2. STUDY AREA

2.1 Boundary of the study area

The need to assess the impact of the proposal on both the estuarine and terrestrial bird communities meant that the study area needed to incorporate the different habitats used by these communities. For the purpose of the estuarine bird assessment the study area included all of the known high tide roosts and major feeding areas in the Lower Tweed River estuary (Figure 1). The study area encompassed the main river from its entrance upstream to Chinderah Bay, Terranora Creek, Cobaki Broadwater, Terranora Broadwater, South Head Beach, and Duroby Marsh (Figure 1). Three freshwater wetlands situated in close proximity to the estuary were also sampled. These sites included the Tweed Heads West and South Sewage Treatment Works, and the Trutes Bay Wetland.

Although the area sampled to assess impacts on estuarine birds includes a large amount of habitat not affected by the proposal the pattern of habitat use by estuarine birds, and migratory shorebirds in particular, demanded an estuary wide approach to impact assessment. Shorebirds (& other waterbirds) are highly mobile, and most likely utilise habitats throughout the estuary. Surveys focussing on only Cobaki Broadwater would fail to gain a full understanding of the impacts of the proposal.

For the purpose of the terrestrial bird assessment the study area encompassed all of the terrestrial habitats, including freshwater wetlands and mangrove forest occurring in NSW and within 500 m of the proposed C4 alignment (Figure 2). Most of the study area is situated in NSW, except for two small sections in the northern and southeastern corners, which are situated in Queensland. The majority of the study area is commonwealth land managed by Gold Coast Airport Limited (GCAL), with private and aboriginal land on the western and southern edges, and land owned by Gold Coast City Council situated in the northern corner. The terrestrial study area extends in a south and easterly direction from the proposed Boyd Street interchange to the proposed Kennedy Drive interchange (Figure 2).

2.2.1 Terms used to describe the areas addressed in this report

A number of terms are referred to in the following report to describe the area sampled to assess the impacts of the proposed C4 alignment on avifauna. These terms are defined briefly below:

Subject site – *Subject site* refers to all habitats within a 500 m radius of the proposed C4 alignment. The subject site includes all of the terrestrial study area, and part of the estuarine study area.

Study area – The term *study area* has been used to describe both the terrestrial and estuarine areas sampled during this survey. The estuarine study area encompasses the lower Tweed River estuary, whilst the terrestrial study area encompasses all terrestrial habitats (including mangroves) within 500 m of the alignment.

Locality – *Locality* refers to a 10 km radius of the proposed alignment. The *locality* encompasses both the *subject site* and the *estuarine* and *terrestrial study areas*.

Nomenclature used throughout the report follows Christidis and Boles (1994).

2.2 Land use within the study area

Land use in the vicinity of the proposed alignment is dominated by Coolangatta Airport. There is a small dredge spoil dump on the northern shore of Cobaki Broadwater that was used during dredging operations within the Broadwater. Access roads through the study area have been used previously by heavy vehicles to access the dredge dump. A small block of land adjacent to the dredge spoil dump is listed on the Register of the National Estate. This area is of significance to the local aboriginal community as well as being one of the few remaining examples of lowland rainforest in north-eastern NSW. A small refuse tip and sewage treatment works are situated in the northern corner (Figure 2). The western side of the study area includes both freehold and aboriginal land. This land is essentially unmanaged except for the maintenance of access tracks, and the presence of a small number of cattle. Land in the south-eastern corner of the study area is owned by TSC and private landholders. The Tweed Heads Pony Club currently leases land from council.

2.3 Existing environment

Habitats surrounding Coolangatta Airport have all suffered from some form of disturbance. Much of the land to the south east of the main airport runway is fragmented by trails, and has suffered disturbance from clearing. Despite the obvious disturbance good examples of heath, and swamp forest habitat occur in this area. Land immediately to the south of the main runway is regularly slashed to reduce the quality of habitat for birds, thereby reducing the risk of bird strike by aircraft. Despite the disturbance to this habitat a small area of saltmarsh, occurs near the eastern edge of Cobaki Broadwater. This habitat is being slowly over-grown by *Juncus* spp.

Land on the eastern edge of the study area that occurs within the area of restricted access surrounding the airport complex, is managed to reduce the risk of bird strike by aircraft (Figure 2). Management of this area includes the use of 'bird fright' to scare birds from the vicinity of the runway, the maintenance of grass levels to reduce the suitability of habitat, and occasionally shooting to remove resident species that are deemed at risk of collision with aircraft. Coolangatta Airport conducts monthly bird monitoring within the restricted access area surrounding the Airport (P. Shaw pers comm).

Land to the west of the restricted access zone includes the dredge spoil dump, national estate, and more land managed by GCAL. Habitat surrounding the dredge spoil dump has been heavily disturbed, and consists of a large open expanse of sand. Dredging within Cobaki Broadwater has recently ceased, and at the time of this study the final loads of sand were being removed from the spoil dump. Land on the eastern side of the National Estate is fragmented by roads, and consists of highly disturbed swamp forest and rainforest. Habitat fringing Cobaki Broadwater is relatively undisturbed with no access tracks. This habitat adjoins an extensive area of swamp forest and dry woodland that extends in a northwest direction. Much of the habitat on the western edge of the study area is relatively undisturbed, although there are several access tracks, and some of the land managed by the GCAL is either cleared, or consists of regrowth vegetation.

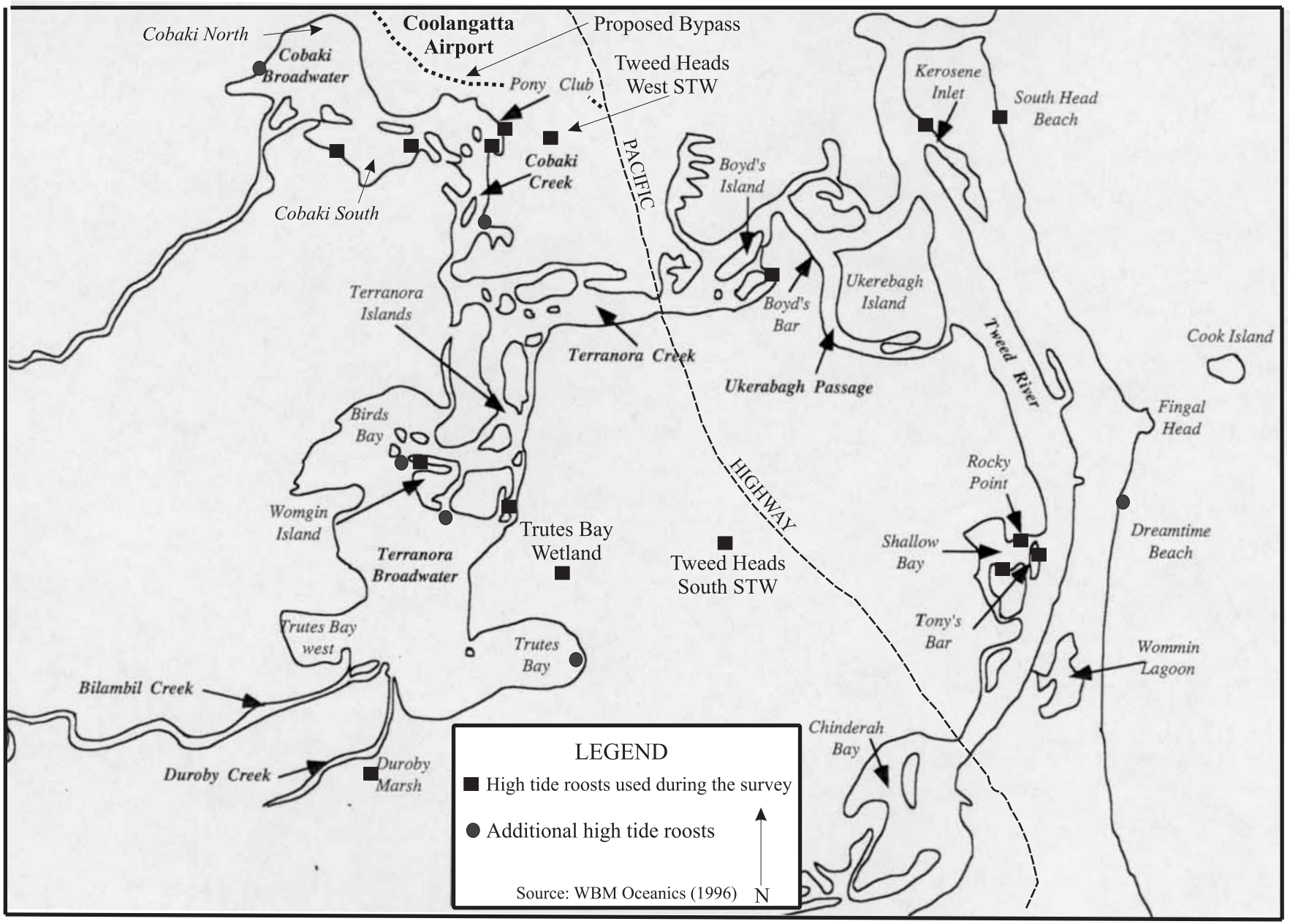


Figure 1: Location of estuarine bird survey sites in the lower Tweed River estuary in relation to the proposed Tugun bypass.

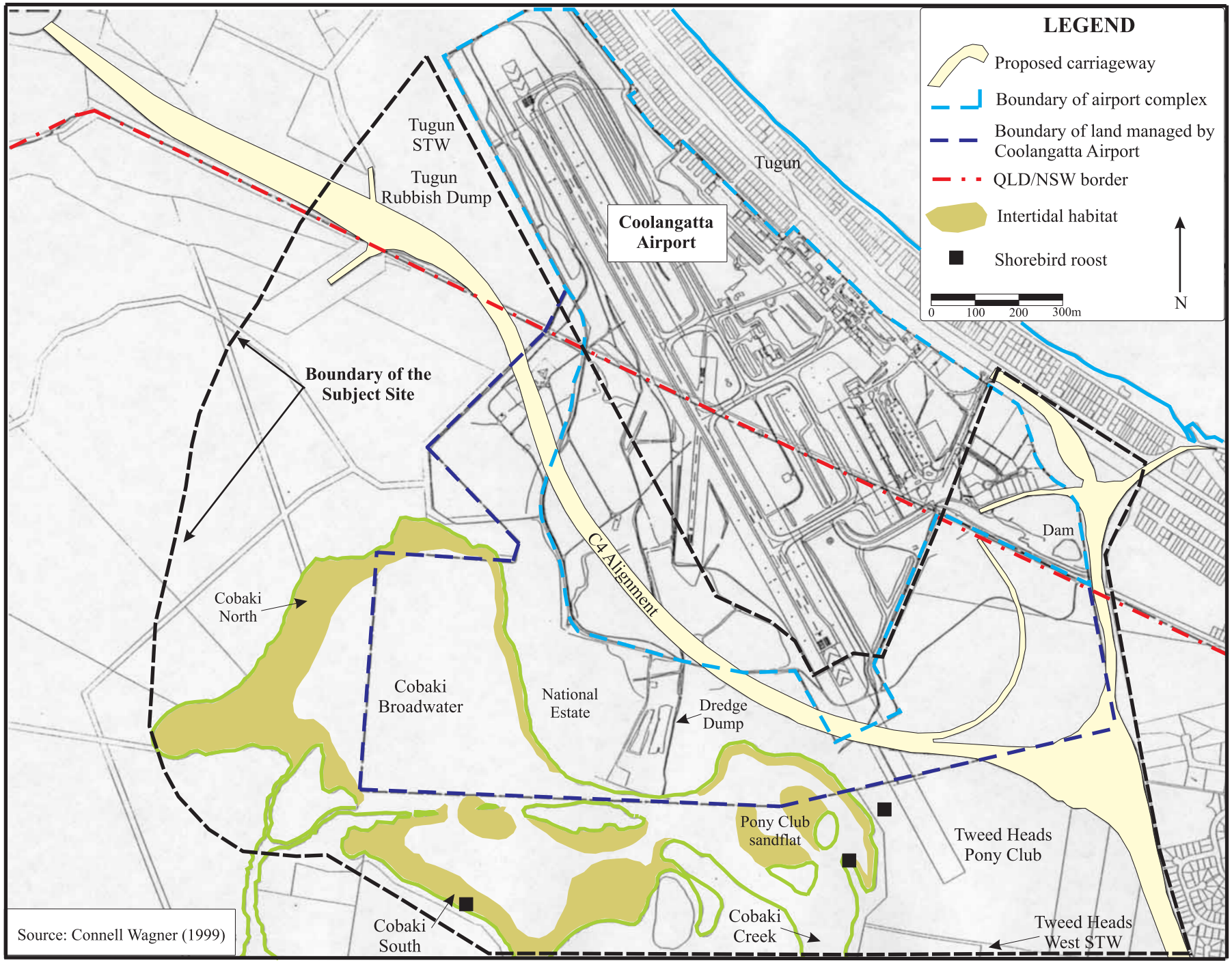


Figure 2: The study area in the vicinity of the proposed Tugun Bypass.

3. METHODS

3.1 Timing

3.1.1 Summer survey

A summer survey was conducted over 10 days, from the 21st of January to the 30th of January 2000. This time was chosen primarily because it coincided with the full moon phase, and covered both a spring and neap tidal cycle. The full moon provided ideal conditions for sampling nocturnal birds', whilst it was essential that habitat use by estuarine birds' be sampled during a spring and neap tidal cycle. Spring tides during the survey were the highest for the summer period at about 2.0 m (Table A, Appendix 1). The timing of the survey also represented a period of relative stability in the migration cycle of migratory shorebirds (Watkins 1993).

3.1.2 Autumn survey

A second survey was conducted over four nights, and four days between the 16th and the 21st of May 2000. The survey was conducted during a full moon phase. The late autumn survey was timed to coincide with the flowering of important plants, such as *Melaleuca quinquenervia*, and *Banksia integrifolia*, and the breeding season of threatened forest owls, and diurnal birds of prey.

3.2 Weather conditions

3.2.1 Summer survey

Weather conditions varied throughout the survey (Table B, Appendix 1). The early part of the survey was characterised by very hot and humid conditions, whilst the middle and later part of the survey was characterised by occasional showers, with mostly fine sunny weather. Rain did occur during the survey although it was generally limited to light showers, which mostly occurred during the night. All of the diurnal bird surveys were conducted during favourable weather conditions, although some of the nocturnal surveys were conducted during periods of heavy cloud and light rain.

3.2.2 Autumn survey

Weather conditions were stable during the autumn survey (Table C, Appendix 1). Mornings were generally cool, with light rain experienced during dawn surveys on the 18/5/2000. Nights were mainly fine with low cloud cover, good visibility, and light winds. Nocturnal surveys were not conducted on the 19/5/2000 due to strong wind and rain.

3.3 Estuarine bird surveys

The proposed bypass is situated in close proximity to known estuarine bird roosting and foraging habitat in Cobaki Broadwater (Martindale 1987). To assess the impact of the proposal on this habitat surveys of the major high tide roosts and low tide feeding areas in the lower Tweed River estuary were conducted.

3.3.1 Review of previous estuarine bird surveys

Since the late 1980's a number of surveys have been conducted on the estuarine bird population within the lower Tweed River estuary (eg. Martindale 1987; WBM Oceanics 1991; WBM Oceanics 1996; Sandpiper Ecological Surveys 1997, 1998, 1999, 2000; Queensland Wader Studies Group (QWSG) unpublished data 1993-2000). These surveys have generated a large body of data on the estuarine bird population within the study area. This information is regarded as valuable to assess the impact of the current proposal on the estuarine bird population within the lower Tweed River estuary. The value of long-term studies is that they can provide information on trends in habitat use and population size that cannot be obtained from 'one off' surveys that are associated with most impact assessments.

Although previous surveys have provided an extensive amount of information there are some limitations on how the data can be used. Differences in methods, particularly the sites sampled and the timing of surveys in relation to high and low tide preclude the comparison of population estimates between all surveys (Table 1). More recent surveys conducted by WBM Oceanics (1996), Sandpiper Ecological Surveys (1997, 1998, 1999, 2000), and the latter surveys by the QWSG (unpublished data 1995-2000) provide the most accurate indication of population size and habitat use. These surveys have included an almost complete coverage of the estuary, with high tide surveys conducted at or around mean high water. The early surveys by the QWSG were deficient in that they were conducted at various times during the tidal cycle, making it difficult to obtain accurate population estimates.

The presence of long-term monitoring data reduced the need to conduct a long-term study on the population dynamics and habitat use by estuarine birds for the purpose of this survey. The findings of previous surveys by the QWSG and Sandpiper Ecological Surveys are presented in the results section of this report, and have been used to assess the impacts of the proposal on the estuarine bird community, and in particular threatened species.

3.3.2 Surveys conducted as part of the present study

Despite the availability of long-term monitoring data a brief assessment of estuarine birds within the study area was required. The objective of this assessment was to ensure that data were gathered on sites of specific interest to this project, and to collect comparative data on important sites during a spring and neap tidal cycle. The timing of the survey coincided with a recognised period of stability in the migratory shorebird population (Watkins 1993).

Although the use of high tide roosts and low tide feeding areas varies between the different species of estuarine bird the timing of surveys ensured that habitats for all species were sampled. Surveys were scheduled around high and low tide to account for changes in habitat use. During high tides most species of estuarine bird, particularly wading birds congregate at areas called roosts, moving to forage at intertidal habitats as the tide recedes. To obtain a thorough understanding of the estuarine bird population it was essential that surveys were conducted at both high and low tide.

Table 1: Summary of the timing, methods, and number of sites sampled during previous surveys of estuarine birds in the lower Tweed River estuary.

Reference	Date of Survey	Purpose of Survey	Sites sampled	Tides	Method	Deficiency
Martindale (1987)	26/1 - 6/2/87	Identify important sites for shorebirds	10 – c, sw, wi, tb, wl, wb, tb, sb, ki, bb	high & low	Simultaneous estimation[1] & maximum counts[2]	incomplete coverage
Department of Public Works (1991)	12/12/90 to 2/4/91	Document use of the estuary by shorebirds	10 – tb, pc, tb, rp, up, ci, wi, db, sb, ki, cd, ci	high & low	Simultaneous estimation & maximum counts	variation in survey effort, incomplete coverage
Lawler (1994)	4-6 & 8/2/92	Document use of the estuary by shorebirds	7 – te, cc, cm, pc, tb, sb, ui	high & low	Simultaneous estimation & maximum counts	incomplete coverage
QWSG unpublished	1 day each month from 12/93 - 12/99	Document use of the estuary by shorebirds	11 – sb, ki, tb (rp), shb, pc, tc, tbr, tb, dm, cb, tsw	high	Simultaneous estimation	early surveys had incomplete coverage, and done at variable tide levels
WBM (1996)	Not stated	Monitoring for dredging proposal	11 – sb, ki, tb (rp), shb, pc, tc, tbr, tb, dm, cb, tsw	high	Not stated	incomplete information provided in report
Sandpiper Ecological Surveys	3 days/ quarter from 3/97 - 6/2000	Monitoring of estuarine birds	23 – sb, ki, db, tb, rp, shb, cb, tr, bi, ui, tc, cc, pc, c, ti, w, bb, t, dm, st1, st2, tw	high & low	Simultaneous estimation & maximum counts	Surveys done quarterly

sb = South Head Beach, ki = Kerosene Inlet, db = Dreamtime Beach, tb = Tony's Bar, rp = Rocky Point, shb = Shallow Bay, cb = Chinderah Bay, tr = Tweed River, bi = Boyd's Island, ui = Ukerabagh Island, tc = Terranora Creek, cc = Cobaki Creek, pc = Pony Club, c = Cobaki Broadwater, ti = Terranora Islands, w = Womgin Island, bb = Birds Bay, t = Terranora Broadwater, dm = Duroby Marsh, st1 = Tweed Heads south STW, st2 & tsw = Tweed Heads west STW, tw = Trutes Bay Wetland, sw = sewage drain, wi = Womgin Island, wl = Wommin Lagoon, wb = Wommin Bay, ci = Caddy's Island, cd = canal developments, te = Terranora entrance, cm = Cobaki Mangroves, tbr = tweed Broadwater.

High tide surveys

High tide surveys were conducted at 23 sites distributed throughout the lower Tweed River estuary (Figure 1). The sites sampled are essentially the same as those sampled by Sandpiper Ecological Surveys since 1997. Surveys were conducted on three consecutive days during a spring tidal cycle (21-23 January), and three consecutive days during a neap tidal cycle (27-29 January). Surveys were scheduled around the timing of high tide as indicated on the tide chart for the Tweed River (National Tidal Facility). The specific timing of each survey changed from one day to the next in accordance with changes in the time of high water (see Table A, Appendix 1).

Sites were sampled in the same order during each high tide survey. High tide surveys commenced at Chinderah Bay approximately one hour prior to high tide (Figure 1). Surveys were then conducted down the Tweed River to Kerosene Inlet, through Ukerabagh Passage, up Terranora Creek and into Terranora Broadwater, and Duroby Marsh. The final site sampled was the Cobaki Fringe. All sites were accessed by boat, with one observer conducting the surveys.

[1] Simultaneous estimation involves visiting as many sites as possible within one high tide period to reduce the risk of double counting.
[2] Maximum counts are obtained by visiting a site repeatedly over a period of time. The count recorded is the maximum number of birds seen in that area over the period of the survey.

The exception to the above protocol was South Head and Dreamtime Beaches, Trutes Bay wetland, and the Tweed Heads west and south sewage treatment works which were accessed by vehicle. A second observer sampled these sites at high tide whilst other estuarine sites were being sampled by boat. Both beaches were surveyed on four occasions only (two spring and two neap tide surveys), whilst the sewage treatment works and Trutes Bay wetland were surveyed on two occasions only (one spring tide and one neap tide).

At each site the number of species and individuals were recorded, and any interesting behaviour or evidence of breeding was noted. Each survey took approximately four hours to complete. Surveys were conducted as rapidly as possible without compromising accuracy. To reduce the opportunity for double counting care was taken to ensure that birds were not disturbed during each survey. High tide surveys in the estuary were conducted using a 20-60 x 80 mm spotting scope, and a pair of 10 x 50 mm binoculars. Surveys at other sites were conducted using a pair of 8 x 40 mm binoculars.

Low tide surveys

Low tide surveys were conducted at the 10 most important intertidal habitats within the study area (Figure 1). The 'importance' of a site was determined from the results of previous monitoring surveys conducted by Sandpiper Ecological Surveys (1997, 1998, 1999, 2000). Sites that generally supported large numbers of estuarine birds at low tide were deemed to be important (Table 2).

Low tide survey sites were placed into two groups depending on their location within the estuary (Table 2). Sites within the Tweed River were sampled during one low tide period, and sites in the Terranora and Cobaki Broadwater's were sampled during another low tide period. Low tide surveys often take a considerable amount of time to complete, consequently it was necessary to divide the survey effort over two days. This provided the opportunity to spend more time at each site and obtain an accurate estimate of the number of individuals and species at that site.

Sampling feeding areas over two days was not detrimental to the survey as the objective of low tide surveys was to document the use of individual sites as opposed to obtaining a population estimate of birds within the study area. Low tide surveys were conducted using a 20-60 x 80 mm spotting scope, and a pair of 10 x 50 mm binoculars.

Table 2: Sites sampled during low tide surveys in the Tweed River estuary and the date that each site was sampled.

Group	Site	Spring tide survey	Neap tide survey
Tweed River	Chinderah Bay	22/1	28/1
	Tony's Bar	22/1	28/1
	Shallow Bay	22/1	28/1
	Kerosene Inlet	22/1	28/1
Broadwater's	Pony Club	21/2	29/1
	Cobaki south	21/2	29/1
	Cobaki north	21/2	29/1
	Womgin Island	21/2	29/1
	Trutes Bay	21/2	29/1
	Charles Bay	21/2	29/1

3.3.3 Habitat use by estuarine birds in Cobaki Broadwater

To obtain further information on the value of habitat within Cobaki Broadwater for estuarine birds, a general survey of habitat use was conducted. The survey focused primarily on migratory shorebirds (bar-tailed godwit *Limosa lapponica*, eastern curlew *Numenius madagascariensis* & whimbrel *N. phaeopus*), although specific attention was also given to osprey (*Pandion haliaetus*), white-bellied sea-eagle (*Haliaeetus leucogaster*), and brahminy kite (*Haliastur indus*).

The use of Cobaki Broadwater by shorebirds was monitored during two ebb (falling), and two flow (rising) tides between the 21st and the 30th of January 2000. Ebb tide surveys were conducted over a four-hour period, commencing two hours after high water (at Cobaki Broadwater), and continuing until low water. Flow tide surveys were also conducted over a four-hour period, commencing at low tide (at Cobaki Broadwater), and continued until two hours prior to high tide.

The objective of the habitat use study was to determine if the use of intertidal habitats in the vicinity of the Pony Club changed throughout the tidal cycle. Of particular concern was whether these sites were used as a mid-tide staging area by birds moving to and from the larger intertidal flats in Cobaki Broadwater. Although low tide counts provide a general indication of the value of intertidal habitats these counts do not provide detailed information on the overall value of a site. Some sites may represent important mid-tide staging areas but are not used by many birds at low tide.

Bird movements

During ebb tide surveys the pattern of bird movement onto intertidal habitats within Cobaki Broadwater was recorded as these habitats became exposed. Surveys focussed primarily on the Pony Club sandflat, and the Cobaki south mudflat (Figure 2). Observations were conducted from the western end of the central Pony Club sandflat. From this point the observer could readily scan the Pony Club sandflat, and record any birds moving along Cobaki Creek to the Cobaki south mudflat.

The number of birds using the Pony Club was recorded every 20 minutes during each survey period. The movement of birds past the Pony Club sandflat sites was documented as it occurred. The number of individuals and species of birds at Cobaki south was recorded every hour. During each scan the number of species and individuals present and their behaviour was recorded. All observations were made using a 20-60 x 80 mm spotting scope or a pair of 10 x 50 mm binoculars.

Flow tide surveys used a similar procedure to ebb tide surveys. Although rather than documenting the movement of birds' onto intertidal habitats flow tide surveys documented the movement of birds from these habitats to roosts was documented. Movement through the study area by birds of prey was documented as it occurred.

Foraging behaviour

The feeding rates of shorebirds using the Pony Club and Cobaki south mudflats were surveyed to gain some understanding of the value of these sites to the daily energy intake of the birds. Between each 20-minute scan birds were selected at random from feeding flocks and their feeding rate was recorded. Birds were observed continually and the time taken to consume five prey items was recorded.

The type and size of each prey item consumed was recorded during each observation. Feeding rate was calculated by dividing the time taken to consume prey by five (the number of prey consumed). Feeding observations were conducted at Pony Club, Cobaki south and Womgin Island in Terranora Broadwater. Observations were conducted using a 20-60 x 80 mm spotting scope, or a pair of 10 x 50 mm binoculars. Specific attention was also focused on foraging and roosting areas used by osprey during low tide.

3.3.4 Estuarine habitat assessment

Intertidal mudflats

A baseline intertidal habitat assessment was conducted to obtain general information on intertidal habitat adjacent to the bypass in relation to habitat available within the lower Tweed River estuary. This assessment was regarded as valuable to determine the importance of intertidal habitat that may be affected by the proposal, and to assist in the interpretation of data gathered on shorebird habitat use.

The assessment sampled a range of habitat attributes that are known to be important to shorebirds. Information on important habitat parameters was obtained from personnel experience, and from Lawler (1994, 1996). A list of the attributes sampled, and a summary of the method used is provided in Table 3. Surveys were conducted during low tide, at the same 10 sites sampled during the low tide estuarine bird surveys.

Table 3: Summary of the parameters sampled during the intertidal habitat assessment of shorebird foraging habitat conducted at 10 sites in the Tweed River estuary.

Major habitat attribute	Parameter Sampled	Method
General features	Type of habitat	Choice of 3: fringing, sandbank, spit
	Area of flat covered by mangroves	Estimate (%) of area covered
Area of mudflat	Area of mudflat	Estimate the area (ha) of mud exposed during a spring low tide
	Average width of the intertidal area	Estimate of the average width (m) of intertidal habitat
	Proximity to roost	Measure the distance (m) from the mudflat to the nearest high tide roost using a 1: 25 000 topographic map
Substratum	Substratum type	Choice of 5: sand; muddy sand, sandy mud, mud, seagrass
	Micro-habitat	% coverage of: dry, moist, wet or shoreline
Seagrass	Seagrass	Area (%) of the substratum covered by seagrass
Invertebrates	Abundance of crabs & ghost shrimps	Average count of the number of surface hollows within 5 replicate 25cm^2 quadrats

Roosts

Sandpiper Ecological Surveys (1998) provide a summary of the major characteristics of high tide roosts in the lower Tweed River estuary. This assessment was conducted in December 1998. Information gathered during the assessment has been used in the present study, with additional information added for sites that have undergone changes since December 1998.

3.4 Terrestrial bird surveys

During the summer survey a comprehensive assessment was conducted of all bird species present within terrestrial habitats in the study area. The summer survey included both targeted surveys for threatened fauna, and general surveys for all bird species. In contrast, the autumn 2000 survey targeted only threatened (or legislatively protected) species, although a list of non-threatened species was compiled.

A variety of methods were employed to survey the terrestrial bird community. The terrestrial bird survey included a combination of methods specified by the NSW National Parks and Wildlife Service (1999), and standard procedures that targeted specific groups of birds. Terrestrial surveys included a general quantitative and qualitative assessment of species richness and relative abundance, within the major habitat types, and targeted surveys for threatened fauna or species of conservation significance in selected habitats.

The major habitats within the study area were identified during site inspections conducted on the 11th and 14th of January 2000, and from information provided by Connell Wagner (1999). The pre-survey inspections facilitated the implementation of a stratified sampling design whereby replicate survey sites were selected within each of the major habitats prior to the commencement of the survey.

3.4.1 Point Counts

To obtain some indication of the relative abundance of birds within different habitats in the study area replicate point counts were conducted in each habitat. Point counts provide a rapid means of obtaining accurate data on the relative abundance of birds within specific habitats (Bibby *et al.* 1992). In the present case point counts were deemed to be superior to transects as the density of the vegetation in a number of habitats (particularly mangroves) greatly affects the ability to detect birds whilst moving along a transect. The use of point counts during the present study also provided data that were comparable to mangrove bird monitoring surveys conducted by Sandpiper Ecological Surveys (unpublished data).

Point count surveys consisted of three point counts along replicate 200 m transects. Each point was separated by 100 m. Five minutes was spent at each point recording the number of birds and species present within a 30 m radius of the observer. Birds were identified through direct observation and call identification. To reduce the impact of disturbance two minutes were spent waiting at each point prior to the commencement of each five-minute observation period (Bibby *et al.* 1992). Each point count site was regarded as a replicate.

A total of 45 point counts were conducted during the survey (Table 4, Figure 3). Each point was surveyed on two non-consecutive mornings by the same observer. The habitats sampled included, woodland, swamp forest, lowland rainforest and mangrove. Point counts were not conducted in heathland, sedgeland or open grassland due to the limited extent of these habitats, and the difficulty associated with getting replicate transects. Each transect was surveyed by one person during favourable weather conditions. Point counts were conducted between 6.00 and 9.00 am (Daylight Savings time).

Although only birds within a 30 m radius were recorded for the purpose of point counts all species outside of this area were recorded as being present. Bird species recorded during a slow traverse between point count locations (i.e. between 0 and 100 m along a transect) were also recorded to provide an indication of species richness. The data gathered during the slow traverse were analogous with the data gathered using the area search technique described below.

3.4.2 Area search

Area searches were used to obtain information on the species richness of birds within each of the habitats in the study area. The data collected during each area search consisted only of the number of species present within a particular habitat. Area searches were conducted between 6.00am and 10.30 am, and involved a 30 to 60 minute meandering traverse by one observer. During a traverse the number of species present within each habitat was recorded by either sight or call.

Repeated area searches were conducted in each of the major habitat types present in the study area (Figure 3). Repeat surveys were generally conducted in the same vicinity as the initial survey however, rarely did repeat surveys follow the same route (Figure 3). A total of 32 area searches were conducted within seven habitats (Table 4). Over 32 hours were spent conducting area searches during the summer survey (Table 4), with a further 16 hours spent conducting area searches during the autumn survey (Table 5).

3.4.3 General traverse

General traverses were conducted in the late afternoon (i.e. between 4.00 and 7.30 pm), and consisted of walk transects through the study area. The objective of general traverses was to survey small habitats and to identify sites, such as small wetlands, that may be suitable for dusk or nocturnal playback. General traverses were conducted within five areas, western woodland, rubbish tip and sewage treatment works, highway lagoon, airport heath, and melaleuca regrowth (Figure 3).

3.4.4 Canoe traverses

Canoe traverses were conducted during early morning high tides at two sites (Figure 3). One traverse was conducted along the northern shore of Cobaki Broadwater, whilst the second traverse was conducted along a drainage channel between land owned by Coolangatta Airport, and land owned by the TSC. Two repeat surveys were conducted at each site.

3.4.5 Playback

Nocturnal playback

Nocturnal playback was conducted during both the summer and autumn surveys. The species targeted during the survey included masked owl (*Tyto novaehollandiae*), barking owl (*Ninox connivens*), powerful owl (*Ninox strenua*) and grass owl (*Tyto capensis*). During summer playback for masked, barking and powerful owls was conducted at five sites, whilst playback for grass owl was conducted at one additional site (Figure 4, Table 6). During the autumn survey playback for masked, barking and powerful owls was conducted at four sites, whilst playback for grass owl was conducted at one site (Figure 4, Table 6). During the autumn survey no playback was conducted at the highway site.

Playback was conducted over two non-consecutive nights at each site during each survey period. The exception to this was the north-western corner of the study area, which was surveyed on only one occasion during the summer survey. Surveys commenced at least 30 minutes after dark (i.e. at about 9.00pm), and were conducted by two observers spaced about 200 m apart.

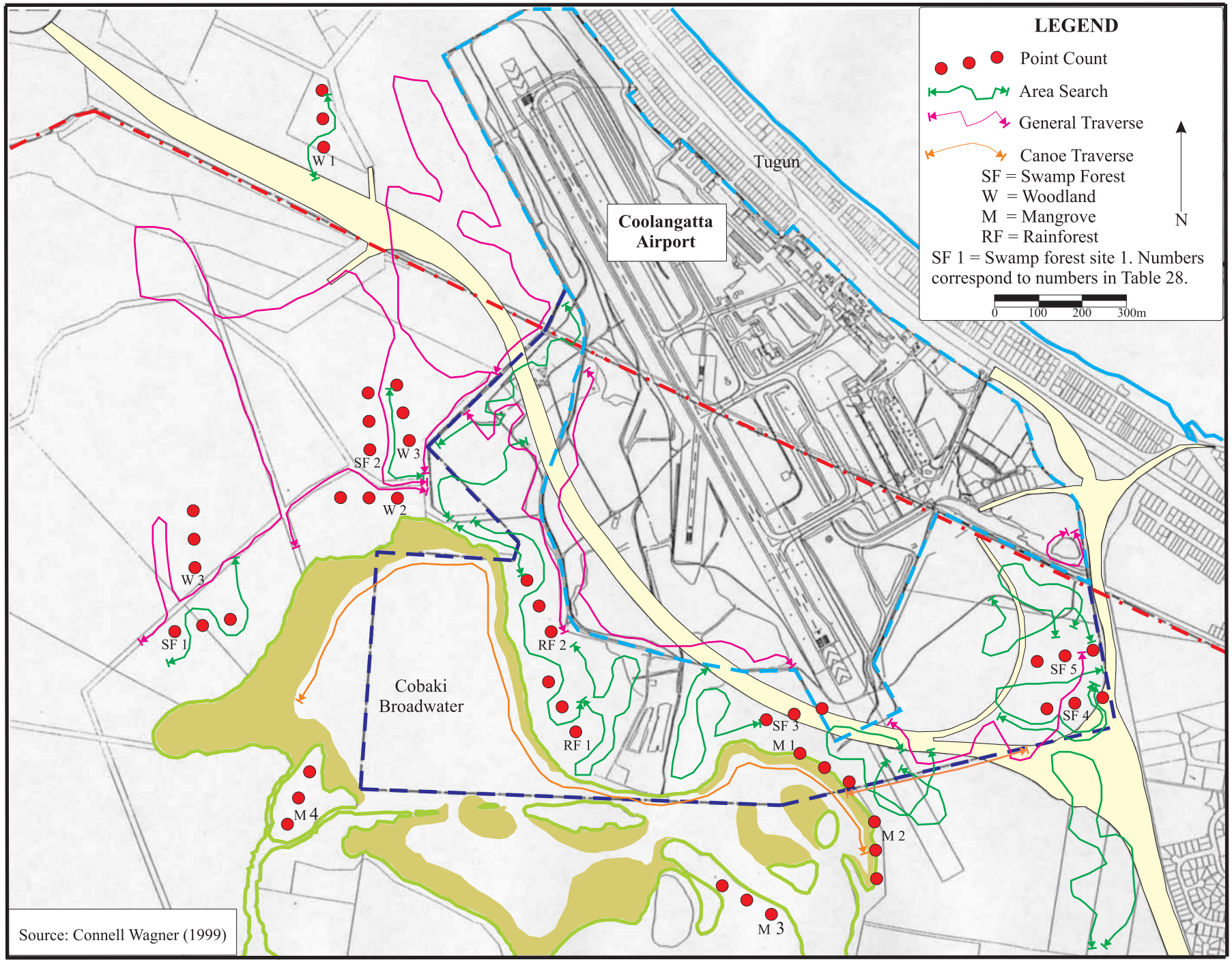


Figure 3: Location of point counts, area searches, general traverses and canoe traverses within the study area..

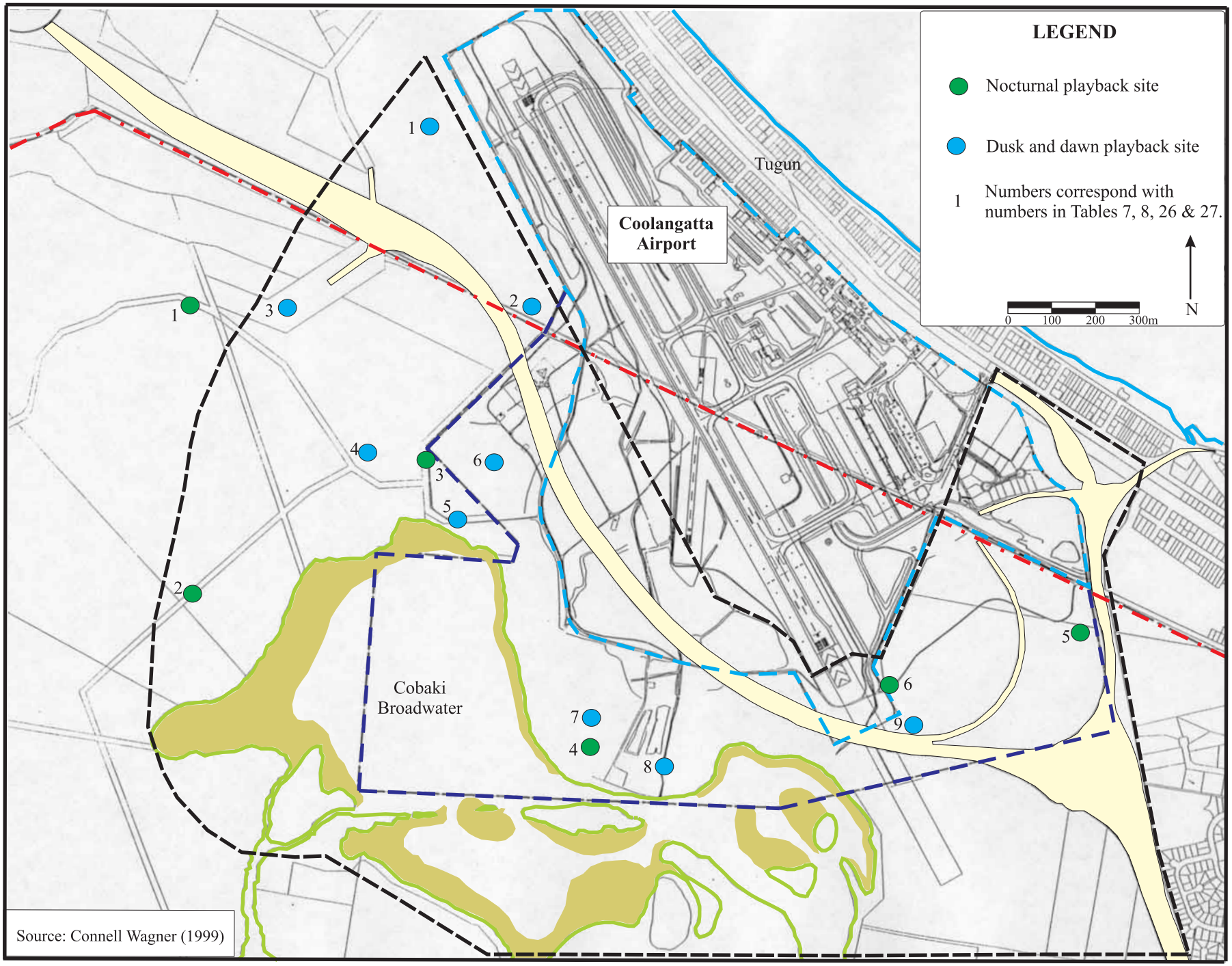


Figure 4: Location of nocturnal, dusk and dawn playback sites within the study area.

Upon arrival at a site 10 minutes was spent listening for owl calls. After this period the calls of each species (in the order powerful, masked and barking owl) were broadcast through a 10 watt megaphone for a period of five minutes, with a two minute gap between calls. The final call was followed by a 10 minute listening period, which was inturn followed by a brief (approximately 200 m) spotlight traverse in the vicinity of the playback site. The objective of the spotlight survey was to detect owls that may have approached the playback site without responding to the broadcast (NPWS 1999).

Table 4: Summary of the survey effort expended during the summer survey of diurnal terrestrial birds for the proposed Tugun Bypass avifauna assessment. * includes time taken during point counts; trans = transect, no. repeats = number of repeated surveys on each transect, traver = traverse.

Habitat	Point Count			Area Search*			General Traverse		
	No. trans.	No repeats	Time (mins)	No. traver	No repeats	Time (mins)	No. traver	No repeats	Time (mins)
Woodland	4	2@2 1@2	90	6	2	236	1	1	150
Swamp forest	5	2	150	9(2)	2	648	1	1	60
Mangrove	4	2	120	4	2	257	0	0	0
Rainforest	2	2	60	5	2@2 1@3	390	0	0	0
Heathland	0	0	0	3	1	150	1	1	45
Sedgeland	0	0	0	3	1	150	1	1	30
Melaleuca regrowth	0	0	0	2	2@1	90	0	0	0
Disturbed	0	0	0	0	0	0	2	1	90

Table 5: Summary of the survey effort expended during the autumn survey of diurnal terrestrial birds for the proposed Tugun Bypass avifauna assessment. * includes time taken during targeted surveys. Abbreviations are the same as Table 5.

Habitat	Area Search*			Edge Effects		
	No. traver	No. repeats	Time (min)	No. traver	No. repeats	Time (min)
Woodland	1	1	45	0	0	0
Swamp forest	6	2@2	210	3	1	135
Mangrove	4	1	140	0	0	0
Rainforest	1	3	255	0	0	0
Heathland	4	1	130	3	1	135
Sedgeland	1	2	50	0	0	0
Melaleuca regrowth	2	1	80	0	0	0
Disturbed	2	2@1	75	0	0	0

Table 6: Nocturnal broadcast sites sampled during the summer and autumn surveys for the proposed Tugun Bypass. Site numbers correspond to those shown on Figure 4. PO = powerful owl, MO = masked owl, BO = barking owl; * playback conducted for these species at this site during autumn only.

Site	Location	Habitats sampled	Calls played	Number of surveys	
				Summer	Autumn
1	NW corner	Woodland; Swamp forest	PO, MO, BO	1	2
2	SW corner	Woodland; Swamp forest	PO, MO, BO	2	2
3	West central	Woodland; Swamp forest	PO, MO, BO	2	0
4	Tide gauge	Rainforest, grassland, mangrove; Swamp forest	PO, MO, BO	2	2
5	Highway	Heath; Swamp forest, Melaleuca regrowth	PO, MO, BO	2	0
6	South Runway	Sedgeland	GO, PO*, MO*, BO*	2	2

Dusk playback

Dusk playback targeted bitterns, crakes and rails, and was conducted at nine sites situated throughout the study area (Figure 4, Table 7). Three of the nine sites were sampled again during the autumn survey (Table 7). Playback specifically targeted Australasian bittern (*Botaurus poiciloptilus*), black bittern (*Ixobrynchus flavicollis*) and bush hen (*Amaurornis olivaceus*), although the calls of Lewins rail (*Rallus pectoralis*), buff-banded rail (*Gallirallus phillipensis*), spotless crake (*Porzana tabuensis*), Baillon's crake (*P. pusilla*), spotted crake (*P. fluminae*), and little bittern (*I. minutus*) were also played in appropriate habitats (Figure 4). Survey sites were selected on the basis of potential habitat, and the suite of calls played was dependent on the habitat present.

Playback for Australasian bittern was conducted at two sites, whilst playback for black bittern and bush hen was conducted at six sites (Figure 4). The method used was the same as that described above for nocturnal playback. Dusk surveys commenced one hour prior to dusk, and generally continued for approximately 30 minutes after sunset. This time was selected as it represents a period of known activity for bitterns, crakes and rails. Two observers were used during the dusk surveys, with a distance of approximately 100-150 m between observers.

Dawn playback

Dawn playback was conducted throughout sedgeland and saltmarsh, at the southern end of the main runway (Figure 4). This site was characterised by a mixture of dense sedge/grassland, low wet heath, tall dense *Phragmites australis* and saltmarsh dominated by salt couch *Sporobolus virginicus* and *Sarcocornia quinqueflora*. During dawn playback the calls of red-backed button quail (*Turnix maculosa*) and Australasian bittern were broadcast for periods of three minutes whilst conducting a slow meandering traverse. Dawn playback was conducted simultaneously with area searches. Dawn playback was conducted on two separate occasions during both the summer and autumn surveys.

Table 7: Dusk broadcast sites sampled during the summer and autumn surveys for the proposed Tugun Bypass. Site numbers correspond to those listed on Figure 4. AB = Australasian bittern, BB = black bittern, LB = little bittern, BH = bush hen, LR = Lewins rail, BBR = buff-banded rail, SC = spotless crake, SPC = spotted crake, BC = Baillon's crake.

Site	Location	Habitats sampled	Calls played	Number of surveys	
				Summer	Autumn
1	Sewage Ponds	Reed beds	AB, BB, LB, BH, LR, BBR, SC, SPC, BC	2	0
2	Refuse tip dam	Dam/reed beds/melaleuca	BH	1	0
3	NW corner	Swamp forest	BB	1	2
4	Creek Crossing	Swamp forest	BB, BH, LR, BBR, SC, SPC, BC	2	1
5	Rainforest nth	Swamp forest, rainforest	BB, BH	1	0
6	Central swamp	Swamp forest	BH, LR, BBR, SC, SPC, BC	1	1
7	National estate	Rainforest/paperbark	BB, BH	1	0
8	Dredge Dump	Sedgeland, drain	BB, BH, AB, LR	1	0
9	South runway	Sedgeland	AB, LB, LR	2	0

3.4.6 Dusk listening

Dusk listening represents an effective way of gathering information on the occurrence of nocturnal and crepuscular birds, and can provide valuable information on the location of diurnal roost sites (NPWS 1999). The basic method employed during dusk listening was to approach a site immediately prior to dusk, and sit quietly at that site for a period of approximately 30 minutes listening for calls of threatened birds. During summer dusk listening was conducted on one night at each of three sites within the study area, whilst during autumn dusk listening was conducted on one night at each of four sites.

3.4.7 Opportunistic

All records of birds made whilst moving around the study area were recorded, and the habitat type used was noted. Opportunistic records have been included into the general bird lists for each habitat type.

3.4.8 Supplementary surveys

In December 2000 supplementary surveys for black bittern were conducted within the study area. These surveys involved dusk playback on two non-consecutive nights at site 3 (NW corner), and a traverse of the creekline situated on the western side of the study area. The objective of the traverse was to assess the quality of habitat for black bittern.

3.4.9 Edge effect associated with the existing Pacific Highway

To determine if the existing Pacific Highway influences the species richness and density of birds in adjacent habitats a brief field survey was conducted. Transects were established perpendicular to the existing Pacific Highway at six sites (Figure 3). Three transects were situated in heathland habitat, and three in swamp forest. Each transect was separated by a distance of between 100-150 m. The number of individuals and species of bird was recorded at six points along each transect. Birds were recorded within a 25 m radius of each point. A distance of 50 m separated points, with the first point commencing at 25 m from the edge of the highway. The final point was situated 275 m from the edge of the highway. The survey design is similar to that used by Baker *et al.* (1998), and Sandpiper Ecological Surveys (2000). Surveys at all sites were conducted between 7.00 am and 9.30 am during autumn 2000, and each site was sampled on only one occasion.

Data for each habitat type were analysed separately using one-way Analysis of Variance (ANOVA) in SPSS 10. The parameters analysed included species richness and relative abundance. It was impossible to analyse data for individual species due to large variability in the occurrence of most species between sites. In the analysis each of the six distances was regarded as a separate treatment. The analysis looked for differences in species richness and relative abundance between distances. The data were also grouped into edge (25, 75 and 125 m), and interior (175, 225 and 275 m) sites for further analysis. The purpose of this analysis was to determine if there were any broad differences between edge and interior samples that were not detected in the initial analysis.

3.4.9 Data manipulation

The large number of methods employed during the study and the inter-relationships between some of the methods (eg. point counts & area searches) increases the likelihood of confusion regarding the origin of records presented in the results. To reduce confusion a summary of how data collected using each method has been used is provided in Table 8. In addition to the methods outlined in Table 8 a summary table of threatened and regionally significant species, and maps showing the location of threatened species records are included in the results. The results of summer and autumn surveys have been combined in the results section, although the data are summarised in Appendix 4.

Table 8: Summary of how the data collected from each of the survey methods has been used in the results.

Method	Summary of how data have been used
Point Counts	• Relative abundance of birds/ha for each habitat sampled • Combined with area search data to compile a species list for each site • Data included in a general species list for each habitat type within the study area
Area Search	• Species list for each site separated by habitat (repeat counts combined) • Data included in a general species list for each habitat type within the study area
General Traverse	• Data included in a general species list for each habitat type within the study area
Canoe Traverse	• Data included in a general species list for each habitat type within the study area
Playback	• Results presented separately for nocturnal, dusk and dawn playback • Data included in a general species list for each habitat type within the study area
Dusk listening	• Data included in a general species list for each habitat type within the study area
Opportunistic	• Data included in a general species list for each habitat type within the study area

4. RESULTS

4.1 Estuarine habitat assessment

4.1.1 Characteristics of high tide roosts in the study area

The major features of 11 high tide roosts within the lower Tweed River estuary are shown in Table 9. Only those sites that are regularly used as roosts by estuarine birds, or that consist of a recognised roost site, have been included. Sites sampled during the survey that do not include a recognised roost include Chinderah Bay, Tweed River, Ukerabagh Island, Terranora Creek, Cobaki Creek, Terranora Islands, Birds Bay, and Terranora Broadwater. Although Caddy's Island represents a separate site it was included with Terranora Creek during this survey.

There are a variety of roost types available to birds within the study area, including ocean beaches, sand islands, sand bars, salt marsh, and mangroves. Unfortunately all of the beach and sand island or sand bar roosts are heavily disturbed by people or are declining in quality due to vegetation encroachment or erosion. Saltmarsh has been deteriorating through vegetation (mainly mangroves and *Juncus* spp.) encroachment. Although there are extensive areas of mangrove habitat that may be used for roosting, this type of roost is generally used only by a small number of species. Most species, and in particular shorebirds prefer open sandy roosts with a gently sloping shoreline.

Table 9: Summary of the major features of high tide roosts surveyed to assess the impact of the proposed Tugun Bypass. * Visual estimate only, Dist = disturbance, D'time = Dreamtime, mang. = mangrove. Data were obtained from Sandpiper Ecological Surveys (1998a).

Site	Spring or neap	Distance to FG > 1ha	Roost Type	Area* exposed @ 1.7 m	Origin	Substratum Type	Land Connection	Deterioration	Dist.
South Beach	neap	4.5 km	Ocean beach	5000 m^2	natural	sand	yes	Erosion	high
D'time Beach	spring	1.25 km	Ocean beach	4000 m^2	natural	sand	yes	None	high
Kerosene Inlet	spring	4 km	Spit, groin	2300 m^2	Human	Sand, rock	yes	Mangroves	high
Tony's Bar	neap	adjoins	island	400m^2	natural	sand	At low tide	Mangroves	high
Rocky Point	spring	adjoins	rocks	5 m^2	human	rock	yes	Mangroves	low
Shallow Bay	spring	adjoins	mangrove	-	natural	-	yes	None	low
Boyd's Island	spring	adjoins	mangrove	-	natural	-	yes	None	low
Pony Club	spring	0.5 km	saltmarsh	2500 m^2	natural	Muddy sand	yes	*Juncus* spp	low
Big Island	spring	0.1 km	mangrove	-	natural	-	no	None	low
Womgin mang.	spring	adjoins	mangrove	-	natural	-	no	none	low
Duroby Marsh	spring	1.75 km	saltmarsh	7500 m^2	natural	Sandy mud	yes	mangroves	low

4.1.2 Characteristics of feeding grounds in the study area

The intertidal habitat assessment provided baseline information on the major characteristics of 10 intertidal mudflats within the study area (Table 10). Intertidal foraging habitat within the study area consists of either extensive mudflats in sheltered bays, such as Chinderah, Shallow, Trutes and Cobaki, and more exposed sandflats in areas of greater tidal flow such as Womgin Island, Pony Club, and Tony's Island (Figure 1). Kerosene Inlet is somewhat unique in that it consists of a sand spit typical of a high-energy environment, although more sheltered sandbars do occur within the inlet.

The results of the assessment emphasises the extent (approximately 30 ha) of intertidal habitat within Cobaki Broadwater, particularly at Cobaki south and Cobaki north. These sites are however, smaller than the intertidal flats in Terranora Broadwater, which total in excess of 40 ha (Table 10). The largest area of intertidal habitat was recorded at Trutes Bay (Table 10). Approximately 3-3.5 ha of intertidal sandflat was recorded at the Pony Club, which is similar in size to sandy intertidal habitats at Kerosene Inlet and Tony's Bar.

Table 10: General features of 10 intertidal habitats within the Tweed River estuary. Each site was sampled at low tide. * visual estimate only.

Site	Habitat Type	Mangrove cover (%)	Estimate of area*	Average width	Proximity to roost	Substratum type	Micro-habitat % cover of				Seagrass
							dry	moist	wet	shore	
Kerosene Inlet	spit	0	3 ha	40 m	adjoining	sand	40	20	35	5	none
Tony's Bar	sandbar	28%	5 ha	60 m	adjoining	muddy sand	40	20	20	20	small
Shallow Bay	fringing	0	3.5 ha	40 m	50 m	mud	25	35	20	20	large
Chinderah Bay	fringing	0	9-10 ha	50 m	2000 m	mud	10	40	30	20	small
Trutes Bay	fringing	0	15-20 ha	80 m	1500 m	mud	5	25	60	10	none
Trutes Bay west	fringing	0	10-15 ha	60	1000 m	mud	5	40	40	15	none
Womgin Is	sandbar	5%	10-15 ha	80 m	2000 m	muddy sand	30	25	25	20	moderate
Pony Club	Sandbar & fringe	0	3-3.5 ha	40 m	100 m	muddy sand	30	20	30	20	none
Cobaki sth	fringing	1%	10-15 ha	80 m	400 m	mud	10	40	25	25	none
Cobaki nth	fringe	0	10-15 ha	100 m	1400 m	mud	10	25	35	30	none

4.2 January 2000 estuarine bird survey

4.2.1 Population estimate, species richness and status of estuarine birds

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 (Table 11). 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 population estimate represents the maximum number of each species of estuarine bird recorded during the six (three neap & three spring) repeat surveys at 20 estuarine sites, and three freshwater wetlands. The population estimates derived during each of the individual surveys is provided in Table 2c, Appendix 2.

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 *TSC* Act;
- two species listed as endangered under the NSW *TSC* Act; and
- one species listed as vulnerable on the Federal *Endangered Species Protection* (ESP) Act (1992).

4.2.2 High tide surveys

A total of 20 estuarine sites were surveyed during high tide. Although not all of these sites are regarded as *high tide roosts* each site was used to some degree by estuarine birds (Table 12). The use of sample sites varied between the different groups of birds.

Waterfowl and waterbirds

Waterfowl were recorded in low numbers at brackish water sites, with the largest numbers recorded at Chinderah Bay, and at Duroby Marsh (Table 12). In contrast, waterbirds were widely distributed throughout the study area, except for South Head and Dreamtime Beaches. The largest number and species richness of waterbirds were recorded at Chinderah Bay, followed by the Tweed River, Ukerabagh Passage, Boyd's Island, Cobaki Creek, Terranora Islands, Terranora Creek and Cobaki Creek (Table 12). Lower species richness but large populations of waterbirds were recorded at Kerosene Inlet. Small numbers of waterbirds were recorded at Pony Club, Cobaki south and Cobaki north (Table 12).

Table 11: Species, and estimates of population size derived from surveys conducted in the Tweed River estuary in January 2000 to assess the impact of the proposed Tugun Bypass. * = regionally significant species, [C] = Species listed on CAMBA, [J] = species listed on JAMBA, [E] = species listed as endangered on the NSW *TSC* Act, [V] = species listed as vulnerable on the NSW TSC Act, [F] = species listed on the Federal *ESP* Act.

Group	Species Name	Common Name	Population Estimate	Type of habitat used	
				Estuarine	Freshwater
Waterfowl	*Chenonetta jubata*	Australian Wood Duck	35	x	x
	Dendrocygna arcuata	Wandering Whistling-Duck*	1		x
	Anas superciliosa	Pacific Black Duck	67	x	x
	Anas gracilis	Grey Teal	28		x
	Anas castanea	Chestnut Teal	14	x	x
	Tachybaptus novaehollandiae	Australasian Grebe	14	x	x
		No Individuals	**159**		
Waterbirds	*Anhinga melanogaster*	Darter	14	x	x
	Phalacrocorax melanoleucos	Little Pied Cormorant	19	x	x
	Phalacrocorax varius	Pied Cormorant	122	x	x
	Phalacrocorax sulcirostris	Little Black Cormorant	232	x	x
	Phalacrocorax carbo	Great Cormorant	3	x	
	Pelecanus conspicillatus	Australian Pelican	89	x	
	Egretta novaehollandiae	White-faced Heron	65	x	x
	Egretta garzetta	Little Egret	15	x	x
	Egretta sacra	Eastern Reef Egret* [C]	1	x	
	Ardea alba	Great Egret [J, C]	23	x	
	Ardea intermedia	Intermediate Egret*	22	x	
	Ardea ibis	Cattle Egret [J, C]	34	x	x
	Butorides striatus	Striated Heron	9	x	
	Nycticorax caledonicus	Nankeen Night Heron	3	x	x
	Threskiornis molucca	Australian White Ibis	81	x	x
	Platalea regia	Royal Spoonbill	13	x	x
	Ephippiorhynchus asiaticus	Black-necked Stork [E]	1	x	
	Rallus pectoralis	Lewins Rail *	1	x	x
	Gallinula tenebrosa	Dusky Moorhen	61		x
	Fulica atra	Eurasian Coot	16		x
	Porphyrio porphyrio	Purple Swamphen	9		x
		No. Individuals	**833**		
Birds of Prey	*Pandion haliaetus*	Osprey [V]	10	x	
	Haliastur sphenurus	Whistling Kite	5	x	x
	Haliastur indus	Brahminy Kite*	4	x	x
	Haliaeetus leucogaster	White-bellied Sea-Eagle* [C]	5	x	
	Aviceda axillaris	Pacific Baza*	2	x	
		No. Individuals	**28**		
Shorebirds	*Gallinago hardwickii*	Latham's Snipe [J, C]	2	x	x
	Limosa lapponica	Bar-tailed Godwit [J, C]	193	x	
	Numenius phaeopus	Whimbrel [J, C]	80	x	
	Numenius madagascariensis	Eastern Curlew [J, C]	117	x	
	Tringa nebularia	Common Greenshank [J, C]	43	x	
	Xenus cinereus	Terek Sandpiper [J, C, V]	1	x	
	Actitis hypoleucos	Common Sandpiper [J, C]	1	x	
	Heteroscelus brevipes	Grey-tailed Tattler [J, C]	61	x	
	Calidris ferruginea	Curlew Sandpiper [J, C]	2	x	
	Calidris acuminata	Sharp-tailed Sandpiper [J, C]	23	x	
	Irediparra gallinacea	Comb-crested Jacana [V]	3		x
	Haematopus longirostris	Pied Oystercatcher [V]	10	x	
	Haematopus fuliginosus	Sooty Oystercatcher [V]	4	x	
	Himantopus himantopus	Black-winged Stilt	127	x	x
	Pluvialis fulva	Pacific Golden Plover [J, C]	24	x	
	Elseyornis melanops	Black-fronted Dotteral	6		x
	Vanellus miles	Masked Lapwing	29	x	x
		No. Individuals	**724**		
Gulls & Terns	*Larus novaehollandiae*	Silver Gull	448	x	
	Sterna caspia	Caspian Tern [J, C]	1	x	
	Sterna bergii	Crested Tern	613	x	
	Sterna albifrons	Little Tern [E J, C, F]	1	x	
		No. Individuals	**1063**		

Table 12: Maximum number of individuals and proportion of the total population of estuarine birds recorded during high tide surveys at 20 estuarine sites in the Tweed River estuary. Sites in Cobaki Broadwater are shown in bold. The proportion of the total population is shown in parentheses. S-E = sea-eagle.

Species	SH	KI	DB	TB	RP	SB	CB	TR	BI	UK	TC	**CC**	**PC**	**CS**	**CN**	TI	W	BB	T	DM
Aust. Wood Duck	-	-	-	-	-	-	15 (43)	2 (6)	-	6 (17)	-	**4 (11)**	**-**	**-**	**-**	-	-	-	-	-
Pacific Black Duck	-	-	-	-	-	-	5 (7)	3 (4)	-	-	-	**-**	**-**	**-**	**-**	-	-	-	-	21 (31)
Chestnut Teal	-	-	-	-	-	-	-	-	-	-	-	**-**	**-**	**-**	**-**	-	-	-	-	6 (43)
Darter	-	-	-	-	-	-	5 (36)	1 (7)	2 (14)	2 (14)	1 (7)	**1 (7)**	**-**	**2 (14)**	**1 (7)**	2 (14)	3 (21)	1 (7)	1 (7)	1 (7)
Little Pied Corm.orant	-	-	-	-	-	-	4 (21)	2 (11)	3 (16)	3 (16)	3 (16)	**2 (11)**	**-**	**1 (5)**	**-**	6 (32)	2 (11)	2 (11)	1 (5)	1 (5)
Pied Cormorant	-	27 (22)	-	-	34 (28)	1 (<1)	9 (7)	3 (2)	2 (2)	27 (22)	2 (2)	**4 (3)**	**-**	**-**	**-**	5 (4)	-	4 (3)	4 (3)	1 (<1)
Little Black Cormorant	-	196 (84)	-	-	-	-	7 (3)	181 (78)	7 (3)	27 (12)	5 (2)	**-**	**-**	**1 (<1)**	**-**	2 (<1)	-	2 (<1)	-	-
Great Cormorant	-	-	-	-	2 (67)	-	2 (67)	-	-	-	-	**-**	**-**	**1 (33)**	**-**	-	-	-	-	-
Australian Pelican	-	1 (1)	-	1 (1)	7 (8)	2 (2)	21 (24)	15 (17)	11 (12)	5 (6)	54 (61)	**-**	**-**	**-**	**-**	4 (4)	11 (12)	14 (16)	10 (11)	5 (6)
White-faced Heron	-	-	-	-1 (<1)	-	-	1 (2)	1 (2)	1 (2)	1 (2)	1 (2)	**1 (2)**	**6 (9)**	**1 (2)**	**1 (2)**	2 (3)	1 (2)	-	-	5 (8)
Little Egret	-	-	-	-	-	-	10 (67)	1 (7)	-	-	-	**-**	**-**	**-**	**-**	1 (7)	2 (13)	5 (33)	-	-
Eastern Reef Egret	-	-1 (100)	-	-	-	-	-	-	-	-	-	**-**	**-**	**-**	**-**	-	-	-	-	-
Great Egret	-	-	-	-1 (4)	-	-	1 (4)	1 (4)	-	2 (9)	1 (4)	**1 (4)**	**-**	**2 (9)**	**-**	1 (4)	1 (4)	-	-	6 (26)
Cattle Egret	-	-	-	-	-	-	-	-	-	-	-	**-**	**-**	**-**	**-**	-	-	-	-	34 (100)
Striated Heron	-	-	-	-	-	1 (1)	3 (33)	1 (1)	-	1 (1)	-	**2 (22)**	**-**	**-**	**1 (1)**	-	1 (1)	-	-	-
Aust. White Ibis	-	-	-	-1 (1)	1 (1)	3 (3)	51 (63)	5 (6)	8 (10)	2 (2)	4 (5)	**8 (10)**	**18 (22)**	**1 (1)**	**8 (10)**	4 (5)	2 (2)	-	-	19 (23)
Royal Spoonbill	-	-	-	-	1 (<1)	6 (46)	1 (<1)	-	1 (<1)	-	-	**1 (<1)**	**-**	**-**	**-**	-	1 (<1)	1 (<1)	1 (<1)	1 (<1)
Osprey	-	-1 (10)	-	-	-	2 (20)	1 (10)	1 (10)	2 (20)	2 (20)	1 (10)	**1 (10)**	**-**	**-**	**1 (10)**	2 (20)	3 (30)	-	-	-
Whistling Kite	-	-1 (20)	-	-	-	-	1 (20)	-	1 (20)	-	3 (60)	**1 (20)**	**1 (20)**	**1 (20)**	**2 (40)**	1 (20)	2 (40)	1 (20)	-	1 (20)
Brahminy Kite	-	-	-	-	-	-	2 (50)	2 (50)	-	-	1 (25)	**1 (25)**	**1 (25)**	**1 (25)**	**2 (50)**	3 (75)	-	-	-	-
White-bellied S-Eagle	-	-	-	-	-	-	2 (40)	1 (20)	1 (20)	-1 (20)	1 (20)	**-**	**-**	**-**	**1 (20)**	2 (40)	-	-	-	1 (20)
Pacific Baza	-	-	-	-	-	-	-	-	-	-	-	**-**	**-**	**-**	**-**	-	-	-	-	2 (100)

SH = South Head Beach; KI = Kerosene Inlet; DB = Dreamtime Beach; TB = Tony's bar; RP = Rocky Point; SB = Shallow Bay; CB = Chinderah Bay; TR = Tweed River; BI = Boyd's Island; UK = Ukerabagh Island; TC = Terranora Creek; CC = Cobaki Creek; PC = Pony Club; CS = Cobaki south; CN = Cobaki north; TI = Terranora Islands; W = Womgin Island; BB = Birds Bay; T = Terranora Broadwater; DM = Duroby Marsh.

Table 12: cont.

Species	SH	KI	DB	TB	RP	SB	CB	TR	BI	UK	TC	CC	PC	CS	CN	TI	W	BB	T	DM
Latham's Snipe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2 (100)
Bar-tailed Godwit	118 (61)	185 (96)	-	70 (36)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Whimbrel	-	5 (6)	-	21 (26)	-	25 (31)	-	-	4 (5)	-1 (1)	1 (1)	**21 (26)**	**23 (29)**	-	-	24 (29)	42 (53)	-	-	1 (1)
Eastern Curlew	18 (15)	43 (37)	-	35 (30)	-	-	-	-	-	-	-	-	**20 (17)**	-	-	-	-	-	-	46 (39)
Common Grnshank	-	-	-	-	-	-	-	-	-	-	-	-	-	**23 (53)**	-	-	-	-	-	12 (28)
Terek Sandpiper	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 (100)	-	-	-
Common Sandpiper	-	-	-	-	-	-	-	-	-	-	-	**1 (100)**	-	-	-	-	1 (100)	-	-	-
Grey-tailed Tattler	-	5 (8)	-	-	19 (31)	-	-	-	5 (8)	-	3 (5)	-	-	**7 (11)**	-	-	21 (34)	-	-	-
Curlew Sandpiper	-	2 (100)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sharp-tled Sandpip.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	23 (100)
Pied Oystercatcher	-	4 (40)	-	4 (40)	-	-	-	-	2 (20)	-	-	-	-	-	-	-	-	2 (20)	2 (20)	-
Sooty Oystercatcher	-	3 (75)	-	2 (50)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Black-winged Stilt	-	-	-	-	-	-	-	-	-	-	-	-	**6 (5)**	-	-	-	-	6 (5)	6 (6)	41 (32)
Pacific Gldn Plover	-	18 (75)	-	-	-	-	-	-	-	-	-	-	**9 (38)**	-	-	-	-	-	-	6 (25)
Masked Lapwing	-	2 (7)	-	1 (3)	-	-	3 (10)	-	-	-	-	**2 (7)**	**1 (3)**	**23 (79)**	-	-	-	-	-	6 (21)
Silver Gull	83 (19)	140 (31)	12 (3)	112 (25)	-	-	112 (25)	63 (14)	6 (1)	51 (11)	148 (33)	**2 (<1)**	-	-	-	1 (<1)	-	32 (7)	22 (5)	-
Caspian Tern	-	1 (100)	-	1 (100)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crested tern	5 (<1)	462 (75)	1 (<1)	16 (3)	-	5 (<1)	1 (<1)	79 (13)	14 (2)	23 (4)	48 (8)	**3 (<1)**	-	**1 (<1)**	-	15 (2)	7 (1)	19 (3)	2 (<1)	81 (13)
Little Tern	-	1 (100)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Birds of prey

Birds of prey were distributed throughout the study area, although the largest numbers and species richness were recorded at the larger survey sites, such as the Tweed River, Chinderah Bay, Terranora Creek, Cobaki Fringe and Terranora Islands (Table 12). Low numbers of birds of prey were recorded at South Head and Dreamtime Beaches, Tony's Bar, Rocky Point and Birds Bay. Osprey was the most widespread species, recorded at 11 of the 19 sites with the largest proportion of the population recorded at Womgin Island. Brahminy kite and white-bellied sea-eagle were recorded at eight sites each. Pacific baza were recorded at one site only, Duroby Marsh.

Birds of prey were recorded at each of the four sites situated in close proximity to the proposed bypass (CC, PC, CS, & CN). Whistling kite and brahminy kite were recorded at all four sites, whilst osprey was recorded at two of the sites, and white-bellied sea-eagle at one site (Table 12). Four of the five species of bird of prey were recorded either roosting or foraging along the northern fringe of Cobaki Broadwater.

Shorebirds

Shorebirds were recorded at a number of sites during high tide; however, the highest species richness and number of individuals were generally recorded at Kerosene Inlet (KI), Duroby Marsh (DM) or Tony's Bar (TB). These three sites often accounted for almost the entire population of bar-tailed godwit, eastern curlew and pacific golden plover (Table 12). Large flocks of bar-tailed godwit and eastern curlew were also recorded at South Head Beach. Other important roosts include Pony Club, Shallow Bay, Rocky Point and Womgin Island. Whimbrels and grey-tailed tattlers were the dominant species at these sites. Pied oystercatchers were recorded at several sites throughout the estuary, although the largest number of individuals was recorded at Kerosene Inlet and Tony's Bar.

Three of the four survey sites (Cobaki Creek, Pony Club & Cobaki Broadwater) situated in close proximity to the proposed bypass were used by shorebirds. Cobaki Creek was used regularly by about 25% of the estuaries whimbrel population, whilst Pony Club at times supported almost 30% of the whimbrel population, 17% of the eastern curlew population, and up to 38% of the pacific golden plover population. Whimbrels roosting at Cobaki Creek would move to the Pony Club if disturbed. A flock of 18-20 eastern curlews were recorded at Pony Club on each day of the survey. Over 50% of the greenshank population, and 11% of the grey-tailed tattler population were recorded roosting in Cobaki Broadwater.

Gulls and terns

Silver gulls and crested terns were distributed widely throughout the study area, with gulls recorded at 13 sites, and terns at 15 sites (Table 12). Both the Caspian and little tern were more restricted in their distribution, favouring sites in the main river channel. The largest flocks of gulls and terns (mainly silver gull and crested tern) were recorded at sites in the Tweed River, particularly at Kerosene Inlet. The largest number of silver gulls was recorded in Terranora Creek adjacent to seafood shops situated along Kennedy Drive.

Gulls and terns were recorded in small numbers at roosts in Cobaki Broadwater, with less than 1% of the total population of silver gulls recorded at Cobaki Creek, and less than 1% of the crested tern population recorded at Cobaki Creek and in Cobaki Broadwater (Table 12).

4.2.3 Feeding grounds

During low tide the 10 most important low-tide foraging grounds within the study area were sampled, including three sites within Cobaki Broadwater that are geographically the closest feeding grounds to the proposed bypass.

Waterfowl and waterbirds

Two species of waterfowl were recorded at low tide, Australian wood duck, and pacific black duck. The largest numbers of both species were recorded at Chinderah Bay (Table 13). A number of species of waterbird were recorded at all or most of the survey sites. The highest species richness and number of waterbirds was recorded at Chinderah Bay and Trutes Bay.

Lower species richness and a smaller number of individuals were recorded at survey sites in Cobaki Broadwater (Table 13). The highest species richness was recorded at the Cobaki north mudflat, where 28% of the white-faced heron population occurred. Small numbers of birds and five species were recorded at the Pony Club sandflat.

Birds of prey

Birds of prey were recorded in low numbers at four sites, with one brahminy kite recorded at the Cobaki mudflat. The low numbers of birds of prey recorded at low tide is attributed to the smaller number of sites sampled, and the type of habitat sampled.

Shorebirds

Bar-tailed godwit, whimbrel and eastern curlew were recorded at all of the survey sites. The largest number of shorebirds was recorded at Trutes Bay followed by Womgin Island, Kerosene Inlet, and Cobaki north. These sites also tended to have the highest species richness (Table 13). Lower numbers but high species richness of shorebirds was recorded at both Pony Club and Cobaki south. Of the 10 sites sampled the lowest number of shorebirds was recorded at the Pony Club sandflat.

Gulls and terns

Three species of gull and tern were recorded at low tide, with the highest concentrations of birds recorded at Kerosene Inlet, Chinderah Bay, Trutes Bay and Tony's Bar (Table 13). Both silver gull and crested tern were recorded at Cobaki north, with no birds recorded at Pony Club or Cobaki south.

Table 13: Maximum number of birds recorded during low tide surveys at 10 intertidal habitats in the Tweed River estuary. Sites in Cobaki Broadwater are shown in bold. The proportion of the total population is shown in parentheses.

Species	Sites									
	KI	TB	SB	CB	**PC**	**CS**	**CN**	Wo	TrB	ChB
Australian Wood Duck				13 (37)					2 (6)	
Pacific Black Duck		7 (10)	2 (3)	12 (18)					2 (3)	
Darter		1 (7)		4 (29)				2 (14)		
Little Pied Cormorant	2 (11)	1 (5)				**1 (5)**		2 (11)		
Pied Cormorant	6 (5)			34 (28)						
Little Black Cormorant	94 (41)			1 (<1)						1 (<1)
Great Cormorant	1 (33)	1 (33)		1 (33)						
Australian Pelican		6 (7)		10 (11)	**1 (1)**			13 (15)	32 (36)	1 (1)
White-faced Heron	1 (2)	2 (3)	6 (9)	7 (11)	**1 (2)**	**7 (11)**	**18 (28)**	5 (8)	38 (58)	3 (5)
Little Egret		1 (7)	1 (7)	6 (40)		**1 (7)**		4 (27)	4 (27)	
Great Egret		2 (9)	5 (22)	1 (4)	**1 (4)**	**2 (9)**	**2 (9)**	2 (9)	16 (70)	3 (13)
Intermediate Egret									22 (100)	
Striated Heron			2 (22)	3 (33)	**1 (11)**	**2 (22)**		1 (11)	1 (11)	
Australian White Ibis	1 (1)	5 (6)	11 (14)	52 (64)	**3 (4)**	**2 (2)**	**2 (2)**	1 (1)	22 (27)	2 (2)
Royal Spoonbill			1 (8)	3 (23)		**1 (8)**		2 (15)	8 (62)	1 (8)
Black-necked Stork										
	105	*26*	*28*	*147*	*7*	***16***	***22***	*32*	*147*	*11*
	6	*9*	*7*	*13*	***5***	*7*	***3***	*9*	*10*	*6*
Osprey	1 (10)									
Whistling Kite				1 (20)						
Brahminy Kite						**1 (25)**				
White-bellied Sea-Eagle				2						1 (20)
	1	-	-	*3*	**-**	***1***	**-**	-	-	*1*
	1			*2*		***1***				*1*
Bar-tailed Godwit	55 (28)	10 (5)	19 (10)	35 (18)	**1 (<1)**	**3 (2)**	**41 (21)**	69 (36)	38 (20)	5 (2)
Whimbrel	2 (2)	4 (5)	4 (5)	3 (4)	**1 (1)**	**9 (11)**	**3 (4)**	23 (29)	9 (12)	1 (1)
Eastern Curlew	3 (2)	11 (7)	4 (3)	11 (7)	**3 (2)**	**9 (8)**	**7 (6)**	6 (5)	15 (13)	6 (5)
Common Greenshank					**1 (2)**	**9 (21)**	**12 (28)**		25 (58)	
Common Sandpiper								1 (50)		
Grey-tailed Tattler	1 (2)	5 (8)	4 (7)			**8 (13)**	**1 (2)**	4 (7)		
Curlew Sandpiper	2 (100)								1 (50)	
Sharp-tailed Sandpiper		2 (9)								
Pied Oystercatcher	2 (20)							2 (20)		
Sooty Oystercatcher	1 (25)									
Black-winged Stilt				2 (2)		**3 (3)**			94 (92)	5 (5)
Pacific Golden Plover	12 (50)				**4 (17)**					
Masked Lapwing	2 (7)			2 (7)	**2 (7)**		**8 (28)**		18 (62)	
	80	*32*	*31*	*53*	***12***	***41***	***72***	*105*	*200*	*17*
	9	*5*	*4*	*5*	***6***	***6***	***6***	*6*	*7*	*4*
Silver Gull	260 (58)	50 (11)		179 (40)			**9 (2)**		150 (33)	
Crested tern	131 (21)	17 (3)		1 (<1)			**1 (<1)**			3 (<1)
Little Tern	1 (100)	1 (100)								
	392	*68*	-	*180*	**-**	**-**	***10***	-	*150*	*3*
	3	*3*		*2*			***2***		*1*	*1*

KI = Kerosene Inlet; TB = Tony's Bar; SB = Shallow Bay; CB = Chinderah Bay; PC = Pony Club; CS = Cobaki south; CN = Cobaki north, Wo = Womgin Island; TrB = Trutes Bay, ChB = Charles Bay.

4.2.4 Use of intertidal mudflats in Cobaki Broadwater by shorebirds

Important foraging habitats in Cobaki Broadwater

There are four main foraging areas in Cobaki Broadwater, Cobaki Creek, Pony Club, Cobaki south and Cobaki north (Figure 5). Both Cobaki Creek and Pony Club are small sites, in comparison to the expansive intertidal mudflats at Cobaki south and north. Data gathered during low-tide surveys (Table 13) provides a fairly good indication of the relative value of the four foraging areas. Although Cobaki Creek was not sampled during the survey it is generally used by a similar number of individuals and species to Pony Club (Pers Obs). The most important foraging areas in Cobaki Broadwater for shorebirds and waterbirds are the Cobaki south and Cobaki north mudflats. Ospreys and white-bellied sea-eagles have been recorded foraging over the entire Broadwater, including the Pony Club and Cobaki Creek.

Movement patterns

Observations conducted in Cobaki Broadwater during the falling and rising tide identified distinct movement patterns by shorebirds in relation to tidal stage. The general movement patterns of eastern curlew, whimbrel and bar-tailed godwit recorded during two ebb and two flowing tides are shown on Figure 5. Observations were focussed on these species, as they comprise the majority of the estuaries shorebird population. It was therefore easier to ensure that enough data would be collected for analysis

Whimbrel and eastern curlew began leaving the Pony Club and Cobaki Creek roosts between 2-2.5 hours after high tide. Some individuals moved to the mangrove fringe at Pony Club and Cobaki where they began foraging, whilst others moved to the neap tide roost at Cobaki south (Figure 5). Whimbrels appeared to disperse more widely than eastern curlew. Birds that staged at the neap tide roost steadily dispersed from this site as the tide receded. Most individuals had left the staging site and commenced foraging about 3.5 hours after high tide. Birds leaving the staging site moved across the Cobaki south flats or moved directly to Cobaki north.

Bar-tailed godwits began arriving in the Broadwater between 3 to 3.5 hours after high tide. Most godwits generally flew directly to the staging site at Cobaki south, although small flocks occasionally stopped at the Pony Club sandflat before moving to forage at Cobaki south or north. Godwits foraging at Cobaki south steadily dispersed from this site to Cobaki north (Figure 5). By low tide the majority of bar-tailed godwits within Cobaki Broadwater were foraging at Cobaki north.

During the rising tide the movement of birds was more rapid, with individuals moving from Cobaki north to the neap tide roost at Cobaki south. Bar-tailed godwits were generally the first individuals to arrive at the roost. Whimbrels and eastern curlews seemed to forage for longer periods by using the mangrove fringe. As mudflats within Cobaki Broadwater became inundated large flocks of bar-tailed godwits were recorded foraging in the vicinity of the neap tide roost at Cobaki south.

During spring tides birds began leaving the neap tide roost at about mid tide, with curlews and whimbrel moving to Pony Club and Cobaki Creek respectively, and bar-tailed godwits moving to Kerosene Inlet. During neap high tides birds remained at the neap roost for a longer period. During the rising tide no birds were recorded moving from Cobaki south or Cobaki north to stage at the Pony Club sandflat. Birds foraging at the Pony Club remained at this site until about mid-tide when the site was totally inundated. Eastern Curlew and pacific golden plover were recorded leaving this site and moving directly to the Pony Club.

Detailed observations on the use of the Pony Club sandflat

Observations at the Pony Club sandflat during low tide recorded a distinct pattern of habitat use. Observations were made on four species of migratory shorebird, eastern curlew, bar-tailed godwit, whimbrel and pacific golden plover. Both eastern curlews and whimbrels were recorded at Pony Club at mid tide. The number of eastern curlews using Pony Club increased steadily until low tide, with a slight decrease was recorded during the rising tide (Figure 6). Whimbrels displayed a similar pattern although the number of birds using the Pony Club began to decrease at least one hour prior to low tide. The number of whimbrels using the Pony Club remained steady during the first three hours of the rising tide.

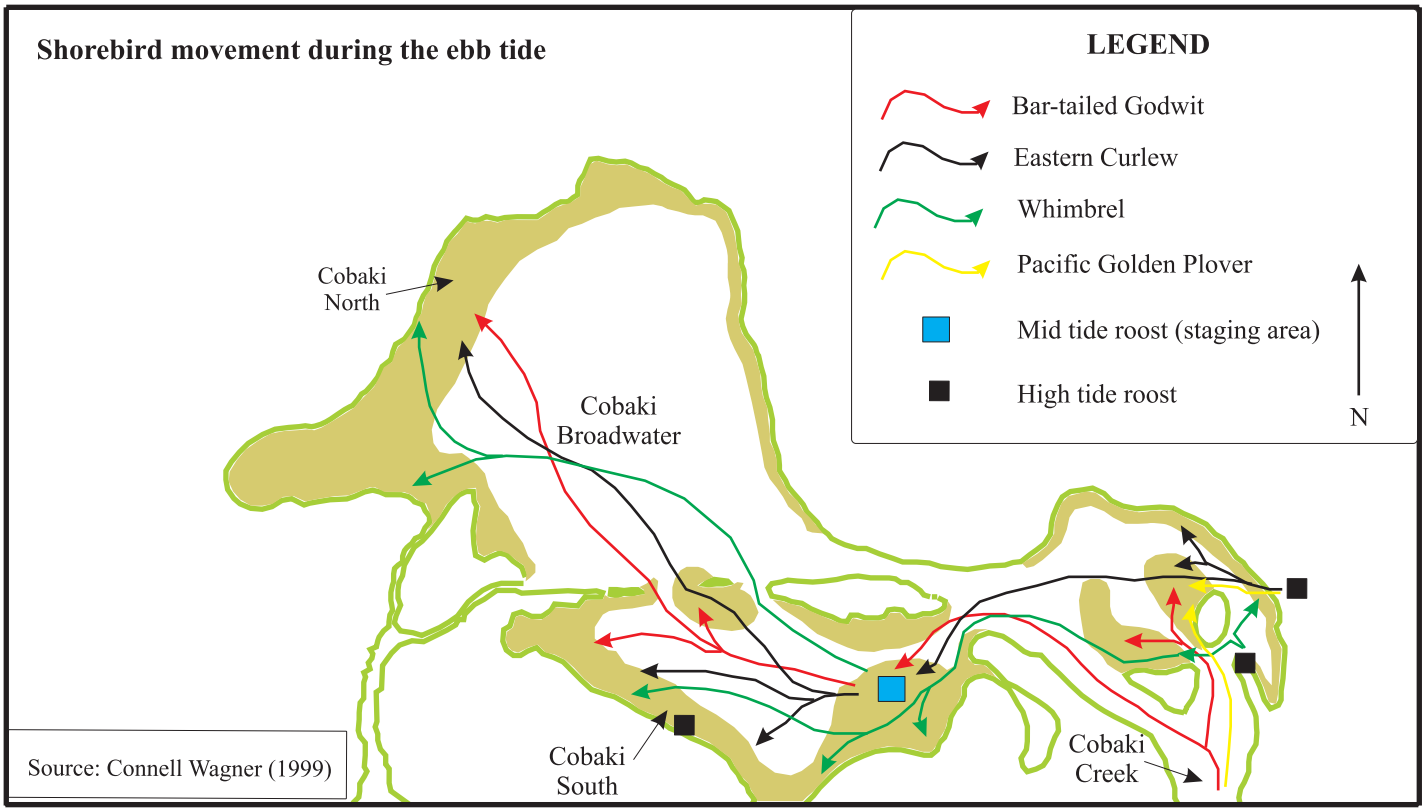
Bar-tailed godwits displayed a distinct peak in their use of Pony Club with small flocks stopping during the early stage of the falling tide. Godwits were observed to forage for a short period at Pony Club before moving to Cobaki north or south. Pacific golden plovers generally began using the Pony Club about 90 minutes prior to low tide, with the number of birds using the site remaining steady until just before mid tide.

Foraging behaviour of shorebirds using intertidal habitats in Cobaki Broadwater

The feeding rates and prey consumed by bar-tailed godwit, whimbrel and eastern curlew was recorded at three sites, Pony Club, Cobaki south and Womgin Island (Table 14). Sample sizes were small consequently the data were not subject to statistical analysis. The data provide only a preliminary indication of feeding rates and prey type. The data suggest that bar-tailed godwits and whimbrel foraging at the Pony Club sandflat achieve similar intake rates and forage on similar prey to birds foraging at either Womgin Island or Cobaki south. The feeding rate recorded for eastern curlew at Pony Club was substantially greater than that recorded at other sites (Table 14).

Bar-tailed godwits foraged on an unidentified species of polychaete worm at all sites, whilst eastern curlew and whimbrel foraged mainly on sentinel crabs *Macropthalamus* spp. One eastern curlew was recorded foraging on a ghost shrimp *Trypaea australiensis*.

Bar-tailed godwits appeared to forage mainly by touch continually jabbing the substratum whilst at the same time walking. Both eastern curlews and whimbrels foraged primarily by sight, walking steadily over the substratum and deliberately probing crab or ghost shrimp burrows. Whimbrels would occasionally wait at burrows for crabs to appear at the surface. Both species were recorded jabbing the substratum when a prey item was detected but not captured. All three species were recorded using the range of microhabitats present at a site, including the waters edge, moist sand, pools and dry sand, although whimbrels most often avoided the waters edge and pools in preference for dryer substrates.



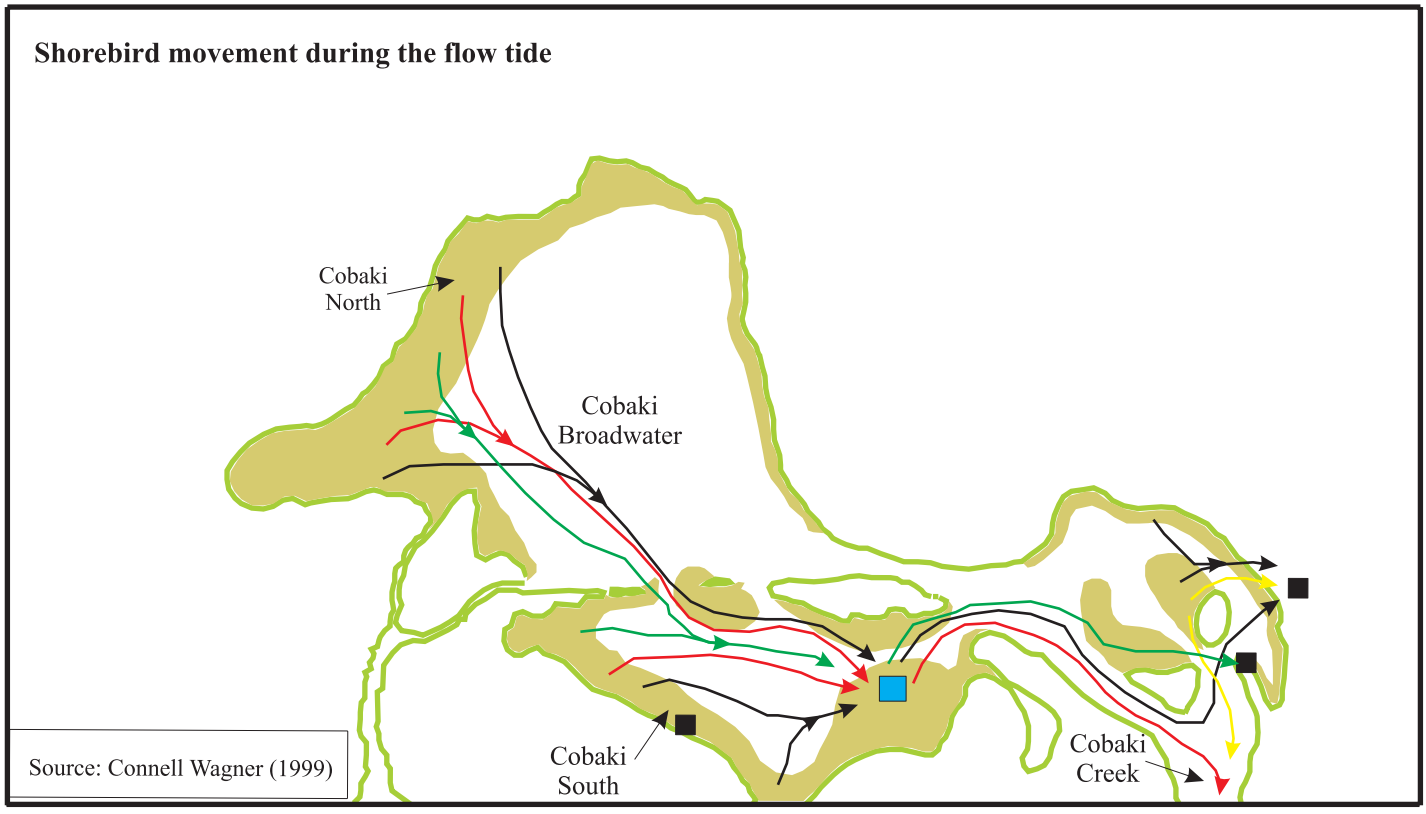
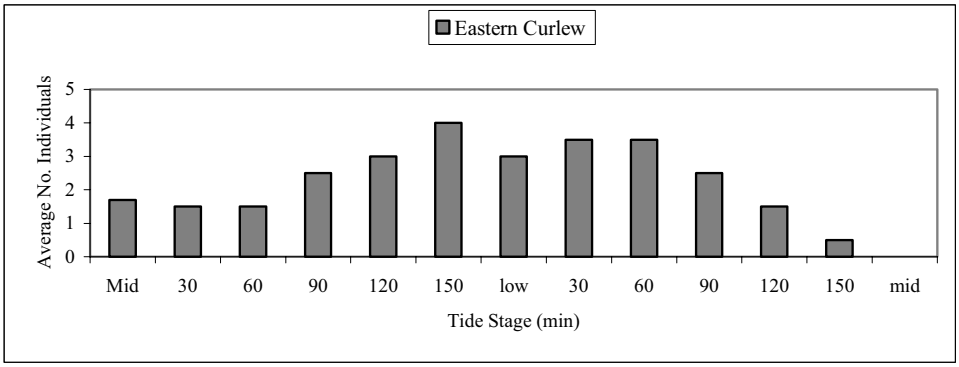
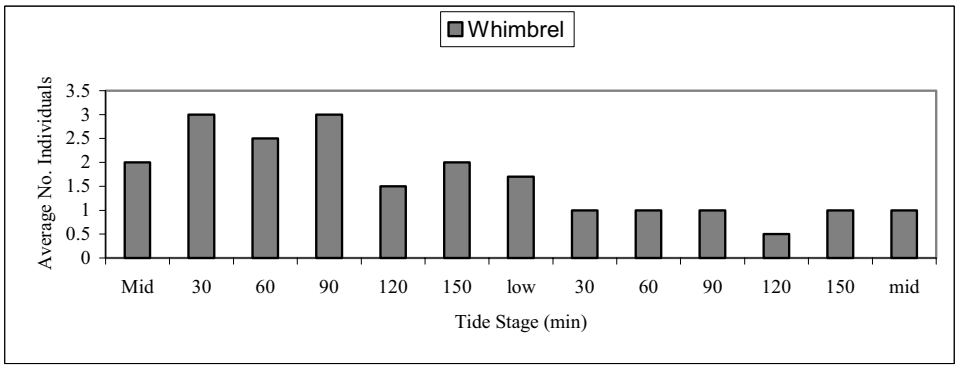
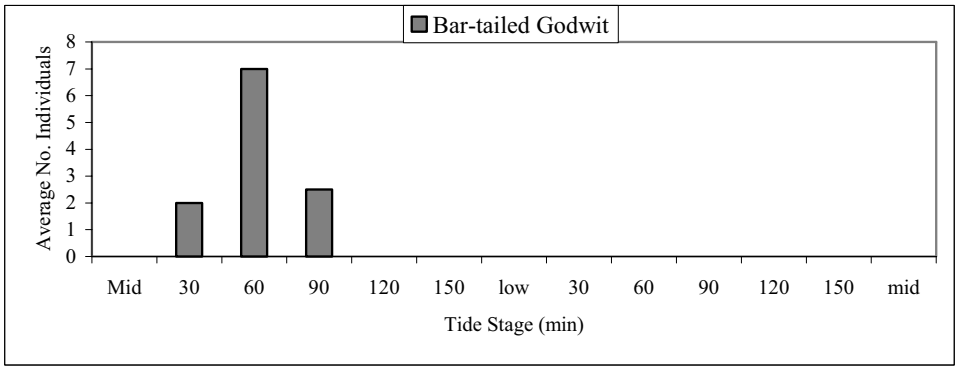


Figure 5: Broad-scale movement of four species of migratory shorebird throughout Cobaki Broadwater during ebb and flow tides.







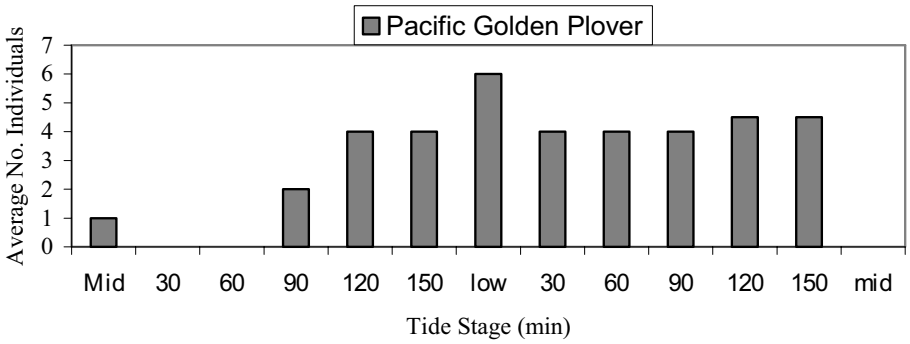


Figure 6: Use of the Pony Club foraging area by four species of migratory shorebird during low tide.

Table 14: Feeding rates and prey types consumed by three species of migratory shorebird at three sites in the Tweed River estuary. Standard error for feeding rate is shown in parentheses.

Species	Site	Sample Size	Feeding Rate (No./minute)	Prey Type	Prey Size Range
Bar-tailed Godwit	Pony Club	3	2.6 (1.0)	Polychaete worms	unknown
	Cobaki south	3	3.7 (1.5)	Polychaete worms	unknown
	Womgin Island	7	2.8 (0.4)	Polychaete worms	1-5 cm
Whimbrel	Pony Club	4	0.7 (0.2)	*Macropthalamus* sp	0.5-1.5 cm
	Cobaki south	3	0.6 (0.2)	*Macropthalamus* sp	0.5-2.0 cm
	Womgin Island	3	1.5 (0.1)	*Macropthalamus* sp	1 cm
Eastern Curlew	Pony Club	18	1.4 (0.2)	*Macropthalamus* sp *Trypaea australiensis*	0.5-1.5 cm 5 cm
	Cobaki south	3	0.8 (0.1)	*Macropthalamus* sp	0.5-1.5 cm
	Womgin Island	3	0.3 (0.1)	Unidentified	unknown

4.3 Review of previous estuarine bird surveys

4.3.1 Methods used in previous surveys

The estuarine bird population (in particular the shorebird population) within the study area has been surveyed on a number of occasions since the first documented survey in 1987 (Martindale 1987). One obvious problem with comparing population estimates between surveys is the variability in the methods used, and in particular the number of sites sampled. Variability in the number of sites sampled makes it difficult to draw firm conclusions on temporal changes in the estuarine bird population.

One positive aspect of the surveys is that they have all (except for some of the early QWSG surveys) sampled the major high tide roosts for shorebirds thereby enabling inferences to be drawn on changes in the shorebird population. The problem with early QWSG surveys stems from a lack of detailed coverage during a single tidal cycle. High tide surveys by the QWSG in 1994, 1995 and 1996 were generally spread over two days thereby reducing the ability to obtain an accurate population estimate. It is likely that the QWSG surveys based on one sample day provide an underestimate of the estuarine bird population.

Possibly the most thorough assessment of the estuarine bird population has been obtained from surveys conducted by Sandpiper Ecological Surveys for Tweed Shire Council, although these surveys lack the frequency of other surveys. Surveys by Sandpiper Ecological Surveys commenced in March 1997 and consist of quarterly surveys at the same sites. The area covered by these surveys is the same as that covered in the present study. The population estimates derived during quarterly surveys by Sandpiper Ecological Surveys are provided in Table 2e, Appendix 2.

4.3.2 Population estimate

Temporal changes in the estuarine bird population

Comparison of temporal changes in the number of waterbirds using the study area in summer (February) is difficult, as most of the early surveys did not specifically target this group of birds. Surveys in 1998, 1999 and 2000 revealed a high degree of variability in the population of a number of species of waterbird. Although the waterbird population was similar in 1998 and 1999 a marked increase in the overall population was recorded in 2000. This increase is most likely due to the presence of large numbers of a few species, such as little black cormorant, Australian pelican, white-faced heron and great egret (Table 15).

Comparison of temporal changes in the bird of prey population between years is also difficult due to the lack of survey effort. Surveys in 1998, 1999 and 2000 do not suggest any temporal changes in the bird of prey population. The number of osprey using the estuary has increased since 1987.

The shorebird population within the study area seems to have declined since 1987 (Table 15). Noticeable declines are evident for pacific golden plover, curlew sandpiper and lesser sand plover, whilst the number of eastern curlew and whimbrel may have also declined. The number of greenshank seems to have remained stable. The results suggest an increase in the population of grey-tailed tattler, although this result may be due to better coverage during latter surveys. Large flocks of marsh sandpiper were recorded in the estuary between 1995 and 1998. The only species whose population has increased is the pied oystercatcher, which has increased from four individuals in the early and mid 1990's to eight individuals in the late 1990's.

The population of migratory shorebirds appears to have declined from about 800 individuals in the late 1980's to just over 600 individuals in 1999 and 2000. The species richness of migratory shorebirds using the estuary in summer also appears to have declined. A number of species that were recorded regularly in the late 1980's and early 1990's have not been recorded during recent surveys. These species include lesser and greater sand plovers, red-necked stint, sanderling, red knot and great knot (Table 15).

The population estimates for gulls and terns are affected by differences in coverage between surveys. Monitoring studies between 1998 and 2000 suggest a decline in overall population size, although, information is required over a longer time period to confirm this trend.

Table 15: Estimates of the population size of estuarine birds in the Tweed River estuary between 1987 and 2000. Estimates are based on the results of surveys conducted in February of each year. 2/87 = Martindale (1987); 2/90 DPWS (1991a); 2/91 DPWS (1991b); 2/92 = Lawler (1994); 1993 = QWSG unpublished; 2/94, 95, 96, 97 = QWSG unpublished; 2/98 Sandpiper Ecological Surveys (1998b); 2/99 = Sandpiper Ecological Surveys (1999); 2/00 Sandpiper Ecological Surveys (2000); * incomplete coverage of the estuary; ? = unknown; + = underestimate

Year of survey	2/87	2/90	2/91	2/92*	1993 QWSG	2/94 QWSG	2/95 QWSG	2/96 QWSG	2/98	2/99	2/00
No. sites sampled	10	?	11	7	?	5	7	9	22	22	22
WATERBIRDS	-	-	-	-	-	-	-	-	-	-	-
Black Swan	-	-	-	-	-	-	-	-	-	1	-
Australian Wood Duck	-	-	-	-		6	21	7	30	29	26
Pacific Black Duck	-	-	85	-	12	47	38	21	71	45	54
Grey Teal	-	-	5	-	-	-	-	-	7	8	15
Chestnut Teal	-	-	14	-	2	6	2	-	29	12	25
Hardhead	-	-	-	-	-	-	-	-	9	-	-
Wandering Whistling-Duck	-	-	-	-	-	-	-	-	-	5	6
Australasian Grebe	-	-	-	-	-	-	-	-	21	6	12
Darter	2	-	-	-	12	24	18	36	28	55	35
Little Pied Cormorant	-	-	19	-	7	25	6	13	7	8	30
Pied Cormorant	140	-	55	-	169	61	52	28	99	67	90
Little Black Cormorant	100	-	P	-	128	42	126	5	157	76	308
Great Cormorant	20	-	P	-	-	-	-	-	2	2	3
Australian Pelican	74	-	17	-	94	21	5	26	37	26	73
White-faced Heron	20+	-	76+	-	7	8	2	4	50	38	75
Little Egret	-	-	4	-		1	2		7	4	8
Eastern Reef Egret	5	-	2	-			7		1	2	2
Great Egret	-	-	3	-	5	5		3	16	11	38
Intermediate Egret	-	-	4	-	-	-	-	-	2	2	-
Cattle Egret	-	-	220+	-	-	-	-	-	70	46	4
Striated Heron	5	-	10	-	5	3	1	1	13	10	10
Nankeen Night Heron	-	-	-	-	-	-	-	-	8	1	4
Glossy Ibis	-	-	7	-	-	-	-	-	-	-	-
Australian White Ibis	-	-	24	-	42	35	12	22	43	151	89
Straw-necked Ibis	-	-	-	-			1		1	-	-
Royal Spoonbill	-	-	14+	-	7	2	7	6	6	10	23
Black-necked Stork	3	-	-	-	-	-	-	2	-	-	-
Spotless Crake	-	-	-	-	-	-	-	-	-	-	-
Purple Swamphen	-	-	-	-	-	-	-	-	1	19	14
Dusky Moorhen	-	-	-	-	-	-	-	-	39	127	98
Eurasian Coot	-	-	-	-	-	-	-	-	13	18	20
Number of individuals	*369*		*535*	-	*490*	*259*	*300*	*174*	*767*	*779*	*1062*
Number of species	*9*		*18*		*12*	*14*	*15*	*13*	*26*	*26*	*24*
BIRDS OF PREY	-	-	-	-	-	-	-	-	-	-	-
Brown Falcon	-	-	-	-	-	-	-	-	1	-	-
Osprey	6	-	1	-	2	1		1	6	10	4
Whistling Kite	-	-	-	-	2	1	3	3	3	2	4
Brahminy Kite	1+	-	3	-	3	1	4		4	4	7
White-bellied Sea-Eagle	1+	-	-	-	1	1	-	-	2	2	2
Australasian Kestrel	-	-	-	-	-	-	-	-	-	1	-
Australian Hobby	-	-	-	-	-	-	-	-	-	-	1
Number of individuals	*8*		*4*	-	*8*	*4*	*7*	*4*	*16*	*19*	*18*
Number of species	*3*		*2*		*4*	*4*	*2*	*2*	*5*	*5*	*5*

Table 15: cont

Year of survey	2/87	2/90	2/91	2/92*	1993 QWSG	2/94 QWSG	2/95 QWSG	2/96 QWSG	2/98	2/99	2/00
No. sites sampled	10	?	11	7	?	5	7	9	22	22	22
SHOREBIRDS	-	-	-	-	-	-	-	-	-	-	-
Latham's Snipe	-	-	-	-	-	-	-	-	3	3	2
Bar-tailed Godwit	230	335	338	271	314	291	191	186	211	180	193
Black-tailed Godwit	3	3	-	-	-	-	-	-	-	-	-
Whimbrel	140	69	62	110	37	39	32		124	59	78
Eastern Curlew	163	127	164	62	121	139	96	97	131	132	117
Marsh Sandpiper	-	1	3	-	-	-	63	20	58		
Common Greenshank	50	52	24	41	30	17	-	44	44	45	47
Terek Sandpiper	7	2	2	2	1	-	-		2	1	1
Common Sandpiper	-	1		1	1	4	-		1		
Grey-tailed Tattler	54	46	13	27	23	10	-	20	70	43	69
Wandering Tattler	-	-	3	-	-	-	-		-	-	-
Ruddy Turnstone	4	15	3	2	3	2	-	2	-	-	-
Red Knot	-	-	-	-	1		-		-	-	-
Great Knot	-	-	-	1	-	7	-	1	-	-	-
Curlew Sandpiper	40	52	18	24	20	16	17	14	15	-	1
Sharp-tailed Sandpiper		6	1	3	1		36	3	26	6	23
Red-necked Stint	1	2	-	-	-	-	-	-	-	-	-
Sanderling	1	-	-	-	-	-	-	-	-	-	-
Comb-crested Jacana	-	-	-	-	-	-	-	-	1	2	2
Beach Stone-Curlew	-	-	-	-	-	-	-	-	-	-	-
Pied Oystercatcher	4		2		2	2	2	2	6	5	12
Sooty Oystercatcher	2					1		2	2	3	2
Black-winged Stilt	180		243	-	29	63	156	-	102	89	49
Red-necked Avocet	-	-	-	-	-	-	-	-	-	-	-
Pacific Golden Plover	80	86	83	37	15	14	19	20	29	27	24
Double-banded Plover	-	1	1	-	-	-	-	-	-	-	-
Red-capped Plover	-	-	-	-	-	-	-	-	-	-	-
Greater Sand Plover	-	6	2		2	2	-	-	-	-	-
Lesser Sand Plover	13	3	4	3	-	-	-	2	-	-	-
Black-fronted Dotterel	-	-	7	-	2	2	3	6	4	10	1
Masked Lapwing	4	-	15	-	9	7	4	9	6	46	10
Number of individuals	*986*	*807*	*998*	*612*	*611*	*616*	*619*	*428*	*835*	*651*	*631*
Number of species	*17*	*17*	*19*	*13*	*17*	*16*	*11*	*15*	*18*	*15*	*16*
GULL & TERNS	-	-	-	-	-	-	-	-	-	-	-
Silver Gull	-	-	53+	-	136	210	120	139	983	446	460
White-winged Black Tern	-	-	-	-	-	-	-	-	-	-	-
Gull-billed Tern	-	-	-	-	3	4	-	-	-	-	-
Common Tern	-	-	31	-	-	1	-	57	-	15	-
Caspian Tern	-	-	7	-	2	-	2	1	-	1	1
Crested Tern	-	-	296	-	68	177	401	243	357	654	406
Little Tern	-	-	14	-	-	36	1	-	1	21	4
Number of individuals	-	-	*401*	-	*209*	*438*	*524*	*440*	*1341*	*1137*	*871*
Number of species			*5*		*4*	*5*	*4*	*4*	*3*	*5*	*4*

4.3.3 Species richness and distribution of estuarine birds

The review of previous surveys identified 91 species of estuarine bird that have been recorded within the study area (Table 16). The list includes 10 species of waterfowl, 27 species of waterbird, 14 species of bird of prey, 32 species of shorebird, and eight species of gulls and terns (Table 16). The review identified 13 species listed as threatened on the NSW *TSC* Act, one species listed on the Federal *ESP* Act, 26 species listed on JAMBA, 29 species listed on CAMBA, and seven species that are recognised to be of conservation significance (Table 16).

Comparison of the distribution of estuarine birds across 23 sites within the lower Tweed River estuary highlights a large degree of variation in distribution between different bird groups (Table 16). Waterfowl were recorded most often at freshwater wetlands, although Pacific black duck and Australian wood duck have been recorded at a number of estuarine sites. Most species of waterbird are widespread throughout the estuary, and have been recorded at the majority of survey sites. The exception to this include dusky moorhen, purple swamphen, Eurasian coot, cattle egret, intermediate egret, straw-necked ibis, nankeen night heron, Lewins rail and spotless crake, which occur mainly at freshwater wetlands, and eastern reef egret, and black-necked stork which have been recorded at only a small number of estuarine sites.

The distribution of birds of prey also varies considerably. Four species (osprey, brahminy kite, whistling kite, & white-bellied sea-eagle) occur throughout the estuary. Other species may be regarded as irregular visitors to estuarine habitats, having been recorded at one site only (Table 16). These species include brown falcon, wedge-tailed eagle, pacific baza, marsh harrier, Australasian kestrel, Australian hobby, little eagle, brown goshawk, black-shouldered kite, and grey goshawk.

There is also considerable variation in the distribution of shorebirds (Table 16). Bar-tailed godwit, whimbrel, eastern curlew, grey-tailed tattler, pacific golden plover, masked lapwing, and pied oystercatcher have been recorded at the majority of sites throughout the estuary. A number of species have been recorded at a small number of sites only. Black-tailed godwit, marsh sandpiper, wandering tattler, great knot, red-necked stint, sanderling, beach stone-curlew, and lesser and greater sandplovers have been recorded at four or less sites. Red-kneed and black-fronted dotteral and Latham's snipe have also been recorded at a small number of sites, with most records of these species from freshwater wetlands.

The distribution of gulls and terns follows a similar pattern to that displayed by other groups. Both silver gull and crested tern have been recorded at the majority of survey sites. Gull-billed tern, common tern, Caspian tern and little tern have been recorded at about 50% of sites, whilst white-winged black-tern have been recorded at only two sites (Table 16).

Significant species of estuarine bird recorded from sites near the proposed bypass

Fifty-eight species of estuarine bird have been recorded previously from five sites situated in close proximity to the proposed alignment. This includes six species of waterfowl, 20 species of waterbird, seven species of bird of prey, 20 species of shorebird (including 15 migratory species), and six species of gulls and terns (Table 16). The list includes 17 species listed on JAMBA, 18 species listed on CAMBA, seven species listed on the NSW *TSC* Act, and one species listed on the Federal *ESP* Act. Species listed on the NSW *TSC* Act and recorded near the study area include osprey, black-tailed godwit, terek sandpiper, great knot, pied oystercatcher, lesser sand plover, and little tern.

Table 16: Species of estuarine bird recorded at 23 sites in the lower Tweed River estuary. Sites in close proximity to the proposed Tugun Bypass are shown in bold. Sources of records include Sandpiper Ecological Surveys (1997, 1998, 1999, 2000), Martindale (1987), QWSG (unpublished data), NSW WSG (unpublished data), Lawler (1994), Department of Public Works (1991). [e] = listed as endangered on the NSW TSC Act, [v] = listed as vulnerable on the NSW TSC Act, [j] = JAMBA, [c] = CAMBA, [f] = listed on the ESP Act, * species of conservation significance.

Species	sh	ki	db	tb	rp	sb	cb	tr	bi	uk	tc	**cc**	**pc**	**cs**	**cn**	**st1**	ti	w	bb	t	dm	st2	tw
Magpie Goose[V]																							x
Black Swan														**x**						x			x
Australian Wood Duck						x	x	x		x	x	**x**				**x**				x	x	x	x
Mallard						x																x	
Pacific Black Duck						x	x	x		x	x					**x**					x	x	x
Grey Teal																**x**						x	x
Chestnut Teal														**x**		**x**				x	x	x	x
Hardhead																**x**						x	x
Australasian Shoveler																**x**							
Wandering Whtling-Duck*																							x
Australasian Grebe														**x**		**x**						x	x
Hoary-headed Grebe																							x
Darter		x		x	x	x	x	x	x	x	x	**x**	**x**	**x**	**x**		x	x	x	x	x		x
Little Pied Cormorant		x		x	x	x	x	x	x	x	x	**x**	**x**	**x**	**x**	**x**	x	x	x	x	x	x	x
Pied Cormorant	x	x		x	x	x	x	x	x	x	x	**x**				**x**	x	x	x	x			
Little Black Cormorant	x	x		x	x	x	x	x	x	x	x	**x**		**x**		**x**	x	x	x	x	x	x	x
Great Cormorant				x	x		x	x											x				x
Australian Pelican	x	x		x	x	x	x	x	x	x	x	**x**		**x**		**x**	x	x	x	x			
White-faced Heron	x	x	x	x	x	x	x	x	x	x	x	**x**	**x**	**x**	**x**	**x**	x	x	x	x	x		x
White-necked Heron																							x
Little Egret		x		x	x	x	x	x	x	x	x	**x**	**x**	**x**	**x**	**x**	x	x	x	x	x		x
Eastern Reef Egret* [C]	x	x									x												
Great Egret [J, C]		x		x	x	x	x	x	x	x	x	**x**	**x**	**x**	**x**		x	x	x	x	x		x
Intermediate Egret*				x						x			**x**					x		x			x
Cattle Egret [J, C]													**x**			**x**					x		x
Striated Heron		x			x	x	x	x	x	x	x	**x**	**x**	**x**	**x**	**x**	x	x	x	x	x		
Nankeen Night Heron										x						**x**					x		x
Glossy Ibis [C]																							x
Australian White Ibis		x		x	x	x	x	x	x	x	x	**x**	**x**	**x**	**x**	**x**	x	x	x	x	x	x	x
Straw-necked Ibis																**x**						x	x
Royal Spoonbill				x	x	x	x	x	x	x	x	**x**	**x**	**x**	**x**	**x**	x	x	x	x	x	x	x
Black-necked Stork [E]									x									x		x			
Spotless Crake																							x
Lewins Rail*																					x		
Purple Swamphen																**x**					x	x	x
Dusky Moorhen														**x**		**x**						x	x
Eurasian Coot																**x**						x	x
Brown Falcon											x												
Osprey [V]	x	x	x	x	x	x	x	x	x	x	x	**x**	**x**	**x**	**x**		x	x	x	x			x
Whistling Kite	x	x		x	x	x	x	x	x	x	x	**x**	**x**	**x**	**x**	**x**	x	x	x	x	x	x	x
Brahminy Kite*	x	x	x	x	x	x	x	x	x	x	x	**x**	**x**	**x**	**x**	**x**	x	x	x	x	x	x	x
White-bellied Sea-Eagle* [C]	x	x		x	x	x	x	x		x		**x**	**x**	**x**	**x**		x	x		x			x
Wedge-tailed Eagle													**x**										
Pacific Baza*																					x		
Marsh Harrier																					x		
Australasian Kestrel																					x		
Australian Hobby															**x**								
Little Eagle											x												
Brown Goshawk												**x**											
Black-shouldered Kite																							
Grey Goshawk																				x			
Latham's Snipe [J, C]						x										**x**					x		x
Bar-tailed Godwit [J, C]	x	x	x	x	x	x	x		x	x	x	**x**	**x**	**x**	**x**		x	x	x	x	x		x
Black-tailed Godwit [J, C, V]		x											**x**										
Whimbrel [J, C]	x	x		x	x	x	x	x	x	x	x	**x**	**x**	**x**	**x**		x	x	x	x	x		x
Eastern Curlew [J, C]	x	x	x	x		x	x	x	x	x	x	**x**	**x**	**x**	**x**		x	x	x	x	x		x
Marsh Sandpiper [J, C]														**x**						x	x		x
Common Greenshank [J, C]					x		x					**x**	**x**	**x**	**x**					x	x		x
Terek Sandpiper [J, C, V]				x		x						**x**	**x**					x		x			
Common Sandpiper [J, C]						x			x			**x**	**x**	**x**				x					
Grey-tailed Tattler [J, C]		x		x	x	x			x	x		**x**	**x**	**x**			x	x	x	x			x
Wandering Tattler [J, C]		x																					
Ruddy Turnstone [J, C]	x	x																					
Red Knot [J, C]																							
Great Knot [J, C, V]		x		x							x			**x**									

Table 16: cont.

Species	sh	ki	db	tb	rp	sb	cb	tr	bi	uk	tc	**cc**	**pc**	**cs**	**cn**	**st1**	ti	w	bb	t	dm	st2	tw
Curlew Sandpiper [J, C]	x	x		x		x						**x**	**x**							x	x		
Sharp-tailed Sandpiper [J, C]													**x**			**x**				x	x		x
Red-necked Stint [J, C]	x	x		x																			
Sanderling [J, C]	x																						
Comb-crested Jacana [V]																							x
Beach Stone-Curlew [V]		x		x						x													
Pied Oystercatcher [V]	x	x		x	x		x	x	x		x	**x**					x	x	x	x			
Sooty Oystercatcher [V]	x	x		x		x		x		x													
Black-winged Stilt						x	x							**x**	**x**	**x**		x	x	x	x	x	x
Red-necked Avocet											x						x	x		x			
Pacific Golden Plover [J, C]		x		x	x	x			x	x	x	**x**	**x**	**x**				x		x	x		
Double-banded Plover	x	x		x							x												
Red-capped Plover				x							x												
Greater Sand Plover [J, C, V]	x	x		x																			
Lesser Sand Plover [J, C, V]	x	x		x									**x**										
Red-kneed Dotterel																**x**					x		
Black-fronted Dotterel																**x**					x		x
Masked Lapwing	x	x		x		x	x	x	x	x	x	**x**	**x**	**x**		**x**		x		x	x	x	x
Silver Gull	x	x	x	x	x	x	x	x	x	x	x	**x**	**x**	**x**			x	x	x	x			
White-winged Black Tern[C]		x		x																			
Gull-billed Tern		x		x		x	x				x			**x**				x		x			
Common Tern [J, C]	x	x	x	x						x	x		**x**										
Caspian Tern [J, C]	x	x	x	x		x				x	x		**x**	**x**				x					
Crested Tern	x	x	x	x		x	x	x	x	x	x	**x**	**x**	**x**			x	x	x	x			
Little Tern [J, C, E, F]	x	x	x	x		x	x	x		x	x			**x**									
Australasian Gannet	x	x	x								x												
Total Species	28	41	11	40	23	35	29	26	25	28	35	**30**	**32**	**33**	**18**	**30**	23	32	23	38	34	19	45

sh = South Head Beach, ki = Kerosene Inlet, db = Dreamtime Beach, tb = Tony's Bar, rp = Rocky Point, sb = Shallow Bay, cb = Chinderah Bay, tr = Tweed River, bi = Boyd's Island, uk = Ukerabagh Island, tc = Terranora Creek, cc = Cobaki Creek, pc = Pony Club, cs = Cobaki Broadwater south, cn = Cobaki Broadwater north, ti = Terranora Islands, w = Womgin Island, bb = Birds Bay, t = Terranora Broadwater, dm = Duroby Marsh, st1 = Tweed Heads west STW, st2 = Tweed Heads south STW, tw = Trutes Bay Wetland.

Total species richness at estuarine sites is similar between Cobaki Creek (30 species), Pony Club (32 species), and Cobaki south (34 species), with fewer species recorded at Cobaki north (18 species). The lower number of species recorded at Cobaki north may be due to less survey effort in this area. Thirty species of bird have been recorded at the Tweed Heads west sewage treatment works (Table 16).

Threatened species have been recorded at a number of sites. Ospreys have been recorded at all of the estuarine sites. Black-tailed godwit, terek sandpiper, and lesser sand plover have been recorded at Pony Club. Great knot and little tern have been recorded at Cobaki south, and pied oystercatcher and terek sandpiper have been recorded at Cobaki Creek. No threatened species have been recorded at the sewage treatment works. White-bellied sea-eagles have been recorded at all four of the estuarine survey sites.

4.3.4 Historical use of high tide roosts

Overview of the use of high tide roosts by shorebirds in Cobaki Broadwater

The use of high tide roosts has varied considerably since surveys in the late 1980's. Variations in roost use have occurred throughout the estuary, however, this section is concerned only with roosts in Cobaki Broadwater. Ten roosts have been identified within Cobaki Broadwater since Martindale (1987; Table 17). Of these, only four continue to be used, and one (Cobaki south) is used only during neap high tides (i.e. tides less than 1.3 m).

Two of the most important shorebird roosts in the entire estuary ('Cobaki' & 'Sewage Drain') identified by Martindale (1987) are no longer used. Birds have not been documented at Cobaki since Martindale's original survey, whilst birds have not been recorded at 'Sewage Drain' since DPWS (1991), although Lawler (1994) recorded a small number of birds roosting on mangroves near this site.

Lawler (1994) was the first to record birds at 'Pony Club' a site situated on the eastern edge of Cobaki Broadwater and on the western edge of land owned by the Tweed Heads Pony Club. 'Pony Club' is situated approximately 250 m north of 'Sewage Drain'. Neither Martindale (1987) nor DPWS (1991b) recorded birds at 'Pony Club. Pony Club has been surveyed regularly since 1994 and continues to be used by shorebirds (eg. WBM Oceanics 1996; QWSG unpublished; Sandpiper Ecological Surveys 1997, 1998, 1999, 2000).

Several other roosts have been documented within Cobaki Broadwater. Additional sites include mangroves opposite 'Sewage Drain', mangroves in Cobaki Creek opposite a small canal estate, and the entrance to Cobaki Creek. The entrance to Cobaki Creek was used during surveys by Lawler (1994) but not in recent surveys. Mangroves opposite the canal estate in Cobaki Creek have not been used during recent surveys, however, birds regularly roosted on rocks at the entrance to the canal estate up to 1998 (QWSG unpublished; Sandpiper Ecological Surveys 1998). Lawler (1994) recorded shorebirds using mangroves opposite 'Sewage Drain', and birds continue to use mangroves in the vicinity of this site (Sandpiper Ecological Surveys 2000; QWSG unpublished).

Table 17: High tide roosts identified in Cobaki Broadwater from previous surveys. * DPWS (1991) referred to 'Sewage Drain' as Pony Club, opp = opposite.

Site	Martindale (1987)	Holmes (1990)	DPWS (1991)	Lawler (1994)	QWSG (unpub)	Sandpiper (97-00)	This Study
Cobaki	x						
Sewage drain	x		x *				
Mangroves opp sewage drain			x	X	x	x	x
Bilambil Creek			x				
Canal estate mangroves			x				
Cobaki Creek entrance			x	X			
Pony Club				X	x	x	x
Canal estate rocks					x	x	
Cobaki south					x	x	
Cobaki Fringe					x	x	x

Historical use of the major high tide roosts in Cobaki Broadwater

Comparison of the use of three high tide roosts by estuarine birds suggests that temporal changes in roost use have occurred (Table 18). The results obtained for Cobaki Creek show a decline in the use of this area by shorebirds since 1997. Birds that continue to roost in Cobaki Creek, now use mangroves adjacent to the Pony Club roost. Use of the Pony Club has declined considerably since the early 1990's when this site was one of the most important roosts within the estuary. Despite the decline the Pony Club remains the most important roost for shorebirds in Cobaki Broadwater. The number of birds roosting within "Cobaki Broadwater" also appears to have declined (Table 18). The large number of shorebirds recorded by Martindale (1987) at 'Cobaki' has not been recorded in more recent surveys. Although the results suggest a decline in the use of Cobaki Broadwater the timing of surveys must be considered. Larger flocks of birds may roost within the Broadwater during neap high tides than during spring high tides.

Table 18: Maximum counts of waterbirds, shorebirds, birds of prey and gulls and terns recorded between 1987 and 2000 at three high tide roosts in Cobaki Broadwater. The number of species is shown in parentheses. (?) = value unknown, * refers to sewage drain.

Year	Site											
	Cobaki Creek				Pony Club				Cobaki Broadwater			
	Water-birds	Shore-birds	Birds of Prey	Gulls & Tern	Water-birds	Shore-birds	Birds of Prey	Gulls & Tern	Water-birds	Shore-birds	Birds of Prey	Gulls & Tern
1987	-	-	-	-	-	104 (4)*	-	-	-	315 (9)*	-	-
1991	nc	nc	nc	nc	nc	161 (8)*	nc	nc	nc	nc	nc	nc
1992	nc	49 (4)	nc	nc	nc	229 (7)	nc	nc	nc	nc	nc	nc
1994	nc	-	nc	nc	nc	93 (5)	nc	nc	nc	nc	nc	nc
95/96	36 (?)	34 (?)	-	-	92 (?)	91 (?)	-	-	nc	nc	nc	nc
1997	22 (6)	48 (4)	3 (2)	-	2 (1)	16 (2)	1 (1)	-	35 (6)	1 (1)	4 (3)	1 (1)
1998	15 (4)	36 (4)	2 (1)	-	10 (2)	31 (4)	1 (1)	-	8 (2)	88 (3)	1 (1)	-
1999	15 (4)	23 (2)	1 (1)	3 (1)	8 (2)	89 (5)	-	-	4 (1)	24 (3)	2 (1)	-
2000	13 (4)	23 (3)	1 (1)	5 (2)	22 (2)	54 (4)	2 (2)	-	10 (2)	51 (3)	4 (3)	1 (1)

1987 = Martindale (1987); 1991 = DPWS (1991); 1992 = Lawler (1994); 1994 = Lawler (1994); 95/96 = WBM Oceanics (1996); 1997-2000 = Sandpiper Ecological Surveys (1997, 1998, 1999, 2000).

Comparison of the use of Cobaki Broadwater by "significant" species between 1991 and 2000 suggests that some obvious declines have occurred (Table 19). The use of Cobaki Creek by grey-tailed tattler has declined since 1992, whilst the number of pacific golden plovers recorded at Pony Club has declined over the same period. The use of the Pony Club by curlew sandpiper, common greenshank, and bar-tailed godwit has also declined. The data suggest that the numbers of whimbrel and eastern curlew using the Pony Club has not declined substantially since 1991. The use of Cobaki Broadwater shows no obvious trends, although the number of both common greenshank and grey-tailed tattler may be increasing.

Table 19: Maximum number of threatened, conservation significant and JAMBA and CAMBA species recorded at three high tide roosts situated within Cobaki Broadwater. Numbers in parentheses refers to the estimated maximum population of that species within the Tweed River estuary during that year.

Species	Site and Year														
	Cobaki Creek					Pony Club						Cobaki Broadwater			
	1992	1997	1998	1999	2000	1991	1992	1997	1998	1999	2000	1997	1998	1999	2000
Great Egret	-	1 (13)	1 (16)	1 (26)	1 (38)	-	-	-	-	-	-	1 (13)	1 (16)	2 (26)	2 (38)
Osprey	-	1 (8)	-	-	1 (4)	-	-	-	-	-	-	2 (8)	2 (11)	-	2 (4)
Brahminy Kite	-	2 (5)	1 (6)	1 (5)	2 (7)	-	-	-	-	-	1 (7)	1 (5)	2 (6)	2 (5)	2 (7)
White-bellied Sea-Eagle	-	1 (3)	-	-	-	-	-	-	-	-	-	-	1 (2)	-	-
Bar-tailed Godwit	-	-	-	-	-	43 (363)	73 (271)	-	-	15 (196)	-	-	33 (243)	-	-
Whimbrel	18 (110)	24 (69)	13 (124)	20 (59)	21 (78)	24 (62)	60 (110)	-	15 (124)	26 (59)	23 (78)	-	30 (124)	1 (59)	1 (78)
Eastern Curlew	-	-	-	-	-	28 (164)	10 (62)	4 (94)	-	24 (132)	20 (117)	-	25 (131)	-	-
Marsh Sandpiper	-	-	-	-	-	-	-	-	-	-	-	-	11 (58)	-	-
Common Greenshank	-	-	-	-	-	20 (24)	35 (41)	-	1 (44)	17 (45)	-	-	17 (44)	18 (45)	23 (47)
Terek Sandpiper	2 (2)					2 (2)	-								
Common Sandpiper	2 (2)	1 (2)	-	-	1 (1)	-	-	-	-	-	-	-	-	-	-
Grey-tailed Tattler	27 (27)	21 (73)	18 (73)	11 (59)	-	5 (35)	-	-	-	-	-	-	-	14 (59)	7 (69)
Curlew Sandpiper	-	1 (9)	9 (15)	-	-	17 (19)	24 (24)	-	-	-	-	-	-	-	-
Sharp-tailed Sandpiper	-					-	3 (3)								
Pied Oystercatcher	-	-	1 (8)	-	-	-	-	-	-	-	-	-	-	-	-
Pacific Golden Plover	-	-	-	-	-	39 (83)	24 (37)	12 (27)	14 (29)	7 (29)	9 (24)	-	-	-	-

4.3.5 Historical use of feeding grounds

Comparison of the number of estuarine birds recorded at three feeding areas in Cobaki Broadwater between 1997 and 2000 suggests that the use of feeding areas fluctuates between surveys (Table 20). Although no definite conclusions can be drawn the data suggest a slight increase in the number of shorebirds using Cobaki Broadwater, and a decline in the number of shorebirds using Cobaki Creek and Pony Club. However, the figures shown are substantially less than those recorded in the late 1980's when in excess of 300 individuals were recorded foraging in the Broadwater (Martindale 87). The number of waterbirds using the Pony Club may be increasing. The numbers of birds of prey and gulls and terns fluctuates between surveys.

Table 20: Maximum counts of waterbirds, shorebirds, birds of prey and gulls and terns recorded between 1997 and 2000 at three foraging areas in Cobaki Broadwater. The number of species recorded during each survey is shown in parentheses.

Date	Site											
	Cobaki Creek				Pony Club				Cobaki Broadwater			
	Water-birds	Shore-birds	Birds of Prey	Gulls & Tern	Water-birds	Shore-birds	Birds of Prey	Gulls & Tern	Water-birds	Shore-birds	Birds of Prey	Gulls & Tern
1997	8 (4)	13 (3)	3 (2)	-	6 (5)	21 (4)	1 (1)	-	67 (7)	79 (6)	3 (2)	4 (2)
1998	22 (9)	39 (4)	1 (1)	5 (1)	9 (2)	30 (5)	1 (1)	1 (1)	91 (7)	99 (6)	6 (2)	25 (2)
1999	12 (6)	11 (3)	1 (1)	-	15 (4)	22 (6)	-	-	41 (6)	95 (7)	4(3)	16 (4)
2000	23 (7)	2 (2)	-	-	21 (6)	12 (5)	1 (1)	1 (1)	61 (7)	90 (6)	5 (3)	10 (2)

A number of significant species have been recorded using foraging grounds in Cobaki Broadwater (Table 21). The results do not suggest any obvious temporal trends in the number of individuals using each site. The number of bar-tailed godwits using Cobaki Broadwater appears to be increasing, whilst the number of whimbrels and eastern curlews may be declining (Table 21). The number of whimbrels using Cobaki Creek and Pony Club may also be decreasing. The use of Pony Club by bar-tailed godwits has fluctuated between surveys. This result may be due to differences in the timing of surveys in relation to low tide, and may emphasise the use of this site during the ebb tide. Further evidence of a decline can be obtained by comparing the results of this study with those of Martindale (1987) who recorded over 400 migratory shorebirds foraging in Cobaki Broadwater during surveys in Feb/Mar 87.

Table 21: Maximum number of individuals of threatened, conservation significant and JAMBA and CAMBA species recorded at three foraging areas in Cobaki Broadwater. The estimated population of each species in the estuary is shown in parentheses.

Species	Site											
	Cobaki Creek				Pony Club				Cobaki Broadwater			
	1997	1998	1999	2000	1997	1998	1999	2000	1997	1998	1999	2000
Great Egret	-	1 (16)	2(26)	1(38)	1(13)	-	1(26)	1(38)	6(13)	7(16)	6(26)	5(38)
Osprey	2 (8)	-	-	-	1 (8)	-	-	-	-	1 (11)	3(10)	1(4)
Brahminy Kite	1 (5)	1 (6)	-	-	-	-	-	-	1 (5)	4 (6)	1 (5)	2(7)
White-bellied Sea-Eagle	-	-	-	-	-	-	-	1(2)	2(3)	2(2)	1(6)	2(2)
Bar-tailed Godwit	-	2(243)	-	-	7(282)	17(243)	10(196)	1(193)	21(282)	27(243)	40(196)	44(193)
Whimbrel	4(69)	3(124)	2(59)	1(78)	4(69)	5(124)	2(59)	1(78)	19(69)	16(124)	14(59)	15(78)
Eastern Curlew	2(94)	2(131)	1(132)	1(117)	3(94)	5(131)	4(132)	5(117)	21(94)	22(131)	16(132)	16(117)
Marsh Sandpiper	-	-	-	-					-	4(58)		-
Common Greenshank	-	-	-	-	1(29)	1(44)	1(45)	1(47)	15(29)	34(44)	17(45)	18(47)
Grey-tailed Tattler	8(73)	28(73)	7(59)	-	7(73)	2(73)	-	-	4(73)	4(73)	14(59)	9(69)
Curlew Sandpiper	-	8(15)	-	-	-	6(15)	-	-	2(9)	-	-	-
Sharp-tailed Sandpiper	-	-	-	-	-	-	-	-	-	3(26)	-	-
Pacific Golden Plover	-	-	-	-	-	6 (27)	4(29)	4(29)	-	-	-	-
Common Tern	-	-	-	-	-	-	-	-	-	-	10(15)	-
Little Tern	-	-	-	-	-	-	-	-	-	-	1(21)	-

4.4 Terrestrial bird surveys

4.4.1 Habitat assessment

Eight terrestrial habitat types were identified during the survey (Table 22, Figure 7). A brief discussion of the major features of each habitat type is provided below.

Dry Woodland

Dry woodland was one of the most extensive habitats within the study area, although it was restricted to the western edge of the site (Figure 7). This habitat type was dominated by scribbly gum (*Eucalyptus signata*) and pink bloodwood (*Corymbia intermedia*), with a dense heathy understorey. A mix of *Acacia* spp., and *Allocasuarina* spp. dominated the midstratum.

Dry woodland has a number of features important for birds, including occasional large (> 15 cm diameter) basal hollows suitable for owls, and several small (5-15 cm diameter) hollows. The habitat is also characterised by dense mid-stratum and ground vegetation suitable for small passerines. At the time of the survey there was considerable food resources available within the woodland habitat, including flowering and fruiting Banksia's, Allocasuarina, and mistletoe.

Lowland Rainforest

Lowland rainforest is restricted to a narrow strip of land adjacent to Cobaki Broadwater (Figure 7). This habitat is dominated by a mix of blue quondong (*Elaeocarpus grandis*), *Ficus* spp. and broad-leaved paperbark (*Melaleuca quinquenervia*) in the overstorey, and bangalow palm (*Archontopheonix cunninghamiana*) in the midstratum. Lowland rainforest is relatively undisturbed with no direct evidence of logging or fire. The habitat has a light weed infestation with both umbrella tree (*Schefflera actinophylla*) and camphor laurel (*Cinnamomum camphora*) recorded in the mid-stratum.

Lowland rainforest has a number of features important to birds. The most distinctive feature of lowland rainforest was the large number of fruiting trees, which included blue quondong, bangalow palm, cheese tree (*Glochidion ferdinandi*), and camphor laurel. Both small and large hollows were recorded in this habitat, although in low numbers only.

Swamp Forest

Swamp forest habitat occurs throughout the study area (Figure 7). This habitat is co-dominant with open woodland on the western part of the study area, where it occurs in shallow depressions, with woodland on the higher swales. A large tract of swamp forest also occurs within the centre of the study area where it extends from near the main runway to mangrove forest along the edge of Cobaki Broadwater (Figure 7). A block of swamp forest also occurs along the eastern edge of the study area between heathland, and cleared land.

Broad-leaved paperbark and swamp mahogany (*Eucalyptus robusta*) dominate the swamp forest, although in some instances habitat is dominated by only one of these species. A mix of *Banksia robor*, *B. integrifolia*, and cheese tree dominates the midstratum, whilst *Blechnum spp.,* and *Lygodium microphyllum* dominate the understorey. Several small freshwater lagoons occur throughout the swamp forest habitat, with two larger, more permanent waterbodies, situated near the western edge of land owned by Coolangatta Airport (Figure 7).

Waterbodies appear suitable for crakes and rails, with aquatic vegetation, shallow littoral areas, and fringing broad-leaved paperbark present at most sites. It is likely that much of the swamp forest habitat becomes inundated after prolonged rainfall. A small permanent creek runs through swamp forest on the western side of the study area.

Swamp forest habitat also has a number of additional features important for birds, including a high density of flowering trees and shrubs (paperbark and banksia). Small and large hollows were recorded throughout swamp forest habitat but only at low densities. The habitat has suffered only minor disturbance, although a small section of swamp forest on the eastern side of the study area has been subject to cattle grazing.

Mangrove

Mangroves are widespread within estuarine habitats in Cobaki Broadwater. A thin fringe of mangrove occurs along the northern edge of Cobaki Broadwater, abutting the terrestrial habitats within the study area (Figure 7). Four small mangrove islands occur within Cobaki Broadwater that also fall within the study area. The study area adjoins a larger tract of mangroves situated along the southern edge of Cobaki Creek.

Mangrove habitat within the study area is dominated by four species. The dominant overstorey species in fringing habitats is the grey mangrove (*Avicennia marina*), with emergent black mangrove (*Bruguiera gymnorhiza*), and river mangrove (*Aegiceras corniculatum*) in the understorey. Mangrove islands are dominated by spider mangrove (*Rhizophora stylosa*), with black mangrove and river mangrove. The milky mangrove (*Excoecaria agallocha*) occurs occasionally along the landward side of the fringing mangrove habitat. Mangroves along the north shore of Cobaki Broadwater are situated adjacent to small areas of saltmarsh and swamp forest dominated by swamp oak (*Casuarina glauca*), and broad-leaved paperbark.

Mangrove habitat provides dense shelter for a range of bird species, and the abundance of insects and regular flowering provides food for both insectivorous and nectivorous species throughout much of the year. Mangrove habitats in the Tweed estuary are known to be used by four endemic mangrove specialists, mangrove honeyeater, collared kingfisher, mangrove gerygone, and shinning flycatcher. This habitat lacks large hollows suitable for owls. Mangroves that fringe drains may provide roosting habitat for bitterns.

Regenerating swamp forest

There are three areas of regenerating swamp forest in the study area. The largest area is situated in the south-eastern corner of the site, in the vicinity of the Tweed Heads Pony Club. Another smaller patch of regenerating forest is situated on the western edge of the sedgeland, with an even smaller block situated to the south of the rubbish dump (Figure 7).

Regenerating swamp forest is dominated by broad-leaved paperbark, with occasional swamp oak (*Casuarina glauca*), swamp box (*Lophostemon suaveolans*), cheese tree, and camphour laurel. Patches of regenerating trees to 15 m are interspersed with open grassland dominated by exotic grasses.

Regenerating swamp forest lacks large or small hollows, and the habitat is open, allowing ready access for aggressive edge specialists such as noisy miners (*Manorina melanocephala*) and pied currawong (*Strepera graculina*). This habitat provides abundant nectar, fruit and insect resources for a range of bird species. Shallow depressions may provide habitat for crakes and rails during wet periods.

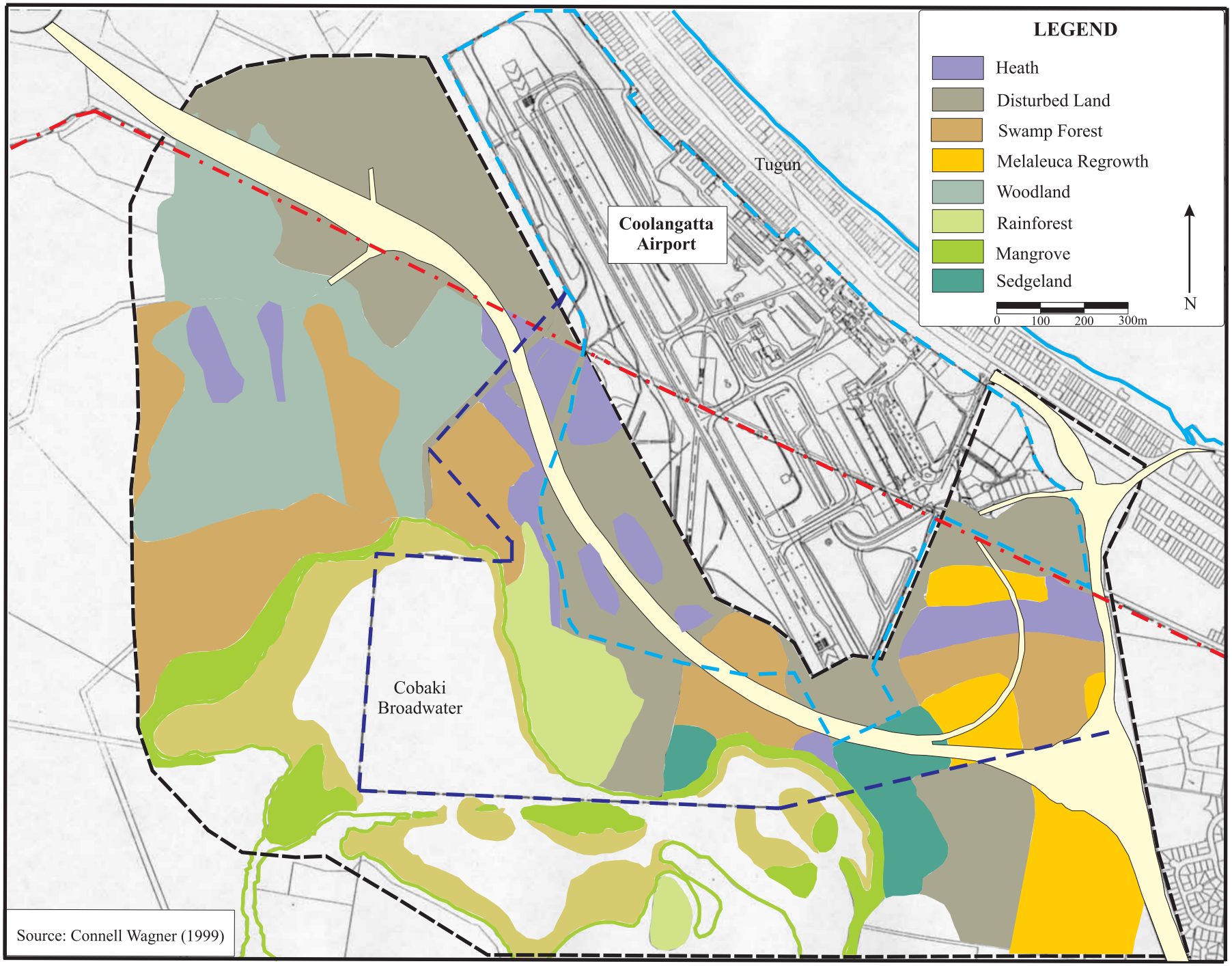


Figure 7: Major habitat types present within the study area.

Heath

The heath habitat type incorporates both dry and wet heath. There are two large tracts of heath within the study area. One is situated on the eastern side, whilst the other is situated near the western boundary (Figure 7). Both tracts adjoin cleared land, and are fragmented by several vehicle tracks. Heath near the eastern side of the study area incorporates a small ephemeral creek dominated by regrowth broad-leaved paperbark.

Heath habitat is characterised by emergent broad-leaved paperbark, and coast banksia (*Banksia integrifolia)*, *Banksia aemula*. A variety of heath species dominate the midstratum, whilst the understorey is dominated by ferns and sedges. Features important to birds include the dense cover, which provides shelter, nesting, and foraging opportunities for a range of small passerines, and the presence of a small number of flowering trees. The heath habitat lacks small or large hollows, and no stags greater than 10 cm DBH were recorded.

Sedgeland

There are several small patches of sedgeland distributed throughout the study area. The largest area of sedgeland extends south from the southern end of the airport runway (Figure 7). This patch is dominated by *Phragmites australis*, with emergent swamp oak along drainage lines. The habitat appears to have formed through clearing and slashing associated with airport maintenance. The sedgeland adjoins a small area of saltmarsh adjacent to mangrove forest along the edge of Cobaki Broadwater. Saltmarsh is dominated by *Sporobolos virginicus*, with some *Sueda australis* and *Sarcocornia quinqueflora*. *Juncus krassi* appears to be expanding into saltmarsh habitat. Another small patch of sedgeland occurs near the western edge of the study area.

The dense ground cover present within the sedgeland is suitable for a number of birds including wrens and quail. Australasian bittern may use the dense cover provided by *P. australis*. No hollows or large stags were recorded in this habitat.

Disturbed land

Disturbed land occurs along a small number of access tracks situated throughout the site, and adjacent to the main areas of activity associated with the airport. Disturbed land is regularly slashed as part of general airport maintenance activities. This habitat is dominated by exotic grass species and provides only limited habitat for birds. Some of the important features of disturbed land include a small dam, and a large tidal drain at the southeastern edge of Coolangatta Airport and the Tugun rubbish tip and sewage treatment works (Figure 2).

Table 22: Characteristics of major terrestrial habitat types identified within the study area. ** = site previously slashed; LH = large hollow, SH = small hollow, M = mistletoe, Ep = epiphytes, FF = fleshy fruits, Fl = flowers, Ac = *Acacia* spp., Ba = *Banksia* spp., Al = *Allocasuarina* spp.

Habitat Type	Topographic position	Disturbance History				Soil		Ground Layer (% cover)				Litter depth	Humus depth
		Fire	Logging	Grazing	Weeds	Depth	Type	Vegt	Soil	Log	Litter		
Dry Open Woodland	Flat, plain	<10 years (mod)	< 15 yrs (light)	nil	nil	shallow	loam	70	10	10	10	0-2cm	0-2cm
Rainforest	Flat, plain	none	none	nil	light	shallow	loam	40	5	15	40	2-10cm	2-10cm
Swamp Forest	Flat, plain	5 years (mod)	none	5 years (light)	light	shallow	loam	90	0	5	5	0-2cm	2-10cm
Mangrove	Flat, plain	none	<15 yrs	none	none	deep	mud	10	85	5	0	absent	absent
Regenerating Swamp Forest	Flat, plain	<10 yrs (light)	Previously cleared	Present (light)	moderate	shallow	sand	90	5	0	5	absent	0-2cm
Heath	Flat, plain	none	none	none	none	shallow	sand	75	20	0	5	0-2cm	0-2cm
Sedgeland	Flat, plain	none	none	none**	light	skeletal	sand	95	5	0	0	0-2cm	0-2cm
Cleared land	Flat, plain	none	Previously cleared	none	light	shallow	sand	95	0	0	5	absent	absent

Habitat Type	Stand Description (% of trees)									Stags >10 cm dbh/ 20x20m	Shrub Growth form	Ground growth form	Dominant midstorey & (height m)	Dominant overstorey & (height m)
	LH	SH	M	Ep	FF	Fl	Ac	Ba	Al					
Dry Open Woodland	5	5-25	5	<5	<5	5- 25	25- 50	5-25	5-25	1-2	heathy	Fern/sedge	*Acacia* sp (4-8)	*Eucalyptus signata* (15-20) *Corymbia gummifera* (15-20)
Rainforest	<5	5	5-25	5	25-50	<5	0	0	0	1-2	mesic	fern	*Ar. cunninghamiana* (10-15)	*Elaeocarpus grandis* (20-25) *Melaleuca quinquenervia* (20-25)
Swamp Forest	5	<5	5	0	5	5	5	25-50	0	1-2	heathy	sedge	*Dodenaea* spp (2-3) *Glochidion* spp. (4-6) *Banksia robor* (1-2)	*Eucalyptus robusta* (20-25) *Melaleuca quinquenervia* (25-30)
Mangrove	0	5-25	<5	0	<5	5	0	0	0	1-2	mesic	na	*Aegiceras corniculatum* (2)	*Avicennia marina* (9-10) *Bruguiera gymnorhiza* (8) *Rhizophora stylosa* (6)
Regenerating Swamp Forest	0	<5	5	0	5-25	25-50	<5	<5	0	0	mixed	Herb/grass	Heath species (3m)	*Melaleuca quinquenervia* (15) *Casuarina glauca* (13)
Heath	0	0	<5	0	0	<5	5	<5	0	0	heathy	sedge		*Melaleuca quinquenervia* (4-10) *Banksia integrifolia* (2-4)
Sedgeland	0	0	<5	0	0	0	0	0	5	0	none	Sedge/rush	*P. australis* (1-2) *Baumea* spp. (0.5m)	*Casuarina glauca* (3-10)
Cleared land	0	0	0	0	0	0	0	0	0	0	-	-	exotic grasses	nil

4.4.2 Total species richness

A total of 147 species of bird were recorded in terrestrial habitats during the summer survey, whilst 94 species were recorded during the autumn survey[3] (Table 23, & Tables 3a & 3b, Appendix 3). Total species richness was determined by combining the results of all survey methods, including point counts, area searches, general traverses, nocturnal and dusk playback, edge effect study, and opportunistic records. Nine species were recorded during the autumn survey that were not recorded during the summer survey. These species included peregrine falcon, grass owl, forest kingfisher, noisy pitta, spotted pardalote, little friarbird, yellow-faced honeyeater, golden whistler and little grassbird. The total number of species recorded within terrestrial habitats in the study area during both the summer and autumn surveys was 156.

Table 23: Number of species of bird recorded in each habitat type during the summer and autumn bird surveys. Also shown is a general indication of survey effort. Sp = species; EF = survey effort in minutes. Survey effort does not include the time spent conducting dawn, dusk and nocturnal playback.

Time of survey	Woodland		Swamp Forest		Rainforest		Mangrove		Sedge		Heath		Regrowth Melaleuca		Disturbed	
	Sp	Ef	Sp	Ef	Sp	Ef	Sp	Ef	Sp	Ef	Sp	Ef	Sp	Ef	Sp	Ef
Summer	59	386	81	708	49	390	59	257	28	180	46	195	42	90	55	120
Autumn	25	45	49	345	28	255	30	140	8	50	38	265	32	80	39	75

The lower total species richness recorded in autumn resulted in lower numbers of species in all habitats, although the decrease was greater for some habitats than others. The primary reason for the larger decrease in species richness recorded in woodland, rainforest, mangrove and sedge habitats than in heath, regrowth and disturbed habitats was due to survey effort. Survey effort in heath, regrowth and disturbed habitats was similar between the two surveys, whilst survey effort varied for the other habitats.

During the summer survey the highest species richness was recorded in swamp forest habitat (81 species), followed by mangroves and woodland (59 species), disturbed (55 species), rainforest (49 species), heathland (46 species), swamp forest regrowth (42 species), and sedgeland (28 species). During the autumn survey the highest species richness was recorded in swamp forest (49 species), followed by disturbed land (39 species), heath (38 species), swamp forest regrowth (32 species), mangrove (30 species), rainforest (28 species), woodland (25 species), and sedgeland (8 species). The relatively large number of species recorded in the disturbed habitat during both the summer and autumn survey is due primarily to the diversity of habitats included in this habitat.

[3] Evidence of glossy black-cockatoos was recorded on the subject site in December 2000 during surveys for the Species Impact Statement. The location of the glossy black-cockatoo record is shown on the appropriate map and is considered in the eight-part test, however, the species has not been included in the number of species recorded during the field survey.

4.4.3 Distribution of bird species

The distribution of bird species varied considerably between the different habitats (Table 24). The species richness of passerines was highest within habitats that had a diverse vegetation structure, including woodland, swamp forest, mangrove, rainforest and heath. Species of non-passerine were distributed throughout the various habitats. Some groups such as the doves and pigeons, parrots, cuckoos, and kingfishers reached their highest species richness in woodland and forest habitats.

The highest species richness of waterbirds and birds of prey was recorded at open habitats or those sites with permanent water. The species richness of waterbirds was also reasonably high at woodland, swamp forest, and mangrove habitats (Table 24). The high species richness of waterbirds recorded in woodland and swamp forest habitat is attributed to the presence of numerous freshwater wetlands within these habitats.

Table 24: Summary of the number of species of birds recorded in the major habitat types sampled within the study area during the summer survey. W = woodland; SF = swamp forest; M = mangrove; Rf = rainforest; H = heath; S = sedge; Mrg = melaleuca regrowth; D = disturbed.

Group	Total species	Number of species recorded in each of the major habitats							
		W	SF	M	Rf	H	S	MR	D
Quail	4	3	1	2	1	2	3	0	1
Waterbirds	27	6	11	8	1	2	5	5	14
Birds of prey	8	1	2	4	1	1	3	3	2
Shorebirds	6	0	0	1	0	1	0	1	4
Doves & pigeons	11	3	3	4	5	3	2	4	2
Parrots	6	2	5	2	1	2	0	1	3
Cuckoos	8	4	4	5	2	1	0	0	0
Nocturnal birds	5	5	3	0	3	0	0	0	1
Swifts	1	1	1	1	0	0	0	0	1
Kingfishers, bee-eater, dollarbird	6	3	3	4	2	3	1	1	1
Treecreeper	1	1	1	0	1	0	0	0	0
Wrens, gerygone, thornbills	11	4	8	4	5	5	2	4	4
Honeyeaters	12	6	10	7	5	5	1	4	4
Robins	2	1	2	0	1	0	2	0	0
Thrush, monarch, flycatcher	9	4	8	1	5	4	1	3	1
Fantails	3	1	2	2	2	2	1	2	2
Figbird, triller, cuckoo-shrike	5	5	5	4	5	1	1	3	1
Woodswallow	1	0	0	1	0	0	0	1	0
Butcherbird, magpie, crow	7	6	6	6	5	7	2	5	4
Bowerbird	1	0	1	0	1	0	0	0	0
Pipit	1	0	0	0	0	1	0	0	1
Finch	4	2	1	0	1	2	1	2	3
Mistletoe bird	1	1	1	1	1	0	0	1	0
Swallow, martins	3	0	2	0	0	1	1	1	2
Grassbirds	3	1	0	1	0	2	2	0	2
Silvereye	1	1	1	1	1	1	1	1	1
Starling	1	0	0	0	0	0	0	0	1

4.4.4 Playback

Nocturnal playback

Six species of bird were recorded during nocturnal playback, including two unconfirmed records of masked owl, and one confirmed record of grass owl (Table 25, Figure 8). The unconfirmed masked owl records made during summer were both of faint calls possibly made in response to playback, and both records were from habitat to the west and south west of the study area. The unconfirmed masked owl record made during autumn was of a single bird that flew over the playback site during the 10 minute listening period that followed playback. No call response was recorded.

One grass owl was recorded in sedgeland at the southern end of the airport runway (Figure 8). This individual flew to the playback site and repeatedly circled above the site without responding to playback. The bird was identified as a grass owl by its distinctive silhouette (i.e. long trailing feet). The bird was initially scared from the site but returned again after a brief period of playback. No records of barking, or powerful owls, or marbled frogmouths were made during the survey. Incidental records of white-throated and owlet nightjars, southern boobook, and tawny frogmouth were also made during the survey. Both species of nightjar were widespread, occurring in a variety of habitats. No species of nocturnal bird were recorded from surveys adjacent to the existing Pacific Highway.

Table 25: Species of bird recorded during nocturnal playback at six sites within the study area. U = unconfirmed; C = confirmed. MO = masked owl, ON = owlet nightjar, WN = white-throated nightjar, SB = southern boobook, TF = tawny frogmouth, GO = grass owl. Site numbers correspond to numbers on Figure 4.

Site	Habitat	No. Surveys		Species recorded		Habitat where species recorded	Notes
		Summer	Winter	Summer	Winter		
1	Woodland/Swamp Forest	2	2	MO (u)	MO (u)	Road/open woodland	250-300 m west/south west
2	Woodland/Swamp Forest	2	2	MO (u) ON (c) WN (c) SB (c)	ON (c)	Unknown Woodland Woodland Woodland	200-250 m south-west
3	Woodland/Swamp Forest	2	0	ON (c) SB (c) TF (c)	-	Heath, Swamp forest Swamp forest Heath, Swamp forest	-
4	Rainforest	2	2	ON (c) WN (c)	ON (c)	Rainforest Rainforest	-
5	Swamp Forest	2	0	nil	-	-	-
6	Sedge	2	2	nil	GO (c)	Sedge	-

Dusk and dawn playback

Three species were recorded during dusk playback (Table 26). A possible black bittern call was heard along a creekline near the northern edge of the study area, whilst bush hen was recorded in the same area of melaleuca swamp on two occasions. During one survey at least three individuals responded to playback. An incidental record of tawny frogmouth was also made during dusk playback at site 4. None of the small crakes and rails responded to playback despite the fact that some species were recorded during point counts and area searches. No birds responded to playback at the sewage farm, sedgeland or dredge dump. No red-backed button-quail were recorded during dawn playback in sedgeland south of the airport runway. No Australasian bittern were recorded during the survey. Black bitterns were not recorded during supplementary surveys in December 2000.

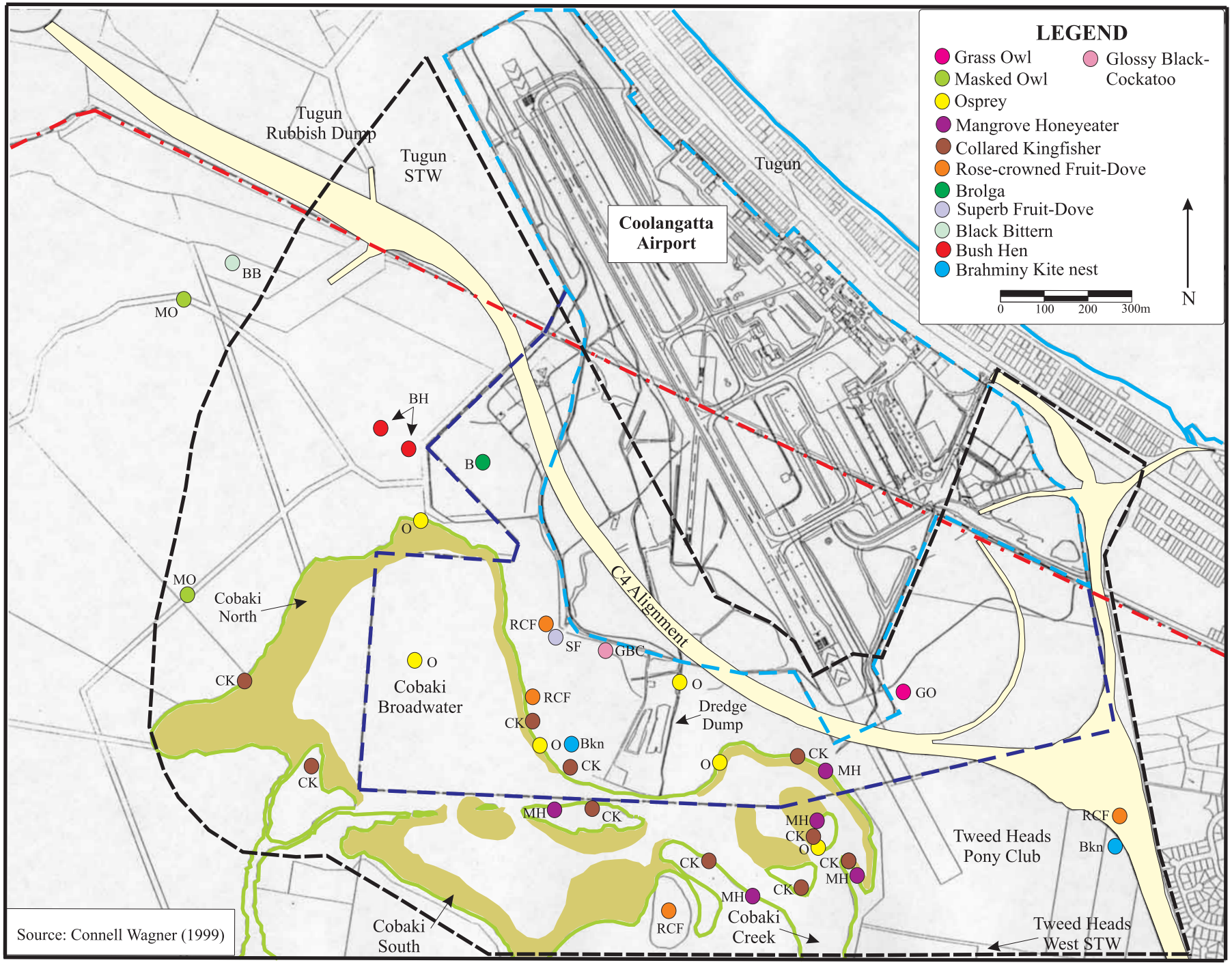


Figure 8: Location of legislatively protected species recorded on the subject site during field surveys for the proposed Tugun Bypass.

Table 26: Results of dusk and dawn playback conducted at six sites in the study area. BB = black bittern, BH = bush hen, TF = tawny frogmouth, u = unconfirmed, c = confirmed. Site numbers correspond to numbers on Figure 4.

Site	Habitat	No. Surveys		Species recorded		Habitat where species recorded	Notes
		Summer	Winter	Summer	Winter		
3	Swamp Forest	1	2	BB (u)	nil	Swamp Forest	faint call from creek line
1	Sewage Ponds	2	0	nil	-	-	-
4	Swamp Forest	2	1	BH (c)	nil	Swamp Forest	3 birds on either side of track
5	Rainforest/Swamp forest	1	0	BH (c) TF (c)	-	Swamp Forest	Same wetland as site 3
9	Sedgeland	2	2	nil	nil	-	-
8	Dredge dump	1	0	nil	-	-	-

4.4.4 Bird density

Replicate point count surveys were conducted at 15 sites (45 point counts) throughout the study area (Table 27). The objective of point counts was to provide baseline data on the density of birds within the major habitat types. Although this has been achieved, scrutiny of the results indicates that a greater number of point counts (replicates) were required at each site. The data collected from point counts show a high degree of variation between counts making it impossible to calculate standard errors for individual species at a number of sites. For this reason only the average density of birds/hectare has been included in the results, and no statistical analysis of the data has been attempted. Despite this limitation the data provide general information on the density of birds in the major habitats.

Mangrove habitat

Mangrove habitat situated along the eastern fringe of Cobaki Broadwater (sites 1 & 2), closest to the proposed alignment had fairly low species richness and density of birds. Both species richness and total density were greater at sites three and four, which were located in more extensive tracts of mangroves. Despite the lower overall density site one supported the highest density of collared kingfisher (3.54 birds/ha), and mangrove honeyeater (4.71 birds/ha). Both these species were also recorded at site two. Another mangrove specialist the mangrove gerygone was recorded at sites one and two but in lower densities than at sites three and four.

Rainforest

Rainforest seemed to support fairly low total densities and species richness of birds, with densities ranging from 19.9 to 21.06 birds/ha (Table 27). The results obtained for rainforest also show only a small degree of similarity between the survey sites. Of the 15 species recorded in rainforest only three species were recorded at both sites.

Woodland

The total density and species richness of birds varied considerably between woodland sites. The highest density and species richness was recorded at sites situated along the western extremity of the study area (Table 27). Lower species richness and density was recorded at sites situated near the edge of the more contiguous vegetation. The high density and richness recorded at sites one and two may be related to a slight increase in habitat diversity and complexity at these sites.

Woodland surveys emphasise the influence that feeding flocks of birds can have on density estimates. Flocks of rainbow lorikeet, rainbow bee-eater and white-cheeked honeyeater may have increased density estimates at both sites one and two. The presence of both white-cheeked honeyeater and rainbow lorikeet at these sites is attributed to the occurrence of flowering trees.

Swamp Forest

The average density and species richness of birds was similar between sites sampled in the swamp forest habitat. The highest density of birds was recorded at sites (four & five) situated adjacent to the existing Pacific Highway, with the lowest densities recorded at sites one and three. Site one is situated on the edge of a large contiguous tract of vegetation, whilst site three is a small isolated patch of habitat situated near the southern end of the airport runway (Figure 7). The high density of birds recorded at sites four and five may be attributed to the presence of flowering shrubs, and the occurrence of large flocks of nectivorous birds including rainbow lorikeet, little wattlebird, and white-cheeked honeyeater.

The highest species richness was recorded at sites two and three, with the lowest richness recorded at sites one and four. White-cheeked honeyeater was the only species recorded at all survey sites, whilst rainbow lorikeet was recorded at four of the five sites. The majority of species (29 of the 34 recorded) were recorded at one or two sites only.

Table 27: Average density of birds per hectare recorded from replicate point counts at 15 sites distributed between the four major habitat types present in the study area. n = 3 for all sites. M = mangrove, R = rainforest, W = woodland, SF = swamp forest.

Site	M1	M2	M3	M4	R1	R2	W1	W2	W3	W4	SF1	SF2	SF3	SF4	SF5
King Quail							1.16								
Australian Wood Duck															2.34
Pacific Black Duck											2.34				
Great Egret							1.16								
Striated Heron				1.16											
Australian White Ibis				5.88					7.08			3.54			
Royal Spoonbill									1.16						
Lewins Rail							2.34								1.16
Whistling Kite				1.16											
Brahminy Kite				1.16											
Spotted Turtle-Dove	1.16														
Peaceful Dove			1.16												
Bar Shouldered-Dove	1.16	4.71	2.34												1.16
Topknot Pigeon					1.16										
Sulphur-crted Cockatoo											1.16				
Rainbow Lorikeet							16.49	4.71			1.16	7.08		1.16	8.25
Fan-tailed Cuckoo								1.16		3.54			2.34		
Brush Cuckoo									1.16						
Cuckoo Sp.							1.16		1.16						
White-thted Needletail								3.54							
Laughing Kookaburra							1.16								
Sacred Kingfisher															1.16
Collared Kingfisher	3.54	1.16		2.34											
Azure Kingfisher				2.34											
Rainbow Bee-eater	1.16							8.25							
Dollarbird				1.16											
White-Thted Treecreep.								1.16			1.16	2.34			
Fairy Wren Sp.			3.54						2.34	1.16		1.16			
Superb Fairy-wren							3.11								
Variegated Fairy-wren													3.54	2.34	
White-Browed Scrubwr						1.16		2.34	1.16		3.54	1.16			
Large-Billed Scrubwren					1.16										
Mangrove Gerygone	2.34	4.71	3.54	17.7											
Brown Gerygone			2.34												
Brown Thornbill		1.16			1.16	2.34				1.16			2.34		
Little Wattlebird							1.16							9.42	1.16
Noisy Friarbird				1.16										2.34	
Lewins Honeyeater	1.16			1.16		2.34	1.16		1.16	1.16			1.16		
Mangrove Honeyeater	4.71	1.16		2.34											
White-cheeked H'eater				1.16			10.62	7.08	5.88		3.54	3.54	2.34	11.79	9.42
Eastern Spinebill									1.16		1.16		1.16		
White-naped H'eater							3.54	2.34							
Brown Honeyeater	9.42	3.54	2.34	4.71			1.16								
Eastern Yellow Robin						2.34		1.16	1.16	1.16		2.34			
Eastern Whipbird					5.88	2.34		1.16	1.16				3.54		
Varied Sitella *														1.16	
Rufous Whistler								1.16		1.16					
Grey Shrike-thrush								1.16		1.16		1.16	1.16		
Little Shrike-thrush						1.16									
Leaden Flycatcher					2.34							1.16			
Grey Fantail	1.33		3.54			3.54		1.16				1.16	1.16		3.54
Black-faced Cck-shrike			2.34					1.16					1.16	3.54	2.34
Cicadabird			1.16	1.16									2.34		
Varied Triller						1.16									
Figbird	1.16		3.54		1.16					1.16					
White-brsted Woodsw		1.16													
Pied Butcherbird							1.16	1.16							
Grey Butcherbird		1.16												1.16	
Pied Currawong															
Spangled Drongo			5.88					2.34						2.34	4.71
Torresian Crow			2.34			2.34	3.54				2.34	1.16			
Double-barred Finch							1.16								
Red-browed Finch												1.16	3.54		
Mistletoebird				1.16	5.88			1.16							
Tree Martin															
Fairy Martin												2.34			
Golden-hded Cisticola							5.88								
Silvereye		1.16		2.34	1.16	2.34	4.71				2.34				
Uknown												1.16			1.16
Relative abundance	27.14	19.92	36.4	48.09	19.9	21.06	60.67	42.2	24.58	11.66	25.04	30.46	25.78	35.25	35.24
No. species	10	9	12	16	8	10	17	17	11	8	9	14	12	9	11

4.4.6 Edge effect of the existing Pacific Highway

Analysis of data gathered on bird species richness and density at various distances (i.e. 25, 75, 125, 175, 225, 275 m) from the existing Pacific Highway failed to identify any significant differences ($P>0.05$). Statistical analysis of edge (25, 75 and 125m) and interior (175, 225 and 275m) sites also failed to identify a significant difference ($P>0.05$). The failure to detect a significant difference cannot be viewed as definitive evidence that the existing highway does not affect bird populations in adjacent habitats. The small sample size used in the present study, the fact that sites were sampled on only one occasion, the disturbed nature, and extent of habitat, are just some of the reasons why the results should be viewed with caution. General observation during the field survey indicated that the highest concentrations of birds occurred where there were large numbers of flowering broad-leaved paperbark. It is likely that the results are strongly influenced by the distribution of flowering trees.

The average values for species richness and relative abundance at each distance, and in heath and swamp forest habitat are presented in Figure 9. The data presented in Figure 9 suggests a general trend of lower species richness and relative abundance immediately adjacent to the highway, increasing richness and relative abundance in the middle survey sites (i.e. 125 and 175 m samples), and decreasing richness and relative abundance at the 275 m survey site (Figure 9). The exact reason for this apparent trend is difficult to determine, however, it may be due to the combined effect of the cleared forest edge, and subtle changes in habitat with distance from the edge. The result could also be due to the influence of forest edges acting at both the 25 and 275 m sites. Regardless of the exact reason for the apparent trend the results suggest that the if the existing highway affects bird species richness or relative abundance, then the effects are likely to be subtle. A more intensive investigation may be required to identify these effects.

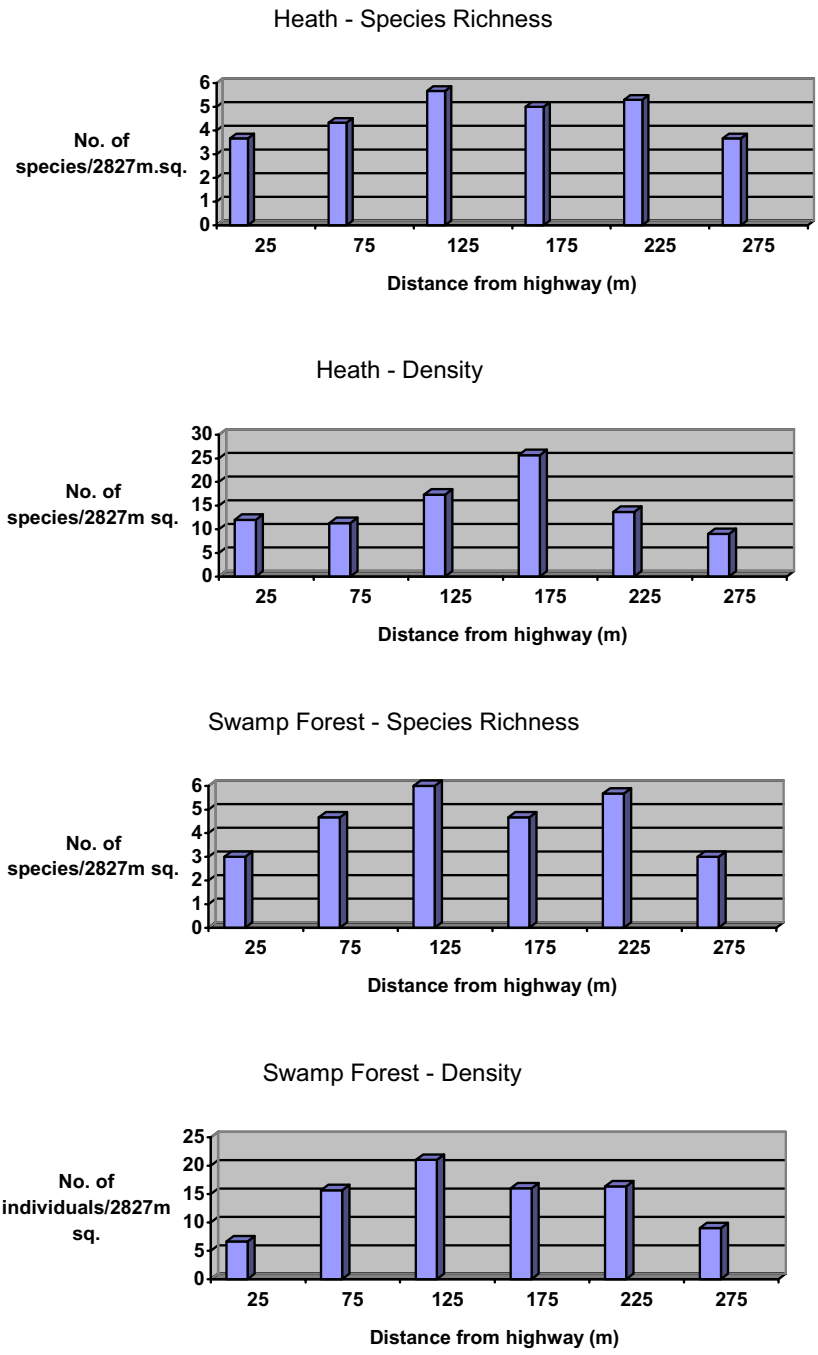


Figure 9: Histograms showing the average relative abundance and species richness of birds recorded in heath and swamp forest/2827m^2 during the edge effects study. n = 3 for each distance in each habitat.

4.4.7 Additional terrestrial bird surveys in the study area

The Tweed Heads Bird Observers Club (TBOC) have been conducting fortnightly bird surveys at three locations within the subject site. The majority of surveys have been conducted by E. Kleiber. The locations where surveys have been conducted include the wetland in the vicinity of the Pony Club shorebird roost, regrowth and mature swamp forest on land managed by the Tweed Heads Pony Club, and lowland rainforest to the west of the dredge spoil dump. Surveys have been conducted on a regular basis since April 2000.

Surveys by the TBOC have recorded 137 species of bird on the subject site, including six species listed on the NSW *TSC Act*, osprey, mangrove honeyeater, collared kingfisher, white-eared monarch, rose-crowned fruit-dove and wompoo fruit-dove. Most importantly the records of white-eared monarch and wompoo fruit-dove are the only ones for these species within the subject site (Table 3c, Appendix 3). Both species were recorded from lowland rainforest to the west of the dredge spoil dump.

Surveys by the TBOC have identified nine species not recorded on the subject site during the terrestrial bird surveys for this project. These species include, chestnut teal, satin flycatcher eastern rosella, little eagle, white-throated honeyeater, regent bowerbird, green catbird, white-eared monarch and wompoo fruit-dove. Seven species have also been recorded breeding in the study area, including, brahminy kite, rainbow lorikeet, grey shrike-thrush, rufous whistler, leaden flycatcher, and golden-headed cisticola.

4.5 Legislatively protected species and species of conservation significance recorded within the locality

4.5.1 Review of historical records

The review of historical records focussed on collecting records of all bird species from within the locality. The locality encompassed the lower Tweed River estuary, including Cobaki Broadwater, and terrestrial habitats adjacent to the proposed alignment. The objective of the review was to identify all of the species of terrestrial and estuarine birds that may utilise habitat on the subject site. Data were gathered from a range of sources, including:

- The *Atlas of NSW Wildlife*. All records within a 10 km radius of the proposed alignment were summarised;
- The *Birds Australia* database, ABC count data. All records from a 1 degree grid square centred on the Tweed Estuary were summarised;
- Surveys conducted by the TBOC at three locations on the subject site;
- Mangrove bird surveys conducted by Cowley (1994) in the Tweed River estuary;
- Surveys conducted by the Queensland Wader Studies Group in the Tweed River Estuary;
- Records compiled during the brief surveys by Martindale (1987); Lawler (1994) and Holmes (1989);
- Mangrove and estuarine bird surveys conducted by Sandpiper Ecological Surveys (unpublished) in the Tweed River estuary; and
- General monitoring surveys conducted at Coolangatta Airport (Coolangatta Airport unpublished) by security staff.

The information gathered during the review overlaps somewhat with the data presented in Table 16, which summarised the species of estuarine bird, recorded at 23 sites in the Tweed River estuary. However, unlike the information included in Table 16 the data presented below are not site specific, although a general overview has been provided to indicate where significant species have been recorded in the locality. The data summarised in Table 16 has been included in this review

A list of all bird species recorded from the above sources is provided in Table 4a Appendix 4. The review of records identified 250 species that have been recorded previously from within 10 km of the study area in an east, west or southerly direction. Records from north of the study area (i.e. Queensland) have not been sourced. Of the 250 species 31 are listed on the NSW TSC Act (Table 28). The majority of threatened species records were obtained from the *Atlas of NSW Wildlife*.

Included in Table 28 are legislatively protected species listed on the NSW TSC Act (1995), the Commonwealth ESP Act (1992), JAMBA and CAMBA, and species of conservation significance. Species of conservation significance include those listed by NPWS (1999) and those species that are known to occur in low population densities within the vicinity of the subject site, which have specific ecological requirements, or which occur at the limits of their known distribution.

Threatened birds have been recorded throughout the lower Tweed River estuary, although a large proportion of records from the *Atlas of NSW Wildlife* are from rainforest habitat to the west of Cobaki Broadwater. A number of species from this area including marbled frogmouth, and Alberts lyrebird are unlikely to occur on the subject site. A number of threatened species have been recorded previously from the immediate vicinity of the study area (i.e. Cobaki Broadwater). These species include: black-necked stork, osprey, square-tailed kite, terek sandpiper, pied oystercatcher, little tern, masked owl, mangrove honeyeater, collared kingfisher, barred cuckoo-shrike, wompoo fruit-dove, rose-crowned fruit-dove, and white-eared monarch.

Two species of conservation significance recorded in Table 28 that are of interest include the dusky honeyeater and shinning flycatcher. Shinning flycatchers are generally considered not to extend south of the Noosa River in southern Queensland. However, there have been several records of shinning flycatchers from Cobaki Broadwater, and the species is regarded as either resident, or a regular visitor to the estuary.

There are two records of dusky honeyeater from the locality, one of which was recorded in swamp forest habitat in the bypass study area in May 2000 by Steve Phillips. The other record was made during the ABC project. Dusky Honeyeaters are regarded as uncommon south of Rockhampton, although confirmed records have been made at Southport (Pizzey & Knight 1997).

Table 28: List of legislatively protected species and species of conservation significance recorded within the locality during this study, and previous studies. S = Sandpiper Ecological Surveys, TS = This Study, A = Atlas of NSW Wildlife, BO = pers comm. Bill O'Donald, AP = Airport surveys, BA = Birds Australia, C = Cowley, Q = QWSG, M = Martindale (1987), 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 major habitat type. Subject site refers to a 500 m radius of the proposed alignment, locality refers to a 10 km radius of the proposed alignment.

Group	Species	Source of record	Status	Habitats where recorded on subject site	Comments on distribution within the locality (i.e. 10 km radius of the proposed alignment)
Waterbirds	Magpie Goose	S	TSC S2	nr	▪ Not recorded from subject site but recorded in locality – Trutes Bay wetland
	Wandering Whistling-Duck	S, TS	CS	SF, D	▪ Recorded flying over the study area at dusk on several occasions; known from Trutes Bay wetland and Banora Golf Club.
	Black Bittern	A, TS, BO	TSC S2	SF	▪ Unconfirmed record from creekline on western edge of study area during this study; recorded from same site by local bird watcher
	Black-necked Stork	A, S, AP, Q	TSC S1	nr	▪ Not recorded on subject site, but known from freshwater wetlands to the west of Cobaki Broadwater, Terranora Broadwater, and Boyd's Island.
	Eastern Reef Egret	A, S, TS, Q	C	nr	▪ Not recorded from the subject site during this study or previous surveys; mainly occurs at sites in the Tweed River.
	Great Egret	A, S, TS, Q	C, J	Se, D	▪ Recorded near woodland on northern edge of subject site, and throughout Tweed estuary
	Intermediate Egret	A, TS, S, Q	CS	nr	▪ Not recorded on the subject site during this study or previous surveys, a large flock recorded at Trutes Bay, and individuals regularly recorded at Trutes Bay wetland.
	Cattle Egret	A, S, TS,Q	C, J	D	▪ Recorded foraging at refuse tip on the subject site; and throughout grassland habitats in the locality
	Bush-hen	TS, A	TSC S2	SF	▪ Three individuals recorded at small ephemeral lagoon, also known from the western extremity of the locality
	Lewins Rail	A, TS	CS	W*, SF, Ma*, Se	▪ Species recorded calling at several sites within the subject site during this study.
	Brolga	TS	TSC S2	SF, D	▪ 1 bird recorded circling the subject site on one occasion; first record for the locality

Table 28 cont.

Group	Species	Source of record	Status	Habitats where recorded on subject site	Comments on distribution within the locality (i.e. 10 km radius of the proposed alignment)
Birds of Prey	Osprey	A, TS, AP, C, S, BA, Q	TSC S2	Ma	▪ Often recorded roosting in mangroves or Melaleucas along the edge of Cobaki Broadwater on subject site; recorded throughout the Tweed River estuary
	Brahminy Kite	A, TS, S, C, AP, Q	CS	Ma, Se, MeR, D	▪ Often recorded roosting along fringe of Cobaki Broadwater; Confirmed nesting in southeastern corner of subject site; recorded throughout locality.
	White-bellied Sea-Eagle	A, TS, S, C, AP, Q	CS, C	Ma	▪ Often recorded roosting along fringe of Cobaki Broadwater on subject site; recorded throughout the locality; unconfirmed nest site on the southern side of Cobaki Broadwater, and known nest site in Terranora Broadwater.
	Pacific Baza	A, TS, S	CS	SF, Se	▪ Single birds recorded at several locations throughout the subject site and locality.
	Square-tailed Kite	A	TSC S2	nr	▪ Recorded from western side of Cobaki Broadwater; not known from the subject site.
Shorebirds	Latham's Snipe	A, TS, S, Q	C, J	D	▪ Birds flushed from near the rubbish tip, and within the Airport on the subject site; recorded throughout the locality
	Bar-tailed Godwit	A, TS, S, Q	J, C	Sand & mudflats	▪ Recorded regularly foraging in Cobaki Broadwater, occasionally roosts at Pony Club on the subject site
	Black-tailed Godwit	S, A, Q	TSC S2, J, C	nr	▪ Not recorded on subject site during this study; recorded previously from the vicinity of the Pony Club
	Whimbrel	S, A, TS, Q	J, C	Sand & mudflats, saltmarsh, ma.	▪ Recorded foraging throughout Cobaki Broadwater, and roosting in Cobaki Creek and at Pony Club on the subject site
	Eastern Curlew	S, A, TS, Q	J, C	Sand & mudflats, saltmarsh	▪ Recorded foraging throughout Cobaki Broadwater, and roosting in Cobaki Creek and at Pony Club on the subject site
	Marsh Sandpiper	S, A, Q	J, C	nr	▪ Not recorded from the subject site; most records from Duroby Creek and Trutes Bay.
	Common Greenshank	S, A, TS, Q	J, C	Sand, mudflat & saltmarsh	▪ Recorded foraging and roosting in Cobaki Broadwater, and roosting at Pony Club on the subject site
	Terek Sandpiper	S, A, TS, Q	TSC S2, J, C	nr	▪ Recorded previously in Cobaki Creek and at Pony Club sandflat, but not during this study; commonly recorded from Womgin Island in Terranora Broadwater.
	Common Sandpiper	S, A, TS, Q	J, C	nr	▪ Not recorded from the subject site during this study; recorded previously from Cobaki Creek, Pony Club, Womgin Island and Boyd's Island
	Grey-tailed Tattler	S, A, TS, Q	J, C	Mangroves & mudflats	▪ Recorded foraging and roosting in Cobaki Broadwater (Cobaki south) on subject site; regularly recorded at Rocky Point, and Womgin Island in Tweed estuary
	Ruddy Turnstone	S, TS, Q	J, C	nr	▪ Not recorded from the subject site, known from Kerosene Inlet and Tony's Bar in the Tweed River
Shorebirds cont.	Curlew Sandpiper	S, A, TS, Q	J, C	nr	▪ Not recorded from Cobaki Broadwater or the subject site during this study; historical records of birds roosting and foraging in the vicinity of the Pony Club.
	Red-necked Stint	A, Q	J, C	nr	▪ Not recorded from the subject site; known mainly from sites in the Tweed River.

Table 28 cont.

Group	Species	Source of record	Status	Habitats where recorded on subject site	Comments on distribution within the locality (i.e. 10 km radius of the proposed alignment)
	Sharp-tailed Sandpiper	A, S, TS, Q	J, C	nr	▪ Not recorded from the subject site during this study; recorded previously from Pony Club; recorded regularly at Duroby Marsh.
	Sanderling	M	TSC S2, J, C	nr	▪ Not recorded from the subject site during this study, or previous studies; recorded only in the Tweed River.
	Red Knot	A, Q	J, C	nr	▪ Not recorded on the subject site; very occasional visitor to the Tweed estuary
	Great Knot	A, Q	TSC S2, J, C	nr	▪ Not recorded on the subject site during this survey; recorded previously at Cobaki south.
	Comb-crested Jacana	S, TS	TSC S2	nr	▪ Not recorded on the subject site; known from several sites in the locality, including Trutes Bay wetland, Banora Golf Club, and Tweed Heads South STW.
	Beach Stone-Curlew	S, Q	TSC S1	nr	▪ Not recorded from the subject site during this survey or previously; recorded previously at Kerosene Inlet, Ukerabagh Island and Tony's Bar.
	Pied Oystercatcher	A, S, TS, Q	TSC S2	nr	▪ Not recorded from the subject site during this study; has been recorded previously from Cobaki Creek but not regularly; resident pairs occur at several sites throughout the estuary.
	Sooty Oystercatcher	A, S, TS, Q	TSC S2	nr	▪ Not recorded from the subject site, known only from sites in the Tweed River and Cook Island.
	Pacific Golden Plover	A, S, TS, Q	J, C	Sandflats & saltmarsh	▪ Recorded on the subject site foraging at Pony Club sandflat and roosting at Pony Club during the present study; regularly recorded at these sites
	Greater Sandplover	A, S, Q	TSC S2, J, C	nr	▪ Not recorded on the subject site during this study or previous surveys; known from sites in the Tweed River.
	Lesser Sandplover	A, S, Q	TSC S2, J, C	nr	▪ Not recorded from the subject site during this study; recorded previously from the Pony Club sandflat, and sites in the Tweed River; Very occasional visitor to Cobaki Broadwater
Terns	Common Tern	A, S, Q	J, C	nr	▪ Not recorded on the subject site during this survey, but recorded previously from the vicinity of the Pony Club sandflat on the subject site; occasional visitor to Cobaki Broadwater; recorded in Tweed River
	Caspian Tern	A, S, Q	J, C	mudflats	▪ Not recorded from subject site during this study, but occasionally recorded in Cobaki Broadwater, including Pony Club and Cobaki south; often recorded at sites in Tweed River
	White-winged Black Tern	A, S	C	nr	▪ Not recorded from the subject site, or Cobaki Broadwater, known only from sites in the Tweed River and ocean beaches
	Little Tern	A, S, TS, Q	J, C, ESP, TSC S1	nr	▪ Not recorded on the subject site during this study; recorded previously at Cobaki south just outside the subject site; very occasional visitor to Cobaki Broadwater; often recorded at sites in the Tweed River.

Table 28 cont.

Group	Species	Source of record	Status	Habitats where recorded on site	Comments on distribution within the locality (i.e. 10 km radius of the proposed alignment)
Terrestrial Birds	Collared Kingfisher	A, S, TS, C, BA,	TSC S2	Ma	▪ Always present in mangroves fringing Cobaki Broadwater on the subject site; also recorded from swamp forest habitat on the subject site. Recorded throughout the Tweed estuary.
	Alberts Lyrebird	A	TSC S2	nr	▪ Not recorded from the subject site; recorded from the western edge of the locality.
	Rose-Crowned Fruit-Dove	A, TS, BA	TSC S2	Rf, SFR	▪ Several individuals recorded in lowland rainforest on the subject site, also known from several sites throughout the estuary, and on the western side of the locality
	Superb Fruit-Dove	TS	TSC S2	Rf	▪ Unconfirmed call heard from lowland rainforest on the subject site; first record for the locality
	Wompoo Fruit-Dove	A	TSC S2	nr	▪ Not recorded from the subject site during this study; recorded from the subject site during surveys by the TBOC; known also from the western side of the locality.
	Glossy Black-Cockatoo	TS	TSC S2	W	▪ Foraging signs (chewed casuarina cones) recorded in woodland along the northern edge of the National Estate land.
	Little Bronze-Cuckoo	A, TS, S	CS	W, Ma, SF, Rf	▪ Recorded at several locations on the subject site, most common in rainforest habitat, also recorded in mangroves fringing Cobaki Broadwater
	Barking Owl	A	TSC S2	nr	▪ One record from the vicinity of Banora Point; not recorded on the subject site.
	Masked Owl	A, TS	TSC S2	W	▪ Unconfirmed record from the western side of the subject site; records from the western side of Cobaki Broadwater.
	Grass Owl	A, TS	TSC S2	S	▪ Recorded at southern end of main airport runway on the subject site, historical records from the vicinity of Trutes Bay wetland, and Chinderah.
	Marbled Frogmouth	A	TSC S2	nr	▪ Not recorded from the subject site; recorded previously in Ukerabagh Nature Reserve in the Tweed Estuary, and on the western edge of the locality.
	White-throated Needletail	A, TS, S	C, J	W, SF, M, D	▪ Recorded in flight over the subject site.
	Rainbow Bee-eater	A, C, AP, BA, S, TS	J	W, SF, Rf, Ma, H, D, Se	▪ Widely distributed within the subject site and the study area
	Little Shrike-thrush	C, TS	CS	Rf, SF	▪ Regularly recorded in rainforest and swamp forest on the subject site.
	Mangrove Honeyeater	C, S, TS, A	TSC S2	Ma	▪ Recorded in mangroves throughout Cobaki Broadwater, including the subject site; regularly recorded at Womgin/Big Islands, Lillies Island, Ukerabagh Island, Caddy's Island, & Shallow Bay
	Dusky Honeyeater	BA,TS	CS	SF	▪ Recorded on the subject site by S. Phillips during mammal surveys, but not detected during the bird surveys; recorded previously in Tweed Estuary during the ABC project.
	Mangrove Gerygone	C, S, A, TS	CS	Ma	▪ Recorded in mangrove habitat throughout Cobaki Broadwater, also known from several sites throughout the Tweed estuary
	Barred Cuckoo-shrike	A	TSC S2	nr	▪ Not recorded on the subject site; recorded previously from the southern side of Cobaki Broadwater.
	Shinning Flycatcher	S, A	CS	nr	▪ Not recorded on the subject site; known form Cobaki Creek and the western side of Cobaki Broadwater.
	White-eared Monarch	A, S	TSC S2	nr	▪ Not recorded on the subject site; recorded in regrowth moist forest to the north of the study area, and on the western edge of the locality.

4.5.2 Legislatively protected and significant species recorded during this study

The estuarine and terrestrial bird surveys recorded a large number of legislatively protected and significant species within the study area (Table 28). This included 18 species listed on the NSW TSC Act, one species listed on the Federal ESP Act, 18 species listed on JAMBA, 19 Species listed on CAMBA, and 10 species of conservation significance. The terrestrial bird surveys alone recorded 10 species listed on schedule two of the NSW TSC Act, eight species of conservation significance, five species listed on JAMBA, and five species listed on CAMBA (Table 28). One additional threatened species, the glossy black-cockatoo, was recorded during surveys for the Species Impact Statement.

Records for three of the threatened species recorded during the survey are regarded as tentative only. Possible masked owl and black bittern calls were heard in response to playback, however in both instances calls were brief and faint and therefore could not be confirmed. A single call of superb fruit-dove was recorded from rainforest during the summer survey, however no individuals were sighted despite targeted searches during both summer and autumn. Targeted surveys for white-eared monarch, and barred cuckoo-shrike failed to detect these species, although suitable habitat for both species does occur in the terrestrial study area, and there are records from the locality.

Of the threatened species recorded during the survey most were recorded in only one habitat type, and often at only one site. Exceptions to this were rose-crowned fruit-dove, which was recorded in rainforest, and swamp forest. Rose-crowned fruit-doves were recorded foraging in large-leaved cheese tree (*Glochidion* spp) near the existing highway. Brolgas were not recorded on site, although one individual was recorded circling above the terrestrial study area.

Threatened species recorded in only one habitat include: black bittern, bush hen, osprey, grass owl, collared kingfisher, superb fruit-dove, and mangrove honeyeater. Both the black bittern and bush hen were recorded in swamp forest on the western side of the study area (Figure 8). Osprey, collared kingfisher, and mangrove honeyeater were recorded in mangroves only. Ospreys were regularly recorded roosting in tall dead mangroves or melaleucas around the edge of Cobaki Broadwater. Both the brahminy kite and white-bellied sea-eagle were also recorded roosting in this area.

Three brahminy kite nests were recorded in swamp forest habitat near the existing highway, with a further two possible nests located in tall melaleucas adjacent to rainforest habitat (Figure 8). A pair of brahminy kites was recorded using one of the nests located near the existing highway during surveys in June 2000 by the Tweed Bird Observers Club (E. Kleiber pers comm.).

In the terrestrial study area most of the JAMBA, CAMBA, and conservation significant species were recorded in a range of habitats. The most widespread species were rainbow bee-eater, white-throated needletail, and Lewins rail. Both the rainbow bee-eater, and white-throated needletail were commonly recorded throughout the study area. Lewins rail were identified mainly by call with individuals recorded in saltmarsh adjacent to mangroves, in small wetlands in woodland, and swamp forest, and in sedgeland. Wandering whistling ducks were not recorded on site during the survey, although individuals were recorded flying over the site on several evenings.

5. DISCUSSION OF RESULTS

5.1 Estuarine Birds

5.1.1 Use of Cobaki Broadwater by significant species of estuarine bird

Fifty-eight species of estuarine bird have been recorded previously from sites adjacent to the proposed alignment. This number compares favourably with the 91 species of estuarine bird recorded previously within the lower Tweed River estuary (Table 16). The large diversity of species recorded in Cobaki Broadwater emphasises the overall value of this area to birds', however, of particular importance is the large number of species listed on JAMBA (17 species), CAMBA (18 species), NSW TSC Act (7 species), and the federal ESP Act (1 species). A further four species of conservation significance have also been recorded in the Broadwater.

Significant species are not confined to one area of Cobaki Broadwater, with a number of significant species recorded at each of the high tide roosts and low tide foraging areas. Although a number of shorebirds listed on the NSW *TSC* Act, have been recorded at the Pony Club roost and feeding ground, no threatened species of shorebird are regularly recorded at these sites. The sites are however, used regularly by several species listed on both JAMBA and CAMBA.

Birds of prey including ospreys, white-bellied sea-eagles, and brahminy kites have been recorded foraging and roosting throughout the Broadwater. The exact numbers of individuals using the site is undetermined, although it seems likely that at least one pair of each species resides in the area. All three species have been recorded roosting in tall dead paperbarks along the northern fringe of the Broadwater. Ospreys were recorded foraging in the vicinity of the Pony Club sandflat during the present study. At least one pair of ospreys and possibly a pair of brahminy kites nest in close proximity to Cobaki Broadwater, and it is likely that the site represents an important foraging habitat for both species during the breeding season. Although undetermined it is considered likely that a pair of white-bellied sea-eagles nest in the vicinity of the Broadwater. Dead trees fringing the Broadwater may represent important sources of nest material for birds of prey.

Square-tailed kites have been recorded previously on the western side of Cobaki Broadwater, however, this species has not been recorded using Cobaki Broadwater or habitats to the east of the Broadwater. A pair of black-necked storks has also been recorded in wetlands to the west of Cobaki Broadwater, and at Coolangatta Airport (P. Shaw pers comm.), however, the species has not been recorded within Cobaki Broadwater or Cobaki Creek during surveys by Sandpiper Ecological Surveys. Most records of black-necked stork within the estuary are from Terranora Broadwater.

Other significant species of estuarine bird recorded in Cobaki Broadwater include great egret, and common and little terns. Both common and little terns are irregular visitors to Cobaki Broadwater, and have been recorded foraging within the Broadwater at low tide. The Broadwater does not represent important feeding habitat for either species, which generally prefer areas with a greater marine influence (Marchant & Higgins 1996; NPWS 2000).Terns may use Cobaki Broadwater on an occasional basis, during periods of strong winds that force birds away from sites in the main river channel.

5.1.2 Roosts

Three major high tide roosts were identified in Cobaki Broadwater during the survey. These roosts have been used regularly over at least the last three years (Sandpiper Ecological Surveys 1997, 1998b, 1999). Despite the continued use of roosts within Cobaki Broadwater by shorebirds long-term data suggest a general trend of declining numbers. The reasons for the decline in the number of birds using some sites is undetermined, although reduced site quality is likely to be a contributing factor.

Vegetation growth appears to have affected the quality of at least four roosts along the eastern shore of Cobaki Creek. Sites that were formerly used such as 'Cobaki', 'Sewage Drain', and 'canal estate' have been overgrown by either *Juncus* spp. mangroves, or *Casuarina glauca*, whilst the 'Pony Club' is currently suffering from vegetation encroachment. Martindale (1987) recorded large numbers of shorebirds at these sites, and 'Cobaki' had the highest number of individuals and species of any roost within the estuary during surveys in 1987. No surveys since those of Martindale (1987) have recorded similar numbers of shorebirds roosting within Cobaki Broadwater. This is despite the fact that proceeding surveys have sampled the same sites (e.g. DPWS 1991; Lawler 1994). The influence of other factors, such as the operation of Coolangatta Airport, on the use of the Pony Club and 'Cobaki' by shorebirds is undetermined, although it could contribute to declining roost use.

The reason for the apparent decline in the number of individuals and species roosting in Cobaki Broadwater may be due to three factors:

- The declining quality of roosts;
- The declining quality of foraging areas; or
- The increasing quality of foraging and/or roosting habitat in other parts of the estuary.

The decline in the quality of roosts in Cobaki Broadwater and the number of birds using these roosts is possibly indicative of an overall decline in the quality of roosting habitat within the Tweed estuary, and is reflected in the number of shorebirds using the estuary.

Despite the obvious reduction in the use of some sites, shorebirds continue to use Pony Club, mangroves in Cobaki Creek, the southern fringe of Cobaki Broadwater, and during neap tides a small sandbar at Cobaki south. These sites do not support populations of the magnitude recorded by Martindale (1987) or DPWS (1991), however, they are important in a local context. During the present survey 17% of the eastern curlew, 29% of the whimbrel, and 38% of the pacific golden plover populations within the estuary were recorded roosting at Pony Club, whilst 53% of the common greenshank population roosted on the southern fringe of Cobaki Broadwater.

The destruction or disturbance of any of the roosts in Cobaki Broadwater could have a significant effect on the population of migratory shorebirds within the lower Tweed River estuary. There is currently a critical shortage of spring tide roosts within the estuary, with only four sites available for the majority of species. These sites include South Head Beach, Kerosene Inlet, Duroby Marsh, and Pony Club. The quality of South Head Beach may be reduced by the Tweed River Entrance Sand Bypassing Project, whilst vegetation encroachment is reducing the suitability of Duroby Marsh and Pony Club, and Kerosene Inlet suffers high levels of human disturbance during most high tides in summer (Sandpiper Ecological Surveys 1998a; Shortlands Wetlands Centre 2000).

Evidence gathered during the present survey indicates that during the ebb tide eastern curlews, whimbrels and pacific golden plovers move from the Pony Club to forage on intertidal flats within Cobaki Broadwater. The number of eastern curlews and whimbrels (and to a lesser extent pacific golden plovers) using the Pony Club at high tide is correlated with the number of individuals of each species recorded foraging within the Broadwater. This result is not unexpected, as shorebirds often select roosts in close proximity to preferred feeding areas (Dann 1987), although the opportunity for predation by raptors can influence roost selection (Piersma *et al.* 1993). Martindale (1987) recorded a similar result during his study, although the number of birds was considerably greater.

Bar-tailed godwit was the only species observed to move to and from Cobaki Broadwater between low and high tides, although eastern curlew and pacific golden plovers are also known to do so on a regular basis. It seems likely that roosts in Cobaki Broadwater are no longer suitable for godwits, which prefer open sites with good visibility. Despite this suggestion bar-tailed godwits are still occasionally recorded at Pony Club, although only in small numbers.

Disturbance to the Pony Club roost would mean that migratory shorebirds would need to fly from sites in the Tweed River during every low tide, returning to the river at high tide. These regular flights would increase the energetic requirements upon the birds, and may possibly affect their ability to migrate, and in turn affect the number of birds using the estuary during proceeding summers (Dann 1987). The reduction in the number of small shorebirds, such as curlew sandpipers, using Cobaki Broadwater may be directly linked to the declining suitability of roosts, and the inability of smaller birds to satisfy their energetic demands whilst travelling large distances between roosts and feeding grounds.

5.1.3 Feeding grounds

A number of groups of estuarine birds forage within Cobaki Broadwater during low tide, although by far the most abundant are the shorebirds and waterbirds. Comparison of the density and number of birds foraging in Cobaki Broadwater recorded by Martindale (1987) with data collected during the present survey suggests that a substantial decline in the use of the Broadwater by migratory shorebirds has occurred over the past 13 years. The decrease is most obvious for pacific golden plover, eastern curlew, whimbrel, grey-tailed tattler, greenshank and curlew sandpiper. A similar number of bar-tailed godwits were recorded using Cobaki Broadwater in 1987 and 2000, although the number in 2000 was greater than that recorded in 1998 or 1999.

The exact reason for the decline in the number of birds foraging in Cobaki Broadwater is undetermined, although it could be attributed to either the decline in roost quality or a decline in the quality of foraging habitat. The number of birds recorded foraging in Cobaki Broadwater by Martindale (1987) was strongly correlated with the number of birds roosting at ‘Cobaki’ and ‘Sewage Drain’ during his survey. This relationship coupled with the correlation between the number of whimbrel and eastern curlew roosting and foraging in the Broadwater during the present study emphasises the possible influence of roost quality on the number of birds foraging within the Broadwater.

Declining quality of foraging habitat may have also affected the number of birds using the Broadwater at low tide. The area of habitat has not varied substantially between 1987 and 2000, however, the quality of this habitat may have been reduced. Dredging operations within Cobaki Broadwater was noted by DPWS (1991) as a possible factor affecting the ecology of the area.

Despite the decline in the number of shorebirds using Cobaki Broadwater the area continues to be significant in an estuary-wide context. For example, during the present study six species, and 20% of the total migratory shorebird population were recorded foraging within the Broadwater. The only site with a greater proportion of the migratory shorebird population was Terranora Broadwater, which supported 37% of the population, and seven species.

The quality of foraging habitat varies considerably throughout the Broadwater. Cobaki south and Cobaki north are by far the most important sites. Pony Club provides a foraging habitat for a small number of whimbrel and eastern curlew, and is used on an occasional basis by pacific golden plovers and bar-tailed godwits. Of the 10 feeding areas sampled during the present study the Pony Club was the least significant, being used by the smallest number of individuals. Summer monitoring surveys conducted by Sandpiper Ecological Surveys support this result (Sandpiper Ecological Surveys 1998, 1999, 2000).

5.2 Terrestrial birds

5.2.1 Use of terrestrial habitats by significant species

Surveys conducted in terrestrial habitats in the vicinity of the proposed alignment recorded 156 species of bird, with an additional 9 species recorded during surveys conducted by the TBOC. The high species diversity emphasises the conservation significance of terrestrial habitats on the subject site. In addition to a high species diversity recorded during this study a number of significant species were also recorded during the terrestrial bird surveys, including five species listed on JAMBA, five species listed on CAMBA, 10 species listed on the NSW TSC Act, and eight species that are of conservation significance (Table 28). An additional two species listed on the NSW TSC Act that were not recorded during this survey have been recorded from the subject site by the TBOC, whilst glossy black-cockatoos were recorded during surveys for the SIS.

The majority of significant species displayed a restricted distribution, occurring in only one or two habitats, and only a small number of sites within the study area. The exception to this was some of the migratory species, such as rainbow bee-eater and white-throated needletail listed on JAMBA and CAMBA, little bronze-cuckoo, and Lewins rail, which are regarded as species of conservation significance. These species were recorded in a variety of habitats and at a number of sites. Both the white-throated needletail, and rainbow bee-eater were common, with large flocks recorded at several sites.

In northern NSW and southern Queensland the little bronze-cuckoo is associated with a variety of habitats including gallery forest, rainforest, mangroves, and woodlands (Higgins 1999). The generality of habitat use documented for little bronze-cuckoos was recorded during the present study with individuals recorded in mangrove, woodland, rainforest and swamp forest habitats. Although little bronze-cuckoos were not recorded during point count surveys the frequency of sightings and calls suggested that the highest number of individuals occurred in lowland rainforest. The reason for this is possibly due to a higher abundance of food, in particular insects, in this habitat (Higgins 1999).

Lewins rail were also widespread within the study area. This species uses a wide range of habitat types, including fresh, brackish and saline wetlands, although dense fringing vegetation may be an important habitat component (Marchant & Higgins 1993). Potential habitat for Lewins rail is widespread within the study area, as suggested by the number of records, and the variety of habitat types in which the species was recorded. Much of the swamp forest and wet heath habitat is likely to be used by this species.

The apparent abundance of Lewins rails in the study area is of considerable interest as this species is classified as *Near Threatened: C* by Garnett and Crowley (2000). This definition means that the species has experienced a significant decline in abundance over 50% of their former range . Habitats such as those in the study area may prove essential to ensure that Lewins rail do not suffer further declines throughout their range.

It is undetermined if some of the species recorded during the survey would actually utilise habitats in the study area. Both the wandering whistling duck and brolga, were recorded flying over the study area, but no individuals were recorded on site. Potential habitat for both species does occur within the study area, although its extent is limited. Brolgas have been recorded using a variety of habitats including saltmarsh and flooded grasslands (Marchant & Higgins 1993), both of which occur in the study area. Wandering whistling ducks generally prefer deep permanent waterbodies with abundant emergent vegetation (Marchant & Higgins 1990). The Trutes Bay wetland situated adjacent to Terranora Broadwater (Figure 1) and drains in the vicinity of Banora Golf Club (pers obs) provide the most suitable habitat for whistling ducks within the study area. Wandering whistling ducks may use the small dam situated in the eastern corner of the study area, whilst grassland habitat within the airport and sedgeland and saltmarsh habitat south of the main runway may be suitable for brolga.

Records of masked owl, superb fruit-dove and black bittern within the study area remain unconfirmed. All three species were identified from brief calls, with both the black bittern and masked owl responding to playback. Habitats within the study area are suitable for each of the species, and masked owls have been recorded in close proximity to the study area (Connell Wagner 1999). Lowland rainforest within the study area is suitable for superb fruit-doves, which have been recorded previously in similar habitat (Higgins & Davies 1996). Superb fruit-doves have also been recorded foraging on both *Archontophoenix* spp., and *Elaeocarpus* spp., both of which occur in the study area (Recher *et al.* 1995; Higgins & Davies 1996). A second unconfirmed record of black bittern within the study area was obtained from a local ornithologist who reportedly had recorded a black bittern calling from swamp forest around the drainage line on the western edge of the study area (B. O'Donnell pers comm.). This record is from the same location as that obtained during the present study.

Four significant bird of prey species were recorded during the survey, and one additional species, square-tailed kite, has been recorded adjacent to the subject site. The use of terrestrial habitats in the study area by osprey, and white-bellied sea-eagle is most likely limited to roosting in tall paperbarks along the fringe of Cobaki Broadwater, although both species may occasionally traverse Coolangatta Airport in search of food or nesting material. Square-tailed kites may also occasionally forage within terrestrial habitats in the study area. This species forages on a range of prey items, including small passerines, in a variety of habitats including woodlands, melaleuca forests and occasionally heaths (Marchant & Higgins 1993; Debus 1998). A pair of square-tailed kites have been recorded regularly over woodland to the southwest of Cobaki Broadwater (Clive Easton, TSC pers comm.), however, no individuals have been recorded in the immediate vicinity of the airport.

Both brahminy kites and pacific bazas were more widespread within the study area than the other birds of prey. Several potential, and one documented brahminy kite nest/s were recorded in tall broad-leaved paperbark trees in the southeast and central sections of the study area and brahminy kites were regularly recorded flying over the study area, and roosting at a small dam near the north-eastern corner of the site. It is likely that pacific bazas reside within the study area, with individuals recorded at several sites in both the swamp forest and sedgeland habitats.

A number of the significant species recorded during the survey are regarded as habitat specialists. These species include the collared kingfisher, mangrove honeyeater, and mangrove gerygone, which were restricted to mangrove habitat, the bush hen, which was restricted to small lagoons in swamp forest habitat, and the grass owl, which is most likely restricted to low wet heath and areas of tall grass. Despite the specialisation of both the collared kingfisher and mangrove honeyeater these species may utilise habitat adjacent to mangroves (Pizzey & Knight 1997). In the present case it is possible that both species utilise swamp forest that fringes Cobaki Broadwater.

Bush hens utilise a variety of freshwater wetlands, although the species is most often associated with permanent wetlands situated in or adjacent to dense vegetation, such as rainforest or closed melaleuca forest (Marchant & Higgins 1993; Muranyi & Baverstock 1996). Potential bush hen habitat appears limited to the swamp forest and lowland rainforest in the centre of the study area. Swamp forest on the eastern side of the study area appears of marginal quality for bush hen, lacking permanent water, and with a more open understorey.

Grass owls are most likely restricted to areas of low wet heath and tall grass, particularly Phragmites situated at the southern end of the main runway. It is undetermined if owls reside permanently in this area, or whether the habitat is used on only an occasional basis by individuals moving between breeding and non-breeding areas. The area of habitat available on the subject site does seem adequate to support a resident pair of owls (Higgins 1999).

Another threatened species that has a restricted distribution within the study area is the rose-crowned fruit-dove. This species was recorded in the highest numbers in lowland rainforest on the northern and southern side of Cobaki Broadwater, with two birds recorded in regrowth melaleuca habitat near the eastern edge of the study area. Rose-crowned fruit-doves are most often associated with rainforest and regrowth habitats with fruiting trees (Recher *et al.* 1995; Higgins & Davies 1996). During the present study individuals were recorded foraging on fruits of blue quandong, bangalow palm, and camphor laurel in lowland rainforest, and cheese tree in regrowth swamp forest.

Cheese tree is particularly widespread within swamp forest habitat in the study area and all of this habitat must be considered as potential foraging habitat for rose-crowned fruit-doves. Lowland habitat such as that in the study area is regarded as critical for rose-crowned fruit-doves (Date *et al.* 1996). Much of this habitat has been cleared and it is likely that the remaining pockets of habitat represent important food resources.

5.2.2 Important bird habitats in the study area

The comparison of species richness between habitat types (Table 23), and the summary of threatened and significant species (Table 28) clearly emphasises the significance of some habitats over others. Swamp forest, mangroves and rainforest habitat types stand out as being of particular significance. These habitats all had a high species richness of birds, and provide habitat for a number of threatened and regionally significant species. Swamp forest habitat appears to be particularly significant with over 80 species, including 9 threatened species recorded from this habitat type. Swamp forest was also one of most widespread habitats in the study area.

In contrast, habitats such as the heathland and disturbed lands are of less significance with fewer species, and less, or no threatened or conservation significant species. Some habitats such as the sedgeland had only a small number of species overall, but a reasonably high number of threatened and regionally significant species.

5.3 Limitations associated with the estuarine and terrestrial bird surveys

Surveys conducted as part of this project have attempted to sample all habitats present within the subject site, and ensure that targeted searches have been conducted for all threatened species of bird that may utilise habitats on the site. Attempts have been made to fill gaps in the information gathered during the field survey by collating records of birds obtained during previous surveys. Together the field surveys and review have provided a comprehensive list of birds that occur on the subject site.

Despite the efforts to provide a comprehensive overview of avifauna within the subject site there is the possibility that some species that utilise the site may not have been detected. Recent surveys conducted by the TBOC provide evidence of this, with nine species recorded during these surveys that were not recorded during this study. The rich avifaunal diversity associated with the subject site, and the fact that the site appears to be used by birds moving between habitats greatly increases the likelihood that additional species will be detected on-site with increasing survey effort.

It is often difficult to obtain a comprehensive list of all birds using a site in a short time-frame, and regular surveys over several years may be required to fully document the suite of birds residing within an area, particularly an area with high species diversity. To compensate for the likelihood that additional species of bird may utilise the subject site a conservative approach has been adopted to determining which legislatively protected species may utilise the site.

5.4 Ecological values of the subject site

Field surveys conducted for this project, and the review of previous records has resulted in the identification of a number of significant ecological values within the subject site (i.e. terrestrial and estuarine habitats within 500 m of the proposed alignment). The presence of these values increases the significance of impacts associated with the project. Each value warrants consideration in the impact assessment process. Significant ecological values identified in the study area include:

- occurrence of significant populations of threatened species, including mangrove honeyeater, and collared kingfisher;
- occurrence of habitat for a range of threatened and conservation 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.

5.4.1 Significant populations of threatened species

The populations of both the collared kingfisher and mangrove honeyeater that occur within the study area are regarded as significant in a regional context. Although it could be argued that any population of a threatened species is significant the overall importance of a population can be increased if that population is located at the limit of a species distribution, or if the study area is recognised as a stronghold for a particular species. The lower Tweed River estuary is of particular importance for both the mangrove honeyeater and collared kingfisher. Both these species have specialised habitat requirements, and restricted distributions in NSW, occurring only in the northeastern corner of the state. Populations of other species that are considered important include little bronze-cuckoo, and Lewins rail. Both these species were recorded throughout the study area. The frequency of sightings for both species exceeds that recorded in similar habitats in northern NSW (pers obs).

5.4.2 Threatened and significant species

The study area provides habitat for a large diversity of threatened and regionally significant species, and species listed on international migratory bird agreements. Eleven species listed on the NSW *TSC Act* were recorded within the subject site, with a further six threatened species recorded in the lower Tweed River estuary during the field survey. A further 13 threatened species have been recorded previously from within the locality (i.e. 10km radius of the study area). Twenty-one of the species recorded during the field survey are listed on either JAMBA or CAMBA, and 11 species are regarded as being of conservation significance. The high density of threatened and significant species recorded within the study area demands a cautious approach to impact assessment, and a thorough evaluation of impacts.

In assessing the impacts of the proposal on threatened species it is essential that current impacts and the specific ecological requirements of some species be considered. There are a number of developments that have recently been approved that will affect populations of threatened birds in the locality. These include developments on the western side of Cobaki Broadwater, and along the Tweed Coast.

5.4.3 High avifauna diversity

In addition to a large concentration of threatened and conservation significant species the study area is of considerable importance from a biodiversity perspective. A total of 188 species of bird were recorded during the field survey, including 151 species recorded from terrestrial habitats in the study area, and a further 37 species recorded during estuarine bird surveys in the lower Tweed River estuary. The fact that 249 species of bird have been recorded from the locality provides ample evidence of the importance of the area for birds. Species with specialised ecological requirements that must be given specific attention include fruit-doves, which require a number of sites with fruiting trees, and lowland habitat, and migratory shorebirds, which require protected roost sites to rest during high tides.

5.4.4 Important habitat for migratory birds

The study area includes a number of sites that are of particular importance for migratory birds, particularly shorebirds, but also rainbow bee-eaters and white-throated needletail's. The study area is also used by latitudinal migrants such as little bronze-cuckoo and grass owl, and the site may represent an essential link in the migration paths used by these species. In addition the site is used by altitudinal migrants such as the noisy pitta, rose robin, and possibly white-eared monarchs.

A reduction in the quality of habitat used by a number of migratory species would be in contravention of both JAMBA and CAMBA to which the Australian government is a signatory, and the loss or disturbance to habitat within migration routes places further pressure on the ability of species to successfully move between summer and winter, or breeding and non-breeding habitat.

5.4.5 Proximity to tidal wetlands in Cobaki Broadwater

Intertidal habitats within Cobaki Broadwater provide important roosting and foraging habitat for a variety of bird species. These habitats are of considerable importance in a local context (i.e. lower Tweed River estuary), particularly for migratory shorebirds, osprey and white-bellied sea-eagle. A reduction in the quality of intertidal habitats in Cobaki Broadwater would affect the bird population within the entire estuary.

5.4.6 Important habitats

The high avifaunal diversity recorded in the study area is due primarily to the type and diversity of habitat types present. Lowland rainforest and swamp forest habitats that occur in the study area provide a rich source of food and nesting opportunities for a wide range of bird species. These habitats have also been extensively cleared in northern NSW, with only small remnant patches remaining. The remaining remnants of lowland rainforest and swamp forest in coastal northern NSW and southern Queensland are likely to represent an important link in the coastal movement corridor.

6. FACTORS ASSOCIATED WITH THE PROPOSAL THAT MAY AFFECT AVIFAUNA

Seven factors have been identified that may affect bird communities within the study area. These factors include: habitat removal; edge effects; barrier effects; road strike; disturbance effects; altered hydrological regimes; and pollution of wetlands. A brief summary of the predicted impacts is provided below.

6.1 Habitat removal and fragmentation

Predictions made by Connell Wagner (1999) indicate that the proposal will remove only 13.3 ha of habitat, which is small in a local context. According to Connell Wagner (1999) the most affected habitat will be heath (2.2 ha), swamp forest (3.3 ha), and dry sclerophyll woodland/open forest (4.4 ha)[4]. The majority of habitat removed will be in the south-eastern corner of the study area in the vicinity of the road and rail interchanges (Figure 7). Habitats affected in this area will include regrowth swamp forest, mature swamp forest, heathland, and sedgeland. The swamp forest, heathland and sedgeland habitats in this area will also be fragmented. The small fragments of habitat created in this area are unlikely to be large enough to support viable populations of some significant species, and species will be forced to move between habitat islands thereby increasing the opportunity for a number of additional impacts such as road strike, and edge effects, which are discussed below.

To the north of this area more swamp forest and heathland habitat will be removed along the western side of the airport. Habitat removal in this area will create further fragmentation of heathland that has already been fragmented through the construction of access tracks.

Vegetation removal will result in the loss of roosting, foraging and possibly breeding habitat for some threatened bird species. The impacts associated with habitat removal will vary considerably between species, and depend largely on the type and extent of the habitat removed. The impact of habitat removal on highly mobile species, such as the masked owl, or nomadic species that follow fruiting trees such as the fruit-doves are difficult to predict. Masked owls occupy large home ranges and often forage in open habitats or along the edge of open and forested habitats (Debus & Rose 1994; Kavanagh & Murray 1996), and therefore may be less affected by the loss of a small area of habitat. Alternatively the removal of roosting or breeding habitat may have a significant impact on the same species, particularly if the availability of nest hollows is limited.

6.2 Edge effects

Edge effects can have a detrimental impact on bird communities, and the significance of these effects should not be underestimated (Laurance 1997). The impact of edge effects varies between species and habitats, and the magnitude of effects will depend on the size of the remnant, with small remnants affected to a greater degree than larger ones (Young & Mitchell 1994). Edge effects may be divided into three groups (Murcia 1995):

- abiotic (changes in physical environment);
- direct biological (changes in the distribution and abundance of species); and
- indirect biological (changes in species interactions).

[4] The habitats identified by Connell Wagner (1999) are not the same as those used in the present study.

Edge effects generally lead to a change in forest structure along the exposed edge, and provide the opportunity for increased access by predators, such as foxes and cats. In previously undisturbed habitat the change in forest structure associated with edge creation can lead to a change in the bird community. In general terms the edge environment becomes unsuitable for species that prefer forested habitats (Baker *et al.* 1998). Edge habitats may be colonised by "edge preferring" species, although the overall species richness may be reduced (Sisk & Margules 1993). The occurrence of edge specialists such as the noisy miner can have a further impact on forest bird communities through disturbance and competitive displacement (Bennett 1999).

Baker *et al.* (1998) in a study on the impact of powerline easements on forest birds found a significant difference in species richness between edge and interior habitats, and a difference in the species using the two habitats. One of the major impacts associated with edge effects on birds is nest predation, which is generally considered to be higher near the edge (Marini *et al.* 1995; Gardner 1998), although there is contrary evidence regarding the influence of edges on nest predation (Taylor 1998; Lindenmayer *et al.* 1999).

A precise definition of the area of forest likely to be affected by edge effects is lacking, and the impact of edge effects will vary between habitats, and species. The influence of newly created forest edges on small, fragmented remnants such as those that occur in the study area is also difficult to assess. These habitats may already be heavily affected by edge effects, and may represent '*edge-modified'* habitats.

The current proposal will create a new forest/road edge in a number of places along the alignment. Edge effects will be most pronounced in forested habitats that have a closed structure. Habitat within the south-eastern corner of the study area will be susceptible to edge effects through the removal of habitat for the road and railway line. The impact of edge effects in this area is not regarded as significant as the habitat is fragmented by numerous tracks, is relatively small in size, and has a long history of disturbance, including grazing by horses and cattle.

A recent study on the extent of edge effects associated with the existing Pacific Highway between Karuah and Bulahdelah in NSW failed to identify any obvious effect on vegetation structure, or the bird community (Sandpiper Ecological Surveys 2000e). The difficulty associated with identifying edge effects on this habitat was due to numerous factors, although the extent of internal habitat fragmentation from trails, cattle grazing, and logging appeared to be the major factors.

6.3 Barrier effects

Roads represent major barriers to fauna movement (Andrews 1990; Bennett 1991, 1999). The impact of barrier effects will vary considerably between different groups of fauna. Barrier effects will be most significant for small mammals and cover dependent species, including some birds (Burnett 1992; Goosem 1997). Some species, may avoid roads altogether, whilst others may attempt to cross and be struck by cars (Goosem 1997). Barrier effects are likely to be most pronounced in areas where roads cut historical movement corridors. Attempts by fauna to continue using these corridors can result in direct mortality, whilst avoidance of the road may reduce genetic exchange or totally disrupt a species life cycle by prohibiting access to breeding or non-breeding areas. Birds may be less affected by barrier effects than other groups of fauna as they have the ability to fly over the barrier.

The barrier effect associated with the current proposal is likely to be minimal. Much of the land to the east of the proposed alignment is modified, and suitable for only a small number of common bird species. These species are unlikely to view the highway as a major barrier to movement. The opportunity for barrier effects will be most pronounced at the southern and northern ends of the alignment where the road and rail corridors isolate small areas of habitat. Birds currently utilising habitat within these isolated pockets may become further isolated from conspecifics, or may become susceptible to road strike. It is, however, unlikely that the small fragments of habitat will be sufficient to support many bird species, particularly threatened species.

6.4 Road strike

Mortality associated with the construction of roads can have a detrimental effect on species trying to maintain historic movement patterns and thus local populations. The impact of road strike is not limited to any one fauna group with documented impacts recorded on frogs (Fahrig *et al.* 1995), ground mammals (Clarke *et al.* 1998), nocturnal birds (Debus & Rose 1994), and koalas (Prevett 1991). A recent compilation of road-kills from 22 road segments in NSW recorded road mortality in a range of vertebrate groups including small mammals, reptiles and birds (Cooper 1998). Goosem (1997) also recorded mortality from each of the vertebrate groups during her study. Mortality of wildlife occurs when animals are trying to cross the road, or when they are using the roadside to forage (Bennett 1991).

The opportunity for birds to be struck by vehicles is present along most roads. In the present case it is likely that an increase in road strike will occur during the initial stages of road operation, prior to birds habituating to the presence of the road. The opportunity for road strike will occur throughout the entire alignment, however, it may be most severe in the northern and southern ends where small patches of habitat to the east of the alignment will become isolated from habitat to the west of the alignment. Some threatened species of fauna are suspected of using road verges for foraging. Two species of particular concern include masked and grass owls. Both species have been recorded as road kills (Debus & Rose 1994; Maceijewski 1996), and both species are suspected to occur in the study area.

6.5 Disturbance effects

There are numerous forms of disturbance associated with highways, including noise, movement, and a general avoidance of the road structure (Andrews 1990). Disturbance effects stem primarily from highway operation, although disturbance will also occur during construction. The disturbance effects of primary concern in the present context include noise and movement. Unfortunately the impact of disturbance effects is difficult to determine, and quantitative studies on Australian fauna are lacking. Zande & Weijden (1980) provide evidence to show that increased traffic density caused a reduction in the density of meadow birds, and Madsen (1985) found that even roads with low traffic volumes inhibited habitat utilisation by geese, in Europe.

Both noise and disturbance effects already exist in close proximity to the proposed alignment. Jets taking-off from, and landing at Coolangatta Airport create considerable noise and movement disturbance for birds utilising habitats in close proximity to the airport, particularly for those species that utilise exposed habitats in the vicinity of Cobaki Broadwater. Additional and more prolonged noise disturbance is created by the more regular flights of light aircraft and helicopters.

Additional disturbance effects stem from the existing Pacific Highway, which creates noise and movement disturbance for birds that utilise habitats in the southern section of the alignment. The baseline edge effect assessment conducted as part of this survey failed to identify a significant effect associated with the existing highway. If an edge effect does exist it is most likely subtle based on the evidence gathered during this study.

The current proposal will extend the existing disturbance effects associated with the highway. Information provided by Connell Wagner (1999) indicates that disturbance may increase as the volume of traffic using the proposed highway increases. The noise associated with the highway differs considerably from that emitted by aircraft. Aircraft noise, particularly jet noise occurs for only a brief period. In contrast, traffic noise is of a continual duration. Disturbance effects associated with the proposed highway will occur in close proximity to shorebird roosting and foraging habitat in Cobaki Broadwater, and mangrove, swamp forest and lowland rainforest habitat used by a number of threatened species. All of these habitats are of considerable importance with respect to birds.

The major concern with respect to disturbance is the potential impact of noise on the ability of birds to remain in contact with mates, or young, and advertise territories. In addition species that prefer secluded habitats away from disturbance may display a negative response to noise. Although it may be argued that birds utilise habitats in the study area despite the presence of aircraft noise, there is some concern that the continual noise associated with the highway will have a greater affect than aircraft noise. The lack of quantitative evidence regarding the impact of noise disturbance makes it exceedingly difficult to assess impacts. Some species of bird are regarded in the literature as being reasonably shy and preferring secluded locations, yet there are examples of these species using habitats in close proximity to human settlement. In addition a number of species have been recorded in reasonably close proximity to highways. These species include: collared kingfisher, mangrove honeyeater, osprey, black bittern and a number of migratory shorebirds.

The impact of noise disturbance may also vary depending on the time of year. For example, both the masked and grass owls are often recorded in the vicinity of major highways indicating that whilst foraging these species may not be affected by noise disturbance. During the breeding season however, these species may prefer quite conditions to ensure that they remain in contact with mates and are able to defend territories from possible intruders.

Without quantitative evidence detailing the effects of noise on birds a cautious approach must be adopted, and the precautionary principle applied (Deville & Harding 1997). Deville and Harding (1997) suggest that the precautionary principle requires that "*we focus on lack of evidence for making environmental management decisions, and we consider actions to avoid damage which appears possible but not certain."* Despite the desire for a precautionary approach the presence of Coolangatta Airport provides some evidence that noise created by the highway may not have a significant effect on threatened species of bird.

The impact of movement disturbance is also difficult to assess, although the movement of lights at night may cause initial disturbance, possibly forcing some birds to seek alternative sites. In assessing the impacts of disturbance effects the current level of fauna activity in the vicinity of Coolangatta Airport, and the existing highway must be considered. The results of the field survey suggest that a number of species may be tolerant of at least some noise and movement disturbance.

6.6 Altered hydrological regimes

The proposal represents a significant engineering task, and impacts on existing hydrological regimes are likely to be associated with any project of this scale. The proximity of the water table to the ground surface and the design of the highway (i.e. tunnel beneath airport runway) may increase the opportunity for impacts on existing ground and surface water flows (Connell Wagner 1999). Of particular concern are activities that affect the flow of water into freshwater wetlands, excessive ponding of water in sedge or saltmarsh habitats, and excessive surface flow that leads to erosion of mangrove forests or intertidal mudflats.

The dominant surface and groundwater flow in the vicinity of the proposed alignment is in an east to west direction (Connell Wagner 1999). This means that much of the runoff associated with the highway will flow into freshwater wetlands adjacent to Cobaki Broadwater, or in some areas directly into the Broadwater. It is likely that surface flow from the highway will be channelled into the existing drainage lines. The potential increase in the amount of water flowing into freshwater wetlands may affect the quality of these sites for wetland birds, including bush hen, black bittern, and Lewins rail. Increased levels of runoff directly into Cobaki Broadwater may cause erosion of intertidal habitat, and possibly increased ponding in saltmarsh habitat adjacent to the Broadwater. This may affect the quality of roosting and foraging habitat for migratory shorebirds.

Also of concern is the suggestion by Connell Wagner (1999) that during construction of the tunnel the groundwater level would need to be lowered. The exact impact of lowering the groundwater table is undetermined, although it is assumed that lowering the water table will involve extracting water from the site. This raises concerns for possible impacts on sedgeland habitat at the tunnel site, and freshwater wetlands to the northwest of the site including those habitats used by aquatic birds such as bush hen.

6.7 Wetland contamination

Associated with the potential changes in surface and groundwater flow is the increased potential for pollution of freshwater and inter-tidal wetlands. The risk of pollution to wetlands will occur during both the construction and operation phases of the project. Construction phase impacts will include:

- potential acid water flows, associated with the exposure of acid sulphate soils;
- contaminated water flows through disturbance of contaminated lands within Coolangatta Airport, and the rubbish tip; and
- sedimentation of wetlands through erosion of exposed soils, and road base.

Operation phase impacts on wetlands may include:

- Runoff from the road surface during rainfall events; and
- Accidents on the highway involving vehicles transporting toxic substances.

Connell Wagner (1999) suggest that acid soils may not be a major issue with respect to the 'C' options, although they do stipulate that a rigorous testing regime will be required, particularly in the vicinity of the tunnel where large amounts of sediment will be extracted. Low lying land in the southern parts of the alignment is situated in close proximity to Cobaki Broadwater.

The numerous channels that drain this area would mean that any acid flows could quickly enter the eastern side of Cobaki Broadwater. Such flows would have a detrimental effect on fish and intertidal invertebrate communities in this area, which is a known feeding site for ospreys, white-bellied sea-eagles, collared kingfishers and migratory shorebirds. It is undetermined if acid flows would be of sufficient magnitude to affect the entire Cobaki Broadwater, and the magnitude of impacts may depend on the tidal stage at the time of acid inflow.

The impacts of contaminated runoff are difficult to determine without prior knowledge of the types of contaminated materials present on site. Given the direction of existing surface and groundwater flow it is likely that contaminated material from the airport and tip have been leaching onto freshwater wetlands and Cobaki Broadwater for some time. The concern with respect to the current proposal is that the speed of movement of contaminated material may be increased. Sedimentation of freshwater and estuarine wetlands is also of concern. Increased turbidity of water in Cobaki Broadwater will affect the foraging efficiency of ospreys, whilst sedimentation of small freshwater wetlands may reduce wetland permanency, and cause changes in vegetation structure.

The primary impacts associated with the operation of the highway stem from the risk associated with a chemical spill. Although a similar risk is present with the existing highway the greater distance between the highway and sensitive wetland habitats increases the opportunity to contain a spill prior to it reaching these areas. The new highway will be much closer to wetlands and therefore the risk of toxic substances entering these habitats is greater. Pollution of Cobaki Broadwater or nearby freshwater wetlands by toxic substances could have a considerable effect on threatened birds. Runoff from the road surface during rainfall events represents another source of pollution. Connell Wagner (1999) recognise the potential significance of toxic substances entering wetlands and suggest the installation of *permanent water quality treatment devices in areas where the carriageway is in close proximity to open water or wetland habitats*.

6.8 Contribution of impacts to threatening processes acting within the locality

A number of threatening processes are already acting within the locality. Possibly the major concern is habitat removal and fragmentation associated with developments along the Tweed Coast, and on the western side of Cobaki Broadwater. The current proposal will contribute to these activities that have already affected the habitat of threatened birds.

7. ASSESSMENT OF IMPACTS

7.1 Section 5a assessment

The section 5a assessment (eight-part test) is included in Appendix 5. The impact of the proposed C4 option was assessed on 24 species listed on the NSW TSC Act, and a further 14 species listed on either JAMBA or CAMBA. Species of conservation significance were not included due to the absence of specific legislative protection pertaining to these species. A summary of impacts on species of conservation significance is included in the following section.

Five threatened species recorded previously in the locality (i.e. 10km radius of subject site) were not included in the assessment due to the absence of suitable habitat that is likely to be affected by the proposal. A more detailed discussion of the process by which species were included or excluded from the assessment is provided in Appendix 5.

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.

7.1.1 Overview of impacts on legislatively protected species

An overview of which impacts will affect each of the legislatively protected species considered in the section 5a assessment is provided in Table 29. The overview highlights the level of concern regarding the impacts of wetland contamination, altered hydrological regimes, disturbance effects, and habitat removal and fragmentation. In the present case only a small number of species will be affected by edge effects, barrier effects or road strike.

The limited impact of edge effects is due to a combination of factors, including the modified nature of habitats affected, and the proven tolerance of some species to edge-modified habitats. In addition edge effects may include impacts that have been separated under the headings of disturbance effects, and altered hydrological regimes. The limited impact anticipated from both barrier effect and road strike is due to two reasons, firstly, the ability of birds to fly over obstacles, such as highways, and secondly, the lack of suitable habitat to the east of the alignment. The limited habitat to the east will mean that birds have less need to cross the highway and therefore will suffer a lower risk of road strike.

Impacts of primary concern with respect to this proposal include altered hydrological regimes, and wetland contamination. A number of threatened birds recorded in the study area rely upon wetlands, and detrimental effects on these habitats are of concern. In assessing the impacts of these factors it has been assumed that at least baseline environmental management procedures will be implemented.

The greatest unknown with respect to the proposal is the impact of disturbance effects, and in particular noise associated with vehicles using the highway. Although a number of species have been recorded previously from habitats situated near disturbance other species may be detrimentally affected.

The presence of birds in close proximity to Coolangatta airport may be regarded as an indication of tolerance to noise disturbance, however, there is concern that the different type of noise, and in particular the duration of noise emitted from the highway may have a greater effect that aircraft noise, which tends to be of brief duration.

Table 29: 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	X	√	√	√	√	√	√
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	√	√

7.1.2 Findings of the section 5a assessment

The section 5a assessment identified a number of issues of concern with respect to the impact of the proposal on threatened species (Table 30). The conclusion of the eight-part test is that a Species Impact Statement (SIS) will be required for at least four species (Table 30). These species include bush hen, black bittern, masked owl and grass owl. The section 5a assessment indicated that impacts on these species was of sufficient magnitude to affect the viability of local populations of each species. Additional species of concern include collared kingfisher, mangrove honeyeater, osprey, rose-crowned fruit-dove and migratory shorebirds.

When interpreting the findings of the assessment consideration must be given to the manner in which the section 5a assessment has been viewed, and particularly the definition of a *local population.* For the purpose of this assessment the conclusion of a detrimental impact on a local population (question *a* in the section 5a) has been regarded as justification to warrant a SIS. Central to this conclusion is the definition of a local population, and consideration of the ecological requirements of the subject species. For the purpose of this assessment the definition of a local population provided by the NPWS (1996) has been used. This definition reads as follows "*a population that occurs within the study area, unless the existence of contiguous or proximal occupied habitat and the movement of individuals or exchange of genetic material across the boundary of the study area can be demonstrated*". A more detailed discussion of the *local population* is provided in Appendix 5.

For some species, such as masked owl the conclusion of a significant effect was based on the small size of the local population, and the slight risk that even one owl hit by a car would represent a significant effect. The local masked owl population may have already been affected by habitat removal on the western side of Cobaki Broadwater. A significant effect on local populations of mangrove honeyeater and collared kingfisher could not be concluded due to the broad distribution of both species throughout Cobaki Broadwater, and the contiguous nature of their habitat throughout the lower Tweed River estuary.

A similar conclusion was derived for osprey, although pollution of the Broadwater would affect at least one pair of ospreys.

Under a worst case scenario the proposal could have a detrimental affect on the pair of ospreys that forage in the eastern section of Cobaki Broadwater, however, the viability of the local osprey population, which includes the entire lower Tweed River estuary, would not be affected.

Determining the exact impact of wetland contamination and altered hydrological regimes was problematic. The assessment of impacts conducted in this report has been 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 may inturn influence the conclusions regarding the impact of these issues on threatened birds.

Without the value of knowing potential mitigation measures a conservative approach to the impact of altered hydrological regimes, and wetland contamination has been adopted. In adopting this approach due consideration has been given to standard environmental management procedures that form part of most major road projects. It is highly likely that standard procedures will reduce impacts associated with contamination of wetlands, particularly within Cobaki Broadwater, although some specialised techniques may be required to reduce impacts to an acceptable level. By considering standard procedures the anticipated level of impact has been reduced.

Failure to acknowledge that baseline impact mitigation would be conducted would have altered the conclusions of the assessment, with a greater level of impact anticipated for Cobaki Broadwater. This would result in a greater level of impact on ospreys, migratory shorebirds, collared kingfishers, and possibly mangrove honeyeater. The mitigation measures proposed in the EIS will influence the outcome of the eight-part test for these species.

7.2 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 unlikely that the proposal will have a substantial effect 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. 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, and it is considered likely that the pair of kites that nest in swamp forest habitat in the vicinity of the Pony Club will abandon their current nest site.

Table 30: 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

7.3 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 replacing 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.

8. REFERENCES

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APPENDIX ONE

WEATHER AND TIDAL CONDITIONS

Table 1a: Height and time, of daytime low and high tides experienced during the survey for estuarine birds. DST = daylight savings time. The time and height of tides was obtained from the National Tidal Facility, The Flinders University of South Australia.

Date	High Tide		Low Tide	
	Tide Height	Time (DST)	Tide Height	Time (DST)
21/1	2.0 m	9.07am	0.1 m	3.48pm
22/1	2.0 m	9.59am	0.1 m	4.37pm
23/1	2.0 m	10.48am	0.1 m	5.25pm
27/1	1.4 m	1.57pm	0.6 m	7.53am
28/1	1.3 m	2.48pm	0.6 m	8.54am
29/1	1.2 m	3.50pm	0.7 m	10.02am

Table 1b: Weather variables recorded during the day and night over the period of the survey. Night weather variables were measured only when nocturnal surveys were conducted. (p) = rain not recorded during the survey but recorded during previous 24 hours; nr = variable not recorded; - = no survey conducted.

Date	Cloud Cover %		Wind Direction		Wind Speed		Rainfall		Air Temperature	
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
21/1	5	5	NE	nr	moderate	light	nil	nil	nr	27
22/1	12	-	n/a	-	nil	-	nil		nr	-
23/1	0	10	NE	nr	moderate	moderate	nil	light	nr	22
24/1	100	100	n/a	n/a	nil	nil	nil (p)	nil (p)	nr	21
25/1	100	15	n/a	nr	nil	light	nil (p)	nil (p)	nr	23
26/1	80	10	n/a	n/a	nil	nil	nil	nil	nr	22
27/1	85	-	NE	-	moderate	-	nil	-	nr	-
28/1	100	100	NE	nr	light	nil	nil (p)	nil (p)	nr	24
29/1	0	100	n/a	nr	nil	nil	nil (p)	nil (p)	nr	24
30/1	80	-	n/a	-	nil	-	nil	-	nr	-

Table 1c: Weather conditions experienced during the autumn bird survey

Date	Cloud Cover %		Wind Direction		Wind Speed		Rainfall		Air Temperature	
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
16/5	na	75	na	-	na	nil	na	nil	na	19
17/5	30	5	Sth	-	light	nil	nil	nil	17	16
18/5	65	50	Sth	Sth	light	mod	light	nil	18	19
19/5	70	na	Sth	na	light	na	nil*	na	14	na
20/5	25	20	Sth	-	light	nil	nil	nil	14	15
21/5	20	na	nil	na	-	na	nil	na	13	na

* rain occurred overnight but not during surveys

APPENDIX TWO

ESTUARINE BIRD DATA

Table 2a: Maximum number of individuals recorded at each site during spring tide surveys

Species	SH	KI	DB	TB	RP	SB	CB	TR	BI	UK	TC	**CC**	**PC**	**C**	**CF**	TI	W	BB	DM
Aust. Wood Duck	-	-	-	-	-	-	15	-	-	-	-	**2**	**-**	**-**	**-**	-	-	-	-
Pacific Black Duck	-	-	-	-	-	-	5	3	-	-	-	**-**	**-**	**-**	**-**	-	-	-	-
Chestnut Teal	-	-	-	-	-	-	-	-	-	-	-	**-**	**-**	**-**	**-**	-	-	-	-
Darter	-	-	-	-	-	-	1	1	2	2	1	**1**	**-**	**2**	**1**	1	3	1	1
Little Pied Corm.	-	-	-	-	-	-	-	2	2	2	1	**2**	**-**	**-**	**-**	2	2	2	-
Pied Cormorant	-	15	-	-	34	1	4	3	-	27	2	**4**	**-**	**-**	**-**	5	-	3	1
Little Black Corm	-	196	-	-	-	-	7	181	1	27	3	**-**	**-**	**1**	**-**	2	-	2	-
Great Cormorant	-	-	-	-	-	-	2	-	-	-	-	**-**	**-**	**1**	**-**	-	-	-	-
Australian Pelican	-	-	-	-	7	2	21	15	2	5	23	**-**	**-**	**-**	**-**	3	10	14	5
White-faced Heron	-	-	-	-	-	-	1	1	-	-	-	**-**	**6**	**1**	**1**	-	1	-	5
Little Egret	-	-	-	-	-	-	10	1	-	-	-	**-**	**-**	**-**	**-**	1	2	5	-
Eastern Reef Egret	-	-	-	-	-	-	-	-	-	-	-	**-**	**-**	**-**	**-**	-	-	-	-
Great Egret	-	-	-	-	-	-	-	1	-	-	-	**1**	**-**	**-**	**-**	1	1	-	6
Cattle Egret	-	-	-	-	-	-	-	-	-	-	-	**-**	**-**	**-**	**-**	-	-	-	-
Striated Heron	-	-	-	-	-	1	3	1	-	-	-	**-**	**-**	**-**	**1**	-	1	-	-
Aust. White Ibis	-	-	-	-	-	3	51	5	1	1	-	**5**	**18**	**-**	**8**	-	-	-	19
Royal Spoonbill	-	-	-	-	1	1	1	-	-	-	-	**-**	**-**	**-**	**-**	-	1	-	-
Osprey	-	-	-	-	-	2	1	1	2	2	1	**1**	**-**	**-**	**1**	2	3	-	-
Whistling Kite	-	-	-	-	-	-	1	-	1	-	-	**1**	**1**	**1**	**2**	-	2	1	1
Brahminy Kite	-	-	-	-	-	-	2	1	-	-	-	**-**	**1**	**1**	**2**	3	-	-	-
White-bellied S-E	-	-	-	-	-	-	2	1	1	-	-	**-**	**-**	**-**	**1**	-	-	-	1
Pacific Baza	-	-	-	-	-	-	-	-	-	-	-	**-**	**-**	**-**	**-**	-	-	-	2
Lewins Rail	-	-	-	-	-	-	-	-	-	-	-	**-**	**-**	**-**	**-**	-	-	-	-
Latham's Snipe	-	-	-	-	-	-	-	-	-	-	-	**-**	**-**	**-**	**-**	-	-	-	-
Bar-tailed Godwit	118	144	-	-	-	-	-	-	-	-	-	**-**	**-**	**-**	**-**	-	-	-	-
Whimbrel	-	5	-	-	-	25	-	-	2	-	1	**21**	**23**	**-**	**-**	23	14	-	-
Eastern Curlew	18	23	-	24	-	-	-	-	-	-	-	**-**	**20**	**-**	**-**	-	-	-	46
Common Grnshank	-	-	-	-	-	-	-	-	-	-	-	**-**	**-**	**22**	**-**	-	-	-	10
Terek Sandpiper	-	-	-	-	-	-	-	-	-	-	-	**-**	**-**	**-**	**-**	-	1	-	-
Comn. Sandpiper	-	-	-	-	-	-	-	-	-	-	-	**1**	**-**	**-**	**-**	-	1	-	-
Grey-tailed Tattler	-	5	-	-	14	-	-	-	3	-	3	**-**	**-**	**7**	**-**	-	17	-	-
Curlew Sandpiper	-	2	-	-	-	-	-	-	-	-	-	**-**	**-**	**-**	**-**	-	-	-	-
Sharp-tled Sandpip.	-	-	-	-	-	-	-	-	-	-	-	**-**	**-**	**-**	**-**	-	-	-	21
Pied Oystercatcher	-	4	-	1	-	-	-	-	2	-	-	**-**	**-**	**-**	**-**	-	-	2	-
Sooty Oystercat.	-	3	-	-	-	-	-	-	-	-	-	**-**	**-**	**-**	**-**	-	-	-	-
Black-winged Stilt	-	-	-	-	-	-	-	-	-	-	-	**-**	**6**	**-**	**-**	-	-	-	41
Pacific Gldn Plover	-	17	-	-	-	-	-	-	-	-	-	**-**	**9**	**-**	**-**	-	-	-	4
Masked Lapwing	-	-	-	1	-	-	3	-	-	-	-	**2**	**-**	**23**	**-**	-	-	-	6
Silver Gull	83	125	12	10	-	-	43	63	6	51	134	**2**	**-**	**-**	**-**	1	-	32	-
Caspian Tern	-	-	-	1	-	-	-	-	-	-	-	**-**	**-**	**-**	**-**	-	-	-	-
Crested tern	5	112	1	16	-	5	16	79	14	23	48	**3**	**-**	**-**	**-**	15	7	19	81
Little Tern	-	-	-	-	-	-	-	-	-	-	-	**-**	**-**	**-**	**-**	-	-	-	-

SH = South Head Beach
KI = Kerosene Inlet
DB = Dreamtime Beach
TB = Tony's Bar
RP = Rocky Point
SB = Shallow Bay
CB = Chinderah Bay
TR = Tweed River
BI = Boyd's Island
UK = Ukerabagh Island
TC = Terranora Creek
CC = Cobaki Creek
PC = Pony Club
C = Cobaki Broadwater
CF = Cobaki Fringe
TI = Terranora Islands
W = Womgin Island
BB = Birds Bay
DM = Duroby Marsh.

Table 2b: Maximum number of individuals recorded at each site during neap tide surveys. Site abbreviations are the same as for Table 1a.

Species	SH	KI	DB	TB	RP	SB	CB	TR	BI	UK	TC	CC	PC	C	CF	TI	W	BB	DM
Aust. Wood Duck	-	-	-	-	-	-	9	2	-	6	-	**4**	-	-	-	-	-	-	-
Pacific Black Duck	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-	21
Chestnut Teal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
Darter	-	-	-	-	1	-	5	-	1	2	-	**1**	-	**1**	-	2	2	1	-
Little Pied Corm.	-	-	-	-	1	-	4	1	3	3	3	**1**	-	**1**	-	6	1	1	1
Pied Cormorant	-	27	-	-	31	-	9	1	2	1	-	-	-	-	-	2	-	4	-
Little Black Corm.	-	80	-	-	-	-	3	90	7	2	5	-	-	-	-	1	-	-	-
Great Cormorant	-	-	-	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Australian Pelican	-	1	-	1	7	1	16	-	11	3	54	-	-	-	-	4	11	10	-
White-faced Heron	-	-	-	1	-	-	1	1	1	1	1	**1**	**3**	**1**	-	2	-	-	5
Little Egret	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-
Eastern Reef Egret	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Great Egret	-	-	-	1	-	-	1	-	-	2	1	**1**	-	**2**	-	1	1	-	1
Cattle Egret	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	34
Striated Heron	-	-	-	-	-	1	-	1	-	1	-	**2**	-	-	-	-	-	-	-
Aust. White Ibis	-	-	-	1	1	-	47	1	8	2	4	**8**	**2**	**1**	-	4	2	-	7
Royal Spoonbill	-	-	-	-	-	6	1	-	1	-	-	**1**	-	-	-	-	-	1	1
Osprey	-	1	-	-	-	1	1	1	2	-	1	-	-	-	-	1	-	-	-
Whistling Kite	-	1	-	-	-	-	1	-	-	-	3	**1**	-	-	-	1	-	-	-
Brahminy Kite	-	-	-	-	-	-	-	2	-	-	1	**1**	-	-	-	1	-	-	-
White-bellied S-E	-	-	-	-	-	-	-	-	1	1	1	-	-	-	-	2	-	-	-
Pacific Baza	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lewins Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Latham's Snipe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Bar-tailed Godwit	-	185	-	70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Whimbrel	-	2	-	21	-	19	-	-	4	1	1	**19**	-	-	-	24	42	-	1
Eastern Curlew	-	43	-	35	-	-	-	-	-	-	-	-	**19**	-	-	-	-	-	38
Com'n Grnshank	-	-	-	-	-	-	-	-	-	-	-	-	-	**23**	-	-	-	-	12
Terek Sandpiper	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Com'n Sandpiper	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Grey-tailed Tattler	-	4	-	-	19	-	-	-	5	-	-	-	-	**5**	-	11	21	-	-
Curlew Sandpiper	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sharp-tled Sandp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	23
Pied Oystercatcher	-	4	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
Sooty Oystercat.	-	2	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Black-winged Stilt	-	-	-	-	-	-	-	-	-	-	-	-	**4**	-	-	-	-	6	25
Pacific Gldn Plov.	-	18	-	-	-	-	-	-	-	-	-	-	**4**	-	-	-	-	-	6
Masked Lapwing	-	2	-	-	-	-	2	-	-	-	-	**2**	**1**	-	-	-	-	-	3
Silver Gull	-	140	-	112	-	-	112	28	1	11	148	-	-	-	-	2	-	22	-
Caspian Tern	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crested Tern	-	462	-	76	-	-	10	48	7	9	19	-	-	**1**	-	5	1	2	-
Little Tern	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 2c: Population estimates derived during each of the estuarine bird surveys

Species	21-Jan Roost	22-Jan Roost	23-Jan Roost	27-Jan Roost	28-Jan Roost	29-Jan Roost	21-Jan Feeding	28-Jan Feeding	Population Estimate
Australian Wood Duck	2		15	9	11	5	2	13	15
Pacific Black Duck	3	5	2	16	22	13	8	19	22
Chestnut Teal				2	6	6			6
Darter	6	5	8	8	9	14	2	5	14
Little Pied Cormorant	10	6	6	17	6	17	2	4	17
Pied Cormorant	44	59	54	53	46	54	34	15	59
Little Black Cormorant	232	15	187	10	14	188		96	232
Great Cormorant		2	2		3	1	1	2	3
Australian Pelican	59	51	59	89	83	53	53	21	89
White-faced Heron	9	13	7	13	5	10	65	30	65
Little Egret	3	15	11	5	4	2	9	11	15
Eastern Reef Egret					1				1
Great Egret	9	3	5	5	6	5	23	17	23
Intermediate Egret							22		22
Cattle Egret					34				34
Striated Heron		6	2	1	4		4	9	9
Australian White Ibis	49	76	68	38	48	81	34	79	81
Royal Spoonbill	1	1	3	3	2	6	10	13	13
Black-necked Stork								1	1
Osprey	10	5	6	4		4		1	10
Whistling Kite	5	3	5	4	3	4	1	1	5
Brahminy Kite	4	4		2	2	3	2		4
White-bellied Sea-Eagle	1	2	5	3	2				5
Pacific Baza	1	2							2
Latham's Snipe						2			2
Bar-tailed Godwit	144	130	131	153	171	193	132	137	193
Whimbrel	72	66	48	75	80	73	40	49	80
Eastern Curlew	107	107	86	62	103	117	34	69	117
Common Greenshank	30	32	29	29	28	35	43	34	43
Terek Sandpiper	1	1	1	1	1	1			1
Common Sandpiper	1	1						1	1
Grey-tailed Tattler	39	36	38	43	41	61	10	15	61
Curlew Sandpiper	1	1	2	1	1	1	2	1	2
Sharp-tailed Sandpiper	21		17	21	23	23	2		23
Pied Oystercatcher	7	7	8	5	7	10	2	2	10
Sooty Oystercatcher	2	2	3	4	2		1		4
Black-winged Stilt	15			29	14	22	70	102	102
Pacific Golden Plover	21	20	24	22	8	24	12	4	24
Masked Lapwing	4	5	29	1	4	10	18	26	29
Silver Gull	365	312	364	379	448	278	426	395	448
Caspian Tern	1					1			1
Crested tern	298	149	410	613	205	305	146	133	613
Little Tern						1	1	1	1
	1577	1142	1635	1720	1447	1623			2502

Table 2d: Maximum number of birds recorded at freshwater wetlands during the field survey

Species	Trutes Bay Wetland	Tweed Heads south STW	Tweed Heads west STW
Australian Wood Duck	4	11	20
Wandering Whistling-Duck	1		
Pacific Black Duck	44	3	20
Grey Teal			28
Chestnut Teal			14
Australasian Grebe			14
Darter	1	1	8
Little Pied Cormorant	2		17
Pied Cormorant			122
Little Black Cormorant	3		44
Great Cormorant	2	1	
Australian Pelican	1		1
White-faced Heron		1	1
Little Egret			1
Great Egret	1		1
Cattle Egret		8	
Australian White Ibis		4	18
Royal Spoonbill	1		8
Osprey		1	
Lewins Rail			1
Dusky Moorhen	26	12	23
Eurasian Coot	13		3
Purple Swamphen	9		
Latham's Snipe			2
Comb-crested Jacana	3		
Black-winged Stilt	94		33
Black-fronted Dotteral			6
Masked Lapwing			5

Table 2e: Population estimates obtained during estuarine bird monitoring conducted by Sandpiper Ecological Surveys between 1997 and 1999.

Species	3/97	3/98	3/99	6/97	6/98	6/99	10/97	10/98	10/99
WATERBIRDS									
• Magpie Goose	-	11	-	-	-	6	-	-	-
Black Swan	-	-	2	-	-	-	-	-	-
Australian Wood Duck*	5	85	95	15	23	34	13	20	54
Mallard	1	-	-	-	-	-	1	2	3
Pacific Black Duck	85	176	106	76	130	52	141	127	92
Grey Teal	3	12	14	17	86	190	55	11	70
Chestnut Teal	21	21	39	9	35	78	40	15	33
Hardhead	-	10	1	-	33	11	18	5	16
Wandering Whistling Duck	-	7	4	-	-	21	-	-	-
Australasian Grebe*	1	42	20	26	38	8	27	11	30
Hoary-headed Grebe	2	-	-	-	-	-	-	-	-
Darter *	6	37	43	17	10	18	16	12	22
Little Pied Cormorant*	14	19	13	21	21	34	11	7	26
Pied Cormorant	59	34	24	87	134	98	202	149	87
Little Black Cormorant	4	169	28	69	366	233	153	192	132
Great Cormorant	2	1	-	2	2	-	3	2	5
Australian Pelican	27	26	18	65	162	127	85	111	99
White-faced Heron	70	12	98	134	169	132	59	5	71
Little Egret	9	11	8	11	11	22	4	4	11
Eastern Reef Egret	4	-	2	-	-	2	1	1	1
Great Egret	13	7	26	10	14	21	11	12	25
Intermediate Egret	1	1	2	1	1	1	-	-	1
Cattle Egret	25	9	3	-	7	5	-	-	
Striated Heron	5	4	2	6	7	7	6	8	8
Nankeen Night Heron	1	-	-	-	-	3	9	-	2
Australian White Ibis	37	35	105	80	79	38	13	14	39
Straw-necked Ibis	-	2	-	10	11	6	-	-	3
Royal Spoonbill	3	11	10	17	31	30	15	11	22
† Black-necked Stork	-	-	-	-	-	-	1	-	-
Spotless Crake	-	-	-	-	1	-	-	-	-
Purple Swamphen	-	27	15	8	46	10	8	11	3
Dusky Moorhen*	16	84	134	51	87	44	45	51	62
Eurasian Coot*	23	26	22	11	41	80	18	-	46
Number of individuals	437	879	834	773	1545	1311	955	781	960
Number of species	25	26	25	23	25	27	25	22	26
BIRDS OF PREY									
Brown Falcon	-	1	-	-	-	-	-	-	1
• Osprey*	6	6	8	8	11	7	8	9	8
Whistling Kite*	5	6	4	5	7	4	5	6	4
Brahminy Kite*	4	6	5	5	4	4	4	5	5
White-bellied Sea-Eagle*	2	1	5	3	2	6	1	2	1
Wedge-tailed Eagle	-	-	-	-	-	-	-	1	-
Pacific Baza	-	-	1	-	-	-	-	1	2
Marsh Harrier	-	-	1	-	1	-	-	-	
Australasian Kestrel	-	-	-	-	-	-	-	-	-
Australian Hobby	-	-	-	-	-	-	-	-	
Little Eagle	-	-	-	-	-	-	-	-	-
Brown Goshawk	-	-	-	-	-	-	-	-	-
Black-shouldered Kite	0	0	0	0	2	0	0	0	0
Grey Goshawk	0	1	0	0	0	0	0	0	0
Number of individuals	17	21	24	21	27	21	18	24	21
Number of species	4	6	6	4	6	4	4	6	6

Table 2e: cont

Species	3/97	3/98	3/99	6/97	6/98	6/99	10/97	10/98	10/99
SHOREBIRDS									
Latham's Snipe	0	0	0	0	0	0	2	2	1
Bar-tailed Godwit	153	29	58	31	34	17	282	243	196
• Black-tailed Godwit	0	0	0	0	0	0	0	1	0
Whimbrel	44	47	30	16	9	2	69	56	51
Eastern Curlew	56	43	17	21	26	2	94	88	91
Marsh Sandpiper	0	6	0	0	0	0	41	9	2
Common Greenshank	25	16	18	0	0	0	29	39	30
• Terek Sandpiper	5	3	1	0	0	0	2	0	1
Common Sandpiper	1	0	0	0	0	0	2	1	1
Grey-tailed Tattler	73	73	59	0	17	2	58	67	34
Ruddy Turnstone	0	0	0	0	0	0	3	2	3
Curlew Sandpiper	0	2	0	0	0	0	9	1	2
Sharp-tailed Sandpiper	0	0	0	0	0	0	28	18	18
• Comb-crested Jacana	0	2	9	0	1	5	1	1	2
•Beach Stone-curlew	1	0	0	1	0	0	0	0	1
• Pied Oystercatcher*	7	7	6	7	8	6	4	5	9
• Sooty Oystercatcher*	2	5	2	2	1	1	1	1	2
Black-winged Stilt	29	168	304	167	325	344	85	0	134
Red-necked Avocet	0	0	0	0	3	3	29	0	0
Pacific Golden Plover	23	24	29	0	0	0	27	26	17
Double-banded Plover	8	14	13	21	21	17	0	0	0
Red-capped Plover	0	0	0	6	0	0	0	0	0
• Greater Sand Plover	1	0	0	0	0	0	0	0	0
Red-kneed Dotteral	0	0	0	0	1	0	0	0	1
Black-fronted Dotterel	2	4	3	0	4	2	1	2	1
Masked Lapwing*	33	8	47	10	6	6	9	5	20
Number of individuals	463	433	587	275	456	407	776	567	614
Number of species	16	16	14	9	13	12	20	18	21
GULL & TERNS									
Silver Gull*	868	531	695	464	412	521	638	669	662
Gull-billed Tern	2	9	4	13	60	47	14	2	38
Common Tern	0	0	0	0	0	0	247	8	0
Caspian Tern	1	1	2	3	1	1	1	2	1
Crested Tern*	226	567	143	60	101	106	577	802	501
• Little Tern	10	0	3	0	0	0	10	0	0
Australasian Gannet	0	0	0	3	1	15	0	0	0
Number of individuals	1107	1108	847	543	575	690	1487	1483	1202
Number of species	5	4	5	5	5	5	6	5	4

Table 2f: Maximum number of birds recorded at intertidal feeding areas during low tide surveys. S = spring tide; N = neap tide.

Species	Low tide feeding grounds																			
	KI S	KI N	TB S	TB N	SB S	SB N	CB S	CB N	**PC S**	**PC N**	**C S**	**C N**	**CF S**	**CF N**	Wo S	Wo N	TrB S	TrB N	TrW S	TrW N
Australian Wood Duck								13									2			
Pacific Black Duck			6	7	2			12									2			
Darter				1			1	4							2					
Little Pied Cormorant		2	1								**1**					2				
Pied Cormorant		6					34	9												
Little Black Cormorant		94						1												1
Great Cormorant	1			1				1												
Australian Pelican			6				2	10		**1**					13	6	32	3		1
White-faced Heron	1		2	2	6	4	1	7	**1**		**2**	**7**	**18**	**3**	5	4	38			3
Little Egret			1	1	1		3	6			**1**				4	3	4	1		
Great Egret			2		5			1	**1**		**2**		**2**	**3**	2	2	16	8		3
Intermediate Egret																	22			
Striated Heron					2	1	2	3		**1**		**2**			1	1	1	1		
Australian White Ibis	1		5		11	4	17	52	**3**			**2**	**2**			1	22	8		2
Royal Spoonbill					1	1	3	2				**1**			2	1	8	7		1
Black-necked Stork																		1		
Osprey		1																		
Whistling Kite								1												
Brahminy Kite											**1**									
White-bellied Sea-Eagle							2													1
Bar-tailed Godwit	55	2	10	1	19	17	35	34		**1**		**3**	**25**	**41**	69	18	38	15		5
Whimbrel	2	1	1	3	3	4		3		**1**	**8**	**9**	**3**	**2**	23	16	6	9		1
Eastern Curlew	1	3	11	4	3	4	6	11	**3**	**5**	**5**	**9**	**5**	**7**	6	5	15	15		6
Common Greenshank									**1**	**1**	**6**	**9**	**12**	**6**			25	18		
Common Sandpiper																1				
Grey-tailed Tattler	1	1		5	1	4					**8**	**1**	**1**		1	4				
Curlew Sandpiper	2																	1		
Sharp-tailed Sandpiper			2																	
Pied Oystercatcher	2	2													2					
Sooty Oystercatcher	1																			
Black-winged Stilt							2					**3**					70	94		5
Pacific Golden Plover	12									**4**										
Masked Lapwing	2							2	**2**					**8**			18	16		
Silver Gull	260	125	23	50			143	179					**9**	**4**			150	37		
Crested tern	131	112	15	17				1					**1**							3
Little Tern		1	1																	

APPENDIX 3

TERRESTRIAL BIRD DATA

Table 3a: Bird species recorded during surveys of terrestrial habitats in the vicinity of the proposed Tugun Bypass in summer. W = woodland, SF = swamp forest, Rf = rainforest, M = mangrove, S = sedgeland, H = heath, RM = regrowth melaleuca, P = disturbed.

Species Name	Site	W	SF	Rf	M	S	H	RM	D
Alectura lathami	Australian Brush-turkey	x	x	x					
Coturnix pectoralis	Stubble Quail						x		
Coturnix ypsilophora	Brown Quail								x
Coturnix chinensis	King Quail	x			x	x	x		
Dendrocygna arcuata	Wandering Whistling-Duck								
Chenonetta jubata	Australian Wood Duck		x					x	
Anas superciliosa	Pacific Black Duck	x	x			x	x		x
Anas gracilis	Grey Teal								x
Anas castanea	Chestnut Teal				x				x
Tachybaptus novaehollandiae	Australian Grebe								x
Anhinger melanogaster	Darter		x		x				x
Phalacrocorax melanoleucos	Little Pied Cormorant		x			x			x
Phalacrocorax varius	Pied Cormorant								
Phalacrocorax sulcirostris	Little Black Cormorant		x						x
Pelecanus conspicillatus	Australian Pelican	x							
Egretta novaehollandiae	White-faced Heron				x				x
Egretta garzetta	Little Egret								
Ardea alba	Great Egret	x	x		x	x			x
Ardea ibis	Cattle Egret							x	x
Butorides striatus	Striated Heron				x				
Nycticorax caledonicus	Nankeen Night Heron			x	x				
Threskiornis molucca	Australian White Ibis	x	x		x	x	x	x	x
Platalea regia	Royal Spoonbill	x							
Pandion haliaetus	Osprey						x		
Aviceda subcristata	Pacific Baza		x			x			
Elanus axillaris	Black-Shouldered Kite								x
Haliaster sphenurus	Whistling Kite	x	x	x	x			x	
Haliaster indus	Brahminy Kite				x	x		x	x
Haliaeetus leucogaster	White-Bellied Sea Eagle								
Accipiter fasciatus	Brown Goshawk							x	
Falco longipennis	Australian Hobby					x			
Grus rubicunda	Brolga		x						
Gallirallus philippensis	Buff-banded Rail							x	x
Rallus pectoralis	Lewins Rail	x	x		x	x		x	
Amaurornis olivaceus	Bush-hen								
Porzana tubuensis	Spotless Crake								
Porphyrio porphyrio	Purple Swamphen								x
Gallinula tenebrosa	Dusky Moorhen								x
Fulica atra	Eurasian Coot								
Gallinago hardwickii	Latham's Snipe								x
Numenius madagascariensis	Eastern Curlew				x				
Himantopus himantopus	Black-winged Stilt								x
Elseyornis melanops	Black-fronted Dotterel								x
Vanellus miles	Masked Lapwing							x	
Larus novaehollandiae	Silver Gull								x
Streptopelia chinensis	Spotted Turtle-Dove	x			x	x	x	x	x
Columba livia	Rock Dove								x
Columba leucomela	White-headed Pigeon			x					

Table 3a: cont.

Species Name	Site	W	SF	Rf	M	S	H	RM	D
Macropygia aboinensis	Brown Cuckoo-Dove					x		x	
Chalcophaps indica	Emerald Dove				x				
Ocyphaps lophotes	Crested Pigeon						x		
Geopelia striata	Peaceful Dove	x	x		x			x	
Geopelia humeralis	Bar Shouldered Dove	x	x	x	x		x	x	x
Ptilinopus superbus	Superb Fruit-Dove			x					
Ptilinopus regina	Rose-Crowned Fruit-Dove		x	x					
Lopholaimus antarcticus	Topknot Pigeon			x					
Cacatua roseicapilla	Galah		x						
Cacatua galerita	Sulphur-crested Cockatoo		x						
Trichoglossus haematodus	Rainbow Lorikeet	x	x	x	x		x	x	x
Trichoglossus chlorolepidotus	Scaly-breasted Lorikeet		x		x				x
Glossopsitta pusilla	Little Lorikeet		x						
Platycerus adscitus	Pale-headed Rosella	x							x
Cuculus pallidus	Pallid Cuckoo				x				
Cacomantis variolosus	Brush Cuckoo	x	x	x					
Cacomantis flabelliformis	Fan-tailed Cuckoo	x	x						
Chrysococcyx lucidus	Shinning Bronze-Cuckoo				x				
Chrysococcyx minutillus	Little Bronze-Cuckoo			x	x				
Eudynamys scolopacea	Common Koel	x					x		
Scythrops novaehollandiae	Channel-billed Cuckoo		x		x				
Centropus phasianinus	Pheasant Coucal	x	x		x				
Ninox novaeseelandiae	Southern Boobook	x							
Podargus strigoides	Tawny Frogmouth	x							x
Eurostopodus mystacalis	White-throated Nightjar								
Aegotheles cristatus	Australian Owlet Nightjar								
Hirundapus caudacutus	White-throated Needletail	x	x		x				x
Alcedo azurea	Azure Kingfisher				x				
Dacelo novaeguineae	Laughing Kookaburra	x	x	x				x	
Todiramphus sanctus	Sacred Kingfisher	x	x				x		
Todiramphus chloris	Collared Kingfisher				x				
Merops ornatus	Rainbow Bee-eater	x	x	x	x	x	x		x
Eurystomus orientalis	Dollarbird		x		x				
Cormobates leucophaeus	White-throated Treecreeper	x	x	x					
Malurus cyaneus	Superb Fairy-wren	x				x	x	x	x
Malurus lamberti	Varigated Fairy-wren	x	x	x			x		x
Malurus melanocephalus	Red-backed Fairy-wren		x		x	x		x	x
Pardalotus striatus	Striated Pardalote		x						
Sericornis frontalis	White-browed Scrubwren	x	x	x			x	x	x
Sericornis magnirostris	Large-billed Scrubwren			x					
Gerygone mouki	Brown gerygone		x		x				
Gerygone levigaster	Mangrove Gerygone				x				
Gerygone olivacea	White-throated Gerygone		x						
Acanthiza pusila	Brown Thornbill	x	x	x	x		x	x	
Acanthiza nana	Yellow Thornbill		x				x		
Anthochaera chrysoptera	Little Wattlebird	x	x	x	x		x	x	
Plectorhyncha lanceolata	Striped Honeyeater		x		x	x			
Philemon corniculatus	Noisy Friarbird	x	x		x				
Entomyzon cyanotis	Blue-Faced Honeyeater							x	
Manorina melanocephala	Noisy Miner		x						
Meliphaga lewinii	Lewins Honeyeater	x	x	x	x		x		x
Lichenostomus fasciogularis	Mangrove Honeyeater				x				

Table 3a: cont.

Species Name	Site	W	SF	Rf	M	S	H	RM	D
Melithreptus lunatus	White-naped Honeyeater	x	x						
Lichmera indistincta	Brown Honeyeater		x	x	x		x		x
Philidonyris nigra	White-cheeked Honeyeater	x	x	x	x		x	x	x
Acanthorhynchus tenuirostris	Eastern Spinebill	x	x	x					x
Myzomela sanguinolenta	Scarlet Honeyeater		x					x	
Petroica rosea	Rose Robin		x						
Eopsaltria australis	Eastern Yellow Robin	x	x	x					
Psophodes olivaceus	Eastern Whipbird	x	x	x			x	x	
Daphoenositta chrysoptera	Varied Sitella *		x						
Pachycephala rufiventris	Rufous Whistler	x	x	x			x		
Colluricincla megarhyncha	Little Shrike-thrush		x	x					
Colluricincla harmonica	Grey Shrike-thrush	x	x	x			x	x	x
Monarcha melanopsis	Black-faced Monarch		x						
Monarcha trivirgatus	Spectacled Monarch		x				x		
Myiagra rubecula	Leaden Flycatcher	x	x	x	x	x		x	
Myiagra inquieta	Restless Flycatcher								
Grallina cyanoleuca	Magpie-lark	x	x		x		x	x	x
Rhipidura rufifrons	Rufous Fantail			x					
Rhipidura fuliginosa	Grey Fantail	x	x	x	x		x	x	x
Rhipidura leucophrys	Willie Wagtail		x		x	x	x	x	x
Dicrurus bracteatus	Spangled Drongo	x	x	x	x	x	x		
Coracina novaehollandiae	Black-faced Cuckoo shrike	x	x	x	x	x	x	x	x
Coracina tenuirostris	Cicadabird	x	x	x	x				
Lalage leucomela	Varied Triller	x	x	x	x			x	
Oriolus sagittatus	Olive-backed Oriole	x	x	x					
Sphecotheres viridis	Figbird	x	x	x	x			x	
Artamus leucorynchus	White-breasted Woodswallow				x			x	
Cracticus torquatus	Grey Butcherbird		x		x		x		
Cracticus nigrogularis	Pied Butcherbird	x	x	x	x		x	x	x
Gymnorhina tibicen	Australian Magpie	x		x	x		x	x	x
Strepera grucelena	Pied Currawong	x	x	x			x	x	
Corvus orru	Torresian Crow	x	x	x	x	x	x	x	x
Ptilonorhynchus violaceus	Satin Bowerbird		x	x					
Anthus novaeseelandiae	Richard's Pipit								x
Passer domesticus	House Sparrow								x
Taeniopygia bichenovii	Double-barred Finch	x						x	x
Neochima temporalis	Red-browed Finch	x	x	x			x	x	x
Lonchura castaneothorax	Chestnut-breasted Mannikin					x			
Dicaeum hirundinaceum	Misletoebird	x	x	x	x			x	
Hirundo neoxena	Welcome Swallow								x
Hirundo nigicans	Tree Martin		x						
Hirundo ariel	Fairy Martin		x			x			x
Acrocephalus stentoreus	Clamorous Reed-Warbler								x
Megalurus timoriensis	Tawny Grassbird					x			x
Cristicola exilis	Golden-headed Cisticola	x			x	x			x
Zosterops lateralis	Silvereye	x	x	x	x	x	x	x	x
Sturnus vulgaris	Common Starling								

WO = Woodland
RF = Lowland rainforest
S = Sedgeland
RM = Regrowth swamp forest
SF = Swamp Forest
Ma = Mangroves
H = Heath
D = Disturbed land.

Table 3b: Species of bird recorded during the autumn 2000 surveys.

Species Name	Common Name	Wo	SF	RF	M	S	H	RM	D
Alectura lathami	Australian Brush-turkey			x					
Anas superciliosa	Pacific Black Duck		x						x
Phalacrocorax melanoleucos	Little Pied Cormorant								x
Phalacrocorax sulcirostris	Little Black Cormorant								x
Egretta novaehollandiae	White-faced Heron				x			x	
Ardea alba	Great Egret								x
Ardea ibis	Cattle Egret					x		x	x
Threskiornis molucca	Australian White Ibis		x		x	x			x
Platalea regia	Royal Spoonbill								x
Elanus axillaris	Black-Shouldered Kite		x				x		x
Haliaster sphenurus	Whistling Kite	x	x		x		x		
Haliaster indus	Brahminy Kite		x		x			x	
Haliaeetus leucogaster	White-bellied Sea Eagle				x				
Accipiter fasciatus	Brown Goshawk	x	x				x		x
Falco peregrinus	Peregrine Falcon			x					
Gallirallus philippensis	Buff-banded Rail					x			
Porphyrio porphyrio	Purple Swamphen								x
Gallinula tenebrosa	Dusky Moorhen								x
Fulica atra	Eurasian Coot								x
Elseyornis melanops	Black-fronted Dotterel								x
Vanellus miles	Masked Lapwing								x
Columba leucomela	White-headed Pigeon		x	x					
Macropygia aboinensis	Brown Cuckoo-Dove			x					
Chalcophaps indica	Emerald Dove			x					
Geopelia humeralis	Bar Shouldered Dove		x		x		x	x	x
Cacatua roseicapilla	Galah						x		
Trichoglossus haematodus	Rainbow Lorikeet	x	x	x	x		x	x	x
Trichoglossus chlorolepidotus	Scaly-breasted Lorikeet			x	x		x		
Glossopsitta pusilla	Little Lorikeet		x						
Cacomantis flabelliformis	Fan-tailed Cuckoo		x	x			x		
Centropus phasianinus	Pheasant Coucal							x	
Tyto capensis	Grass Owl					x			
Podargus strigoides	Tawny Frogmouth	x	x						
Aegotheles cristatus	Australian Owlet Nightjar	x	x						
Alcedo azurea	Azure Kingfisher				x			x	
Dacelo novaeguineae	Laughing Kookaburra	x							
Todiramphus macleayi	Forest Kingfisher		x						
Todiramphus sanctus	Sacred Kingfisher		x	x					x
Todiramphus chloris	Collared Kingfisher				x				
Merops ornatus	Rainbow Bee-eater		x		x				x
Pitta versicolor	Noisy Pitta			x					
Cormobates leucophaeus	White-throated Treecreeper	x	x	x					
Malurus cyaneus	Superb Fairy-wren			x			x		x
Malurus lamberti	Varigated Fairy-wren		x		x	x	x		x
Malurus melanocephalus	Red-Backed Fairy-wren		x			x		x	x
Pardalotus punctatus	Spotted Pardalote	x					x		
Pardalotus striatus	Striated Pardalote		x	x					
Sericornis frontalis	White-browed Scrubwren		x	x			x		
Sericornis magnirostris	Large-billed Scrubwren			x					
Gerygone levigaster	Mangrove Gerygone				x				
Acanthiza pusila	Brown Thornbill			x					
Acanthiza nana	Yellow Thornbill							x	
Anthochaera chrysoptera	Little Wattlebird		x					x	
Plectorhyncha lanceolata	Striped Honeyeater		x						
Philemon corniculatus	Noisy Friarbird	x	x				x	x	
Philemon citreogularis	Little Friarbird				x		x		
Entomyzon cyanotis	Blue-faced Honeyeater						x		
Manorina melanocephala	Noisy Miner							x	x
Meliphaga lewinii	Lewins Honeyeater	x	x	x	x		x	x	

Table 3b: cont

Species Name	Common Name	Wo	SF	RF	Ma	S	Heath	RM	D
Lichenostomus chrysops	Yellow-faced Honeyeater	x	x		x		x	x	x
Lichenostomus fasciogularis	Mangrove Honeyeater				x				
Lichmera indistincta	Brown Honeyeater	x	x		x		x	x	x
Philidonyris nigra	White-cheeked Honeyeater	x	x		x		x	x	
Acanthorhynchus tenuirostris	Eastern Spinebill	x	x	x				x	
Myzomela sanguinolenta	Scarlet Honeyeater	x	x		x		x		
Petroica rosea	Rose Robin				x				
Eopsaltria australis	Eastern Yellow Robin		x	x					
Psophodes olivaceus	Eastern Whipbird		x	x	x		x		
Pachycephala pectoralis	Golden Whistler		x	x					
Pachycephala rufiventris	Rufous Whistler	x	x				x	x	x
Colluricincla harmonica	Grey Shrike-thrush	x	x	x	x		x	x	x
Myiagra rubecula	Leaden Flycatcher		x					x	
Grallina cyanoleuca	Magpie-lark								x
Rhipidura fuliginosa	Grey Fantail	x	x	x	x		x	x	x
Rhipidura leucophrys	Willie Wagtail		x		x		x	x	x
Dicrurus bracteatus	Spangled Drongo	x	x	x			x	x	
Coracina novaehollandiae	Black-faced Cuckoo-shrike		x				x		
Lalage leucomela	Varied Triller			x				x	
Sphecotheres viridis	Figbird	x	x	x	x				
Artamus leucorynchus	White-breasted Woodswallow			x					
Cracticus nigrogularis	Pied Butcherbird	x	x					x	
Gymnorhina tibicen	Australian Magpie		x				x	x	x
Strepera grucelena	Pied Currawong	x	x	x			x		
Corvus orru	Torresian Crow	x	x		x		x	x	x
Anthus novaeseelandiae	Richard's Pipit						x		x
Taeniopygia bichenovii	Double-barred Finch		x		x		x	x	
Neochima temporalis	Red-browed Finch						x	x	x
Dicaeum hirundinaceum	Mistletoebird	x	x		x			x	
Hirundo neoxena	Welcome Swallow						x		x
Megalurus timoriensis	Tawny Grassbird					x		x	x
Megalurus gramineus	Little Grassbird								x
Cristicola exilis	Golden-headed Cisticola					x			x
Zosterops lateralis	Silvereye	x	x	x	x		x	x	x
Sturnus vulgaris	Common Starling								x

WO = Woodland
RF = Lowland rainforest
S = Sedgeland
RM = Regrowth swamp forest
SF = Swamp Forest
Ma = Mangroves
H = Heath
D = Disturbed land.

Table 3c: Bird species recorded on the subject site by E. Kleiber of the TBOC during surveys for the Birds Australia Atlas of Australian Birds Project, 1998-Nov 2000.

Common Name	Wetland	Woodland	Rainforest
Australian Brush-turkey			x
Brown Quail	x		
Australian Wood Duck		x	
Pacific Black Duck	x	x	
Chestnut Teal	x		
Darter	x	x	x
Little Pied Cormorant	x	x	
Little Black Cormorant	x		
White-faced Heron	x	x	
Little Egret	x		
Great Egret	x		
Cattle Egret	x	x	
Striated Heron	x	x	x
Australian White Ibis	x	x	x
Straw-necked Ibis			x
Royal Spoonbill	x	x	
Lewins Rail	x		
Osprey	x	x	x
Whistling Kite	x	x	x
Brahminy Kite	x	x	x
White-bellied Sea-Eagle			x
Pacific Baza			x
Nankeen Kestrel			x
Australian Hobby			x
Little Eagle		x	
Bar-tailed Godwit	x		
Whimbrel	x		
Eastern Curlew	x		
Black-winged Stilt	x		x
Pacific Golden Plover	x		
Masked Lapwing	x	x	x
Spotted Turtle Dove	x	x	
Crested Pigeon		x	
Bar Shouldered Dove	x	x	x
Brown Cuckoo-Dove			x
Emerald Dove			x
White-headed Pigeon			x
Rose-Crowned Fruit-Dove			x
Wompoo Fruit-Dove			x
Galah	x	x	
Australian King Parrot		x	
Rainbow Lorikeet	x	x	x
Pale-headed Rosella		x	
Eastern Rosella		x	
Fan-tailed Cuckoo		x	x
Shinning Bronze-Cuckoo		x	x
Pheasant Coucal	x	x	
Common Koel			x
Australian Owlet Nightjar		x	
White-throated Needletail	x		
Azure Kingfisher	x	x	
Laughing Kookaburra	x	x	x
Forest Kingfisher	x	x	x

Table 3c cont.

Common Name	Wetland	Woodland	Rainforest
Sacred Kingfisher	x	x	x
Collared Kingfisher	x		
Rainbow Bee-eater	x	x	x
Dollarbird	x	x	x
White-throated Treecreeper			x
Superb Fairy-wren	x	x	
Varigated Fairy-wren		x	x
Red-Backed Fairy-wren	x	x	
Striated Pardalote	x	x	x
Spotted Pardalote			x
White-browed Scrubwren		x	
Large-billed Scrubwren			x
Mangrove Gerygone	x		
Brown Gerygone			x
White-throated Gerygone		x	
Striated Thornbill			x
Brown Thornbill		x	x
Yellow-rumped Thornbill		x	
Yellow Thornbill		x	
Little Wattlebird		x	x
Noisy Friarbird		x	
Blue-faced Honeyeater	x		
Noisy Miner		x	
Lewins Honeyeater	x	x	x
Yellow-faced Honeyeater	x	x	x
Mangrove Honeyeater	x		
White-throated Honeyeater		x	
Brown Honeyeater	x	x	x
White-cheeked Honeyeater	x	x	x
Scarlet Honeyeater	x	x	x
Eastern Spinebill			x
Rose Robin			x
Eastern Yellow Robin		x	x
Eastern Whipbird		x	x
Golden Whistler		x	x
Rufous Whistler		x	x
Little Shrike-thrush		x	x
Grey Shrike-thrush		x	x
Leaden Flycatcher		x	x
Satin Flycatcher		x	x
Restless Flycatcher		x	
Spectacled Monarch			x
Black-faced Monarch			x
White-eared Monarch			x
Magpie-lark		x	
Grey Fantail	x	x	x
Rufous Fantail			x
Willie Wagtail	x	x	x
Spangled Drongo		x	x
Black-faced Cuckoo-shrike	x	x	x
Cicadabird		x	x
Varied Triller		x	x
Olive-backed Oriole		x	x
Figbird	x	x	x

Table 3c: cont.

Common Name	Wetland	Woodland	Rainforest
White-breasted Woodswallow	x		x
Pied Butcherbird	x	x	x
Grey Butcherbird			x
Australian Magpie	x	x	
Pied Currawong	x	x	x
Torresian Crow	x	x	x
Green Catbird			x
Satin Bowerbird		x	
Regent Bowerbird			x
Richard's Pipit	x		x
Red-browed Finch	x	x	x
Mistletoebird			x
Welcome Swallow	x		x
Fairy Martin	x		x
Tawny Grassbird	x	x	x
Little Grassbird	x	x	
Golden-headed Cisticola	x		x
Clamorous Reed Warbler			x
Silvereye		x	x
Common Starling		x	x

APPENDIX 4

SUMMARY OF HISTORICAL RECORDS

Table 4a: Species recorded previously within a 10km radius of the study area. Airport = monitoring surveys conducted by staff at Coolangatta Airport, Cowley = mangrove bird surveys conducted by Cowley (1994), ABC = records made during the Australian Bird Count Project (Birds Australia), SES = mangrove bird surveys conducted by Sandpiper Ecological Surveys (unpublished), and ATLAS = records included on the *Atlas of NSW Wildlife*. Other surveys refers to additional records obtained from sources listed for Table 16, however not all species listed in Table 16 are included in the following Table. Birds Australia refers to records obtained from the Birds Australia database for surveys conducted at three locations on the subject site between 1998 and Nov 2000.

Bird Species	Airport	Cowley	ABC	SES	ATLAS	Other Survey	Birds Australia
Australian Brush-turkey				x	x		x
Brown Quail			x	x	x		x
Stubble Quail						x	
Brown Quail						x	
Magpie Goose				**x**			
Black Swan				x			
Australian Wood Duck				x	x		x
Feral Duck				x			
Mallard				x	x		
Pacific Black Duck	x			x	x		x
Grey Teal				x	x		
Chestnut Teal					x		x
Hardhead					x		
Wandering Whistling-Duck				x	x		
Whistling Duck sp	x			x			
Australasian Shoveler					x		
Australasian Grebe				x	x		
Darter				x	x		x
Little Pied Cormorant							x
Pied Cormorant				x	x		
Little Black Cormorant	x			x	x		x
Great Cormorant				x	x		
Australian Pelican	x			x	x		
White-faced Heron	x			x	x		x
White-necked Heron	x				x		
Little Egret	x			x	x		x
Eastern Reef Egret				x	x		
Great Egret	x			x	x		x
Intermediate Egret				x	x		
Cattle Egret				x	x		x
Striated Heron				x	x		x
Nankeen Night Heron				x	x		
Black Bittern					**x**		
Bittern sp.	x						
Glossy Ibis						x	
Australian White Ibis	x			x	x		x
Straw necked ibis	x			x	x		x
Royal Spoonbill	x			x	x		x
Black-necked Stork	**x**			**x**	**x**		
Brolga						**x**	
Spotless Crake				x			
Purple Swamphen	x			x	x		
Dusky Moorhen	x			x	x		
Eurasian Coot	x			x	x		
Buff-banded Rail	x				x		
Lewins Rail					x		x

Table 4a: cont.

Bird Species	Airport	Cowley	ABC	SES	ATLAS	Other survey	Birds Australia
Osprey	**x**	**x**	**x**	**x**	**x**		**x**
Brahminy Kite	x	x		x	x		x
Whistling Kite			x	x	x		x
Square-tailed Kite					**x**		
White-bellied Sea-Eagle				x	x		x
Little Eagle				x			x
Wedge-tailed Eagle					x		
Pacific Baza		x		x	x		x
Marsh Harrier				x	x		
Brown Falcon				x			
Brown Goshawk				x	x		
Grey Goshawk	x			x	x		
Australian Hobby	x			x			x
Australian Kestrel	x		x	x	x		x
Black Shouldered Kite	x			x	x		
Collared Sparrowhawk					x		
Bush Hen					**x**		
Latham's Snipe				x	x		
Bar-tailed Godwit				x	x		x
Black-tailed Godwit				**x**	**x**		
Whimbrel				x	x		x
Eastern Curlew				x	x		x
Marsh Sandpiper				x	x		
Common Greenshank				x	x		
Terek Sandpiper				**x**	**x**		
Common Sandpiper				x	x		
Grey-tailed Tattler				x	x		
Wandering Tattler						x	
Ruddy Turnstone				x			
Curlew Sandpiper				x	x		
Red-necked Stint					x		
Sanderling						x	
Sharp-tailed Sandpiper				x	x		
Sandpiper spp	x						
Red Knot					x		
Great Knot					**x**		
Comb-crested Jacana				**x**			
Beach Stone-Curlew				**x**			
Pied Oystercatcher				**x**	**x**		
Sooty Oystercatcher				**x**	**x**		
Black-winged Stilt	x			x			x
Red-necked Avocet				x	x		
Pacific Golden Plover				x			x
Double-banded Plover				x	x		
Red-capped Plover				x	x		
Greater Sand Plover				**x**	**x**		
Lesser Sand Plover					**x**		
Red-kneed Dotteral				x	x		
Black front Dotteral	x			x	x		
Masked lapwing	x			x	x		x
Silver Gull	x			x	x		
Gull-billed Tern				x	x		
Common Tern				x	x		
Caspian Tern				x	x		
Crested Tern				x	x		
Whiskered Tern					x		
White-winged Black-Tern					x		

Table 4a: cont

Bird Species	Airport	Cowley	ABC	SES	ATLAS	Other survey	Birds Australia
Black-naped Tern					x		
Sooty Tern	x						
Little Tern				**x**	**x**		
Common Noddy					x		
Australasian Gannet				x	x		
Bar-shouldered Dove		x	x	x	x		x
Crested Pigeon	x	x	x	x	x		x
Brush Bronzewing					x		
Rock Dove			x	x	x		
Spotted Turtle-Dove	x	x		x	x		x
Laughing Turtle-dove			x				
Rose-crowned Fruit-dove			**x**		**x**		**x**
Superb Fruit-dove						**x**	
Brown Cuckoo-Dove					x		x
Emerald Dove					x		x
Peaceful Dove	x	x		x	x		
White-headed Pigeon					x		x
Wonga Pigeon					x		
Wompoo Fruit-Dove					**x**		**x**
Topknot Pigeon					x		
Sulphur-crested Cockatoo	x		x	x	x		
Yellow-tailed Black-Cockatoo					x		
Galah	x		x	x	x		x
Crimson Rosella					x		
Eastern Rosella		x			x		x
Pale-headed Rosella			x	x	x		x
Cockatiel			x				
Long-billed Corella	x			x	x		
Little Corella					x		
King Parrot					x		x
Little Lorikeet					x		
Musk Lorikeet					x		
Scaly-breasted Lorikeet		x	x	x	x		
Rainbow Lorikeet	x	x	x	x	x		x
Channel-billed Cuckoo			x		x		
Fan-tailed Cuckoo		x		x	x		x
Horsefields Bronze-Cuckoo					x		
Shinning Bronze-Cuckoo						x	x
Brush Cuckoo					x		
Little Bronze-Cuckoo					x		
Pallid Cuckoo					x		
Common Koel				x	x		x
Pheasant Coucal	x			x	x	x	x
Barking Owl					**x**		
Masked Owl					**x**		
Marbled Frogmouth					**x**		
Southern Boobook					x		
Tawny Frogmouth					x		
White-throated Nightjar					x		
Australian Owlet Nightjar					x		x
Fork-tailed Swift			x		x		
White-throated Needletail	x			x	x		x
Dollarbird				x	x	x	x
Collared Kingfisher		**x**	**x**	**x**	**x**		**x**
Forest Kingfisher		x		x	x		x

Table 4a: cont

Bird Species	Airport	Cowley	ABC	SES	ATLAS	Other Survey	Birds Australia
Sacred Kingfisher		x	x	x	x		x
Azure Kingfisher	x	x		x			x
Laughing Kookaburra	x		x	x	x		x
Rainbow Bee-eater	x	x	x	x	x		x
Noisy Pitta					x		
Alberts Lyrebird					**x**		
White-throated Treecreeper					x		x
Superb Fairy-wren		x	x	x	x		x
Variegated Fairy-wren			x	x	x		x
Red-backed Fairy-wren					x		x
Spotted Pardalote			x	x	x		x
Striated Pardalote		x			x		x
White-browed Scrubwren					x		x
Yellow-throated Scrubwren					x		
Large-billed Scrubwren					x		x
Brown Gerygone					x		x
White-throated Gerygone					x		x
Mangrove Gerygone		x		x	x		x
Yellow Thornbill				x			x
Yellow-rumped Thornbill							x
Striated Thornbill					x		x
Buff-rumped Thornbill					x		
Brown Thornbill					x		x
Little Wattlebird					x		x
Little Friarbird		x	x	x			
Noisy Friarbird	x			x	x		x
Blue-faced Honeyeater			x	x	x		x
Noisy Miner		x		x	x		x
Fuscous Honeyeater				x			
Lewin's Honeyeater		x		x	x		x
Scarlet Honeyeater		x		x	x		x
Striped Honeyeater			x	x	x		
Mangrove Honeyeater		**x**		**x**	**x**		**x**
White-cheeked Honeyeater				x	x		x
White-throated Honeyeater					x		
White-eared Honeyeater					x		
White-naped Honeyeater					x		x
Yellow-faced Honeyeater		X		x	x		x
Yellow-tufted Honeyeater					x		
Brown Honeyeater		x	x	x	x		x
Brown-headed Honeyeater			x				
Eastern Spinebill					x		x
Jacky Winter		x					
Scarlet Robin					x		
Rose Robin				x			x
Eastern Yellow Robin					x		x
Pale-yellow Robin					x		
Logrunner					x		
Eastern Whipbird	x	x		x	x		x
Spotted Quail-thrush			x				
Varied Sitella					x		
Rufous Whistler		x	x	x	x		x
Golden Whistler		x		x	x		x
Grey Shrike-thrush		x		x	x		x
Little Shrike-thrush		x					x
Black-faced Monarch					x		x
Spectacled Monarch					x		x

Table 4a: cont

Bird Species	Airport	Cowley	ABC	SES	ATLAS	Other Survey	Birds Australia
White-eared Monarch					**x**		**x**
Leaden Flycatcher				x	x		x
Restless Flycatcher				x			x
Satin Flycatcher					x		x
Shinning Flycatcher				x	x		
Magpie-lark	x	x	x	x	x		x
Grey Fantail		x		x	x		x
Rufous Fantail					x		x
Willy Wagtail	x	x	x	x	x		x
Spangled Drongo	x	x	x	x	x		x
Barred Cuckoo-Shrike					**x**		
Black-faced Cuckoo-shrike	x	x	x	x	x		x
White-bellied Cuckoo-Shrike					x		
Cicadabird			x	x	x		x
Varied Triller		x		x	x		x
White-winged Triller					x		
Olive-backed oriole				x	x		x
Figbird		x	x	x	x		x
White-breasted Woodswallow				x	x		x
Grey Butcherbird			x		x		x
Pied Butcherbird			x	x	x		x
Australian Magpie	x		x	x	x		x
Pied Currawong	x	x	x	x	x		x
Paradise Riflebird					x		
Australian Raven		x					
Torresian Crow	x	x		x	x		x
Green Catbird					x		x
Satin Bowerbird					x		x
Regent Bowerbird							x
Singing Bush-lark			x				
Richards Pipit	x		x	x	x		x
House Sparrow			x	x			
Red-browed Finch					x		x
Chestnut-breasted Mannikin					x		
European Goldfinch			x				
Mistletoebird		x	x	x	x		x
Welcome Swallow	x	x	x	x	x		x
Tree Martin					x		
Fairy Martin	x		x	x	x		x
Tawny Grassbird					x		x
Little Grassbird	x		x				x
Golden-headed Cisticola			x	x	x		x
Clamorous Reed Warbler							x
Silvereye		x	x	x	x		x
Common Starling	x			x			x

APPENDIX 5

SECTION 5a ASSESSMENT

1. BACKGROUND

The NSW *Threatened Species Conservation Act* (1995) has modified the NSW *Environmental Planning and Assessment Act* (1979) by including eight factors that must be considered when assessing the impacts of a particular proposal. The eight factors to be considered are generally referred to as either an *eight-part test* or a *section 5a assessment*. For the purpose of this report the term *section 5a assessment* has been adopted. The objective of the *section 5a assessment* is to determine if a proposal is likely to have a *significant effect* on threatened species, populations or ecological communities, or their habitats (NPWS 1996).

2. DEFINITIONS

2.1 Local population

The *NSW Threatened Species Conservation Act* (1995) defines a local population as "*a population that occurs within the study area, unless the existence of contiguous or proximal occupied habitat and the movement of individuals or exchange of genetic material across the boundary of the study area can be demonstrated*" (NPWS 1996).

A standard definition of a local population is difficult as it varies between species. Highly mobile species such as fruit-doves range over large areas following changes in their food supply. Other species such as the eastern bristlebird (*Dasyornis brachypterus*) have smaller home ranges and tend to be fairly sedentary.

A large number of threatened birds do not require contiguous habitat to move between areas. A number of species occurring within the study area undertake regular migrations between the northern and southern hemispheres (i.e. shorebirds), whilst others undertake regular movements to exploit changes in the availability of food (e.g. fruit-doves). The mobility of birds makes it difficult to define a local population, and draw conclusions regarding the impact of disturbing a small area of habitat on such a population. In general the definition of 'a local population' will vary widely between different groups of birds.

For the purpose of this assessment two definitions have been adopted. The local population of estuarine birds (including migratory shorebirds) is defined as the population of a particular species residing within the lower Tweed River estuary (Figure 1; main report). For terrestrial birds (including mangrove bird communities) the local population has been defined as the population of birds residing within one kilometre of the proposed alignment (between Kennedy Drive and Boyd street). This includes all habitats surrounding Cobaki Broadwater, and all habitats included within the study area for the field survey. This definition is limited by the extent of information regarding habitat use by threatened birds. For example, mangrove habitats are virtually contiguous (or only separated by small channels) around the entire perimeter of the Tweed estuary. It is possible that species such as mangrove honeyeater, and collared kingfisher could readily move between sites, however, the lack of information on the ecology of these species precludes the ability to draw such conclusions.

2.1.1 Viability of the local population

The assessment of impacts using the section 5a assessment relies heavily on the ability to determine if the viability of a local population will be compromised by the proposal in question. A viable local population is defined by the NPWS (1996) as "*a population that has the capacity to live, develop and reproduce under normal conditions*". This definition is most applicable to species that breed within the study area, and it is more difficult to assess impacts on the viability of migratory species, particularly species that breed in the northern hemisphere.

This creates specific problems for the present assessment, which includes a number of migratory species that do not breed within the study area. The assessment of impacts on these species has considered a viable population as that population which resides within the locality. In the present case this means the population of migratory shorebirds that resides in the lower Tweed River estuary. No judgement has been made regarding the impacts of the proposal on the reproductive capabilities of migratory shorebirds.

Drawing conclusions on the effect of removing only part of the habitat available for a local population is difficult without detailed information on the demographics and habitat use of the subject species. With the level of detail available on how birds utilise habitats within the study area it is virtually impossible to determine how much habitat could be affected before the viability of a population would be compromised. The assessment of population viability must be based on a certain amount of good judgement and baseline information on a particular species ecology. Although the long-term viability of some isolated populations could be questioned this is generally not the case with respect to bird populations in the study area. Despite the disturbed and fragmented nature of much of the habitat surrounding the study area this area could not be regarded as isolated from a bird perspective.

2.2 Regional population

The survey region is based on the interim biogeographic regionalisation of Australia (NPWS 1996). The subject site is situated within the *New South Wales North Coast* biogeographic region (Thackway & Cresswell 1995). This region extends from the QLD/NSW Border south to about Port Stephens, and west to the Great Dividing Range.

3. SPECIES CONSIDERED IN THE ASSESSMENT

A number of significant species were recorded during field surveys in the study area, and additional species were identified during the review of historical records (Table 1). The species listed in Table 1 are regarded as significant for a variety of reasons. Some are listed on relevant state and federal threatened species legislation, and others are listed on international migratory bird agreements. A number of additional species that are regarded as being of conservation significance by either the NSW NPWS (1999), or by the author, and which were recorded during the survey have not been listed in Table 1.

Some species of conservation significance may warrant inclusion on the NSW *TSC Act* in the future, or are relatively uncommon within the survey region. Despite the presence of risks to these species they have not been included in this eight part-test as they have no official legislative status. Impacts on species of conservation significance have been discussed in section 7 of the main report. Species of conservation significance recorded during the survey included wandering whistling duck, intermediate egret, Lewins rail, brahminy kite, pacific baza, little shrike-thrush, mangrove gerygone, and shinning flycatcher.

A conservative approach has been adopted in identifying which legislatively protected species require consideration in the section 5a assessment. Such an approach is regarded as essential given the lack of understanding of how birds respond to impacts such as noise disturbance, and the difficulty associated with assessing impacts without considering potential impact amelioration measures. Despite adopting a conservative approach not all species listed in Table 1 warrant consideration in the section 5a assessments. Species listed in the table can be divided into six groups according to the anticipated level of impact.

The six groups include:

1. those species listed on the *TSC Act* that, although recorded in the study area, are not likely to utilise habitats in the vicinity of the proposal, or utilise habitats affected by activities associated with the proposal. Included within this group are magpie goose, comb-crested jacana, sanderling, beach stone-curlew, and sooty oystercatcher.

2. those species listed on either JAMBA or CAMBA that do not utilise habitats likely to be affected by the proposal, or which are common within the study area, the survey region and throughout their range, and which are unlikely to be affected by the proposal. Included within this group are eastern reef egret, cattle egret, glossy ibis, wandering tattler, ruddy turnstone, white-winged black tern, common tern, Caspian tern, white-throated needletail, and rainbow bee-eater.

3. those species listed on JAMBA and CAMBA that are of conservation significance due to considerable impacts on habitat throughout their range, or which occur in only low numbers in the study area, and which utilise habitats that may be affected by the proposal. Included within this group is great egret, and all of the remaining migratory shorebirds, including those species listed on the NSW *TSC Act*.

4. those species listed on the NSW *TSC Act* and/or the Commonwealth *ESP Act* that were recorded in the study area during the present survey. Included within this group are brolga, black bittern, black-necked stork, bush hen, osprey, pied oystercatcher, little tern, collared kingfisher, rose-crowned fruit-dove, superb fruit-dove, little bronze-cuckoo, masked owl, grass owl, and mangrove honeyeater.

5. those species listed on the NSW *TSC Act* or Federal *ESP Act* that were not recorded during the present survey but have been recorded during previous studies, or which have been recorded in the locality, and/or which are known to utilise habitat types similar to those affected by the proposal. Included within this group are Australasian bittern, wompoo fruit-dove, white-eared monarch, barred cuckoo-shrike, red-tailed black-cockatoo, and glossy black-cockatoo.

6. those species listed on the NSW *TSC Act* that are known to utilise habitats similar to those in the study area but which were not detected despite intensive searching, or are unlikely to occur due to extensive range contraction. Included within this group is the double-eyed fig parrot.

The impact of the proposal on species listed in groups 3, 4 and 5 is assessed in the following section. Due to obvious similarities in habitat requirements, and the similar effect of impacts some species have been assessed in groups. Species that have been assessed in groups include the migratory shorebirds, except Latham's snipe, and the fruit-doves. Latham's snipe was not included in the joint assessment on migratory shorebirds due to differences in habitat use, and the fact that it is the only migratory shorebird that will be affected directly through habitat removal.

Table 1: Legislatively protected bird species recorded in the vicinity of the proposed alignment during the present survey and previous surveys. N = no, Y = yes, TS = this survey, PS = previous survey, AS = species recorded during additional surveys in Queensland, TSC = Threatened Species Conservation Act, C = CAMBA, J = JAMBA, ESP = Endangered Species Protection Act, CS = conservation significance, sae = study area estuarine, sat = study area terrestrial, nr = not recorded.

Bird group	Common Name	Species included in assessment	Status	Origin of record in study area	Location of record – this study
Waterfowl	Magpie Goose	N	TSC	TS, PS	sae
	Brolga	Y	TSC	TS	sat
	Black Bittern	Y	TSC	TS	sat
	Australasian Bittern	Y	TSC	nr	nr
	Eastern Reef Egret	N	C	TS, PS	sae
	Great Egret	Y	J, C	TS, PS	sae, sat
	Cattle Egret	N	J, C	TS, PS	sae
	Glossy Ibis	N	C	PS	nr
	Black-necked Stork	Y	TSC	TS, PS	sae
	Bush Hen	Y	TSC	TS	sat
	Comb-crested Jacana	N	TSC	TS, PS	sae
Birds of Prey	Osprey	Y	TSC	TS, PS	sae, sat
	White-bellied Sea-Eagle	Y	CS, C	TS, PS	sae
	Square-tailed Kite	Y	TSC	PS	nr
Migratory Shorebirds	Latham's Snipe	Y	J, C	TS, PS	sae, sat
	Bar-tailed Godwit	Y	J, C	TS, PS	sae
	Black-tailed Godwit	Y	J, C, TSC	PS	nr
	Whimbrel	Y	J, C	TS, PS	sae
	Eastern Curlew	Y	J, C	TS, PS	sae
	Marsh Sandpiper	Y	J, C	PS	sae
	Common Greenshank	Y	J, C	TS, PS	sae
	Terek Sandpiper	Y	J, C, TSC	TS, PS	sae
	Common Sandpiper	Y	J, C	TS, PS	sae
	Grey-tailed Tattler	Y	J, C	TS, PS	sae
	Wandering Tattler	N	J, C	PS	nr
	Ruddy Turnstone	N	J, C	PS	sae
	Red Knot	Y	J, C	PS	nr
	Great Knot	Y	J, C, TSC	PS	nr
	Curlew Sandpiper	Y	J, C	TS, PS	sae
	Sharp-tailed Sandpiper	Y	J, C	TS, PS	sae
	Red-necked Stint	Y	J, C	PS	nr
	Sanderling	N	J, C, TSC	PS	nr
	Pacific Golden Plover	Y	J, C	TS, PS	sae
	Greater Sand Plover	Y	J, C, TSC	PS	nr
	Lesser Sand Plover	Y	J, C, TSC	PS	nr
Resident Shorebirds	Beach Stone-curlew	N	TSC	PS	nr
	Pied Oystercatcher	Y	TSC	TS, PS	sae
	Sooty Oystercatcher	N	TSC	TS, PS	sae
Gulls & Terns	White-winged Black Tern	N	C	PS	nr
	Common Tern	N	J, C	PS	nr
	Caspian Tern	N	J, C	TS, PS	sae
	Little Tern	Y	J, C, TSC, ESP	TS, PS	sae
Terrestrial Birds	Collared Kingfisher	Y	TSC	TS, PS	sat
	Wompoo Fruit-Dove	Y	TSC	nr	nr
	Rose-crowned fruit-dove	Y	TSC	TS, PS	sat
	Superb fruit-dove	Y	TSC	TS	sat
	Double-eyed Fig-Parrot	N	TSC	nr	nr
	Glossy Black-Cockatoo	Y	TSC	nr	nr
	Red-tailed Black-Cockatoo	Y	TSC	nr	nr
	Masked Owl	Y	TSC	TS	sat
	Grass Owl	Y	TSC	TS	sat
	Marbled Frogmouth	N	TSC	nr	nr
	White-throated Needletail	N	J, C	TS, PS	sat
	Rainbow Bee-eater	N	J	TS, PS	sat
	Mangrove Honeyeater	Y	TSC	TS, PS	sat
	White-eared Monarch	Y	TSC	AS	nr
	Barred Cuckoo-Shrike	Y	TSC	PS	nr

The decision to exclude species in groups 1, 2 and 6 was based on personal and published data regarding the distribution, abundance and habitats used by these species. The double-eyed fig parrot (group 6) was excluded after considering the results of targeted surveys for this species in NSW. The NPWS (1999) suggest that if double-eyed fig parrots continue to utilise habitats in northern NSW they would most likely be found in the western parts of the Border Ranges National Park.

4. SECTION 5a ASSESSMENT

4.1 Shorebirds

4.1.1 Migratory shorebirds

Several species of migratory shorebird were recorded in the study area during the present study, whilst a number of additional species have been recorded during previous surveys (Table 1). The following assessment addresses the impacts of the proposal on 18 species listed on both JAMBA and CAMBA, six of which are also listed on the NSW TSC Act (Table 1). Of the six species listed on the TSC Act, only four have been recorded previously in Cobaki Broadwater. These species include black-tailed godwit, terek sandpiper, great knot and lesser sand plover. All of these species are uncommon in the Tweed estuary, and only occasionally utilise habitats within the study area. None of the threatened species could be regarded as having a population within the study area.

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

The primary habitat requirements for migratory shorebirds include roosts where birds congregate at high tide, and feeding grounds where birds forage at low tide (Lane 1987). The current proposal may affect both roosts and feeding grounds in the vicinity of Cobaki Broadwater. Cobaki Broadwater is recognised as one of the most important habitats for migratory shorebirds within the lower Tweed River estuary, although historical data suggests that the number of birds roosting and foraging within the Broadwater has declined over the past decade.

Roosts

Migratory shorebirds have been recorded roosting at 7 sites within Cobaki Broadwater. However, only four of these sites are currently used, and one of these (Cobaki south) is used only during neap high tides. Only two of the roosts currently used by shorebirds (Pony Club & Cobaki Creek) may be affected by the current proposal, which passes within approximately 200m of the Pony Club roost (Connell Wagner 1999). The remaining two sites (Cobaki south & Cobaki fringe) are situated at least 500 m from the alignment and are unlikely to be affected.

Both the Pony Club and Cobaki Creek sites are regarded as important high tide roosts in a local context. During the present study three species and approximately 10% of the migratory shorebird population were recorded roosting at the Pony Club, including 17% of the eastern curlew, 29% of the whimbrel, and 38% of the pacific golden plover populations. This roost is also occasionally used by bar-tailed godwit and common greenshank.

Twenty-three percent of the whimbrel population within the Tweed River estuary were recorded roosting in mangroves in Cobaki Creek during this study. The Cobaki Creek roost is situated in close proximity to the Pony Club, and whimbrels move to the Pony Club if disturbed. Birds roosting at Pony Club and Cobaki Creek forage within Cobaki Broadwater.

Although the use of the Pony Club roost has declined over the past decade the results suggest that the site is still important in a local context. The exact reason for the declining use of roost and feeding grounds in Cobaki Broadwater by shorebirds is undetermined, although it may be due to a combination of factors including, declining roost quality, declining foraging ground quality, and possibly the operation of Coolangatta Airport, and dredging.

The current proposal will not result in the destruction of any shorebird roosts, however, there is the possibility that noise and movement disturbance associated with highway construction and operation, and changes in surface water flow will reduce the suitability of the Pony Club roost. Both the Pony Club and Cobaki Creek are currently affected by noise and movement disturbance associated with aircraft using Coolangatta Airport. Jets taking-off from Coolangatta Airport are often only 100 m above the Pony Club roost, providing strong opportunity for both movement and noise disturbance.

The major difference between disturbance created by aircraft, and that created by a highway is the duration of each disturbance event. The highway is likely to result in prolonged noise, and regular movement at a distance of about 200 m, whilst aircraft disturbance involves short bursts of 'intense' noise and movement. It is assumed that if shorebirds are to be affected by movement disturbance then an aircraft flying over a roost at low altitude may have a greater affect than cars travelling along a road. Studies on the impact of seaplanes and boats on breeding terns identified a significant difference, with planes 17 times more likely to cause disturbance than boats (Hicks *et al.* 1986). Cars have been recorded to have a significant effect on habitat use by meadow birds (Zande *et al.*1980) and geese (Madsen 1985), although there is no evidence that cars affect roosting shorebirds.

In northern NSW there is evidence of shorebirds using roosts in close proximity to major arterial roads. Chickiba Lake in the Richmond River estuary is situated about 60 m from a major arterial road. This site is regarded as one of the most important roosts in the estuary, and in northern NSW (Unpublished data). Shorebirds have continued to utilise the roost since the construction of the road in the mid 1990's.

The impact of disturbance affects, such as noise and movement are difficult to predict, as there are a lack of published data on these issues. Unlike other species of birds assessed in this section shorebirds do not rely on calls during the non-breeding season, and background noise may have less effect on behaviour and habitat use. Shorebirds that currently utilise Cobaki Creek and Pony Club appear to be unaffected by aircraft movement and noise. However, this is not to say that such activities have no affect on roosting shorebirds as it is possible that the operation of Coolangatta Airport has contributed to the declining number of shorebirds roosting in Cobaki Broadwater over the past decade. Despite the potential impact of aircraft it is important to note that both eastern curlew and whimbrel are generally wary of disturbance, and often alight when approached, even at considerable distances. The continued use of Pony Club by both species suggests at least some tolerance to noise and disturbance effects.

Changes in surface water flow, and particularly increased flow may further reduce the quality of the Pony Club. Increased surface flow that causes 'ponding' of water in the vicinity of the roost could lead to increased vegetation growth, and a reduction in the area of habitat available for roosting. The possible impact of increased surface flow may be readily addressed by ensuring that water is drained away from the roost.

Of particular concern with respect to the proposal is the current lack of spring tide roosts within the lower Tweed River estuary. Of the roosts available, only four are suitable for the majority of individuals during spring tides, and the quality of all of these sites for migratory shorebirds is declining. The long-term viability of the Pony Club is also questionable given the proposed extensions to Coolangatta Airport. Figures included by Connell Wagner (1999) show the stage two extensions of the main runway extending over the Pony Club roost.

The level of disturbance and degradation already occurring at high tide roosts in the Tweed estuary means that any further disturbance or habitat loss must be avoided. Although it is possible that birds displaced from the Pony Club could utilise other roosts this would involve regular long-distance flights to and from roost and feeding grounds. These flights would place increased pressure on the energy requirements of the birds, which may inturn affect their ability to migrate, and in the long-term result in fewer birds using the estuary.

Although impacts on high tide roosts in Cobaki Broadwater are indirect, and possibly minor, poor state of roosts within the estuary means that any activity that affects the suitability of a roost is of concern. The lack of alternative sites means that a reduction in the suitability of one site may have a significant effect on the entire estuary. Although it is impossible to conclude that the current proposal will have a significant effect on high tide roost used by migratory shorebirds there is cause for concern, and it is recommended that options be explored to minimise impacts on shorebird roosts in Cobaki Broadwater.

Feeding grounds

There are at least four intertidal feeding grounds within Cobaki Broadwater. Three of these sites are situated more than 500 m from the proposed alignment, and are unlikely to be affected by the proposal. However, one site 'Pony Club' is situated in the northeastern corner of Cobaki Broadwater, less than 100 m from the proposed alignment. The Pony Club foraging area consists of an extensive mangrove fringe along the edge of Cobaki Broadwater, and three sandflats situated near the entrance to Cobaki Creek. The total area of intertidal habitat at Pony Club is approximately 3.5 ha. Pony Club is used by a small number of migratory shorebirds, including at least two eastern curlews, which appear to maintain feeding territories at the site. Of the 10 intertidal habitats sampled during the present study the smallest number of individuals was recorded at Pony Club.

The current proposal will not remove any intertidal foraging habitat for migratory shorebirds. Impacts may stem from disturbance effects caused by highway construction and operation, and possibly pollution and erosion of fringing intertidal habitat through runoff from the highway. Impacts associated with disturbance effects are likely to be minimal. Even if migratory shorebirds abandoned the Pony Club feeding area, this would not affect the viability of the local population. In any case foraging observations conducted during the present survey indicated that shorebirds were not affected by jet aircraft taking-off from, and landing at Coolangatta Airport. During observations some individuals stopped foraging to look at aircraft, but resumed foraging after a short period. Anglers stopping to pump bait at the Pony Club sandflat caused greater disturbance to birds than jet aircraft using Coolangatta Airport.

The apparent tolerance of foraging shorebirds to the movement and noise created by aircraft reduces the likelihood that noise and movement disturbance associated with the proposed highway would affect migratory shorebirds foraging at Pony Club or at any other site within Cobaki Broadwater. The thick belt of mangroves and swamp oak that fringe Cobaki Broadwater will reduce the impact of movement disturbance.

Impacts on migratory shorebirds from increased surface runoff also seem unlikely. Water draining from habitats to the northeast of Cobaki Broadwater currently flows through a number of small channels directly into the Broadwater, or flows into swamp forest before draining slowly into the Broadwater. Under normal circumstances runoff into Cobaki Broadwater is unlikely to flow directly over intertidal habitats. Small drainage lines already cut through mudflats fringing the Broadwater. Although increased surface flows may lead to minor erosion that is unlikely to affect shorebirds.

Of greater cause for concern is the potential for contaminated water to enter Cobaki Broadwater from accidents on the highway, or through the exposure of acid sulphate soils, or contaminated landfill. The impact of contamination will ultimately depend on the type and amount of material that enters the Broadwater, and the tidal stage at the time of entry. In an extreme case contamination could affect invertebrate communities at Pony Club, and possibly within the entire Broadwater causing a reduction in prey availability, and as a consequence affecting the ability of migratory shorebirds to maintain daily energy intake rates. It would be unlikely that such an event could occur unnoticed, and without the implementation of appropriate mitigation measures that would minimise impacts within Cobaki Broadwater.

Despite the obvious cause for concern regarding contamination the opportunity for such an event to occur is already present. Major arterial roads and the Pacific Highway cross or run adjacent to the lower Tweed estuary in a number of places. The opportunity for hazardous chemicals to enter the estuary and affect migratory shorebirds is already an issue of concern.

Summary

The above assessment does not provide conclusive evidence that the proposal will have a significant effect on the viability of the local migratory shorebird population. This conclusion is based on the following:

- The apparent tolerance of migratory shorebirds roosting at Pony Club and Cobaki Creek to the noise and movement caused by jet aircraft using Coolangatta Airport;

- The limited impacts anticipated from noise and movement disturbance, and the difficulty associated with concluding that these impacts will exceed those already caused by the operation of Coolangatta Airport;

- The limited value of foraging habitat in the vicinity of the proposed carriageway in a local context, and the limited likelihood of impacts on this habitat; and

- The ability to mitigate against the effects of increased surface runoff and contamination by channelling flows away from sensitive habitat, and installing water quality control devices in drainage channels.

Despite the above four points a cautious approach to assessing impacts is recommended. The current status of shorebird roosts in the study area demands that caution be exercised, and that opportunities for creating additional roosting habitat be considered.

b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

The migratory shorebird population within the lower Tweed River estuary is not listed on Schedule 1 of the TSC Act as an endangered population.

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

Roosting and foraging habitat for migratory shorebirds occurs in each of the major estuaries in the study region (Smith 1991). An extensive area of known roosting and foraging habitat used by species recorded in the present study also occurs in Moreton Bay just north of the study area (Driscoll 1998; Thompson 1993). The amount of roosting habitat available in northern NSW estuaries is often limited, and the habitat available is often affected by development, vegetation encroachment, or human disturbance (pers obs). Roosting habitat in most estuaries is regarded as adequate, although there is generally not a surplus of habitat available.

Due to the limited extent of spring tide roosts the removal or modification of a site such as the Pony Club would be regarded as significant in a regional context. However, it seems unlikely that the current proposal will remove or modify the Pony Club or Cobaki Creek roosts, therefore a significant area of habitat will not be affected.

Foraging habitat is widespread within the survey region. The current proposal will not remove or modify a significant area of known foraging habitat for migratory shorebirds.

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

The current proposal will not isolate habitat used by migratory shorebirds.

e) whether critical habitat will be effected.

No critical habitat occurs within the study area.

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

High tide roosts and foraging areas used by migratory shorebirds are not adequately represented in regional conservation reserves.

g) whether the action proposed is of a class of action that is recognised as a threatening process.

The impact of acid flows on shorebirds has not been documented, however, given the known effects of acid on aquatic ecosystems it is considered likely that a risk of acid flows could be regarded as a threatening process. Contamination from spills of toxic substances is not likely to be considered as a threatening process due to the rarity of events, although the scientific community would condemn such spills of toxic substances. The current proposal is not listed on schedule 3 of the *TSC Act* as a key threatening process.

h) whether any threatened species or ecological community is at the limit of its known distribution.

None of the migratory shorebirds addressed in this assessment occur at the limit of their known distribution, although there are only scattered records of terek sandpipers south of the study area (Higgins & Davies 1996).

4.1.2 Latham's snipe

During the field survey Latham's snipe were recorded at four sites, with a maximum count of three individuals recorded in long grass at the Tugun sewage treatment works.

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

Latham's snipe utilise a range of different habitat types, although birds most often roost in rank grass or sedges situated in close proximity to shallow freshwater wetlands (Smith 1991; Marchant & Higgins 1996). In the study area the species was recorded roosting in long grass near the margins of shallow drains adjacent to the main airport runway, in long grass adjacent to drains near the Tugun sewage treatment works, along the edge of ponds at the Tweed Heads west sewage treatment works, and in saltmarsh at Duroby Marsh. It is likely that Latham's snipe also forage in the vicinity of these sites.

The population of Latham's snipe in northern NSW and southern Queensland is considered to consist primarily of individuals on passage during north and south migration (Smith 1991). However, the results of the present study suggest that a small number of birds may remain within the locality during summer. The sporadic nature of records obtained by the QWSG, and from bird monitoring at Coolangatta Airport suggests that birds may be mobile, utilising a range of sites. This type of behaviour appears typical of the species. The habitats used by Latham's snipe in the vicinity of the proposed highway are not considered as optimal, and are quite limited in their extent. These habitats are unlikely to support large populations during migration or during the summer period.

The sporadic nature of records, and the time over which records were made during the present study makes it impossible to predict the size of the Latham's snipe population within the study area. It is also virtually impossible to predict how many snipe would utilise habitat affected by the project. The mobile behaviour of this species means that the numbers of individuals at a site could fluctuate from day to day.

January 2000 was the first occasion that Latham's snipe were recorded at Coolangatta airport during the monthly bird-monitoring program conducted at the airport (P. Shaw pers comm.). The presence of birds during the January survey was attributed to the presence of longer grass, which was being trailed as a means of reducing the quality of bird habitat (P. Shaw pers comm.). Under normal management conditions grass levels within the airport would be unsuitable for snipe. The suitability of habitat in the vicinity of the STW may also vary depending on the maintenance of grass levels.

The current proposal will remove a small area of foraging and roosting habitat for Latham's snipe in the vicinity of the Tugun STW. Isolation of habitat in Coolangatta airport is not considered likely as this habitat is generally unsuitable for the subject species. The impact of habitat removal on the local Latham's snipe population is considered as minimal. The proposal will affect only a small area of known habitat. Similar habitat is widespread within the locality. It is likely that individuals displaced from near the alignment could readily find alternative habitat. The current proposal is unlikely to affect the viability of the local Latham's snipe population.

b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

The Latham's snipe population within the lower Tweed River estuary is not listed on Schedule 1 of the NSW *TSC* Act as an endangered population.

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

Habitat affected by the proposal consists of rank grass subject to periodic inundation, situated adjacent to freshwater drains and ponds associated with a sewage treatment works. Habitat similar to that affected by the proposal is widespread within the survey region, and the proposal will not modify or remove a significant area of known habitat.

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

If habitat within Coolangatta Airport was retained in a similar state to that present during the field survey then the proposal would isolate a small area of habitat used by Latham's snipe. However, it is likely that habitat within the airport would be slashed, and a shorter grass level retained. The proposal is not likely to isolate potential habitat for Latham's snipe.

e) whether critical habitat will be effected.

No critical habitat occurs within the study area.

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

Suitable habitat for Latham's snipe is known to occur in regional conservation reserves, although it is unlikely that the area of habitat reserved is adequate in a regional context.

g) whether the action proposed is of a class of action that is recognised as a threatening process.

Schedule 3 of the TSC Act lists six key threatening processes. The current proposal is not regarded as a key threatening process, and is not likely to promote a key threatening process. Although the scientific community would regard habitat removal as a threatening process, the are of is habitat affected by the current proposal is unlikely to be viewed as a threatening process.

h) whether any threatened species or ecological community is at the limit of its known distribution.

Latham's snipe occur throughout eastern Australia, although only small numbers of individuals occur in northern NSW and southern Queensland (Higgins & Davies 1996).

4.1.3 Pied Oystercatcher

No individuals were recorded in the study area during the present survey, although individuals have been recorded previously using Cobaki Creek. The pied oystercatcher population within the lower Tweed River estuary is generally comprised of about seven adults (Sandpiper Ecological Surveys 2000). The population of 10 birds recorded during the present study included seven adults and three fledglings.

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

Pied oystercatchers utilise a variety of different habitat types, including estuarine sand and mudflats and ocean beaches (Higgins and Davies 1996). In northern NSW the majority of the population utilises ocean beaches (Owner 1997). Pied oystercatchers within the study area display a very regimented pattern of habitat use. Pairs of birds often occur at Birds Bay (in Terranora Broadwater), Boyd's Island (in Terranora Creek), and at either Tony's Bar, Kerosene Inlet or South Head Beach (Sandpiper Ecological Surveys 1997-2000).

Pied oystercatchers have been recorded at a number of sites throughout the estuary, although they have been recorded at only one site in Cobaki Broadwater during the quarterly estuarine bird-monitoring surveys (Sandpiper Ecological Surveys between 1997 and 2000). This record was of a single bird roosting on rocks at the entrance to a small canal estate in Cobaki Creek. No individuals have been recorded using the Pony Club roost.

Monitoring data obtained from the QWSG for the period 1994 and 2000 included four records of pied oystercatcher in Cobaki Broadwater, with five birds recorded in January 1995, two birds recorded in May 1997, two birds in June 1997 and two birds in November 1998 (QWSG unpublished). The limited number of records obtained over the monitoring period of seven years indicates that pied oystercatchers only occasionally utilise habitat within Cobaki Broadwater.

Although birds have most often been recorded roosting in Cobaki Broadwater it is likely that the species also forages in this area. Pied oystercatchers generally prefer sandy substrates upon which to forage and birds are most likely to forage at Pony Club or in Cobaki Creek as opposed to foraging on muddy habitat at either Cobaki south or Cobaki north. Impacts on pied oystercatchers foraging at Pony Club are likely to be similar to those discussed for migratory shorebirds.

Based on the results of long-term monitoring it is unlikely that the proposal will affect the viability of the local pied oystercatcher population. This conclusion is based on the following:

- The limited use of roosts and feeding areas in close proximity to the proposed alignment;
- The absence of records of birds roosting at Pony Club; and
- The limited impact of the proposal on potential pied oystercatcher foraging habitat at Pony Club.

b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

The pied oystercatcher population within the lower Tweed River estuary is not listed on Schedule 1 of the *TSC* Act.

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

Potential habitat for pied oystercatchers is widespread within the study region, particularly along ocean beaches between Ballina and Iluka (Owner 1997). Although potential pied oystercatcher habitat does occur in Cobaki Broadwater the extent of this habitat is regarded as minimal in a regional context. Even in a local context habitat within Cobaki Broadwater is used less intensively than habitat in other areas of the Tweed River estuary.

The current proposal will not modify or remove a significant area of known habitat used by the pied oystercatcher. Impacts on potential pied oystercatcher foraging habitat at Pony Club are regarded as minimal, and the species has not been recorded roosting at the Pony Club.

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

The current proposal will not isolate potential habitat for the pied oystercatcher.

e) whether critical habitat will be effected.

No critical habitat occurs within the study area.

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

Potential habitat for the pied oystercatcher is not well represented in regional conservation reserves. The majority of the population utilises ocean beach or estuarine habitats that occur outside conservation reserves.

g) whether the action proposed is of a class of action that is recognised as a threatening process.

Schedule 3 of the TSC Act lists six key threatening processes. The current proposal is not regarded as a key threatening process, and is not likely to promote a key threatening process, with respect to the pied oystercatcher.

h) whether any threatened species or ecological community is at the limit of its known distribution.

The pied oystercatcher does not reach the limits of its known distribution in the study area (Higgins & Davies 1996).

4.1.4 Little Tern

No little terns were recorded in the study area during the field survey, although they are regularly recorded in the lower Tweed River estuary, and have been recorded previously from Cobaki Broadwater. Two little terns were recorded foraging in Cobaki Broadwater in February 1999 (Sandpiper Ecological Surveys 1999c).

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

The study area does not include potential roosting habitat for little terns, which generally prefer to roost on sandy substrates on ocean beaches or sand spits (Higgins & Davies 1996). Cobaki Broadwater does provide foraging habitat, although this habitat is used on only an occasional basis, with only one recorded from quarterly monitoring surveys conducted between 1997 and 2000.

The little tern population within the lower Tweed River estuary consists mainly of birds stopping during migration, with only a small number of individuals residing in the area over the summer months (Shortlands Wetlands Centre 2000). Both migrating and resident birds concentrate their activity in preferred habitat in the Tweed River (i.e. Tony's Bar or Kerosene Inlet), or along the adjacent ocean beaches.

Habitat within the study area is of limited direct value to little terns. Impacts on Cobaki Broadwater from increased runoff or pollution are unlikely to affect the viability of the local little tern population.

b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

The little tern population within the lower Tweed River estuary is not listed on Schedule 1 of the *TSC* Act as an endangered population.

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

The proposal will not modify or remove a significant area of known habitat for little terns.

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

The proposal will not isolate little tern habitat.

e) whether critical habitat will be effected.

No critical habitat occurs within the study area.

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

Suitable habitat for little terns does occur in a small number of conservation reserves in the survey region, including, Yuraygir National Park and Bongil Bongil National Park.

g) whether the action proposed is of a class of action that is recognised as a threatening process.

Schedule 3 of the TSC Act lists six key threatening processes. The current proposal is not regarded as a key threatening process, and is not likely to promote a key threatening process. Given the limited chance of impact it is unlikely that the scientific community would regard the proposal as a threatening process.

h) whether any threatened species or ecological community is at the limit of its known distribution.

The little tern does not reach the limits of its known distribution in the study area (Higgins & Davies 1996).

4.2 Waterbirds

4.2.1 Brolga

During the field survey one brolga was recorded soaring above the study area, to the southwest of Coolangatta airport. No individuals were recorded using habitats within the study area, and the species has not been recorded previously from within the lower Tweed River estuary.

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

Brolga's are relatively uncommon in coastal northeastern NSW, although the species has been recorded in low numbers at a wide range of sites. In northern NSW brolga's are most often recorded from shallow freshwater marshes, although the species has also been recorded in low wet heath, saltmarsh, and flooded grassland (Marchant & Higgins 1994; pers obs).

The behaviour of the brolga recorded during the present survey indicated that the bird was searching for suitable habitat. Suitable habitat for brolga's does occur in the vicinity of the study area, with a large area of potential habitat situated to the south west of Cobaki Broadwater. Small areas of potential habitat exist within the study area, with the largest area of habitat occurring to the south of the main runway. This site is not regarded as good quality habitat due to the absence of permanent water, and the limited availability of food. Although it is possible that brolga's utilise habitat at the southern end of the runway this seems unlikely as no individuals were recorded during the present study, or during previous monitoring surveys conducted in the vicinity of the Pony Club.

The extent and quality of habitat present on the subject site is not sufficient to be regarded as significant in a local context. It is highly unlikely that the habitat affected by this proposal will have any affect on a viable local population of brolga.

b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No population of brolga has been listed on Schedule 1 of the *TSC* Act as an endangered population.

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

There is no known brolga habitat in the study area, and the extent and quality of potential habitat is not regarded as significant in a regional context. Potential and known habitat for brolga's is widely distributed within the survey region.

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

The proposal will not isolate known habitat for brolga's.

e) whether critical habitat will be effected.

No critical habitat occurs within the study area.

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

Known habitat for brolga's does occur within regional conservation reserves. The species has been recorded previously from both Broadwater and Bundjalung National Parks, however, it is unlikely that adequate habitat for brolga's is adequately represented in conservation reserves within the survey region.

g) whether the action proposed is of a class of action that is recognised as a threatening process.

The removal of habitat could be regarded as a threatening process, however, the low quality of habitat affected means that in this instance, habitat removal is unlikely to be regarded as a threatening process. The proposal will not enhance any threatening processes listed on schedule 3 of the *TSC* Act.

h) whether any threatened species or ecological community is at the limit of its known distribution.

The study area is not situated at the limit of the known distribution of the brolga (Marchant & Higgins 1993).

4.2.2 Black bittern

The presence of black bittern in the study area remains unconfirmed, with an unconfirmed response recorded to playback from swamp forest near the northwestern edge of the study area. There is also an unconfirmed record of a single black bittern calling from this area (B. O'Donald pers comm.). More detailed sampling of this area in December 2000 failed to detect the species or record the presence of good quality habitat. One historical record (in 1967) of black bittern exists from near Ukerabagh Island (Atlas of NSW Wildlife). The presence of potential habitat, historical records and an unconfirmed record from the present study warrants the inclusion of black bittern in the eight-part test.

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

In northern NSW black bitterns are most often recorded in riparian habitats along fresh or brackish streams, although the species is also known to utilise drains, permanently inundated swamp forest, and freshwater wetlands (pers obs). A variety of habitats suitable for black bittern occur within the study area, including mangrove fringed drains, and seasonally inundated swamp forest with a permanent creek. The habitats present in the study area are not regarded as optimal, but could be used on an occasional or seasonal basis. A thorough inspection of swamp forest habitat recorded small areas of potential habitat for black bitterns, although in general the habitat was considered to be unsuitable, with only limited foraging area available. Additional playback near the Boyd Street intersection also failed to detect the species.

The bypass will have a direct effect on potential black bittern habitat (i.e. tidal drains) in the southeastern corner of the study area. Some of this habitat will be removed, whilst the remaining habitat will become fragmented, and isolated. Despite the impact on potential habitat it is considered unlikely to have a significant effect on a local population. Potential bittern habitat in the southeastern corner of the study area has been surveyed on several occasions, during both summer and autumn, and no evidence of black bittern has been obtained. The results of surveys suggest that if bitterns use this habitat it is likely to be on only an occasional basis.

Of greater concern are impacts on black bittern habitat to the west of the study area, in the vicinity of the Boyd Street interchange where two unconfirmed records have been obtained. The proposed C4 alignment is situated approximately 200 m to the north of this habitat, and despite the absence of direct impacts, such as habitat removal and fragmentation the proposal may alter the hydrology of the site and possibly cause sediment deposition, both of which could reduce the quality of habitat. Despite the presence of unconfirmed records habitat does not appear ideal for black bitterns as it appears to lack open areas that are used by the birds for foraging.

In addition to the loss and fragmentation of potential habitat in the southeastern corner of the study area, and possible hydrological and sedimentation concerns, disturbance effects could also affect black bittern. Black bittern are often regarded as a shy species that may be sensitive to disturbance, however, individuals have been recorded previously in habitat immediately adjacent to the Pacific Highway at Coombabah Creek (Rohweder & Banks 1996), and within 200m of the Gateway Arterial Road in southern Queensland (B. Lane pers comm.). At Coombabah Creek a pair of birds were recorded repeatedly with 40m of the highway over a five-day period. The presence of birds at this site suggests at least some tolerance to noise and movement disturbance associated with a major highway.

The current proposal will not remove known or ‘high quality’ potential habitat for black bitterns and the available evidence suggests that birds will tolerate noise disturbance associated with highways. There is however, the risk of impacts associated with changes in the hydrology of the creek draining swamp forest habitat along the western side of the study area, and the risk of sediment deposition in this creek. Although habitat in this area is not considered optimal the presence of two unconfirmed records cannot be ignored. If uncontrolled, sedimentation and changes in hydrology could reduce the quality of black bittern habitat, possibly to the detriment of the local population. However, impacts on black bittern can be readily remediated through the maintenance of existing hydrological regimes, and through the application of strict sediment control procedures. For the purpose of this assessment it is concluded that the project could affect the local black bittern population, however, impacts will be reduced if appropriate mitigation measures are followed.

b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No population of black bittern has been listed on schedule 1 of the *TSC* Act as an endangered population.

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

The proposal will not remove known black bittern habitat, however, changes to the existing hydrological regime and sediment deposition could cause modification to swamp forest habitat used by black bitterns. Despite the potential impacts associated with the proposal the total area of habitat that could be modified is not regarded as significant in a regional context. Known habitat for black bitterns is reasonably widespread within the survey region.

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

The proposal will not isolate known black bittern habitat, however, sub-optimal habitat along drains in the southeastern corner of the study area will become fragmented. Based on the results of the field survey, which included targeted searches, it seems unlikely that black bittern use this habitat.

e) whether critical habitat will be effected.

No critical habitat occurs within the study area.

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

It is unlikely that suitable habitat for black bittern is adequately represented in conservation reserves. In northern NSW most records of black bittern occur along freshwater streams in the middle reaches of larger creeks and rivers. In most cases conservation reserves are situated in the upper or lower reaches of creeks and rivers.

g) whether the action proposed is of a class of action that is recognised as a threatening process.

The removal of habitat could be regarded as a threatening process, however, the quality of black bittern habitat affected by the proposal means that in this instance habitat removal is unlikely to be regarded as a threatening process. The proposal will not enhance any threatening process listed on schedule 3 of the *TSC* Act.

h) whether any threatened species or ecological community is at the limit of its known distribution.

The study area is not situated near the limit of the known distribution of black bittern (Marchant & Higgins 1990).

4.2.3 Australasian Bittern

No records of Australasian bittern were made during the survey despite intensive sampling in potential habitat. There are no historical records of Australasian bittern from within the study area. Despite the absence of confirmed records, Australasian bittern has been included in this assessment due to the presence of potential habitat, and the difficulty associated with detecting this species even when present at a site.

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

In the case of Australasian bittern it is unlikely that the study area provides habitat that is essential for a local population. It is possible however, that habitat within the study area is used on an occasional basis. Potential Australasian bittern habitat in the study area is limited to a large area of sedgeland at the southern end of the main airport runway. Sedgeland includes dense stands of *Phragmites australis*, adjoining more open saltmarsh with isolated clumps of *Juncus* spp. Australasian bittern have been recorded previously using this type of habitat (Marchant & Higgins 1990; pers obs).

Records of Australasian bittern in northern NSW are scarce, and the species may make regular movements between habitats. The information available on the breeding dispersion of Australasian bittern suggests breeding densities of one pair/40-50 ha of habitat (Marchant & Higgins 1990). Given these densities it seems highly unlikely that habitat within the study area could support a breeding pair.

Potential Australasian bittern habitat will be affected by the proposal. A large proportion of the *Phragmites* habitat will be removed, and the adjacent saltmarsh will be subject to intense noise disturbance, and changes in drainage. It is unlikely that the remaining habitat would be suitable for Australasian bitterns after the construction of the highway. Changes in the water table during construction and particularly the lowering of the watertable during tunnel construction may have a significant effect on habitat. Structure.

Despite the magnitude of impacts on potential habitat it is impossible to conclude that the proposal will affect the viability of the local Australasian bittern population. This conclusion is based on the fact that the habitat available in the study area is not of sufficient size to support a viable population, the habitat is situated at the northern limit of the species distribution, and the fact that if used this habitat may only be used on a very occasional basis.

b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No population of Australasian bittern has been listed on Schedule 1 of the *TSC* Act as an endangered population.

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

Based on the available evidence it seems unlikely that the proposal will modify or remove a significant area of known habitat. The proposal will have a substantial effect on the small area of potential Australasian bittern habitat that occurs in the study area, however, this is not known habitat.

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

The proposal will not isolate interconnecting or proximate areas of habitat for Australasian bittern. The proposal will remove the eastern edge of the potential habitat, leaving (but possibly modifying) habitat on the western side of the highway. It is unlikely that bittern habitat occurs to the north or east of the proposed alignment.

e) whether critical habitat will be effected.

No critical habitat occurs within the study area.

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

It is unlikely that habitat for Australasian bittern is adequately represented in regional conservation reserves, although the limited number of records available for this species makes any assessment difficult. It is likely that suitable habitat occurs within coastal conservation reserves, including Broadwater, Bundjalung and Yuraygir National Parks.

g) whether the action proposed is of a class of action that is recognised as a threatening process.

The removal of Australasian bittern habitat could be regarded as a threatening process, however, the quality of habitat affected by the current proposal means that in this instance habitat removal is unlikely to be regarded as a threatening process. The proposal will not enhance any threatening processes listed on schedule 3 of the *TSC* Act.

h) whether any threatened species or ecological community is at the limit of its known distribution.

The study area is situated at the northeastern limit of the known distribution of Australasian bittern (Marchant & Higgins 1990).

4.2.4 Great Egret

Great egret is not listed on the NSW TSC Act, but it is listed on both JAMBA and CAMBA, and has therefore been considered in this assessment. Great egrets were recorded throughout the study area, in both estuarine and terrestrial habitats.

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

Throughout their range great egrets utilise a variety of different habitat types (Recher & Holmes 1982; Marchant & Higgins 1990). In the study area the species was most frequently recorded foraging on intertidal habitats within Cobaki Broadwater, foraging on moist grassland, or sedgeland, or foraging within the large drain along the eastern edge of the study area. Great egrets have been recorded from Cobaki Broadwater in all seasons and it is assumed that they are resident within the study area. The species is not known to breed within the study area, although breeding pairs have been recorded at the Murwillumbah egret colony, which is situated approximately 40 km southwest of the study area (Baxter 1994).

The Tugun bypass will affect known great egret habitat, however, the area of habitat affected is small, even in a local context. Part of the known foraging habitat at the southern end of the main airport runway, will be removed, whilst the remainder may be modified through acid sulphate runoff and/or the lowering of the water table. Foraging habitat along the main drain will be affected by construction of the rail line. Individual great egrets were recorded foraging at both these sites during the survey. The affected sites do not represent critical foraging habitat, with the majority of the local population foraging on intertidal habitat throughout the lower Tweed River estuary. The major foraging areas in Cobaki Broadwater will not be directly affected by the project. Impacts on great egrets foraging in Cobaki Broadwater will be similar to those discussed for migratory shorebirds. One or two great egrets are often recorded foraging on intertidal habitats at the Pony Club.

The impact of the proposal on great egret habitat will not affect the viability of the local great egret population. This conclusion is based on the small area of habitat affected, and the limited number of individuals that utilise this habitat. In general great egrets are regarded as relatively common both locally and regionally. The maximum population within the lower Tweed River estuary has been estimated at 38 in February 2000 (Sandpiper Ecological Surveys 2000d).

b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No population of great egret has been listed on Schedule 1 of the TSC Act as an endangered population.

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

The proposal will not modify or remove a significant area of known habitat from within the survey region. Potential foraging habitat for great egret is widespread within the lower Tweed River estuary, and throughout most estuaries and freshwater wetlands in the survey region.

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

The proposal will partially isolate foraging habitats that occur within Coolangatta Airport from habitat in Cobaki Broadwater. It is likely that a small number of great egrets may occasionally move between the airport and Cobaki Broadwater depending on the tidal stage. Once the highway is completed these birds will need to negotiate both highway and air traffic. The isolating effect of the highway on a large bird is difficult to predict, although it is likely that egrets will readily fly over the highway with limited chance of collision with vehicles. From an air safety perspective it may be preferable if the proposal reduced the opportunity for egrets to move between the airport and Broadwater.

e) whether critical habitat will be effected.

No critical habitat occurs within the study area.

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

Known foraging habitat for great egret is represented within regional conservation reserves, including the Tweed Estuary, Brunswick Heads, Ballina, and Richmond River Nature Reserves, and Bundjalung, Broadwater, and Yuraygir National Parks.

g) whether the action proposed is of a class of action that is recognised as a threatening process.

The removal of known foraging habitat would be regarded by the scientific community as a threatening process, however, the small area of habitat affected, even in a local context, reduces the significance of habitat removal. In the present case habitat removal is not likely to be considered as a threatening process. The proposal will not enhance any threatening process listed on schedule 3 of the *TSC* Act.

h) whether any threatened species or ecological community is at the limit of its known distribution.

The study area is not situated at the known limits of the distribution of great egrets (Marchant & Higgins 1990).

4.2.5 Black-necked Stork

One black-necked stork was recorded in Terranora Broadwater during the field survey, and there are previous records of this species from within Coolangatta Airport, and in littoral habitats to the west of Cobaki Broadwater. Black-necked storks have not been recorded from Cobaki Broadwater during monitoring surveys conducted by Sandpiper Ecological Surveys.

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

The results of the present study, and historical evidence indicate that the study area does not provide habitat for a population of black-necked stork. Although potential stork habitat does occur in the study area there is no evidence to show that this habitat is used. The low population density of black-necked storks in northern NSW means that it is possible to have potential habitat that is not utilised. A pair of black-necked storks was previously known to reside within the lower Tweed River estuary, however, there are reports to suggest that both birds may have died during the mid 1990's. During monitoring surveys in the late 1990's storks have been recorded on only an occasional basis (Sandpiper Ecological Surveys 1997-2000).

Black-necked storks most often forage around the margins of wetlands or wade within water searching for fish, eels, frogs and crustaceans. Terrestrial habitats within the study area are not regarded as suitable for foraging or breeding. Freshwater wetlands in the study area are not regarded as suitable due to the presence of dense littoral vegetation. Flooded pasture may provide foraging habitat on a very occasional basis. Known foraging habitat does occur within Coolangatta Airport, and potential foraging habitat does occur within Cobaki Broadwater. A known nest site is situated near Tallebudgera Creek to the north of the study area (S. Phillips pers comm.).

The sedgeland situated at the southern end of the main airport runway is regarded as potential roosting habitat, which storks could use during high tides. Despite this possibility the species has not been recorded in this area during previous surveys (e.g. monitoring surveys by Sandpiper Ecological Surveys, Martindale 1987; Lawler 1994; or the QWSG). Known foraging habitat within Coolangatta Airport will not be affected by this proposal.

Potential foraging habitat within Cobaki Broadwater will not be directly affected, although this habitat may be affected by noise disturbance and contamination. Noise disturbance in Cobaki Broadwater is not considered of a sufficient magnitude to affect black-necked storks, which have not actually been recorded in this area. Water contamination from acid flows or a toxic spill would reduce the suitability of potential foraging habitat in the vicinity of the Pony Club. Given the low population density and extent of potential foraging habitat such an effect is not regarded as significant with respect to black-necked storks. Black-necked storks have been recorded foraging previously within Coolangatta Airport, within 100 m of the main runway (pers obs). The use of this habitat suggests at least some tolerance to noise disturbance.

The lack of confirmed sightings within habitat affected by the proposal, and the sub-optimal quality of terrestrial habitats in the study area reduces the likelihood of impacts on black-necked storks. It is unlikely that the proposed Tugun bypass would have a significant effect on the viability of the local black-necked stork population. In assessing the potential impact of the proposal consideration has been given to the current proposal to enhance wetland habitat on the western side of Cobaki Broadwater. It is likely that this habitat enhancement will benefit the local population of storks, which are known to use this site.

b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No population of black-necked stork has been listed on Schedule 1 of the *TSC* Act as an endangered population.

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

The current proposal will not modify or remove a significant area of known habitat for black-necked storks in a regional context. The habitat directly affected by the proposal is not regarded as suitable for storks, and impacts on adjacent (potential) habitats are not regarded as of sufficient magnitude to conclude that a significant effect will occur.

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

The highway will partially isolate foraging habitat in Coolangatta Airport from habitat within Cobaki Broadwater, although it is undetermined if storks continue to utilise habitat within the airport. In addition it is likely that a large bird such as a stork will be readily capable of flying well above the highway. Black-necked storks are not a species that is generally considered as being susceptible to roadstrike. From an air safety perspective it may be preferable if storks were deterred from using habitat within Coolangatta Airport.

e) whether critical habitat will be effected.

No critical habitat occurs within the study area.

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

Known habitat for black-necked storks does occur within conservation reserves in the study region, however, it is unlikely that suitable habitat is adequately represented.

g) whether the action proposed is of a class of action that is recognised as a threatening process.

The action proposed is not recognised as a threatening process in relation to black-necked storks. The proposal will not enhance any threatening process listed on schedule 3 of the *TSC* Act.

h) whether any threatened species or ecological community is at the limit of its known distribution.

The study area is not situated at the known limit of the distribution of black-necked stork (Marchant & Higgins 1990).

4.2.6 Bush Hen

At least three bush hens were recorded during the summer survey. All individuals were recorded in swamp forest habitat along the western edge of the study area. Additional surveys in autumn failed to detect any bush hens at this site.

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

Bush hens generally prefer areas of dense vegetation situated adjacent to permanent freshwater wetlands (Pringle 1985; Marchant & Higgins 1993). The site where the species was recorded during the summer survey differs from this description in that it was a seasonal freshwater wetland. During autumn surveys the wetland was virtually dry, and no birds were recorded. The failure to record birds during autumn may be due simply to a seasonal change in calling behaviour as opposed to the absence of birds at the site (Pringle 1985).

Suitable habitat for bush hens is widespread within the western section of the study area, although birds were recorded at only two (proximal) sites, despite survey effort over a broader area. Apart from a small dam on the eastern edge of the study area much of the habitat in the southern and eastern sides is not considered suitable for this species, as it lacks areas of standing water with dense fringing vegetation. The permanent dam may be used on an occasional basis, although no evidence of bush hens was obtained from this site during the survey. This site is also fairly isolated and exposed.

The proposal will not directly affect known bush hen habitat, although known habitat will be subject to increased levels of noise disturbance, and to changes in surface water flows and contamination. The highway will pass within approximately 300 m of known habitat, and within approximately 200 m of potential habitat. The exact impact of noise disturbance on bush hens is difficult to determine.

Bush hens are generally regarded as a secretive species that prefers sheltered/quite habitats, yet there are records from habitat adjacent to major arterial roads, and the species has been recorded from suburban areas around Brisbane (Marchant & Higgins 19943; pers obs). The habitats known to be used by bush hens in the study area are not subject to intensive aircraft noise, and the highway will most likely increase noise levels above current levels.

Bush hen habitat will be affected by changes in surface water flows. Water draining from the highway may increase the frequency and duration of wetland inundation, possibly leading to changes in size, and the vegetation structure of wetlands. During the construction phase of the project bush hen habitat may be affected by a decrease in water levels associated with a draw down of the water table during construction of the tunnel. Bush hen habitat will also be subject to potential contamination from sediment and toxic substances, which may reduce the overall suitability of habitat through changes in water depth and vegetation.

Given the potential risk to a known population of bush hens it is concluded that the proposal may affect the viability of the local population. The suitability of potential and known habitat may be reduced through noise disturbance, whilst the structure and function of wetlands may be affected by changes to the water table or through contamination.

b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No population of bush hen has been listed on Schedule 1 of the *TSC* Act as an endangered population.

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

The bush hen has a restricted distribution in NSW, with regular records recorded only as far south as Evans Head, and as far west as Woodenbong (Muranyi & Baverstock 1996). Despite its restricted distribution bush hen habitat appears to be widespread within the Tweed, and Brunswick River catchments, and northern sections of the Richmond River catchment. The extent of habitat affected in the study area is not regarded as significant in a regional context.

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

The proposal will isolate potential bush hen habitat around the small dam on the eastern edge of the study area from known and potential habitat on the western side of the proposed alignment. If bush hens do utilise the small dam then it is possible that birds moving between sites would face the risk of road strike. Bush hens are considered to be possibly nomadic moving in response to rain (Marchant & Higgins 1993), and they are therefore likely to be capable of flying over the highway to move between sites. Notwithstanding their flight capabilities, the crepuscular and nocturnal behaviour of bush hens means that most movements will occur around dusk or during the night. This may place birds at greater risk of being dazzled by lights of vehicles using the highway. Overall the risk of habitat isolation is regarded as low.

e) whether critical habitat will be effected.

No critical habitat occurs within the study area.

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

Suitable habitat for bush hens does occur within conservation reserves in the survey region, however, it is unlikely that habitat is adequately represented.

g) whether the action proposed is of a class of action that is recognised as a threatening process.

The major impacts on bush hens stem from noise disturbance, changes in surface water flows, and wetland contamination. Given the lack of quantitative evidence regarding the impact of noise disturbance it is impossible to conclude that the action proposed is a threatening process, however, changes in the hydrology, and an increased risk of contamination of wetlands used by threatened species may be regarded as a threatening process. The proposal will not enhance any threatening process listed on schedule 3 of the *TSC* Act.

h) whether any threatened species or ecological community is at the limit of its known distribution.

The study area is not situated at the limit of the known distribution of bush hen (Marchant & Higgins 1993).

4.3 Birds of prey

4.3.1 Osprey

A pair of ospreys was recorded regularly within the study area during both the summer and autumn surveys. Birds were regularly observed foraging within Cobaki Broadwater, or roosting in tall dead stags along the northern fringe of the Broadwater. On two occasions (1 in summer, and 1 in autumn) birds were recorded flying over terrestrial habitat in the study area. Ospreys have been recorded from Cobaki Broadwater over an extended period (Atlas of NSW Wildlife). A long-term nest site is located on the south side of Cobaki Broadwater, with another nest site along Cobaki Creek to the west of the Broadwater (E. Kleiber pers comm.).

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

The study area represents known foraging and roosting habitat for a pair of ospreys that nest in a large stag on the southern side of Cobaki Broadwater. This pair of birds resides within the Broadwater, with at least one individual recorded during each of the seasonal monitoring surveys conducted by Sandpiper Ecological Surveys between 1997 and 2000. The occasional observation of birds flying over terrestrial habitat most likely represents an individual in transit between foraging areas within the Broadwater, or possibly individuals searching for nesting material.

The proposal will not remove any known or potential foraging, roosting or nesting habitat for ospreys, although there will be indirect effects on habitat within Cobaki Broadwater. Potential impacts on ospreys will stem from an increase in noise levels, and possible pollution of foraging habitat. Impacts associated with noise disturbance are not considered significant. In the Tweed estuary ospreys nest and forage in close proximity to major arterial roads. Current nest sites are situated adjacent to Kennedy Drive, and Tweed Street. The proposal may remove a small source of potential nesting material, however, extensive areas of nesting material will remain unaffected around the fringe of Cobaki Broadwater.

The greatest potential for impacts on ospreys may stem from pollution of foraging habitat in Cobaki Broadwater. Impacts could stem from chemical pollution that reduces food supply, or sedimentation that increases turbidity and reduces the ability of birds to detect and capture fish (NPWS 1999). Sedimentation may be a particular problem during the construction phase of the project.

In assessing the impacts of these factors it must be considered that runoff from the existing highway already enters Cobaki Broadwater. Given the size of Cobaki Broadwater it is likely that any chemical spill would need to be of a large magnitude to have a significant effect on the availability of fish, which form the major part of the diet of ospreys. Contamination of food supplies may also have a flow-on effect on ospreys, which are known to be effected by chemical contamination (Olsen 95). Water contamination, whether it is from acid sulphate runoff, or toxic chemical spills could reduce fish numbers in the vicinity of the Pony Club sandflat, and in a severe (uncontrolled) case within Cobaki Broadwater.

Increased water turbidity associated with sediment runoff can have a substantial effect on the foraging efficiency of ospreys. Severe flood events that reduce water clarity for prolonged periods can reduce the ability of birds to forage, and possibly to fledge young.

It is likely that sediment runoff associated with construction would be most severe in the southeastern corner of the Broadwater in the vicinity of the Pony Club mudflat. This area appears to be an important low-tide foraging area for ospreys. It is possible that during low tide, turbidity levels in the remaining area of Cobaki Broadwater are too high to enable efficient foraging, so birds concentrate there foraging efforts in the downstream sections of the Broadwater. Increased sedimentation of this area could affect the ability of ospreys to gather food. This could have significant repercussions if sedimentation occurs during the breeding season, during incubation, or prior to chicks fledging.

Despite the potential impact of increased sedimentation and water contamination it is likely that impacts would be restricted to the pair of ospreys that reside in Cobaki Broadwater. Birds further downstream are unlikely to be affected. A chemical spill or acidification would have to be extremely severe to affect more pairs of ospreys. The limiting of impacts to only one pair of ospreys negates the likelihood that the proposal will have a significant effect on the viability of the local osprey population. There are at least six pairs of ospreys in the lower Tweed River estuary with additional pairs further upstream.

b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No population of osprey has been listed on Schedule 1 of the *TSC* Act as an endangered population.

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

The proposal will not modify or remove a significant area of known habitat for the osprey in a regional context. Osprey habitat occurs within most (if not all) of the coastal estuaries within the survey region.

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

The proposal will not isolate known habitat for ospreys.

e) whether critical habitat will be effected.

No critical habitat occurs within the study area.

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

Ospreys and their habitat are not adequately represented in regional conservation reserves. Estuarine conservation reserves will be required to ensure the adequate reservation of osprey habitat.

g) whether the action proposed is of a class of action that is recognised as a threatening process.

Pollution of estuarine habitats known to be used by threatened species, by acid runoff, is likely to be considered as a threatening process. The proposal will not enhance any threatening process listed on schedule 3 of the *TSC* Act.

h) whether any threatened species or ecological community is at the limit of its known distribution.

The study area is not situated at the limits of the known distribution of ospreys (Marchant & Higgins 1993).

4.3.2 Square-tailed Kite

Square-tailed kites were not recorded in the study area during this survey, and there are no historical records of this species from within the study area. There are however, records of square-tailed kites from the western side of Cobaki Broadwater, where a pair of birds has been recorded.

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

Square-tailed kites are most often recorded from open forest, woodland and heath, and the most important habitat feature appears to be an abundant supply of passerines upon which they forage (Olsen 1995; Debus 1998; NPWS 1999). Habitat within the study area is suitable for square-tailed kites. The high abundance of passerines, particularly during autumn, and the presence of suitable habitat in the form of woodland with nearby heath satisfies the primary habitat requirements for this species (Marchant & Higgins 1993).

The occurrence of a pair of square-tailed kites immediately to the west of the study area, and the extensive home range that this species uses means that it is possible that birds could utilise habitats within the study area for foraging and possibly for roosting and nesting. Breeding pairs of square-tailed kites may have territorial ranges estimated at many 10's of square kilometres (NPWS 1999).

Raptor nests located in swamp forest within the study area were assessed in relation to square-tailed kite. The conclusion was that these nests were in general too small to belong to this species. The absence of confirmed records of square-tailed kites from the study area, or in transit between the study area and the western side of Cobaki Broadwater, does not preclude the possible occurrence of this species.

Square-tailed kites can be readily confused with other more common birds of prey, such as whistling kites (Debus 1998), which occur throughout the study area. It is also possible that individuals may gain access to the study area by following woodland vegetation around the northern edge of Cobaki Broadwater. This could explain why birds have not been recorded flying across Cobaki Broadwater during estuarine bird monitoring surveys. The large home range of square-tailed kites may also mean that they only occasionally visit the study area. The potential impact of disturbance already present within the study area (e.g. air traffic) is undetermined, although this could deter birds. If used it is likely that the study area would occur on the edge of a kites range, with habitat further east of the study area unsuitable.

The proposal will remove potential foraging habitat for square-tailed kites in the form of heath and adjacent swamp forest. There will also be increased disturbance effects in woodland habitat along the western side of the study area. The impact of habitat removal is difficult to determine. If viewed in isolation it could be argued that the area of habitat affected is minor in relation to the size of a home range. However, the current removal of potential foraging habitat to the west of Cobaki Broadwater must be considered when assessing the impacts of this proposal.

It is possible that disturbance already present within the study area may deter birds from using the site. If this is the case then the extension of disturbance effects associated with this proposal may reduce the suitability of woodland habitat to the west of the study area. Square-tailed kites have recently been recorded nesting in close proximity to the Pacific Highway in NSW indicating that the species may tolerate at least some noise and movement disturbance.

The open nature of habitats surrounding the airport may reduce the ability of kites to access heathland and swamp forest in the southeastern corner of the site, and it is possible that birds may only utilise the western side of the study area. This area will not be directly affected, although it will suffer increased noise disturbance the impact of which is probably minimal.

The failure to detect square-tailed kites within the study area during the 14 day survey conducted for this assessment indicates that the species may only be a very occasional visitor to the site. Given the limited use of the site, it is impossible to conclude that the project will have a significant effect on the viability of the local square-tailed kite population.

b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No population of square-tailed kites have been listed on Schedule 1 of the TSC Act as an endangered population.

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

The proposal will not modify or remove a significant area of known habitat for square-tailed kites within the survey region. Square-tailed kites occur in low densities throughout the region, and potential habitat is widespread.

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

The proposal is not likely to isolate habitat for square-tailed kites. Although small areas of suitable habitat will be retained in the south-eastern corner of the site these patches of habitat will most likely be too small for foraging or nesting.

e) whether critical habitat will be effected.

No critical habitat occurs within the study area.

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

Potential square-tailed kite habitat is likely to be adequately represented in regional conservation reserves, however it is unlikely that an adequate population is present within these reserves. This conclusion is based simply on the low population density, and sporadic nature of records for this species. Square-tailed kites have been recorded from Bundjalung National Park, in northern NSW.

g) whether the action proposed is of a class of action that is recognised as a threatening process.

The removal of potential habitat is regarded as a threatening process. The proposal will not enhance any threatening process listed on schedule 3 of the TSC Act.

h) whether any threatened species or ecological community is at the limit of its known distribution.

The study area is not situated at the limits of the known distribution for square-tailed kites (Marchant & Higgins 1993).

4.3.3 White-bellied Sea-Eagle

A pair of adult white-bellied sea-eagles was recorded in the study area during the summer estuarine bird surveys. Individual sea-eagles were also recorded roosting along the northern fringe of Cobaki Broadwater. A pair of birds has also been recorded nesting to the southwest of Cobaki Broadwater (B. McDonald pers comm.).

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

The white-bellied sea-eagle is fairly widespread in NSW. Although most common along the coast, sea-eagles are regularly recorded along major creeks and rivers, or large freshwater swamps, and range a considerable distance inland (Marchant & Higgins 1993; Debus 1998). Unlike ospreys, sea-eagles have a more cosmopolitan diet, and often forage over terrestrial habitats.

In the study area a pair of sea-eagles are often recorded in Cobaki Broadwater. This pair of birds has been reported nesting in forested habitat on the southern side of Cobaki Broadwater approximately 1-1.5km from the proposed alignment. Fledglings have also been recorded in the Broadwater, although none were recorded during this study. The major impacts on sea-eagles in NSW seem to be the loss of potential nest sites through habitat removal (Marchant & Higgins 1993).

The current proposal will not remove known nesting or important foraging habitat for white-bellied sea-eagles. Although birds may occasional search terrestrial habitats in the study area for potential prey the area is not regarded as primary habitat. The area of habitat affected by this proposal is not considered to be significant in a local context. As has been discussed for other species the proposal could affect the quality of foraging habitat in the vicinity of the Pony Club sandflat, however, this is unlikely. White-bellied sea-eagles have not been recorded foraging in this area, although the may do so on an occasional basis. Air traffic in the vicinity of the Pony Club may already suppress activity by sea-eagles in this area. The proposal will not reduce the availability of nest material for this species. Considerable nest material resources will be retained in the vicinity of the Broadwater.

Given the limited extent of impacts associated with the proposal, the extensive home range of the subject species, the distance between a known nest site and the proposed highway, and the limited use of habitats affected it is concluded that the project will not affect the viability of the local white-bellied sea-eagle population.

b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

The white-bellied sea-eagle population within the lower Tweed River estuary is not listed on Schedule 1 of the *TSC* Act as an endangered population.

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

The proposal will not modify or remove a significant area of habitat used by white-bellied sea-eagle in a regional context.

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

The proposal will not isolate habitat used by white-bellied sea-eagles.

e) whether critical habitat will be effected.

No critical habitat occurs within the study area.

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

White-bellied sea-eagle habitat does occur in regional conservation reserves, however given the home range used by this species, and its preference for estuarine habitats it is unlikely that populations are adequately represented.

g) whether the action proposed is of a class of action that is recognised as a threatening process.

Schedule 3 of the TSC Act lists six key threatening processes. The current proposal is not regarded as a key threatening process, and is not likely to promote a key threatening process. Given the limited chance of impact it is unlikely that the scientific community would regard impacts on white-bellied sea-eagles as threatening processes.

h) whether any threatened species or ecological community is at the limit of its known distribution.

White-bellied sea-eagles do not reach the limit of their known distribution in the study area (Marchant & Higgins 1993).

4.4 Terrestrial birds

4.4.1 Collared kingfisher

Collared kingfishers reside within the mangrove habitats in Cobaki Broadwater. Individuals were recorded on several occasions during the present survey, with birds often recorded within mangroves along the northern fringe of the Broadwater. Eight calling individuals were recorded along the northern fringe during an early morning canoe traverse, and densities of up to 3.5 birds/hectare were recorded during mangrove bird surveys.

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

In Australia, collared kingfishers are essentially confined to mangrove forests, and immediately adjacent habitats (Schodde & Tideman 1990; Higgins 1999). During low tides individuals are often recorded foraging on exposed mudflats (pers obs). In the study area collared kingfishers were recorded only along the mangrove fringe, and in the ecotone between mangroves and swamp forest. Ecotone habitat consisted of a mix of *Casuarina glauca*, *Melaleuca quinqunervia* and mangroves. Potential nest sites in the form of arboreal termitaria with access holes were recorded from within the mangrove fringe. Collared kingfishers have been recorded breeding within mangrove habitats in Cobaki Broadwater, and the species has been recorded from the Broadwater in all seasons (pers obs).

The current proposal will not remove any habitat that is known to be used by collared kingfishers. The proposal will however, increase noise disturbance in mangrove habitat situated in the north-eastern corner of Cobaki Broadwater. Habitats within this area may also be susceptible to pollution associated with runoff from the new highway. The proposed carriageway will traverse within 75 m of mangrove habitat used by collared kingfishers.

The impact of noise disturbance on collared kingfishers that forage and nest along the northern fringe of Cobaki Broadwater is difficult to assess. One of the most obvious effects of noise is that it will reduce the distance at which calls can be detected. This may inturn affect the ability of birds to communicate with mates, advertise territories, and remain in contact with fledglings. Mangrove habitats in the vicinity of the Pony Club already suffer noise disturbance from aircraft using Coolangatta Airport. Despite the presence of aircraft noise birds continue to utilise these habitats.

Collared kingfishers have also been recorded on several occasions in mangroves within 100m of the Bruce Highway, the Hornibrook Highway, and the Gateway Arterial Road in southern Queensland suggesting some tolerance to noise disturbance (B. Lane pers comm.). Individuals have not been recorded nesting at these sites, but specific searches for nest sites have not been conducted.

It is possible that the infrequent nature of existing (aircraft) noise disturbance may provide birds with ample opportunity to communicate with mates. This ability may be reduced with the continual noise disturbance associated with vehicle use. One benefit for collared kingfishers is that they have a loud penetrating call that may be heard above background noise levels. Highway noise and bird calls are likely to occur at different frequencies. Although calls of individual collared kingfishers may be heard above highway noise the distance over which this call will be detected may be reduced due to the 'drowning' effect of low frequency highway noise. This may have implications for mate contact and territorial defence. Unfortunately there is no information available to assess the potential impact of noise disturbance on this species, or any other species of bird. Impacts associated with runoff from the highway, and particularly water contamination could have an indirect affect on collared kingfishers through a reduction in food availability.

Despite the potential detrimental impact associated with noise disturbance, and water contamination it is impossible to conclude that these impacts would have a significant effect on the viability of the local collared kingfisher population. Collared kingfishers occur throughout Cobaki Broadwater, and detrimental effects, should they occur, will affect only a small proportion of the local population. Under a worst case scenario only kingfishers using habitat in the vicinity of the Pony Club sandflat will be affected.

Noise impacts on collared kingfishers will be reduced by the presence of the tunnel. A further reduction in noise could be achieved by constructing earth walls on the southern side of approaches to the tunnel.

b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No population of collared kingfisher has been listed on Schedule 1 of the TSC Act as an endangered population.

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

Habitat for collared kingfishers is limited within the survey region, with most of the habitat restricted to the lower Tweed River estuary. Despite the restricted extent of habitat the magnitude and type of impacts associated with this proposal make it difficult to conclude that a significant area of habitat will be modified or removed. Under a worst case scenario the proposal would affect only a small percentage of habitat known to be used by collared kingfishers.

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

The proposal will not isolate potential habitat for the collared kingfisher.

e) whether critical habitat will be effected.

No critical habitat occurs within the study area.

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

Known habitat for collared kingfishers is well represented within the Tweed Estuary and Ukerabagh Nature Reserves. Given the natural limits of their distribution it seems likely that habitat for collared kingfishers is adequately represented in conservation reserves in the survey region. A large proportion of habitat within the Tweed estuary occurs within the above two nature reserves.

g) whether the action proposed is of a class of action that is recognised as a threatening process.

The limited quantitative evidence regarding the impact of noise disturbance means that it is unlikely to be considered by the scientific community as being a threatening process. Contamination of estuarine habitat used by threatened species would most likely be considered as a threatening process, however, the magnitude of impacts associated with the proposal reduces the overall effect. The proposal will not enhance any threatening processes listed on schedule 3 of the TSC Act.

h) whether any threatened species or ecological community is at the limit of its known distribution.

The study area is situated at the southern limit of the known distribution of collared kingfisher (Higgins 1999).

4.4.2 Fruit-Doves

This section addresses potential impacts on rose-crowned, superb, and wompoo fruit-doves. All three species of threatened fruit-dove have been recorded on the subject site, although the record of the superb fruit-dove requires confirmation. Several rose-crowned fruit-doves were recorded in lowland rainforest, and a pair of birds was recorded on the edge of regrowth swamp forest, and swamp forest in the southeastern corner of the study area. Rose-crowned fruit-doves were also recorded in rainforest habitat on the southern side of Cobaki Broadwater, and at Duroby Creek. Wompoo fruit-doves were not recorded on the subject site during this survey but they have been recorded in lowland rainforest during surveys by Edward Kleiber as part of the *Birds Australia* atlas project.

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

Suitable habitat does exist within the study area for all three species of threatened fruit-dove (Recher *et al.* 1995). Despite the presence of suitable habitat the extent of use is likely to vary between species. Rose-crowned fruit-doves tend to be more of a habitat generalist than either of the other two species, and are more likely to utilise swamp forest habitat. Habitats within the study area most likely represent a seasonal foraging resource for all three species of fruit-dove. Fruiting trees within the study area, including bangalow palm (*Archontophoenix cunninghamiana*), blue quondong (*Eleocarpus grandis*), camphour laurel (*Cinnamomum camphora*), and *Ficus* spp., are all recognised food sources for threatened fruit-doves (Recher *et al.* 1995; Higgins & Davies 1996).

In addition to the use of rainforest, all three species have been recorded using other habitat types, including mangroves and eucalypt forests, and rose-crowned fruit-doves are often recorded from habitat dominated by *Melaleuca* (Higgins & Davies 1996). This information conforms to the observation made during the present study of rose-crowned fruit-doves foraging in cheese tree (*Glochidion ferdinandi*) in regrowth swamp forest.

The available evidence indicates that all three species utilise lowland rainforest habitat, and adjacent swamp forest habitat within the study area for foraging. It seems less likely that birds would nest within the study area, although evidence in the literature suggests that this is possible for both rose-crowned and wompoo fruit-doves (Recher *et al.* 1995; Higgins & Davies 1996; NPWS 1999).

The current proposal would remove, and fragment known foraging habitat for rose-crowned fruit-doves in the south-eastern corner of the study area. Habitat remaining in this area will become fragmented through the construction of the road and rail lines, this may increase the risk of road strike if birds attempt to access these habitats after completion of the project. Both superb and wompoo fruit-doves could face similar impacts although impacts on these species is considered less likely.

Additional impacts on fruit-doves may occur through an increase in noise disturbance. The proposed alignment will be positioned approximately 175 m from lowland rainforest, which is regarded as the optimal habitat for fruit-doves in the study area. Although a negative response to noise disturbance is possible there is evidence to suggest that this may not occur. All three species have been recorded foraging in urban areas (Higgins & Davies 1996), and during the present study rose-crowned fruit-doves were recorded foraging within approximately 100 m of the existing highway.

In assessing the impacts of habitat removal and fragmentation, and a possible detrimental effect of noise disturbance the overall value of affected habitat within the locality must be considered. Additional foraging (and nesting) habitat does occur immediately adjacent to the study area, along the southern edge of Cobaki Broadwater, and rose-crowned fruit-doves were recorded from this area during the summer survey. A small area of additional habitat also occurs on the southern end of Terranora Broadwater. Despite the presence of these patches of vegetation suitable habitat for fruit-doves in limited within the locality, and the habitat within the study area is of considerable conservation significance. NPWS (1999) and Date *et al.* (1996) emphasise the importance of low elevation rainforest for the fruit-doves, and suggest that the removal of low-elevation forest is one of the major threats facing these species.

The reliance of fruit-doves on an abundant supply of edible fleshy fruits means that they often require access to a number of sites at any one time. A reduction in the suitability of habitat within the study area could reduce the ability of birds to successfully exploit habitat in other parts of the Tweed estuary. Although a detrimental effect could occur if the habitat affected contained a large number of fruiting trees this is not the case. The habitat directly affected by the proposal, although known to be used by rose-crowned fruit-doves, is not regarded as essential foraging habitat. Essential foraging habitat in the study area includes lowland rainforest, which will not be affected by the proposal. The small area of swamp forest habitat directly affected by the proposal is most likely used on only an occasional basis.

Given the quality of habitat affected by the proposal, the fact that important lowland rainforest habitat will not be affected, and the tolerance of rose-crowned fruit-doves to noise disturbance it is considered unlikely that the proposal will have a significant effect on the viability of the local fruit-dove population.

b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No population of superb, rose-crowned, or wompoo fruit-doves have been listed on Schedule 1 of the TSC Act as an endangered population.

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

The proposal will not modify or remove a significant area of known habitat for any of the threatened fruit-doves in a regional context.

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

The proposal will isolate small patches of known foraging habitat in the south-eastern corner of the study area. Fragmented habitat will continue to provide foraging resources for fruit-doves, although birds attempting to access the site will suffer an increased risk of mortality from collisions with vehicles.

e) whether critical habitat will be effected.

No critical habitat occurs within the study area.

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

Habitat for fruit-doves is widespread within conservation reserves in the survey region. Based on the figure provided by Recher *et al.* (1995) it seems likely that this representation is adequate. Rainforest and riparian habitat within state forests is also excluded from logging activities.

g) whether the action proposed is of a class of action that is recognised as a threatening process.

The removal and fragmentation of known foraging habitat for a threatened species is likely to be considered by the scientific community as a threatening process. The proposal will not enhance any threatening processes listed on schedule 3 of the TSC Act.

h) whether any threatened species or ecological community is at the limit of its known distribution.

The study area is not situated at the limits of the known distribution for rose-crowned, wompoo, or superb fruit-doves (Higgins & Davies 1996).

4.4.3 Masked Owl

Unconfirmed records of masked owl were obtained from survey sites situated on the western side of the study area. There are historical records of masked owl to the southwest of the study area.

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

The available data indicates that masked owls may utilise the study area. There are confirmed historical records from habitats adjacent to the study area, and the study area includes suitable habitat. Masked owls are known to utilise a broad range of habitats, although they are most often recorded in open forest and woodland with a sparse understorey and adjacent open areas (Hollands 1991; Debus & Rose 1994).

Essential habitat features include the presence of suitable roosting and nesting hollows (Higgins 1999), and an abundant supply of ground-dwelling or scansorial mammals (Kavanagh 1996). Masked owls are known to forage and roost within previously disturbed habitat (Hollands 1991; Kavanagh 1996). Most foraging occurs within open forest or along roads and tracks. The frequency of road kills indicates that birds often forage along roadsides or use roads to move between foraging sites (Debus & Rose 1994). Road-killed birds have been recorded adjacent to the Pacific Highway in NSW (ERM 1999).

The study area includes potential roosting and nesting hollows and suitable foraging habitat. The majority of suitable hollows occur in woodland along the western edge of the study area, with occasional suitable-sized hollows in swamp forest habitat. The extent to which masked owls utilise the study area is difficult to predict. Although no birds were actually recorded within the study area suitable foraging habitat occurs throughout the site. The apparent absence of birds may be due more to the difficulty associated with detecting this species rather than being indicative of unsuitable habitat (Kavanagh 1996). The extensive areas of edge habitat present within the study area, and a high abundance of ground-dwelling mammals provide ideal foraging habitat for masked owls.

Habitats directly affected by the proposed bypass most likely represent a small area of foraging habitat on the edge of a home range. It is considered unlikely that masked owls would utilise urban areas to the east of the study area. Habitat removed during highway construction is unlikely to directly affect masked owls, however, it is possible that birds will be subject to increased risk of road strike if they attempt to forage along the edge of the highway, or attempt to cross the highway to access foraging habitat in small forest fragments. Masked owls occupy large home ranges (NPWS 1999), and it is possible that the study area forms the eastern edge of a home range.

The available evidence does suggest that the habitat affected by the proposal is unlikely to be used on a regular basis by masked owls, however, it seems likely that owls would at some stage forage within the study area. Birds foraging within the study area will suffer increased risk of mortality associated with road strike. The mortality of one individual from a breeding pair is enough to conclude that the proposal will have a significant effect on the viability of the local masked owl population. In drawing this conclusion consideration has been given to the current removal of potential masked owl habitat to the west of Cobaki Broadwater.

b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No population of masked owl has been listed on Schedule 1 of the TSC Act as an endangered population.

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

Masked owls occur throughout the survey region, and suitable habitat is widespread within this area. The current proposal will not modify or remove a significant area of known habitat in a regional context.

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

The proposal will not isolate known habitat, however, potential foraging habitat in the south-eastern corner of the study area will become isolated from habitat to the west of the proposed alignment.

e) whether critical habitat will be effected.

No critical habitat occurs within the study area.

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

Suitable habitat for masked owls is well represented in conservation reserves throughout the survey region, however given the apparent rarity of this species and its large home range it seems unlikely that populations are adequately represented in regional conservation reserves. Masked owls have been recorded previously from Border Ranges National Park, Bundjalung National Park in north-eastern NSW, and several reserves throughout the Clarence Basin.

g) whether the action proposed is of a class of action that is recognised as a threatening process.

The removal and fragmentation of known foraging habitat for a threatened species is likely to be considered by the scientific community as a threatening process. The proposal will not enhance any threatening processes listed on schedule 3 of the TSC Act.

h) whether any threatened species or ecological community is at the limit of its known distribution.

The study area is not situated at the limits of the known distribution for masked owls (Higgins 1999).

4.4.4 Grass Owl

One grass owl was recorded during the field survey. This individual responded to playback conducted in sedgeland at the southern end of the main airport runway. The bird was initially recorded approaching the playback site from heathland habitat to the east. After a brief period circling over the playback site the bird moved away from the site in an easterly direction.

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

In northern NSW grass owls utilise a number of different habitat types (Maciejewski 1996). Birds are often recorded from low wet heath or sedgeland in coastal conservation reserves, or in agricultural land, particularly cane fields (Maciejewski 1996; Higgins 1999). Birds have also been recorded using sites with dense tall blady grass (*Imperata cylindrica*; Hollands 1991). During the day birds roost on the ground in areas of dense vegetation, often with a moist ground layer. At night individuals forage over heathlands or along the edges of heaths or agricultural land (Higgins 1999). In the vicinity of Ballina in northern NSW birds are often recorded as road kills along the edge of the Pacific Highway, suggesting that they may utilise the road verge for foraging (Maciejewski 1996; pers obs).

The grass owl population in northern NSW and southern Queensland is considered to consist of resident birds. The marked increase in records obtained during late autumn and winter is thought to be indicative of juvenile dispersal as opposed to seasonal movements (Maciejewski 1996). It is possible that the bird recorded in the study area in late May, may have been part of a breeding pair, although this is unconfirmed. It is also unknown if birds using the study area would also utilise habitat outside this area. Based on information provided in Higgins (1999) the extent of potential habitat within the study area would be of a suitable size to support a resident pair of birds.

There are two additional records of grass owls listed on the Atlas of NSW Wildlife. One record was from Vintage Lakes an area that is now heavily developed, whilst the second record was from Chinderah on the southern side of the Tweed River. Given the extent of development in the Tweed area it is possible that the study area could provide important habitat for resident pair of birds.

Habitat within the study area appears suitable for both roosting and foraging. The sedgeland at the southern end of the main airport runway, low heathland distributed throughout the study area, and patches of disturbed habitat with tall blady grass could be used as diurnal roosts and nocturnal foraging areas.

The current proposal will remove and fragment a substantial proportion of the available grass owl habitat in the study area. A reduction in the water table during tunnel construction may also lead to changes in habitat structure, whilst post construction changes in surface flows may result in increased ponding. The proposal will essentially reduce the amount and quality of available habitat, and birds attempting to forage in fragmented habitat will be susceptible to road strike. It is therefore concluded that the proposal will have a significant effect on the viability of the local grass owl population. This assessment regards the local grass owl population as those birds within the study area.

b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No population of grass owl has been listed on Schedule 1 of the TSC Act as an endangered population.

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

The area of habitat affected by this proposal is not regarded as significant in a regional context. Known grass owl habitat is widespread throughout coastal north-eastern NSW.

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

The proposal will fragment potential habitat in the south-eastern corner of the study area. Owls attempting to access this habitat will be susceptible to road strike.

e) whether critical habitat will be effected.

No critical habitat occurs within the study area.

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

Extensive areas of known grass owl habitat occur within conservation reserves in the survey region. Resident populations are known to occur in Tyagarah Nature Reserve, and Broadwater and Bundjalung National Parks (Maciejewski 1996). Given the frequency with which individuals are struck by cars along the Pacific Highway it seems likely that a large number of individuals occur outside conservation reserves.

g) whether the action proposed is of a class of action that is recognised as a threatening process.

The removal and fragmentation of foraging and roosting habitat for a threatened species is likely to be considered by the scientific community as a threatening process. The proposal will not enhance any threatening processes listed on schedule 3 of the TSC Act.

h) whether any threatened species or ecological community is at the limit of its known distribution.

The study area is not situated at the limits of the known distribution for grass owls (Higgins 1999).

4.4.5 Mangrove Honeyeater

Mangrove honeyeaters were recorded in mangrove habitats throughout the study area. Densities of almost five birds/hectare were recorded along the mangrove fringe in the vicinity of the Pony Club, with densities of over two birds/hectare recorded on the western side of Cobaki Broadwater.

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

In the study area mangrove honeyeaters were recorded only in mangrove habitats fringing Cobaki Broadwater, or on small mangrove islands within the Broadwater. Mangrove honeyeaters appear to be resident within the study area, being recorded in all seasons during monitoring surveys conducted by Sandpiper Ecological Surveys. Although regarded as a mangrove specialist mangrove honeyeaters have been recorded from eucalypt woodlands adjacent to mangroves, and trees in coastal towns (Schodde & Tideman 1990; Pizzey and Knight 1997).

The current proposal will not remove or fragment known habitat for mangrove honeyeaters. Primary impacts on mangrove honeyeaters will stem from an increase in noise disturbance. At its closest point, the proposed highway will be positioned within approximately 100m of mangrove habitat along the northeastern fringe of Cobaki Broadwater, in the vicinity of the Pony Club sandflat.

The exact impact of noise disturbance on mangrove honeyeaters is difficult to determine. This species is highly vocal and may actively defend territories during the breeding season. It is therefore important that breeding pairs are able to communicate readily with one another. There are no published examples of mangrove honeyeaters using habitat situated in close proximity to major roads, and the largest populations of mangrove honeyeaters in the Tweed, Richmond and Clarence Rivers tend to occur in secluded habitats away from disturbance. Mangrove honeyeaters have also been recorded within 300m of the Bruce Highway in southeastern Queensland (B. Lane pers comm.).

It is possible that the apparent concentration of birds in secluded areas may be due more to habitat than the effects of disturbance, with birds recorded previously from urban gardens. Mangrove honeyeaters in the vicinity of the Pony Club also seem to tolerate the existing levels of noise associated with jet and propeller driven aircraft using Coolangatta airport. As discussed for other species there is some difference in the extent and duration of noise created by aircraft and that created by the highway.

The lack of quantitative evidence regarding the impact of noise means that a conservative approach should be adopted. With this in mind it is considered possible that the proposal may reduce the quality of mangrove habitat in the northeastern fringe of Cobaki Broadwater (i.e. in the vicinity of the Pony Club) for mangrove honeyeaters. However, even if the overall utility of this habitat is reduced it may still be used on an occasional basis. If the proposal does cause birds to avoid mangroves in the vicinity of the Pony Club sandflat it is unlikely that it will have a significant affect on the viability of the local mangrove honeyeater population. This conclusion is based on the relatively small area of habitat affected in a local context. Mangrove habitat occurs around the entire fringe of Cobaki Broadwater, and mangrove honeyeaters are known to utilise all of this habitat.

b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No population of mangrove honeyeater has been listed on Schedule 1 of the TSC Act as an endangered population.

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

The proposal will not modify or remove a significant area of known habitat for the mangrove honeyeater in a regional context. Suitable habitat for mangrove honeyeaters is widespread within the lower Tweed River estuary, the upper reaches of North Creek (Richmond River estuary), and in parts of the Clarence estuary.

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

The proposal will not isolate potential habitat for mangrove honeyeaters.

e) whether critical habitat will be effected.

No critical habitat occurs within the study area.

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

Known mangrove honeyeater habitat does occur in the Ukerabagh, Tweed Estuary and Ballina Nature Reserves. It is considered unlikely however, that habitat for mangrove honeyeaters is adequately represented in regional conservation reserves.

g) whether the action proposed is of a class of action that is recognised as a threatening process.

Quantitative data on the impact of noise on bird communities is lacking. Although the scientific community would most likely advocate a precautionary approach to assessing the impacts of noise, it is unlikely that noise would be regarded as a threatening process. The proposal will not enhance any threatening processes listed on schedule 3 of the TSC Act.

h) whether any threatened species or ecological community is at the limit of its known distribution.

The study area is not situated at the limits of the known distribution for mangrove honeyeater (Pizzey & Knight 1997).

4.4.6 White-eared Monarch

White-eared monarchs were not recorded in the study area during this study, despite extensive general surveys in summer and targeted surveys in late autumn. This species has however, been recorded previously in lowland rainforest habitat within the subject site (E. Kleiber pers comm.), and from regrowth forest approximately 2km north of the subject site.

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

The white-eared monarch is considered to be a probable autumn-winter migrant to lower elevations, spending the spring/summer period at higher elevations (Pizzey & Knight 1997). Records of white-eared monarchs in the locality have all been during the winter/spring period. White-eared monarchs have been recorded using a variety of habitat types, although birds seem to show a preference for rainforest, riparian forest and mangroves. In the study area white-eared monarchs would primarily utilise lowland rainforest, swamp forest and adjacent mangrove habitats.

The proposed Tugun Bypass will remove a small area of marginal quality habitat for the white-eared monarch in the vicinity of the southern interchange, and a small area of suitable swamp forest habitat near the southwestern end of the airport. In addition mangrove, swamp forest and lowland rainforest habitat will suffer from increased levels of noise disturbance. The impact of noise disturbance on white-eared monarchs is of less concern than that described in the previous section for mangrove honeyeater. White-eared monarchs are unlikely to breed within the study area.

Differences in the quality of swamp forest habitat within the study area are due primarily from differences in the extent of disturbance. Swamp forest in the southeastern corner of the study area has been heavily disturbed, and the midstratum vegetation, which is regarded as important, has been fragmented or removed. In contrast swamp forest to the southwest and west of the airport has a reasonably intact midstorey, which in places is quite dense.

The concentration of impacts on marginal quality habitat and the extent of similar habitats in the locality mean that it is unlikely that the proposal will have a significant effect on the viability of the local white-eared monarch population.

b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No population of white-eared monarch has been listed on Schedule 1 of the TSC Act as an endangered population.

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

The current proposal will not modify or remove a significant area of known habitat for the white-eared monarch in either a local or regional context. In the study area white-eared monarchs have only been recorded from lowland rainforest. Bo lowland rainforest will be removed or modified by the proposal.

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

The proposal will not isolate known or potential habitat for white-eared monarch.

e) whether critical habitat will be effected.

No critical habitat occurs within the study area.

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

High elevation habitat used by white-eared monarchs in the spring/summer period is adequately represented in conservation reserves in the survey region, however, lowland habitat is unlikely to be adequately represented. Much of the lowland rainforest in northeast NSW has been cleared, and only small areas of suitable mangrove habitat have been incorporated into the reserve system.

g) whether the action proposed is of a class of action that is recognised as a threatening process.

Quantitative data on the impact of noise on bird communities is lacking. Although the scientific community would most likely advocate a precautionary approach to assessing the impacts of noise, it is unlikely that noise would be regarded as a threatening process in the present case. The marginal quality of habitat affected for white-eared monarchs is also unlikely to be considered as a threatening process. The proposal will not enhance any threatening processes listed on schedule 3 of the TSC Act.

h) whether any threatened species or ecological community is at the limit of its known distribution.

The study area is not situated at the limits of the known distribution for white-eared monarch (Pizzey & Knight 1997).

4.4.7 Barred Cuckoo-Shrike

Barred cuckoo-shrikes were not recorded during the field survey, although historical records for this species exist from the southern side of Cobaki Broadwater, and habitats within the study area are suitable.

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

Barred cuckoo-shrikes are most often recorded in subtropical, dry and littoral rainforests, or along the margins of these habitats, although there are records from adjacent eucalypt and Melaleuca forests (Pizzey & Knight 1997; NPWS 1999). Suitable habitat does exist in the study area in the form of lowland rainforest, with adjacent swamp forest. Despite the failure to record barred cuckoo-shrikes during the field survey it is considered likely that they would utilise habitats in the study area, particularly in view of historical records within approximately 500 m.

The current proposal will have a direct impact on secondary habitat (i.e. swamp forest), and an indirect impact on primary habitat (i.e. rainforest), through increased noise levels. The extent and type of habitat removed is not regarded as significant. In addition the failure to record barred cuckoo-shrikes in the study area despite intensive searching during summer suggests that rainforest habitat may be used on only an occasional basis. If this assumption is correct it seems unlikely that increase noise levels associated with the highway will have a significant effect on barred cuckoo-shrikes.

b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No population of barred cuckoo-shrike has been listed on Schedule 1 of the TSC Act as an endangered population.

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

The proposal will not modify or remove a significant area of known habitat for the barred cuckoo-shrike.

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

The proposal will fragment potential habitat in the south-eastern corner of the study area, however, no known habitat will be affected by the proposal.

e) whether critical habitat will be effected.

No critical habitat occurs within the study area.

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

Barred cuckoo-shrikes have been recorded from a small number of conservation reserves in the survey region. It is likely that an extensive area of potential habitat does occur within regional conservation reserves, although it is unconfirmed if the population of barred cuckoo-shrikes are adequately represented in these areas.

g) whether the action proposed is of a class of action that is recognised as a threatening process.

The current proposal will not remove known habitat for barred cuckoo-shrikes, and it is considered unlikely that the action proposed would be considered as a threatening process. The proposal will not enhance any threatening processes listed on schedule 3 of the TSC Act.

h) whether any threatened species or ecological community is at the limit of its known distribution.

The study area is not situated at the limits of the known distribution for the barred cuckoo-shrike (Pizzey & Knight 1997).

4.4.8 Glossy Black-Cockatoo

Evidence of glossy black-cockatoos in the form of chewed *Allocasuarina* fruit was recorded along the northern edge of the National Estate land. No evidence of this species was recorded at any other location within the study area despite targeted searches. There are records of glossy black-cockatoos from coastal habitats to the south of the study area.

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

The primary habitat requirements for glossy black-cockatoos include a good supply of food in the form of *Allocasuarina* fruit, and large hollows for nesting (Higgins 1999; Pepper *et al.* 2000). Nest hollows range in size, although Garnett *et al.* (1999) recorded an average nest hollow height of 30 cm, and an average width of 19 cm. Preferred habitat is often in dry open forest or woodland.

Suitable foraging and nesting habitat for glossy black-cockatoos does occur in the study area. Large areas of *Allocasuarina littoralis* were recorded in woodland and heathland habitat on the western side of the study area. Evidence of birds using the site was recorded at only one location. Between 30 and 50 chewed *Allocasuarina* spp. fruit were recorded beneath two trees on the northern edge of the National Estate. No further evidence was recorded despite intensive searching throughout the entire study area.

The extent to which glossy black-cockatoos utilise resources within the study area suggests that the area does not represent important habitat for this species. The results suggest that birds may very occasional stop to forage within the study area whilst in transit between preferred sites. Alternatively the resource utilisation recorded during this study may signify an increase in use in the future, as birds are forced away from preferred habitat.

An abundant supply of food was present in the study area during the survey and food availability is not regarded as a limiting factor. Other factors that may limit use of the site by glossy black-cockatoos include the density of habitat in which the *Allocasuarina* occurs, and possibly the seed content of the fruit, which may not be sufficient to sustain a resident population (Clout 1989; Pepper *et al.* 2000). Glossy black-cockatoos generally prefer open habitats, where they can readily move between trees, although in the present case it would be possible for birds to forage along access tracks as has been recorded at other sites (pers obs).

The current proposal will remove only a small area of potential foraging habitat. Thorough searching of this habitat failed to detect any evidence of glossy black-cockatoo. Given the limited use of the study area by glossy black-cockatoos, and the extent of similar unused habitat to the west of the study area it seems unlikely that the proposal will have a significant effect on the viability of the local glossy black-cockatoo population.

b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No population of glossy black-cockatoo has been listed on Schedule 1 of the TSC Act as an endangered population.

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

No known glossy black-cockatoo habitat will be affected by the proposal, although a small area of potential habitat will be removed. The area of habitat affected is not regarded as significant in a local or regional context.

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

The proposal will not isolate known habitat for the glossy black-cockatoo.

e) whether critical habitat will be effected.

No critical habitat occurs within the study area.

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

Glossy black-cockatoos have been recorded from a number of conservation reserves within the survey region. It is likely that suitable foraging habitat is adequately represented in conservation reserves, however, it undetermined if suitable nesting resources are adequately conserved.

g) whether the action proposed is of a class of action that is recognised as a threatening process.

The current proposal will not remove known habitat for glossy black-cockatoo, and it is considered unlikely that the action proposed would be considered as a threatening process. The proposal will not enhance any threatening processes listed on schedule 3 of the TSC Act.

h) whether any threatened species or ecological community is at the limit of its known distribution.

The study area is not situated at the limits of the known distribution for glossy black-cockatoos (Pizzey & Knight 1997).

4.4.9 Red-tailed Black-Cockatoo

No red-tailed black-cockatoos were recorded during the survey, although the species has been recorded previously in coastal habitats to the south of the study area, and suitable habitat does occur in the study area.

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

Red-tailed black-cockatoos utilise a range of habitats, although they tend to prefer eucalypt forests or woodlands (Higgins 1999). Food includes the seeds of eucalypts, casuarinas, acacias, and banksias, and fleshy fruits. Red-tailed black-cockatoos are only occasionally recorded in northern NSW, although there are reliable records from the Tweed Coast (NPWS 1999). The species has been recorded from sites with a mosaic of habitat types including, rainforest, and wet and dry sclerophyll forest (NPWS 1999).

The study area includes potential foraging habitat for this species. Some of this habitat particularly coast banksia (*Banksia integrifolia*) will be removed during construction. The proposal will also increase disturbance effects in other sites that contain potential habitat.

Given the small population of red-tailed black-cockatoos in northern NSW, the rarity of records in the Tweed coast, and the limited extent of habitat affected (even considering the removal of habitat associated with other developments along the coast) it is unlikely that this proposal will have a significant effect on the viability of the local population.

b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No population of red-tailed black-cockatoo has been listed on Schedule 1 of the TSC Act as an endangered population.

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

There is no known habitat for red-tailed black-cockatoos in the study area. No known habitat will be affected by this proposal.

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

The proposal will not isolate known habitat for red-tailed black-cockatoos.

e) whether critical habitat will be effected.

No critical habitat occurs within the study area.

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

Suitable foraging habitat for red-tailed black-cockatoos does occur in the Border Ranges National Park, although the extent of nesting sites is undetermined.

g) whether the action proposed is of a class of action that is recognised as a threatening process.

The current proposal will not remove known habitat for red-tailed black-cockatoos, and it is considered unlikely that the action proposed would be considered as a threatening process. The proposal will not enhance any threatening processes listed on schedule 3 of the TSC Act.

h) whether any threatened species or ecological community is at the limit of its known distribution.

The study area is not situated near the southern limit of the known distribution for red-tailed black-cockatoo (Pizzey & Knight 1997).

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Appendix B

Tugun Bypass Assessment of Impacts on Birds: Boyd Street Interchange to Stewart Road (Sandpiper Ecological Surveys 2001b)

TUGUN BYPASS

ASSESSMENT OF IMPACTS ON BIRDS:

BOYD STREET INTERCHANGE TO STEWART ROAD

MAY 2001

Sandpiper Ecological Surveys

TUGUN BYPASS

ASSESSMENT OF IMPACTS ON BIRDS:

BOYD STREET INTERCHANGE TO STEWART ROAD

MAY 2001

Report prepared for
PPK Environment & Infrastructure

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EXECUTIVE SUMMARY

Background

PPK Environment and Infrastructure contracted Sandpiper Ecological Surveys P/L to assess the potential impact of the northern section of the proposed Tugun Bypass on birds. The assessment follows on from previous surveys conducted along the southern section of the proposed alignment. The assessment focussed on the revised C4 alignment between the Boyd Street Interchange and Stewart Road. The study area included all habitats within 500 m of the proposed alignment.

Methods

Desktop review

A desktop review was conducted to determine which legislatively protected bird species could be expected to occur within the study area. Legislatively protected species included species listed on the Queensland *Nature Conservation Wildlife Regulation (QNCWR) 1994*; the NSW *Threatened Species Conservation (TSC) Act 1995*, the Japan/Australia Migratory Bird Agreement (JAMBA), and the China/Australia Migratory Bird Agreement (CAMBA). The proposal is not subject to the requirements of the Commonwealth *Environmental Protection and Biodiversity Conservation Act* 1999, and species listed on this act have not been considered.

The review identified the possible presence of 143 species of bird, including five species listed on the *QNCWR 1994*, 11 species listed on the NSW *TSC Act 1995*, 10 species listed on JAMBA, and nine species listed on CAMBA. Species recorded from the locality was summarised to obtain a list of subject species. The subject species list included species recorded previously from the locality (Table A). The list of subject species included 10 species listed on the *QNCWR 1994* and 17 species listed on the NSW *TSC Act 1995* (Table A). These species were targeted during the survey.

Field survey

The field survey was conducted over two five-day periods, one in October 2000, and one in February 2001. Surveys were conducted by two personnel using a range of standard survey methods. Habitats within the study area were identified prior to the commencement of field work, and survey methods were stratified on the basis of habitat (Tables B & C). The methods used during the survey included:

- Point counts;
- Area searches;
- General traverses;
- Call playback (dawn, dusk and nocturnal); and
- Fauna habitat assessment.

Table A: List of subject species compiled after initial surveys of the study area, and from reviewing species listed on the *QNCWR 1994*, NSW *TSC Act 1995*. ** = species recorded south of the locality. J = JAMBA, C = CAMBA, Q = QNCWR, N = NSW TSC Act.

Common Name	Relevant legislation	Recorded previously in locality
Wedge-tailed Shearwater	J, C	Yes
Sooty Shearwater	J, C	Yes
Black-necked Stork	Q, N	Yes
Cattle Egret	J, C	Yes
Great Egret	J, C	Yes**
Osprey	N	Yes
White-bellied Sea-Eagle	C	Yes
Square-tailed Kite	Q, N	Yes**
Grey Goshawk	Q	Yes
Bush Hen	N	Yes
Black Bittern	N	Yes
Lewins Rail	Q	Yes
Latham's Snipe	J, C	Yes
South Polar Skua	J	Yes
Common Tern	J, C	Yes
Little Tern	C, Q, N, J	Yes
Common Noddy	J, C	Yes
Glossy Black-Cockatoo	Q, N	Yes**
Rose-Crowned Fruit Dove	N	Yes
Superb Fruit-Dove	N	Yes**
Wompoo Fruit-Dove	N	Yes**
Powerful Owl	Q, N	Yes
Barking Owl	N	Yes
Sooty Owl	Q, N	Yes
Masked Owl	N	Yes**
Marbled Frogmouth	Q, N	No
Oriental Cuckoo	J, C	Yes
Collared Kingfisher	N	Yes**
White-throated Needletail	J, C	Yes
Fork-tailed Swift	J, C	Yes**
Rainbow Bee-eater	J	Yes**
Southern Emu-Wren	Q	No
White-eared Monarch	N	No

Table B: Summary of the survey effort expended during the spring and summer bird surveys for the proposed Tugun Bypass, Boyd Street to Stewart Road. * includes time taken during point counts; repeats = number of repeated surveys on each transect, traver = traverse.

Habitat	Point Count			Area Search*			General Traverse		
	No. points	No repeats	Time (mins)	No. traver	No repeats	Time (mins)	No. traver	No repeats	Time (mins)
Dry open forest	12	4@3 3@3 2@6	165	15	1	513	6	1	385
Regrowth rainforest	3	4	60	7	1	283	4	1	245
Moist regrowth	3	4	60	3	2	110	1	1	20
Swamp forest	6	4	120	8	1	224	0	0	0
Disturbed land	3	2	30	3	1	66	3	1	140
Woodland	-	-	-	-	-	-	1	1	90

Table C: Summary of call playback survey effort during nocturnal, dawn and dusk periods. PO = powerful owl, MO = masked owl, BO = barking owl, GO = grass owl; SO, sooty owl, BaO = barn owl, MF = marbled frogmouth; DOF = dry open forest, DG = Disturbed grassland, RR = Regrowth rainforest, SF = Swamp forest, W = Woodland; RCFD = rose-crowned fruit-dove, WF = wompoo fruit-dove, SF = superb fruit-dove, WEM = white-eared monarch, BH = bush-hen, BB = black bittern, AB = Australasian bittern, LR – Lewin's rail.

Time	Number of Sites	Number of Repeats/site	Species Targeted	Habitats Sampled
Nocturnal	6	4 @ 2 sites 3 @ 1 site 2 @ 2 sites 1 @ 1 site	PO, MO, BO, SO, BaO, GO, MF	DOF, DG, RR, SF, W
Dawn	2	3	RCFD, WF, SF, WEM	RR, MR
Dusk	2	3	BH, BB, AB, LR	RR, DG

Results

Bird habitat

Five habitat types were identified within the study area, including dry open forest, regrowth rainforest, moist regrowth, swamp forest, woodland, and disturbed grassland. Dry open forest was the most extensive habitat type covering most of the eastern slope of Woodgee Hill, and a large block of land near Stewart Road. Regrowth rainforest was restricted to a small gully known as Hidden Valley, situated on the western side of Woodgee Hill. A large tract of disturbed grassland was situated in the vicinity of a disused sand and gravel quarry between Hidden Valley and Stewart Road. Swamp forest and woodland are restricted to the lower eastern slope of Woodgee Hill. The proposal would remove approximately 10.2 ha of vegetation.

Bird diversity

A total of 125 species of bird were recorded in the study area during the spring and summer surveys. Ninety-eight species were recorded during the spring survey, with 108 species recorded during the summer survey. Eighty species were recorded during both surveys, with 17 species recorded in spring but not summer, and 28 species recorded in summer but not spring.

Legislatively protected species

Thirteen legislatively protected species and six species of conservation significance were recorded during the survey, with a further six species expected to occur in the study area (Table D). Of the 19 subject species seven are listed on either or both JAMBA and CAMBA, nine are listed on the NSW *TSC Act 1995*, and four are listed on the *QNCWR 1994*.

Three species of fruit-dove and a suspected breeding pair of bush-hens were recorded in Hidden Valley. Unconfirmed records of bush-hen and black bittern were obtained in the vicinity of the Boyd Street Interchange. Rose-crowned fruit-doves were recorded in moist regrowth near Stewart Road, and Lewin's rail was recorded in disturbed grassland near Stewart Road. White-eared monarchs were recorded in moist regrowth near Stewart Road, and this species is also considered likely to utilise habitat in Hidden Valley.

Glossy black-cockatoos were recorded foraging on black oak (*Allocasuarina littoralis)* south of the Boyd Street Interchange. Suitable foraging and roosting habitat for glossy black-cockatoos occurs within the study area, particularly on the eastern slope of Woodgee Hill. No legislatively protected species of nocturnal bird were recorded during the survey, although masked owls were recorded in the immediate vicinity during previous surveys. White-throated needletails and fork-tailed swifts were recorded regularly throughout the study area, although individuals were most commonly recorded in the vicinity of the quarry.

Based on the habitat types present, and records from the vicinity it is predicted that grey goshawk, square-tailed kite, marbled frogmouth and oriental cuckoo could occur in the study area. Each of the species listed in Table D were considered during the impact assessment.

Impacts on legislatively protected species

Primary impacts on legislatively protected species include the removal of habitat, increased disturbance, and pollution of habitat. Impacts associated with edge effects, barrier effects, and road strike are regarded as minimal. The proposal involves the removal of approximately 10.2 ha of vegetation. The majority of the vegetation to be removed is dry open forest (7.57 ha) on the eastern slope of Woodgee Hill, and in the vicinity of Stewart Road, with small areas of swamp forest (0.11 ha), woodland (1.16 ha) and regrowth rainforest also affected (0.82 ha). Regrowth rainforest habitat would be removed from Hidden Valley during the process of bridge construction.

Vegetation removal is unlikely to have a substantial impact on legislatively protected species, although it would involve the removal of a small area of foraging habitat for glossy black-cockatoo, masked owl, grey goshawk, Lewins rail, bush-hen and fruit-doves.

Coupled with vegetation removal is an extension of disturbance affects. Much of the habitat within the study area already suffers disturbance affects from planes, motorbikes, and nearby urban areas. The increase in disturbance affects associated with the proposal would be most pronounced in Hidden Valley. Disturbance affects in Hidden Valley would be reduced to some extent by placing the highway on a bridge above the vegetation. Disturbance affects in Hidden Valley may be most pronounced during the construction phase of the project. During construction it is likely that noise and movement disturbance could affect bush-hens, fruit-doves and other species using the regrowth rainforest habitat.

Table D: Legislatively protected species of bird recorded during the field survey or expected to occur on the basis of habitat and previous records.

Common Name	Status	Likelihood of Occurrence in Qld	Likelihood of Occurrence in NSW
Cattle Egret	JAMBA, CAMBA	Confirmed	Confirmed
Great Egret	JAMBA, CAMBA	Confirmed	Confirmed
White-bellied Sea-Eagle	CAMBA	Unlikely	Confirmed
Square-tailed Kite	NSW TSC Act	Possible	Possible
Grey Goshawk	QNCWR	Likely	Likely
Bush Hen	NSW TSC Act	Confirmed	Possible
Black Bittern	NSW TSC Act	Unlikely	Possible
Lewins Rail	QNCWR	Confirmed	Likely
Glossy Black-Cockatoo	QNCWR, NSW TSC Act	Likely	Confirmed
Rose-Crowned Fruit Dove	NSW TSC Act	Confirmed	Likely
Superb Fruit-Dove	NSW TSC Act	Possible	Unlikely
Wompoo Fruit-Dove	NSW TSC Act	Confirmed	Unlikely
Masked Owl	NSW TSC Act	Likely	Confirmed
Marbled Frogmouth	QNCWR, NSW TSC Act	Possible	Unlikely
Oriental Cuckoo	JAMBA, CAMBA	Possible	Possible
White-throated Needletail	JAMBA, CAMBA	Confirmed	Confirmed
Fork-tailed Swift	JAMBA, CAMBA	Confirmed	Confirmed
Rainbow Bee-eater	JAMBA, CAMBA	Confirmed	Confirmed
White-eared Monarch	NSW TSC Act	Confirmed	Possible

Pollution of aquatic habitats may occur during both the construction and operation phases of the project. The risk of pollution affecting habitat of legislatively protected species would be greater at Hidden Valley and in swamp forest habitat near the Boyd Street Interchange. Impacts in Hidden Valley may be minimal as the proposed bridge is situated near the downstream edge of the habitat and pollutants would be quickly transported away from the habitat. Impacts on swamp forest may be more severe, and could affect possible habitat for black bittern and bush-hen.

Road strike is likely to be associated with the operation of the proposed highway, as is the case with the existing Pacific Highway. Evidence gathered during the field survey indicated that at present the majority of birds crossing the site fly well above the existing ground surface and would not be subject to road strike. There is no reason to believe that birds would fly lower once the road was constructed, although flight height may change in response to weather conditions. Impacts associated with road strike may be most severe in Hidden Valley, although it is likely that birds would habituate to the presence of the bridge before the highway is open to traffic.

Cumulatively it is suggested that the project would have the greatest impact on birds using Hidden Valley. The valley contains the highest concentration of legislatively protected species in the study area, and would suffer impacts associated with vegetation removal, pollution, disturbance and road strike. There is no evidence to suggest that the proposal would cause any species of bird to abandon the valley. It is possible that bush-hens may continue to utilise the subject site, and possibly continue to breed in this area. Fruit-doves are likely to continue using the valley once the highway becomes operational.

Impact mitigation

The following measures are proposed to minimise impacts associated with the project:

- Where possible place sediment ponds, spoil dumps, and work depots in either disturbed land, or in small habitat fragments created through vegetation clearing. Avoid removing additional vegetation to site these facilities;
- Control runoff into Hidden Valley and swamp forest habitat in NSW. Preferably channel all runoff away from these areas;
- Revegetate sediment ponds, particularly if a pond is positioned in disturbed grassland near Stewart Road. A pond in this area should be revegetated with dense grasses to provide potential habitat for Lewins rail;
- Where appropriate revegetate the disturbed road edge to reduce edge effects. Revegetation is primarily warranted on the southern side of the alignment on the eastern slope of Woodgee Hill. In conducting revegetation it is essential that that revegetation should be conducted at a similar density to the existing vegetation to avoid excessive shading, and the creation of additional edge effects;
- Assess the potential impact of shading on vegetation in Hidden Valley. To minimise the risk of plant dieback and weed invasion it may be appropriate to plant the shade-affected area with shade tolerant species;
- Minimise disturbance during the construction of the road to the base of the bridge in Hidden Valley. Ideally this road should commence at the quarry. Additional impacts would occur if the road is placed on the opposite side of the valley;
- During construction of the bridge and associated infrastructure minimise impacts on the small dam/pond utilised by bush-hens. It appears as though this pond is outside the construction footprint, however, the location of the pond should be clearly marked and all attempts made to avoid it;
- During the construction of the bridge in Hidden Valley all attempts should be made to minimise the removal of known food trees for fruit-doves, particularly Bangalow Palms; and,
- Time construction activities outside of the breeding season for legislatively protected species. Ideally vegetation removal and construction in Hidden Valley should be conducted during late autumn, winter and spring, which is outside the breeding season for bush-hens. This time period would however, coincide with the period when fruit-doves are most likely to utilise habitats in the valley.

1. INTRODUCTION

The Queensland Department of Main Roads (DMR) proposes 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 C4 option involves a full bypass of the Tugun/Bilinga area, by constructing a four-lane highway on the western side of Gold Coast Airport, and across the northern edge of Woodgee Hill (Figure 1). The re-alignment extends from Stewart Road, Currumbin, to Kennedy Drive, Tweed Heads. The proposal includes the construction of a highway, and a railway line, with the railway line terminating at Gold Coast 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. PPK Environment and Infrastructure have been contracted to prepare the EIS. PPK has contracted Sandpiper Ecological Surveys to provide background information on the potential impacts of the proposal on birds. For the purpose of this assessment the alignment has been divided into two sections. Kennedy Drive to Boyd Street, and Boyd Street to Stewart Road. This report assesses the impact of the Boyd Street to Stewart Road section of the revised[1] C4 alignment on birds. The impact of the Kennedy Drive to Boyd Street section is assessed in a different report (Sandpiper Ecological Surveys 2001).

The report presents the results of field surveys conducted within the vicinity of the proposed alignment and summarises data collected during previous surveys. Although most of the study area occurs in Queensland (Qld) a small section at the southern end occurs in New South Wales (NSW). Off-site impacts associated with the proposal could also affect habitat in NSW. In assessing the impacts of the proposal consideration has been given to species listed on the Queensland *Nature Conservation Wildlife Regulation (QNCWR) 1994*, the NSW *Threatened Species Conservation (TSC) Act 1995*, the *Japan-Australia Migratory Bird Agreement* (JAMBA), and the *China-Australia Migratory Bird Agreement* (CAMBA). The proposal is not subject to the requirements of the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999*.

1.1 Project objectives

The objectives of this project were to:

- Undertake a survey of birds in terrestrial habitats that may be affected by the proposed C4 option between Boyd Street & Stewart Road;
- Assess the impact of the proposal on birds within terrestrial 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.

[1] The C4 option underwent minor revision after issues raised at a Value Management Workshop held at Coolangatta in September 2000.

2. STUDY AREA

2.1 Boundary of the study area

The study area extends from the Boyd Street interchange at Tugun to the intersection of Stewart Road and the Pacific Highway at Currumbin. The study area includes all vegetated habitats within 500 m either side of the proposed C4 alignment. Included within this area are Woodgee Hill, Hidden Valley, and a large block of land owned by Gold Coast City Council that abuts the existing Pacific Highway (Figure 1).

2.2 Existing land use in the study area

Land use varies throughout the study area. Most of the land is privately owned apart from a block of regenerating moist forest along the southern edge of the Pacific Highway near the Stewart Road intersection, which is owned and managed by Gold Coast City Council. Land to the west and southeast of this block is owned by Newman Developments, and includes a disused quarry, with remnant dry open forest. A large area of grassland occurs in the vicinity of a sand quarry situated to the south of Stewart Road. This area is heavily disturbed, being used regularly by motorbike riders. Land owned by council and Newman Developments is surrounded by urban development.

Immediately to the east of the quarry is an area known as Hidden Valley, and Woodgee Hill. This area represents a large block of contiguous habitat that includes a mix of regrowth rainforest and dry open forest, with some mature dry open forest. Both Hidden Valley and Woodgee Hill are privately owned, however, disturbance by humans appears limited. The southeastern end of the study area (i.e. in the vicinity of Boyd Street) consists of a mix of grassland, swamp forest and dry woodland. Land to the west of this area is currently being developed as part of the Cobaki Lakes development.

2.2.1 Terms used to describe the areas addressed in this report

A number of terms are referred to in the following report to describe the area sampled to assess the impacts of the revised C4 alignment on avifauna. These terms are defined briefly below:

Subject site – *Subject site* refers to an area including and 15 m either side of the proposed alignment. The subject site is the area within which most direct impacts would occur.

Study area – The *study area* includes all habitats within a 500 m radius of the proposed C4 alignment.

Locality – *Locality* refers to a 10 km radius of the proposed alignment. The *locality* encompasses both the *subject site* and the *study area.*

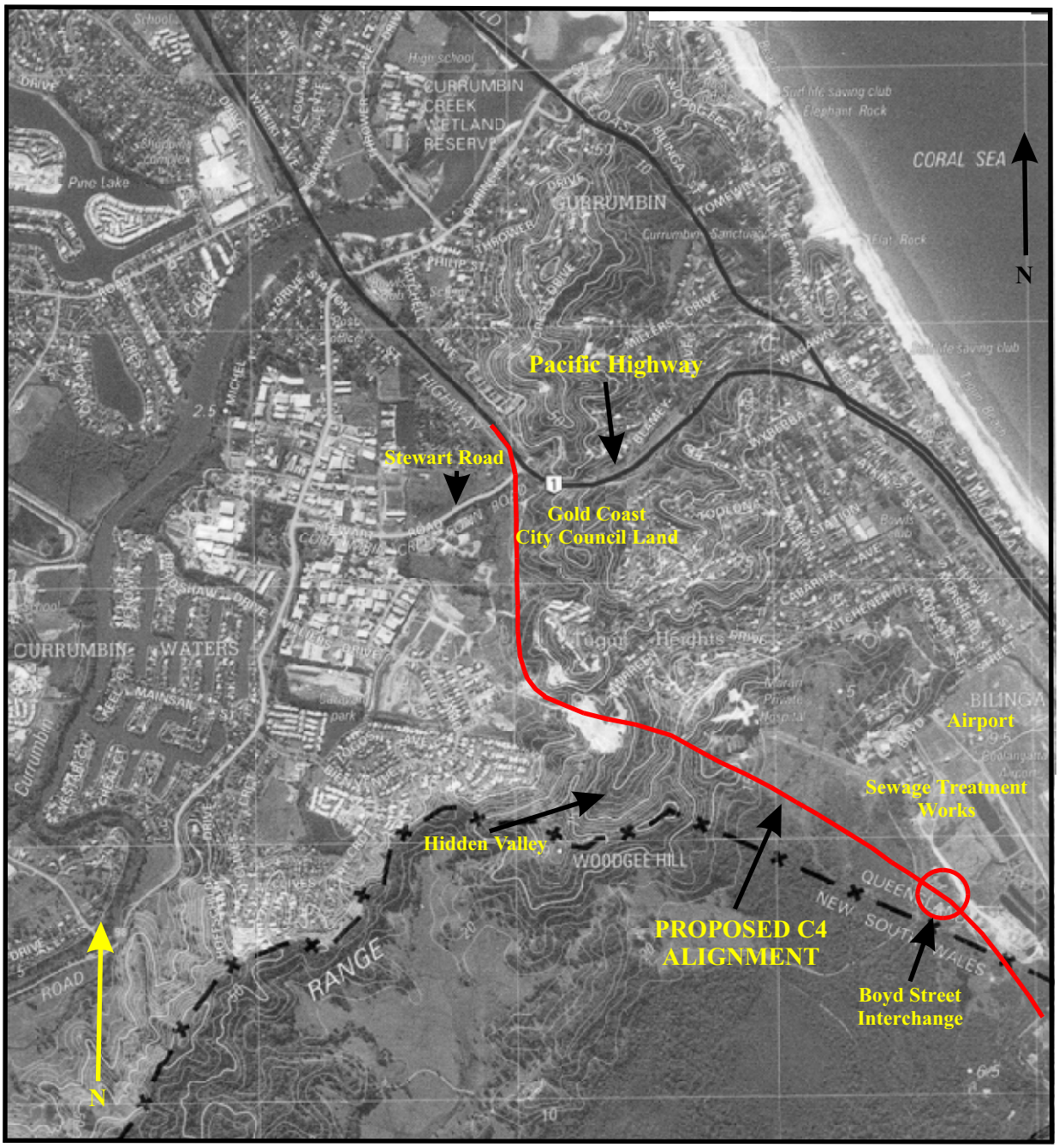

Figure 1: Location of the northern section of the proposed Tugun Bypass in relation to Gold Coast Airport and Currumbin. (Scale = 1: 25 000, Source: Qld Dept of Lands 1995)

3. DESKTOP REVIEW

3.1 Review of bird records from the locality

The objective of the desktop review was to compile a list of bird species that have been recorded previously from the locality (Table 1a, Appendix 1). In the present context the locality includes all habitats within a 10 km arc north of the study area. All bird species recorded previously within a 10 km arc to the south of the study area are summarised in Sandpiper Ecological Surveys (2001). Sources of information for the desktop review included records held on the Wildnet database, and records summarised by Parker (1999) for the Cobaki Lakes development.

The review identified 143 bird species that have been recorded previously from the locality. A large proportion of the species included on the Wildnet database are seabirds or estuarine birds that would not utilise habitats in the study area. Included within the list are five species listed on the *QNCWR 1994*, 11 species listed on the NSW *TSC Act 1995*, 10 species listed on JAMBA, and nine species listed on CAMBA. Legislatively protected species recorded previously from the locality are summarised in Table 1.

Black-necked stork and powerful owl have been recorded only in NSW, whilst masked owl and osprey have been recorded from both states (Table 1a, Appendix 1). Lewins rail, little tern, rose-crowned fruit-dove, barking owl, sooty owl, bush-hen, black bittern and collared kingfisher have been recorded only from the Queensland section of the locality (Table 1a, Appendix 1).

3.2 Subject species

To ensure that the field survey was adequate in assessing the occurrence of legislatively protected species a list of subject (or target) species was compiled. This list was finalised after the initial field surveys in October 2000, and was based on a prediction of which legislatively protected species may utilise the habitat types present in the study area. Legislatively protected species included those species listed on the *QNCWR 1994*, NSW *TSC Act 1995*, JAMBA and CAMBA.

All of the species recorded previously from the locality were regarded as subject species. In addition, legislatively protected species recorded during surveys for the southern section of the proposed bypass have also been included. The list of subject species is included in Table 2. The resulting list includes 21 species, 10 of which are listed on the *QNCWR 1994*, and 17 are listed on the NSW *TSC Act 1995*.

Table 1: Legislatively protected species recorded previously from the locality. These records were sourced from the Wildnet database and Parker (1999), NCWR = Qld *Nature Conservation Wildlife Regulation 1994*, TSC = NSW *Threatened Species Conservation Act 1995*, JAMBA = *Japan/Australia Migratory Bird Agreement*, CAMBA = *China/Australia Migratory Bird Agreement*.

Common Name	NCWR	TSC Act	JAMBA	CAMBA
Wedge-tailed Shearwater			X	
Sooty Shearwater			X	X
Black-necked Stork	X	X		
Black Bittern		X		
Cattle Egret			X	X
Osprey		X		
White-bellied Sea-Eagle				X
Bush Hen		X		
Lewins Rail	X			
Latham's Snipe			X	X
South Polar Skua			X	
Common Tern			X	X
Little Tern	X	X	X	X
Common Noddy			X	X
Rose-Crowned Fruit Dove		X		
Powerful Owl	X	X		
Barking Owl		X		
Sooty Owl	X	X		
Masked Owl		X		
Oriental Cuckoo			X	X
Collared Kingfisher		X		
White-throated Needletail			X	X

Table 2: List of subject species compiled after initial surveys of the study area, and from reviewing species listed on the *QNCWR 1994*, NSW *TSC Act 1995*. ** = species recorded south of the locality. J = JAMBA, C = CAMBA, Q = *QNCWR*, N = NSW *TSC Act*, E = *ESP Act*.

Common Name	Relevant legislation	Recorded previously in locality
Wedge-tailed Shearwater	J, C	Yes
Sooty Shearwater	J, C	Yes
Black-necked Stork	E, Q, N	Yes
Cattle Egret	J, C	Yes
Great Egret	J, C	Yes**
Osprey	N	Yes
White-bellied Sea-Eagle	C	Yes
Square-tailed Kite	Q, N	Yes**
Grey Goshawk	Q	Yes
Bush Hen	N	Yes
Black Bittern	N	Yes
Lewins Rail	Q	Yes
Latham's Snipe	J, C	Yes
South Polar Skua	J	Yes
Common Tern	J, C	Yes
Little Tern	C, Q, N, J, E	Yes
Common Noddy	J, C	Yes
Glossy Black-Cockatoo	Q, N	Yes**
Rose-Crowned Fruit Dove	N	Yes
Superb Fruit-Dove	N	Yes**
Wompoo Fruit-Dove	N	Yes**
Powerful Owl	Q, N	Yes
Barking Owl	N	Yes
Sooty Owl	Q, N	Yes
Masked Owl	N	Yes**
Marbled Frogmouth	Q, N	No
Oriental Cuckoo	J, C	Yes
Collared Kingfisher	N	Yes**
White-throated Needletail	J, C	Yes
Fork-tailed Swift	J, C	Yes**
Rainbow Bee-eater	J	Yes**
Southern Emu-Wren	Q	No
White-eared Monarch	N	No