3. Study Area Characteristics

3.1 Local Community

3.1.1 Overview

The study area is located on the north coast of NSW. Important characteristics of the north coast include:

- Popularity as a tourist destination;
- Attraction for retirees and others migrating from urban areas in NSW and other states;
- Historic reliance on agriculture and forestry as a mainstay of the regional economy; and
- Sensitive biophysical environment.

The study area is located approximately mid way between two important regional centres – Grafton to the north, and Coffs Harbour to the south. Woolgoolga is the closest major town, located approximately five kilometres south of the study area.

The study area is dominated by rural land and forest reserves, with scattered rural residential development and commercial enterprises throughout.

Portions of the villages of Corindi Beach and Arrawarra are located in the south of the study area. Other villages / localities include Corindi, Halfway Creek and Wells Crossing.

Key features of the study area are shown on Figure 1.2.

3.1.2 Socio-Economic Characteristics

A review of potential social effects was undertaken to provide input to the selection of route options. The review involved examining the existing community profile, identifying key issues and community concerns, and identifying the types of social impacts that may occur as a result of the project.

Key socio-economic features of the study area are summarised below. It is noted that the population figures are based on data from the six Australian Bureau of Statistics (ABS) collector districts that coincide with the study area – some of which have boundaries extending beyond the study area.

Demographic Characteristics

- In 2001, the population of the study area and surrounds comprised 3,835 people. Population densities are higher towards the coast; and
- The study area has a substantially lower proportion of adults aged 20-39 years and 70 years and over than the mid north coast statistical division as a whole.

Social Aspects

- The existing highway currently passes through the village of Corindi and in close proximity to Corindi Beach; and
- Two caravan parks (Darlington Beach Resort and Lorikeet Tourist Park and Home Village) are located to the east of the highway, between Arrawarra and Corindi Beach.

Employment and Industry

- The study area has a substantially higher proportion of its workforce in agriculture, forestry and fishing compared with the mid north coast statistical division;
- State forests within and in the vicinity of the study area supply timber to local timber mills;
- Cattle grazing and orchard enterprises are important rural economic activities in the study area. Blueberry Farms Australia, located on Range Road, accounts for over 40% of Australia's blueberry production, and employs up to 500 people during picking periods;
- There are a number of businesses located in the study area that rely on passing traffic for a proportion of their business. These include the two service stations near Halfway Creek, Benefields Rose Farm, and Big Garden Furniture. Other businesses rely on the highway for the transport of goods and services and the provision of access to their business; and
- Corindi Beach, Red Rock and the Yuraygir National Park are important tourist destinations in the vicinity of the study area. These features also contribute to the coastal, rural and agricultural character of the region.

3.1.3 Community Issues

A summary of key issues raised by the community prior to the route options display is provided below.

Safety

The community raised many issues associated with road safety. These include the need to:

- Improve the safety of access to and from the highway, especially right hand turns off the highway;
- Increase the width of the shoulder to allow sufficient space to pull over;
- Ensure that lanes are wide enough to accommodate caravans and B-double trucks;
- Improve the positioning of roadside barriers, as they are considered too close to the existing highway and do not provide sufficient space for breakdowns;
- Improve the arrangement of merging / exit lanes – the current arrangement is considered to be unsatisfactory; and
- Establish more bus stops / bus bays at appropriate locations.

The community also identified that adequate attention should be given to the following:

- Location of rest areas;
- Location of pedestrian crossings, especially those associated with bus stops;
- The needs of cyclists; and
- Access for bushfire controls – connectivity is required along principal fire trails.

Access To / From Highway for the Local Community

Although the safety benefits of limiting the number of direct accesses to the highway were recognised, the community expressed concern about the implications of limiting direct access.

Business owners in particular identified the need to maintain access to their business. A number of business owners stated that passing trade plays a very important role in their business. For example:

- The owners of the Halfway Creek truck stop and motel estimated that they received passing trade from both directions (60% from southbound traffic and 40% from northbound traffic);
- The owners of the service station located on the corner of Kungala Road indicated that their fuel sales were mainly from through traffic (predominantly northbound), with local traffic only making up a small percentage;
- Big Garden Furniture estimated that 70% to 80% of their business came from passing trade (mainly southbound traffic); and
- Benefields Rose Farm estimated that 50% of their business is either from passing trade or beyond the local area.

Environmental and Cultural Features

The community identified that there are a number of important environmental and cultural features in the local area, including:

- Wells Crossing Flora Reserve;
- Aboriginal camps in Newfoundland State Forest; and
- Aboriginal men's site near Halfway Creek.

Construction Impacts

The community identified concerns about potential construction impacts. Concerns / issues identified included:

- Potential noise impacts;
- Potential air quality impacts;
- Inconvenience that would be experienced during the construction period; and
- How safety would be maintained.

Other Issues

- Land acquisition – a number of queries were raised about the acquisition process, when it would occur and how it would be managed;
- Project timeframe – concerns were expressed about the length of time until a decision on the preferred route is made, and when construction would commence. The need to address immediate needs (particularly those relating to safety) was raised as a concern; and
- Future developments – information was sought on how proposed developments would be considered as part of the decision making process.

3.2 Existing Highway Corridor and Alignment

An assessment of the existing highway geometry was undertaken to determine upgrading opportunities. Opportunities to achieve a 110 km/h alignment, in accordance with new highway design standards, were considered. The objective of the assessment was to compare the current alignment with the proposed 110 km/h design speed, but not to compare with current design speeds. The results of this assessment are summarised below.

3.2.1 Road Reserve

The existing road reserve width varies considerably along the length of the highway, however it has a nominal width of 100 metres. Some sections of the road reserve have sufficient width to accommodate the upgrade with provisions for local access roads where required. However much of the road reserve is not of sufficient width for a 110 km/h design speed and property acquisition would be required. Acquisition would be required if the highway is to be upgraded by duplication of the existing carriageway or by realignment to Class A (Arterial) or Class M (Motorway) standards.

3.2.2 Carriageway Configuration

All lanes and overtaking lanes along the highway are 3.5 metres wide.

Within the study area (including the Halfway Creek duplication), there are five overtaking lanes along the northbound carriageway providing overtaking opportunities for 42% of the length. There are also five overtaking lanes along the southbound carriageway providing overtaking opportunities for 34% of the length.

Shoulder widths vary, particularly if an overtaking lane exists. Adjacent to single lanes, shoulders are generally two metres wide. Adjacent to overtaking lanes, shoulders are generally one metre wide.

Over the project length, pavement crossfall varies. Along the straights, crossfall is between 2% and 3% and on horizontal curves with radii less than 1,000 metres superelevation of up to 5% exists.

3.2.3 Horizontal and Vertical Alignment

The horizontal and vertical geometry of the carriageway contains long lengths that do not comply with the 110 km/h design criteria for the Pacific Highway upgrade. Approximately 80% of the horizontal curves do not meet the current design standard in either radii or length. Approximately 40% of the vertical curves do not meet the design standard in either “k” value or length. A large proportion of these areas are crest curves that do not meet the desirable vertical design standard for 110 km/h.

There are two sections of the project where the geometry does not meet the design standard and the design speeds are less than 110 km/h:

- Corindi River to the top of Dirty Creek Range; and
- Lemon Tree Road to Bald Knob Tick Gate Road.

There are two sections where the existing geometry complies with the highway design standards:

- Arrawarra Creek to Corindi River; and
- From the top of Dirty Creek Range and Lemon Tree Road.

The carriageway between the top of Dirty Creek Range and Lemon Tree Road meets the design standards, with the exception of two horizontal curve lengths, located where the new Halfway Creek duplication connects with the existing highway. These curves would require reconstruction to achieve design standards.

The straight section preceding the southern end of the Halfway Creek duplication does not line up with either of the new carriageways. Reconstruction of 500 metres of the new works, or reconstruction of nearly one kilometre of the preceding straight section, would be required to tie-in to the new duplication and achieve the 110 km/h design speed.

3.2.4 Clear Zones

Batter slopes vary from 1 in 1.5 fills to 1 in 2 cuts. In general, fills steeper than 1 in 3 are protected by safety barriers. Flat areas and 1 in 4 fills have a clear zone of generally four to five metres to the tree line. Sections in cut have clearances from the base of the cutting to the lane line of the through carriageway of generally three to four metres. The minimum clear zone required in the 110 km/h "New Highway" design standards is 11 metres.

Considerable work would need to be done to flatten batters and clear roadside obstacles on the existing alignment to achieve clear zone requirements. The provision of safety barriers instead of minimum clear zones may increase crash likelihood but conversely may reduce their severity.

The provision of clear zones would substantially reduce crashes. The current crash data indicates that "off road on path" are the main type of crashes on the existing highway in the study area.

3.2.5 Intersections

Of the 27 intersections within the project, 13 do not comply with the 100 km/h visibility standards for a Class A (Arterial) upgrade scenario. The majority of the affected intersections are located adjacent to horizontal curves or crest curves that restrict visibility.

Of the 13 intersections that do not comply with 100 km/h visibility standards, 11 are located in areas deficient in horizontal and vertical alignment. The remaining two intersections are at Kangaroo Trail Road and McPhillips Road.

There are 42 private accesses / tracks of which 24 do not comply with 100 km/h visibility standards.

3.2.6 Structures

The bridges on the existing highway are summarised in Table 3.1 with respect to width and load design capacity. The RTA's *Upgrading the Pacific Highway, Upgrading Program beyond 2006: Design Standards* suggests a minimum width of 10.5 metres for a two-lane facility with a SM1600 load standard. Table 3.1 shows that none of the existing bridges meet the new criteria as specified in AS5100. The existing bridges were also assessed against the T44 load standard, the predecessor to the new SM1600 load standard. SM1600 was introduced to reflect the heavier loads being transported on NSW roads. The Blackadder Gully bridge, which partially conforms, is not on a suitable alignment for the upgrade.

Table 3.1 Existing Bridge Width and Load Conditions

Bridge	Width Between Kerbs (metres)	Existing Load Condition	Existing Barrier Rating to Australian Standard AS 5100
Arrawarra Creek	8.5	<T44	No
Corindi River	8.6	T44	No
Blackadder Gully	12.8	T44	Low / regular OK
Cassons Creek	8.8	T44 likely	No
Halfway Creek	9.2	T44	Low OK
Wells Crossing	9.4	T44 (widening only) (possible T44 on original)	Low OK (widened section only)

3.2.7 Drainage Infrastructure

All of the bridge decks have Q100 flood (1% AEP) immunity based on preliminary analysis.

Stormwater drainage along the project consists of lined or unlined table or batter drains, and transverse drainage utilising bridges, culverts or pipes. Longitudinal and median drainage is only provided along the Halfway Creek duplication section of the project.

Subsurface drainage has not been investigated as part of this phase of the project.

3.2.8 Asset Condition

The condition of road pavement varies within the study area, however a detailed assessment of pavement condition was not conducted as part of this project. It is assumed the highway will be in reasonable condition at the time of project construction and will have a residual asset worth. The existing pavement would be rehabilitated as part of the RTA's ongoing maintenance program.

The bridges on the existing highway are generally in good condition and have residual life.

3.2.9 Highway Accesses

There are a number of accesses along the highway, as shown in Table 3.2. The project needs to consider treatment of accesses to the highway in the form of local access roads, access control, intersection form and / or interchanges.

Table 3.2 Accesses Along Pacific Highway

Section	Public Roads		Private Roads		Driveways		Total Accesses
	East	West	East	West	East	West	
Arrawarra Creek to Corindi Beach (Coral Street)	3	4	0	2	0	1	10
Corindi Beach to foot of Dirty Creek Range	5	4	3	4	5	4	25
Dirty Creek Range to Halfway Creek duplication (Lemon Tree Road)	2	3	4	4	1	1	15
Halfway Creek duplication to Bald Knob Tick Gate Road	3	3	5	4	1	3	19
Total Accesses	13	14	12	14	7	9	69

3.3 Traffic and Transport Characteristics

3.3.1 Existing Road Network and Performance

Existing Traffic Characteristics

Traffic characteristics have been determined from recent tube count surveys and are summarised below.

- The Annual Average Daily Traffic (AADT) is greater at the southern end of the job than the northern end;
- The AADT range for the highway is 7,330 to 10,217 vehicles per day. Heavy vehicles comprise approximately 20% of the highway traffic;
- The AADT traffic flow profile is similar along the route with the exception of the area south of Corindi Beach, which shows a higher traffic profile. This indicates more locally generated traffic towards the southern end of the project;
- Traffic from 10pm to 5am is low, averaging around 100 vehicles per hour, of which over 50% are heavy vehicles;
- The greatest volume of heavy vehicles occurs during the period between 3pm and 11pm;
- The average 85th percentile speed is 107 km/h; the average speed is 101 km/h based on speed surveys completed at four locations along the highway over seven days;
- The highest speeds occur during the early morning hours (midnight – 6am); and
- The proportion of heavy vehicles as part of the traffic stream at night is more than double that during the day.

The traffic conditions of major roads can be quantified in terms of their operating level of service (LoS). Level of service is defined by Austroads (1988) as a qualitative measure of features that include speed, travel time, traffic interruptions, freedom to manoeuvre, safety, driving comfort, convenience and operating costs. Level of service ranges from A to F as described below:

- LoS A – Generally free flow conditions. Vehicles are unimpeded in manoeuvring in the traffic stream;
- LoS B – Stable flow. Manoeuvring in traffic stream only slightly restricted with the possibility of slight delays;
- LoS C – Stable flow. Manoeuvring becoming more restricted however any delays are acceptable;
- LoS D – Approaching unstable flow. Delays are common but tolerable;
- LoS E – Unstable flow. Traffic stream is congested with intolerable delays; and
- LoS F – Forced flow. Any movement of traffic stream is at very slow speed.

Table 3.3 shows that the highway is currently operating at level of service (LoS) D between Arrawarra Creek and Dirty Creek Range. It may already be experiencing unstable traffic flow conditions (where travel speeds are affected by congestion) between Arrawarra Creek and Dirty Creek Range in the peak periods. The remainder of the highway within the study area is operating at LoS C, which represents stable flow.

Table 3.3 Highway Traffic Volumes and Level of Service (2004)

Section	AADT(1)	LoS(2)	v/c(3)
Arrawarra Creek – Corindi Beach	10,217	D(4)	0.56
Corindi Beach – Dirty Creek Range	7,954	D	0.59
Dirty Creek Range – Halfway Creek	7,642	C	0.42
Halfway Creek – Wells Crossing	7,330	C	0.40

Notes: (1) Annual Average Daily Traffic (AADT) – The number of vehicles crossing at a specific site per year and dividing this number by the number of days in the year (366 days in 2004);
(2) LoS determined from Austroads' *Guide to Traffic Engineering Practice – Part 2: Roadway Capacity*;
(3) v/c is volume / capacity ratio; and
(4) Passing lanes in this section have been assumed to add 20% additional capacity.

Traffic Hierarchy

The traffic data indicates that a mix of local, regional and interstate traffic use the highway. The mix of local and through traffic reduces the capacity of the highway for other users. A solution is to separate the interstate and possibly regional traffic from the local traffic and construct local access roads for local traffic. This suggested road hierarchy is consistent with the Class A (Arterial) / Class M (Motorway) scenarios proposed for the upgrading of the highway.

Origin Destination Investigation

Number plate surveys were carried out in November 2004 to determine the proportion of through and local traffic. A summary is shown in Table 3.4.

The base data from the matches of the number plates for light and heavy vehicles are displayed in Table 3.4. This data indicates that only 37% of northbound traffic at Arrawarra Creek continues along the highway to Bald Knob Tick Gate Road and similarly 44% of southbound traffic at Bald Knob Tick Gate Road continues past the southern end of the project at Little Arrawarra Creek (44% of the light and 46% of the heavy vehicles). Only 29% of southbound traffic at Little Arrawarra Creek originated north of Bald Knob Tick Gate Road, yet 56% of northbound traffic at Bald Knob Tick Gate Road originated south of Little Arrawarra Creek.

This data is for 12 hours during the day and the percentage that is classified as through traffic may increase substantially at night. A review of the traffic counter data for night and day travel indicates that the through heavy vehicle component appears to increase substantially to 90%, by component of through vehicles in the evening hours. However there appears to be no substantial change in the light vehicle travel patterns. This indicates that the travel patterns only seem to change at night for heavy vehicles where the proportion of through vehicles nearly doubles.

Table 3.4 Matched Number Plates – Total Traffic

	Out			
In	**Bald Knob Tick Gate Road – Northbound**	**Little Arrawarra Creek – Southbound**	**Total**	**% Through Traffic**
Bald Knob Tick Gate Road – Southbound	7 (0)	1168 (241)	2677 (528)	44% (46%)
Little Arrawarra Creek – Northbound	1404 (231)	99 (21)	3789 (564)	37% (41%)
Total	2527(436)	4026 (601)		
% Through Traffic	56% (53%)	29% (40%)		

Note: Numbers in parenthesis are heavy vehicles.

Heavy Vehicles

In August 2002 the full length of the highway was declared a designated B-double route for 25 metre B-doubles following the opening of the Yelgun to Chinderah section of the Pacific Highway. Previous to this, B-doubles were only allowed to use the Pacific Highway between Hexham and Ballina, and between the Queensland border and Condong. As a result, there was a sudden increase in the volume of heavy traffic. Heavy vehicles make up approximately 20% of the existing traffic stream. Of the total number of heavy vehicles in the study area, semi trailers account for 53% and B-doubles 17%.

Key generators of heavy vehicle movements within the study area include:

- Blueberry Farms Australia at Range Road – this operation generates significant heavy vehicle movements in the picking season;
- State Forests – access for logging in the state forests includes Barcoongere Way at the foot of Dirty Creek Range. This is also an access for Yuraygir National Park. The timber is transported by semi trailer to mills in Woolgoolga, Coffs Harbour or Grafton; and
- Corindi Beach – further development of Corindi Beach is likely to generate heavy vehicle movements associated with construction activities.

As a result there are a number of local heavy vehicle movements along the highway, as well as the regional through traffic movements associated with the movement of freight.

Rest areas that cater for heavy vehicles currently exist at Lemon Tree Road adjacent to both the northbound and southbound carriageways. These rest stops would be either retained in their current locations or relocated as part of the upgrade. Consideration would also given to constructing a new truck stop / rest area between Arrawarra Creek and Corindi Beach.

Intersections

The project objectives include provision of intersections designed to achieve at least a level of service C in 2036 for the 100th highest hourly volume (15% of AADT).

The operation of the intersections (as at-grade facilities) at 2016 is:

- Tasman Street / Pacific Highway – operates satisfactorily;
- Coral Street / Pacific Highway – does not operate satisfactorily (LoS F on side road);
- Range Road / Pacific Highway (access to the blueberry farms) – operates satisfactorily; and
- Kungala Road / Pacific Highway – operates satisfactorily (LoS C on side road).

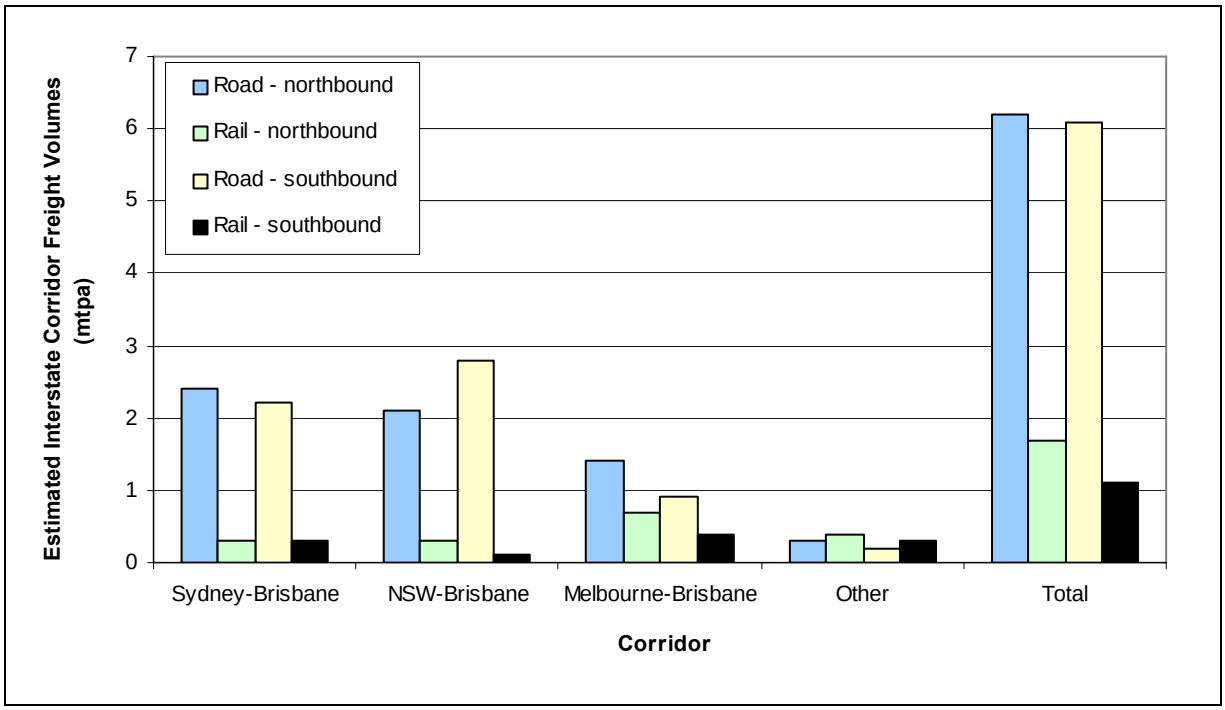
3.3.2 Other Transport Infrastructure

The North Coast Railway (NCR) runs between Sydney and Brisbane. Rail currently caters for approximately 11% of the freight transported between Sydney to Brisbane as shown on Figure 3.1.

Under proposed upgrades to the NCR between Sydney and Brisbane in AusLink and by the Australian Rail Track Corporation (ARTC), the modal split between road and rail is expected to change to between 14% and 35% by 2026 as shown on Figures 3.2 and 3.3. However the growth in heavy vehicle traffic is still predicted to approximately double the current road freight task between Brisbane and Sydney.

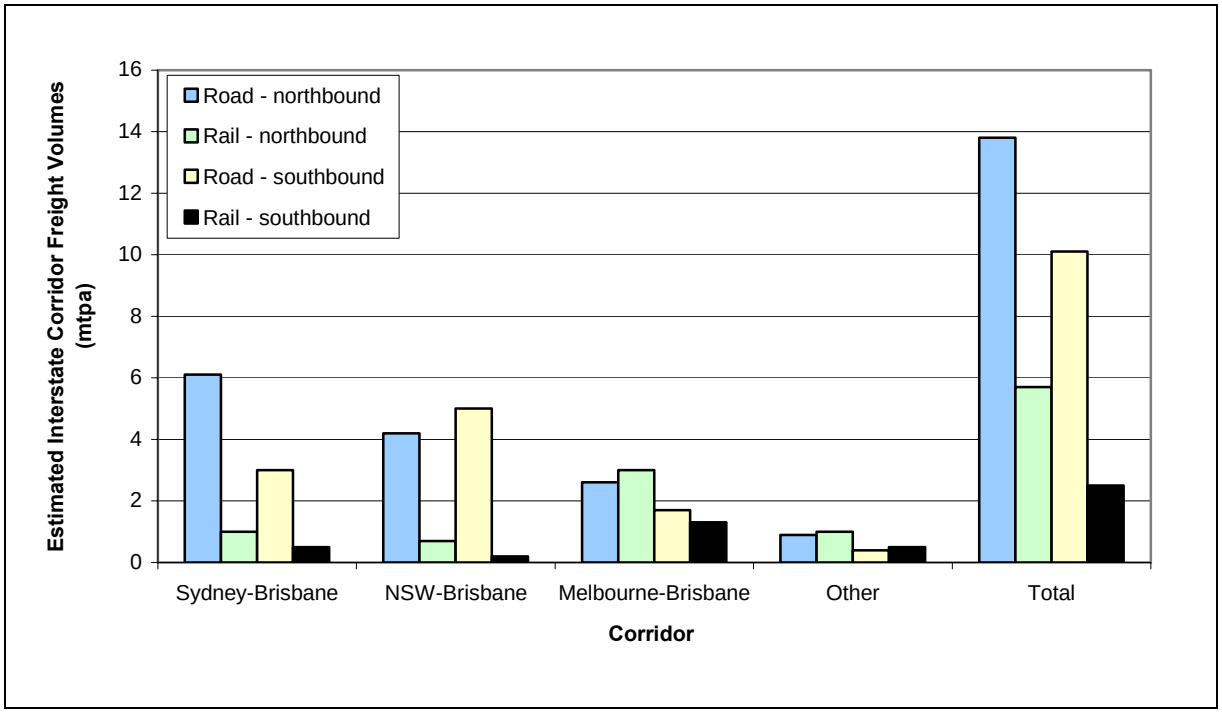
As a result, whilst the NCR can provide some relief for the highway, the modal shift will not be of sufficient magnitude to preclude the requirement to upgrade the highway.

Figure 3.1 Estimated Interstate Freight Movements (2002 – Million Tonnes Per Annum)



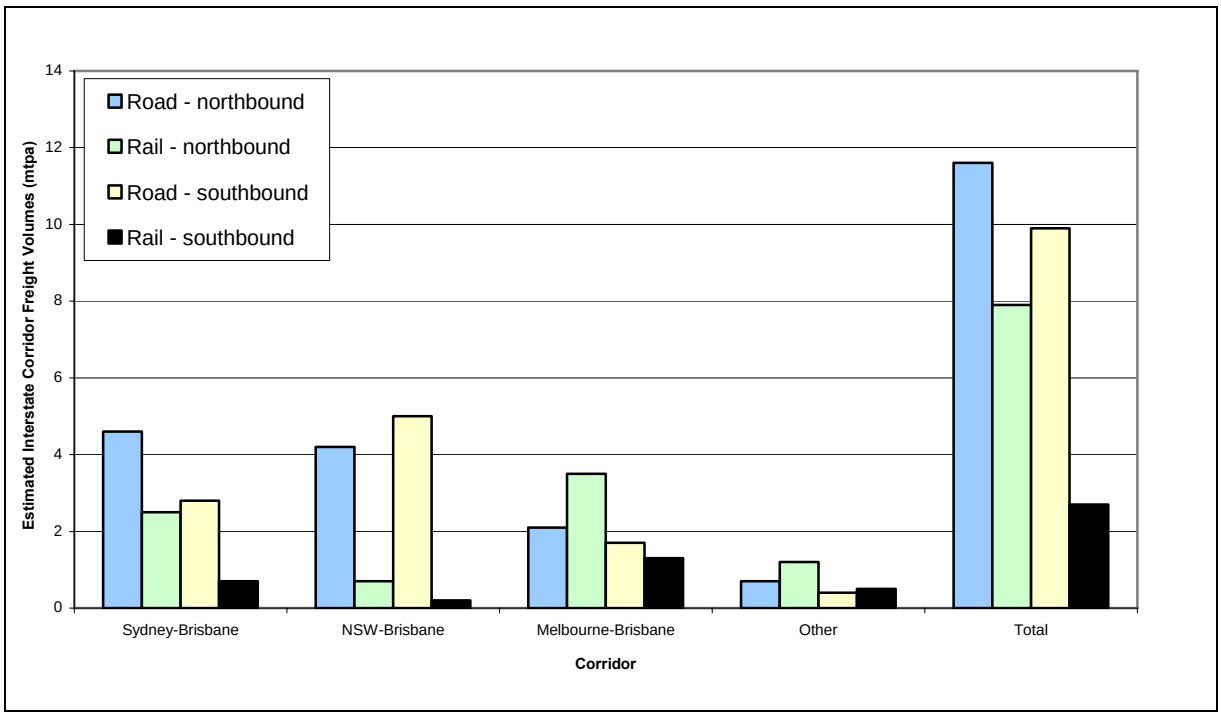
Source: GHD and Booz Allen Hamilton, 2005, 'South East Queensland Inter-Model Freight Terminal Study, Stage 2'

Figure 3.2 Estimate Interstate Freight Movements 2026 (Low Rail Share – Million Tonnes Per Annum)



Source: GHD and Booz Allen Hamilton, 2005, 'South East Queensland Inter-Model Freight Terminal Study, Stage 2'

Figure 3.3 Estimate Interstate Freight Movements 2026 (High Rail Share – Million Tonnes Per Annum)



Source: GHD and Booz Allen Hamilton, 2005, 'South East Queensland Inter-Model Freight Terminal Study, Stage 2'

3.3.3 Crash History

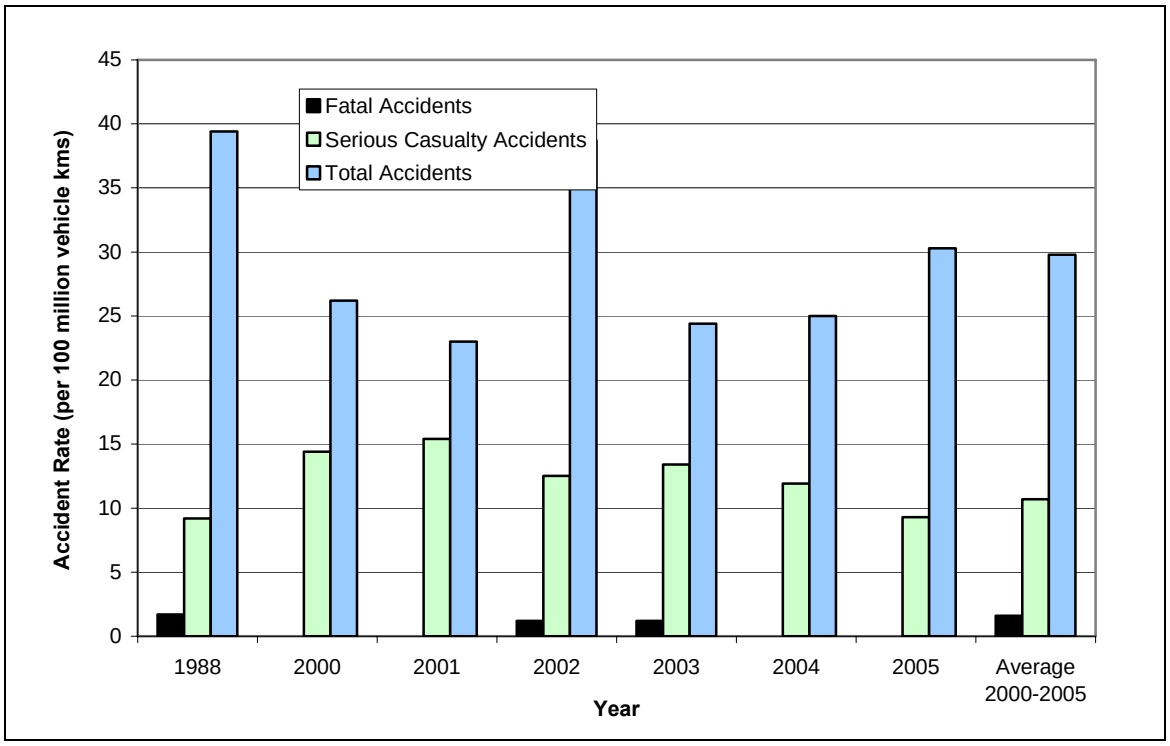
A total of 111 crashes have occurred in the study area between June 2000 and June 2005 including:

- Two crashes leading to two fatalities;
- 52 injury crashes leading to people being injured; and
- 57 other crashes.

Crash Rates

Comparing the current crash rates against those in the RTA Road Design Guide indicate that the crash rates are less than what was encountered during 1988. Current crash rates are approximately 76% of those encountered during the late 1980's as shown on Figure 3.4. As a result this indicates that fatal crashes over this section of the highway are consistent with what would be expected, although serious casualty accidents are higher.

Figure 3.4 Crash Rate Per 100 Million Vehicle Kilometres



Note: The 1988 rates have been modified from the RTA Road Design Guide based on the overall reduction in crashes between 1988 and 2004 (approximately 71%).

Crash Type Summary

The main crash types in the study area for the period 1 July 2000 to 30 June 2005 are as follows:

- Off path, on straight – 35.1%;
- Vehicles from same direction – 18.0%;
- On path – 15.3%; and
- Off path, on curve – 20.7%.

The majority of crashes involved vehicles travelling in the same direction or vehicles losing control. Further analysis reveals the following:

- Vehicles in the same direction:
  - 74% are rear end crashes due to fast moving vehicles colliding with slower accelerating or decelerating vehicles from behind;
  - 26% are right rear crashes where vehicles are hit from behind as they attempt to turn right into private roads or accesses along the highway;
- On path crashes:
  - 59% involve animals on the roadway;
  - 24% involve objects on the roadway;
- Off path, on straight crashes:
  - 64% occur when the vehicle leaves the roadway and crashes into an object;

  - 10% occur when the vehicle leaves the roadway to the left without hitting any other object;
- Off path, on curve crashes:
  - 61% of the crashes involve leaving the roadway on a left hand curve; and
  - 30% of the crashes involve leaving the roadway on a right hand curve.

Figure 3.5 illustrates the locations of all crashes over the period 2000-2005 along this section of the Pacific Highway. This data indicates that the greatest majority of crashes occur between Corindi and the base of Dirty Creek Range and immediately north of Dirty Creek Range. The section that now forms part of the Halfway Creek duplication is another high crash zone, however with the recently completed upgrade, this high accident rate is expected to decrease.

The categories of crashes highlighted in Figure 3.5 are described below:

- Fatality – a crash where there has been a fatality;
- Serious Casualty Crash – a crash where an injury has resulted that required hospitalisation; and
- Minor Crash – An accident where only minor injuries have been received and / or the vehicles involved were required to be removed.

3.4 Land Use

The study area is characterised by rural land, forests and scattered residential areas. Existing land uses within the study area generally consist of the following broad categories:

- Residential – villages and small rural localities including Arrawarra, Corindi Beach, Corindi, and Halfway Creek;
- Rural – mainly grazing lands, small orchards, the rose farm on Kungala Road, and the extensive blueberry plantation at the top of Dirty Creek Range;
- Commercial enterprises – including service stations, caravan parks and miscellaneous businesses; and
- State forests and reserves – state forests (Wedding Bells State Forest, Newfoundland State Forest and Glenugie State Forest) and conservation areas (Yuraygir State Conservation Area and Wells Crossing Flora Reserve).

Coffs Harbour City Council, as part of its current review of its settlement strategy, has identified land generally to the north of Corindi Beach as an urban investigation area. Land on the corner of Tasman Street and the existing highway has also been identified for possible commercial purposes.

Existing land use is depicted in Figure 3.6.

3.5 Heritage

3.5.1 Indigenous Heritage

Searches of relevant Commonwealth, State and local government heritage registers and a review of previous indigenous heritage investigations and studies have been undertaken. Consultation with the local Aboriginal community has also been undertaken.

Historical Characteristics

The study area is located within a region used by the Kumbainggiri (Gumbaingirr) people. A language, with likely three or four dialects, belonging to the Kumbainggeric Group was spoken over a wide area of the mid north coast. Estimates of population density are highly varied – between 0.4 and three persons per square kilometre in the coastal zone, and in the order of five persons per square kilometre in the foothills. The coastal and riverine zones contained abundant food resources that would have been extensively utilised by Aboriginal peoples.

Early contact with Europeans was often friendly, but frequently degenerated into violent clashes. Cedar getters often used Aborigines as labourers. When settlers moved in, widespread clearing occurred, resulting in systematic dispossession of Aboriginal people from their land.

In the latter part of the 1800's, the Aborigines Protection Association was formed. However, the Gumbaingirr people living at Corindi successfully established themselves outside the reserve system and the local Aboriginal people and many aspects of their traditional knowledge and culture survived.

Key Findings

Fifteen Aboriginal heritage sites listed on the NSW Department of Environment and Conservation Aboriginal Heritage Information Management System Register are located within the study area. These are (along with their listing identification numbers):

- Two isolated artefacts (13-4-0092 and 22-1-0153 / 22-1-0156);
- Three artefact scatters (22-1-0034, 22-1-0076 and 22-1-0098);
- Five shell middens (22-1-0021 and 22-1-0032 / 22-1-0033);
- A shell midden and artefact scatter (22-1-0146);
- Two scarred trees (22-1-0154 / 22-1-0155 and 22-1-0158);
- A natural mythological site and scarred tree (22-1-0082); and
- A burial site (22-1-0114).

Sites of indigenous heritage significance within the study area are depicted on Figure 3.7.

There were no items listed under either Commonwealth or local government heritage registers or planning instruments within the study area.

An indicative natural place (ID #16399) provisionally listed on the Register of the National Estate under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, marginally encroaches into the eastern edge of the study area. This site encompasses an extensive area of the coastline between Moonee Beach and Corindi Beach. This listing is under assessment and currently has no legal bearing.

The predictive model of site location indicates that additional indigenous heritage resources (in particular stone artefacts) are likely to occur throughout the study area. Such evidence may not be unique to the study area. Detailed field survey is required to assess their presence.

The study area also includes lands vested in the Aboriginal community in accordance with the *Aboriginal Lands Right Act 1983* as shown on Figure 3.7.

Aboriginal Community Consultation

The study area lies within the boundaries of the Coffs Harbour and District Local Aboriginal Land Council (LALC) and Grafton-Ngerrie LALC, and within an area of interest to the Yarrawarra Aboriginal Corporation (including the Garby Elders). The LALC boundary is shown on Figure 3.7.

A number of areas of cultural sensitivity to the local Aboriginal community, inclusive of both registered and unregistered sites, are also known to occur within the study area as shown on Figure 3.7. This has been confirmed as a result of consultations with the Aboriginal community. These areas include:

- A men's ceremonial site in the southwestern corner of the study area;
- Corridors of movement and associated cultural areas in the southern part of the study area;
- Historical camp sites within Wedding Bells State Forest west of the existing highway;
- Burial site west of Corindi Beach and largely north of Kangaroo Trail Road;
- Historical camp sites, associations, resource use, "Widow Tree", burial and associated cultural areas around Corindi Beach;
- Massacre site generally between Cassons and Blackadder Creek, extending to Red Rock;
- An unspecified area of sensitivity within Dirty Creek Range around the Wooli Wooli River on the eastern edge of the study area;
- Historical camp sites generally between the top of Dirty Creek Range and the Halfway Creek duplication;
- A bora / ceremonial site located in the vicinity of Halfway Creek; and
- Historical travel route and campsites traversing the northern part of the study area near Wells Crossing.

3.5.2 Non-Indigenous Heritage

An assessment of non-indigenous heritage characteristics of the study area and surrounding locality was undertaken. The assessment included searches of relevant Commonwealth, State and local government heritage registers and planning instruments, and research of local historical records.

Historically, timber was an important activity. By the end of the 1820's, groups of timber cutters began moving northward beyond Port Macquarie. The Coffs Harbour region was overlooked for some time because of the lack of a navigable river and it was not until the 1870's that the timber was cut in any quantity. With the construction of a jetty at Coffs Harbour in 1892, sawmills began to be built in the area.

Timber was an important industry in Woolgoolga. The British Australian Timber (BAT) and the Great Northern Timber (GNT) companies worked from Woolgoolga in the early 1900's. They both built tramlines inland to replace the bullock teams that previously hauled the logs to port. Review of historical mapping indicates that one of these tramlines travelled north of Woolgoolga partially along the route of the Pacific Highway and terminated inland near Corindi River.

The road linking Kempsey and Grafton originally traversed inland via Ebor. It was not until 1875 that a coastal route linked Coffs Harbour with both the north and the south. Agricultural production commenced in the vicinity of Coffs Harbour in the 1880's and by the turn of the century bananas were being grown in the vicinity of Woolgoolga. Soldier settlement following World War I resulted in an increase of small farm holdings, however large tracts of land remained within state forests.

Listed heritage items are not located within or in the immediate vicinity of the study area. However, historical records indicate that a range of industries and activities were carried out in the locality, evidence of which in the form of historical relics has the potential to occur within the study area. The study area topographic map denotes the location of two sets of "ruins" within the study area, immediately to the northwest of Corindi. Further investigation is essential to identify the nature of these relics. Such evidence may be protected under the *NSW Heritage Act 1977* where it is 50 years or older.

3.6 Visual Amenity

The study area is set within the coastal plain and coastal hinterland between Coffs Harbour and Grafton. In contrast, the highway to the south is characterised by the coastal settlement and steep coastal hills around Coffs Harbour, and to the north by the Clarence River floodplain.

The southern part of the study area is located on the coastal plain behind Arrawarra Headland and Corindi Beach, where it passes through forested and wetland areas.

The highway then passes through pastureland with scattered woodland areas. Corindi Beach occupies much of the land between the highway and the coast in this location and is largely visually separated from the existing highway.

North of Corindi Beach, the highway passes through the floodplain of the Corindi River and associated tributaries. Visual features in this area include pastureland and the village of Corindi, which is located on both sides of the existing highway.

The highway then enters a mainly forested landscape as it rises out of the Corindi River floodplain. The straight horizontal alignment of the highway in this area allows some views north to the Dirty Creek Range.

At the end of this straight section, the highway rises more dramatically as it climbs the Dirty Creek Range. Visually, the range and Eucalypt forests dominate this area.

Enclosed forest, with some partially cleared pastureland occurs along the relatively flat and straight section of the highway between Grays Road and Lemon Tree Road, and through to the end of the project north of Wells Crossing. Views in this area are relatively enclosed. The only interruption to the landscape in this area is the small collection of buildings (including the service station and motel) and the rest area at Lemon Tree Road, and the community of Halfway Creek.

3.7 Noise

Noise from the existing highway alignment was calculated at each potential receiver identified within the study area. Potential receivers were identified based on aerial photographic interpretation and limited ground truthing work.

The noise level from the existing highway was calculated using procedures based on the *CoRTN* prediction algorithms. This model was implemented using ROADent software. Modelling was undertaken for a typical weekday based on the surveyed traffic volume, traffic speed and composition provided for the existing highway.

The modelled results were compared with the NSW Department of Environment and Conservation's criteria for a "Redeveloped Highway" of 60 dB(A) during the day and 55 dB(A) during the night. These criteria would apply where it is proposed to upgrade the existing highway without major deviation from the existing alignment, and as such potentially represents the possible minimum upgrade for this project in some sections.

The preferred route may include sections that significantly deviate from the existing alignment of the highway. These locations would be subject to the DEC's "New Highway" criteria of 55 dB(A) during the day and 50 dB(A) at night.

The modelling results indicate that 55, or approximately 8% of the potential receivers currently experience daytime noise levels that exceed the DEC's "Redeveloped Highway" criteria. The results also indicate that 178, or approximately 25% of the potential receivers experience night time noise levels that exceed the DEC's "Redeveloped Highway" criteria.

The majority of these receivers are located in the vicinity of Corindi Beach and in the caravan parks to the east of the existing highway south of Corindi Beach. Additional isolated receivers are distributed along the remainder of the existing highway.

A preliminary comparison of the modelled, or predicted existing noise levels, with noise monitoring results collected during post-construction monitoring of the completed Halfway Creek duplication, indicate the predicted levels are comparable.

3.8 Ecology

This project has been divided into terrestrial and aquatic ecology based on the following study boundaries:

- Terrestrial ecology covers all non-aquatic habitats, as well as vertebrate non-fish fauna species that may occupy swamps and marshes; and
- Aquatic ecology covers all wetland habitats such as creeks and rivers, including their immediate riparian habitats, and swamps and marshes.

The investigations have considered, as relevant, the following key matters:

- Threatened species populations and endangered ecological communities listed under the NSW *Threatened Species Conservation Act 1995* (TSC Act), NSW *Fisheries Management Act 1994* (FM Act) or Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act);
- Rare flora species are those identified by Briggs and Leigh (1996), *Rare or Threatened Australian Plants* (RoTAP). Rare flora species may also be listed as threatened;

- Migratory species as listed under the EPBC Act. Migratory species may also be listed as threatened;
- Protected species are defined as those listed under the FM Act 1994 or *National Parks and Wildlife Act 1974* (NPW Act); and
- Wetlands listed as being of State significance under *State Environmental Planning Policy No. 14 – Coastal Wetlands* (SEPP 14), of national importance as listed under the Directory of Important Wetlands in Australia, or international importance (Ramsar) as protected under the EPBC Act.

3.8.1 Terrestrial Ecology

Features of the Study Area

The natural environment in the study area varies. At the southern end the topography is flat, low-lying and contains large areas of brackish or freshwater coastal paperbark and she-oak swamps. This part of the study area is well vegetated.

In the vicinity of Corindi River much of the land has been cleared and little natural vegetation remains apart from remnant paddock trees and remnant patches of vegetation.

The undulating terrain of Dirty Creek Range is characterised by areas of natural forest, including wet sclerophyll forest with rainforest elements to the east of the highway.

The northern part of the study area is relatively flat or gently undulating. It contains of mixture of small cleared farm areas and large forest areas consisting of a diversity of forest types. These include blackbutt and wet sclerophyll forest, scribbly gum forest, rough-barked apple scrub, spotted gum-ironbark forest and riparian vegetation.

Scope of Investigations

The ecological investigations undertaken to date have been based on an initial preliminary field survey, supplemented by further more detailed field work in the vicinity of the developed route options in key parts of the study area.

For route options assessment these investigations are preliminary only. The environmental assessment of the preferred route will include detailed ecological assessments in accordance with relevant DEC guidelines including the currently draft Threatened Biodiversity Guidelines.

The preliminary survey generally involved:

- Review of the TSC Act and EPBC Act, including any recent determinations and any recently released relevant reports or mapping studies;
- Review of key threatened species databases including the NSW Department of Environment and Conservation and Bird Atlas of NSW lists of known or potential threatened species, endangered ecological communities and endangered populations for the study locality and study area;
- Preparation of maps indicating the likely location of any threatened species, endangered ecological communities and endangered populations within the study area;
- Describing the existing biological environment of the study area in relation to flora and fauna, based on preliminary field examination of habitats along the existing highway and interpretation of air photographs and maps for areas that have not been ground-truthed; and

- Discussion of the potential constraints and impacts of each route option with regards to threatened species, populations or ecological communities and other limiting factors, such as wildlife corridors, that are known or may potentially occur based on a review of flora and fauna databases.

Supplementary investigations were undertaken in key parts of the study area where the developed route options deviated significantly (i.e. Sections B and C) and generally included the following:

- A flora and fauna habitat assessment within vegetated areas of all route option investigation areas;
- Preparation of maps of the broad vegetation associations within the route options investigation areas based on a combination of the field data and aerial photograph interpretation;
- Describing the nature and characteristics of each broad vegetation association; including habitat, structure and dominant or characteristic species;
- Determining which of the vegetation associations are likely to constitute endangered ecological communities;
- Identifying areas of potentially key habitat for fauna species on maps, particularly threatened fauna;
- Mapping the locations of any fauna habitat features of particular importance, for example mature habitat trees; and
- Describing the particular fauna habitat features for each route option, and identify the threatened fauna species that could potentially utilise these habitat features.

Key Findings

Key areas of terrestrial ecological characteristics are depicted in Figures 3.8 to 3.11 (terrestrial flora) and Figures 3.12 to 3.13 (terrestrial fauna).

Terrestrial Flora

Threatened Species

A desktop review of threatened species records from a variety of sources indicated the following:

- Within 10 km of the existing highway, 24 threatened flora species have been recorded;
- Within two kilometres of the existing highway, seven threatened flora species have been recorded;
- DEC have advised that one additional threatened flora species (*Acacia chrysotricha*) listed under the TSC Act 1995, but not previously recorded within the locality, is potentially present; and
- The Commonwealth Department of Environment and Heritage (DEH) Protected Matters Search Tool identified four additional threatened flora species that have the potential to occur but have not been previously recorded.

These threatened flora species are listed in Table 3.5.

Rare Flora Species

A review of RoTAP listings indicates that an additional 19 rare flora species have been recorded or have the potential to be present. Of these, six have been recorded within two kilometres of the existing highway, and two of these have been recorded within the study area:

- Water-shield (*Brasenia schreberi*); and
- Austral moonwort (*Botrychium australe*).

These rare flora species are listed in Table 3.5.

Table 3.5 Threatened Flora Species With Potential to be Present Within the Study Area

Common Name	Scientific Name	TSC Act 1995 Status	EPBC Act Status	RoTAP Status
N/A	*Lindsaea incisa*	Endangered	N/A	N/A
Square-fruited ironbark	*Eucalyptus tetrapleura*	Vulnerable	Vulnerable	2VCa
N/A	*Phaius australis*	Endangered	Endangered	3VCa
Rusty plum	*Amorphospermum whitei*	Vulnerable	N/A	3ECa
N/A	*Leucopogon confertus*	Endangered	Endangered	3E
N/A	*Boronia umbellata*	Vulnerable	Vulnerable	2VC-
Water-shield	*Brasenia schreberi*	N/A	N/A	V
N/A	*Marsdenia longiloba*	Endangered	Vulnerable	3RC-
N/A	*Acacia chrsotricha*	Endangered	N/A	2R
N/A	*Plectranthus suaveolens*	N/A	N/A	K
N/A	*Olearia stilwelliae*	N/A	N/A	R
N/A	*Acianthus amplexicaulis*	N/A	N/A	R
Austral moonwort	*Botrychium australe*	N/A	N/A	R
N/A	*Acianthus exiguus*	N/A	N/A	3RC-

Note:
RoTAP coding (Briggs and Leigh 1996):
2 Geographic range in Australia less than 100 km;
3 Geographic range in Australia greater than 100 km;
E Endangered Species: At risk of disappearing from the wild within 10-20 years if present land use and other threats continue to operate;
V Vulnerable Species: Not presently endangered, but possibly at risk in future due to continuing depletion or land-use change;
R Rare Species: Rare in Australia, but currently without any identifiable threat;
C Reserved: Indicates taxon has at least one population within a national park, or other proclaimed conservation reserve or in an area otherwise dedicated for the protection of flora;
K Poorly known;
a Indicates that 1000 plants or more are known to occur within a conservation reserve(s); and
- Reserved population size is not accurately known.

Vegetation Communities

As previously discussed, maps of the broad vegetation communities within the supplementary route option investigation areas have been prepared, based on a combination of the field data and aerial photograph interpretation.

The results of the vegetation community mapping is shown on Figure 3.10.

Flora Habitat Values

Based on interpretation of the vegetation community mapping, flora habitat features for each route option were assessed, and the threatened flora species that could potentially occur were identified.

There was no habitat for species in addition to the threatened and rare flora species listed in Table 3.5 identified within the study area.

Endangered Ecological Communities

Three endangered ecological communities listed under the TSC Act were found during field investigations to occur within the study area:

- Lowland rainforest on floodplain in the NSW North Coast bioregion;
- Swamp sclerophyll forest on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions; and
- Subtropical coastal floodplain forest of the NSW North Coast bioregion.

Three endangered ecological communities listed under the TSC Act are known to occur within the vicinity of the study area:

- Coastal saltmarsh in the NSW North Coast, Sydney Basin and South East Corner bioregions;
- Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions; and
- Swamp Oak floodplain forest of the NSW North Coast, Sydney Basin and South East Corner bioregions.

The wetlands and associated low-lying coastal areas in the study area may contain these communities.

The following endangered ecological communities listed under the TSC Act have the potential to occur, but are considered unlikely to be present within the study area:

- Hunter lowland redgum forest in the Sydney Basin and NSW North Coast bioregions; and
- White box, yellow box, Blakely's red gum woodland.

Based on the investigations conducted to date, the locations of confirmed and potential endangered ecological communities are shown on Figure 3.11. This mapping is based primarily on the supplementary investigations undertaken in the vicinity of the developed route options in Sections B and C. It is likely that other areas of endangered ecological communities exist within the study area, particularly on the Corindi River floodplain.

Forest Ecosystem Mapping

As part of the Regional Forest Agreement (RFA) process, a Comprehensive Regional Assessment (CRA) was undertaken to assess a number of values, including ecological, within the Lower North East CRA regions. The CRA provided scientific information for the development of a comprehensive, adequate and representative forest reserve system.

The CRA included development of a forest ecosystem classification system that was derived by splitting and amalgamation of existing Forest NSW forest types based on analysis of variation between field survey plots with regard to environmental variables. These were then mapped based on existing mapping (primarily from aerial photography) and predictive mapping. The mapping was undertaken using a 100 metre grid system.

The data collected on each of the forest ecosystems included predicted area of the ecosystem pre-1750 and present; and the area remaining within reserve systems. It should be noted that the CRA data has not been verified by detailed field survey for the whole study area, and given the level of mapping used to derive this data, it is expected that there will be some inaccuracies.

This data was previously used for the Woolgoolga to Wells Crossing project as it represented the only complete vegetation data set for the study area. However, following completion of the supplementary field investigations, which included vegetation community mapping, significant inaccuracies were identified in the CRA data. As a result this data has not been referenced in this report.

Coffs Harbour City Council Vegetation Mapping

Coffs Harbour City Council has undertaken vegetation mapping on private land within the study area, initially only within the previous LGA boundary (generally east of the existing highway between Corindi Beach and Arrawarra, and more recently up to the new LGA boundary near Dirty Creek Range.

This vegetation data was referenced in the development of the vegetation community maps (Figure 3.10) following the completion of the supplementary investigations for this project.

Compensatory Habitat

The Department of Planning has advised that there are a number of parcels of vegetation in the immediate vicinity of the large blueberry farm operated by Blueberry Farms (Chiquita) on Range Road in Section C, that are subject to a yet to be formalised conservation agreement. These areas were identified for flora and fauna protection to allow expanded cropping operations. While this agreement has not been formally signed off the Department of Planning has advised that they would request the RTA to compensate for any loss of these areas by protecting a similar area of vegetation in the immediate area.

Terrestrial Fauna

Threatened and Migratory Species

A desktop review of threatened and migratory species records from a variety of sources indicated the following:

- Within 10 km of the existing highway, 56 threatened fauna species have been recorded;
- Within two kilometres of the existing highway, 31 threatened fauna species have been recorded;
- DEC have advised that one additional threatened fauna species listed under the TSC Act 1995 (*Hoplocephalus bitorquatus* – Pale-headed snake), but not previously recorded within the locality, is potentially present;
- The Commonwealth Department of Environment and Heritage (DEH) Protected Matters Search Tool identified 11 additional threatened fauna species that have the potential to occur but have not previously been recorded. Of these, potential habitat is present in the study area for three of these species; and
- The DEH Protected Matters Search Tool identified seven terrestrial migratory species that may use the area for nesting habitat and require consideration. One of these species, the Regent honeyeater (*Xanthomyza phyrygia*), was also listed as threatened.

Threatened and migratory fauna species known to be present, or with the potential to be present (based on known habitats), within the study area are summarised in Table 3.6 and are shown on Figure 3.12.

Table 3.6 Threatened Fauna Species With Potential to be Present Within the Study Area

Common Name	Scientific Name	TSC Act Status	EPBC Act Status
Birds			
Glossy black cockatoo	*Calyptorhynchus lathami*	Vulnerable	N/A
Great knot	*Calidris tenuirostris*	Vulnerable	Migratory
Square-tailed kite	*Lophoictinia isura*	Vulnerable	N/A
Powerful owl	*Ninox strenua*	Vulnerable	N/A
Masked owl	*Tyto novaehollandiae*	Vulnerable	N/A
Barking owl	*Ninox connivens*	Vulnerable	N/A
Swift parrot	*Lathamus discolour*	Endangered	Endangered
Black bittern	*Ixobrychus flavicollis*	Vulnerable	N/A
Black-necked stork	*Ephippiorhynchus asiaticus*	Vulnerable	N/A
Freckled duck	*Stictonetta naevosa*	Vulnerable	N/A
Collared kingfisher	*Todiramphus chloris*	Vulnerable	N/A
Little tern	*Sterna albifrons*	Endangered	Migratory
Ground parrot (eastern subsp.)	*Pezoporus wallicus wallicus*	Vulnerable	N/A
Brolga	*Grus rubicundus*	Vulnerable	N/A
Osprey	*Pandion haliaetus*	Vulnerable	Migratory
Brown treecreeper	*Climacteris picumnus*	Vulnerable	N/A
Barred cuckoo-shrike	*Coracina lineata*	Vulnerable	N/A
Wompoo fruit-dove	*Ptilinopus magnificus*	Vulnerable	N/A
White-bellied sea-eagle	*Haliaeetus leucogaster*	N/A	Migratory
White-throated needletail	*Hirundapus caudacutus*	N/A	Migratory
Black-faced monarch	*Monarcha melanopsis*	N/A	Migratory
Satin flycatcher	*Myiagra cyanoleuca*	N/A	Migratory
Rufous fantail	*Rhipidura rufifrons*	N/A	Migratory
Spectacled monarch	*Monarcha trivirgatus*	N/A	Migratory
Regent honeyeater	*Xanthomyza phyrygia*	N/A	Endangered / Migratory

Common Name	Scientific Name	TSC Act Status	EPBC Act Status
Frogs			
Olongburra frog	*Litoria olongburensis*	Vulnerable	Vulnerable
Wallum froglet	*Crinia tinnula*	Vulnerable	N/A
Stuttering frog	*Mixopyes balbus*	Endangered	Vulnerable
Reptiles			
Stephen's banded snake	*Hoplocephalus stephensii*	Vulnerable	N/A
Non-Flying Terrestrial Mammals			
Koala	*Phascolarctos cinereus*	Vulnerable	N/A
Brush-tailed phascogale	*Phascogale tapoatafa*	Vulnerable	N/A
Common planigale	*Planigale maculata*	Vulnerable	N/A
Spotted-tailed quoll	*Dasyurus maculatus maculatus*	Vulnerable	Endangered
Squirrel glider	*Petaurus norfolcensis*	Vulnerable	N/A
Yellow-bellied glider	*Petaurus australis*	Vulnerable	N/A
Rufous bettong	*Aepyprymnus rufescens*	Vulnerable	N/A
Long-nosed potoroo	*Potorous tridactylous tridactylous*	N/A	Vulnerable
Flying Terrestrial Mammals			
Grey-headed flying-fox	*Pteropus poliocephalus*	Vulnerable	Vulnerable
Little bent-wing bat	*Miniopterus australis*	Vulnerable	N/A
Hoary wattled bat	*Chalinolobus nigrogriseus*	Vulnerable	N/A
Common blossom bat	*Syconycteris australis*	Vulnerable	N/A
Golden-tipped bat	*Kerivoula papvensis*	Vulnerable	N/A
Large-eared pied bat	*Chalinolobus dwyeri*	N/A	Vulnerable

Fauna Habitat Values

Based on interpretation of the vegetation community mapping, fauna habitat features for each route option were assessed and the threatened fauna species that could potentially utilise these habitat features were identified.

In addition to the threatened fauna species listed in Table 3.6, potential habitat for an additional twenty-three threatened fauna species were identified:

- Eastern false pipistrelle;
- Greater broad-nosed bat;
- Eastern bentwing-bat;
- Southern myotis;
- East-coast freetail bat;
- Yellow-bellied sheathtail bat;
- Black flying fox;
- Bush stone curlew;
- Comb-crested jacana;
- Painted honeyeater;
- Black-chinned honeyeater;
- Hooded robin;
- Turquoise parrot;
- Grey-crowned babbler;
- Diamond firetail;
- Sooty owl;
- Red goshawk;
- Superb fruit-dove;
- Rose-crowned fruit-dove;
- Eastern pygmy possum;
- Green and golden bell frog;
- Giant barred frog; and
- Pale headed snake.

Koala Habitat Values

The Coffs Harbour Koala Plan of Management (1998) applies to the southern part of the study area within the old Coffs Harbour City LGA generally to the east of the existing highway between Arrawarra and Corindi Beach.

Secondary koala habitat is mapped in the plan of management on the eastern side of the existing highway in this part of the study area as shown on Figure 3.12.

Endangered Populations

One endangered fauna population, emu (*Dromaius novaehollandiae*), could be present within the locality. While there are no records within two kilometres of the study area, the potential presence of emus requires consideration.

There are no known endangered flora populations within, or in the immediate vicinity of the study area.

Key Habitats and Wildlife Corridors

Key habitats and wildlife corridors have been mapped by NPWS as part of the Key Habitats and Corridors in North East NSW Mapping Project. A review of this mapping has found that:

- Eleven wildlife corridors pass through the study area; and
- Two wildlife corridors are located just to the north of the study area.

A number of patches of key habitat are located within the study area.

Other Terrestrial Matters Protected Under the EPBC Act 1999

The Yuraygir National Park is listed on the Register of the National Estate as a natural site. This area represents a diverse range of high quality habitats and is located to the north and northeast of the study area. The headwaters of a number of catchments including Corindi River enter the park after traversing the study area.

3.8.2 Aquatic Ecology

Features of the Study Area

The following key aquatic habitat features have been identified within the study area and are shown on Figure 3.14:

- Small coastal lagoons and sandplain wetlands south of Corindi Beach. These wetlands from behind the dunal barriers and tend to be brackish and seasonal. Wetlands such as these are often referred to as "wallum" swamps, and characteristic vegetation includes Broad-leaf Paperbark (*Melaleuca quinquenervia*) swamp forests, heathland and sedgelands;
- Wetlands listed under *State Environmental Planning Policy 14 – Coastal Wetlands* (SEPP 14) are located near Corindi Beach, east of the highway;
- Solitary Islands Marine Park covers an extensive coastal area adjacent to the study area. The park extends along Arrawarra Creek within the study area to a point approximately 300 metres to the east of the existing highway. The park also extends along the Corindi River to a point just within the eastern boundary of the study area. Both Arrawarra Creek and Corindi River within these extents are mapped as habitat protection zones;
- There are a number of creeks and rivers within the study area that contain aquatic habitats. While some wetland plants are present in ponds, characteristic wetland vegetation is typically sparse or absent on the stream banks; and
- There are wetlands associated with Halfway Creek.

Key Findings

Threatened Species

Database searches revealed that there are no aquatic flora species within the study area listed as threatened under the NSW *Threatened Species Conservation Act 1995* (TSC Act 1995), the NSW *Fisheries Management Act 1994* (FM Act 1994) or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act 1999).

Although not listed on the NSW National Parks and Wildlife Service's *Wildlife Atlas* database three threatened wetland plants species are known to be present on the north coast of New South Wales in habitat types that occur in the study area:

- Maundia (Maundia triglochinoides);
- Swamp Orchid (*Phaius tankervilliae*); and
- The orchid Phaius australis.

The endangered fish species Oxleyan Pygmy Perch (*Nannoperca oxleyana*) is known to be present in streams in wallum swamps north of Forster with records near Wooli, northeast of the study area. This species could potentially be present in the study area. Mapping provided by the Department of Primary Industries (NSW Fisheries) indicates that Redbank Creek and Cassons Creek within the study area is known habitat for the Oxleyan Pygmy Perch, while some of the upper tributaries of the Corindi River (to the west of the study area) are potential habitat (Figure 3.14).

Further, the endangered Eastern Freshwater Cod (*Maccullochella ikei*), while considered unlikely to be present, requires consideration.

Rare Flora Species

In addition to the above statutory listings, one species (*Hydrocharis dubia*) listed on the Briggs and Leigh (1995) list of Rare or Threatened Australian Plants (RoTAP) is known to be present on the north coast, mainly north from the Clarence River. This species grows in small shallow freshwater bodies or swamps.

Protected Aquatic Species

The following aquatic species, while not threatened, are listed as protected under the FM Act or NPW Act:

- Red-fruited saw edge (*Gahnia sieberiana*);
- Tassel-rush (Restio tetraphyllus);
- Pink swamp heath (*Sprengelia incarnata*);
- Grass trees (Xanthorrhoea spp.);
- Christmas bells (Blandfordia grandiflora);
- Seaweeds;
- Seagrasses; and
- Mangroves.

Solitary Islands Marine Park

As noted above the Solitary Islands Marine Park covers an extensive coastal area adjacent to the study area, and extends along Arrawarra Creek within the study area to a point approximately 300 metres to the east of the existing highway and along the Corindi River to a point just within the eastern boundary of the study area.

The Woolgoolga to Wells Crossing project begins north of Arrawarra Creek, where it joins the preferred route for the Sapphire to Woolgoolga project. The environmental assessment of the preferred route would need to further consider potential water quality impacts on the marine park.

Listed Wetlands

There are two SEPP 14 wetlands located within the study area, both of which are located between Arrawarra and Corindi Beach and are shown on Figure 3.14. Further, there are an additional two SEPP 14 wetlands located downstream of the study area to the north of Corindi Beach.

There are no nationally or internationally listed wetlands in the immediate vicinity of the study area as identified by the DEH Protected Matters Search Tool.

3.9 Topography, Geology and Soils

3.9.1 Topography

The study area can be divided into three distinct terrain domains – coastal, range and tableland. Within the study area, the land rises from sea level to heights of up to 200 metres.

The topography to the southeast is generally flat, characterised by a coastal plain. Further northwest, the plain gradually transitions to undulating ground before reaching the foothills of the Dirty Creek Range, in the middle of the study area. The Dirty Creek Range features very steep terrain with well defined peaks, ridgelines, gullies and escarpments.

West of the range, the landform flattens out to the tableland domain. The landform in this area is flat to undulating with meandering watercourses.

Figure 3.15 depicts the topography of the study area. The figure indicates that the existing highway alignment avoids the steep and high elevation terrain in and in close proximity to the study area.

3.9.2 Regional Geology

The coastal plains in the southeast of the study area feature extensive low lying alluvial, aeolian and estuarine swamp deposits, which occur between lowland hills and beach / dune landscapes. Some of the larger coastal river systems, such as the Corindi River, also contain Quaternary alluvial deposits extending inland towards the Dirty Creek Range.

Immediately inland from the coastal plains are the Carboniferous aged Coramba Beds forming a lowland range topography of hills, spurs and ridges. This geological unit comprises low-grade metamorphic and sedimentary rock including greywacke, slate, siltstone, quartzite and chert.

The Dirty Creek Range consists of Triassic / Jurassic aged sedimentary strata. The geological units from east to west include:

- Corindi Conglomerate – a quartz pebble conglomerate forming the east side of the range;
- Marburg Formation – comprising sandstone, shale siltstone with minor coal and conglomerate; and
- Walloon Coal Measures – comprising shale, sandstone and coal.

West of the range the land is formed by Jurassic / Cretaceous aged sedimentary strata. The Kangaroo Creek Sandstone and overlying Grafton Formation includes sandstone, siltstone, claystone and coal with minor conglomerate. Some localised gravel deposits occur in the area.

3.9.3 Rock Stability

There are some issues associated with the rock stability in the study area. The central portion of the study area contains the most elevated terrain associated with Dirty Creek Range. Within this area the existing highway batters slope at 1H:1V (every one metre horizontally corresponds to an increase of one metre in vertical height). The cuttings in this area located within the Lower Marburg Formation are characterised by localised instability in the form of undercutting, ravelling and sliding associated with the presence of erodible siltstone seams.

The Lower Marburg Formation has inclined bedding with a jointed rock mass. The combination of these geological structures provides a potential mechanism for large-scale rock cutting instability. Constructing future batter slopes at 2H:1V would reduce future maintenance associated with the observed localised instability. The steeper cutting geometry could be retained with shotcrete protection applied to the erodible seams.

The other major geological unit observed within existing cuttings is the Corindi Conglomerate. Excavations have been undertaken to 40 to 50 metres within this geological unit at a quarry within the study area. These excavations had subvertical batters and five metre wide berms with minimal rock mass instability with the exception of small scale fretting and erosion of siltstone beds. From observations of the quarry and cuttings within this geological unit on the existing highway, there is a low potential for large-scale rock cutting instability within the Corindi Conglomerate unit. Based on preliminary assessments, future cuttings within the Corindi Conglomerate unit could remain at the existing batter slopes of 1H:1V.

3.9.4 Soil Issues

There is a high probability of the presence of acid sulphate soils in the coastal plains. A high risk of encountering acid sulphate soils has been identified in the vicinity of Corindi River, and varying levels of risk have been identified in the vicinity of Arrawarra Creek.

The highway upgrade is expected to have negligible impact on groundwater levels within the potential acid sulphate soils. Consequently there is a very low probability that acid water will be generated through in-situ oxidisation of acid sulphate soils due to groundwater lowering.

Preliminary subsurface investigations conducted within the Corindi floodplain found a relatively thin (1.5 metre) layer of soft soil north of Corindi River. Due to its small thickness and existing overburden pressure, limited settlement can be expected as a result of the construction of embankments. It is anticipated that specialist construction techniques can be avoided and hence such limited settlement could be accommodated in conventional embankment design.

Preliminary investigations south of the Corindi River did not encounter soft soil. While the findings of the preliminary investigation suggest that shallow soft soils are unlikely to occur in the area, the possibility of encountering such soils elsewhere in the alluvial plains cannot be discounted. This includes the Arrawarra Creek floodplain where there is a likelihood of soft soils.

There is some potential for soil contamination in the study area. Past and present activities that may have caused contamination include agriculture (particularly banana, blueberry and livestock farming), service station and sawmill operations, quarrying and wastewater treatment. Possible areas are shown on Figure 3.6.

Figure 3.16 shows the likely locations of soft soils and Figure 3.17 shows the likely location of acid sulphate producing soils.

3.10 Geotechnical Issues

3.10.1 Rock Cuttings

In the southern portion of the study area, up to Barcoongere Way, cuttings on the existing highway are performing adequately at batter angles of around 45° (1H:1V). However, some localised instability including small scale slumping of weathered materials and localised toppling failures may require stabilisation. Flattening of batter slopes to 2H:1V would reduce future maintenance associated with such localised instability.

The highway through Dirty Creek Range traverses two geological units, namely the Corindi Conglomerate unit and the Lower Marburg Formation, which includes sandstone, siltstone and some minor conglomerate. The Corindi Conglomerate dominates a quarry near the existing highway where excavations have been undertaken to 40 to 50 metres in depth with subvertical batters and five metre wide berms. From the performance of this quarry, and other cuttings within this rock unit on the existing highway, there is a low potential for large-scale rock cutting instability in this rock unit. For the purpose of preliminary cut batter angles for route assessment, it can be assumed to be 1H:1V as per the existing road cuttings in this rock unit.

The existing cuttings through Dirty Creek Range show blasting drill holes for cuttings up to 15 metres depth. It is expected that blasting will be required for the new alignment, particularly as cuttings up to 30 metres depth may be necessary. Further investigation and analysis is required to confirm the need for blasting.

Cuttings located within the Lower Marburg Formation will encounter inclined bedding within a jointed rock mass. The combination of these geological structures provides a potential mechanism for large-scale rock cutting instability. Based on the performance of the existing cuttings within the Lower Marburg Formation, the cuttings within Dirty Creek Range can expect localised instability in the form of undercutting, ravelling and sliding associated with the presence of erodible siltstone seams. Erodible claystone and coal seams also occur in parts. Flattening of batter slopes from 1H:1V to 2H:1V would reduce future maintenance associated with such localised instability or alternatively the steeper cutting geometry could be retained with shotcrete protection applied to the erodible seams.

North from Lemon Tree Road the cuts are predominantly in soil. Field investigations found evidence of dispersive erosion of existing cuttings. Therefore a cut batter angle of no steeper than 2H:1V should be used. This should permit vegetation to establish on the cut batter to minimise erosion.

3.10.2 Embankment Design

Embankments would be required to traverse alluvial materials and / or residual soil gullies. Generally, construction of embankments on residual gullies less than five metres in height would most likely incorporate conventional embankment construction. Embankments over five metres in height on residual soils and embankments on soft soils (particularly on the Corindi floodplain) would require more detailed embankment design.

Where fill embankments are required on steeper slopes some embankment foundation preparation may be required to remove shallow colluvium that could be subject to instability and soil creep. Based on the fill materials that would be generated from the cuts within the study area an embankment slope angle of no steeper than 2H:1V should be considered for route options development assessment.

3.10.3 Trafficability

The alluvial flood plain is expected to include waterlogged ground, as evidenced by the prominence of grassed swamps and wet grazing land within the alluvial plain. Bridging layers are likely to be required to cross the alluvial plain. Areas underlain by residual soils may be seasonally waterlogged in the vicinity of drainage gullies and basins located within tributaries to the creeks, for example the tributaries of Redbank Creek and Cassons Creek.

The elevated alluvial areas and drainage depressions within the vicinity of Dirty Creek Range and north to Bald Knob Tick Gate Road, may contain some localised waterlogged ground. Therefore some sections of bridging layers may be required in this area.

3.10.4 Earthworks Materials

The Corindi Conglomerate, which is expected to provide good quality fill suitable for use as select layer material and possibly as sub-base material, is encountered within the Dirty Creek Range. Sandstone material generated from cuttings within the Upper Marburg Formation may also be suitable as select material.

It is noted that coal was not observed in the existing highway cuttings in the section underlain by the Walloon Coal Measures. If coal is encountered, it may need to be spoiled or incorporated within a zoned embankment. Similar treatment may be required for claystones that are known to occur in the area, although outcrops of these units are not expected to be extensive.

The remainder of material sourced from cuttings is expected to be suitable for general fill only.

3.11 Hydrology and Flooding

Existing drainage infrastructure, current and future land uses and hydrologic and hydraulic analysis of major catchments have been assessed together with groundwater, erosion and sedimentation and ecological issues relevant to drainage infrastructure.

Sixty existing drainage structures including seven bridges, numerous box culverts and pipe culverts have been identified and analysed. Preliminary hydraulic modelling of the minor drainage structures indicates that the outlet velocity at 16 structures may exceed 2 m/s. To reduce scour at these outlets, upgrading of the culverts will be necessary either with energy dissipation or scour protection.

Future land uses within the catchments are expected to generally remain the same as the existing land uses.

Hydrologic models have been developed for sub-catchments within the major river catchments – Halfway Creek, Corindi River, and Arrawarra Creek. Design floods in each catchment have been determined for the 1%, 5% and 20% Annual Exceedance Probability (AEP) event and for the Probable Maximum Flood (PMF) event. These floods have been routed through the catchments to determine flood immunity of the existing bridges and the existing highway. Hydraulic modelling of the existing bridge decks indicates that 1% AEP flood immunity is achieved at all bridges. The soffits of existing bridges at Wells Crossing, Halfway Creek and Arrawarra Creek do not have flood immunity in the 1% AEP event.

Table 3.7 provides more information on existing bridge flooding characteristics.

Table 3.7 Flooding Characteristics at Existing Bridges

Location	Deck Level (m AHD)	Predicted 1% AEP Flood Level (m AHD)	Predicted 1% AEP Flood Free Condition	
			Deck	Soffit[1]
Arrawarra Creek	8.0	7.2	✓	x
Corindi River	11.6	9.8	✓	✓
Blackadder Gully	11.0	9.6	✓	✓
Cassons Creek	11.2	9.5	✓	✓
Halfway Creek	59.8	59.5	✓	x
Wells Crossing	58.0	57.7	✓	x

Note: (1) Soffit refers to the underside of the bridge.

The existing highway between Coral Street and Blackadder Gully Road has a history of frequent flooding. Hydrologic modelling in this area has been completed to illustrate possible road and drainage works along the existing highway to achieve flood immunity levels. These results are shown in Table 3.8. The existing road pavement through this area varies from 8.5 metres AHD to 9.0 metres AHD. Combinations of 3.3 metre x 1.8 metre box culverts have been assessed to improve immunity for the existing highway across the Corindi River / Blackadder Gully floodplain as shown in Table 3.8. Bridges may be viable alternatives for the 1% and 5% flood immunity condition.

Table 3.8 Flood Immunity Works for Existing Highway at Corindi River / Blackadder Gully Floodplain

Immunity Level (% AEP)	Raised Road Level (metres AHD)	Preliminary Drainage Structures
20	9.60	7 x 3.3m x 1.8m RCBC[1]
5	9.80	15 x 3.3m x 1.8m RCBC[1]
1	10.00	25 x 3.3m x 1.8m RCBC[1]

Note: (1) Reinforced Concrete Box Culvert (RCBC).

Figure 3.18 shows the watercourses in the study area, and the results of preliminary assessments of flooding at existing bridges.

3.12 Public Utilities

A number of overhead and underground public utilities exist within the study. Depending on the type of utility, local, regional and / or interstate connections may be provided.

There is no known information regarding possible planned future upgrades to public utility assets in the study area.

The utilities that exist within the study area include:

Telecommunications

- Telstra – trunk optic fibre and distribution copper networks;
- Optus – trunk optic fibre network; and
- Visionstream Nextgen – trunk optic fibre network.

Electricity

- Country Energy high voltage network (66 kV, 33 kV and 11 kV) and low voltage distribution.

Water

- Clarence Valley Council and Coffs Harbour City Council have potable water reticulation within the study area using pipes ranging from 150 mm to 300 mm in diameter.

Sewerage

- Coffs Harbour City Council services Corindi Beach with a 150 mm diameter rising sewer main that crosses the Pacific Highway at Tasman Street; and
- Coffs Harbour City Council owns and operates a sewage treatment plant on Kangaroo Trail Road.

The public utilities within the study area are shown in Figure 3.19.