12. Earthworks

Since the announcement of the preferred route, geotechnical investigations have been carried out along the preferred route corridor.

Further detailed geotechnical investigations will be required during the development of the project towards environmental assessment and detailed design (to be completed by others).

12.1 Risk

The main geotechnical risk within the project is that the design for the Dirty Creek Range cutting has been carried out with limited investigations. Further investigations during the detail design stage are recommended.

Other potential geotechnical issues that may arise in future stages of the project include:

- Buried paleochannels in the Corindi floodplain.
- Excavatability of cutting, quality of material, bridging layers and soft soils in the Corindi Floodplain.

A detailed description of remaining geotechnical risks within the project is provided within Section 8 of the Geotechnical Design Report (GHD Geotechnics, 2007).

12.2 Cuttings

12.2.1 Dirty Creek Range

The main geotechnical feature of the project is a deep cutting at Dirty Creek Range. The cutting has a maximum depth of 45 m, with an average depth of the order of 16m. The geotechnical investigations indicated that material won from the cutting, deeper than 7 m below the existing surface, would be suitable for use as select material during construction. It was also noted that blasting would be required for excavation in rock in the Dirty Creek Range cutting. The batter slope for this cutting has been designed at 2:1 for the first 13 m below existing surface level, then at 0.7:1 until the base of the cutting.

12.2.2 Other cuttings

All other cuttings within the project are less than 14m in depth. Material won from each cutting would be of suitable quality to use as general fill. Batter slopes in all other cuttings would be 3:1 for the first 7 m. Batters higher than 7 m would include a 4.5 m wide bench with a 2:1 batter above the bench.

12.3 Embankments

12.3.1 General embankment design

Based on the review of materials that will be utilised for fill embankments, it is recommended that embankment slopes of no steeper than two (horizontal) to one (vertical) should be considered.

In some area, for example floodplain crossings, a flatter embankment slope may prove beneficial, as this would provide a more stable slope for vegetation and thus better performance for scour erosion.

12.3.2 Dirty Creek Range embankment

The largest embankment for the project is located at the northern end of Section B, around Ch 9500. The embankment would have a total batter slope length of up to 37 m, with a maximum height of 16 m and an average height of approximately 10m. It is recommended that a berm be provided on high fills at slope length intervals of no greater than 22 m. To ensure maintenance of these berms can be undertaken the berms shall be 4.5 m wide with a five (horizontal) to one (vertical) slope back into the batter, with longitudinal drainage to be located within the berm. Longitudinal alignment of berms should be selected to avoid grades of greater than 2 per cent. If grades greater than 2 per cent cannot be avoided, erosion / scour protection should be provided.

12.4 Bridges

Table 12-1 provides a summary of the recommended foundations for the proposed bridge structures throughout the route.

Table 12-1 Summary of preliminary bridge foundation types

Bridge name	Chainage	Potential foundation type		
		Bored piles	Shallow footings	Driven piles
Kangaroo Trail Road	4500	Yes	Yes	No
Corindi River Bridge	5550	Yes	No	Yes
Other Corindi Floodplain	6200	No recommendation – Performance based specification		
Redbank Creek Bridge	7650	No longer required – Culvert proposed in this location		
Pacific Highway Overbridge	11400	Yes	No	No
McPhillips Road Bridge	Not required in arterial road scenario			
Grays Road Bridge	Not required in arterial road scenario			
Lemon Tree Road Bridge	Not required in arterial road scenario			
Halfway Creek Bridge	22700	Yes	No	Yes
Wells Crossing Bridge	24500	Yes	No	Yes

12.5 Quantities

12.5.1 General

The concept design has been developed so that the cut and fill volumes are approximately balanced on the basis of bank volumes.

Overall the volume of cut material is estimated at 2,200,000m^3. The total fill volume is expected to be 1,800,000m^3.

It is estimated that 200,000 cubic metres of select fill will be required for the project, of which approximately 150,000 cubic metres would be won on site. A total volume of 200,000 cubic metres of fill is expected to be required for topsoiling.

Once allowance is included for topsoiling and use of cut material for select, the overall estimate for earthworks indicates that cut and fill quantities are approximately balanced.

12.5.2 Cutting at Dirty Creek Range

A 45 m deep rock cutting at Dirty Creek Range would provide a significant proportion of the select material required for construction. Overall, approximately 480,000 m^3 of select material would be won from the cutting, which would be used throughout the project.

12.6 Soft soils

Preliminary geotechnical investigations undertaken to date indicate that there are no extensive soft soil deposits throughout the length of the project. However, localised surficial soft soil deposits can be expected within the floodplain areas. These areas could be treated during foundation preparations for embankment construction and as such, settlement is expected to be of minor consequence to embankment (pavement) behaviour.

12.7 Acid sulfate soils

Two potential areas of acid sulfate soil risk were identified within the project area. These are:

- Arrawarra Creek – includes Arrawarra Gully sediments and coastal sediments within the eastern portion of the study area. This area is no longer within the project extents.
- Corindi River Floodplain – includes Redbank Creek, Cassons Creek and Blackadder Gully sediments.

The proposed highway upgrade in the Corindi Floodplain areas will require embankment construction with bridge and culvert crossings. This type of construction for the highway upgrade in this area will generally avoid disturbance of potential acid sulfate soils, with the exception of pile and culvert excavations. These excavations may require treatment of spoil material to negate the acid sulfate soil risk.

Similarly, the new road is expected to have negligible impact on groundwater levels within the area of potential acid sulfate soils. Consequently, there is a very low probability that acid water will be generated through in-situ oxidisation of acid sulfate soils due to groundwater lowering. This issue should be reviewed further during the development of the project to detail design stage.

12.8 Contaminated soils

A preliminary contamination assessment was undertaken within the study area to determine potential signification contamination issues that may affect the construction of the proposed highway. The assessment identified 16 sites of potential contamination within the study area, including cattle dips, mechanical workshops, farming activities, a banana plantation, a sawmill, two service stations and a quarry.

Of these sites, only the service stations at Lemon Tree Road and Halfway Creek, and the banana plantation have potential for significant contamination issues. These sites could be remediated if required, and are not expected to impact construction activities. Further investigations would be required to assess the impacts in these areas.

13. Urban design

This section summarises the urban design framework for the Woolgoolga to Wells Crossing Project. Further details regarding urban design are included in the Final urban and regional design / landscaping plan working paper.

13.1 Study area

The Woolgoolga to Wells Crossing section of the Pacific Highway is set within the coastal plain and hinterland between Coffs Harbour and Grafton. To the south the Coffs Harbour region is typified by steep coastal hills and to the north the Grafton area is the Clarence River floodplain. Overall the land use adjoining the highway upgrade is typically rural in nature, consisting of forests and agricultural or pastoral land uses.

The southern section of the highway upgrade is located west of the Arrawarra Headland and Corindi Beach. The highway passes through the Wedding Bells State Forest and also melaleuca forest and wetlands before rising into a predominantly rural area used for agricultural activities. East of the rural area lies the town of Corindi Beach. There is visual separation between Corindi Beach and the highway, with access to the Corindi Beach via Kangaroo Trail Road.

North of Corindi Beach the highway upgrade passes through Corindi River floodplain where the predominant land use is agriculture activities. The upgraded highway will be elevated relative to the floodplain to provide some level of flood immunity.

North of the Corindi River floodplain the highway rises through the Dirty Creek Range where the vegetation is typically tall eucalypt forest. The Halfway Creek valley houses the upgrade alignment through the steeper parts of the range. Vegetation at this location is generally enclosed forest with isolated cleared areas. These cleared areas allow for views across the landscape.

13.2 Urban and regional design framework

The RTA's *Pacific Highway Urban Design Framework* provides six urban design objectives that should be considered in route selection, project development and procurement process for the highway upgrade. These objectives are:

- Provide a flowing road alignment that is responsive and integrated with the landscape.
- Provide a well vegetated natural road reserve.
- Provide an enjoyable interesting highway.
- Respect the communities and towns along the road.
- Provide consistency-with-variety in road elements.
- Provide a simplified and unobtrusive road design.

The RTA's framework reinforces the essential character of the Pacific Highway corridor. It builds upon lessons learnt from the first stage of upgrade and stresses the need for a consistency of vision so that future projects are designed as part of a unified scenic highway.

13.3 Areas of aesthetic significance

The project area comprises of rural / agricultural land uses and forests. The rural / agricultural land is typically located within broad floodplain areas. The forests are generally located within the elevated areas such as Dirty Creek Range. Table 13-1 below lists the broad geographic features of the project with aesthetic significance.

Table 13-1 Areas of aesthetic significance

Location
Coastal plain west of Arrawarra Headland and Corindi Beach.
Lorikeet Tourist Park.
Wedding Bells State Forest.
Corindi Beach (township).
Corindi River floodplain.
Corindi.
Dirty Creek Range.
Newfoundland State Forest.
Yuraygir State Conservation Area.

13.4 Proposed landscaping treatment

The proposed landscape treatments seek to maintain and reinforce the character of the vegetation communities of the existing environment along the highway corridor. Five landscape treatments are proposed for the upgrade to satisfy the above objectives, comprising of:

- Rounding of cut batters to reduce the visual impact of embankments.
- Revegetation of cut batters and fill embankments within verges.
- Revegetation to medians.
- Revegetation to ecologically sensitive areas such as creek lines and fauna crossings.
- Enhancing vegetation connectivity in key habitat areas.

13.5 Proposed bridge treatments

Bridges are to be treated in accordance with various RTA reference documents including:

- Pacific Highway Urban Design Framework, RTA March 2005.
- Beyond the Pavement, Urban and Regional Design Practice Notes, RTA September 1999.
- Shotcrete Design Guidelines, RTA 1998.

Typically for bridges, the design criteria implemented includes:

- Supports to be simple tapered or pillars.
- Abutments to be spill through to allow a wider viewshed.

- The outer face of bridge deck parapets to be smooth single planes slanted outwards to the bottom.
- Traffic barriers to be precast concrete with steel rails.

Mass planting will occur either side of the bridges to integrate the bridge structures with the surrounding environment.

13.6 Specific urban and regional design treatments

There is only one location along the project upgrade where specific treatments are proposed. This location is where the new alignment merges with the existing highway alignment in the Dirty Creek Range. Significant cut and fill batters are required along with twin bridge structures. The prime treatment to be implemented is significant vegetation planting on fill batters and the upper slopes of the cut batters where a two to one slope is proposed. This will reduce the visual impact to road and highway users, and from the floodplain at a distance.

13.7 Conclusion

The visual impact assessment concluded that with regards to key viewpoints along the upgrade route there is generally negligible visual impact cause by the upgrade. This is due in a large part to the duplication occurring on the western side of the existing carriageway, low population in towns along the route, limited visibility due to landform and existing vegetation cover along the route. There is a potential adverse impact within the Dirty Creek Range, due to the depth of the Dirty Creek Range cutting and this is to be mitigated through extensive use of vegetation treatment and screening.

14. Public utilities

14.1 Existing utilities

There is significant number of existing services on the proposed upgrade alignment. The services infrastructure within the study area includes: communications, electricity, water and sewer infrastructure.

The public utilities provided within the study area are summarised in Table 14-1.

Table 14-1 Major utilities within the study area

Utility class	Authority	Location	Service description
Communications	Telstra	Throughout	Trunk optic fibre and co-axial and copper networks, distribution copper networks.
	Optus	Section B	GSM mobile (radio relay station) tower on Kangaroo Trail Road.
Electricity	Country Energy	Throughout	66kV, 11kV and low voltage
Water	Coffs Harbour City Council	Section A and B	150 mm-300 mm diameter potable water mains
Sewerage	Coffs harbour City Council	Tasman Street, Corindi Sewerage Treatment Plant	150 mm diameter rising sewer main

14.2 Utilities impacted by the project

14.2.1 Communications

Telstra

Telstra has an extensive infrastructure network throughout the study area with key Sydney to Brisbane Optic Fibre cables, co-axial cable and copper distribution networks impacted by the proposed alignment. Due to the rural environment, some portions of the co-axial and copper network are included in the “Main Cable” network. The Main Cable network distributes information between local network exchanges and services isolated properties. Table 14-2 summarises the impacts to the Telstra Network from the proposed alignment.

Table 14-2 Telstra utilities impacted by the proposed alignment

Section	Telstra asset	Impacts	Adjustment / protection measure
Section A	Optic Fibre (OF)	The Telstra OF Sydney to Brisbane cable currently impacted where the proposed	Protection of the OF line will be required prior to commencement of

Section	Telstra asset	Impacts	Adjustment / protection measure
		alignment deviates from the existing highway at Ch 3750.	construction.
Section B	Main Cable	Three copper main cable lines cross the proposed alignment.	Relocation of the copper main cable lines required in the arterial upgrade scenario.
Section C	Optic Fibre (OF)	Duplication of the highway through Dirty Creek Range (Ch 11,800) impacts on dual OF crossing.	Construction of new optical fibre link required near Ch 11,800.
	Main Cable	Copper main cable located adjacent to the alignment from Ch 11,000 to 13,500.	Relocation of the copper main cable lines required in the arterial upgrade scenario.
Section D	Optic Fibre (OF)	Of potentially impacted by the Motorway standard service road in the existing Halfway Creek duplication.	No adjustment for Arterial upgrade.
	Local copper	Local copper network potentially impacted by proposed service road in existing Halfway Creek Duplication.	No adjustment for Arterial upgrade.
Section E	Optic Fibre (OF)	OF runs adjacent to proposed service roads in the motorway standard upgrade.	No adjustment for Arterial upgrade.
	Local Copper	Local copper network impacted by arterial and motorway standard upgrade.	No adjustment for Arterial upgrade.

Optus

An Optus GSM radio transmission tower near Kangaroo Trail Road is not impacted by the proposed alignment.

14.2.2 Electricity

Country Energy

Country Energy provides electricity to the rural properties along the existing route. The Country Energy network consists of eleven kilovolt overhead transmission lines and low voltage overhead and underground transmission lines servicing rural properties and lighting adjacent to the existing highway. Table 14-3 summarises the impacts to the Country Energy Network from the proposed alignment.

Table 14-3 Country Energy utilities impacted by the proposed alignment

Section	Country Energy asset	Impacts	Adjustment / protection measure
Section A	11 kilovolt (kV)	Country Energy transmission line will cross the proposed alignment where the proposed alignment deviates from the existing highway at Ch 3750.	Relocation of power poles and overhead line required at Ch 3750
Section B	11 kilovolt (kV)	Two 11kV overhead transmission lines cross the proposed route in Section B.	Minor adjustments to the location of power poles and overhead line required
Section C	11 kilovolt (kV)	Existing 11kV overhead transmission lines cross the highway at Range Road East and Ch 12,300. The 11kV follows the proposed alignment for approximately 1 km. This will be impacted by the proposed motorway standard service road.	Minor adjustments to the location of power poles and overhead line required at Ch 12,300 No other impacts in the arterial upgrade scenario.
Section D	11 kilovolt (kV)	Existing 11kV overhead transmission line crosses the highway at Dunmar Lane. The proposed motorway standard service road will impact the transmission line in the vicinity Grays Road. 11kV line in the vicinity of Lemon Tree Road will be impacted in the motorway standard upgrade.	No impacts in the arterial upgrade scenario.
	Low Voltage	Low voltage underground transmission lines servicing lights at the intersection of Lemon Tree Road will be impacted in the motorway standard upgrade.	No impacts in the arterial upgrade scenario.
Section E	11 kilovolt (kV)	11kV overhead transmission line will be impacted in vicinity of Kungala Road and Luthers Road will be impacted in the motorway standard upgrade.	No impacts in the arterial upgrade scenario.

Section	Country Energy asset	Impacts	Adjustment / protection measure
	Low Voltage	Low voltage transmission lines in the vicinity of Kungala Road will be impacted in the motorway standard upgrade.	No impacts in the arterial upgrade scenario.

14.2.3 Water

The existing Coffs Harbour City Council 150 to 300 mm water main on the eastern side of the existing highway from Tasman Street to Arrawarra Beach Road will not be impacted by the proposed highway upgrade. No adjustment or protection is required.

14.2.4 Sewerage

A Coffs Harbour City Council Sewer Rising Main crosses the existing highway in Section A at Tasman Street and continues to the Corindi Sewerage Treatment Plant. The proposed alignment will cross this sewer rising main at approximately Chainage 4000. Protection of the existing sewer rising main is required.

15. Signage, linemarking and barriers

15.1 Barriers

Safety barriers have been specified at numerous locations throughout the project in accordance with the RTA's Road Design Guide. Thrie beam and w-beam has been specified adjacent to bridges, while wire rope safety fence has been specified as required in most other locations.

Safety barrier is provided where cut batters are at a slope greater than four to one. Specifically, safety barrier has been provided across the Corindi Floodplain where two to one batters have been designed.

Wherever wire rope safety fence is specified, the design has been prepared in accordance with the Pacific Highway Design Guidelines, Upgrading Program Beyond 2006 – Design Guidelines, July 2005, Issue 2.1, RTA's Road Design Guide and standard RTA model drawings.

- The berm behind the safety fence has been increased to 1.5m in width.
- At each terminal, the verge has been widened.
- Standard transitions between wire rope safety fence and w-beam have been provided.

15.2 Signposting policies

Signposting designs for regulatory, warning and directional signs have been prepared in accordance with:

- AS 1742.
- Pacific Highway Design Guidelines, Upgrading Program Beyond 2006 – Design Guidelines, July 2005, Issue 2.1.
- RTA's Road Design Guide and model drawings.
- Austroads Guide to Traffic Engineering Practice, Part 8 – Traffic Control Devices.

The signposting design includes allowance for towns such as Corindi Beach and Red Rock. The requirements are defined in RTA's Traffic Engineering Manual, Part 12, Tourist Signposting.

Signposting designs are included in the concept design drawings (Volume 2 of this report).

15.3 Linemarking Designs

All linemarking has been prepared in accordance with:

- AS 1742.
- Pacific Highway Design Guidelines, Upgrading Program Beyond 2006 – Design Guidelines, July 2005, Issue 2.1.
- RTA's Road Design Guide and model drawings.

Linemarking designs are included in the concept design drawings.

16. Terrestrial ecology

The environmental features of the study area vary as the route progresses from south to north. Accordingly the terrestrial ecology characteristics of the route are quite diverse and species composition varies from south to north.

The broad ecological features of the area can be described commencing in the south as coastal plain, passing into forested and wetland areas prior to progressing into pastureland and scattered woodlands.

Corindi Beach is located to the east of the highway in this section. North of Corindi Beach, the route passes through the agricultural setting of the Corindi River floodplain. As the route approaches the Dirty Creek Range, the environment becomes more forested and then the route climbs into the steep and heavily forested Dirty Creek Range dominated by eucalypt forests. The route then passes along the comparatively flat section where there is pastureland present within the predominantly forested area north to Wells Crossing.

Three Endangered Ecological Communities identified by the *NSW Threatened Species Conservation Act 1995* are found in numerous places along the route, and a number of Endangered Ecological Communities are impacted.

Twenty six threatened fauna species listed under the *Threatened Species Conservation Act 1995* and two threatened fauna species under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* were recorded in the study area from field survey or the Department of Environment and Climate Change Wildlife Atlas. One threatened flora species that is listed under both the *Threatened Species Conservation Act 1995* and *Environmental Protection and Biodiversity Conservation Act 1999* was recorded.

Further details regarding the terrestrial ecology are provided in the Terrestrial Ecology Report working paper.

16.1 Field investigations

Field investigations have been undertaken at different stages of the project development to ascertain the ecological constraints and to inform the requirements for the concept design. Initial preliminary surveys were undertaken at the route development stage, and further targeted surveys were undertaken where the developed route options deviated from the existing highway alignment.

Following the announcement of the Preferred Route by the Minister for Roads on 28 August 2006, the strategy for the advanced terrestrial ecology field investigations was formulated in order to comply with the Department of Environment and Climate Change's "Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities. Working Draft 2004". Two separate seasonal field investigation surveys were planned. Targeted field investigations were undertaken in early spring 2006 and late summer 2007 to satisfy the requirements of the Department of Environment and Climate Change Guidelines. The seasonal variation of species that can be detected, and in particular fauna species that seasonally migrate into and out of ecosystems, were accounted for by undertaking the field studies at these times.

The findings from the advanced terrestrial ecology field investigations have been incorporated into the Advanced Terrestrial Ecology Assessment Report and data collected has been mapped into the Geographical Information System platform to inform the concept design process.

16.2 Potential impacts during construction

The construction of the highway upgrade has the potential to impose impacts on the ecological characteristics and biodiversity integrity of the affected area if appropriate management measures are not implemented.

The construction of the highway has the potential to impose impacts on:

- Endangered ecological communities.
- Threatened species.
- Terrestrial and aquatic fauna habitat.
- Terrestrial and aquatic flora species.
- Water quality.
- Fauna movement corridors.

16.3 Potential impacts during operation

The route selection process was undertaken with the aim of minimising the impact on the environment by making informed decisions with information gathered during initial fieldwork and through an environmentally sensitive approach to selecting the ultimate alignment. The effectiveness of the measures proposed during the concept and detailed designs will determine the level and nature of ongoing impacts of the operation of the highway. The concept design strategy has been to formulate design measures aimed at further minimising the highway upgrade's impact on the ecological integrity and environmental characteristics of the area.

Management measures may require revision post-construction if it is found that impacts to the area's biodiversity, ecology and natural environment are unacceptable.

The operation of the highway has the potential to impose impacts on:

- Terrestrial fauna in the form of vehicle strikes if fauna crossings are not adequately implemented and maintained.
- Aquatic and amphibian fauna where waterway crossings are blocked, impeded or significantly altered.
- Flora species in terms of limiting propagation and colonisation opportunities for native species.
- Fauna in the form of degraded water quality.
- Adjoining habitats in the form of degraded water quality.

16.4 Recommended terrestrial flora and fauna mitigation measures prior to and during construction

More detailed mitigation and management measures will be developed during the environmental assessment, as a result of the conditions of approval, and the subsequent detailed design for the project. Detailed management and mitigation measures will be formulated and documented in a Construction Environmental Management Plan.

The flora and fauna mitigation measures that have been incorporated into the concept design have been formulated to provide performance-based outcomes. This approach differs from rigid design criteria. Performance-based approaches are less prescriptive in the way in which a desirable outcome is to be achieved, but more targeted in determining the performance requirements for the desired outcome.

This approach is consistent with the approach being adopted by the NSW Department of Planning for the environmental assessment under Part 3A of the Environmental Planning and Assessment Act for major transport infrastructure projects. It is anticipated that the Woolgoolga to Wells Crossing Project would be subject to a Part 3A Assessment (or the equivalent) at the time of progression to the environmental assessment phase.

The terrestrial ecology outcomes that have been addressed by the approach taken in developing the concept design are:

- Minimise impact on endangered ecological communities.
- Minimise impact on threatened flora and fauna species.
- Minimise impact on key habitat areas.
- Minimise impact key fauna movement corridors.
- Minimise impact on aquatic ecosystems.
- Ensure the location and sizing of fauna crossings are such that fauna species are not disadvantaged or threatened by their usage.
- Provide adequate passage for fauna species across the upgraded highway, and ensure that fauna is not channelled onto adjoining roads such as the old highway or busy service roads.
- Key recommendations from the outcomes of the concept design, environmental assessment phase and subsequent approvals, will allow the development of a Revegetation Plan to accompany the Construction Environmental Management Plain and provide a suitable and maintainable revegetation strategy.

16.4.1 Pre-construction

In order to target and address the required outcomes, the concept design has included the consideration of:

- Appropriate location and sizing of fauna crossings.
- Appropriate accommodation of fauna crossings in key fauna movement corridors and key fauna habitat.
- Indicative locations of fauna fencing.
- General arrangements for amphibian-friendly culvert designs.

- Minimisation of intrusion into sensitive ecosystems such as endangered ecological communities, SEPP 14 wetlands, key fauna habitat and key fauna movement corridors.
- Minimisation of intrusion into nature reserves, national parks and state conservation areas.
- Adequate assessment of the loss of hollow-bearing trees and potentially examine hollow replacement strategies.

Immediately prior to construction it is recommended that a qualified ecologist traverse the path to locate and safely remove fauna and threatened flora species from the construction path.

A Flora and Fauna Management Plan would also be formulated for incorporation into the Construction Environmental Management Plan.

16.4.2 During construction

The performance objectives of the environmental management and mitigation measures that have been developed and incorporated into the concept design will be further developed and documented in the Construction Environmental Management Plan. An environmental representative is to be appointed to monitor compliance with the environmental protection measures contained within the Construction Environmental Management Plan.

Environmental controls to be developed in the Construction Environmental Management Plan, and monitored by the environmental management representative, will include procedures to ensure that during construction the performance objectives can at minimum be met.

It is also recommended that a qualified ecologist be available to identify and safely relocate fauna and threatened flora species at the commencement of land clearing.

16.5 Indicative terrestrial flora and fauna management measures during operation

The primary mitigation and management measures that will be in place for the operational phase of the project will be those that have been developed in the concept design, and those that will be further expanded and refined during the detailed design phase. These measures include:

- Fauna crossing size and locations. A condition of approval may include the monitoring of these fauna crossings for adequacy and performance.
- Fauna fencing.
- Water quality and sedimentation ponds.

Based on the information gathered from the advanced terrestrial ecology field surveys and the information provided by stakeholders such as the Department of Environment and Climate Change, the Community Liaison Group and Ecological Focus Group forums, the management and mitigation provisions take into account the following:

- Known locations of threatened and/or endangered species.
- Vicinity of key fauna habitat.
- Local hydrological conditions.
- Known fauna movement corridors.
- Distance to adjoining fauna crossings.

The locations of proposed drainage culverts have formed the platform for the siting of fauna crossings. However, a number of purpose-specific fauna crossings have been proposed where there is an identified fauna movement corridor, where there is key fauna habitat that is severed by the route or where the vertical alignment allows for stand-alone fauna crossings in areas where there is a significant distance to adjoining crossings.

A summary of the provisions proposed for fauna movement across the upgraded highway are provided in Table 16-1. A summary of the proposed cattle and fauna fencing is also provided in Table 16-2.

Notes:

- BC = box culvert.
- RCP = reinforced concrete pipe.

Dimensions are in metres: number of cells by width by height eg 2 x 3 m x 3 m = two 3 m wide by 3 m high.

Fauna underpasses are to be designed to adopt the principles of the Department of Environment and Client Change and Department Primary Industry - Fisheries guidelines. Principles include allowing for dry passage for terrestrial fauna, allowing for line of sight through crossing and allowing for potential fish passage in drainage lines.

Generally the culverts shown in Table 16-1 also function as drainage lines, however Culverts 27F, 29F, 31F, 36BF, 61F and 61F1 are for Fauna movements only.

Table 16-1 Indicative fauna underpass structures

Location	Chainage	Structure*	Comments / species targeted
Culvert 6 Arrawarra, south of Darlington Beach Resort	2730	3.3 m x 1.8 m box culvert	Opposite Wedding Bells State Forest, which is key habitat and just north of a key fauna movement corridor.
Culvert 7 Approx 450m north of Sherwood Creek Road	2800	2 x 3 m x 1.8 m box culverts	Opposite Wedding Bells State Forest which is key habitat and a key fauna movement corridor.
Culvert 11 South of Kangaroo Trail Road and the northern boundary of Wedding Bells State Forest. Corindi Treatment Plant	4100	2 x 3 m x 2.4 m box culverts	Key habitat and movement corridor both to the west and south.

Location	Chainage	Structure*	Comments / species targeted
Culvert 11F Approx 300m north of Kangaroo Trail Road	4820	3 m x 2.7 m box culvert	Key habitat to the west, likely macropod crossing.
Corindi Creek Bridge	5507 to 5592	285 m Bridge	Bridge with fauna passage under. Fauna required to travel a total of 36 m beneath two bridge carriageways and median.
M4 floodplain bridge – Corindi Creek Floodplain	6025 to 6305	Floodplain bridge approx 3.5 m height	Floodplain bridge to be used for farm vehicles.
M6 floodplain culvert – Corindi Creek Floodplain	6420	2 x 2.7 m x 1.2 m box culverts + 1x 3 m x 3 m box culvert	Floodplain crossing likely used by macropods and others. Sub-regional fauna movement corridor located to the west.
Culvert 24 Approx 1200m south of Section C	8185	Bridge or arch structure with minimum 4.3 m clearance. Drainage for creek included	Culvert combined with property access and cattle underpass on a rural property. Small pockets of Swamp Sclerophyll Forest on Coastal Floodplain, both Endangered Ecological Communities, are located in the vicinity also. Key habitat and fauna movement corridors are to the west.
Culvert 27F West of Bottlebrush Drive.	8770	3 m x 3 m box culvert	Located within a key sub-regional fauna movement corridor and within a small pocket of the Swamp Sclerophyll Forest on Coastal Floodplain Endangered Ecological Community.
Culvert 28A Commencement of Section C	9465	3 m x 3 m box culvert	Located within a key sub-regional fauna movement corridor.
Culvert 29 F North of blueberry farms	10,535	3 m x 3 m box culvert	Located just west of a key sub-regional fauna movement corridor.
Culvert 31F	11,000	3 m x 3 m box culvert	Located just north of the blueberry farmland and where the old and new alignments merge. To the north of the existing alignment is a remaining pocket of Endangered Ecological Community and key habitat.
Culvert 33A North of Range Road	12,120	3 m x 3 m box culvert. Adjoining service road will need re-grading	Located within a key sub-regional fauna movement corridor.

Location	Chainage	Structure*	Comments / species targeted
Culvert 35A Vicinity of Dundoo Creek	12,820	3 m x 3 m box culvert	Located within a key sub-regional fauna movement corridor and within a small pocket of Subtropical Coastal Floodplain Forest, an Endangered Ecological Community.
Culvert 36F South of The Siding and Falconers Lane	13,815	3 m x 3 m box culvert	Located within a key regional fauna movement corridor and adjacent to key habitat.
Culvert 37 Just north of Falconers Lane	14,380	3 m x 3 m box culvert	Located within a key regional fauna movement corridor and adjacent to key habitat.
Culvert 39 Vicinity of Boneys Creek and McPhillips Road	14,940	3 m x 3 m box culvert	Located within a key regional fauna movement corridor and adjacent to key habitat.
Culvert 40 Boneys Creek	15,370	2 x 3m x 3m box culverts to be extended	Located within a key regional fauna movement corridor and adjacent to key habitat and within a small pocket of Subtropical Coastal Floodplain Forest, an Endangered Ecological Community.
Culvert 41	15,890	3 m x 3 m box culvert	Located adjacent to key habitat and in between two pockets of Endangered Ecological Communities. Newfoundland State Forest is adjacent. Just south of the Halfway Creek Duplication.
Culvert 42	16,100	2 x 1.35 m reinforced concrete pipes	Although concrete pipes, this crossing should be suitable for fauna passage, particularly in dry times. Just south of the Halfway Creek Duplication.
Halfway Creek Duplication 16,150 to 19,400 No works to be carried out			
Culvert 52	21,240	3 m x 2.4 m box culvert	Located on the north-eastern edge of the Swamp Sclerophyll Forest on Coastal Floodplain Endangered Ecological Community, and just east of a key regional fauna movement corridor.
Culvert 53	21,700	2 m x 2.4 m box culvert	Located within a key regional fauna movement corridor and adjacent to a pocket of Swamp Sclerophyll Forest on Coastal Floodplain Endangered Ecological Community.

Location	Chainage	Structure*	Comments / species targeted
Culvert 56	22,710	4 x 3 m x 2.4 m box culverts to be extended	Located just to the west of a key regional fauna movement corridor and adjacent to two Endangered Ecological Communities - Swamp Sclerophyll Forest on Coastal Floodplain and Subtropical Coastal Floodplain Forest.
57 - Wells Crossing Bridge	22,785	Wells Crossing Bridge	Wells Crossing bridge with fauna passage under. Fauna required to travel a total of 36m beneath two bridge carriageways and median.
Culvert 58	22,925	3 m x 1.8 m box culvert	Located just to the west of a key regional fauna movement corridor and just north of two Endangered Ecological Communities - Swamp Sclerophyll Forest on Coastal Floodplain and Subtropical Coastal Floodplain Forest.
Culvert 59	23,335	3m x 3m box culvert	Located just to the west of a key regional fauna movement corridor.
60 Bridge	24,435	Bridge	Bridge with fauna passage under.
Culvert 61F	25,185	3 m x 1.8 m box culvert	Located within key habitat and within a key sub-regional fauna movement corridor. Is also located just north of a pocket of Swamp Sclerophyll Forest on Coastal Floodplain Endangered Ecological Community.
Culvert 61F1	25,800	3 m x 1.8 m box culvert	Located within key habitat and within a key sub-regional fauna movement corridor.
Culvert 62	26,650	3 m x 1.8 m box culvert. Regrade required.	Located within key habitat and within a key sub-regional fauna movement corridor.
Culvert 63	26,690	3 m x 1.8 m box culvert. Regrade required.	Located within key habitat and within a key sub-regional fauna movement corridor.

Table 16-2 Indicative proposed fauna and cattle fencing

Location (side of highway)	Chainage	Length	Type
West	1700 – 11,400	9700 m	Fauna fencing
East	1700 – 11,350	9650 m	Fauna fencing
East	3500 – 11,400	7850 m	Cattle fencing
West	3500 – 16,275	12,775 m	Cattle fencing
East	11,400 – 12,350	950 m	Cattle fencing
East	11,400 – 15,250	3800 m	Fauna fencing
West	11,650 – 16,275	4675 m	Fauna fencing
West	19,000 – 22,375	3375 m	Fauna fencing
West	19,000 – 23,750	4750 m	Cattle fencing
East	19,500 – 27,400	7900 m	Fauna fencing
East	19,500 – 20,600	1100 m	Cattle fencing
East	21,550 – 27,400	5850 m	Cattle fencing
West	22,800 – 27,400	4600 m	Fauna fencing
Total – fauna fencing		**43,700 m**	
Total – cattle fencing		**33,275 m**	

17. Aquatic ecology

The preferred route for the highway traverses a number of different aquatic environments. The Corindi River and its floodplain are located towards the southern end of the route. The route also crosses a number of smaller streams and Halfway Creek towards the northern end. The route bypasses two areas identified under State Environmental Planning Policy Number 14 in the Corindi Beach area, but does not directly impact them.

The concept design of the highway has been developed with the goal of minimising the impacts on the aquatic habitats of the area.

The Aquatic Ecology Report working paper contains further details regarding the investigations and impacts on the Aquatic Ecology.

17.1 Field investigations

A series of field investigations have been undertaken to ascertain the ecological constraints of the proposed highway upgrade in relation to the requirements of the *Fisheries Management Act 1994*, and to ascertain constraints and opportunities for the concept design.

Field investigations have been undertaken at different stages of the project development. Initial preliminary surveys were undertaken at the route development stage, and further targeted surveys were undertaken where the developed route options deviated from the existing highway alignment.

Following the announcement of the Preferred Route by the Minister of Roads on 28 August 2006, advanced aquatic ecology field investigations were undertaken. The findings from the aquatic ecology field investigations have been incorporated into the Advanced Aquatic Ecology Survey Report and data collected has been mapped into the Geographical Information System platform to inform the concept design process.

17.2 Impacts during construction

The construction of the upgraded highway has the potential to impact the aquatic ecological values and integrity of the area both in the short and long term if appropriate environmental management measures are not incorporated into the concept and detailed designs and employed during construction.

The construction of the highway has the potential to impose impacts on:

- Endangered Ecological Communities in terms of degraded or polluted water entering the ecosystem and affecting ecological health.
- Aquatic and amphibian fauna where waterway crossings are blocked, impeded or significantly altered.
- Populations of threatened aquatic species being disturbed. No threatened aquatic species were found during the fieldwork, however the habitat has the potential to support threatened aquatic species.
- Aquatic fauna habitat in the form of water degradation together with degradation of water quality downstream of the highway.
- Dislocation of aquatic and amphibian fauna populations due to impediment of aquatic fauna passage.

17.3 Impacts during operation

The route selection process was undertaken with the aim of minimising the impact on the environment by making informed decisions with information gathered during initial fieldwork and through an environmentally sensitive approach to selecting the ultimate alignment. The effectiveness of the measures proposed during the concept and detailed designs will determine the level and nature of ongoing impacts of the operation of the highway. The concept design strategy has been to formulate design measures aimed at further minimising the highway upgrade's impact on the ecological integrity and environmental characteristics of the area.

Management measures developed for the concept design may require revision post-construction if it is found that impacts to the area' biodiversity, ecology and natural environment are unacceptable.

17.4 Recommended aquatic flora and fauna mitigation measures during construction

The major potential construction impacts identified at the concept design stage, and those that will require management and mitigation are:

- Avoidable loss of riparian vegetation.
- Siltation of adjoining waterways from exposed soils.
- Contamination of adjoining waterways by fuels and chemicals from construction plant and equipment.
- Death or injury to aquatic fauna from construction equipment and habitat disruption.
- Scouring or erosion of river and creek banks as a result of improper placement of construction equipment.
- Obstruction to aquatic and amphibian fauna movement during construction resulting in the isolation and fragmentation of populations, which may result in long-term detrimental impacts.

Management and mitigation measures to be implemented during construction are to be developed during the detailed design stage and further developed by the construction contractor to be incorporated into the Construction Environmental Management Plan. A number of sub-plans addressing construction impacts on aquatic flora and fauna will be required.

17.5 Recommended aquatic flora and fauna mitigation measures during operation

The primary mitigation and management measures that will be in place for the operational phase of the project will be those that have been developed in the concept design, and those that will be further expanded and refined during the detailed design phase. These measures include:

- Fish-friendly and amphibian-friendly culvert designs meeting Department of Primary Industries – Fisheries requirements.
- Water quality and sedimentation ponds.

Based on the information gathered from the advanced aquatic ecology field surveys and the information provided by stakeholders such as the Department of Environment and Climate Change, the Community Liaison Group and the Ecological Focus Group forums, the management and mitigation provisions developed during the concept design stage have considered the following:

- Known locations of threatened and/or endangered species.
- Vicinity of key aquatic fauna habitat.
- Adequate provision of fish and amphibian-friendly culverts and waterway crossings.

Where bridges and culverts are to be installed in waterways, the guidelines developed by the Department of Primary Industries (Fisheries) and recommendations from the Department of Environment and Climate Change are to be addressed in finalising the structure design at the detailed design stage.

Fish and amphibian friendly culvert designs, developed in accordance with the above guidelines and recommendations, would be required in order to limit the potential long-term impacts on the viability of aquatic and amphibian populations in the areas impacted by the highway upgrade project.