring

Major terrestrial mitigation measures include two frog culverts, a wet/dry culvert and fauna-exclusion and frog-exclusion fencing (Figure 7.1).

Frog Culverts

Given the experimental nature of the proposed mitigation measures for the Wallum Sedge Frog and Wallum Froglet, it is important to monitor frog culverts and frog-exclusion fencing. Frog culverts are not suitable for trials, as it would be difficult or impossible to re-create the actual conditions associated with the operational bypass (length of culvert, noise and light levels). It may be more practical to monitor the effectiveness of constructed culverts. This monitoring should be undertaken in conjunction with other more general frog monitoring undertaken in the area. Guidelines for monitoring would be finalised with the NSW Department of Environment and Conservation and the Commonwealth Department of Environment and Heritage and could include:

- undertaking pitfall trapping at the entrance to each culvert on a seasonal basis (following rainfall events) for a minimum of two years post construction;
- surveys should be conducted during and immediately following rainfall events and occur at least once during the breeding season of the Wallum Froglet (i.e. April to August) and once during the Wallum Sedge Frog breeding season (i.e. September to April);
- constructing a drift fence in a semicircular arc with the culvert entrance/exit at its centre, and placing pitfall traps on both sides of the fence;
- marking all captured frogs and releasing them across the drift fence;
- using an ink tray and paper inside the culverts to identify frogs crossing through the culverts; and
- remote sensing cameras may be able to be installed to monitor culvert use.

If some or both of the culverts prove to be successful, then the monitoring can be halted. If culverts are not used, then there may be some limited opportunities to alter the design once the bypass is operational.

Fauna-exclusion Fencing

Fauna-exclusion fencing, in particular floppy-top Koala-exclusion fencing, is commonly used along roadsides in NSW. Fauna-exclusion fencing would be erected along both sides of the bypass in the south and on the western side of the bypass north of the Tugun Landfill. Fencing would consist of a chain-link fence (without floppy-top). Fencing would be maintained in order to prevent overgrown vegetation from providing a potential crossing point for some fauna species. This fencing has proven successful in other NSW Roads and Traffic Authority projects and would only require monitoring to make repairs if required.

Frog-exclusion Fencing

Frog-exclusion fencing erected at Bulahdelah, NSW comprised fauna-exclusion fencing with some silt fence or geofabric attached to the bottom. This type of exclusion fence is

not considered to be impermeable to the Wallum Sedge Frog (Frank Lemckert, pers. comm.) and is therefore unsuited to the Tugun study area.

As the use of frog-exclusion fencing and culverts with the two Wallum frogs is considered to be experimental and it is important to monitor their effectiveness in minimising road mortality and facilitating movements under the road. Trials would be undertaken to gauge the effectiveness of frog-exclusion fencing using the following broad guidelines:

- a trial exclusion fence would be constructed around the perimeter of Site 5, a pond that would be removed as a result of construction of the proposed bypass;
- ten diurnal and ten nocturnal searches would be undertaken over a period of three months within the trial exclusion area;
- all individual frogs captured would be marked and relocated into nearby suitable habitat or mitigation ponds; and
- monitoring of Site 5 would then be undertaken to determine if the trapped frogs are gaining access back to the pond over the exclusion fencing.

If one or more marked individuals is recaptured within the exclusion area, then the design may have to be modified accordingly.

Once the bypass is operational, the effectiveness of the frog-exclusion fencing in relation to minimising road mortality would be monitored. This would be undertaken partly in conjunction with the general frog monitoring and would include:

- conducting walking transects along the bypass (where fencing is erected) at monthly intervals during at least the first year of operation during or immediately following rainfall events to see if frogs are found on the road-side of the frog-exclusion fencing; and
- during the survey the number and locations of any road-killed frogs would be recorded.

If no frog road mortalities are recorded, then further monitoring may not be required. However, it may be important to examine the fence several times per year for maintenance purposes or following storms. If road kills are prevalent, then the design of the frog-exclusion fencing may have to be modified.

Wet/Dry Culvert

The wet/dry culvert would be located north of the road tunnel. The final design of the monitoring undertaken in this culvert would be developed in consultation with the Department of Environment and Conservation and finalised in the Flora and Fauna Management Plan. Monitored could include the use of sand-traps and/or ink trays and possibly remote sensing cameras. Monitoring would be undertaken on a seasonal basis (four times per year).

9.7 Monitoring Tree Hollows and Nest Boxes

Detailed monitoring programs would be prepared as part of the Construction and Operation Environmental Management Plan, Flora and Fauna Management Plan. Any tree hollows or nest boxes that are reinstated in suitable vegetation adjacent to the footprint will need to be monitored. These will be combined into a practical monitoring program undertaken twice a year for a minimum of 3 years.

Reinstated tree hollows would be monitored using the stagwatching technique. The monitoring protocol would be undertaken according to the following broad guidelines:

- medium to large reinstated hollows (suitable for gliders) should be examined externally for signs of use between June and September;
- small reinstated hollows (suitable for bats) should be examined between June and August (hibernation) and November to February (breeding);
- any hollows showing signs of use should be subjected to dusk stagwatching accompanied by spotlighting and/or ultrasonic bat detecting to positively identify occupants; and
- a representative sample of medium and small reinstated hollows should be monitored by stagwatching (at least twice a year over 3 years) to determine the timing of occupation.

Nest boxes would be monitored by a suitably qualified ecologist using the following broad guidelines:

- all nest boxes would be accessed by ladder and opened during daylight hours to detect and identify occupants;
- all gliders and bats found nesting/roosting in next boxes would be marked appropriately for future identification;
- nest boxes suitable for Squirrel Gliders would be monitored at least once during June to September; and
- nest boxes suitable for microbats would be monitored at least once during June to August and at least once during November to February.

9.8 Summary of Monitoring

Table 9.1 provides a summary of the monitoring required for flora and fauna issues associated with the Tugun Bypass.

Table9.1: Summary of monitoring required (may vary depending upon results)

Species/Mitigation Measure	Monitoring Required	Time of Survey	Duration per Monitoring Event	Time of Year
Habitat Rehabilitation/ Revegetation	Monitor growth rate, species composition, levels of weed infestation, general vigour and health, and areas that have not re-established	Biannually (2 years) Annually (3 years)	3 days	Spring & Autumn
Plant Translocations	Monitor growth rates, general health and reproductive status	Quarterly (1 year) Biannually (4 years)	2 days	Seasonally then Spring & Autumn
Wallum Froglet and Wallum Sedge Frog	Intensive survey including pit falling, acoustic calls and active searches	Monthly (1 years) Bimonthly (1 years) Quarterly (3 years)	6 days	Monthly then Seasonally
Common Planigale	Pit falling	Biannually (5 years)	6 days	Autumn & Early Spring

Species/Mitigation Measure	Monitoring Required	Time of Survey	Duration per Monitoring Event	Time of Year
Frog Culverts	Survey possibly including pit falling, ink pads or remote sensing cameras	Quarterly (2 years post-construction)	Minimum 6 days	Seasonally
Frog-exclusion Fencing	Active searches in trial area Active searches along road side recording frog kills	3 month trial period Monthly (first year during operation)	10 days 2 days	September – April Monthly
Wet/Dry Culvert	Survey possibly including pit falling, ink pads or remote sensing cameras	Quarterly (1-2 years)	6 days	Seasonally
Tree Hollows/Nest Boxes	Stagwatching hollows and inspection of nest boxes	Biannually (3 years)	5 days	Winter & Summer

10. Conclusions

The Tugun study area is considered to be of national significance for nature conservation. It supports a high diversity of terrestrial flora and fauna of conservation significance as well as important populations of Swamp Orchid, Little Wattle, Match Sticks, Wallum Froglet, Wallum Sedge Frog, Long-nosed Potoroo and Common Planigale. Permanent fragmentation of populations would increase the risk of isolated subpopulations going extinct.

Ten sites of conservation significance were identified along the proposed corridor on the basis of their ecological values. The potential impacts of the proposed bypass and the effectiveness of mitigation measures on these sites were assessed. The proposed bypass is expected to have local to high local impacts on most of these sites. However, the populations of Wallum Sedge Frog and Common Planigale in ES5 may be affected at the regional level. This is primarily associated with fragmentation of habitat for these regionally significant populations and legislatively significant species. Although underpasses and fencing would be constructed in order to minimise the barrier effects resulting from the proposed bypass, it is unknown whether they would use 60 metres long culverts. Frog-exclusion fencing for frogs that can climb has not been trialled before and its effectiveness in minimising road kills is unknown. There are no opportunities to facilitate movement by Common Planigales in known habitat because of the tunnel ramps, although revegetation of habitat along the edges of the road would hope to direct this species to the wet/dry culvert to the north.

While the proposed bypass is unlikely to have a significant impact on the Long-nosed Potoroo population, the addition of fragmentation and edge effects associated with the Cobaki Lakes development may result in the extinction of this regionally significant population, in particular the small sub-population that has been isolated to the north of the Cobaki Lakes development access track. Compensatory measures have therefore been recommended to improve habitat quality for this species through provision of the following:

- fencing around part of the Cobaki Lakes development (if approved by developers);
- fox control in adjacent NSW Crown land; and
- preparation and implementation of a fire management plan in the NSW Crown land.

Cumulative impacts associated with the proposed bypass may also have a significant impact on the southernmost population of Little Wattle and the population of Match Sticks in Queensland. It is recommended that these species be considered for incorporation into revegetation plans in adjacent areas.

Cumulative impacts associated with the proposed railway may have a significant impact on Wallum Froglet, Wallum Sedge Frog and Common Planigale populations in ES5, and on Wallum Froglet, Eastern Grass Owl, a sub-regional fauna corridor at ES10. Also affected by proposed developments in the area would be state and regionally significant vegetation communities, regionally significant plant species and internationally important migratory bird species. However, these proposed developments and their associated mitigation would be the subject of future approvals processes.

A total of 26.5 hectares of key habitat would be removed or edge-affected in NSW with corresponding values of 23.8 hectares in Queensland and 20.8 hectares on Commonwealth land. A preferred compensatory habitat package has been described and agreed to in principle by NSW Department of Environment and Conservation. It provides an opportunity to acquire and manage land with the aim of conserving local and regional biodiversity in the long-term. The land package would form a strategically located link that provides an opportunity for the establishment of a continuous area of habitat having environmental protection around the Cobaki Broadwater. The loss of *State Environmental Planning Policy Number 14* wetlands and other significant wetlands habitats would also be compensated.

References

Andrews A. 1990, Fragmentation of Habitat by Roads and Utility Corridors: A Review, *Australian Zoologist*, **26**:130-141.

ANZECC 2000, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

Australian Museum Business Services 2001, *Fauna Underpass Monitoring Stage One – Final Report – Bulahdelah to Coolongolook,* prepared for the NSW Roads and Traffic Authority.

Australian Network for Plant Conservation Translocation Working Group 2004, *Guidelines for the Translocation of Threatened Plants in Australia*. Australian Network for Plant Conservation, Canberra.

Australian Society for Fish Biology and Conservation and IUCN 1999, *Conservation Status of Australian Fishes* – 1999.

Bali R., Lewis B. and Brown K. 2003, *The Status and Distribution of the Cobaki Long-nosed Potoroo Population*.

Bali R. 2000, *Discussion Paper – Compensating for Edge Effects*, prepared for the Roads and Traffic Authority, Sydney.

Bennett A.F. 1991, Roads, Roadsides and Wildlife Conservation: A Review, pp99-117, in: Saunders D.A. and Jobbs R.J. (Eds), *Nature Conservation 2; The Role of Corridors*, Surrey Beatty and Sons Pty Ltd, NSW.

Bennett A.F. 1999, *Linkages in the Landscape: the Role of Corridors and Connectivity in Wildlife Conservation*, IUCN, Gland Switzerland.

Benson J. 1989, Establishing Priorities for the Conservation of Rare or Threatened Plants and Plant Associations in NSW, in: Hicks M. and Eiser P. (eds) *Conservation of Australian Plans and Their Habitats*, Australian Committee for IUCN, Canberra.

Briggs J.D. and Leigh J.H. 1996, *Rare or Threatened Australian Plants,* CSIRO Australia.

Burbidge A.A. and McKenzie N.L. 1989, Patterns in the Modern Decline of Western Australia's Vertebrate Fauna: Causes and Conservation Implications. *Biological. Conservation,* **50**: 143-98.

Christidis L. and Boles W.E. 1994, *The Taxonomy and Species of Birds of Australia and its Territories*, Royal Australasian Ornithologists Union, Monograph 2.

Cogger H. G. 1992, *Reptiles and Amphibians of Australia,* 5th Edition, Reed, Sydney.

Denton J.S., Hitchings S.P., Beebee T.J. and Gent A. 1997, A Recovery Program for the Natterjack Toad (*Bufo calamita*) in Britain. *Conservation. Biology*. **11**:1329-38.

Dodd C.K. and Seigel R.A. 1991, Relocation, Repatriation and Translocation of Amphibians and Reptiles: are they *Conservation Strategies* that Work? *Herpetologica* **47**: 336-350.

Ecograph and Mary Maher & Associates 1997, *Gold Coast City Council Nature Conservation Strategy,* prepared for Gold Coast City Council.

Ecosure Environmental Consultants 2003, *Coolangatta Creek Fauna Monitoring Program, Gold Coast Airport, Annual Report*, prepared for Gold Coast Airport Limited.

FRC Environmental 2001, *Tugun Bypass* Proposal – Aquatic Flora and Fauna, prepared for PPK Environment & Infrastructure, Brisbane

Garnett S.T. and Crowley G.M. 2000, *The Action Plan for Australian Birds,* Environment Australia, Canberra.

Gilmore A.M. and Parnaby H.E. 1994, *Vertebrate Fauna of Conservation Significance in North-east NSW Forests*, North East Forests Biodiversity Study Report Number 3e, unpublished report, NSW National Parks and Wildlife Service.

Gold Coast Airport Limited 2001, *Coolangatta Airport Final Master Plan,* Gold Coast Airport Limited, August.

Gold Coast City Council 2003, *Draft Living City – Gold Coast Planning Scheme*.

Grant E.M. 1991, *Guide to Fishes,* Department of Harbours and Marine, Brisbane, Queensland.

Griffith S. 1993, *Conservation Status of Coastal Plant Communities*, report to the NSW National Parks and Wildlife Service.

Harden G.J. 1990-3, *Flora of NSW,* Volumes 1-4, NSW University Press, Sydney.

Herbrecs 2000, Herbrecs Database Search of Queensland Herbarium Records from the Herbarium. Environmental Protection Agency, Brisbane.

Hero J-M, Phillips S. and Shoo L. 2001a, *Survey for Reptiles, Amphibians and Mammals Inhabiting the Northern Section of the Proposed Tugun Bypass,* report prepared for PPK Environment & Infrastructure, Brisbane.

Hero J-M, Phillips S. and Shoo L. 2001b, *Supplementary Surveys of Common Planigales, Eastern Long-eared Bat and Wallum Sedge Frogs within the Proposed Tugun Bypass,* report prepared for PPK Environment & Infrastructure, Brisbane.

Hero H.M., Schoo L. and Phillips S. 2001c, *Amelioration and Monitoring Measures for the Conservation of Herpetofauna Along the Proposed Tugun Bypass,* report prepared for PPK Environment & Infrastructure, Brisbane.

Hero J-M, Phillips S. and Shoo L. 2000, *Survey for Reptiles, Amphibians and Mammals Inhabiting Coastal Lowland Areas Associated with the Proposed Tugun Bypass, r*eport prepared for the Queensland Department of Main Roads.

Hoye, G. 1994 *Report on the Survey of the Bat Fauna of an Area Proposed for the Diversion of the New England Highway at Belford near Branxton, New South Wales*. Report prepared for the NSW Roads and Traffic Authority

Hutchins B. and Swainston R. 1986, *Sea Fishes of Southern Australia,* Swainston Publishing, Perth.

Kelly C. 1998, *Conservation Biology of* Phaius spp. (Orchidaceae) *in Australia*. Honours Thesis, submitted to the School of Environmental and Applied Sciences, Griffith University.

Kingston M.B., Turnbull P.W., Hall P.W., Boulton S.C. and Storey R.J. 1999, *Tweed Vegetation Management Plan,* Volume 1, report prepared for the Tweed Shire Council.

Land for Wildlife 1991 Nest boxes for wildlife. *Land for Wildlife Victoria note* No. 14.

Lewis B. 2004a, *Systematic Surveys for the Coastal Planigale* (Planigale maculate) *on Crown Lands and a Detailed Habitat Appraisal of the Tugun/Cobaki Locality*, report prepared for Parsons Brinckerhoff (Brisbane) an dthe Queensland Department of Main Roads (Nerang) by Lewis Ecological Surveys.

Lewis B. 2004b, *Identification and Preliminary Design of an Artificial Frog Pond*, unpublished report to Ecopro.

Mason R. 1993, *Report on the Long-nosed Potoroo* Potorous tridactylus *at Cobaki*, prepared for the NSW National Parks and Wildlife Service Northern Region, Grafton.

Merric J.R. and Schmida G.E. 1984, *Australian Freshwater Fishes,* Griffin Press, Netley South Australia.

NSW Department of Public Works 1990, *Tweed Entrance Feasibility Report: Environmental Consideration of Options*, draft report prepared by Environmental Management Pty. Ltd., W.S. Rooney & Associates and Glen Holmes & Associates.

NSW Department of Public Works 1991, *Lower Tweed Estuary River Management Plan - Technical Summary,* Report Number 91053.

NSW Department of Planning 1985, *State Environmental Planning Policy Number 14 – Coastal Wetlands*.

NSW Department of Planning 1985, *State Environmental Planning Policy Number 44 – Koala Habitat Protection*.

NSW Environment Protection Authority 1997, *NSW State of Environment Report,* NSW Environment Protection Authority, Sydney.

NSW Fisheries 1999, *Policy and Guidelines for Bridges, Roads, Causeways, Culverts and Similar Structures,* (Eds. S. Fairfull and S. Carter), NSW Fisheries, Sydney.

NSW National Parks and Wildlife Service 1998a, *The Threatened Vascular Flora of North-Eastern NSW – Inventory, Assessment and Conservation,* Draft Proceedings of Threatened Flora Expert Workshop.

NSW National Parks and Wildlife Service 1998b, *Policy for the Translocation of Threatened Fauna in NSW,* National Parks and Wildlife Service, Threatened Species Management Information Circular Number. 6. National Parks and Wildlife Service, Sydney.

NSW National Parks and Wildlife Service 1999a, *Forest Ecosystem Classification and Mapping for the Upper and Lower North East CRA Region,* NSW National Parks and Wildlife Service, Northern Zone, Coffs Harbour.

NSW National Parks and Wildlife Service 1999b, *Guidelines for Flora and Fauna Survey Methods for the Pacific Highway Upgrade Projects,* draft report prepared by NSW National Parks and Wildlife Service, Coffs Harbour.

NSW Roads and Traffic Authority (draft). *Road Development and Impacts on Habitat Amelioration Measures – Compensatory Habitat,* Draft dated 12/11/98. Roads and Traffic Authority, Sydney.

Parker P. 1999, *Cobaki Lakes Development, Development Application Number 2 – Parcels 11-21 Inclusive, Species Impact Statement,* report prepared for Leda Manorstead Pty. Ltd.

Pease, B.C. and Grinberg A. 1995, *NSW Commercial Fisheries Statistics 1940 to 1992,* NSW Fisheries.

Phillips S. and Callaghan J. 1995, The Spot Assessment Technique for Determining the Significance of habitat Utilisation by Koalas, in *Proceedings of a Conference on the Status of the Koala in 1995,* Australian Koala Foundation, Brisbane.

Phillips S. and Callaghan J. 1996, *Koala Habitat Atlas Project Number 4: Tweed Coast,* prepared for Tweed Shire Council, September.

PlanningNSW 2002, *State Environmnetal Planning Policy Number 71 – Coastal Protection*, October.

Pressey, R.L. and Griffith, S.J. 1987, *Coastal Wetlands and Associated Communities in Tweed Shire, Northern NSW*. Prepared for NSW National Parks and Wildlife Service.

Queensland Department of Main Roads 2003, *Species Impact Statement under the* Threatened Species Conservation Act 1995 *and Equivalent Environmental Assessments under the Relevant Queensland and Commonwealth Legislation,* report prepared by Parsons Brinkerhoff, Brisbane, June.

Queensland Department of Main Roads 1999, *Pacific Highway at Tugun - Route Selection Report,* prepared by Connell Wagner, Brisbane.

Queensland Environmental Protection Agency 2001a, *Regional Ecosystem Mapping and Analysis Tool* (REMAT), Spatial Information and Analysis Unit, Environmental Protection Agency, Brisbane.

Queensland Environmental Protection Agency 2001b, *Draft Regional Conservation Strategy for South-east Queensland 2001-6*.

Queensland Herbarium 1997, *Queensland Plants. Names and Distribution,* Ed. Henderson R .J.F., Queensland Herbarium, Brisbane.

Queensland Transport 1997, *Southern Gold Coast – Tweed Corridor Study, Working Paper Number 1, Biological Constraints Analysis*, report prepared by Connell Wagner.

Quinn R.H. 1992, *Fisheries Resources of the Moreton Bay Region,* Queensland Fish Management Authority, Brisbane.

Reeves, D. 2001, *Survey for the Giant Dragonflies*, Petalura gigantea and Petalura litorea *and the Swordgrass Brown Butterfly* Tisiphone abeona morrisi, report prepared for PPK Environment & Infrastructure, Brisbane.

Reinert H.K. 1991. Translocation as a Conservation Strategy for Amphibians and Reptiles: Some Comments, Concerns and Observations, *Herpetologica* **47**: 357-363.

Sandpiper Ecological Surveys 2001a, *Assessment of the Impact of the Proposed Tugun Bypass: Terrestrial and Estuarine Birds*, prepared for Queensland Department of Main Roads.

Sandpiper Ecological Surveys 2001b, *Tugun Bypass Assessment of Impacts on Birds: Boyd Street Interchange to Stewart Road,* prepared for PPK Environment & Infrastructure, Brisbane.

Sattler and Williams 1999, *The Conservation Status of Queensland Bioregional Ecosystems*, Queensland Environmental Protection Agency, Brisbane.

Scotts, D. and Drielsma, M. 2003 'Developing landscape frameworks for regional conservation planning: an approach integrating fauna spatial distributions and ecological principles', *Pacific Conservation Biology* 8(4), pp 235-254.

Sharpe P.R. 1986, Keys to Cyperaceae, Restionaceae and Juncaceae of Queensland, *Queensland Botany Bulletin Number 5*, Queensland Department of Primary Industries, Brisbane.

Sheringham P. and Westaway J. 1995, *Significant Vascular Plants of Upper North East NSW,* report by the NSW National Parks and Wildlife Service to the Natural Resources Audit Council.

Simon B. 1993, *A Key to Australian Grasses,* Second Edition, Queensland Department of Primary Industries, Brisbane.

Spiller Gibbins Swan Pty. Ltd. 2001, *Coolangatta Airport Enterprise Park Feasibility Study*, prepared for the Tweed Economic Development Corporation.

Stanisic J. 2001, *Survey for the Land Snail* Thersites mitchellae*: Proposed Tugun Bypass Route*, report prepared for PPK Environment & Infrastructure, Brisbane.

Stanley T.D. and Ross E.M. 1983, *Flora of South-eastern Queensland,* Volumes 1-3, Queensland Department of Primary Industries, Brisbane.

Strahan R. (Ed.) 1998, *The Mammals of Australia,* Reed Books Ltd.

Theischinger G. 1999, A New Species of *Petalura leach* from South-eastern Queensland (Odonata: Petaluridae). *Linzer Biol. Beitr*. **31**: 159-66.

United States Department of Agriculture 1992, *Potential Impacts of Aircraft Overflights of National Forest System Wildernesses,* Report to Congress, U.S. Department of Agriculture Forest Service.

Van der Zande A.N., Keurs W.J. and Weijden W.J. 1980, The Impact of Roads on the Densities of Four Bird Species in an Open Field Habitat – Evidence of a Long Distance Effect, *Biological Conservation*, **67**: 63-72.

Walker J. and Hopkins M.S. 1984, Vegetation, in: McDonald R.C., Isbell R.F., Specht J.G., Walker J., Hopkins M.S. (eds.). *Australian Soils and Land Survey Field Handbook,* Pp. 44-67, Incata Press, Melbourne.

Warren J. 1994, *Flora and Fauna Assessment – Phase 1 Residential Development at Cobaki Lakes,* report prepared for Ray Corporation Pty. Ltd.

Warren J. 1992, *Fauna Impact Assessment on Crown Lands between Cobaki Lakes and the Queensland/NSW Border*, report prepared for Cobaki Lakes, Southport.

Watkins 1993, *A National Action Plan for Shorebird Conservation in Australia*, Australian Wader Studies Group, Royal Australasian Ornithologists Union, Report Number 90.

West, R.J., Thorogood, C., Walford, T. and Williams, R.J. 1985. *An estuarine inventory for NSW, Australia*. Fisheries Bulletin 2, Department of Agriculture NSW.

Williams L.E. 1997, *Queensland's Fisheries Resources: Current Condition and Trends 1988-1995,* Queensland Department of Primary Industries Information Series QI97007, pp. 101.

Yanes M., Velasco J.M. and Suarez F. 1995, Permeability of Roads and Railroads to Vertebrates: The Importance of Culverts, *Biological Conservation*, **71**: 217-22.

Young P.A.R. and Dilleward H.A. 1999, Chapter 12. South-east Queensland, in: *The Conservation Status of Queensland's Bioregional Ecosystems,* (eds. P.S. Sattler and R.D. Williams), Queensland Environmental Protection Agency, Brisbane.

Legislation

Commonwealth

Australian Heritage Commission Act 1975.

Environment Protection and Biodiversity Conservation Act 1999.

Endangered Species Protection Act 1992.

NSW

Environmental Planning and Assessment Act 1979.

Fisheries Management Act 1994.

Forestry Act 1916.

National Parks and Wildlife Act 1979.

Native Vegetation Conservation Act 1998.

North Coast Regional Environmental Plan 1988

Roads Act 1993.

Threatened Species Conservation Act 1995.

Queensland

Environmental Protection Act 1994.

Fisheries Act 1994.

Fisheries Regulations 1995.

Integrated Planning Act 1997.

Nature Conservation Act 1992.

Nature Conservation (Wildlife) Regulation 1994.

Vegetation Management Act 1999.

Vegetation Management Regulation 2000.

Appendix A

Assessment of the Impact of the Proposed Tugun Bypass: Terrestrial and Estuarine Birds (Sandpiper Ecological Surveys 2001a)

ASSESSMENT OF THE IMPACT OF THE PROPOSED TUGUN BYPASS:

OPTION C4 – KENNEDY DRIVE TO BOYD STREET

TERRESTRIAL AND ESTUARINE BIRDS

JANUARY 2001

Sandpiper Ecological Surveys

ASSESSMENT OF THE IMPACT OF THE PROPOSED TUGUN BYPASS:

OPTION C4 – KENNEDY DRIVE TO BOYD STREET

TERRESTRIAL AND ESTUARINE BIRDS

JANUARY 2001

Report prepared for the QLD Department of Main Roads, by

D. A. Rohweder (PhD)

Sandpiper Ecological Surveys
4/25 Tamar Street Ballina, 2478

TABLE OF CONTENTS

LIST OF TABLES

Table No. ***Page***

LIST OF TABLES

LIST OF FIGURES

Figure No. ***Page***

ACKNOWLEDGEMENTS

Project Management:	I. Smith QLD Main Roads
Survey Design:	D. Rohweder Sandpiper Ecological Surveys
Field Survey:	D. Rohweder & B. Lewis Sandpiper Ecological Surveys
Data Summary:	B. Lewis & D. Rohweder Sandpiper Ecological Surveys
Report writing	D. Rohweder
Comments on draft:	I. Smith, QDMR & B. Lane PPK.

Staff at Coolangatta Airport provided a key for access to GCAL land. Airport security staff promptly assisted with access through the airport, and staff provided bird monitoring records. Edward Kleiber provided information on the nest site used by Brahminy Kites.

EXECUTIVE SUMMARY

1. INTRODUCTION

Background

Sandpiper Ecological Surveys was contracted by the Queensland Department of Main Roads to assess the potential impact of the proposed Tugun Bypass on birds. The option selected for assessment was C4, which involves a full bypass of the Tugun/Bilinga area. This report deals specifically with the area of the bypass that occurs in New South Wales, and addresses the impacts of the proposal with respect to NSW and commonwealth legislation.

Objectives

The objectives of this project were to:

- Undertake a survey of birds in terrestrial and estuarine habitats that may be affected by the proposed C4 option;
- Assess the impact of the proposal on birds within terrestrial and estuarine habitats;
- Summarise the results of previous bird surveys conducted within the vicinity of the study area; and
- Provide recommendations to minimise impacts on birds and their habitats.

2. STUDY AREA

The study area included both estuarine and terrestrial habitats. The estuarine study area encompassed the lower Tweed River estuary including Terranora and Cobaki Broadwater's, Terranora Creek and the Tweed River from its mouth upstream to Chinderah Bay. Three freshwater wetlands situated in close proximity to estuarine habitats were also sampled, these sites included the Tweed Heads west and Tweed Heads south sewage treatment works, and Trutes Bay wetland.

The terrestrial study area included all terrestrial habitats within a 500 m radius of the proposed C4 alignment that occurred in NSW. This area included mangroves and saltmarsh surrounding Cobaki Broadwater, and the adjacent swamp forest, lowland rainforest and heath. Although a broad area was sampled during the survey specific attention has been focussed on habitats in NSW that occur within 500 m of the proposed C4 alignment, as this area is considered most likely to be affected by the proposal.

3. METHODS

Timing

Surveys were conducted during summer and autumn 2000. Summer surveys were conducted over a period of 10 days and autumn surveys were conducted over a period of four days. The summer surveys coincided with both a spring and neap tidal cycle and a full moon phase, and included fruiting period for a number of important feed tree species. The autumn survey was conducted during the peak flowering period for *Melaleuca quinqunervia*, and coincided with a full moon phase. The autumn surveys focussed primarily on detecting potential threatened species that may utilise the study area but which were not detected during the summer survey.

Assessment of estuarine birds

The estuarine surveys included:

- a review of previous estuarine bird surveys conducted in the lower Tweed River estuary;
- a survey of the estuarine bird population during two, three day periods, one during a spring tidal cycle, and one during a neap tidal cycle. A total of 20 estuarine and 3 freshwater sites were sampled during the survey;
- an assessment of habitat use in Cobaki Broadwater by four species of migratory shorebird; and
- an assessment of estuarine habitat types present within the study area.

Regular surveys of the estuarine bird population over a twelve month period was not deemed necessary due to the presence of reliable data on habitat use and seasonal variation in population size. Long-term monitoring data used to assess potential impacts included quarterly monitoring surveys conducted by Sandpiper Ecological Surveys since March 1997, and monthly surveys conducted by the Queensland Wader Studies Group (QWSG) since 1994.

Specific information on the use of Cobaki Broadwater by shorebirds was obtained to assess the importance of feeding grounds and roosts situated in close proximity to the proposed C4 alignment. This study included a baseline assessment of bird movements throughout the Broadwater during low tide periods, and an assessment of the feeding rates achieved by birds foraging at sites close to the alignment.

Assessment of terrestrial birds

A variety of different methods were used to sample the terrestrial bird community, including:

- Point counts – 45 point count sites were established, with sites in each of the major habitat types. The objective of point count surveys was to obtain an indication of relative abundance of birds within the major habitats present in the study area;
- Area search – 30-60 minute periods were spent conducting area searches at replicate sites in each habitat type. Area searches generally covered an area of approximately 1 ha. The objective of area searches was to obtain a comprehensive species list for each habitat type;
- General traverse – meandering traverse throughout the study area searching specific habitats for birds;
- Canoe traverse – Canoe traverses were conducted on two occasions at each of two sites. One site was situated along the northern shore of Cobaki Broadwater, whilst the second site was situated along a drainage line adjacent to the Tweed Heads Pony Club;
- Playback – Playback for legislatively protected species was conducted at several sites throughout the study area, with repeated surveys conducted during summer and autumn. Playback was conducted during three time periods, night, dawn and dusk, depending on the species being targeted;

- Dusk listening – Dusk listening was conducted at 7 sites throughout the study area. This method involved sitting quietly for a period of 30 minutes prior to nightfall and listening for calls of nocturnal or crepuscular birds;

- Edge effect study – To obtain some understanding of the possible affect of highways on birds a baseline edge effect study was conducted. This study involved sampling replicate point count sites at set distances from the highway/forest edge. The study was not meant to provide a definitive assessment of the impacts of highways on birds but was aimed at providing baseline information that could prove useful in assessing the impacts of the proposal.

- Habitat assessment – a detailed assessment of habitat types present within the study area was conducted to ensure that all habitat types were sampled.

Each point count and area search site was sampled on two non-consecutive mornings. Point count surveys were conducted between 6.00am and 9.00 am, whilst area searches were conducted between 6.00am and 10.30 am. General traverses were generally conducted in the afternoon.

4. RESULTS

Estuarine

Population estimate

A total of 53 species of estuarine bird were recorded during the survey, and the population of estuarine birds utilising the lower Tweed River estuary was estimated to be approximately 2807 individuals. The population was comprised of 159 waterfowl (six species), 833 waterbirds (21 species), 724 shorebirds (17 species), 28 birds of prey (five species), and 1063 gulls and terns (four species).

The species of bird recorded during the estuarine survey included:

- 17 species listed on the China-Australia Migratory Bird Agreement (CAMBA);

- 15 species listed on the Japan-Australia Migratory Bird Agreement (JAMBA);

- five species listed as vulnerable under the NSW *Threatened Species Conservation* (TSC) Act (1995);

- two species listed as endangered under the NSW *TSC* Act; and

- one species listed as vulnerable on the Commonwealth *Endangered Species Protection* (ESP) Act (1992).

Roosts in Cobaki Broadwater

Three of the four roosts situated in close proximity to the proposed bypass were used during the survey. These sites included Pony Club, Cobaki Creek and Cobaki Broadwater (south). Cobaki Creek was used regularly by 25% of the estuaries whimbrel population, whilst 30% of the whimbrel population was occasionally recorded at Pony Club. Pony Club was also used by 17% of the eastern curlew and 38% of the Pacific golden plover population. Over 50% of the greenshank population and 11% of the grey-tailed tattler population roosted in Cobaki Broadwater.

Feeding grounds in Cobaki Broadwater

There are four feeding grounds in Cobaki Broadwater, Cobaki Creek, Pony Club, Cobaki south and Cobaki north. All of these sites are used by migratory shorebirds and other species of estuarine bird. The most important sites within the Broadwater include the Cobaki south and Cobaki north mudflats, which cover extensive areas and support a large number and high species diversity of birds. A small number of species and individuals were recorded at the Pony Club sandflat, which is the closest feeding area to the proposed alignment. The Pony Club sandflat is considered to be of limited value as a foraging habitat, being used by only small numbers of individuals and species. To confirm the results of the low-tide surveys more detailed sampling was conducted at Pony Club.

Movement of shorebirds within Cobaki Broadwater

Observations on tidal induced movements of shorebirds in Cobaki Broadwater confirm the results of counts conducted at low tide surveys. Observations conducted at Pony Club during ebb tide indicate that most birds moving into the estuary to forage fly directly to Cobaki south and disperse from there to Cobaki north. A small number (i.e. 1 or 2 individuals) of whimbrel and eastern curlew forage at Pony Club throughout the low tide period. Small flocks of bar-tailed godwits may occasionally stop at the Pony Club sandflat to forage for a brief period before moving to Cobaki south. Pacific golden plovers were recorded foraging at the Pony Club sandflat throughout the low tide period.

Review of previous estuarine bird surveys

The review of previous surveys focussed on data gathered during monthly surveys by the QWSG since 1994, quarterly surveys conducted by Sandpiper Ecological Surveys since 1997, surveys in 1991-1992 and 1996 by WBM Oceanics, surveys in 1992 by Wayne Lawler, surveys in 1989 by Glenn Holmes, and surveys in 1987 by John Martindale.

The coverage of the various groups of estuarine birds varies considerably between the various surveys. Shorebirds are the only group that has been covered in detail during each of the surveys. Comparison of the estuaries shorebird population between years suggests a steady decline in population size, particularly for migratory species. This trend is reflected in comparisons of the number of shorebirds using roosts and feeding grounds in Cobaki Broadwater. Surveys in the late 1980's and early 1990's recorded large numbers of birds roosting and foraging in the Broadwater, however, recent surveys have recorded fewer individuals and species.

Terrestrial

Habitat assessment

Eight habitat types were identified during the terrestrial habitat assessment, including dry woodland, lowland rainforest, swamp forest, mangrove forest, regenerating swamp forest, heath, sedgeland, and disturbed land. Swamp forest was the most widespread habitat covering extensive areas in the eastern and central sections of the study area, this habitat also contained a number of small freshwater wetlands.

Species richness

A total of 156 species of bird were recorded using terrestrial habitats during both the summer and autumn surveys. During summer the highest species richness was recorded in swamp forest (81 species), followed by mangroves and woodland (59 species), disturbed land (55 species), rainforest (49 species), heathland (46 species), regrowth swamp forest (42 species), and sedgeland (28 species).

During the summer survey 147 species were recorded, whilst 94 species were recorded during the autumn survey. Nine species were recorded in autumn that were not recorded in summer. The study area was found to be used by altitudinal migrants, such as noisy pittas and rose robins that move to coastal forests in winter. The study area also provides a plentiful food resource for a variety of species including honeyeaters, and frugivorous pigeons.

A number of legislatively protected and conservation significant species were recorded during the terrestrial bird survey, including:

- 10 species listed on the NSW TSC Act, including, black bittern, bush hen, brolga, osprey, collared kingfisher, rose-crowned fruit-dove, superb fruit-dove, masked owl, grass owl and mangrove honeyeater;
- 8 species that are regarded as being of conservation significance;
- 5 species listed on JAMBA; and
- 5 species listed on CAMBA.

Records of three species listed on the NSW TSC Act remain unconfirmed despite targeted searches. These species include superb fruit-dove, masked owl and black bittern. One additional threatened species, the glossy black-cockatoo, was recorded during surveys for the Species Impact Statement in December 2000.

Legislatively protected species were generally restricted to one habitat type, the exception being rose-crowned fruit-doves, which were recorded foraging in lowland rainforest and swamp forest. A number of legislatively protected, and conservation significant species were recorded in swamp forest (9 species), mangroves (10 species) and lowland rainforest (5 species) habitats. The large number of significant species recorded in these habitats is indicative of the high conservation value of habitats within the study area.

Summary of birds recorded in the locality

A review of previous surveys and known databases was conducted to obtain a thorough indication of the species of bird that may utilise habitats within the study area. This information was combined with data gathered during field investigations for this project to provide a comprehensive list of birds recorded within a 10 km radius of the proposed C4 alignment. The area within 10 km of the alignment is referred to as the locality. The review included sources of information discussed previously for the estuarine bird surveys, in addition records contained within the Atlas of NSW Wildlife, Birds Australia's ABC and Atlas database, the results of surveys by Cowley (1994), unpublished data collected by Sandpiper Ecological Surveys, and the results of general monitoring surveys conducted by staff at Coolangatta Airport.

The review identified a total of 250 species of bird that have been recorded previously from the locality, many of which have been recorded in close proximity to the proposed alignment (Table 1). The review also identified two species listed on the NSW TSC Act that have been recorded previously from the subject site, wompoo fruit-dove and white-eared monarch. Both of these species have been recorded from lowland rainforest habitat. The list of species collated from the review of previous surveys included:

- 31 species listed on the NSW TSC Act (1995);
- 29 species listed on CAMBA;
- 27 Species listed on JAMBA;
- 11 species of conservation significance; and
- 1 species listed on the ESP Act (1992).

Table 1: List of legislatively protected species and species of conservation significance recorded within the locality during this study, and previous studies. TSC = Threatened Species Conservation Act, ESP = Endangered Species Protection Act, SF = swamp forest, D = disturbed, W = woodland, Ma = mangrove, Se = sedgeland, Ma = mangrove, SFR = swamp forest regrowth, Rf = rainforest, * recorded in micro-habitat within another habitat type., ** recorded by S. Phillips. Subject site refers to a 500 m radius of the proposed C4 alignment, nr = not recorded on the subject site during this study.

Group	Species	Status	Species recorded during this study	Habitats where recorded on subject site
Waterbirds	Magpie Goose	TSC S2	X	nr
	Wandering Whistling Duck	CS	X	SF, D
	Black Bittern	TSC S2	X	SF
	Black-necked Stork	TSC S1	X	nr
	Eastern Reef Egret	C	X	nr
	Great Egret	C, J	X	Se, D
	Intermediate Egret	CS	X	nr
	Cattle Egret	C, J	X	D
	Bush Hen	TSC S2	X	SF
	Lewins Rail	CS	X	W*, SF, Ma*, Se
	Brolga	TSC S2	X	SF, D
Birds of Prey	Osprey	TSC S2	X	Ma
	Brahminy Kite	CS	X	Ma, Se, MeR, D
	White-bellied Sea-Eagle	CS, C	X	Ma
	Pacific Baza	CS	X	SF, Se
	Square-tailed Kite	TSC S2	nr	nr
Shorebirds	Latham's Snipe	C, J	X	D
	Bar-tailed Godwit	J, C	X	Sand & mudflats
	Black-tailed Godwit	TSC S2, J, C	nr	nr
	Whimbrel	J, C	X	Sand & mudflats, saltmarsh, mangroves
	Eastern Curlew	J, C	X	Sand & mudflats, saltmarsh
	Marsh Sandpiper	J, C	nr	nr
	Common Greenshank	J, C	X	Sand, mudflat & saltmarsh
	Terek Sandpiper	TSC S2, J, C	X	nr
	Common Sandpiper	J, C	X	nr
	Grey-tailed Tattler	J, C	X	Mangroves & mudflats
	Ruddy Turnstone	J, C	X	nr
	Curlew Sandpiper	J, C	X	nr
	Red-necked Stint	J, C	nr	nr
	Sharp-tailed Sandpiper	J, C	X	nr
	Sanderling	TSC S2, J, C	nr	nr
	Red Knot	J, C	nr	nr
	Great Knot	TSC S2, J, C	nr	nr
	Comb-crested Jacana	TSC S2	X	nr
	Beach Stone-curlew	TSC S1	nr	nr
	Pied Oystercatcher	TSC S2	X	nr
	Sooty Oystercatcher	TSC S2	X	nr
	Pacific Golden Plover	J, C	X	Sandflats & saltmarsh
	Greater Sandplover	TSC S2, J, C	nr	nr
	Lesser Sandplover	TSC S2, J, C	nr	nr

Table 1: cont.

Group	Species	Status	Species recorded during this study	Habitats where recorded on subject site
Terns	Common Tern	J, C	nr	nr
	Caspian Tern	J, C	X	mudflat
	White-winged Black Tern	C	nr	nr
	Little Tern	J, C, ESP, TSC S1	X	nr
Terrestrial Birds	Collared Kingfisher	TSC S2	X	Ma
	Alberts Lyrebird	TSC S2	nr	nr
	Rose-Crowned Fruit-Dove	TSC S2	X	Rf, SFR
	Superb Fruit-Dove	TSC S2	X	Rf
	Wompoo Fruit-Dove	TSC S2	nr	Rf
	Glossy Black-Cockatoo	TSC S2	X	W
	Little Bronze Cuckoo	CS	X	W, Ma, SF, Rf
	Barking Owl	TSC S2	nr	nr
	Masked Owl	TSC S2	X	W
	Grass Owl	TSC S2	X	S
	Marbled Frogmouth	TSC S2	nr	nr
	White-throated Needletail	C, J	X	W, SF, M, D
	Rainbow Bee-eater	J	X	W, SF, Rf, Ma, H, D, Se
	Little Shrike Thrush	CS	X	Rf, SF
	Mangrove Honeyeater	TSC S2	X	Ma
	Dusky Honeyeater**	CS	X	SF
	Mangrove Gerygone	CS	X	Ma
	Barred Cuckoo-Shrike	TSC S2	nr	nr
	Shinning Flycatcher	CS	nr	nr
	White-eared Monarch	TSC S2	nr	nr

5. DISCUSSION

Important ecological values of the subject site

A number of important ecological values were identified within the subject site that must be considered in assessing the impacts of the proposal. These values include:

- occurrence of important populations of threatened species, including mangrove honeyeater, and collared kingfisher;
- occurrence of habitat for a large number of threatened and significant bird species;
- high avifauna diversity;
- occurrence of habitat critical for use by a number of species listed on international migratory bird agreements;
- proximity of the proposal to tidal wetlands in Cobaki Broadwater;
- presence of habitats with a limited regional distribution; and
- presence of lowland habitat used by altitudinal and latitudinal migrants.

Impacts associated with the proposal

Seven factors were identified that may affect the bird community within the subject site. These factors include:

- Habitat removal and fragmentation;
- Edge effects;
- Barrier effects;
- Road strike;
- Disturbance effects;
- Altered hydrological regimes; and
- Wetland contamination.

The impact of the above factors on legislatively protected species that are known or suspected to utilise habitats within 500 m of the proposed alignment is summarised in Table 2. In Table 2 migratory shorebirds have been assessed together due to the similarity in habitats used by these species.

Table 2: Impacts that may have a detrimental affect on legislatively protected species occurring in the study area. √ = no impact, X = impact.

Species	Habitat removal & fragmentation	Edge effects	Barrier Effects	Road Strike	Disturbance Effects	Altered Hydrological Regime	Wetland Contamination
Brolga	√	√	√	√	√	√	√
Black Bittern	X	√	√	√	√	X	X
Australasian Bittern	X	√	√	√	X	X	X
Great Egret	X	√	√	√	√	X	X
Black-necked Stork	√	√	√	√	√	√	√
Bush Hen	√	√	X	√	X	X	X
Osprey	√	√	√	√	√	√	X
White-bellied Sea-Eagle	√	√	√	√	X	√	X
Square-tailed Kite	X	√	√	√	X	√	√
Latham's Snipe	X	√	√	√	√	X	X
Migratory Shorebirds	√	√	√	√	√	X	X
Pied Oystercatcher	√	√	√	√	√	√	X
Little Tern	√	√	√	√	√	√	X
Collared Kingfisher	√	√	√	√	X	√	X
Fruit-Doves	X	√	√	X	X	√	√
Glossy Black-Cockatoo	√	√	√	√	√	√	√
Red-tailed Black-Cockatoo	√	√	√	√	√	√	√
Little Bronze Cuckoo	X	X	√	X	X	√	√
Masked Owl	X	√	√	X	√	√	√
Grass Owl	X	X	√	X	X	X	X
Mangrove Honeyeater	√	√	√	√	X	√	√
White-eared Monarch	X	√	√	X	X	√	√
Barred Cuckoo-Shrike	X	√	√	X	X	√	√

Findings of the section 5a assessment

The section 5a assessment is based on the original C4 alignment as defined in Connell Wagner (1999). Modifications to the C4 alignment will influence the outcome of the assessment, and a revision of the section 5a assessment would be warranted should the alignment be modified. The assessment identified a number of issues of concern with respect to the proposal (Table 3). The conclusion of the eight-part test is that a Species Impact Statement (SIS) will be required for at least four species. These species include bush hen, black bittern, masked owl and grass owl. Additional species of concern include collared kingfisher, mangrove honeyeater, osprey, rose-crowned fruit-dove and migratory shorebirds.

Assessing the exact impact of some factors such as wetland contamination and altered hydrological regimes was problematic. The assessment of impacts conducted in this report is based on the information available at the time of report preparation. A full assessment of some impacts, in particular those relating to water contamination, and hydrological regimes can only be made after more detailed hydrological surveys have been conducted, and the proposed mitigation measures are considered. It is likely that with appropriate mitigation measures some of the issues of concern regarding hydrological regimes, and water contamination may be adequately addressed. This will inturn influence the conclusions regarding the impact of these factors on threatened birds.

Table 3: Summary of the findings of the section 5a assessment on legislatively protected species that utilise habitats in the vicinity of the proposed Tugun bypass. √ = positive response, X = negative response.

	Eight part test questions								SIS
Common Name	a)	b)	c)	d)	e)	f)	g)	h)	required
Brolga	√	√	√	√	√	√	√	√	NO
Black Bittern	X	√	√	√	√	X	√	√	YES
Australasian Bittern	√	√	√	√	√	√	√	X	NO
Great Egret	√	√	√	X	√	√	√	√	NO
Black-necked Stork	√	√	√	X	√	X	√	√	NO
Bush Hen	X	√	√	√	√	X	X	√	YES
Osprey	√	√	√	√	√	X	X	X	NO
White-bellied Sea-Eagle	√	√	√	√	√	√	√	√	NO
Square-tailed Kite	√	√	√	√	√	√	X	√	NO
Latham's Snipe	√	√	√	√	√	X	√	√	NO
Migratory Shorebirds	√	√	√	√	√	X	X	√	NO
Pied Oystercatcher	√	√	√	√	√	X	√	√	NO
Little Tern	√	√	√	√	√	X	√	√	NO
Collared Kingfisher	√	√	√	√	√	√	X	X	NO
Fruit-Doves	X	√	√	X	√	√	X	X	NO
Glossy Black-Cockatoo	√	√	√	√	√	X	√	√	NO
Red-tailed Black-Cockatoo	√	√	√	√	√	X	√	X	NO
Masked Owl	X	√	√	√	√	X	X	√	YES
Grass Owl	X	√	√	X	√	√	X	√	YES
Mangrove Honeyeater	√	√	√	√	√	X	√	√	NO
White-eared Monarch	√	√	√	√	√	X	√	√	NO
Barred Cuckoo-Shrike	√	√	√	√	√	√	√	√	NO

Impacts on non-legislatively protected species

The proposal will affect a number of non-legislatively protected species, although it is unlikely that any additional species will be affected to such a degree that a local population would become unviable. It is also considered unlikely that the proposal will have a substantial affect on the biodiversity of birds in the study area. Species relying on heathland habitats will be most affected as this vegetation community is the most heavily impacted by habitat removal and fragmentation associated with the C4 option. Although the proposal will remove more swamp forest than heath a greater proportion of the total available heath habitat will be removed.

Fortunately the majority of bird species recorded in heathland habitat were also recorded in other habitat types in the study area, or are capable of exploited small fragmented habitats. In addition to habitat removal and fragmentation heathland birds will be subject to the impacts of road strike and barrier effects, particularly during the early stages of highway operation.

Lewin's rail will be affected through habitat removal, changes in hydrological regimes, and contamination of wetlands. The study area may become less suitable for Lewin's rail. The proposal will also remove and fragment known nesting and foraging habitat for brahminy kites. The pair of kites that currently reside in the study area will most likely abandon their existing nesting location.

Recommendations

There are a variety of impact mitigation measures that could be integrated into the design of the project to minimise impacts on birds. Proposed measures are discussed briefly below.

1. Realign the carriageway between the southern end of the main airport runway, and the airport signal towers situated approximately 1 km further north. The realignment of the carriageway approximately 100 m further east would reduce the extent of noise impacts on lowland rainforest, swamp forest and mangroves, reduce the area of swamp forest removed, and provide a greater opportunity to intercept chemicals spilled from the highway before these reach Cobaki Broadwater. The proposed re-alignment would be most similar to the "C2" option discussed by Connell Wagner (1999), with further modification at the southern end of the alignment.

2. Construct large earth walls on the southern side of the carriageway at each end of the proposed tunnel to further reduce noise impacts on habitats to the southeast of the alignment.

3. Install water quality treatment devices on all drains leading from the highway into Cobaki Broadwater.

4. Initiate appropriate measures to minimise the risk of acid sulphate and contaminated soil runoff during the construction phase. Undertake a comprehensive soil assessment.

5. Ensure that appropriate drainage measures are initiated to avoid excessive drainage into existing wetlands. Attempts should be made to ensure that post construction drainage into wetlands is similar to pre-construction levels.

6. Provide a detailed assessment of the likely impact of the proposal on the existing water table, and the effects that this may have on wetlands used by bush hens. Undertake a comprehensive hydrological assessment.

7. Liase with Coolangatta Airport to assess the feasibility of undertaking wetland rehabilitation work within the old dredge spoil dump. This land may be suitable for the construction of a shorebird roost, and creation of freshwater wetland habitat suitable for both birds and frogs.

8. Assess the feasibility of revegetating land above the proposed tunnel to its present state.

9. Revegetate land on the western side of the carriageway to reduce the impacts of noise and movement disturbance, and to compensate for habitat removed during construction.

10. Undertake a detailed assessment of the potential impacts of noise disturbance on legislatively protected species, including monitoring of existing noise levels and the response of birds to noise.

11. Undertake revegetation on currently disturbed land in the vicinity of the dredge spoil dump. Revegetation should focus on replanting food resources for fruit-doves that are removed by the project.

12. Undertake a Species Impact Statement to further clarify the impacts of the proposal, and identify appropriate impact mitigation procedures.

1. INTRODUCTION

The Queensland Department of Main Roads (DMR) propose to re-align the Pacific Highway between Currumbin and Tweed Heads. The objective of the project is to relieve traffic congestion along the combined Gold Coast and Pacific Highway corridor between Tugun, and Coolangatta/Tweed Heads. To identify a preferred route the DMR has undertaken a study that evaluated the suitability of a range of options (Connell Wagner 1999). The preferred route identified by this study was Option C4.

The preferred option involves a full bypass of the Tugun/Bilinga area, by constructing a four lane highway on the western side of Coolangatta Airport. The re-alignment extends from Stewarts Road, Currumbin, to Kennedy Drive, Tweed Heads. The proposal includes the construction of a highway, and a railway line. The railway line terminates at Coolangatta Airport.

The proposed road corridor includes land under the jurisdiction of Queensland, New South Wales, and the Commonwealth governments. Main Roads propose to prepare a single Environmental Impact Statement (EIS) to evaluate the impacts associated with the preferred route. To assist in the preparation of the EIS Main Roads has contracted Sandpiper Ecological Surveys to assess the potential impacts of the proposal on birds. Due to differences in environmental legislation between Queensland (QLD) and New South Wales (NSW) two separate reports have been prepared, one for that part of the alignment that occurs in NSW, and another for that part of the alignment that occurs in QLD. The following report addresses impacts of the proposed C4 alignment on avifauna in NSW.

The report presents the results of field surveys conducted within the vicinity of the proposed alignment and summarises data collected during previous surveys. A preliminary section 5a assessment (eight-part test) has also been included. The assessment is regarded as preliminary as it does not consider the range of impact mitigation measures that are likely to be proposed in the EIS.

In assessing the impacts of the proposal consideration has been given to species listed on the New South Wales *Threatened Species Conservation* (TSC) *Act* (1995), the *Commonwealth Endangered Species Protection* (ESP) *Act* (1992), the *Japan-Australia Migratory Bird Agreement* (JAMBA), and the *China-Australia Migratory Bird Agreement* (CAMBA).

1.1 Project objectives

The objectives of this project were to:

- Undertake a survey of birds in terrestrial and estuarine habitats that may be affected by the proposed C4 option;
- Assess the impact of the proposal on birds within terrestrial and estuarine habitats;
- Summarise the results of previous bird surveys conducted within the vicinity of the study area; and
- Provide recommendations to minimise impacts on birds and their habitats.